

For the Commission by the Division of Market Regulation, pursuant to delegated authority.

January 12, 1981.

George A. Fitzsimmons,
Secretary.

[FR Doc. 81-1506 Filed 1-15-81; 8:45 am]

BILLING CODE 8010-01-M

[Release No. 34-17442; File No. SR-PHLX 80-29]

Self-Regulatory Organizations; Proposed Rule Change by Philadelphia Stock Exchange, Inc.

Pursuant to Section 19(b)(1) of the Securities Exchange Act of 1934, 15 U.S.C. 78s(b)(1), as amended by Pub. L. No. 94-24, 16 (June 4, 1975), notice is hereby given that on January 2, 1981, the above-mentioned self-regulatory organization filed with the Securities and Exchange Commission a proposed rule change as follows:

The Exchange's Statement of the Terms of Substance of the Proposed Rule Change

The Philadelphia Stock Exchange ("PHLX"), pursuant to Rule 19b-4 of the Securities Exchange Act of 1934 ("Act") proposes to amend Rule 631 ("Connection with Non-Members"), as follows: (brackets indicate words to be deleted; italics indicate words to be added).

Rule 631. No member or member organization shall establish or maintain any private wire connection, private radio, television or wireless system, between his or its offices and the office of any non-member without (notification) *application to and approval by the Committee.*

Every such means of communication shall be registered with the Committee. Notice of the discontinuance of any such means of communication shall be promptly given to the Committee.

The Exchange's Basis and Purpose of Proposed Rule Change

The purpose of the proposed rule change is to clarify the intent of the Rule 631 by providing that formal application to and approval by the Committee is a prerequisite to the installation of any type of communication line between the offices of a member or member organization and that of a non-member. Approval of such installation is based on compliance with the rules and policies of the Exchange and the Act and the rules and regulations thereunder.

The proposed rule change would enhance the PHLX's capacity to comply and enforce compliance by its members

and persons associated with its members with the Act, the rules and regulations thereunder and its own rules.

Comments were not solicited or received.

The PHLX has determined that the proposed amendment will not impose any burden on competition.

Within 35 days of the date of publication of this notice in the Federal Register, or within such longer period (i) as the Commission may designate up to 90 days of such date if it finds such longer period to be appropriate and publishes its reasons for so finding or (ii) as to which the above-mentioned self-regulatory organization consents, the Commission will:

(a) By order approve such proposed rule change, or

(b) Institute proceedings to determine whether the proposed rule change should be disapproved.

Interested persons are invited to submit written data, views and arguments concerning the foregoing. Persons desiring to make written submissions should file six copies thereof with the Secretary of the Commission, Securities and Exchange Commission, Washington, D.C. 20549. Copies of the filing with respect to the foregoing and of all written submissions will be available for inspection and copying in the Public Reference Room, 1100 "L" Street, N.W., Washington, D.C. Copies of such filing will also be available for inspection and copying at the principal office of the above-mentioned self-regulatory organization. All submissions should refer to the file number referenced in the caption above and should be submitted on or before February 9, 1981.

For the Commission by the Division of Market Regulation, pursuant to delegated authority.

George A. Fitzsimmons,
Secretary.

January 12, 1981.

[FR Doc. 81-1506 Filed 1-15-81; 8:45 am]

BILLING CODE 8010-01-M

VETERANS ADMINISTRATION

Station Committee on Educational Allowances; Meeting

Notice is hereby given pursuant to Section V, Review Procedure and Hearing Rules, Station Committee on Educational Allowances that on February 10, 1981, at 9:00 a.m., the Veterans Administration Regional Office, St. Petersburg, Florida, Station Committee on Educational Allowances shall, at the Federal Building, Room 621,

144 1st Avenue South, St. Petersburg, Florida, conduct a hearing to determine whether Veterans Administration benefits to all eligible persons enrolled in Lakeland College of Business and Fashion, Lakeland, Florida, should be discontinued, as provided in 38 CFR 21.4143, because a requirement of law is not being met or a provision of the law has been violated. All interested persons shall be permitted to attend, appear before, or file statements with the committee at that time and place.

Dated: January 9, 1981.

Carlos L. Rainwater,
Director.

[FR Doc. 81-1503 Filed 1-15-81; 8:45 am]

BILLING CODE 8320-01-M

Vocational Rehabilitation and Counseling; Policies and Procedures

AGENCY: Veterans Administration.

ACTION: Public notice and request for comment.

SUMMARY: The Veterans Administration is publishing for public notice and comment a summary of new provisions to be administered in the vocational rehabilitation and counseling program. This summary of the Veterans' Rehabilitation and Education Amendments of 1980 will acquaint veterans, educational institutions and the public at large with the anticipated changes in the vocational rehabilitation and counseling program.

DATE: Comments must be received on or before February 17, 1981.

ADDRESS: Send written comments to: Administrator of Veterans Affairs (271A), Veterans Administration, 810 Vermont Avenue, N.W., Washington, D.C. 20420.

Comments will be available for inspection at the address shown above during normal business hours until February 27, 1981.

FOR FURTHER INFORMATION CONTACT:

Dr. Stephen L. Lemons, Assistant Director for Policy and Program Development, Vocational Rehabilitation and Counseling Service (282), Veterans Administration, 810 Vermont Avenue, N.W., Washington, D.C. 20420 (202-389-2026).

SUPPLEMENTARY INFORMATION: This publication contains DVB Circular 28-80-3, Vocational Rehabilitation and Counseling Provisions of the Veterans' Rehabilitation and Education Amendments of 1980 (Pub. L. 96-466). This circular contains a summary of the Veterans Administration vocational rehabilitation program. This circular has been implemented and has been

distributed through normal channels to interested persons. Comments received will be used in developing VA Regulations and policies to implement Pub. L. 96-466.

ADDITIONAL COMMENT INFORMATION

Interested persons are invited to submit written comments, suggestions, or objections regarding this document to the Administrator of Veterans Affairs (271A), Veterans Administration, 810 Vermont Avenue, NW., Washington, D.C. 20420. All written comments received will be available for public inspection at the above address only between the hours of 8 am and 4:30 pm, Monday through Friday (except holidays) until February 27, 1981. Any person visiting Veterans Administration Central Office in Washington, D.C. for the purpose of inspecting any such comments will be received by the Central Office Veterans Services Unit in room 132. Such visitors to a VA field station will be informed that the records are available for inspection only in Central Office and furnished the above address and room number.

Approved: January 7, 1981.

Max Cleland,
Administrator.

Vocational Rehabilitation and Counseling Provisions of the Veterans' Rehabilitation and Education Amendments of 1980 (Pub. L. 96-466); DVB Circular 28-80-3

November 7, 1980.

1. *Purpose.* This issue is to inform DVB field staff about changes to Chapter 31, title 38 U.S.C., resulting from the enactment of Pub. L. 96-466. While the focus is on the vocational rehabilitation provisions of the law, other aspects relevant to VR&C (Vocational Rehabilitation and Counseling) operations are also discussed.

2. *Background.* During FY 1978 the VA completed and submitted to the Congress a study of the VA vocational rehabilitation program as mandated by Pub. L. 95-202. The study included an analysis of the VA vocational rehabilitation program, a comparison of Chapter 31 provisions with the State/Federal program provisions, and recommendations for administrative and legislative changes needed to up-date and modernize the program. Subsequently, proposed legislation was introduced in both houses of Congress by request of the VA. After consideration of these and other proposals, Congress enacted Pub. L. 96-466, "Veterans' Rehabilitation and

Education Amendments of 1980," which was signed into law on October 17, 1980. Title I of Pub. L. 96-466 updates and expands the VA vocational rehabilitation program. This complete revision of Chapter 31, the first since its inception in 1943, improves the vocational rehabilitation program and assures that service-connected disabled veterans will benefit from the latest concepts and methods developed in the field of rehabilitation. The VA has the authority to make the Chapter 31 program more responsive to the needs of service-disabled veterans, especially the more seriously disabled.

3. *Overview.* a. *Title I—Rehabilitation Amendments.* (1) *Purposes.* The purpose of the rehabilitation program is expanded to provide for all services and assistance necessary to enable service-disabled veterans to achieve maximum independence in daily living, and to the maximum extent feasible, to become employable and to obtain and maintain suitable employment. This statement of purpose significantly differs from the traditional view which limited vocational rehabilitation to restoration of employability through training, and the provisions of the new law clearly reflect this fundamental change in philosophy.

(2) *Eligibility and Entitlement.* Eligibility for and entitlement to services are organized around two basic concepts—employment handicap and serious employment handicap. Employment handicap must be shown in each case as part of the determination of basic entitlement. The basic period of eligibility has been extended from 9 to 12 years. Rehabilitation programs will not exceed 48 months, unless a longer period is warranted in the individual case. A finding of a serious employment handicap is a key factor in most provisions for extension of the period of eligibility beyond the basic 12-year period and for extension of the duration of a rehabilitation program beyond 48 months.

(3) *Extended Evaluation and Independent Living Services.* Those veterans for whom feasibility of vocational rehabilitation cannot be immediately determined will now enter extended evaluation programs and receive pretraining services. Such evaluation and services will be provided to determine if the veteran may attain a level necessary to either enter vocational rehabilitation training or a rehabilitation program having the objective of achieving maximum independence in daily living. For this last purpose, a special pilot program of limited scope and duration has been

authorized to enable some of the most severely disabled veterans to undergo an intensive and innovative program of independent living services.

(4) *Individualized Planning.* Rehabilitation planning will now include not only those services needed to improve the veteran's ability to function in employment, but also in his or her family and community. An individual written rehabilitation plan, to be jointly developed by VA staff and the veteran, will be the means through which the goals of most rehabilitation programs are developed, and will delineate the means and time by which these goals will be achieved.

(5) *Allowances.* Enhanced financial provisions include an overall 17 percent increase in subsistence allowance, an increase in the revolving fund loan maximum, increased subsistence allowance for nominal pay or nonpay training, subsistence allowance during periods of extended evaluation, liberalization of post-rehabilitation payment and other considerations. Under a new option, Chapter 31 participants with remaining Chapter 34 entitlement may elect to receive the higher Chapter 34 educational allowance, in lieu of subsistence allowance and other training costs, while still being able to receive almost the full range of Chapter 31 services.

(6) *Employment Assistance.* To carry out the full purposes of the program, the scope of services and assistance has been broadened to include employment assistance as an integral part of the program for service-connected veterans who are or have been in vocational rehabilitation programs. In this way, veterans will be assisted to obtain and retain employment.

b. *Title III—Educational Assistance Program Adjustments.* While the basic provisions of this title are addressed in DVB Circular 22-80-39, VR&C staff should make note that effective October 1, 1980, mandatory counseling under Chapter 35 is repealed. Provisions for special restorative training, specialized vocational training and requested counseling are retained.

c. *Title IV—Post-Vietnam Era Veterans' Educational Assistance Program Adjustments.* Clarification of Chapter 32 is provided to indicate that effective October 1, 1980, individuals under this contributory program are eligible for counseling on request.

d. *Title V—Veterans' Employment Assistance Amendments.* This title addresses a variety of employment-related issues in title 38, U.S.C., Chapters 41, 42, and other chapters. The DVOP (Disabled Veterans Outreach Program) is continued and strengthened.

Specific priority groups of veterans are established; appointments of DVOP personnel are tied to State veteran population; and assignments of personnel are apportioned between local State employment offices and VA locations. These provisions, effective October 1, 1980, will assist the VR&C effort in fulfilling Chapter 31 training and employment initiatives. They will be discussed more fully in separate issues.

4. Implementation. Provisions effective October 1, 1980, or upon enactment are discussed in paragraph 5. These are for immediate implementation. During the period from enactment to March 31, 1981, all other provisions of Chapter 31, Title 38, U.S.C., will remain in effect. Provisions effective April 1, 1981, are discussed briefly in paragraph 6 and will be more fully developed in subsequent issues prior to the effective date.

5. Provisions Effective October 1, 1980. a. Section 1508—Allowances. This section deals with a variety of issues involving payment of subsistence allowance, including rate increases. The following provisions are for immediate implementation.

(1) *Subsistence Allowance.* Rates are increased 17 percent (see exhibit A). Hines DPC will adjust running IHL and NCD awards to show the new rates and will notify RO's (regional offices) of those cases in which RO input will be necessary. All new awards should use the new rates for periods of payment extending beyond October 1, 1980.

(2) *Nonpay Training.* On-job or work experience trainees in a Federal agency at nominal or no pay are eligible for subsistence allowance at the institutional rate, rather than OJT rate.

(a) All new entrance or reentrance awards for nonpay OJT trainees will be at institutional rates of subsistence allowance effective October 1, 1980. Both the authorization document (VA Form 22-1905, Authorization and Certification of Entrance or Reentrance Into Training and Certification of Trainee Status) and the award document (VA Form 22-1907a, Authorization of Subsistence Allowance) will be annotated in the "Remarks" section as follows: "Unpaid Federal work experience: in the receipt of institutional rates effective October 1, 1980."

(b) VR&C staff in each RO will immediately undertake a search to identify all Federal OJT or work experience cases with running awards paying the old OJT rate. VA Form 22-1905 will be prepared with the annotation in the "Remarks" section: "Adjust award for unpaid Federal work

experience to pay institutional rates effective October 1, 1980." Upon receipt of VA Form 22-1905, the adjudicator will prepare VA Form 22-1907a and annotate the "Remarks" section of the award form, "Unpaid Federal work experience: in receipt of institutional rates effective October 1, 1980." This project, including award preparation, should be completed no later than December 15, 1980.

(3) *Post-Rehabilitation Pay.* Post-rehabilitation pay will now extend for a 2-month period following the training program and will no longer be paid as a lump sum. Payment will be at the full-time rate for the type of training pursued, regardless of the rate of pursuit during the final enrollment period. When preparing VA Form 22-1905 for a post-rehabilitation payment, the VR&C staff member must clearly specify in the "Remarks" section that a 2-month post-rehabilitation payment should be made. Upon receipt of VA Form 22-1905, the adjudicator will prepare a reentrance award on VA Form 22-1907a to extend the veteran's last award period for exactly 2 months. In the "Remarks" section, the adjudicator will annotate: "Award represents 2-month post-rehabilitation payment." The lump-sum payment indicator in item 4 of the VA Form 22-1907a will no longer be used.

(4) *Incarcerated Chapter 31 Trainees.* Specific provisions of the law now restrict and, in some instances, prohibit payment of chapter 31 subsistence allowance to veterans incarcerated in a Federal, State or local penal institution, halfway house, or participating in a work release program. Immediately, VR&C staff will identify such trainees and suspend all running awards. Detailed instructions for processing these cases will be forthcoming in an appendix to this circular.

b. *Section 1512—Revolving Fund Loans.* The existing RFL (Revolving Fund Loan) benefit is modified to increase the maximum loan which may be authorized from \$200 to an amount twice the monthly subsistence rate for a single veteran in institutional training (currently \$564).

(1) *Loan Approval and Documentation.* Prudent management is a critical aspect of administering this substantially increased benefit. Strict assurance must be given that loans in any amount are authorized only for meritorious reasons. The VRS must make careful evaluation of the need for the loan and the amount of the loan. The VRS will document findings of the evaluation on VA Form 22-1905d, Special Report of Training.

(2) *Loan Amount and Repayment.* The loan amount shall not exceed that needed to assure the veteran's

continuation in the program. Repayment should be made as quickly as possible, taking into account the effect of such terms upon the veteran's ability to continue in his or her rehabilitation program. The VRS must review with the veteran whether there is a need for other kinds of assistance, for example, assistance in budgeting.

(3) *Special Considerations.*

(a) New loan requests will not be approved until any outstanding RFL has been fully recouped.

(b) Any loan in excess of \$200 will require Central Office approval. Such requests accompanied by complete documentation justifying the request will be forwarded to the Field Director (28).

(4) *Other Provisions.* Chapter 34 educational assistance allowance has been added to sources for RFL repayment. Also, note that chapter 31 trainees who elect to receive a chapter 34 educational assistance allowance are not eligible for the RFL benefit.

c. *Section 1516—Promotion of Employment and Training.* Employment as the goal of rehabilitation is emphasized by targeting veterans who are or have been participating under the chapter 31 program, any veterans with service-connected disabilities and Vietnam era veterans targeted under Title 38, U.S.C., Chapter 42, "Employment and Training of Disabled and Vietnam Era Veterans." Both direct outreach efforts to employers by VA staff and coordination with other Agencies are mandated in order to develop and establish employment and on-the-job training opportunities. Stations should include this in all VA/DOL (Department of Labor) local agreements. This section also authorizes payment to an employer/trainer which does not exceed the direct expenses incurred in providing on-job training or employment. Regulations to implement the provisions for payment to an employer/trainer will be developed in consultation with the DOL and distributed. No local action on payment to an employer/trainer will be taken until these regulations are received.

d. *Section 1518—Personnel Training, Development and Qualifications.* Ongoing professional training for VR&C personnel is authorized to enable them to provide such services under Chapter 31 in accordance with the most advanced knowledge, methods, and techniques available. VA may contract with consultants and/or agencies to provide training and staff development. Training in areas of mutual concern will be coordinated by the VA with DOL and RSA (Rehabilitation Services Administration). The Administrator will

establish qualifications for professional staff providing evaluation and rehabilitation services under Chapter 31.

e. Section 1519—Rehabilitation Research and Special Projects.

Research and special projects are authorized to advance psychological, educational, employment social, vocational, industrial and economic aspects of rehabilitation of veterans. Authorization is given to actively engage in and/or support studies, projects and research and to make grants and enter into contracts with educational institutions and other agencies. Cooperation with RSA, DOL, and NIHR (National Institute for Handicapped Research) in areas of mutual concern is also mandated. All such efforts will be undertaken only with prior Central Office approval.

f. Section 1520—Pilot Program of Independent Living Services and Assistance. Beginning in FY 1982 and continuing through FY 1985, a pilot program of independent living services will be provided for severely handicapped service-connected veterans for whom a vocational goal is not reasonably feasible, including veterans in long-term care facilities of the VA. Each year up to 500 veterans may enter this program, which will be implemented in the various geographic regions of the United States. An individualized written plan will be prepared in the same manner as for a veteran in a vocational rehabilitation program. Services necessary to carry out the rehabilitation plan will be provided through contractual arrangements made with outside agencies and organizations or through DM&S (Department of Medicine and Surgery). A report on these programs including accomplishments, cost effectiveness and legislative recommendations must be submitted to the Congress by September 30, 1984. Although the effective date for funding the pilot program is October 1, 1981, planning for program establishment will begin on October 1, 1980, the effective date of the program.

g. Section 1521—Veterans' Advisory Committee on Rehabilitation. This section requires the Administrator to appoint an advisory committee with whom to consult on a regular basis concerning the chapter 31 program. The members will include veterans with service-connected disabilities and persons distinguished in the general and special fields of rehabilitation. Ex officio members will represent DVB, DM&S, RSA, NIHR, and DOL. An annual report will be submitted to the Administrator and forwarded to Congress along with

other relevant reports and recommendations.

h. Other Provisions. (1) *Section 1780—Payment of Educational Allowance or Subsistence Allowance.* Chapter 36, Title 38, U.S.C., is amended to provide that, in addition to weekends and legal holidays, up to 5 days in a 12-month period will not be counted as absences if the institution is not in session on those days due to teacher conferences or teacher training sessions, and regularly scheduled classes would otherwise have been held.

(2) *Section 1781—Limitations on Educational Assistance.* Chapter 36, Title 38, U.S.C., is amended to include subsistence allowance granted under chapter 31 as an additional category of prohibited payments to certain servicepersons and Government employees receiving training. This codifies existing VA Regulation 10022.

(3) *Section 1795—Limitation on Period of Assistance Under Two or More Programs.* Chapter 36, Title 38, U.S.C., is amended to include Chapter 32 entitlement used in consideration of the 48-month limitation under two or more programs. Although assistance received under Chapter 31 must be included with assistance under other chapters in considering the aggregate 48-month limitation on total training, additional months of benefits may be allowed under Chapter 31 when determined necessary to accomplish rehabilitation in the individual case.

i. Title V—Disabled Veterans Outreach Program. (1) *Scope and Eligibility.* The DVOP is placed on a continuing basis at a level of approximately 2,000 specialists nationwide. DVOP personnel are assigned only those duties directly related to meeting the employment needs of eligible veterans. Priority is as follows: Disabled Vietnam veterans who are participating in or have completed a program of vocational rehabilitation under Chapter 31, other disabled veterans, and eligible veterans included under employment emphasis under Chapter 42.

(2) *Location of DVOP Personnel.* No more than three-fourths of DVOP staff stationed in each State will be stationed at local State employment offices. DVOP staff not stationed at local employment offices shall be stationed at VA centers providing a program of readjustment counseling, veterans assistance offices, or other sites as may be determined appropriate for coordinated development of job training and employment opportunities.

6. Provisions Effective April 1, 1981. The majority of the provisions which complete the updating and expansion of

the vocational rehabilitation program are effective April 1, 1981. Instructions governing the implementation of these provisions will be issued prior to that effective date.

a. Section 1500—Purpose. The purposes of chapter 31 are modified to include all services and assistance needed to "enable veterans with service-connected disabilities to achieve maximum independence in daily living and, to the maximum extent feasible, to become employable and to obtain and maintain suitable employment."

b. Section 1501—Definitions. Terms defined include employment handicap, serious employment handicap, rehabilitation program, vocational goal, vocational rehabilitation program, independence in daily living, program of independent living services and assistance, and rehabilitated to the point of employability.

c. Section 1502—Basic Entitlements. The conditions of basic entitlement for rehabilitation include the existence of a service-connected compensable disability incurred or aggravated during or after World War II. In addition, a serviceperson with a service-connected disability which will probably be classified as compensable who is hospitalized pending discharge is eligible. Need for rehabilitation because of an "employment handicap" must be established in all cases.

d. Section 1503—Periods of Eligibility. The basic 9-year period currently in effect is extended to 12 years. Conditions for extension beyond the basic period of eligibility have been liberalized for veterans with "serious employment handicaps," for veterans prevented from participating in a vocational rehabilitation program due to medical factors or due to eligibility not being established, and for severely disabled veterans participating in the pilot program of independent living services and assistance.

e. Section 1504—Scope of Services and Assistance. The statutory range of services and assistance available is expanded while retaining all services and assistance furnished under current law and regulations. New provisions include authorization for extended evaluation and reevaluations to determine potential for rehabilitation, to determine whether a serious employment handicap exists, to provide a basis for planning a rehabilitation program, and/or to improve the rehabilitation potential of a veteran. Placement and followup services and assistance necessary to establish severely disabled veterans in self-employment are also added. Many services and types of assistance

currently available through VA regulations are now included specifically in the law.

f. Section 1505—Duration of Rehabilitation Programs. The current basic 48-month period for rehabilitation services is continued, and conditions for an extension beyond 48 months have been liberalized to accomplish the purposes of vocational rehabilitation for a veteran with a serious employment handicap. A period for extended evaluation of up to 12 months is authorized if the VA is unable to determine whether the veteran can achieve a vocational goal, with additional 6-month extensions of that period possible for an individual veteran. A severely disabled veteran found to be in need of a program of independent living services and assistance may be authorized a rehabilitation program for a basic period of 24 months, but the period may be extended if it is determined that a longer period is necessary and likely to result in a substantial increase in the level of independent living.

g. Section 1506—Initial and Extended Evaluations. An initial evaluation will be made in all cases to establish eligibility for the Chapter 31 program, to determine whether a serious employment handicap exists, and to determine whether the achievement of a vocational goal is feasible. That initial evaluation shall consist of counseling and diagnostic or other services. In addition, an extended evaluation will be authorized when it cannot be determined whether the achievement of a vocational goal is reasonably feasible. Each veteran with a serious employment handicap will be provided counseling and an individually written vocational rehabilitation plan, whether pursuing a vocational goal or an independent living goal.

h. Section 1507—Individualized Vocational Rehabilitation Plan. The minimum essential elements of an individualized written plan of vocational rehabilitation are prescribed in the law for the veteran with a serious employment handicap. The plan developed jointly with the veteran will be reviewed annually and redeveloped if appropriate. A veteran not in agreement with an original or redeveloped plan may submit his or her objections and request a VA review of the plan. Time limits are established for the review process.

i. Section 1508—Allowances. (1) *Election of Chapter 34 Allowance.* A Chapter 31 eligible veteran may elect to use remaining Chapter 34 entitlement and receive educational assistance in lieu of subsistence allowance, but

remain eligible for certain other Chapter 31 services. Despite election of Chapter 34 allowance, the veteran is a vocational rehabilitation trainee. The St. Paul DPC statistical system will be updated to reflect Chapter 34 award periods which form part of a program of vocational rehabilitation. System modifications to simultaneously reduce remaining Chapters 31 and 34 entitlement for such veterans will be developed.

(2) *Extended Evaluation.* Subsistence allowance is now authorized for veterans participating in extended evaluation.

(3) *Specialized Rehabilitation Facility.* For a veteran pursuing a rehabilitation program in residence at a special rehabilitation facility, authority has been granted to make payment to the facility for room and board in lieu of subsistence allowance. If such a payment to the facility is made, however, the veteran will receive the portion of the subsistence allowance for dependents for a full-time institutional program.

(4) *Temporary Hospitalization Rating.* If a hospitalized trainee is temporarily receiving compensation at the 100 percent level as a result of hospitalization in excess of 21 days, the sum of the combined Chapter 31 subsistence allowance and compensation benefits is limited either to the sum of the subsistence allowance due and the pre-hospitalization compensation rate received, or the 100 percent disability compensation rate, whichever is the greater.

j. Section 1509—Entitlement to Independent Living Services and Assistance. If it is determined that the achievement of a vocational goal is not reasonably feasible, a veteran is entitled to be considered as one of those selected to be in the pilot program of independent living services and assistance to achieve maximum independence in daily living.

k. Section 1510—Leaves of Absence. The authority to grant leaves of absence to veterans pursuing vocational rehabilitation training is continued. The current 30-day limit during a 12-month period is eliminated.

l. Section 1511—Regulations to Promote Satisfactory Conduct and Cooperation. Authority to establish regulations to promote satisfactory conduct and cooperation is continued. In addition, the VA must determine that all reasonable counseling efforts have been made prior to discontinuing services and assistance for failure to maintain satisfactory conduct and cooperation. The specific penalties formerly stated in the law are removed.

m. Section 1513—Vocational Rehabilitation for Hospitalized Members of the Armed Forces and Veterans. The VA will continue to afford vocational rehabilitation services and assistance to persons hospitalized pending discharge from military service. However, payment of subsistence allowance is prohibited. In addition, Chapter 31 services, including subsistence, subject to limitations in subparagraph i(4) above, may be provided to a veteran receiving care in a VA facility or other medical or hospital facility.

n. Section 1514—Vocational Rehabilitation Outside the United States. Regulations will be prescribed to allow provision of a vocational rehabilitation program outside the United States, if it is determined to be necessary for purposes of rehabilitation, and if it is in the best interests of the veteran and the Government. Some provisions of the previous law are eliminated and more flexibility is delegated to the VA than was formerly permitted.

o. Section 1515—Rehabilitation Resources. The VA will utilize facilities, staff and resources of the VA and those of other Agencies or public and private facilities or individuals for purposes of providing training, work experience, or other rehabilitation services, through contract agreement or other arrangements. A veteran pursuing on-job training or work experience in a Federal agency continues to be considered an employee of the United States under Chapter 81, title 5, U.S.C., but not for purposes of laws administered by the OPM (Office of Personnel Management). Medical care is to be provided in VA facilities or as otherwise set forth under Chapter 17, title 38, U.S.C.

p. Section 1517—Employment Assistance. The VA is now required to provide employment assistance to veterans with a service-connected disability who have participated under Chapter 31 or in a similar program under the Rehabilitation Act of 1973. The services to veterans include direct placement, assistance of DVOP staff, use of DOL's employment services, the services of OPM, placement facilities provided under the Rehabilitation Act of 1973 or other public or nonprofit organizations. The VA must assure that the veteran rehabilitated for self-employment in a small business is provided the full benefit of the resources of the SBA (Small Business Administration), including veterans preference. If a veteran trained under a State program is unable to obtain

necessary equipment, initial stocks and supplies through that program or from other sources, the VA may provide them.

7. Inservice Training. This legislation represents the most important change in the program since it was established in 1943, and it is essential that provisions are communicated to the regional office Director and to VR&C and other staffs who will be carrying out the program. Each person in the VR&C Division will be furnished a copy of this issue. A staff meeting will be scheduled and the circular's provisions will be reviewed in-depth. Staffs in other Divisions, including Adjudication and Veterans Services, will be invited to participate in these meetings or, if desired, the VR&C Officer will brief staffs of those Divisions as part of their own inservice training programs.

Dorothy L. Starbuck,

Chief Benefits Director.

**RATES FOR SUBSISTENCE ALLOWANCE
UNDER CHAPTER 31 OF TITLE 38, U.S.C.**

Type of program	No deps.	One dep.	Two deps.	Add'l amt. for each dep. over two
Institutional training:¹				
Full time	\$282	\$349	\$411	\$30
Three-quarter time	212	262	308	23
Half time	141	175	206	15
Farm-cooperative, apprenticeship or other on-job training:				
Full time	246	297	343	22
Extended evaluation:				
Full time	282	349	411	30
Independent living training:				
Full time	282	349	411	30
Three-quarter time	212	262	308	23
Half time	141	175	206	15

¹ Institutional training includes IHL, NCD, and nonpay or minimal pay OJT or work experience in a Federal agency.

[PR Doc. 81-1839 Filed 1-15-81; 8:45 am]

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Sunshine Act Meetings

Federal Register

Vol. 46, No. 11

Friday, January 16, 1981

This section of the FEDERAL REGISTER contains notices of meetings published under the "Government in the Sunshine Act" (Pub. L. 94-409) 5 U.S.C. 552b(e)(3).

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1

FEDERAL COMMUNICATIONS COMMISSION.

The Federal Communications Commission voted to hold a Closed Meeting on Thursday, January 29, 1981, following the Regular Open Meeting, at 1919 M Street, N.W., Washington, D.C. on the following subject:

Internal Personnel Matters

Additional information concerning this meeting may be obtained from Edward Dooley, FCC Public Affairs Office, telephone number (202) 254-7674.

The Public Notices for the Regular Open and Closed Meeting, for the above dates will be issued at a later date.

Issued: January 13, 1981.

Federal Communications Commission.

William J. Tricarico,
Secretary.

[S-0070-81 Filed 1-14-81; 10:08 am]

BILLING CODE 6712-01-M

2

FEDERAL COMMUNICATIONS COMMISSION.

During the Open Meeting scheduled for January 8, 1981, the Commission discussed the consideration of *FOIA Request for Employee Disqualification Statements filed pursuant to Section 19.735-204(e)(3) of the Rules.*

The prompt and orderly conduct of Commission business did not permit prior notice of this additional item.

Additional information concerning this matter may be obtained from Edward Dooley, FCC Public Affairs Office, telephone number (202) 254-7674.

Issued: January 13, 1981.

Federal Communications Commission.

William J. Tricarico,
Secretary.

[S-0069-81 Filed 1-14-81; 10:07 am]

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3

FEDERAL COMMUNICATIONS COMMISSION.

The Federal Communications Commission held an Emergency Closed Meeting on Thursday, January 8, 1981 following the Regular Open Meeting, at 1919 M Street, N.W., Washington, D.C. on the following subject:

Internal Personnel Matters

The prompt and orderly conduct of Commission business did not permit announcement of this matter prior to the meeting.

Additional information concerning this meeting may be obtained from Edward Dooley, FCC Public Affairs Office, telephone number (202) 254-7674.

Issued: January 13, 1981.

Federal Communications Commission

William J. Tricarico,
Secretary.

[S-0068-81 Filed 1-14-81; 10:08 am]

BILLING CODE 6712-01-M

4

FEDERAL RESERVE SYSTEM.

BOARD OF GOVERNORS

TIME AND DATE: 10 A.M., WEDNESDAY, JANUARY 21, 1981.

PLACE: Board Building, C Street entrance between 20th and 21st Streets NW., Washington, D.C. 20551.

STATUS: Open.

MATTERS TO BE CONSIDERED:

1. Proposal to revise Regulation C (Home Mortgage Disclosure) to implement amendments to the Home Mortgage Disclosure Act.

2. Request for an interpretation of Regulation Y (Bank Holding Companies and Change in Bank Control) that placement of equity interests in real estate projects is within the regulation's permissible lending activities.

3. Any items carried forward from a previously announced meeting.

Note.—This meeting will be recorded for the benefit of those unable to attend. Cassettes will be available for listening in the Board's Freedom of Information Office, and copies may be ordered for \$5 per cassette by calling (202) 452-3684 or by writing to: Freedom of Information Office, Board of Governors of the Federal Reserve System, Washington, D.C. 20551.

CONTACT PERSON FOR MORE

INFORMATION: Mr. Joseph R. Coyne, Assistant to the Board (202) 452-3204.

Dated: January 13, 1981.

James McAfee,

Assistant Secretary of the Board.

[S-0066-81 Filed 1-13-81; 4:30 pm]

BILLING CODE 6210-01-M

5

FEDERAL RESERVE SYSTEM.

Board of Governors

TIME AND DATE: Approximately 11:00 a.m., Wednesday, January 21, 1981, following a recess at the conclusion of the open meeting.

PLACE: 20th Street and Constitution Avenue, NW., Washington, D.C. 20551.

STATUS: Closed.

MATTERS TO BE CONSIDERED:

1. Personnel actions (appointments, promotions, assignments, reassignments, and salary actions) involving individual Federal Reserve System employees.

2. Any items carried forward from a previously announced meeting.

CONTACT PERSON FOR MORE

INFORMATION: Mr. Joseph R. Coyne, Assistant to the Board.

Dated: January 13, 1981.

James McAfee,

Assistant Secretary of the Board.

[S-0067-81 Filed 1-14-81; 8:46 am]

BILLING CODE 6210-01-M

6

MERIT SYSTEMS PROTECTION BOARD.

AGENCY HOLDING THE MEETING: Merit Systems Protection Board.

TIME AND DATE: 11 a.m., Monday, January 19, 1981.

PLACE: Hearing Room, Merit Systems Protection Board, 1717 H Street NW., Washington, D.C. 20419.

STATUS: Open.

MATTERS TO BE CONSIDERED: Oral Arguments on Motion for Subpoena in *Acting Special Counsel v. Paul D. Sullivan*, Docket No. HQ120600018.

CONTACT PERSON FOR MORE

INFORMATION: Kathy W. Semone, Director, Division of Records and Inquiries, Office of the Secretary, 202-632-4525.

January 14, 1981.

Merit Systems Protection Board.

Ruth T. Prokop,

Chairwoman.

[S-0071-81 Filed 1-14-81; 2:32 pm]

BILLING CODE 7400-02-M

NUCLEAR REGULATORY COMMISSION.

DATE: Monday, January 19 and
Wednesday, January 21, 1981.

PLACE: Commissioners' Conference
Room, 1717 H Street NW., Washington,
D.C.

STATUS: Open/closed.

MATTERS TO BE CONSIDERED: *Monday,*
January 19:

2:30 p.m.

1. Briefing on Spent Fuel Storage
(approximately 1 hour, public meeting)
2. Briefing on a Significant Enforcement
Action (approximately 1 hour, closed)

Wednesday, January 21:

10:00 a.m.

1. Meeting with AIF on Future of Nuclear
Power Regulation (approximately 1½ hours,
public meeting)

2:00 p.m.

1. Briefing on Adequacy of Sequoyah
Ignition Systems (approximately 1½ hours,
public meeting)

AUTOMATIC TELEPHONE ANSWERING

SERVICE FOR SCHEDULE UPDATE: (202)

634-1498. Those planning to attend a
meeting should reverify the status on the
day of the meeting.

CONTACT PERSON FOR MORE

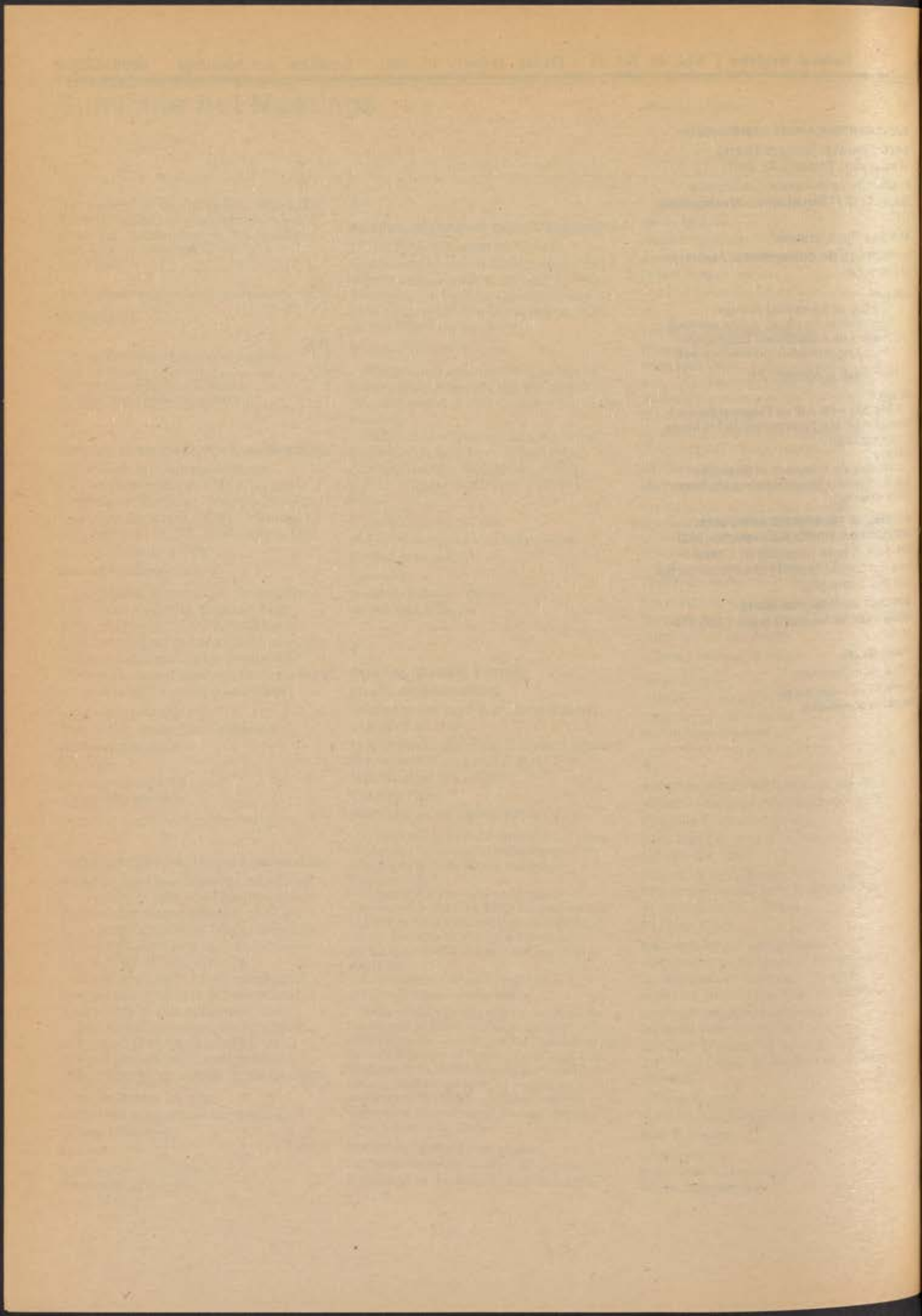
INFORMATION: Walter Magee (202) 634-
1410.

Walter Magee,

Office of the Secretary.

[S-0072-81 Filed 1-14-81; 3:55 pm]

BILLING CODE 7590-01-M



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At the end of each month, the Office of the Federal Register publishes separately a list of CFR Sections Affected (LSA), which lists parts and sections affected by documents published since the revision date of each title.

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AGENCY PUBLICATION ON ASSIGNED DAYS OF THE WEEK

The following agencies have agreed to publish all documents on two assigned days of the week (Monday/Thursday or Tuesday/Friday).

This is a voluntary program. (See OFR NOTICE 41 FR 32914, August 6, 1976.)

Monday	Tuesday	Wednesday	Thursday	Friday
DOT/SECRETARY	USDA/ASCS		DOT/SECRETARY	USDA/ASCS
DOT/COAST GUARD	USDA/FNS		DOT/COAST GUARD	USDA/FNS
DOT/FAA	USDA/FSQS		DOT/FAA	USDA/FSQS
DOT/FHWA	USDA/REA		DOT/FHWA	USDA/REA
DOT/FRA	MSPB/OPM		DOT/FRA	MSPB/OPM
DOT/NHTSA	LABOR		DOT/NHTSA	LABOR
DOT/RSPA	HHS/FDA		DOT/RSPA	HHS/FDA
DOT/SLSDC			DOT/SLSDC	
DOT/UMTA			DOT/UMTA	
CSA			CSA	

Documents normally scheduled for publication on a day that will be a Federal holiday will be published the next work day following the holiday. Comments on this program are still invited. Comments should be submitted to the Day-of-the-Week Program Coordinator, Office of the Federal Register, National Archives and Records Service, General Services Administration, Washington, D.C. 20408

NOTE: As of September 2, 1980, documents from the Animal and Plant Health Inspection Service, Department of Agriculture, will no longer be assigned to the Tuesday/Friday publication schedule.

REMINDERS

The "reminders" below identify documents that appeared in issues of the **Federal Register** 15 days or more ago. Inclusion or exclusion from this list has no legal significance.

Rules Going Into Effect Today

AGRICULTURE DEPARTMENT

Agricultural Marketing Service—

- 82909 12-17-80 / Tomatoes grown in South Texas; production research and marketing promotion, committee membership, penalties for late assessment payments, etc.

ENVIRONMENTAL PROTECTION AGENCY

- 47832 7-16-80 / Identification and listing of hazardous waste; additions

INTERIOR DEPARTMENT

Indian Affairs Bureau—

- 82921 12-17-80 / Descendancy rolls of certain Delaware Indians; preparation, certification, and approval

- 82918 12-17-80 / Membership roll of Delaware Indians of Western Oklahoma; preparation, certification, and approval

Surface Mining Reclamation and Enforcement Office—

- 83166 12-17-80 / Steep-slope mining; interim variances from requirement to return mined land to original contour

JUSTICE DEPARTMENT

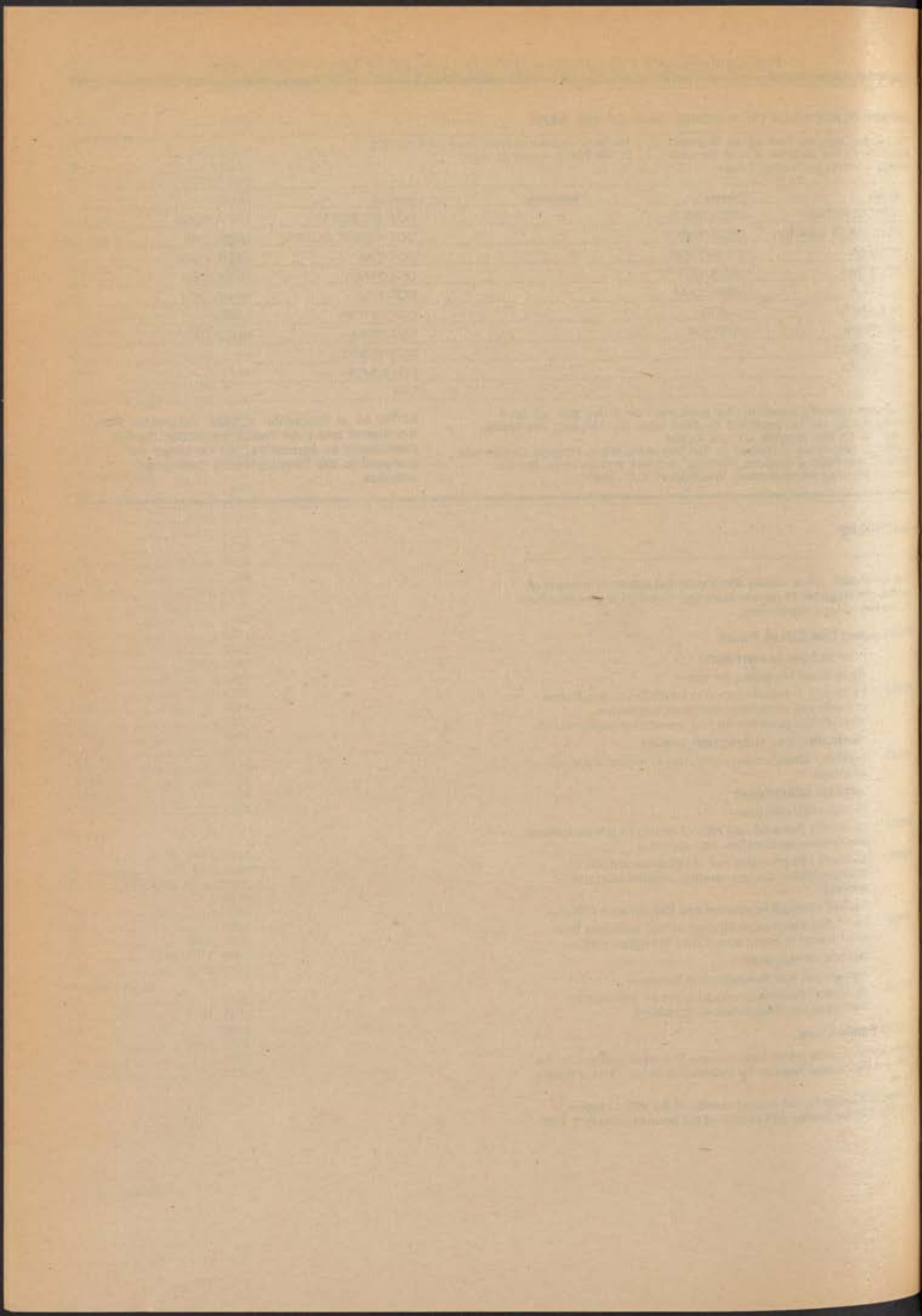
Immigration and Naturalization Service—

- 83195 12-18-80 / Preliminary examination on petitions for naturalization; designation of examiners

List of Public Laws

Note: No public bills which have become law were received by the Office of the Federal Register for inclusion in today's List of Public Laws.

A complete listing for the second session of the 96th Congress is published in the Reader Aid section of the issue of January 7, 1981



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| 4182 | Part IV—Labor/OSHA:
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federal register

Friday
January 16, 1981

Part II

Department of Labor

Occupational Safety and Health
Administration

Electrical Standards

DEPARTMENT OF LABOR

Occupational Safety and Health Administration

29 CFR Part 1910

Electrical Standards

AGENCY: Occupational Safety and Health Administration, U.S. Department of Labor.

ACTION: Final standard

SUMMARY: In this final standard, the Occupational Safety and Health Administration (OSHA) establishes "Design Safety Standards for Electrical Systems." This standard revises Subpart S of 29 CFR Part 1910 and is intended to simplify and update the former standard. OSHA has determined that electrical hazards in the workplace pose a significant risk of injury or death to employees, and that these regulations which draw heavily on the experience of the National Electrical Code are reasonably necessary to provide protection from these hazards. The final rule places relevant requirements of the National Electrical Code (NEC) into the text of the regulations, making it unnecessary for employers to refer to the NEC to determine their obligations and unnecessary for OSHA to continue to incorporate the NEC by reference. Additionally, the final rule clarifies certain provisions which were misunderstood by certain interested parties.

EFFECTIVE DATE: This revision of 29 CFR Part 1910, Subpart S becomes effective on April 16, 1981.

FOR FURTHER INFORMATION CONTACT: For information on the standard contact: Mr. Jerry Leonard or Mr. David Wallis; Office of Electrical and Electronic Engineering Safety Standards; OSHA; Rm. N3510; 200 Constitution Avenue, NW., Washington, D.C. 20210. (202-523-7207).

For information on compliance contact: Mr. Peter Wasko; Federal Compliance and State Programs; Division of Safety Programming; OSHA; Rm. N3106; 200 Constitution Avenue, NW, Washington, D.C. 20210. (202-523-8124).

For additional copies of this regulation contact: OSHA Office of Publications; U.S. Department of Labor; Room S-1212; Washington, D.C. 20210. (202-523-8677).

SUPPLEMENTARY INFORMATION:

I. Background

(1) Safety Problems of Electric Shock

It is well known that the human body will conduct electricity, and that if direct body contact is made with an electrically energized part while a similar contact is made simultaneously with another conductive surface which is maintained at a different electrical potential, a current will flow, entering the body at one contact point, traversing the body and then exiting at the other contact point, usually the ground. Each year many workers suffer pain, injuries and death from such electric shocks and throughout the past decade the National Center for Health Statistics has reported approximately 1000 accidental electrocutions annually in the United States with about a fourth being industry and farm related.

The effects that electric shock will have on an individual will depend upon the type of circuit, its voltage, resistance, amperage, pathway through the body and the duration of the contact. For example, electric shocks produced by alternating currents of powerline frequency (normally 60 Hertz) passing through the body from hand to foot for an average adult worker for one second can cause various effects on the body. Such effects range from a condition of being barely perceptible at 1 milliamperes to involuntary muscular control from 9 to 25 milliamperes. The passage of still higher currents can produce ventricular fibrillation of the heart (cessation of rhythmic pumping action) from 75 milliamperes to 4 amperes and finally immediate cardiac arrest at over 4 amperes. Nearly instantaneous fatalities from electric shock can result from either direct paralysis of the respiratory system (at 20 milliamperes or more), failure of the heart to pump due to ventricular fibrillation (at 75 milliamperes or more), or immediate and complete heart stoppage (at 4 amperes or more). Even if the shocking current does not pass through vital organs or nerve centers, severe injuries such as deep internal burns can still occur. In some cases, injuries caused by electric shock can be a contributory cause of delayed fatalities.

Burns suffered in electrical accidents are of great concern. These burns may be of three basic types: electrical burns, arc burns and thermal contact burns. Electrical burns are the result of the electric current flowing in the tissues and may be either skin deep or may affect deeper layers (muscles, bones, etc.) or both. Tissue damage is caused by the heat generated from the current flow; if the energy delivered by the

electrical shock is high, the body cannot dissipate the heat and the tissue is burned. Typically, such electrical burns are slow to heal. Arc burns, on the other hand are the result of high temperatures in close proximity to the body produced by electric arcs or by explosions. These burns are similar to burns and blisters produced by any high temperature source. Finally, thermal contact burns are those normally experienced from the skin contacting hot surfaces of overheated electrical conductors, conduits, or other energized equipment. All types of burns may be produced simultaneously.

Electrical shock currents, even at levels as low as 3 milliamperes, can also cause injuries of an indirect or secondary nature in which involuntary muscular reaction from the electrical shock can cause bruises, bone fractures and even death resulting from collisions or falls.

(2) Hazards Associated With Electricity

Most electrical systems use the earth to establish an electrical voltage reference system with respect to ground. This is done by connecting a portion of the circuit to ground. Since these systems use conductors which have voltages to ground, a shock hazard exists for persons who are in electrical contact with the earth and are exposed to the conductors. If a person comes in contact with an ungrounded conductor while he is in contact with the ground, he becomes part of the circuit and current passes through his body.

In addition to the shock hazard, electricity poses other hazards to employees. For example, when a short circuit occurs or current flow is interrupted, hazards are created from the resultant arcs. If high current is involved, these arcs can cause injury or can start a fire. Fires can also be created by overheating equipment or by conductors carrying too much current. Extremely high-energy arcs can damage equipment causing fragmented metal to fly in all directions. In atmospheres which contain explosive gases or vapors or combustible dusts, even low-energy arcs can cause violent explosions.

(3) Nature of Electrical Accidents

Electrical accidents, when initially studied, often appear to be caused by circumstances which are varied and peculiar to the particular incidents involved. However, further consideration usually reveals the underlying cause to be a combination of three possible factors. These consist of work involving unsafe equipment and installations, workplaces made unsafe

by the environment, and unsafe work performance.

(a) *Basic Contributory Factors.* Some unsafe electrical equipment and installations can be identified, for example, by the presence of faulty insulation, improper grounding, loose connections, defective parts, ground faults in equipment or unguarded live parts. The environment can also be a contributory factor to electrical accidents in a number of ways. Some unsafe environments affecting electrical safety would be, for example, atmospheres containing flammable vapors, liquids or gases, areas containing corrosive atmospheres, and wet and damp locations. Finally, some typical unsafe acts can be recognized as, for example, the failure to deenergize electrical equipment when it is being repaired or inspected, the intentional use of obviously defective and unsafe tools, or the use of tools or equipment too close to energized parts. For purposes of convenience, the first and second accident causing situations are sometimes combined and simply referred to as unsafe conditions. Thus, electrical accidents can be generally considered as being caused by unsafe conditions, unsafe acts, or, what is usually the case, combinations of the two. It should also be noted that inadequate maintenance can cause equipment or installations, which were originally considered safe, to deteriorate, resulting in an unsafe condition.

(b) *Typical Accidents from Unsafe Conditions.* Of the two primary causative factors influencing electrical accidents (i.e., unsafe conditions and unsafe acts) the ones involving unsafe conditions are more directly addressed by the provisions of the National Electrical Code. Since OSHA's revised electrical safety standards are initially directed towards minimizing unsafe conditions, a few typical examples of related accidents are given to illustrate these situations.

(i) *California—1972.* A nurseryman was electrocuted when he touched a conduit riser in a greenhouse. The greenhouse was wired with overhead open wiring on insulators. A short section of conduit was installed to enclose conductors feeding down to a time clock. A faulty splice in the clock energized the clock frame and conduit.

(ii) *Florida—1973.* A lead foreman and set-up man for a plastics corporation was installing a new injection molding machine. The employee was electrocuted when he touched a temperature control unit used in conjunction with the molding machine.

The temperature control unit had been improperly wired.

(iii) *Hawaii—1971.* An installer of refrigerators for the retail-wholesale trade was electrocuted using an electric drill. While working on top of a prefabricated walk-in unit, the worker was in continuous ground contact when an electrical fault developed in the drill plug and the accident occurred.

(iv) *California—1971.* A worker engaged in electroplating was electrocuted when he touched an ungrounded 9 volt D.C. bus on an electroplating tank while in contact with the grounded tank. It was found that a 120-volt terminal on an A.C. timer coil was installed within $\frac{1}{8}$ inch of the D.C. bus. A fault path had developed and a leakage current of 70 milliamperes at 120 volts was measured between the electroplating bus and the grounded tank.

(v) *Florida—1974.* A slag house operator for a slag plant was on a catwalk repairing and replacing guards on belt drives and pulleys. He had gained access to the catwalk by using a wooden ladder, but he descended from the catwalk by means of a power pole erected at the end of the platform. A 440-volt line with deteriorated insulation was anchored to the pole, and metal spikes for climbing and descending had been driven into the pole. As the victim stepped on the first cleat, he grabbed his chest, lost his grip and fell ten feet to the concrete floor. Electric shock was found to be the cause of death.

(vi) *Idaho—1974.* A lubricator working in the molding department of a plastics manufacturing plant was electrocuted. The accident resulted when the worker contacted a nozzle adaptor which was energized on the molding machine.

(vii) *California—1966.* An electrician received flash burns on his face when he closed a large 480-volt switch after replacing a blown fuse. The ceramic insulating block holding one end of the fuse was defective and apparently had originally caused the fuse to blow.

(viii) *California—1972.* A worker was electrocuted when he grasped the metal nozzle of a steam cleaning hose which was metal reinforced. The 120-volt switch in the motor terminal enclosure of the steam cleaning unit had vibrated loose and a terminal was contacting the metal enclosure. The unit was supplied by a three conductor cord; however, the ground prong on the attachment plug had been broken off. Another worker received a severe shock when he attempted to help the first worker.

(ix) *Massachusetts—1970.* A repairman working in an automobile body shop was electrocuted when the

portable grinder which he was using developed a short circuit.

(x) *Florida—1973.* A carpenter's helper for a boat manufacturing firm was electrocuted when he plugged the router cord into an extension cord outlet box. Examination of the extension cord outlet box showed the ungrounded conductor had separated from its terminal and was touching the metal box.

While these electrical accident descriptions are typical, it must be emphasized that they only represent accidents within the category of unsafe conditions.

(c) *Accident References.* Although descriptive accident data was reviewed from a variety of sources, the typical representative data presented herein was taken from the following:

(i) *Electrical Work Injuries in California*, Department of Industrial Relations, Division of Industrial Safety, State of California, 455 Golden Gate Avenue, San Francisco, CA 94101.

(ii) *"Live and Learn"* Publication, Department of Labor and Employment Security, Industrial Safety, State of Florida 1321 Executive Center Drive, East Tallahassee, Florida 32301.

(iii) *Publication of Occupational-Related Electrocutions*, Department of Labor and Industrial Relations, State of Hawaii, 825 Millilani Street, Honolulu, Hawaii 96813.

(iv) *Industrial Accidents*, Industrial Commission, State of Idaho, 317 Main Street, Boise, Idaho 83707.

(v) *Department of Labor and Industries*, Division of Industrial Safety, Commonwealth of Massachusetts, Leverett Saltonstall Bldg., Government Center, 100 Cambridge Street, Boston, MA 02202.

(4) *Protective Measures and Present Regulations*

There are various general ways of protecting employees from the hazards of electric shock, including insulation and guarding of live parts. Insulation provides an electrical barrier to the flow of current. To be effective, the insulation must be appropriate for the voltage, and the insulating material should be clean and dry. Guarding prevents the employee from coming too close to energized parts. It can be in the form of a physical barricade, or it can be provided by installing the live parts out of reach from the working surface. (This technique is known as "guarding by location.")

Grounding is another method of protecting employees from electric shock; however, it is normally a secondary protective measure. To keep guards or enclosures at a common

potential with earth, they are connected, by means of a grounding conductor, to ground. If a live part accidentally comes in contact with a grounded enclosure, any current flow is directed back to earth and the circuit protective devices (e.g., fuses and circuit breakers) can interrupt the circuit.

When employees are working with electrical equipment, they must use safe work practices. Such safety-related employee work practices include keeping a prescribed distance from exposed energized lines, avoiding the use of electrical equipment while wet, and locking-out and tagging equipment which is deenergized for maintenance.

Another important safety practice involves the use of electrical protective devices, such as rubber gloves and rubber mats for purposes of insulation against live parts, or hot sticks for purposes of both insulation and actuation of energized parts from a distance. However, to assure the protection of the employee, this equipment must be properly manufactured and maintained. With this equipment, regular maintenance becomes an important consideration in order to keep the equipment from deteriorating into an unsafe condition.

The regulations formerly contained in Subpart S of Part 1910 adopted the 1971 National Electrical Code by reference and set forth definitions with respect to some of the terms used by the NEC. The National Electrical Code is the most widely used code to safeguard people and property from the potential hazards associated with electricity. This code had its beginning prior to the turn of the century when the use of electricity was just starting. At this time, the code serves as the cornerstone of electrical safety in the United States. As such, it provides the basis for electrical safety regulations in over 2000 municipalities throughout all 50 States. Thirty-seven States and the District of Columbia have adopted it as their electrical safety law, and it is enforced by over 12,000 governmental electrical inspectors. This national system provides important assistance to OSHA in its mission to afford electrical safety in the workplace.

(5) Reasons for Proposed Revision

As noted earlier, electricity has long been recognized as a serious workplace hazard, exposing employees to such dangers as electric shock, electrocution, fires, and explosions. Indeed, the long history of the National Electrical Code attests to this fact. Since 1896, the NEC has represented the continuing efforts of experts in electrical safety to deal with these recognized hazards and to provide for safety in all electrical installations,

including workplaces. OSHA has determined that electrical hazards in the workplace pose a significant risk of injury or death to employees, and that these regulations which draw heavily on the experience of the NEC, are reasonably necessary to provide protection from these hazards.

OSHA recognizes the important role that the NEC has played over the years in defining basic requirements for safety in electrical installations. The revision of Subpart S being promulgated by this document will maintain the protection presently afforded to employees by the 1971 NEC, as incorporated by reference in the present standards. While carrying forward those provisions which are considered necessary for employee safety, OSHA is providing greater flexibility for compliance with these provisions to the extent that employee safety warrants. OSHA has determined, therefore, that this revision of Subpart S contains requirements derived from the NEC which are reasonably necessary to protect employees from electrical hazards in the workplace.

Since the National Electrical Code (NEC) NFPA 70-1971 was adopted as a national consensus standard under Section 6(a) of the Act, three revisions of the NEC have been issued, the most recent being the 1981 edition. Because of the continual process by the National Fire Protection Association (NFPA) of updating the Code every three years, any specific edition which OSHA might adopt would likely be outdated within a few years. In addition, since the rulemaking process can become somewhat lengthy, a complete revision of the OSHA electrical safety standards every three years to keep pace with the NEC changes is not practical. To remedy this problem, OSHA's electrical safety standards should accommodate changes in technology without the need for constant revision and, where possible, be written in performance terms in order to allow alternative installation methods if they provide comparable safety to the employee.

Another difficulty with the current incorporation of the entire NEC by reference is that the NEC contains many details which are not directly related to employee safety. In addition, a further objective of OSHA in revising the standard is to obtain an improved standard which will provide employee safety and will be easier to use and understand, but will still be comprehensive enough to cover all significant electrical hazards.

Finally, since the NEC is an electrical installation design document, it does not generally contain explicit requirements for electrical safety-related work

practices, electrical equipment maintenance or safety requirements for special equipment. OSHA, therefore, will also consider the development of regulations in these areas in subsequent rulemaking proceedings.

(6) General Approach

In view of the existing constraints and limitations imposed by the continued use of the 1971 version of the NEC, discussed previously, OSHA concluded that a revised standard tailored to fulfill OSHA's responsibilities and which would extract suitable portions from the NEC and other safety standards applicable to electrical safety was needed.

At the same time, and after discussions with OSHA staff, the NFPA decided that the NEC Correlating Committee, which periodically evaluates the NEC, should examine the feasibility of developing a document to be used as a basis for providing electrical safety in the workplace. In 1976, NFPA established the "70E Committee" to prepare a consensus standard for possible use by OSHA in developing a proposal for subsequent rulemaking. The 70E Committee visualized a standard consisting of four major parts:

- Part I—Installation Safety Requirements,
- Part II—Safety Related Work Practices,
- Part III—Safety-Related Maintenance Requirements,
- Part IV—Safety Requirements for Special Equipment.

The name given to this new document became NFPA 70E, "Electrical Safety Requirements for Employee Workplaces."

(7) Criteria for Part I of NFPA 70E

The NFPA 70E Committee derived Part I from the 1978 NEC; however, unlike the NEC, this Part was not intended to be applied as a design, installation, modification, or construction standard for an electrical installation or system. Rather, its content was excerpted from the NEC in order to apply only to electrical utilization systems which were part of the workplace. Although Part I of NFPA 70E is compatible with corresponding provisions of the NEC, it is not intended to be used, nor can it be used, in lieu of the NEC for the design and initial installation of utilization systems and equipment.

Although all of the requirements of the NEC may be related to electrical hazards, for practical purposes the Committee included in Part I of NFPA 70E provisions which are most directly associated with employee safety. In

determining which provisions should be included in Part I, the following guidelines were used by the 70E Committee.

(a) The provisions should give protection to the employee from electrical hazards.

(b) The provisions should be excerpted from the NEC in a manner that will maintain their intent as they apply to employee safety.

(c) The provisions should be selected and written in a manner that will reduce the need for frequent revision and avoid technological obsolescence.

(d) Compliance with the provisions should be determinable by means of an inspection during the normal state of employee occupancy without requiring shutdown of the electrical installation or damage to the building or finish.

(e) The provisions should not be encumbered with unnecessary details.

(f) The provisions should be written so as to enhance their understanding by the employer and employee.

(g) The provisions must not add any requirements not found in the NEC, nor may the intent of the NEC be changed even if the wording is changed.

(8) Source of 70E

The 1978 edition of the NEC was used as a source document for NFPA 70E, instead of the 1971 edition. Part I of 70E reflects a considerable improvement over the present OSHA standards incorporated in Subpart S. Generally, this improvement may be considered as being one achieved more from the elimination of requirements inappropriate to OSHA's needs rather than from the addition of new requirements. Typical examples of this method of simplification in the preparation of Part I of 70E relate to NEC chapters 3, 4, 6, 7, and 9, as discussed below. Although 70E does contain some additional requirements not contained in the 1971 NEC (as in chapters 6 and 7 of the 1978 NEC), such new provisions are relatively few in number.

Major deletions and additions, typical of those made in the preparation of 70E, are given in the following paragraphs:

(a) *Principal Deletions.* Chapters 3 and 4 of the 1971 and 1978 NEC deal with wiring methods and materials (Chapter 3) and equipment for general use (Chapter 4). Tables containing various specialized technical information have been deleted in 70E.

Typical topics of these chapters included insulation characteristics, allowable ampacities, electrical box sizes, flexible cord and motor full load currents. This type of information was deleted because it deals with items not

directly related to the electrical hazard. For example, the composition of insulation on a conductor was deleted; however, the actual requirement that the conductor be insulated and that the insulation be approved for its intended purpose was retained. These changes result in a standard which is more performance oriented.

Chapter 6 of the 1971 and 1978 NEC describes special equipment requirements. Requirements from this chapter dealing with electrically operated organs and the installation of equipment and wiring used for sound-recording and reproduction have been deleted in 70E because electrical safety for employees is not directly affected by these items. Any hazard to the employee related to this type of equipment would most likely arise in the supply system which will still be covered.

Chapter 7 of the 1971 and 1978 NEC deals with special conditions. All requirements from this chapter involving stand-by power generation systems permanently installed, other than emergency systems, have been deleted. In these situations, primary electrical hazards to the worker are minimal since the effects of power outage are generally limited to product or process damage.

Chapter 9 of the 1971 and 1978 NEC provides a collection of tables containing technical data, together with a number of sample computations. This entire chapter is not included in 70E because it is solely and instructive guide for the design of certain electrical systems.

(b) *Principal Additions.* Chapter 6 of the 1971 NEC which deals with special equipment, has been supplemented by additional requirements found in the 1978 edition of the NEC. These additions are included in 70E. Specifically, new provisions for workplaces containing electrically driven or controlled irrigation machines and workplaces using electrolytic cells have been added. In the first type of workplace, the related electrical hazard is associated with the presence of an electrically driven or controlled machine, with one or more motors, used primarily to transport and distribute water for agricultural purposes. In the second type of workplace, equipment is installed consisting of electrolytic cells used for the purpose of refining or producing various materials. Such an installation contains electrical hazards because the employee's work is normally performed on or in the vicinity of exposed energized surfaces of the electrolytic cell lines and their attachments. As a consequence, special electrical safety requirements are needed and hence such provisions are included in 70E.

Chapter 7 of the 1971 NEC covers special conditions. An addition contained in the 1978 NEC involves fire protective signaling systems. Inasmuch as the installation of wiring and equipment of fire protective signaling systems, operating at 600 volts or less, has a definite effect on workplace safety, the new provisions have been included in 70E.

II. History of Regulation

The need for an uncomplicated and readily understandable standard, sufficiently general to minimize the need for changes, appeared to be satisfied by Part I of the NFPA 70E recommendations. OSHA carefully reviewed the work product of the 70E Committee and determined that its use as a source document for OSHA's design safety standard for electrical utilization systems and equipment was appropriate and offered certain advantages in achieving a more simplified standard. OSHA prepared a notice of proposed rulemaking which contained proposed amendments of the electrical safety standards in Subpart S of 29 CFR Part 1910. The proposal was published in the Federal Register (44 FR 55274) on September 25, 1979. On November 20, 1979, OSHA published a notice correcting the proposal and extending the comment period (44 FR 66621).

The proposal represented an attempt to develop a comprehensive standard which would protect employees from recognized electrical hazards in the workplace. This was accomplished by examining the existing standards, the 1975 and 1978 edition of the NEC. The proposal streamlined the existing standard, which incorporated by reference the whole 1971 NEC, by deleting portions of the NEC which were not directly related to employee safety. OSHA's proposed revisions provided more flexibility, allowing employers alternative methods of compliance by phrasing the standard in terms of performance instead of specification.

The notice of proposed rulemaking invited interested persons to submit written comments on the proposed standard, to participate in a public meeting (which was held on November 8, 1979), and to file objections and requests for a public hearing. The original date for the close of the comment period was set for November 30, 1979, but was subsequently extended, at the request of commenters, to December 31, 1979 (44 FR 66621). Over 190 written comments were received, including several requests for a hearing which identified eight major issues:

1. Whether the proposal should be more performance oriented or, on the other hand, should provide greater specification.

2. Whether the scope of the standard is clear with respect to its coverage of public utilities.

3. Whether the proposal would change the existing "grandfathering" and "retroactive" provisions.

4. Whether the marking and approval requirements in proposed §§ 1910.303(a), 1910.303(e), and 1910.307(b)(4) deviate from the existing regulations and whether they relate to employee safety.

5. Whether the impedance and ampacity requirements of National Electrical Code (NEC) Section 250-51 should be included in the standard.

6. Whether the prohibition of the use of structural metal frames of buildings as the equipment grounding conductor (1978 NEC 250-58(a)) should be included in the standard.

7. Whether the definitions for Class II locations and their associated explanatory notes should be changed.

8. Whether installations of electrolytic cells should be covered by the guarding provisions of proposed § 1910.303.

In response to these hearing requests, OSHA published a notice of public hearing, listing these issues (45 FR 10375). The informal rulemaking hearing was convened by Judge Harmon Maxson on May 6, 1980, pursuant to section 6(b)(3) of the Act (29 U.S.C. 655(b)(3)) and 29 CFR Part 1911. The hearing lasted through May 8, 1980, and included testimony from over 50 witnesses. Judge Maxson established a post-hearing period for the submission of additional comments and briefs extending through July 8, 1980.

The entire record, including 73 exhibits, 5 addenda, and 490 transcript pages, was certified by Judge Maxson on August 27, 1980, in accordance with 29 CFR 1911.17. Copies of materials in the record, as well as an index of the record, may be obtained from the OSHA Docket Office, Room S6212, Frances Perkins Building, 200 Constitution Avenue, NW, Washington, D.C. 20210.

This final standard is based on a full consideration of the entire record of this proceeding including materials discussed or relied on in the proposal, the record of the informal hearing, and all written comments and exhibits received.

III. Issues

The evidence submitted into the record is summarized and evaluated in the following discussions of each issue. The numbers in brackets refer to specific references in the May 6, 7, and

8, 1980, hearing exhibits (Ex.) and hearing transcript page numbers (Tr.).

1. *Whether the proposal should be more performance oriented or, on the other hand, should provide greater specification.*

Most of the language of the proposed standards was taken directly from the National Electrical Code. This was done to maintain continuity with the existing regulations, which incorporated the entire 1971 NEC by reference. Where the NEC language was rewritten emphasis was given to performance oriented terms. As stated by one witness, the criteria used by the NFPA 70E Committee in developing the base document was: "Whenever practicable, the standard promulgated shall be expressed in terms of objective criteria and of the performance desired" (Tr. 394). However, some commenters felt that the proposal was still too specific and suggested that the entire standard be more general. One commenter stated:

Most accidents do not result from lack of or conformance to specification, but are performance failures, such as human and/or environmental failures. Another deficiency of specification standards is that the inflexibility of specification standards leads to specification-type citations which frequently fail to correct accident causes.

... So long as a standard is specification oriented, it is sterile and freezes in place the state of technology and scientific applications to the industry (Ex. 44).

In a later submission, the same commenter stated, "The standards should allow the employer the use of reasoned judgment in the application of innovative methods, new technology and cost-saving practices so long as worker safety is not jeopardized" (Ex. 61). This commenter had earlier submitted an annotated copy of the proposal with suggested changes for all paragraphs which they felt were too specific (Ex. 2). Another comment contained a suggested revision of the entire standard which would reduce it to two pages of very general terms and stated, "Performance orientation allows for rapid technological improvements, alternative methods of accomplishing employee safety and a reduction of nuisance citations" (Ex. 12). In addition, a witness stated, "When specifications are detailed to this degree, they place a burden on OSHA compliance officers to become unnecessarily proficient in the technical language and application of the National Electrical Code and the proposed regulations" (Tr. 417-418).

In contrast to testimony supporting more general standards, one witness stated, "The most obvious and serious defect is the emphasis on writing the standard in general terms * * * The

[Review] Commission and the circuit courts have ruled, in some instances, that standards written in general terms are vague and unenforceable" (Tr. 227).

A certain balance is required in order to make the standard both flexible and at the same time enforceable. OSHA has tried to make the standard as performance oriented as possible. However, it is impossible to express the standard in only performance terms without providing some specifications for employers and compliance officers. The final rule as adopted, therefore, is essentially a performance standard, with specifications included where necessary.

2. *Whether the scope of the standard is clear with respect to its coverage of public utilities.*

The scope of OSHA's former standard was stated in § 1910.308(c). The so-called "utility exemption" was contained in paragraph (c)(2)(v) and was identical to 1971 NEC Section 90-2(b)(5). In the proposal, OSHA continued the "exemption" in § 1910.302(e)(2)(v), which read the same as the earlier version:

(2) *Not covered.* * * *

(v) Installations under the exclusive control of electric utilities for the purpose of communication or metering; or for the generation, control, transformation, transmission, and distribution of electric energy, located in buildings used exclusively by the utilities for such purposes or located outdoors on property owned or leased by the utility, or on public highways, streets, roads, etc., or outdoors by established rights on private property.

OSHA's interpretation of this regulation, as stated at the public hearing, has been that "this provision excludes the *installations* of electric utilities used for such purposes as the generation, control, transformation, transmission and distribution of electric energy. Other codes and standards such as ANSI C-2, National Electrical Safety Code, address the installation design requirements for these facilities. Therefore, the NEC does not address these areas of electric design" (Tr. 25, emphasis added).

As stated by witnesses at the hearing, the scope provision of the standard does not grant exemptions (Tr. 68, 259, 426). Instead, the "utility exemption", as it is referred to, is simply a statement of installations which were never intended to be within the scope of the NEC, or of this standard. In other words the standard, like the NEC, does not contain provisions which are appropriate for dealing with utility installations either for the generation, control, transformation, transmission, and

distribution of electric energy, or for the purpose of communication or metering.

However, other utility installations not of the type noted above are covered. A proposal was submitted to the 1981 code writing panels to clarify the intent of the scope paragraphs. As noted by some witnesses (Tr. 261, 427), this proposal was accepted and a revised fine print note was added to the proposed 1981 NEC, reading as follows:

It is the intent of this section that this Code covers all premises' wiring or wiring other than utility owned metering equipment, on the load side of the service point of buildings, structures, or any other premises not owned or leased by the utility. Also, it is the intent that this Code cover installations in buildings used by the utility for purposes other than listed in (b-5) above, such as office buildings, warehouses, garages, machine shops, recreational buildings which are not an integral part of a generating plant, substation, or control center.

The language of § 1910.302(a)(2)(v) provides that portions of a utility installation which are not integral parts of a generating plant, substation, or control center are covered by the standard.

The position that all aspects of public utilities operation should be covered by the proposed regulations was raised by two commenters. The first commenter expressed the concern that a large number of workers would not be protected by an electrical standard if the public utility industry were exempted from this standard. He cited a Bureau of Labor Statistics News Release which stated that six of every 10 fatalities from contact with electric current occurred to workers in the construction, transportation and public utilities industries (Ex. 25). However, most of those fatalities were in the construction industry; and, since the causes of those fatalities occurring in the transportation and public utilities industries were not broken down, it is not clear how many may have been caused by conditions covered in the regulations of this Subpart. Expressing the same concern, the other commenter stated, "To exclude the utility industry from Subpart S (electrical) of the Occupational Safety and Health Act is to deny fair and equal safety coverage to the largest number of workers exposed to these hazards on a daily basis." In support of his objection, this witness described several electrical accidents of which he had personal knowledge (Ex. 28). However, it must be noted that the causes of these accidents were related to construction and maintenance of power transmission and distribution lines and equipment; the electrical standards of Part 1910 do not apply to construction activities.

(Regulations for the construction of power transmission and distribution lines are contained in OSHA's construction standards (29 CFR Part 1926). Regulations on the maintenance and design of these lines and equipment will be considered in future rulemakings.)

The question of whether other industries should have the same exemption as public utilities in areas where they are performing the same operations was raised by steel industry representatives (Ex. 61). As they noted, the National Electrical Safety Code (ANSI C-2) contains regulations covering the generation, control, transformation, transmission and distribution of electric energy. ANSI C-2 does specifically say in its scope that it is applicable to the systems and equipment operated by utilities, or similar systems and equipment of an industrial establishment or complex under the control of qualified persons. While questioning a witness representing the Edison Electric Institute, a steel industry representative noted that while the NEC and OSHA's Subpart S cover industrial substations, the ANSI C-2 Code says that it, too, covers industrial equipment, thus producing a conflict or overlap (Tr. 350).

The NEC and OSHA's Subpart S do contain provisions which are appropriate for most industrial substations. Such facilities are included in the scope of this standard, because they vary widely in the power and voltage involved and in the type of equipment that is used. While some industrial facilities may only include utility type equipment and operate similarly to a utility, this is not the general case. As a rule utilities operate at much higher voltages and with specially trained employees. In the situations where the industrial operation may be the same as that of an electric utility, there would not be an overlap since ANSI C-2 contains the provisions which would apply and neither the NEC nor OSHA's Subpart S contain provisions which would be applicable. However, since provisions are included in these standards which are appropriate for most industrial substations, these installations have been included in the scope of the final rule.

3. *Whether the proposal would change the existing "grandfathering" and "retroactive" provisions.*

a. Terminology.

The term "retroactive" has been used during this rulemaking to refer to provisions which were required by former § 1910.309(a) (and by proposed § 1910.302(b)(1)) to be implemented

without regard to when the electrical installation was made. OSHA recognizes that this is an unorthodox use of the term "retroactive," since these provisions do not involve retroactivity in the true sense of the word. The so-called "retroactive" provisions of § 1910.309(a) required certain previously installed equipment to be updated as of the standard's effective date to meet a list of requirements from the 1971 NEC. In that sense, its application to existing installations was no different than that of the other national consensus standards which OSHA adopted under section 6(a) of the Act. In other words, employers who had not voluntarily met these standards before OSHA adopted them were now required to bring their facilities into compliance.

In this preamble, OSHA will refer to the requirements of § 1910.309(a) and proposed § 1910.302(b) as the "retroactive" provisions of Subpart S, in order to avoid further confusion, even though the term is not accurate.

Similarly, § 1910.309(b) (and proposed § 1910.302(b)(2)) which apply the entire electrical standard to installations made after March 15, 1972, are referred to as the "grandfathering" provisions, because they did not require that installations made before March 15, 1972, comply with the entire 1971 NEC (or as stated in § 1910.302(b)(2), comply with all of Subpart S).

b. *Background of the former § 1910.309*
OSHA's former General Industry Electrical Safety Standard included §§ 1910.309 (a) and (b), which read as follows:

(a) The requirements contained in the following articles and sections of the National Electrical Code, NFPA 70-1971; ANSI C1-1971 (Rev. of C1-1968) shall apply to all electrical installations and utilization equipment: [4 articles and 74 provisions of the 1971 NEC were listed].

(b) Every new electrical installations and all new utilization equipment installed after March 15, 1972, and every replacement, modification, or repair or rehabilitation, after March 15, 1972, of any part of any electrical installation or utilization equipment installed before March 15, 1972, shall be installed or made, and maintained, in accordance with the provisions of the 1971 National Electrical Code, NFPA 70-1971; ANSI C1-1971 (Rev. of C1-1968).

Under these provisions, the 4 articles and 74 provisions of the 1971 NEC, as listed in § 1910.309(a), applied to all electrical installations and utilization equipment, including those installed before the rule was published. If these installations and equipment did not comply with the listed provisions, they were required to be brought into compliance. Paragraph 1910.309(b), then, provided that equipment and

installations made after March 15, 1972, were subject to the entire 1971 NEC.

To the extent that § 1910.302(b) of the proposal was developed directly from these provisions, OSHA believed that it was clear that no new requirements were proposed for installations and equipment installed prior to March 15, 1972. In fact, the list of provisions in proposed § 1910.302(b)(1) was shortened, and the listed provisions were simplified significantly from those in § 1910.309(a).

However, as the rulemaking on Subpart S progressed, it became evident that there was considerable confusion over proposed § 1910.302(b)(1) and its antecedent, § 1910.309(a). Some parties contended that proposed § 1910.302(b)(1) actually added new "retroactive" requirements not found in § 1910.309(a). Others indicated that they did not understand either the proposed or the existing "retroactive" provisions. In this regard, OSHA believes that it will be helpful at this point to discuss the development of § 1910.309 as it has appeared in Subpart S since 1972.

On May 29, 1971, OSHA published, under Section 6(a) of the Act, its first package of national consensus and established Federal standards in 29 CFR Part 1910 (36 FR 10486). Various amendments were made less than three months later, on August 13-14, 1971, (36 FR 15101, 15438). Included in the initial package of standards was Subpart S of Part 1910, entitled "Electrical." Certain substantive provisions from the 1968 NEC were published nearly verbatim in Subpart S as § 1910.308 and §§ 1910.310-1910.328. The August 13, 1971 amendments provided that these sections became effective on August 27, 1971 (36 FR 15101). The remaining provisions of the 1968 NEC were incorporated by reference in § 1910.309, and employers were given an additional 5½ months, until February 15, 1972, to adjust to and come into compliance with these requirements.

However, before the expiration of the two year period established by section 6(a) of the Act for the adoption of national consensus standards as OSHA standards, the NFPA issued its 1971 edition of the NEC. The 1971 NEC thus became the latest edition of the national consensus standards for electrical safety. OSHA reviewed its existing standards and determined that there were potential conflicts between the two consensus standards, namely, the 1968 NEC and 1971 NEC. Under section 6(a) of the Act, the Assistant Secretary eliminated such conflicts by promulgating the standard which assured the greatest protection for employees.

OSHA determined that original §§ 1910.310-1910.328, as originally promulgated, were necessary elements of employee safety in existing installations, and that their coverage should be continued for all electrical installations, regardless of when made. It was also determined that for future installations and modifications of existing installations, the entire 1971 NEC should be applicable.

For existing installations, then, OSHA adopted only the Articles and Sections of the 1971 NEC which, in their 1968 versions, had been the sources for original §§ 1910.310-1910.328 (37 FR 3431, February 16, 1972). Where there was conflict between the 1968 provisions and the 1971 provisions, section 6(a) of the Act required the adoption of the version which "assures the greatest protection of the safety or health of the affected employees." (29 USC 655(a).) The Assistant Secretary selected the 1971 versions as being more protective than those of 1968. (This determination was also congruent with the NFPA's own determination, as stated in a new provision of the 1971 NEC, Section 90-1, that the 1971 Code contained "requirements considered necessary for safety.")

OSHA did not then publish sections 1910.308 and 1910.310-1910.328, taken from the 1971 Code, to replace those sections originally taken from the 1968 Code. Instead of publishing the text of these NEC articles and sections verbatim within Subpart S, OSHA chose to list them and incorporate them by reference in paragraph (a) of § 1910.309 and apply them to all electrical installations. Paragraph (b), on the other hand, incorporated the entire 1971 NEC by reference for application only to installations, modifications, repairs, and renovations made after March 15, 1972 (37 FR 3431, Feb. 16, 1972).

The format and content of § 1910.309, as promulgated in February 1972 has remained unchanged since then, except for the revision of a requirement from the 1971 NEC relating to ground-fault protection on construction sites.

It is clear from this discussion that OSHA's actions in applying only certain provisions of the 1971 NEC to existing installations were well within the authority of the Assistant Secretary under section 6(a) of the Act. Indeed, the promulgation of former § 1910.309 did not constitute the fullest possible exercise of section 6(a) authority, which could have resulted in the entire 1971 NEC being applied to all electrical installations. The Assistant Secretary acted to resolve the conflict between consensus standards in a manner which did not compromise the good faith

efforts of employers to comply with the electrical standards as originally promulgated.

c. Background of proposed § 1910.302(b)

OSHA proposed to retain most of the requirements of former § 1910.309 in proposed § 1910.302(b). The proposed provision retained the dichotomy between old and new installations as contained in § 1910.309, as follows:

(b) *Extent of application.* (1) The requirements contained in the sections listed below shall apply to all electrical installations and utilization equipment regardless of when they were designed or installed: [28 sections of proposed Subpart S were listed, containing 46 provisions].

(2) Every new electric utilization system and all new utilization equipment installed after March 15, 1972, and every replacement, modification, repair, or rehabilitation, after March 15, 1972, of any part of any electric utilization system or utilization equipment installed before March 15, 1972, shall be installed or made, and maintained, in accordance with the provisions of §§ 1910.302 through 1910.308 of this subpart.

The requirements listed in proposed § 1910.302(b)(1) were all based on the 1971 NEC Articles and Sections contained in the former § 1910.309(a) list. Some of the requirements in the old list were proposed to be deleted (e.g., NEC Section 422-17). Others were written in more performance-oriented terms (e.g., NEC Articles 500, 501, 502, and 503), allowing alternative methods of compliance to those specified in the 1971 NEC. (These changes are noted in detail in section IV of this preamble.) Thus, the proposal provided much greater flexibility for the employer than did the former regulation.

The "retroactive" provisions in proposed § 1910.302(b)(1) related to such critical areas as grounding, guarding live parts, use of flexible cords, overcurrent protection, hazardous locations, identification of equipment and disconnecting means, and inspection of equipment. In evaluating the need for these requirements, OSHA reviewed 1971 and 1972 electrical accident data from the State of California. From this data, OSHA concluded that 70 percent of the electrical accidents which were attributable to unsafe conditions involved hazards addressed by the "retroactive" requirements.

Most of the comments and testimony introduced on the issue of the "retroactive" provisions were submitted by representatives of a single industry, involving feed and grain production (Tr. 168-169, 250-251, 264-269, 420; Ex. 19, 21, 28, 31, 32, 39, 54). Some argued that OSHA's former regulation was not recognized by industry as applying "retroactively" and that OSHA

compliance officers were interpreting it inconsistently (Ex. 31, 44).

However, the record clearly indicates that the "retroactive" provisions of § 1910.309(a) have been uniformly applied by OSHA to installations made prior to March 15, 1972. This fact is indicated by the evidence of citations submitted into the record (Ex. 55G). In addition, testimony of representatives from organizations such as the American Petroleum Institute, Underwriters Laboratories, Inc., and the National Fire Protection Association shows that industry in general has been well aware of the "retroactive" provisions of § 1910.309(a) during the nearly nine years since their original promulgation (Tr. 307, 324, 408-409).

Furthermore, the Occupational Safety and Health Review Commission, in *Delaware and Hudson Railway* (1980 OSHD ¶ 24,422), has ruled definitively that the "retroactive" provisions of § 1910.309(a) do apply to equipment installed before March 15, 1972. As the Commission noted:

Respondent submits that section 1910.309(b) limits the application of section 1910.309(a) to equipment installed after March 15, 1972.

Sections 1910.309 (a) and (b) must be read together. Section 1910.309(a) incorporates by reference certain specified sections of the NEC as occupational safety and health standards and provides that they "shall apply to all electrical installations. . . ." (emphasis added). Section 1910.309(a) contains no clause excluding previously installed equipment from its coverage. Section 1910.309(b), on the other hand, goes further than section 1910.309(a)'s incorporation of only specific sections of the NEC, and requires compliance with the entire electrical code. The terms of section 1910.309(b), however, limit its application to equipment installed, replaced, repaired, or rehabilitated after March 15, 1972. Because Respondent was cited for a failure to comply with an NEC provision specifically incorporated in section 1910.309(a), the date of installation of Respondent's equipment is irrelevant. (1980 OSHD ¶ 24,422, at p. 29787).

Several commenters argued that even if § 1910.309(a) by its terms applies to installations made prior to March 15, 1972, the NEC was not intended by its drafters to be applied "retroactively" in this way, but was only intended to be used prospectively, as an installation standard (Ex. 31, 32, 54, 69). These commenters argued that there was no evidence in the record that any other State or governmental agency had adopted the NEC "retroactively."

The 1971 NEC was totally silent on the question of its application to existing facilities. Had the drafters intended to limit its application to new installations, they could easily have included a

statement to that effect in the scope provisions (Section 90-2) of the Code. (In fact, the NEC Code Making Panel which is responsible for the scope and introduction to the NEC rejected a proposal for the 1975 NEC which would have provided an exemption for existing installations. See pp. 1-3, *Preprint of the Proposed Amendments for the 1974 National Electrical Code*, Part II (NFPA, 1973).) Moreover, the 1971 NEC clearly indicated an intention to leave all such questions of application and enforcement to the enforcing authority. For example, section 90-7 provided:

This Code is intended to be suitable for mandatory application by governmental bodies exercising legal jurisdiction over electrical installations. . . . The administrative authority supervising such enforcement of the Code will have the responsibility for making interpretations of the rules, for deciding upon the approval of equipment and materials, and for granting the special permission contemplated in a number of the rules.

In addition, section 90-1(b) of the 1971 NEC did not distinguish between safety in existing installations and safety in new installations:

This code contains provisions considered necessary for safety. Compliance therewith and proper maintenance will result in an installation essentially free from hazard. . . .

Thus, the 1971 NEC contained no provisions which indicated an intent for that Code to apply only to new electrical installations. The question of how the Code would be applied was left to the authorities enforcing it, including OSHA.

Section 6(a) of the Act was enacted to provide protection to employees from workplace hazards as soon as possible. The urgency of this action was underscored by Congress' authorization to OSHA to proceed without regard to the rulemaking procedures of the Administrative Procedure Act (5 U.S.C. 553). Had OSHA chosen to apply the 1971 NEC only to new installations, such action would not have resulted in any improvement in employee safety under existing conditions. Furthermore, there would have been no coverage at all for these conditions.

OSHA's selection of provisions from the 1971 NEC to apply to all installations represented a means of complying with the letter and the spirit of section 6(a) of the Act. Virtually all of the "retroactive" provisions in former § 1910.309(a) (and, necessarily, in proposed § 1910.302(b)(1)) had been in the NEC in one form or another for many years prior to the 1971 edition. Hence, although they were now mandatory on a National scale for the first time, these provisions were already well known to employers across the country.

It is important to note that former § 1910.309(a) listed only a small portion of the 1971 NEC for application to installations made before March 15,

1972. Additionally, the overwhelming majority of these provisions originated in editions of the NEC dated 1937 or earlier (see Table following).

Table of "Retroactive" Provisions

"Retroactive" provisions in OSHA's former standards (§ 1910.309(a))		NEC edition and page numbers in which provisions first appeared	Provisions not "retroactive" in OSHA's proposal (§ 1910.302(b)(1))
Sections:			
250-58 (a) and (b)	Equipment on Structural Metal	1930, p. 125	X
250-59 (a), (b), and (c)	Portable and/or Cord Connected and Plug Connected Equipment, Grounding Method	1930, p. 132; 1935, p. 138; 1937, p. 65	X
400-3 (a) and (b)	Flexible Cords and Cable, Uses	1930, p. 132; 1937, p. 127	
400-4	Flexible Cords and Cable Prohibited	1935, p. 206	
400-5	Flexible Cords and Cables, Splices	1947, p. 121	
400-9	Overcurrent Protection and Ampacities of Flexible Cords	1930, p. 83; 1937, p. 127	
400-10	Pull at Joints and Terminals of Flexible Cords and Cables	1930, p. 82	
422-8	Installation of Appliances with Flexible Cords	1930, p. 70	X
422-9	Installation of Portable Immersion Heaters	1935, p. 182	X
422-10	Installation Appliances Adjacent to Combustible Material	1935, p. 182	X
422-11	Stands for Portable Appliances	1935, p. 182	X
422-12	Signals for Heated Appliances	1935, p. 182	X
422-14	Water Heaters	1956, pp. 70-181	X
422-15 (a), (b), and (c)	Installation of Infrared Lamp and Industrial Heating Appliances	1947, p. 144	X
110-14 (a) and (b)	Electric Connection	1930, p. 14; 1935, p. 16	
110-17 (a), (b), and (c)	Guarding of Live Parts	1936, p. 19	
110-18	Arcing Parts	1937, p. 20	
110-21	Marking	1937, p. 20; 1899, pp. 10, 22, 33, 43	
110-22	Identification	1965, p. 16	
240-16 (a), (b), (c), and (d)	Location in Premises (for Overcurrent Protection Devices)	1930, p. 100	
240-19 (a) and (b)	Guarding of Arcing or Suddenly Moving Parts of Overcurrent Protection Devices	1930, p. 98	
250-3 (a) and (b)	D.C. System Grounding	1930, p. 137; 1925, p. 85	
250-5 (a), (b), and (c)	A.C. Circuits and Systems To be Grounded	1930, pp. 127-128; 1925, p. 85	
250-7	Circuits not to be Grounded	1936, p. 57	X
250-42 (a), (b), (c), and (d)	Fixed Equipment Grounding, General	1930, p. 130; 1937, p. 58	
250-43 (a), (b), (c), (d), (e), (f), (g), (h), and (i)	Fixed Equipment, Grounding, Specific	1930, p. 130; 1937, pp. 58-59	X
250-14 (a), (b), (c), (d), and (e)	Nonelectrical Equipment, Grounding	1930, p. 131; 1937, p. 60	
250-45 (a), (b), (c), and (d)	Equipment Connected by Cord and Plug, Grounding	1930, p. 132	
430-142 (a), (b), (c), and (d)	Stationary Motor, Grounding	1937, p. 158	X
430-143	Portable Motors, Grounding	1937, p. 159	X
250-50 (a) and (b)	Equipment Grounding Connections	1947, p. 65	
250-51	Effective Grounding	1937, p. 63	
250-57 (a) and (b)	Fixed Equipment, Method of Grounding	1937, p. 65	
422-16	Appliance Grounding	1937, p. 138	X
422-17	Installation of Wall-mounted Ovens and Counter-mounted Cooking Units	1937, p. 137, 139	X
Articles:			
500	Hazardous Locations		
501	Class I Installations (Hazardous Locations)	1925, 1928; 1930, p. 165	
502	Class II Installations (Hazardous Locations)		
503	Class III Installations (Hazardous Locations)		
"Approval Requirements" ¹		1899, pp. 6, 20, 26, 27, and 29 supplement	

¹ The general approval requirement is not "retroactive" either in OSHA's present or proposed regulations. It is shown here to indicate its genesis.

Lastly, several commenters claimed that "retroactive" application of OSHA's electrical standards would result in a vast economic burden on employers without being necessary for employee safety (Tr. 169-171; Ex. 31, 56, 61, 62). To support their claim, two organizations submitted economic impact studies on their respective industries (Ex. 55, 58).

As discussed more fully in the section on regulatory assessment (Section V), the exaggerated cost estimates in these industry studies can be attributed to a lack of clarity and proper organization in § 1910.307 as proposed. During the rulemaking, as is later noted, proposed

§ 1910.307 was viewed by various parties as imposing an "approval" requirement for electrical equipment in hazardous locations. This section applied to all such equipment, regardless of when installed, by virtue of its inclusion in the "retroactive" list in § 1910.302(b)(1). Thus, based upon this interpretation, the cost estimates in the industry studies included the unnecessary and enormous expense of removing acceptable equipment which was not "approved."

OSHA recognizes that proposed § 1910.307, as drafted, may have been susceptible to such reading. However, as

issue 4 in this section of the preamble makes clear, it was never OSHA's intention to require "approval" or "listing" or "labeling" of equipment in hazardous locations installed before March 15, 1972. Approval of this sort was only one of three alternatives which OSHA intended to allow for these locations. Although approval of equipment is certainly an acceptable means of compliance, § 1910.307 provides that other equipment will also be acceptable if it is intrinsically safe or if the employer can demonstrate that the equipment is of a type and design which provides protection from the hazards of the hazardous location. This performance requirement is, if anything, a less burdensome provision than the requirements from the 1971 NEC which have been enforced under § 1910.309(a).

Thus, many of the costs submitted in the industry studies are not imposed by the revision of Subpart S. The reorganization of § 1910.307 in the final standards will help to clarify the situation and remove the cause of the controversy surrounding both this section and the other "retroactive" provisions of § 1910.302(b)(1).

OSHA has considered the recommendations for eliminating "retroactive" provisions for older electrical installations and has concluded that a total exemption of all existing facilities is unwarranted. "Retroactive" application of the requirements listed in § 1910.302(b)(1) has been shown to be reasonably necessary for employee safety and has not been shown to be an unwarranted or extremely costly burden on employers. Therefore, § 1910.302(b)(1) has been adopted with no change from the proposal.

4. *Whether the marking and approval requirements in proposed §§ 1910.303(a), 1910.303(e), and 1910.307(b)(4) deviate from the existing regulations and whether they relate to employee safety.*

a. *Marking*

OSHA's previous standards on the general marking of electrical equipment were contained in 1971 NEC Sections 110-21 and 500-2(b). In the former standards, both requirements were "retroactive," and they read as follows:

110-21. *Marking.* The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified, shall be placed on all electrical equipment. Other markings shall be provided giving voltage, current, wattage, or other ratings as are prescribed elsewhere in this Code. The marking shall be of sufficient durability to withstand the environment involved.

500-2. *Special Precaution.* * * *

(b) *Marking.* Approved equipment shall be marked to show the Class, Group and

operating temperature, or temperature range, based on operation in a 40° C ambient for which it is approved.

The temperature range, if provided, shall be indicated in identification numbers, as shown in Table 500-2(b).

Identification numbers marked on equipment nameplates shall be in accordance with Table 500-2(b).

Exception: Equipment of the nonheat-producing type, such as junction boxes, conduit and fittings, are not required to have a marked operating temperature.

OSHA proposed to retain both provisions, with some minor modifications. Paragraph 1910.303(e) proposed requirements equivalent to NEC Section 110-21, except with the words "as are prescribed elsewhere in this Code" changed to the more performance-oriented "as may be required." In proposed § 1910.307(b)(4), the second and third sentences of NEC Section 500-2(b) were deleted, a related sentence from 1971 NEC Section 500-2(c) was added, and two new exceptions were also added. These changes resulted in no new obligations for employers.

Some commenters were concerned with the "retroactive" application of the general marking requirements, § 1910.303(e) (Tr. 309, 396-397; Ex. 19, 31). However, it must be noted that this requirement was not new to the NEC when the first OSHA electrical standards were promulgated. Indeed, this requirement can be found as far back as the 1918 National Electrical Code,¹ and it has been carried forward in all subsequent editions. More than half a century later, it was reasonable for OSHA to expect that most, if not all workplaces were in compliance with this provision when Subpart S was first promulgated.

The commenters also suggested that marking was not related to employee safety. However, since the required markings provide for proper identification and utilization of equipment, the requirement clearly provides protection for operating and maintenance personnel (Tr. 64, 73-74).

One commenter (Ex. 56) was concerned that otherwise safe equipment would have to be replaced for lack of the required markings and suggested that OSHA allow the employer to mark the equipment. In this regard, the standard does not specify that markings are only acceptable if they are part of the manufacturers' nameplates (though a nameplate would

be acceptable). The standard allows the employer to place the required marking on equipment provided that it is done in a manner which ensures sufficient durability.

Many of the comments on OSHA's proposal, as well as some of the hearing exhibits, reflected misinterpretations of OSHA's marking requirements (Exs. 2, 19, 21, 31). The terms "marking", "labeling", and "approval", each of which has its own distinctive meaning within the context of Subpart S, were nonetheless used interchangeably by the commenters and witnesses. In this regard, it may be helpful to discuss the meanings of and relationships between these terms in the context of the standards.

"Marking" means no more than the identification of the key electrical parameters of a piece of electrical equipment. As noted above, § 1910.303(e) does not require that this "marking" take the form of a manufacturer's nameplate. Marking may be accomplished by any means which will provide the necessary information and will be capable of withstanding the operating environment of the equipment.

"Marking" does not mean the same thing as "labeling", as used in both the NEC and Subpart S. "Labeling" refers to the label of a nationally recognized testing laboratory, such as Underwriters Laboratories, Inc. (UL), or Factory Mutual Engineering Corporation, which indicates that the equipment in question has met criteria set by that laboratory for electrical safety. "Labeling," unlike "marking," is not required by Subpart S; however, if equipment is required by the Subpart to be "approved," equipment which is "labeled" is acceptable to OSHA.

The general requirement that all equipment be "approved", which was carried forward in proposed § 1910.303(a), only applies to installations made after March 15, 1972. This requirement was not contained in the list of "retroactive" provisions in former § 1910.309(a) and was also not contained in the list of proposed § 1910.302(b)(1). (See discussion of *Approval* in Section III, Issue 4b of this preamble.)

In brief, the general requirements for marking in § 1910.303(e) apply to all electric equipment; the general approval requirement in § 1910.303(a) applies to equipment installed after March 15, 1972; and there is no labeling requirement. If equipment is required to be "approved", unapproved equipment generally has to be replaced with "approved" equipment. On the other hand, equipment which is not properly marked need not be replaced but need

¹ P. 128 (Class D, Markings) 1918 "National Electrical Code", Regulations of the National Board of Fire Underwriters for Electric Wiring and Apparatus, as Recommended by the National Fire Protection Association.

only be marked with the necessary information.

Other commenters addressed § 1910.307(b)(4). They claimed that this paragraph required unnecessary marking of dust-tight equipment, which did not need to be marked for use in Class II, Division 2 locations (Tr. 274-275; Ex. 19, 34, 56). To support their views, they cited the 1981 NEC which has clarified the marking requirement by including an exception to Section 500-2(b) for dust-tight equipment in Class II, Division 2 and Class III locations. So that OSHA's standard would not conflict with the NEC, they suggested that § 1910.307(b)(4) be changed to read as follows:

(4) *Marking.* Approved equipment not covered in paragraphs (b)(4)(i) through (b)(4)(iv) of this section shall be marked to show the class, group, and operating temperature, or temperature range, based on operation in a 40° C ambient, for which it is approved. The temperature marking shall not exceed the ignition temperature of the specific gas or vapor to be encountered.

(i) Equipment of the nonheat-producing type, such as junction boxes, conduit, and fittings and equipment of the heat producing type having a maximum temperature not more than 100° C (212° F), shall not be required to have a marked operating temperature or temperature range.

(ii) Fixed lighting fixtures marked for use in Class I, Division 2 locations only, need not be marked to indicate the Group.

(iii) Fixed general purpose equipment in Class I locations other than fixed lighting fixtures which is acceptable for use in Class I Division 2 locations shall not be required to be marked with the Class, Group, Division or operating temperature.

(iv) Fixed dust tight equipment other than fixed lighting fixtures which are acceptable for use in Class II Division 2 and Class III locations shall not be required to be marked with the Class, Group, Division or operating temperature.

The proposed version allowed general-purpose equipment suitable for any Division 2 location to be unmarked. Since dust-tight equipment was acceptable for installation in Class II, Division 2 locations, proposed § 1910.307(b)(4)(iii) already accepted the use of unmarked, dust-tight equipment in Class II, Division 2 locations. However, in an effort to clarify this point and in agreement with the comments received, the suggested change has been included in the final rule.

b. *Approval*

OSHA's former regulation requiring all equipment to be approved was contained in 1971 NEC Section 110-2, which was not made applicable to equipment installed before March 15, 1972. Definitions and clarifications relating to approval were contained in

former § 1910.308(d), and paragraph (d)(1) stated that approved meant "acceptable to the Assistant Secretary of Labor for Occupational Safety and Health." For the purpose of the former regulations, § 1910.308(d)(2) listed the types of installations or equipment which would be acceptable (and therefore "approved"). The definitions applied both to the general approval requirement and to provisions of the 1971 NEC which contained their own specific approval requirements.

In proposed § 1910.303(a), OSHA retained the same approval requirement as that contained in 1971 NEC Section 110-2. The definitions relating to approval were also retained. In keeping with the former standards, § 1910.303(a) was not proposed to be made applicable to equipment installed before March 15, 1972. However, § 1910.307 (dealing with equipment installed in hazardous locations) was proposed to be made applicable to all electric equipment. This proposed section corresponded to Articles 500-503 of the 1971 NEC, which were listed in § 1910.309(a) of the former standards as being "retroactive." Proposed § 1910.307 did contain some requirements relating to approval of equipment. In paragraph (c), this section required equipment to be one or more of the following: (1) intrinsically safe, (2) approved for the hazardous location, or (3) of a type and design which provides protection from the hazards arising from the combustibility and flammability of vapors, liquids, gases, dusts or fibers.

Equipment "approval" was intended to be only one means of compliance. Paragraphs (b)(1) and (b)(2) were not intended to establish substantive requirements unless the employer selected the means of compliance in § 1910.307(c)(2). Since they related only to approval, these paragraphs were not applicable if one of the other two methods of compliance were chosen.

There seemed to be confusion among the commenters about these approval requirements (Tr. 294; Ex. 31, 49). One assumed that the proposal required all equipment in hazardous locations to be approved regardless of when it had been installed and claimed that retrofitting of existing equipment would be required solely because such equipment was not approved (Ex. 56). The extent of the confusion is indicated by the testimony of one witness who believed that U.L. listed motors built between 1973 and 1975 would have to be replaced, because Underwriters Laboratories subsequently changed their standards (Tr. 275-276).

However, OSHA does not intend to require all equipment in hazardous locations to be "approved." Although hazardous locations are required to

comply with § 1910.307, the approval requirement contained therein is only one of the three alternate methods by which employers can comply. The standard does not require existing equipment to be "approved," as long as the employer can demonstrate that it is safe for the hazardous location.

OSHA intended the requirements for approved and intrinsically safe equipment, as set forth in proposed paragraph (b) of § 1910.307 to be read totally in the context of the alternatives for compliance under paragraph (c) of that section. Thus, if an employer chose to comply with § 1910.307 by using approved or intrinsically safe equipment in hazardous locations, the requirements applicable to such equipment in paragraph (b) would specify what each compliance option entailed.

The general approval requirements in § 1910.303(a), then, do not apply to installations made before March 15, 1972. Therefore, that section does not require any changes to an employer's equipment if that equipment was installed before March 15, 1972. Additionally, with respect to the approval-related options contained in § 1910.307, OSHA has reorganized the final rule to state the agency's intent more clearly. Section 1910.307 requires that equipment in hazardous locations be one or more of the following: (1) intrinsically safe (§ 1910.307(b)(1)); (2) approved for the hazardous location (§ 1910.307(b)(2)); or (3) of a type and design which provides protection from the hazards arising from the combustibility and flammability of vapors, liquids, gases, dusts, or fibers (§ 1910.307(b)(3)). Requirements addressing each alternative set forth in § 1910.307 have been relocated to show that they apply only to that alternative. For example, if the employer selects to use approved equipment as a means of complying with § 1910.307(b), then new § 1910.307(b)(2)(i) indicates that such equipment must be approved not only for the Class and Division but also for the group of atmosphere involved.

5. *Whether the impedance and ampacity requirements of National Electrical Code (NEC) Section 250-51 should be included in the standard.*

Section 1910.304(f)(4) of the proposed electrical standards, which requires that the path to ground from circuits, equipment, and enclosures be permanent and continuous, was derived from Section 250-51 of the 1978 NEC. However, it does not contain the ampacity and impedance requirements of the grounding path which are in both the 1978 NEC (Section 250-51) and the former OSHA standards.

The proposed requirements of § 1910.304 specify that conductors and equipment be protected in accordance with their ability to safely conduct current, and § 1910.305 requires that wiring methods, components, and equipment for general use be approved for the purpose. It follows that if these two performance requirements are met, then all basic requirements applicable to ampacity and impedance will likewise be satisfied. For this reason, the ampacity and impedance requirements are omitted here without affecting employee safety. These changes reflect the general approach to simplify and clarify the proposed standard.

The record reflects general agreement that deletion of the ampacity requirement was justified (Ex. 22; Tr. 94, 398). The ampacity requirement of NEC Section 250-51 should be satisfied at the time of initial installation of the electrical utilization equipment or systems in which the equipment grounding conductors are a part.

There was considerable testimony plus comment in the record, however, on the proposed deletion of the impedance requirement. It was contended that the omission of this requirement would reduce the protection of employees against shock and electrocution. To achieve employee protection against shock and electrocution, it was argued the equipment grounding conductor must not only have continuity, it must also present a low impedance path which will permit sufficient fault current to flow thus assuring the rapid operation of the overcurrent device protecting the circuit (Ex. 22).

The same commenter, however, further indicated that a return to the impedance requirements of NEC 250-51 would still be inadequate because the quality of the equipment ground is generally an unknown value and requires verification. For example, NEC 250-51 paragraph (c) specifies no quantitative values but requires only that the grounding path have "sufficiently low impedance" to limit the voltage to ground and to facilitate the operation of the circuit protective devices in the circuit. Thus, the NEC specifies the ground path requirements in terms of performance and does not specify values of impedance. The commenter recommended (Ex. 22) that OSHA change the proposed § 1910.304(f)(4) to read as follows: "The path to ground from circuits, equipment and enclosures shall be permanent, continuous and have sufficiently low impedance to limit the voltage to ground and to facilitate the operation of the circuit protective devices in the circuit.

The impedance of this path shall not exceed the levels given in Table S-4." (Table S-4 is contained in Exhibit 22 and specifies a maximum equipment ground impedance for different overcurrent device ratings at various circuit voltages.)

Mr. Robert West, an expert in the area of electrical grounding and its relationship to occupational safety standards, stated at the hearing (Tr. 113) that the impedance of equipment grounding conductors for most of the circuits in many operational workplaces cannot be accurately verified by testing. The reason for this is that the test current will flow in unknown conducting paths that are in parallel with the equipment grounding conductors. The witness cited (Tr. 110) examples of test situations which could occur with commercial testers showing the presence of a low impedance equipment grounding conductor when, in fact, the equipment grounding conductor is disconnected. Because of these problems, it was Mr. West's view that the standard should not require impedance testing. Mr. West indicated (Tr. 113) that the requirement for the path to ground from circuits, equipment, and enclosures to be permanent and continuous can be verified in most operational workplaces by visually inspecting grounding conductors and by checking the grounding conductor connections for tightness.

A representative of Monsanto Company (Tr. 337) also agreed with OSHA's deletion of the impedance requirement and submitted the results of a series of field tests performed to evaluate a particular equipment grounding conductor impedance measuring technique (Ex. 36). According to this witness, the tests were conducted to determine whether or not meaningful values of equipment grounding conductor impedance could be obtained through measurements using a commercially available tester designed for this purpose. The test results showed generally how the existence of parallel paths affect the measurement of equipment grounding conductor impedances. One significant test result was that impedance measurements will not always reveal a break (open conductor) in, or the absence of, the equipment grounding conductor.

In one instance, one commenter submitted what appeared to be inconsistent testimony concerning impedance testing. The initial submittal (Ex. 22) stated: "Instrumentation is commercially available that will quickly, easily and accurately measure the impedance of *only the equipment*

grounding conductor under live circuit conditions" (emphasis added). However, in his post-hearing comment, the same commenter concluded that the impedance tester would not be able to measure the impedance of the conductor alone, but would only be able to measure the impedance of the total fault path: "The purpose of the impedance tester is to accurately determine the amount of impedance *in the anticipated fault path whether it is called an equipment grounding conductor or anything else*" (Ex. 68A) (emphasis added).

Where non-current-carrying metal parts of electrical equipment are required to be grounded, § 1910.304(f) specifies that only equipment grounding conductors be used and that the equipment grounding conductor must be installed either along with the circuit conductors or enclose the circuit conductors. The reason for keeping the ground return path and the phase legs in close proximity is to minimize the impedance of the fault circuit by placing conductors so their magnetic fields cancel each other and mutual inductance is minimized. This reduces the inductive reactance and allows sufficient current to flow, thus facilitating operation of the circuit protective devices.

Where conduit is used as an equipment grounding conductor, the ground-fault current flows through a conductor inside the conduit and returns through the conduit. When this occurs, practically all of the magnetic field is inside the conduit. This results in practically all of the inductive reactance of the circuit appearing on the inside conductor while the impedance of the conduit becomes approximately equal to its DC resistance.

Low resistance paths in parallel with the equipment grounding conductor will carry some portion of the total ground-fault current. These unknown and undefined parallel paths make it impossible to separate and measure the impedance of only the equipment grounding conductor alone.

Tests have shown that ground path impedance measurements involving extraneous parallel paths can give incorrect indications regarding disconnected or open grounding conductors (Ex. 17, 36). Under these conditions, as noted above, impedance measurements may not detect the presence of serious electrical hazards. They may well give the employee a false sense of security as to the safety of an installation. With limitations of this type, it appears that visual inspection and periodic maintenance are the only practical approach to assure a safe

condition of the equipment grounding conductor.

Additionally, one commenter (Ex. 22) referenced accident data involving electrical work injuries in California (1972) and claimed that a major factor contributing to the injuries was equipment not being grounded or having poor or inadequate grounding connections. A review of the actual accident descriptions, however, indicated the presence of such other causal factors as the total absence of proper equipment grounding means, interruption in the continuity of the equipment grounding conductor, or improper connection of grounding conductors. The data did not, therefore, indicate that the ohmic value of the equipment grounding conductor impedance was a significant factor in the accidents.

Grounding path resistances are usually determined in the design stage of equipment and electrical installations and are not intended to be measured in the field on a routine basis. OSHA's recognition of this fact has previously been incorporated into the OSHA standard on ground-fault protection (§ 1926.400(h) is the cognizant standard), where only a continuity test of the equipment grounding conductor is required. A quantitative test including an ohmic value is not considered necessary or appropriate for determining the presence of the equipment grounding conductor.

It is OSHA's belief that equipment grounding systems, installed in accordance with the requirements of this Subpart, will significantly reduce the chances for personnel injuries provided the continuity and permanence of the equipment grounding conductors and connections are maintained after the systems are placed in operation.

The path to ground from circuits, equipment and enclosures can usually be verified as being permanent and continuous by an inspection of equipment grounding conductors and the grounding conductor connections. In certain special cases, where extraneous parallel paths are not a problem, continuity tests can also be made to verify the presence and integrity of equipment grounding conductors. OSHA recognizes that impedance testing may lead to false assurances of the impedance, or even the very presence of the grounding conductor. Therefore, for this reason and since maintenance requirements are not the subject of this rulemaking, OSHA is not requiring such testing in these standards.

6. *Whether the prohibition of the use of structural metal frames of buildings as the equipment grounding conductor*

(1978 NEC 250-58(a)) should be included in the standard.

The comments addressing this issue refer to proposed § 1910.304(f)(6), dealing with methods of grounding fixed equipment. Specifically, the comments concern the use of structural metal frames of buildings as equipment grounding conductors for AC equipment. Such use is permitted in the 1971 NEC and was carried forward in the proposed standard.

One commenter (Ex. 22) cited the 1978 NEC (Section 250-58) which explicitly states that this use is not acceptable, and argued that a similarly explicit statement should be included in the proposed OSHA standard.

It is noted that although the building of structural metal will, in many installations, possess sufficient ampacity to safely conduct ground-fault currents, the NEC no longer considers such a grounding path to be a valid substitute for the required equipment grounding conductor. The code's current position is that there is always the possibility that any path to ground other than the equipment grounding conductor may have insufficient capacity. This can result in a serious hazard in those installations where the presence of large-capacity circuits have the capability of producing thousands of amperes of fault-current. Also, where high-magnitude ground-fault currents are forced to flow in paths that are remote from the circuit conductors, magnetic fields are generated which can induce voltages in adjacent conductors. Such induced voltages may cause failure of components in low energy electric systems. Stray ground currents have also been known to cause arcing in piping systems.

On the other hand, from the standpoint of employee safety, installations where electric equipment is secured to, and in metallic contact with, the grounded structural metal frame of a building are essentially free of electrical shock hazards. This condition occurs because the electric equipment enclosures and the metal building frame will be approximately at the same potential if a ground fault occurs and will provide a measure of employee safety.

Mr. Robert West suggested that the proposed standard be changed to prevent the structural metal frame of a building from being used as an acceptable equipment grounding conductor for installations made after the date of the final rule (Tr. 115-116). However, he contended that the change should be applicable only to new installations. He noted that prior to the 1978 NEC, Section 250-58 of previous

editions, including the 1971 NEC incorporated by OSHA, specifically stated that electrical equipment secured to and in electrical contact with the structural frame of a building was acceptably grounded. Therefore, he argued that it would be impractical to require changes to existing installations.

As a result of the testimony, OSHA has concluded that § 1910.304(f)(6)(ii) should be changed to reflect the latest NEC requirements. This change is accomplished by deleting the first sentence of proposed § 1910.304(f)(6)(ii) and adding two sentences as follows: "Electric equipment is considered to be effectively grounded if it is secured to, and in electrical contact with, a metal rack or structure that is provided for its support and the metal rack or structure is grounded by the method specified for the noncurrent-carrying metal parts of fixed equipment in paragraph (f)(6)(i) of this section. For installations made before April 16, 1981 only, electric equipment is considered to be effectively grounded if it is secured to, and in metallic contact with, the grounded structural metal frame of a building."

7. *Whether the definitions for Class II locations and their associated explanatory notes should be changed.*

The proposed definition of a Class II, Division 1 location (§ 1910.399(a)(25)(i)) was identical to the definition in OSHA's previous regulations and read as follows:

A Class II, Division 1 location is a location: (1) in which combustible dust is or may be in suspension in the air continuously, intermittently, or periodically under normal operating conditions, in quantities sufficient to produce explosive or ignitable mixtures; or (2) where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitable mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, operation of protection devices, or from other causes; or (3) in which combustible dusts of an electrically conductive nature may be present. (Emphasis added.)

In other words, a location in which a hazardous concentration of combustible dust could be suspended in the air under normal operations was classified as Class II, Division 1.

Contending that the proposed definitions were confusing and would conflict with the 1981 NEC, several grain- and feed-affiliated organizations objected to the proposal (Exs. 18, 19, 21, 31, 32, 39, 49 & 54). Their objections included the following:

(1) The definitions contain vague and improper terminology which requires subjective judgments to be made (Ex. 19).

(2) Code Making Panel 14 of the NEC which is responsible for the content of these definitions in the NEC has changed the definition of Class II hazardous locations in the 1981 National Electrical Code (Ex. 31). Thus, OSHA's proposed definition is inconsistent with the latest NEC.

(3) Hazardous location definitions contained in the proposed 1981 NEC would better identify types of potential hazards through the establishment of performance standards (Ex. 18).

The revised definition as submitted by Panel 14 and accepted for the 1981 NEC reads as follows:

A Class II, Division 1 location is a location: (1) in which combustible dust is in the air under normal operating conditions, in quantities sufficient to produce explosive or ignitable mixtures; or (2) where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitable mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, operation of protection devices, or from other causes; or (3) in which combustible dusts of an electrically conductive nature may be present. (Emphasis added).

This change would remove the words "or may be in suspension" and "continuously, intermittently, or periodically" from OSHA's former and proposed definitions. However, as stated by an OSHA witness, Dr. Jerry Purswell, Director of Safety Standards, this change "removes the clarification which is needed to realistically describe conditions which are encountered in these locations. Utilizing the proposed 1981 NEC change would permit one to classify a location as a Class II, Division 1 only when dust is actually witnessed, and to disregard the real and frequently existing situations which are presently described in the existing rules" (Tr. 32).

After hearing testimony relative to possible interpretations of the suggested definitions, two members of Code Making Panel 14 who were at the hearing, made the following statements: Mr. Leonard Corey—"After hearing the comments that have been made during this hearing, it would be my recommendation that the panel review this material one more time so that everyone gets a fair hearing on it" (Tr. 410); Mr. Peter J. Schram—"I submit that if the proposed revision of the code is interpreted in this manner [as stated before by Dr. Purswell] the area is not being classified as I intended as a member of Code Panel 14. Had this type of an interpretation been brought up at the meeting or during the voting, I do not believe I would have voted for all of the deletions in Section 500-5(a) of the code for the 1981 edition" (Tr. 464). Since the

deadline for commenting on the proposed 1981 NEC had expired, these concerns could not be considered by the NEC Panel before the adoption of the 1981 NEC.

OSHA believes that the deletion of the words "or may be in suspension" would seriously compromise employee safety. It is necessary for the definition to cover not only situations in which explosive or ignitable concentrations of dusts are actually present, but also situations in which such concentrations may arise under normal operating conditions. In this respect, the definition of Class II, Division 1 locations contained in the 1981 NEC represents a potential decrease in employee safety compared to OSHA's former standard, and OSHA has decided not to delete the words "or may be in suspension" from the definitions.

However, based on the comments in the record, the words "continuously, intermittently, or periodically" have been deleted from the definition of Class II, Division 1 locations. For consistency, the language has also been deleted from the definition of Class I, Division 1, locations although most of the comments dealt only with Class II locations. OSHA agrees that these words are possibly confusing and do not enhance the definition.

Therefore, under § 6(b)(8) of the Act, the Assistant Secretary has determined that the 1971 NEC definition of Class II, Division 1 locations, except as noted above, better effectuates the purpose of the Act to provide a safe place of employment than the definition in the 1981 NEC.

The proposed definition of a Class II, Division 2 location (§ 1910.399(a)(25)(ii)) was also identical to the definition in OSHA's previous standards and read as follows:

A Class II, Division 2 location is a location in which combustible dust will not normally be in suspension in the air or will not be likely to be thrown into suspension by the normal operation of equipment or apparatus in quantities sufficient to produce explosive or ignitable mixtures, but: (a) Where deposits or accumulations of such combustible dust may be sufficient to interfere with the safe dissipation of heat from electric equipment or apparatus; or (b) where such deposits or accumulations of combustible dust on, in, or in the vicinity of electric equipment might be ignited by arcs, sparks, or burning material from such equipment.

Several commenters suggested that OSHA adopt the changes made in the definition of a Class II, Division 2 location in the 1981 NEC (Ex. 19, 32, 55L). They stated that OSHA's adoption of the suggested wording would clarify the difference between Division 1 and

Division 2 in Class II locations. The suggested change was as follows:

Class II, Division 2. A Class II, Division 2 location is a location in which (a) combustible dust will not normally be in suspension in the air in quantities sufficient to produce explosive or ignitable mixtures, and dust accumulations are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus; or (b) dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment, and dust accumulations resulting therefrom may be ignitable by abnormal operation or failure of electrical equipment or other apparatus.

OSHA agrees with these comments and, in view of the absence of any opposition to this change, adopts it in the final standard. Although the wording has been revised, the intent of the definition remains the same and is clearer than that of the proposal, by giving specific examples and by better organization.

The proposed "fine print" notes to the definitions of Class II locations were basically the same as those in OSHA's former regulations (Article 500-5(a) and (b) of the 1971 NEC), and the proposal read as follows:

Class II, Division 1

Note.—This classification usually includes the working areas of grain handling and storage plants; rooms containing grinders or pulverizers, cleaners, graders, scalpers, open conveyors or spouts, open bins or hoppers, mixers or blenders, automatic or hopper scales, packing machinery, elevator heads and boots, stock distributors, dust and stock collectors (except all-metal collectors vented to the outside), and all similar dust-producing machinery and equipment in grain-processing plants, starch plants, sugar-pulverizing plants, malting plants, hay-grinding plants, and other occupancies of similar nature; coal-pulverizing plants (except where the pulverizing equipment is essentially dust-tight); all working areas where metal dusts and powders are produced, processed, handled, packed, or stored (except in tight containers); and all other similar locations where combustible dust may, under normal operating conditions, be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

Combustible dusts which are electrically nonconductive include dusts produced in the handling and processing of grain and grain products, pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and woodflour, oil meal from beans and seed, dried hay, and other organic materials which may produce combustible dust when processed or handled. Electrically conductive nonmetallic dusts include dusts from pulverized coal, coke, carbon black, and charcoal. Dusts containing magnesium or aluminum are particularly hazardous and the use of extreme precaution will be necessary to avoid ignition and explosion.

Several commenters claimed that the proposed fine print note is 25 years old and outmoded and that its emphasis is on types of machinery rather than on types of operation being performed. (Ex. 2, 19, 49, 56). One commenter stated that in many instances, with modern methods of dust control or complete rehandling of the grain or grain product, it is possible that many of the locations noted in the fine print notes would no longer be classified as either Class II, Division 1 or a Class II, Division 2 area (Ex. 49). It was further argued that these notes have been consistently misinterpreted by OSHA compliance officers as firm requirements for classification of locations instead of as guidelines (Ex. 56).

Regarding the explanatory fine print note, OSHA agrees with the comments of the grain and feed industry that the note should reflect the operation being done in the area rather than what equipment is located there. Commenters submitted to the record revised explanatory notes for both Class II, Division 1 and Class II, Division 2 locations (addendum #3). Since these suggested notes more accurately reflect the intent of the definition and describe operations rather than equipment, they have been included, with minor editorial changes, in the final rule. The new notes read as follows:

Class II, Division 1

Note.—This classification may include areas of grain handling and processing plants, starch plants, sugar-pulverizing plants, malting plants, hay-grinding plants, coal-pulverizing plants, areas where metal dusts and powders are produced or processed, and other similar locations which contain dust producing machinery and equipment (except where the equipment is dust-tight or vented to the outside). These areas would have combustible dust in the air, under normal operating conditions, in quantities sufficient to produce explosive or ignitable mixtures.

Combustible dusts which are electrically nonconductive include dusts produced in the handling and processing of grain and grain products, pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and woodflour, oil meal from beans and seed, dried hay, and other organic materials which may produce combustible dust when processed or handled. Dust containing magnesium or aluminum are particularly hazardous and the use of extreme precaution will be necessary to avoid ignition and explosion.

Class II, Division 2

This classification includes locations where dangerous concentrations of suspended dust would not be likely but where accumulations might form on or in the vicinity of electric equipment. These areas may contain equipment from which

appreciable quantities of dust would escape under abnormal operation conditions or be adjacent to a Class II, Division 1 location, as described above, into which an explosive or ignitable concentration of dust may be put into suspension under abnormal operating conditions.

8. Whether installations of electrolytic cells should be covered by the guarding provisions of proposed § 1910.303.

Section 110-17 of the 1971 NEC, which is referenced in the former regulations, requires live parts of equipment operating at 50 volts or more to be guarded. The 1978 NEC included a new Article 668 which permits electrolytic cells to operate with live parts exposed, provided that specific alternate safety measures are employed.

Electrolytic cells differ in certain respects from standard electrical installations. In a standard electrical circuit, all live parts are required to be insulated or guarded. One side of the circuit is connected to ground to provide a common reference and to stabilize voltages, and thus a potential exists between any live conductor and any grounded surface. A person coming in contact with both a live conductor and a grounded surface will provide a path for electric current to flow and will receive a shock varying in severity with the amount of current that flows through the body. The purpose of the guarding provisions of the NEC is to prevent contact with live parts since contact with grounded surfaces is very common.

In an electrolytic cell line, however, the actual working parts and some working surfaces are, by necessity, the bare live parts of an electric circuit. Employee contact with these live parts is necessary in normal electrolytic cell working procedures. Therefore, whereas a standard circuit necessitates guarding of live parts, employees working on electrolytic cells must be protected against contact with ground. The provisions of Article 668 of the 1978 NEC recognize the different working conditions of electrolytic cell lines and outline the procedures to be used as an alternative to guarding of live parts. The proposed regulations incorporated these electrolytic cell provisions in § 1910.306(h)(3).

Only one commenter (Ex. 20) objected to the provisions proposed in § 1910.306(h)(3). His position was that leaving the energized portions of the cell line unguarded would result in decreased safety protection for workers. To support his position, he cited an electrocution of a worker who died when he stepped into a floor hold and fell against the energized portion of an electrolytic cell. The commenter also

stated, "The workers typically wear rubber gloves and rubber boots. But if any other portion of the worker's body touches the cell, the worker is electrocuted" (Ex. 20).

As previously discussed, a worker would have to come in contact with both the energized portion of a cell and a grounded surface in order to be electrocuted. The accident referred to resulted when a floor hole was not covered and an otherwise guarded grounded surface was exposed to contact. However, this accident could have happened with a standard electrical circuit if a guard was left off of an energized portion of a conductor, and a worker came in contact with this conductor and a grounded surface.

Ten witnesses (Ex. 23, 24, 29, 38, 40, 41, 46, 51, 52 and 53) appeared in support of the provisions contained in § 1910.306(h)(3). The witnesses included representatives from the aluminum, chlorine, and copper industries. The operations of these industries differ but each requires the actual physical contact with the energized portion of the cell line for proper operation. Various methods of isolating the cell lines from ground were presented, including the insulation of any structural member with wood or fiberglass, and the guarding of grounding parts by distance. The witnesses contended that the addition of guards for the live parts would not enhance employee safety but would actually hinder cell operation and would create a safety hazard by blocking access and egress in emergency situations. As pointed out at the hearing, if access to the cell is impeded by guards in an emergency situation such as a dry cell, a shorted cell, or an overflow, employees in the area would be subjected to acid burns, electrical flash burns, or injury from flying molten metal (Ex. 40).

The evidence submitted to the record reflects that the alternative procedures being used in cell line operation will provide a safer workplace for electrolytic cell employees than would guarding live parts of cells. In fact, the evidence in the record indicates that guarding live parts of cells may actually reduce employee safety. Therefore, the final rule incorporates the electrolytic cell provisions of § 1910.306(h)(3) as proposed.

IV. Summary and Explanation of the Final Standard

The final standard revising 29 CFR Part 1910, Subpart S, follows the language and format of the proposal with some changes. Most of the changes are editorial in nature. However, those that are substantive are discussed in

detail below. Where changes have been made concerning areas of the proposal which were major issues at the hearing, reference is made to the discussion of such issues in Section III of this preamble. The resulting final standard, which is based on the record considered as a whole, simplifies and clarifies the former Subpart S. The significance of this simplification is indicated by the reduction from the approximately 250,000 words in the National Electrical Code to the approximately 15,000 words in this final standard. As a consequence, the 1971 NEC (NFPA-70) will no longer be incorporated by reference in the OSHA standards.

Subpart S of Part 1910 as revised provides a systematic format both to satisfy present requirements and to accommodate future growth. Subpart S will eventually contain four major parts covering not only the design safety standards for electrical systems contained in this rulemaking (Part I), but also safety-related work practices (Part II), safety-related maintenance requirements (Part III), and safety requirements for special equipment (Part IV).

Some parts of the former §§ 1910.308 and 1910.309 have been deleted. Other parts of these sections have been incorporated into new sections without substantive change. (Any changes made were only editorial to reflect the change in format of the Subpart.) The following table summarizes the numbering changes from the former Subpart S to the final standard:

Redesignation Table

Former paragraph	New paragraph
§ 1910.308(a)	Deleted—unnecessary.
§ 1910.308(b)	Deleted—unnecessary.
§ 1910.308(c)	§ 1910.302(a).
§ 1910.308(d)(1)	§ 1910.309(a)(7).
§ 1910.308(d)(2)	§ 1910.309(a)(8).
§ 1910.308(d)(3)	§ 1910.309(a)(7)(i).
§ 1910.308(d)(3)(i)	§ 1910.309(a)(7)(i).
§ 1910.308(d)(3)(ii)	§ 1910.309(a)(7)(ii).
§ 1910.308(d)(3)(iii)	§ 1910.309(a)(7)(iii).
§ 1910.308(d)(3)(iv)	§ 1910.309(a)(7)(iv).
§ 1910.308(d)(3)(v)	§ 1910.309(a)(7)(v).
§ 1910.309(a)	§ 1910.302(b)(1).
§ 1910.309(b)	§ 1910.302(b)(2).
§ 1910.309(c)	§ 1910.304(b)(6).

The following discussion summarizes the final standard and the effects this rulemaking has on the former provisions of §§ 1910.308 and 1910.309. Any changes made from the proposal are noted; otherwise, the requirements in the proposal have been adopted with no substantive change.

§ 1910.301 Introduction. The former introductory paragraphs, § 1910.308 (a) and (b), which incorporated the 1971 NEC into Subpart S by reference, have been deleted. A new introductory § 1910.301 addresses the new format

followed in this Subpart. The basic areas which are or will be included in Subpart S of Part 1910 are set forth as follows:

(a) Design Safety Standards for Electrical Systems. The standards which are the subject to this rulemaking are contained in §§ 1910.302 through 1910.330. (At this time, however, only §§ 1910.302 through 1910.308 are being promulgated; §§ 1910.309 through 1910.330 have been reserved for possible future design safety standards for other electrical systems, such as power generating systems.)

(b) Safety-Related Work Practices. These regulations will be contained in §§ 1910.331 through 1910.360.

(c) Safety-Related Maintenance Requirements. These requirements will be contained in §§ 1910.361 through 1910.380.

(d) Safety Requirements for Special Equipment. These requirements will be contained in §§ 1910.381 through 1910.398.

(e) Definitions applicable to each of these four major divisions are contained in a common § 1910.399.

Since the areas covered by each of these four major divisions represent broadly diverse equipment, installations and practices, it is intended that each division will be further subdivided where appropriate. For example, within the category involving design safety standards for electrical systems, separate subgroupings could include electrical utilization systems, electrical power generation and transformation systems, electrical power transmission and distribution systems, and others, in the future.

The changes to Subpart S contained in the present document are limited to electrical utilization systems, as covered by the former OSHA electrical standards.

This standard places the relevant requirements of the National Electrical Code into the text of the regulations making it unnecessary to incorporate the National Electrical Code by reference. The former incorporation of the entire NEC is therefore being deleted.

§ 1910.302 Electric Utilization Systems (Scope and Extent of Application).

§ 1910.302(a). The provisions formerly in the scope paragraph, § 1910.308(c), have been carried forward in new scope paragraph § 1910.302(a). Additionally, as proposed, § 1910.302(a)(vi) in the final rule includes "industrial substations", which was inadvertently omitted in the adoption of the former OSHA standard.

§ 1910.302(b)(1). The National Electrical Code requirements formerly listed in paragraph § 1910.309(a), which

were applicable to all electrical installations and utilization equipment, have been retained in part and deleted in part. The retained part no longer references sections of the NEC, but instead references the corresponding provisions of Subpart S. These requirements are carried forward as § 1910.302(b)(1). The deleted portion consists of the sections of the 1971 NEC which are inappropriate for OSHA's use or otherwise covered in this subpart. The specific sections deleted, along with the reasons for the deletions, and the new paragraph numbers of the retained NEC sections are given in the following distribution table:

Distribution Table

1971 NEC provision referenced in former § 1910.309(a)	New section of subpart S
Articles: 500	These Articles were rewritten in performance terms and combined into § 1910.307.
501	
502	
503	
Sections: 110-14(a)	Deleted—Covered by § 1910.303(a).
110-14(b)	§ 1910.303(c).
110-17(a), (b), and (c)	§ 1910.303(g)(2).
110-18	§ 1910.303(d).
110-21	§ 1910.303(e).
110-22	§ 1910.303(f).
240-16	§ 1910.304(e)(1)(iv).
240-19(a) and (b)	§ 1910.304(e)(1)(v).
250-3(a)	§ 1910.304(f)(1)(i).
250-3(b)	Deleted—Inappropriate; this section is not a requirement but only states that certain systems over 300 volts may be grounded.
250-5 (a), (b), and (c)	§ 1910.304(f)(1)(ii), (iv), and (v).
250-7	Deleted—covered in § 1910.307.
250-42 (a), (b), (c), and (d)	§ 1910.304(f)(5)(iv) (a), (b), (c), and (d).
250-43 (a), (b), (c), (d), (e), (f), (g), (h) and (i)	Deleted—covered in § 1910.304(f)(5)(iv).
250-44 (a), (b), (c), and (d)	§ 1910.304(f)(5)(v).
250-44(e)	Deleted—covered by § 1910.304(f)(5)(iv).
250-45 (a), (b), and (d)	§ 1910.304(f)(5)(iv).
250-45(c)	Deleted—Inappropriate; applies only to residences.
250-50 (a) and (b)	§ 1910.304(f)(3).
250-51	§ 1910.304(f)(4).
250-57(a) and (b)	§ 1910.304(f)(6)(i).
250-58 (a) and (b)	Deleted—Inappropriate; these are not requirements but optional methods of meeting the grounding requirement.
250-59 (a), (b) and (c)	Deleted—Inappropriate; these sections are not requirements but only suggest methods of grounding.
400-3 (a) and (b)	§ 1910.305(g)(1) (i) and (ii).
400-4	§ 1910.305(g)(1)(iii).
400-5	§ 1910.305(g)(2)(ii).
400-9	§ 1910.304(e)(1)(v).
400-10	§ 1910.305(g)(2)(iv).
422-8	Deleted—covered by § 1910.305(g)(1)(i).
422-9	Deleted—covered by § 1910.303(g)(2).
422-10	Deleted—covered by § 1910.303(b).

Distribution Table—Continued

1971 NEC provision referenced in former § 1910.309(a)	New section of subpart S
422-11	Deleted—inappropriate; this section addresses appliance construction detail requirements.
422-12	Deleted—inappropriate; this section addresses appliance construction detail requirements.
422-14	Deleted—inappropriate; this section addresses appliance construction detail requirements.
422-15 (a), (b) and (c)	Deleted—covered by § 1910.303(a).
422-16	Deleted—covered by § 1910.304(f) and the standard procedure for a variance request.
422-17(a)	Deleted—inappropriate; this is not a requirement, but a definition of a term no longer used in the standard.
422-17(b)	Deleted—covered by § 1910.303(a).
430-142	Deleted—covered by § 1910.304(f)(5)(iv).
430-143	Deleted—covered by § 1910.304(f)(5)(v).

The provisions which are listed in § 1910.302(b)(1) apply to all electrical installations and utilization equipment regardless of when they were designed or installed. For discussion of comments on and objections to the application of these provisions, see Issue 3 in Section III of this preamble.

§ 1910.302(b)(2). Proposed § 1910.302(b)(2), as well as former § 1910.309(b), applied the full coverage of Subpart S to "every replacement, modification, repair, or rehabilitation made to an existing installation after March 15, 1972." At the November 8, 1979, public meeting (Meeting Tr. 9-10) and at the public hearing (Tr. 26), OSHA officials interpreted this provision as being limited to "major" replacements, modifications, repairs, or rehabilitations. Other witnesses supported this interpretation but requested that the word "major" be added to § 1910.302(b)(2). To ensure consistent application by compliance personnel (Tr. 170, 269-270, 294).

Concerned that such wording could be ambiguous, OSHA requested the hearing witnesses to supply definitions or clarifications of what would be "major replacement, modifications, repairs, or rehabilitations." The respondents contended that "major" should refer to work which is similar to that involved when a new building or facility is built, a new wing is added, or an entire floor is renovated (Ex. 19, 55K, 62).

There is no objection to the addition of the word "major" to § 1910.302(b)(2) and OSHA agrees that it more accurately reflects the intent of this paragraph. Therefore, § 1910.302(b)(2) has been modified to indicate that "every major replacement, modification, repair, or rehabilitation, after March 15, 1972," must comply with all the

requirements of § 1910.302 through 1910.308. Also, a note has been added to indicate that such "major" work includes work of a magnitude similar to that involved when a new building is built, a new wing is added to an existing facility, or an entire floor is renovated.

§ 1910.302(b)(3). A new § 1910.302(b)(3) has been added which contains a list of paragraphs that impose new requirements which were not in the 1971 NEC. Since the requirements in these paragraphs were not in the former standards, they will only apply to installations made after the effective date of these standards. The paragraphs involved are the following:

- § 1910.303(h)(4)(i) and (ii)—Entrance and access to workspace (over 600 volts).
- § 1910.304(e)(i)(vi)(b)—Circuit breakers operated vertically.
- § 1910.304(e)(i)(vi)(c)—Circuit breakers used as switches.
- § 1910.304(f)(7)(ii)—Grounding of systems of 1000 volts or more supplying portable or mobile equipment.
- § 1910.305(j)(8)(ii)(b)—Switching series capacitors over 800 volts.
- § 1910.306(c)(2)—Warning signs for elevators and escalators.
- § 1910.306(i)—Electrically controlled irrigation machines.
- § 1910.306(j)(5)—Ground-fault circuit interrupters for fountains.
- § 1910.308(a)(1)(ii)—Physical protection of conductors over 600 volts.
- § 1910.308(c)(2)—Marking of Class 2 and Class 3 power supplies.
- § 1910.308(d)—Fire protective signaling circuits.

The effective date for these provisions is discussed and explained in Section VI of this preamble.

General

As was the case with the former provisions of Subpart S, the revised Subpart does not apply to construction and agriculture. It does apply to all other workplaces covered by OSHA, except that for maritime, § 1910.302(a)(2)(i) provides that ships and other watercraft are not covered. Some commenters pointed out that the proposed standard inadvertently contained requirements pertaining to construction, even though (as noted in the preamble to the proposal) 29 CFR Part 1910, Subpart S does not apply to this industry (Ex. 30). Therefore, the final standard reflects the deletion of the following proposed provisions or references which deal exclusively with construction.

- § 1910.305(a)(2)(i)(a)—Use of temporary wiring for construction.
- § 1910.305(a)(2)(iii)(g)—Splices on construction sites.

§ 1910.303 General Requirements. This section contains general requirements for electrical installations.

These requirements address approval and use of equipment, splices, marking and identification, working clearances, and guarding of live parts. Approval and marking requirements were the only regulations in this section which were major issues. For detailed discussion on these topics, see Issue 4 in Section III of this preamble. Specific paragraphs and substantive changes from the proposal are discussed as follows:

Paragraph (a) requires approval of electrical equipment, while paragraph (b) gives provisions for the equipment's inspection and use. These two paragraphs basically require employers to provide equipment which is in safe condition and to ensure that it is used safely.

Paragraph (c) requires splices to be suitably made and insulated. Parts of electric equipment that produce arcs, sparks, or molten metal are required to be appropriately guarded by § 1910.303(d).

Marking and identification are covered in § 1910.303(e) and (f). In paragraph (e), electric equipment is required to be marked to identify who made the equipment and what the necessary electrical ratings are. Paragraph (f) requires branch circuits, feeders, services, and disconnecting means for equipment to be identified. In the proposal, this requirement read as follows:

(f) Identification of disconnecting means. Each disconnecting means required by this subpart for motors and appliances shall be legibly marked unless located and arranged so that its purpose is evident; and each disconnecting means required by this subpart for each service, feeder, or branch circuit shall be legibly marked to indicate its purpose at the point where the service, feeder or branch circuit originates. The marking shall be of sufficient durability to withstand the environment involved.

This wording is slightly different from the NEC and NFPA 70E. It was changed in an attempt to clarify the requirement without changing the intent. However, as evidenced by some of the comments received (Ex. 2), the modification created additional confusion regarding marking of service, feeder, and branch circuit disconnects. For example, the proposed subpart contained no requirements for these circuits to have disconnecting means, seemingly making the identification requirement for such disconnecting means superfluous. Therefore, OSHA is again revising the language to clarify the intent of the rule. This paragraph now clearly requires each service, feeder, or branch circuit to be identified, at its disconnecting means or overcurrent device, to indicate the circuit's purpose. However, no marking

is necessary if the purpose of the circuit is evident. This clarification, which is consistent with OSHA's former regulation, the NEC, and NFPA 70E, should clear up any misunderstanding created by the proposed requirement.

Paragraphs (g) and (h) set forth requirements pertaining to guarding of and working clearances around live parts of electric equipment. Regulations applying to equipment 600 volts or less can be found in § 1910.303(g), while paragraph (h) applies over 600 volts. One commenter (Ex. 12) pointed out that OSHA's proposal and NFPA 70-E contained an error in the exception to § 1910.303(h)(3)(i). In the second sentence, it was noted that "energized" should be "de-energized", as it is in 1978 NEC Section 110-34(a) from which the OSHA requirement was derived. The final rule contains this correction.

4. § 1910.304 Wiring Design and Protection. This section covers the design requirements for wiring systems from the service conductors to the branch circuit conductors. It also covers requirements for the protection of electric conductors from both overcurrent and physical hazards.

Paragraph (a) requires that both the grounded circuit conductor and the equipment grounding conductor be identifiable and distinguishable from other conductors. These regulations have been written in more performance oriented terms than the former requirements which required that those conductors be identified in a specific manner.

A comment was received suggesting the inclusion of a provision which was contained in Section 410-55(c) of the 1971 NEC, but was not carried forward in the proposal on the presumption that it was covered by other proposed provisions. This provision prohibited the use of grounding terminals or grounding-type devices for purposes other than grounding. It was claimed that several fatalities in South Carolina were attributable to the placing of an ungrounded conductor on the grounding terminal of a receptacle, plug, or connector (Ex. 2). Similar accidents have been found in OSHA's records (Ex. 4).

Upon examining proposed provisions relating to grounding, OSHA has determined that the requirement of 1971 NEC Section 410-55(c) was not adequately covered elsewhere in the proposal. Therefore, since this provision is contained in OSHA's former regulations and since fatalities have occurred which are directly attributable to violations of this requirement, the following paragraph has been added to the final standard as new § 1910.304(a)(3):

(3) *Grounding Terminal.* A grounding terminal or grounding-type device on a receptacle, cord connector, or attachment plug may not be used for purposes other than grounding.

Paragraph (b) includes the requirements for sizing of outlet devices and for ground-fault protection for personnel on construction sites.

Paragraph (c) contains location and clearance requirements for low voltage (600 volts or less) conductors and lamps that are located outside. Paragraph (d) of this section requires that a disconnecting means be provided for the service entrance conductors. It also contains the location, marking and operational requirements for that disconnect.

Paragraph (e) contains overcurrent protection requirements for both low voltage and high voltage conductors.

Paragraph (e)(1)(vi) has been broken down into three separate paragraphs. The two provisions dealing with mounting and marking of circuit breakers have been renumbered as (e)(1)(vi)(b) and (c), and are effective only to equipment installed after the effective date of this standard, as noted in § 1910.303(b)(3).

The grounding requirements for electric systems are contained in paragraph (f) of this section. This paragraph is subdivided into seven categories as follows:

- (1) Systems to be grounded.
- (2) Conductors to be grounded.
- (3) Grounding connections.
- (4) Grounding path.
- (5) Supports, enclosures, and equipment to be grounded.
- (6) Methods of grounding fixed equipment.
- (7) Grounding of systems and circuits of 1,000 volts and over (high voltage).

There were two major issues raised on the regulations contained in paragraph (f). One involved new § 1910.304(f)(4) *Grounding path*. This requirement, which is unchanged from the proposal, is discussed in issue number 5 of Section III of this preamble. The other major issue concerned new § 1910.304(f)(6) *Methods of grounding fixed equipment*. Paragraph (f)(6)(i) has been modified to prohibit the use of building steel as the equipment grounding conductor for installations made after the effective date of these standards. This subject is discussed in Issue 6 of Section III of this preamble.

All of the remaining requirements contained in paragraph (f) were contained in the former regulation, and any changes to those requirements are strictly editorial. For example, the word "devices" has been changed to "appliances" in § 1910.304(f)(5)(iv)(f)(2)

because the equipment does not meet the definition of a "device", as set forth in § 1910.399(a)(38), meaning "a unit of an electrical system which is intended to carry but not utilize electric energy." Similarly, the word "portable" as used in § 1910.304(f)(7)(ii) has been changed to "portable or mobile", the equipment referred to in the applicable paragraphs is mobile but not necessarily easily carried. A similar change has also been made in the 1981 NEC.

§ 1910.305 Wiring Methods, Components, and Equipment for General Use. This section contains installation requirements for equipment (in general), wiring components, and wiring methods. None of the requirements of this section were major issues during the rulemaking proceeding, except as to whether they should be more or less performance-oriented. (The performance vs. specification question is discussed in Issue 1 of Section III of this preamble.)

In response to comments received, OSHA has revised some provisions, and these revisions are discussed along with the requirements of this section:

Paragraph (a) deals with wiring methods. General wiring requirements (electrical continuity and wiring in ducts) are the subject of § 1910.305(a)(1). In this paragraph, continuity of metal raceways and enclosures is required and wiring in certain ducts is prohibited.

Paragraph (a)(2) gives requirements on temporary wiring, including its permitted uses. In general, temporary wiring is permitted to be of a class less than permanent wiring, but must follow most of the rules of permanent installations, except as noted in that paragraph. For the reasons discussed earlier under § 1910.302, the references to construction in §§ 1910.305(a)(2)(i)(a) and (a)(2)(ii) have been deleted. Similarly, the first sentence of proposed § 1910.305(a)(2)(iii)(g), which related solely to construction, has been deleted.

Paragraphs (a)(3) and (a)(4) address two wiring methods, namely, cable trays and open wiring. These provisions give general installation and use requirements. In the final rule, proposed § 1910.305(a)(3)(i)(b)(3) has been renumbered § 1910.305(a)(3)(i)(c).

Paragraph (b) requires cabinets, boxes, and fittings to provide a complete enclosure for conductors and to have only smooth surfaces in contact with conductors.

Paragraphs (c) and (d) relate to switches, switchboards, and panelboards, and require protection from live parts.

Weatherproof enclosures are required for wet locations in paragraph (e).

Paragraph (f) requires conductors to have suitable insulation.

Paragraphs (g) and (h) cover the use of flexible cords and portable cables. Uses which are permitted and not permitted are listed in paragraph (g)(1), while paragraph (g)(2) details requirements for identification, splices, and termination of flexible cords. Requirements applicable to portable cables for use over 600 volts are contained in paragraph (h).

Fixture wires are addressed in § 1910.305(i). This paragraph gives permitted uses for fixture wires and does not allow their use for general branch circuit wiring.

Paragraph (j) contains requirements for wiring of equipment for general use. Paragraphs (j)(1) and (2) cover lighting equipment, plugs, and receptacles. Marking, guarding, and disconnection requirements for appliances are given in § 1910.305(j)(3).

Requirements for motors are contained in paragraph (j)(4). Motors are required to have suitable cover current protection and disconnection means. Guarding requirements are also provided in that paragraph.

Paragraph (j)(5) gives safeguarding requirements for transformer installations. Depending on their rating, some transformers must be in a vault. Stated in performance language, § 1910.305(j)(5)(vi) requires such vaults to be able to contain fires and combustible liquids. Although no specific fire rating is given, any vault constructed in accordance with NEC specifications in Article 450 would be acceptable.

Capacitor switching and charge drainage are addressed in § 1910.305(j)(6). Paragraph 1910.305(j)(6)(ii)(b), which gives switching specifications for series capacitors over 600 volts, was proposed as a new requirement and will apply only to installations made after the effective date of these standards.

Paragraph (j)(7) requires storage battery installations to have adequate ventilation.

6. § 1910.306 *Specific Purpose Equipment and Installations.* This section contains regulations for equipment which is not adequately covered by the general requirement elsewhere in Subpart S.

Paragraph (a) covers electric signs and outline lighting. It includes specific requirements for disconnecting means and a requirement that access doors be interlocked to deenergize any live parts operating at over 600 volts when the sign or outline lighting is accessible to other than qualified persons. Paragraph (b) covers cranes and hoists and

includes specific requirements for disconnects, control switches, and required working clearance.

Paragraph (c) includes specific requirements for disconnects and location of control panels associated with elevators, dumbwaiters, escalators, and moving walks.

A new provision requiring that a warning sign be mounted on or adjacent to the disconnecting means under certain conditions was included in § 1910.306(c)(1) of the proposal. This requirement has been renumbered in the final standard as § 1910.306(c)(2) and applies only to installations made after the effective date of these standards.

Specific requirements relating to disconnecting means, controls, guarding, grounding and labeling for electric welders, X-ray equipment for nonmedical and nondental use, and induction and dielectric heating equipment are included in paragraphs (d), (f), and (g).

Paragraph (e) contains disconnect requirements for data processing systems and was divided in the proposal into requirements for data processing rooms and requirements for general building areas. OSHA received comments (Ex. 2) stating that clarification should be made to indicate that disconnection of all equipment, such as typewriters and lights is not addressed by this paragraph. In addition, these same commenters questioned the extent of application to general building areas and requested clarification regarding when additional disconnects were required in those areas. The comments in the record are further supported by the decision of the NFPA 1981 NEC Code Committee to limit this requirement to electronic equipment, and only when installed in a computer room or data processing room. The change was made to avoid requiring associated equipment such as typewriters and even fire warning and fire suppression systems to be disconnected with the data processing systems. These machines have nothing to do with protecting employees from hazards associated with data processing systems. Paragraph (e) in the final standard has therefore been modified to reflect these changes.

Paragraph (h) includes specific regulations on electrolytic cells. These requirements were not contained in the former standard but were proposed because of the unique operational requirements of these cells. These provisions, which are discussed in issue number 8 of Section III, have been adopted in the final rule as proposed.

Paragraph (i) contains specific requirements, which were not in the

former standard, relating to electrically driven or controlled irrigation machines. This paragraph is applicable only to installations made after the effective date of these standards.

Paragraph (j) contains regulations for swimming pools, fountains, and similar installations other than therapeutic pools in health care facilities. Specific provisions include location requirements for lighting and receptacles and methods for determining which circuits require ground-fault circuit interrupters. Paragraph (j)(2)(c) in the proposal has been renumbered (j)(3) to make it clear that this requirement applies to all cord- and plug-connected equipment and not just to lighting fixtures and lighting outlets. Proposed paragraphs (j)(3) and (j)(4) have also been renumbered as (j)(4) and (j)(5) respectively and a note has been added to new § 1910.306(j)(5) indicating that it is applicable only to installations made after the effective date of these standards.

7. § 1910.307 *Hazardous Locations.* Paragraph (a) gives the scope of this section and lists typical hazardous locations.

The remainder of this section was completely rearranged from the proposal to indicate its intent more clearly. The basic requirements for hazardous locations were contained in proposed § 1910.307(c), which read as follows:

(c) *Electrical installations.* Equipment wiring methods, and installations of equipment in classified locations shall be one or more of the following:

- (1) Intrinsically safe.
- (2) Approved for the classified location.
- (3) Of a type and design which provides protection from the hazards arising from the combustibility and flammability of vapors, liquids, gases, dusts, or fibers.

The proposal was confusing to many interested persons in that other requirements or guidelines, which explained the three alternatives of § 1910.307(c), were scattered throughout § 1910.307. Confusion about these provisions appears to have been the cause of many of the misunderstandings discussed in relation to Issues 3 and 4 of Section III of this preamble.

In order to avoid the confusion and clarify the wording, OSHA has reorganized the final standard to combine the basic requirements with their respective related provisions. For example, provisions related to "approved" equipment have been combined under the option which allows the use of equipment which is "approved for the classified location." OSHA believes that this reorganization of § 1910.307 will make the section easier to understand.

Guidelines for determining what equipment and installations are "safe for the hazardous location" and thus meet § 1910.307(b)(3) of the final standard (proposed § 1910.307(c)(3)) are contained in Chapter 5 of the current National Electrical Code (NFPA 70). However, these guidelines are not the only means of complying with the standard. Any equipment or installation which is shown by the employer to provide protection from the hazards involved will be acceptable. This performance-oriented approach will allow the employer maximum flexibility in providing safety for his employees.

8. § 1910.308 Special Systems. Paragraph (a) of this section addresses electrical systems over 600 volts, nominal. Requirements are given for wiring methods, interrupting and isolating means, mobile and portable equipment, and tunnel installations. The provision in proposed paragraph (a)(1) requiring conductors emerging from the ground to be enclosed is a new requirement not in OSHA's previous standards. Therefore, in the final standard, this provision has been renumbered as paragraph (a)(1)(ii) and applies only to installations made after the effective date of these standards.

Paragraph (b) covers emergency power systems. Wiring for these systems is required to be separate from the normal supply wiring. Additionally, where emergency lighting is required, no space may be left in total darkness as a result of the failure of a single emergency lighting element.

Requirements for remote control, signaling, and power-limited circuits are contained in paragraph (c). Depending on the voltage, current, and power limitation, these circuits have been designated as Class 1, Class 2, or Class 3. Paragraph (c)(2) requires Class 2 and Class 3 systems to be marked; however, this requirement applies only to systems installed after the effective date of these standards, since this is a new requirement.

Fire protective signaling systems are covered in paragraph (d), which addresses classification, separation, and identification of these systems. Since this entire paragraph was not contained in OSHA's former standards, it applies only to installations made after the effective date of these standards.

Paragraph (e) applies to communications systems and contains provisions on protective devices, conductor and equipment locations, and grounding. Some commenters indicated that the proposal conflicted with both the 1971 and 1978 NEC by not making § 1910.308(e) the only provision in Subpart S covering communications

systems (Ex. 45, 48). They suggested that OSHA include a statement in the regulation stating that communications systems were covered only in § 1910.308(e).

The omission of such a statement from the proposal was an oversight on OSHA's part. To correct this, OSHA has added the following sentence in § 1910.308(e):

These installations need not comply with the provisions of §§ 1910.303 through 1910.308(d).

9. § 1910.399 Definitions. This section provides definitions for Subpart S. The definitions in the final rule remain as proposed, except as follows:

(a)(24) "Class I locations": The definition of a Class I, Division 1 location has been changed by deleting the words "continuously, intermittently, or periodically." The rationale for this change is discussed in Issue 7 of Section III of this preamble. The note following this section has also been changed to more clearly describe this type of location.

(a)(25) "Class II locations": The definition of a Class II, Division 1 location has been changed by deleting the words "continuously, intermittently, or periodically." The definition of a Class II, Division 2 location (§ 1910.399(a)(25)(ii)) has also been changed to clarify the difference between Division 1 and Division 2 locations. Additionally, the fine print notes following these definitions have been modified to more accurately reflect examples of locations which could be classified as Class II locations considering advances in grain handling technology. The rationale for these changes is discussed in Issue 7 of Section III of this preamble.

(a)(128) "Utilization system": One commenter (Ex. 30) questioned this definition, stating that it was redundant with the definition of "premises wiring." However, the terms are not synonymous, and the final rule has been modified to clearly state that the utilization system includes not only the premises wiring system, but its associated utilization equipment as well.

V. Regulatory Assessment

In accordance with Executive Order No. 12044 (43 FR 12961, March 24, 1978), OSHA assessed the potential economic impact of the proposal. Based on the economic identification criteria developed by the Department of Labor (44 FR 5570, January 28, 1979), OSHA concluded that the subject matter of the proposal was not a "major" action which would necessitate further economic impact evaluation and the preparation of a Regulatory Analysis.

The proposal dealt with electrical installation safety requirements and was derived from the National Electrical Code, which was used as OSHA's previous standard. Since the proposal resulted in an overall simplification of OSHA's standards, the estimated cost of compliance was concluded not to be higher than the cost of compliance with the current OSHA standards.

This determination was based on a May 11, 1979, report by JRB Associates, Inc. The major finding of the economic impact assessment was that there would be no significant economic effect resulting from the promulgation of the proposed revisions to 29 CFR Part 1910, Subpart S, Electrical. The rationale for this conclusion was as follows:

—The proposed regulation contained no requirements other than those found in either 29 CFR Part 1910, Subpart S, or the 1978 National Electrical Code.

—Current industry practice for new installation is to conform to the 1978 National Electrical Code.

—Provisions in the proposed Subpart S had an antecedent in the 1978 National Electrical Code.

Several commenters took issue with OSHA's determination that the proposed revisions to Subpart S would not have a major economic impact on the affected industries. Detailed studies were submitted to the record by certain industry groups, notably the grain elevator industry and the feed manufacturing industry, which indicated that the costs of compliance with Subpart S as revised would be far greater than those associated with compliance with the current provisions. (Ex. 55, 58). However, a review of these studies reveals that their findings are based on certain misunderstandings of the scope and application of the former standards and OSHA's proposed revisions. These areas of concern are also discussed in detail in section III of this preamble, which deal with the "retroactive" and hazardous locations provisions of the standard. Nonetheless, OSHA believes that it may also be helpful to discuss these major areas of misunderstanding in the context of the regulatory assessment of the proposed standards.

OSHA's intent in proposing changes to Subpart S was to simplify compliance with the electrical standards, without reducing any of the employee protection currently provided. To that end, the proposed revisions to Subpart S approached the problem in three ways: first, performance language was substituted for the detailed requirements of the 1971 NEC, to provide flexibility for the employer; second, provisions of the 1971 NEC which were directed

primarily at property protection and not at employee protection were deleted; and third, all relevant provisions from the NEC were placed within Subpart S in place of the incorporation by reference of the NEC itself. The net result of the proposed revisions, therefore, was a significant decrease in the regulatory burden imposed by the electrical standards. In the limited circumstances in which the proposed standards imposed obligations not contained in the 1971 NEC as applied in the present standards, OSHA intended that these new obligations only apply to installations made after the effective date of the revised standards. (As noted in section VI of this preamble, OSHA acknowledged that this intention was not implemented totally in the proposal; such new provisions are more carefully and completely distinguished in the final standards.)

Concerning the question of the listed "retroactive" provisions in proposed § 1910.302(b)(1), it should be noted that the proposed revisions did no more than carry forward the provisions of current § 1910.309(a), which presently apply to all electrical installations, regardless of when they were made. Indeed, where the list has been modified, the changes simplify and reduce the compliance burden by eliminating requirements and allowing alternative compliance methods. There is no requirement imposed by the new § 1910.302(b)(1) that is not currently imposed on employers by virtue of § 1910.309(a) of the former standards. Thus, the costs of complying with these requirements cannot be attributed to the proposal.

OSHA based its economic impact analysis on the requirements of Executive Order No. 12044 (43 FR 12661, March 24, 1978), as supplemented by Department of Labor regulations (44 FR 5570, January 26, 1979). The regulatory assessment of the proposed regulations was intended to evaluate the incremental cost impact of the proposal over that of the existing regulations.

Since OSHA's proposal did not increase existing compliance requirements or establish new compliance requirements, it was found not to result in a major impact.

To support their view that OSHA's assessment was inadequate, two trade associations submitted studies of the economic impact on their respective industries, based upon their interpretations of the proposal. One study claimed that it would cost the feed manufacturing industry about \$785,000,000 to comply with OSHA's proposal, the other estimated costs of \$825,000,000 for the grain elevator industry (Ex. 55J, 58).

It is difficult to evaluate the industry studies in depth: although specific compliance elements are mentioned in each study, the actual cost data are not adequately broken down to correspond to those elements. Therefore, there is no way to determine how much of their total cost estimates are attributable to which compliance activity. This is particularly troublesome for two reasons: first, when the costs are calculated based on an inaccurate reading of the standards, the magnitude of these unnecessary costs cannot be determined. It is noted, however, that in their other comments and testimony submitted to the record, these parties' primary concerns with the proposal centered on the costs of removal and replacement of unmarked, unlabeled and unapproved equipment in hazardous (classified) locations. As noted earlier, such requirements, and, therefore, their costs, are illusory. Clearly, then, if these costs constitute the greatest share of the total estimated compliance costs in these studies, the studies greatly overestimate the resources necessary for compliance with the standards.

Second, where repair costs are included as costs of compliance, such costs are also not properly attributable to the proposal. The proposal did not add any new requirements for existing installations; thus, where repairs are required for compliance with the proposal, they would also be necessary for compliance with the current standards. In addition, some repair costs may well be directed more towards routine operating repairs for continuing or resuming production in currently idle facilities than they are towards compliance with OSHA standards.

The inaccurate assumptions which appear to be the basis of much of the cost data in the industry studies have been discussed in depth in earlier sections of this preamble. The following discussion, therefore, represents a summation of the relevant issues as they pertain to the regulatory assessment.

Both industry studies assumed that all installations in hazardous locations were required to have "approved" equipment. (See issue 4(b) in section III of this preamble.)

The studies also confused the terms "marking", "labeling", and "approval" and assumed that OSHA's standard differed from the NEC as to those terms (See Issue 4(a) in section III of this preamble). Contrary to the implications in the studies, the marking provisions in the standard do not require labeling or approval; they simply require identification of the various parameters of the equipment. This identification

may be placed on the equipment using any means that is legible and durable enough to withstand the operating environment. As such, many of the costs indicated by the studies would not be incurred as employers would not be required to affix official manufacturers' labels or replace equipment which does not have such labels. Furthermore, the studies included in their estimates the cost of replacing otherwise acceptable equipment which is not listed or labeled, and hence not "approved." Such replacement of unapproved but otherwise acceptable equipment is not required by the standard if the equipment can be shown to meet one of the other compliance alternatives in § 1910.307.

Should some items of equipment not meet any of the compliance alternatives in § 1910.307, replacement of that equipment would be necessary. Assuming that an item of equipment would need to be replaced, the study did not take into account any possible salvage value of the used equipment. In addition, the studies did not consider the savings that might result from reduction in insurance premiums, property losses, and liability costs as a result of replacing unsafe equipment with safe equipment.

Where costs are imposed by the existing standards, the proposal does not increase these costs; to the contrary, as the assessment points out, the net impact of the proposal is expected to be an overall reduction in compliance costs due to the use of performance language and other reductions in the regulatory burdens imposed by the former standard.

One commenter contended that OSHA should have conducted a field survey to ascertain the present level of compliance with the current "retroactive" provisions in § 1910.309(a). Based on that survey, it was argued, OSHA should then have assessed not only the costs of compliance with new requirements imposed by the proposal, but the added costs of coming into compliance with the existing standards. (Ex. 69).

Because the proposed "retroactive" provision of § 1910.302(b)(1) did not increase compliance requirements over those of § 1910.309(a) (see Issue 3 in section III of this preamble), OSHA determined that the impact of the proposal in this regard was not major. Where industry is not currently in compliance with the existing standards, these costs cannot be attributed to the proposal. The regulatory assessment therefore, properly evaluated the incremental costs to be imposed by the proposed standard.

The regulatory assessment concluded that the only area in which increased costs might be expected is that of new provisions which were taken from the 1978 NEC and which were not in the 1971 NEC. Such costs were determined to be insignificant, particularly if the new provisions were to be applied only to installations made after the effective date of the final standards. This condition has been met by OSHA in the final revisions of Subpart S.

Therefore, after a careful review of the rulemaking record, OSHA has determined that this final standard is not a major action as defined in Executive Order 12044 and the Department economic criteria.

VI. Effective Date and Dates of Application

The scope and application of Subpart S, as set forth in paragraphs (b)(1) and (b)(2) of § 1910.302, essentially carry forward the provisions of § 1910.309 of the former standards. (The background and issues surrounding this section have been discussed at length in both Section III and Section IV of this preamble.) As in the case of previous § 1910.309(a), the provisions of Subpart S which are listed in new § 1910.302(b)(1) apply to all electrical installations, regardless of when they were made. Former § 1910.309(b) provided that the entire 1971 NEC applied to installations and modifications made after March 15, 1972. To be consistent with the former standard, the revision, in § 1910.302(b)(2), provides that the entire Subpart S applies to the same installations and modifications.

However, some of the provisions contained in the proposed regulations differed from or were not found in the previous regulations. These differences resulted from the use of the 1978 National Electrical Code as a base document. Since the previous regulations referenced the 1971 NEC, changes which were made in the subsequent editions of the NEC and which were included in the proposal appeared to impose new requirements. OSHA had intended that all

provisions in the proposal which were more stringent than the OSHA electrical standards in effect at the time would not apply to existing installations. Existing installations would not have to be retrofitted to meet these new requirements.

OSHA has added a new § 1910.302(b)(3) to indicate that the following new provisions apply only to installations made after April 16, 1981, the effective date of these standards.

(1) §§ 1910.303(h)(4)(i) and (ii). These requirements relate to access and

entrance to workspace about equipment rated over 600 volts.

(2) § 1910.304(e)(1)(vi)(b). This requires the handle of vertically mounted circuit breakers to be in the up position when the breaker is on.

(3) § 1910.304(e)(1)(vi)(c). This provision would require circuit breakers used as switches in fluorescent lighting circuits to be marked "SWD."

(4) § 1910.305(j)(6)(ii)(b). This regulation addresses proper switching of series capacitors over 600 volts.

(5) § 1910.306(c)(2). This provision requires a warning sign for multitar elevator or escalator installations, under certain conditions.

(6) § 1910.306(i). This paragraph contains requirements for lighting protection and disconnection of electrically controlled or driven irrigation machines.

(7) § 1910.306(j)(4). This provision requires ground-fault circuit interrupters for fountain installations.

(8) § 1910.308(a)(1)(ii). This provision requires conductors over 600 volts emerging from the ground to be enclosed in a raceway.

(9) § 1910.308(c)(2) requires marking on Class 2 and Class 3 power supply units.

(10) § 1910.308(d). This paragraph contains requirements for fire protective signaling circuits.

In summary, § 1910.302(b) provides for three sets of provisions within Subpart S: paragraph (b)(1) contains the list of provisions applicable to all electrical installations; paragraph (b)(3) provides that the new requirements listed in that paragraph are only applicable to installations made after the effective date of these standards; and paragraph (b)(2) provides for the remainder of Subpart S to apply to new installations and major modifications made after March 15, 1972.

The effective date of these standards is (90 days after publication). The 90-day period between the issuance of the standards and their effective date is intended to provide sufficient time for employers and employees to become informed of the existence of the standards and their requirements.

The standards currently found in the existing Subpart S [§§ 1910.308-1910.309] will remain in effect until the standards contained in this document actually go into effect. Should the new standards be stayed, judicially or administratively, or should the standards not sustain legal challenge under section 6(f) of the Act, the current standards in Subpart S will remain in effect.

Any petitions for administrative reconsiderations of these standards or for an administrative stay pending

judicial review must be filed with the Assistant Secretary of Labor for Occupational Safety and Health on or before March 2, 1981. Any petitions filed after this date will be considered to be filed untimely. This requirement is considered essential to permit the Agency to give full consideration to each petition and respond in advance of the effective date of the standards.

VII. Appendices

For informational purposes, one Appendix has been provided and two others reserved in this final standard. At this time only Appendix A is being promulgated. It contains a list of references which can provide guidance for employers who wish to know specifically what constitutes compliance with the performance standards. If an employer complies with the specific guidelines (the National Electrical Code, NFPA 70, in particular), that employer will be considered to be in compliance with the performance requirements given in OSHA's standard. At the same time, an employer may be in compliance with the standard although not complying with the specific requirements of the guidelines. In construing the meaning of the performance language in the standards in circumstances where the employer chooses not to comply with the specific provisions of the guidelines, OSHA will look at the specific guidelines among other things to determine whether the employer has complied with the standards' performance requirements. However, nothing contained in the appendices should be construed as establishing a mandatory requirement not otherwise imposed by the standard, or as detracting from an obligation which the standard does impose. In view of the nature of the appendices, changes in their contents may subsequently be made without rulemaking.

Three documents have been added to the list contained in the proposal. They are:

- NMAB 353-1-79 Matrix of Combustion—Relevant Properties and Classifications of Gases, Vapors, and Selected Solids.
- NMAB 353-2-79 Test Equipment For Use in Determining Classifications of Combustible Dusts
- NMAB-353-80 Classification of Combustible Dusts in Accordance with the National Electrical Code

VIII. Authority

This document was prepared under the direction of Eula Bingham, Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of

Labor, Third Street and Constitution Avenue, NW., Washington, D.C. 20210.

Accordingly, pursuant to sections 4(b)(2) and 6(b) of the Occupational Safety and Health Act of 1970 [84 Stat. 1592, 1593, 29 U.S.C. 653, 655], Secretary of Labor's Order No. 8-76 (41 FR 25059), and 29 CFR Part 1911, Subpart S of 29 CFR Part 1910 is revised as set forth below.

Signed at Washington, D.C. this 8th day of January, 1981.

Eula Bingham,

Assistant Secretary of Labor.

Part 1910 of Title 29 of the Code of Federal Regulations is hereby amended by revising Subpart S, Electrical, to read as follows:

Subpart S—Electrical

General

Sec.

1910.301 Introduction.

Design Safety Standards for Electrical Systems

- 1910.302 Electric utilization systems.
- 1910.303 General requirements.
- 1910.304 Wiring design and protection.
- 1910.305 Wiring methods, components, and equipment for general use.
- 1910.306 Specific purpose equipment and installations.
- 1910.307 Hazardous (classified) locations.
- 1910.308 Special systems.
- 1910.309—1910.330 [Reserved]

Safety-Related Work Practices

1910.331—1910.360 [Reserved]

Safety-Related Maintenance Requirements

1910.361—1910.380 [Reserved]

Safety Requirements for Special Equipment

1910.381—1910.398 [Reserved]

Definitions

1910.399 Definitions applicable to this subpart.

Appendix A—Reference Documents.

Appendix B—Explanatory Data [Reserved]

Appendix C—Tables, Notes, and Charts [Reserved]

Authority: Secs. 4(b)(2) and 6(b), 84 Stat. 1592, 1593 (29 U.S.C. 653, 655), Secretary of Labor's Order No. 8-76 (41 FR 25059), 29 CFR Part 1911.

Subpart S—Electrical

General

§ 1910.301 Introduction.

This subpart addresses electrical safety requirements that are necessary for the practical safeguarding of employees in their workplaces and is divided into four major divisions as follows:

(a) *Design safety standards for electrical systems.* These regulations are

contained in §§ 1910.302 through 1910.330. Sections 1910.302 through 1910.308 contain design safety standards for electric utilization systems. Included in this category are all electric equipment and installations used to provide electric power and light for employee workplaces. Sections 1910.309 through 1910.330 are reserved for possible future design safety standards for other electrical systems.

(b) *Safety-related work practices.* These regulations will be contained in §§ 1910.331 through 1910.360.

(c) *Safety-related maintenance requirements.* These regulations will be contained in §§ 1910.361 through 1910.380.

(d) *Safety requirements for special equipment.* These regulations will be contained in §§ 1910.381 through 1910.398.

(e) *Definitions* applicable to each division are contained in § 1910.399.

Design Safety Standards for Electrical Systems

§ 1910.302 Electric utilization systems.

Sections 1910.302 through 1910.308 contain design safety standards for electric utilization systems.

(a) *Scope.* (1) *Covered.* The provisions of §§ 1910.302 through 1910.308 of this subpart cover electrical installations and utilization equipment installed or used within or on buildings, structures, and other premises including:

- (i) Yards,
- (ii) Carnivals,
- (iii) Parking and other lots,
- (iv) Mobile homes,
- (v) Recreational vehicles,
- (vi) Industrial substations,
- (vii) Conductors that connect the installations to a supply of electricity, and
- (viii) Other outside conductors on the premises.

(2) *Not covered.* The provisions of §§ 1910.302 through 1910.308 of this subpart do not cover:

- (i) Installations in ships, watercraft, railway rolling stock, aircraft, or automotive vehicles other than mobile homes and recreational vehicles.
- (ii) Installations underground in mines.
- (iii) Installations of railways for generation, transformation, transmission, or distribution of power used exclusively for operation of rolling stock or installations used exclusively for signaling and communication purposes.

(iv) Installations of communication equipment under the exclusive control of communication utilities, located outdoors or in building spaces used exclusively for such installations.

(v) Installations under the exclusive control of electric utilities for the purpose of communication or metering; or for the generation, control, transformation, transmission, and distribution of electric energy located in buildings used exclusively by utilities for such purposes or located outdoors on property owned or leased by the utility or on public highways, streets, roads, etc., or outdoors by established rights on private property.

(b) *Extent of application.* (1) The requirements contained in the sections listed below shall apply to all electrical installations and utilization equipment, regardless of when they were designed or installed:

Sections:

1910.303(b)	Examination, installation, and use of equipment.
1910.303(c)	Splices.
1910.303(d)	Arcing paths.
1910.303(e)	Marking.
1910.303(f)	Identification of disconnecting means.
1910.303(g)(2)	Guarding of live parts.
1910.304(e)(7)(v)	Protection of conductors and equipment.
1910.304(e)(8)(v)	Location in or on premises.
1910.304(e)(9)(v)	Arcing or suddenly moving parts.
1910.304(f)(1)(v)	2-Wire DC systems to be grounded.
1910.304(f)(2)(v)	AC Systems to be grounded.
1910.304(f)(3)(v)	AC Systems 50 to 1000 volts not required to be grounded.
1910.304(f)(4)	Grounding connections.
1910.304(f)(5)(v)	Grounding path.
1910.304(f)(5)(v)(i)	Fixed equipment required to be grounded.
1910.304(f)(5)(v)(ii)	Grounding of equipment connected by cord and plug.
1910.304(f)(5)(v)(iii)	Grounding of nonelectrical equipment.
1910.304(f)(6)(v)	Methods of grounding fixed equipment.
1910.305(g)(1)(v)	Flexible cords and cables, used.
1910.305(g)(2)(v)	Flexible cords and cables prohibited.
1910.305(g)(2)(v)(i)	Flexible cords and cables, splices.
1910.305(g)(2)(v)(ii)	Pull at joints and terminals of flexible cords and cables.
1910.307	Hazardous (classified) location.

(2) Every electric utilization system and all utilization equipment installed after March 15, 1972, and every major replacement, modification, repair, or rehabilitation, after March 15, 1972, of any part of any electric utilization system or utilization equipment installed before March 15, 1972, shall comply with the provisions of §§ 1910.302 through 1910.308.

Note.—"Major replacements, modifications, repairs, or rehabilitations" include work similar to that involved when a new building or facility is built, a new wing is added, or an entire floor is renovated.

(3) The following provisions apply to electric utilization systems and utilization equipment installed after April 16, 1981:

§ 1910.303(f)(4) (i)	Entrance and access to work-space (over 600 volts).
§ 1910.304(e)(1)(v)(b)	Circuit breakers operated vertically.
§ 1910.304(e)(1)(v)(c)	Circuit breakers used as switches.
§ 1910.304(f)(7)(a)	Grounding of systems of 1000 volts or more supplying portable or mobile equipment.
§ 1910.305(j)(5)(ii)	Switching series capacitors over 600 volts.
§ 1910.306(c)(2)	Warning signs for elevators and escalators.
§ 1910.306(i)	Electrically controlled irrigation machines.
§ 1910.306(j)(5)	Ground-fault circuit interrupters for fountains.
§ 1910.308(a)(1)(i)	Physical protection of conductors over 600 volts.
§ 1910.308(c)(2)	Marking of Class 2 and Class 3 power supplies.
§ 1910.308(d)	Fire protective signaling circuits.

§ 1910.303 General requirements.

(a) *Approval.* The conductors and equipment required or permitted by this subpart shall be acceptable only if approved.

(b) *Examination, installation, and use of equipment.* (1) *Examination.*

Electrical equipment shall be free from recognized hazards that are likely to cause death or serious physical harm to employees. Safety of equipment shall be determined using the following considerations:

(i) *Suitability for installation and use in conformity with the provisions of this subpart.* Suitability of equipment for an identified purpose may be evidenced by listing or labeling for that identified purpose.

(ii) *Mechanical strength and durability.* Including, for parts designed to enclose and protect other equipment, the adequacy of the protection thus provided.

(iii) *Electrical insulation.*

(iv) *Heating effects under conditions of use.*

(v) *Arcing effects.*

(vi) *Classification by type, size, voltage, current capacity, specific use.*

(vii) *Other factors which contribute to the practical safeguarding of employees using or likely to come in contact with the equipment.*

(2) *Installation and use.* Listed or labeled equipment shall be used or installed in accordance with any instructions included in the listing or labeling.

(c) *Splices.* Conductors shall be spliced or joined with splicing devices suitable for the use or by brazing, welding, or soldering with a fusible metal or alloy. Soldered splices shall first be so spliced or joined as to be mechanically and electrically secure without solder and then soldered. All splices and joints and the free ends of conductors shall be covered with an insulation equivalent to that of the

conductors or with an insulating device suitable for the purpose.

(d) *Arcing parts.* Parts of electric equipment which in ordinary operation produce arcs, sparks, flames, or molten metal shall be enclosed or separated and isolated from all combustible material.

(e) *Marking.* Electrical equipment may not be used unless the manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified is placed on the equipment. Other markings shall be provided giving voltage, current, wattage, and other ratings as necessary. The marking shall be of sufficient durability to withstand the environment involved.

(f) *Identification of disconnecting means and circuits.* Each disconnecting means required by this subpart for motors and appliances shall be legibly marked to indicate its purpose, unless located and arranged so the purpose is evident. Each service, feeder, and branch circuit, at its disconnecting means or overcurrent device, shall be legibly marked to indicate its purpose, unless located and arranged so the purpose is evident. These markings shall be of sufficient durability to withstand the environment involvement involved.

(g) *600 Volts, nominal, or less.* (1) *Working space about electric equipment.* Sufficient access and working space shall be provided and maintained about all electric equipment to permit ready and safe operation and maintenance of such equipment.

(i) *Working clearances.* Except as required or permitted elsewhere in this subpart, the dimension of the working space in the direction of access to live parts operating at 600 volts or less and likely to require examination, adjustment, servicing, or maintenance while alive may not be less than indicated in Table S-1. In addition to the dimensions shown in Table S-1, workspace may not be less than 30 inches wide in front of the electric equipment. Distances shall be measured from the live parts if they are exposed, or from the enclosure front or opening if the live parts are enclosed. Concrete, brick, or tile walls are considered to be grounded. Working space is not required in back of assemblies such as dead-front switchboards or motor control centers where there are no renewable or adjustable parts such as fuses or switches on the back and where all connections are accessible from locations other than the back.

Table S-1.—Working clearances

Nominal voltage to ground	Minimum clear distance for condition ² (ft)		
	(a)	(b)	(c)
0-150	1 3/4	1 3/4	3
151-600	1 3/4	3 1/2	4

¹ Minimum clear distances may be 2 feet 8 inches for installations built prior to April 16, 1981.

² Conditions (a), (b), and (c), are as follows: (a) Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by suitable wood or other insulating material. Insulated wire or insulated busbars operating at not over 300 volts are not considered live parts. (b) Exposed live parts on one side and grounded parts on the other side. (c) Exposed live parts on both sides of the workspace (not guarded as provided in Condition (a)) with the operator between.

(ii) *Clear spaces.* Working space required by this subpart may not be used for storage. When normally enclosed live parts are exposed for inspection or servicing, the working space, if in a passageway or general open space, shall be suitably guarded.

(iii) *Access and entrance to working space.* At least one entrance of sufficient area shall be provided to give access to the working space about electric equipment.

(iv) *Front working space.* Where there are live parts normally exposed on the front of switchboards or motor control centers, the working space in front of such equipment may not be less than 3 feet.

(v) *Illumination.* Illumination shall be provided for all working spaces about service equipment, switchboards, panelboards, and motor control centers installed indoors.

(vi) *Headroom.* The minimum headroom of working spaces about service equipment, switchboards, panelboards, or motor control centers shall be 6 feet 3 inches.

Note.—As used in this section a motor control center is an assembly of one or more enclosed sections having a common power bus and principally containing motor control units.

(2) *Guarding of live parts.* (i) Except as required or permitted elsewhere in this subpart, live parts of electric equipment operating at 50 volts or more shall be guarded against accidental contact by approved cabinets or other forms of approved enclosures, or by any of the following means:

(a) By location in a room, vault, or similar enclosure that is accessible only to qualified persons.

(b) By suitable permanent, substantial partitions or screens so arranged that only qualified persons will have access to the space within reach of the live parts. Any openings in such partitions or screens shall be so sized and located that persons are not likely to come into accidental contact with the live parts or

to bring conducting objects into contact with them.

(c) By location on a suitable balcony, gallery, or platform so elevated and arranged as to exclude unqualified persons.

(d) By elevation of 8 feet or more above the floor or other working surface.

(ii) In locations where electric equipment would be exposed to physical damage, enclosures or guards shall be so arranged and of such strength as to prevent such damage.

(iii) Entrances to rooms and other guarded locations containing exposed live parts shall be marked with conspicuous warning signs forbidding unqualified persons to enter.

(h) *Over 600 volts, nominal.* (1) *General.* Conductors and equipment used on circuits exceeding 600 volts, nominal, shall comply with all applicable provisions of paragraphs (a) through (g) of this section and with the following provisions which supplement or modify those requirements. The provisions of paragraphs (h)(2), (h)(3), and (h)(4) of this section do not apply to equipment on the supply side of the service conductors.

(2) *Enclosure for electrical installations.* Electrical installations in a vault, room, closet or in an area surrounded by a wall, screen, or fence, access to which is controlled by lock and key or other approved means, are considered to be accessible to qualified persons only. A wall, screen, or fence less than 8 feet in height is not considered to prevent access unless it has other features that provide a degree of isolation equivalent to an 8 foot fence. The entrances to all buildings, rooms, or enclosures containing exposed live parts or exposed conductors operating at over 600 volts, nominal, shall be kept locked or shall be under the observation of a qualified person at all times.

(i) *Installations accessible to qualified persons only.* Electrical installations having exposed live parts shall be accessible to qualified persons only and shall comply with the applicable provisions of paragraph (h)(3) of this section.

(ii) *Installations accessible to unqualified persons.* Electrical installations that are open to unqualified persons shall be made with metal-enclosed equipment or shall be enclosed in a vault or in an area, access to which is controlled by a lock. If metal-enclosed equipment is installed so that the bottom of the enclosure is less than 8 feet above the floor, the door or cover shall be kept locked. Metal-enclosed switchgear, unit substations, transformers, pull boxes, connection boxes, and other similar associated

equipment shall be marked with appropriate caution signs. If equipment is exposed to physical damage from vehicular traffic, suitable guards shall be provided to prevent such damage. Ventilating or similar openings in metal-enclosed equipment shall be designed so that foreign objects inserted through these openings will be deflected from energized parts.

(3) *Workspace about equipment.* Sufficient space shall be provided and maintained about electric equipment to permit ready and safe operation and maintenance of such equipment. Where energized parts are exposed, the minimum clear workspace may not be less than 6 feet 6 inches high (measured vertically from the floor or platform), or less than 3 feet wide (measured parallel to the equipment). The depth shall be as required in Table S-2. The workspace shall be adequate to permit at least a 90-degree opening of doors or hinged panels.

(i) *Working space.* The minimum clear working space in front of electric equipment such as switchboards, control panels, switches, circuit breakers, motor controllers, relays, and similar equipment may not be less than specified in Table S-2 unless otherwise specified in this subpart. Distances shall be measured from the live parts if they are exposed, or from the enclosure front or opening if the live parts are enclosed. However, working space is not required in back of equipment such as deadfront switchboards or control assemblies where there are no renewable or adjustable parts (such as fuses or switches) on the back and where all connections are accessible from locations other than the back. Where rear access is required to work on de-energized parts on the back of enclosed equipment, a minimum working space of 30 inches horizontally shall be provided.

Table S-2.—Minimum Depth of Clear working Space in Front of Electric Equipment

Nominal voltage to ground	Conditions* (ft)		
	(a)	(b)	(c)
601 to 2,500	3	4	5
2,501 to 9,000	4	5	6
9,001 to 25,000	5	6	8
25,001 to 75kV ¹	6	8	10
Above 75kV ¹	8	10	12

¹ Minimum depth of clear working space in front of electric equipment with a nominal voltage to ground above 25,000 volts may be the same as for 25,000 volts under Conditions (a), (b), and (c) for installations built prior to April 16, 1981.

² Conditions (a), (b), and (c) are as follows: (a) Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials. Insulated wire or insulated busbars operating at not over 300 volts are not considered live parts. (b) Exposed live parts on one side and grounded parts on the other side. Concrete, brick, or tile walls will be considered as grounded surfaces. (c) Exposed live parts on both sides of the workspace not guarded as provided in Condition (a) with the operator between.

(ii) *Illumination.* Adequate illumination shall be provided for all working spaces about electric equipment. The lighting outlets shall be so arranged that persons changing lamps or making repairs on the lighting system will not be endangered by live parts or other equipment. The points of control shall be so located that persons are not likely to come in contact with any live part or moving part of the equipment while turning on the lights.

(iii) *Elevation of unguarded live parts.* Unguarded live parts above working space shall be maintained at elevations not less than specified in Table S-3.

Table S-3.—Elevation of Unguarded Energized Parts Above Working Space

Nominal voltage between phases	Minimum elevation
601 to 7,500	8 feet 6 inches.
7,501 to 35,000	9 feet.
Over 35kV	9 feet + 0.37 inches per kV above 35kV.

*Note.—Minimum elevation may be 8 feet 0 inches for installations built prior to April 16, 1981 if the nominal voltage between phases is in the range of 601–6600 volts.

(4) *Entrance and access to workspace.* (See § 1910.302(b)(3).)

(i) At least one entrance not less than 24 inches wide and 6 feet 6 inches high shall be provided to give access to the working space about electric equipment. On switchboard and control panels exceeding 48 inches in width, there shall be one entrance at each end of such board where practicable. Where bare energized parts at any voltage or insulated energized parts above 600 volts are located adjacent to such entrance, they shall be suitably guarded.

(ii) Permanent ladders or stairways shall be provided to give safe access to the working space around electric equipment installed on platforms, balconies, mezzanine floors, or in attic or roof rooms or spaces.

§ 1910.304 Wiring design and protection.

(a) *Use and identification of grounded and grounding conductors.* (1) *Identification of conductors.* A conductor used as a grounded conductor shall be identifiable and distinguishable from all other conductors. A conductor used as an equipment grounding conductor shall be identifiable and distinguishable from all other conductors.

(2) *Polarity of connections.* No grounded conductor may be attached to any terminal or lead so as to reverse designated polarity.

(3) *Use of grounding terminals and devices.* A grounding terminal or grounding-type device on a receptacle, cord connector, or attachment plug may

not be used for purposes other than grounding.

(b) *Branch circuits.* (1) *Ground-fault protection for personnel on construction sites.* The employer shall use either ground-fault circuit interrupters as specified in paragraph (b)(1)(i) of this section or an assured equipment grounding conductor program as specified in paragraph (b)(1)(ii) of this section, to protect employees on construction sites. These requirements are in addition to any other requirements for equipment grounding conductors.

(i) *Ground-fault circuit interrupters.* All 120-volt, single-phase, 15- and 20-ampere receptacle outlets on construction sites, which are not a part of the permanent wiring of the building or structure and which are in use by employees, shall have approved ground-fault circuit interrupters for personnel protection. Receptacles on a two-wire, single-phase portable or vehicle-mounted generator rated not more than 5 kW, where the circuit conductors of the generator are insulated from the generator frame and all other grounded surfaces, need not be protected with ground-fault circuit interrupters.

(ii) *Assured equipment grounding conductor program.* The employer shall establish and implement an assured equipment grounding conductor program on construction sites covering all cord sets, receptacles which are not a part of the permanent wiring of the building or structure, and equipment connected by cord and plug, which are available for use or used by employees. This program shall comply with the following minimum requirements:

(o) A written description of the program, including the specific procedures adopted by the employer, shall be available at the jobsite for inspection and copying by the Assistant Secretary and any affected employee.

(b) The employer shall designate one or more competent persons (as defined in 29 CFR 1926.32(f)) to implement the program.

(c) Each cord set, attachment cap, plug and receptacle of cord sets, and any equipment connected by cord and plug, except cord sets and receptacles which are fixed and not exposed to damage, shall be visually inspected before each day's use for external defects, such as deformed or missing pins or insulation damage, and for indication of possible internal damage. Equipment found damaged or defective may not be used until repaired.

(d) The following tests shall be performed on all cord sets, receptacles which are not a part of the permanent wiring of the building or structure, and

cord- and plug-connected equipment required to be grounded:

(1) All equipment grounding conductors shall be tested for continuity and shall be electrically continuous.

(2) Each receptacle and attachment cap or plug shall be tested for correct attachment of the equipment grounding conductor. The equipment grounding conductor shall be connected to its proper terminal.

(e) All required tests shall be performed:

(1) Before first use;

(2) Before equipment is returned to service following any repairs;

(3) Before equipment is used after any incident which can be reasonably suspected to have caused damage (for example, when a cord set is run over); and

(4) At intervals not to exceed 3 months, except that cord sets and receptacles which are fixed and not exposed to damage shall be tested at intervals not exceeding 6 months.

(f) The employer may not make available or permit the use by employees of any equipment which has not met the requirements of this paragraph (b)(1)(ii) of this section.

(g) Tests performed as required in this paragraph shall be recorded. This test record shall identify each receptacle, cord set, and cord- and plug-connected equipment that passed the test, and shall indicate the last date it was tested or the interval for which it was tested. This record shall be kept by means of logs, color coding, or other effective means, and shall be maintained until replaced by a more current record. The record shall be made available on the jobsite for inspection by the Assistant Secretary and any affected employee.

(2) *Outlet devices.* Outlet devices shall have an ampere rating not less than the load to be served.

(c) *Outside conductors, 600 volts, nominal, or less.* Paragraphs (c)(1), (c)(2), (c)(3), and (c)(4) of this section apply to branch circuit, feeder, and service conductors rated 600 volts, nominal, or less and run outdoors as open conductors. Paragraph (c)(5) applies to lamps installed under such conductors.

(1) *Conductors on poles.* Conductors supported on poles shall provide a horizontal climbing space not less than the following:

(i) Power conductors below communication conductors—30 inches.

(ii) Power conductors alone or above communication conductors: 300 volts or less—24 inches; more than 300 volts—30 inches.

(iii) Communication conductors below power conductors with power

conductors 300 volts or less—24 inches; more than 300 volts—30 inches.

(2) *Clearance from ground.* Open conductors shall conform to the following minimum clearances:

(i) 10 feet—above finished grade, sidewalks, or from any platform or projection from which they might be reached.

(ii) 12 feet—over areas subject to vehicular traffic other than truck traffic.

(iii) 15 feet—over areas other than those specified in paragraph (c)(2)(iv) of this section that are subject to truck traffic.

(iv) 18 feet—over public streets, alleys, roads, and driveways.

(3) *Clearance from building openings.* Conductors shall have a clearance of at least 3 feet from windows, doors, porches, fire escapes, or similar locations. Conductors run above the top level of a window are considered to be out of reach from that window and, therefore, do not have to be 3 feet away.

(4) *Clearance over roofs.* Conductors shall have a clearance of not less than 8 feet from the highest point of roofs over which they pass, except that

(i) Where the voltage between conductors is 300 volts or less and the roof has a slope of not less than 4 inches in 12, the clearance from roofs shall be at least 3 feet, or

(ii) Where the voltage between conductors is 300 volts or less and the conductors do not pass over more than 4 feet of the overhang portion of the roof and they are terminated at a through-the-roof raceway or approved support, the clearance from roofs shall be at least 18 inches.

(5) *Location of outdoor lamps.* Lamps for outdoor lighting shall be located below all live conductors, transformers, or other electric equipment, unless such equipment is controlled by a disconnecting means that can be locked in the open position or unless adequate clearances or other safeguards are provided for relamping operations.

(d) *Services.* (1) *Disconnecting means.* (i) *General.* Means shall be provided to disconnect all conductors in a building or other structure from the service-entrance conductors. The disconnecting means shall plainly indicate whether it is in the open or closed position and shall be installed at a readily accessible location nearest the point of entrance of the service-entrance conductors.

(ii) *Simultaneous opening of poles.* Each service disconnecting means shall simultaneously disconnect all ungrounded conductors.

(2) *Services over 600 volts, nominal.* The following additional requirements apply to services over 600 volts, nominal.

(i) *Guarding.* Service-entrance conductors installed as open wires shall be guarded to make them accessible only to qualified persons.

(ii) *Warning signs.* Signs warning of high voltage shall be posted where other than qualified employees might come in contact with live parts.

(e) *Overcurrent protection.* (1) 600 volts, nominal, or less. The following requirements apply to overcurrent protection of circuits rated 600 volts, nominal, or less.

(i) *Protection of conductors and equipment.* Conductors and equipment shall be protected from overcurrent in accordance with their ability to safely conduct current.

(ii) *Grounded conductors.* Except for motor running overload protection, overcurrent devices may not interrupt the continuity of the grounded conductor unless all conductors of the circuit are opened simultaneously.

(iii) *Disconnection of fuses and thermal cutouts.* Except for service fuses, all cartridge fuses which are accessible to other than qualified persons and all fuses and thermal cutouts on circuits over 150 volts to ground shall be provided with disconnecting means. This disconnecting means shall be installed so that the fuse or thermal cutout can be disconnected from its supply without disrupting service to equipment and circuits unrelated to those protected by the overcurrent device.

(iv) *Location in or on premises.* Overcurrent devices shall be readily accessible to each employee or authorized building management personnel. These overcurrent devices may not be located where they will be exposed to physical damage nor in the vicinity of easily ignitable material.

(v) *Arcing or suddenly moving parts.* Fuses and circuit breakers shall be so located or shielded that employees will not be burned or otherwise injured by their operation.

(vi) *Circuit breakers.* (a) Circuit breakers shall clearly indicate whether they are in the open (off) or closed (on) position.

(b) Where circuit breaker handles on switchboards are operated vertically rather than horizontally or rotationally, the up position of the handle shall be the closed (on) position. (See § 1910.302(b)(3).)

(c) If used as switches in 120-volt, fluorescent lighting circuits, circuit breakers shall be approved for the purpose and marked "SWD." (See § 1910.302(b)(3).)

(2) *Over 600 volts, nominal.* Feeders and branch circuits over 600 volts,

nominal, shall have short-circuit protection.

(f) *Grounding.* Paragraphs (f)(1) through (f)(7) of this section contain grounding requirements for systems, circuits, and equipment.

(1) *Systems to be grounded.* The following systems which supply premises wiring shall be grounded:

(i) All 3-wire DC systems shall have their neutral conductor grounded.

(ii) Two-wire DC systems operating at over 50 volts through 300 volts between conductors shall be grounded unless:

(a) They supply only industrial equipment in limited areas and are equipped with a ground detector; or

(b) They are rectifier-derived from an AC system complying with paragraphs (f)(1)(iii), (f)(1)(v), and (f)(1)(v) of this section; or

(c) They are fire-protective signaling circuits having a maximum current of 0.030 amperes.

(iii) AC circuits of less than 50 volts shall be grounded if they are installed as overhead conductors outside of buildings or if they are supplied by transformers and the transformer primary supply system is ungrounded or exceeds 150 volts to ground.

(iv) AC systems of 50 volts to 1000 volts shall be grounded under any of the following conditions, unless exempted by paragraph (f)(1)(v) of this section:

(a) If the system can be so grounded that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts;

(b) If the system is nominally rated 480Y/277 volt, 3-phase, 4-wire in which the neutral is used as a circuit conductor;

(c) If the system is nominally rated 240/120 volt, 3-phase, 4-wire in which the midpoint of one phase is used as a circuit conductor; or

(d) If a service conductor is uninsulated.

(v) AC systems of 50 volts to 1000 volts are not required to be grounded under any of the following conditions:

(a) If the system is used exclusively to supply industrial electric furnaces for melting, refining, tempering, and the like.

(b) If the system is separately derived and is used exclusively for rectifiers supplying only adjustable speed industrial drives.

(c) If the system is separately derived and is supplied by a transformer that has a primary voltage rating less than 1000 volts, provided all of the following conditions are met:

(1) The system is used exclusively for control circuits,

(2) The conditions of maintenance and supervision assure that only qualified persons will service the installation,

(3) Continuity of control power is required, and

(4) Ground detectors are installed on the control system.

(d) If the system is an isolated power system that supplies circuits in health care facilities.

(2) *Conductors to be grounded.* For AC premises wiring systems the identified conductor shall be grounded.

(3) *Grounding connections.* (i) For a grounded system, a grounding electrode conductor shall be used to connect both the equipment grounding conductor and the grounded circuit conductor to the grounding electrode. Both the equipment grounding conductor and the grounding electrode conductor shall be connected to the grounded circuit conductor on the supply side of the service disconnecting means, or on the supply side of the system disconnecting means or overcurrent devices if the system is separately derived.

(ii) For an ungrounded service-supplied system, the equipment grounding conductor shall be connected to the grounding electrode conductor at the service equipment. For an ungrounded separately derived system, the equipment grounding conductor shall be connected to the grounding electrode conductor at, or ahead of, the system disconnecting means or overcurrent devices.

(iii) On extensions of existing branch circuits which do not have an equipment grounding conductor, grounding-type receptacles may be grounded to a grounded cold water pipe near the equipment.

(4) *Grounding path.* The path to ground from circuits, equipment, and enclosures shall be permanent and continuous.

(5) *Supports, enclosures, and equipment to be grounded.*—(i) *Supports and enclosures for conductors.* Metal cable trays, metal raceways, and metal enclosures for conductors shall be grounded, except that:

(a) Metal enclosures such as sleeves that are used to protect cable assemblies from physical damage need not be grounded; or

(b) Metal enclosures for conductors added to existing installations of open wire, knob-and-tube wiring, and nonmetallic-sheathed cable need not be grounded if all of the following conditions are met: (1) runs are less than 25 feet; (2) enclosures are free from probable contact with ground, grounded metal, metal laths, or other conductive materials; and (3) enclosures are guarded against employee contact.

(ii) *Service equipment enclosures.* Metal enclosures for service equipment shall be grounded.

(iii) *Frames of ranges and clothes dryers.* Frames of electric ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers, and metal outlet or junction boxes which are part of the circuit for these appliances shall be grounded.

(iv) *Fixed equipment.* Exposed non-current-carrying metal parts of fixed equipment which may become energized shall be grounded under any of the following conditions:

(a) If within 8 feet vertically or 5 feet horizontally of ground or grounded metal objects and subject to employee contact.

(b) If located in a wet or damp location and not isolated.

(c) If in electrical contact with metal.

(d) If in a hazardous (classified) location.

(e) If supplied by a metal-clad, metal-sheathed, or grounded metal raceway wiring method.

(f) If equipment operates with any terminal at over 150 volts to ground; however, the following need not be grounded:

(1) Enclosures for switches or circuit breakers used for other than service equipment and accessible to qualified persons only;

(2) Metal frames of electrically heated appliances which are permanently and effectively insulated from ground; and

(3) The cases of distribution apparatus such as transformers and capacitors mounted on wooden poles at a height exceeding 8 feet above ground or grade level.

(v) *Equipment connected by cord and plug.* Under any of the conditions described in paragraphs (f)(5)(v)(a) through (f)(5)(v)(c) of this section, exposed non-current-carrying metal parts of cord- and plug-connected equipment which may become energized shall be grounded.

(a) If in hazardous (classified) locations (see § 1910.306).

(b) If operated at over 150 volts to ground, except for guarded motors and metal frames of electrically heated appliances if the appliance frames are permanently and effectively insulated from ground.

(c) If the equipment is of the following types:

(1) Refrigerators, freezers, and air conditioners;

(2) Clothes-washing, clothes-drying and dishwashing machines, sump pumps, and electrical aquarium equipment;

(3) Hand-held motoroperated tools;

(4) Motoroperated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers;

(5) Cord- and plug-connected appliances used in damp or wet locations or by employees standing on the ground or on metal floors or working inside of metal tanks or boilers;

(6) Portable and mobile X-ray and associated equipment;

(7) Tools likely to be used in wet and conductive locations; and

(8) Portable hand lamps.

Tools likely to be used in wet and conductive locations need not be grounded if supplied through an isolating transformer with an ungrounded secondary of not over 50 volts. Listed or labeled portable tools and appliances protected by an approved system of double insulation, or its equivalent, need not be grounded. If such a system is employed, the equipment shall be distinctively marked to indicate that the tool or appliance utilizes an approved system of double insulation.

(vi) *Nonelectrical equipment.* The metal parts of the following nonelectrical equipment shall be grounded: frames and tracks of electrically operated cranes; frames of nonelectrically driven elevator cars to which electric conductors are attached; hand operated metal shifting ropes or cables of electric elevators, and metal partitions, grill work, and similar metal enclosures around equipment of over 750 volts between conductors.

(6) *Methods of grounding fixed equipment.* (i) Non-current-carrying metal parts of fixed equipment, if required to be grounded by this subpart, shall be grounded by an equipment grounding conductor which is contained within the same raceway, cable, or cord, or runs with or encloses the circuit conductors. For DC circuits only, the equipment grounding conductor may be run separately from the circuit conductors.

(ii) Electric equipment shall be considered to be effectively grounded if it is secured to, and in electrical contact with, a metal rack or structure that is provided for its support and the metal rack or structure is grounded by the method specified for the non-current-carrying metal parts of fixed equipment in paragraph (f)(6)(i) of this section. For installations made before April 16, 1981, only, electric equipment shall be also considered to be effectively grounded if it is secured to, and in metallic contact with, the grounded structural metal frame of a building. Metal car frames supported by metal hoisting cables attached to or running over metal sheaves or drums of grounded elevator machines are also considered to be effectively grounded.

(7) *Grounding of systems and circuits of 1000 volts and over (high voltage).*—

(i) *General.* If high voltage systems are grounded, they shall comply with all applicable provisions of paragraphs (f)(1) through (f)(8) of this section as supplemented and modified by this paragraph (f)(7).

(ii) *Grounding of systems supplying portable or mobile equipment.* (See § 1910.302(b)(3).) Systems supplying portable or mobile high voltage equipment, other than substations installed on a temporary basis, shall comply with the following:

(a) Portable and mobile high voltage equipment shall be supplied from a system having its neutral grounded through an impedance. If a delta-connected high voltage system is used to supply the equipment, a system neutral shall be derived.

(b) Exposed non-current-carrying metal parts of portable and mobile equipment shall be connected by an equipment grounding conductor to the point at which the system neutral impedance is grounded.

(c) Ground-fault detection and relaying shall be provided to automatically de-energize any high voltage system component which has developed a ground fault. The continuity of the equipment grounding conductor shall be continuously monitored so as to de-energize automatically the high voltage feeder to the portable equipment upon loss of continuity of the equipment grounding conductor.

(d) The grounding electrode to which the portable or mobile equipment system neutral impedance is connected shall be isolated from and separated in the ground by at least 20 feet from any other system or equipment grounding electrode, and there shall be no direct connection between the grounding electrodes, such as buried pipe, fence, etc.

(iii) *Grounding of equipment.* All non-current-carrying metal parts of portable equipment and fixed equipment including their associated fences, housings, enclosures, and supporting structures shall be grounded. However, equipment which is guarded by location and isolated from ground need not be grounded. Additionally, pole-mounted distribution apparatus at a height exceeding 8 feet above ground or grade level need not be grounded.

§ 1910.305 Wiring methods, components, and equipment for general use.

(a) *Wiring methods.* The provisions of this section do not apply to the conductors that are an integral part of factory-assembled equipment.

(1) *General requirements.*—(i) *Electrical continuity of metal raceways and enclosures.* Metal raceways, cable armor, and other metal enclosures for conductors shall be metallically joined together into a continuous electric conductor and shall be so connected to all boxes, fittings, and cabinets as to provide effective electrical continuity.

(ii) *Wiring in ducts.* No wiring systems of any type shall be installed in ducts used to transport dust, loose stock or flammable vapors. No wiring system of any type may be installed in any duct used for vapor removal or for ventilation of commercial-type cooking equipment, or in any shaft containing only such ducts.

(2) *Temporary wiring.* Temporary electrical power and lighting wiring methods may be of a class less than would be required for a permanent installation. Except as specifically modified in this paragraph, all other requirements of this subpart for permanent wiring shall apply to temporary wiring installations.

(i) *Uses permitted, 600 volts, nominal, or less.* Temporary electrical power and lighting installations 600 volts, nominal, or less may be used only:

(a) During and for remodeling, maintenance, repair, or demolition of buildings, structures, or equipment, and similar activities;

(b) For experimental or development work, and

(c) For a period not to exceed 90 days for Christmas decorative lighting, carnivals, and similar purposes.

(ii) *Uses permitted, over 600 volts, nominal.* Temporary wiring over 600 volts, nominal, may be used only during periods of tests, experiments, or emergencies.

(iii) *General requirements for temporary wiring.*—(a) Feeders shall originate in an approval distribution center. The conductors shall be run as multiconductor cord or cable assemblies, or, where not subject to physical damage, they may be run as open conductors on insulators not more than 10 feet apart.

(b) Branch circuits shall originate in an approved power outlet or panelboard. Conductors shall be multiconductor cord or cable assemblies or open conductors. If run as open conductors they shall be fastened at ceiling height every 10 feet. No branch-circuit conductor may be laid on the floor. Each branch circuit that supplies receptacles or fixed equipment shall contain a separate equipment grounding conductor if run as open conductors.

(c) Receptacles shall be of the grounding type. Unless installed in a complete metallic raceway, each branch

circuit shall contain a separate equipment grounding conductor and all receptacles shall be electrically connected to the grounding conductor.

(d) No bare conductors nor earth returns may be used for the wiring of any temporary circuit.

(e) Suitable disconnecting switches or plug connectors shall be installed to permit the disconnection of all ungrounded conductors of each temporary circuit.

(f) Lamps for general illumination shall be protected from accidental contact or breakage. Protection shall be provided by elevation of at least 7 feet from normal working surface or by a suitable fixture of lampholder with a guard.

(g) Flexible cords and cables shall be protected from accidental damage. Sharp corners and projections shall be avoided. Where passing through doorways or other pinch points, flexible cords and cables shall be provided with protection to avoid damage.

(3) *Cable trays.* (i) *Uses permitted.* (a) Only the following may be installed in cable tray systems:

(1) Mineral-insulated metal-sheathed cable (Type MI);

(2) Armored cable (Type AC);

(3) Metal-clad cable (Type MC);

(4) Power-limited tray cable (Type PLTC);

(5) Nonmetallic-sheathed cable (Type NM or NMC);

(6) Shielded Nonmetallic-sheathed cable (Type SNM);

(7) Multiconductor service-entrance cable (Type SE or USE);

(8) Multiconductor underground feeder and branch-circuit cable (Type UF);

(9) Power and control tray cable (Type TC);

(10) Other factory-assembled, multiconductor control, signal, or power cables which are specifically approved for installation in cable trays; or

(11) Any approved conduit or raceway with its contained conductors.

(b) In industrial establishments only, where conditions of maintenance and supervision assure that only qualified persons will service the installed cable tray system, the following cables may also be installed in ladder, ventilated trough, or 4 inch ventilated channel-type cable trays:

(1) Single conductor cables which are 250 MCM or larger and are Types RHH, RHW, MV, USE, or THW, and 250 MCM or larger single conductor cables if specifically approved for installation in cable trays. Where exposed to direct rays of the sun, cables shall be sunlight-resistant.

(2) Type MV cables, where exposed to direct rays of the sun, shall be sunlight-resistant.

(c) Cable trays in hazardous (classified) locations shall contain only the cable types permitted in such locations.

(ii) *Uses not permitted.* Cable tray systems may not be used in hoistways or where subjected to severe physical damage.

(4) *Open wiring on insulators.*—(i) *Uses permitted.* Open wiring on insulators is only permitted on systems of 600 volts, nominal, or less for industrial or agricultural establishments and for services.

(ii) *Conductor supports.* Conductors shall be rigidly supported on noncombustible, nonabsorbent insulating materials and may not contact any other objects.

(iii) *Flexible nonmetallic tubing.* In dry locations where not exposed to severe physical damage, conductors may be separately enclosed in flexible nonmetallic tubing. The tubing shall be in continuous lengths not exceeding 15 feet and secured to the surface by straps at intervals not exceeding 4 feet 6 inches.

(iv) *Through walls, floors, wood cross members, etc.* Open conductors shall be separated from contact with walls, floors, wood cross members, or partitions through which they pass by tubes or bushings of noncombustible, nonabsorbent insulating material. If the bushing is shorter than the hole, a waterproof sleeve of nonconductive material shall be inserted in the hole and an insulating bushing slipped into the sleeve at each end in such a manner as to keep the conductors absolutely out of contact with the sleeve. Each conductor shall be carried through a separate tube or sleeve.

(v) *Protection from physical damage.* Conductors within 7 feet from the floor are considered exposed to physical damage. Where open conductors cross ceiling joints and wall studs and are exposed to physical damage, they shall be protected.

(b) *Cabinets, boxes, and fittings.*—(1) *Conductors entering boxes, cabinets, or fittings.* Conductors entering boxes, cabinets, or fittings shall be protected from abrasion, and openings through which conductors enter shall be effectively closed. Unused openings in cabinets, boxes, and fittings shall be also effectively closed.

(2) *Covers and canopies.* All pull boxes, junction boxes, and fittings shall be provided with covers approved for the purpose. If metal covers are used they shall be grounded. In completed installations each outlet box shall have

a cover, faceplate, or fixture canopy. Covers of outlet boxes having holes through which flexible cord pendants pass shall be provided with bushings designed for the purpose or shall have smooth, well-rounded surfaces on which the cords may bear.

(3) *Pull and junction boxes for systems over 600 volts, nominal.* In addition to other requirements in this section for pull and junction boxes, the following shall apply to these boxes for systems over 600 volts, nominal:

(i) Boxes shall provide a complete enclosure for the contained conductors or cables.

(ii) Boxes shall be closed by suitable covers securely fastened in place. Underground box covers that weigh over 100 pounds meet this requirement. Covers for boxes shall be permanently marked "HIGH VOLTAGE." The marking shall be on the outside of the box cover and shall be readily visible and legible.

(c) *Switches.*—(1) *Knife switches.* Single-throw knife switches shall be so connected that the blades are dead when the switch is in the open position. Single-throw knife switches shall be so placed that gravity will not tend to close them. Single-throw knife switches approved for use in the inverted position shall be provided with a locking device that will ensure that the blades remain in the open position when so set. Double-throw knife switches may be mounted so that the throw will be either vertical or horizontal. However, if the throw is vertical a locking device shall be provided to ensure that the blades remain in the open position when so set.

(2) *Faceplates for flush-mounted snap switches.* Flush snap switches that are mounted in ungrounded metal boxes and located within reach of conducting floors or other conducting surfaces shall be provided with faceplates of nonconducting, noncombustible material.

(d) *Switchboards and panelboards.* Switchboards that have any exposed live parts shall be located in permanently dry locations and accessible only to qualified persons. Panelboards shall be mounted in cabinets, cutout boxes, or enclosures approved for the purpose and shall be dead front. However, panelboards other than the dead front externally-operable type are permitted where accessible only to qualified persons. Exposed blades of knife switches shall be dead when open.

(e) *Enclosures for damp or wet locations.* (1) Cabinets, cutout boxes, fittings, boxes, and panelboard enclosures in damp or wet locations shall be installed so as to prevent

moisture or water from entering and accumulating within the enclosures. In wet locations the enclosures shall be weatherproof.

(2) Switches, circuit breakers, and switchboards installed in wet locations shall be enclosed in weatherproof enclosures.

(f) *Conductors for general wiring.* All conductors used for general wiring shall be insulated unless otherwise permitted in this Subpart. The conductor insulation shall be of a type that is approved for the voltage, operating temperature, and location of use. Insulated conductors shall be distinguishable by appropriate color or other suitable means as being grounded conductors, ungrounded conductors, or equipment grounding conductors.

(g) *Flexible cords and cables.*—(1)

Use of flexible cords and cables. (i) Flexible cords and cables shall be approved and suitable for conditions of use and location. Flexible cords and cables shall be used only for:

(a) Pendants;
(b) Wiring of fixtures;
(c) Connection of portable lamps or appliances;

(d) Elevator cables;
(e) Wiring of cranes and hoists;

(f) Connection of stationary equipment to facilitate their frequent interchange;

(g) Prevention of the transmission of noise or vibration;

(h) Appliances where the fastening means and mechanical connections are designed to permit removal for maintenance and repair; or

(i) Data processing cables approved as a part of the data processing system.

(ii) If used as permitted in paragraphs (g)(1)(i)(c), (g)(1)(i)(f), or (g)(1)(i)(h) of this section, the flexible cord shall be equipped with an attachment plug and shall be energized from an approved receptacle outlet.

(iii) Unless specifically permitted in paragraph (g)(1)(i) of this section, flexible cords and cables may not be used:

(a) As a substitute for the fixed wiring of a structure;

(b) Where run through holes in walls, ceilings, or floors;

(c) Where run through doorways, windows, or similar openings;

(d) Where attached to building surfaces; or

(e) Where concealed behind building walls, ceilings, or floors.

(iv) Flexible cords used to show windows and showcases shall be Type S, SO, SJ, SJO, ST, STO, SJT, SJTO, or AFS except for the wiring of chain-supported lighting fixtures and supply cords for portable lamps and other

merchandise being displayed or exhibited.

(2) *Identification, splices, and terminations.*

(i) A conductor of a flexible cord or cable that is used as a grounded conductor or an equipment grounding conductor shall be distinguishable from other conductors. Types SJ, SJO, SJT, SJTO, S, SO, ST, and STO shall be durably marked on the surface with the type designation, size, and number of conductors.

(ii) Flexible cords shall be used only in continuous lengths without splice or tap. Hard service flexible cords No. 12 or larger may be repaired if spliced so that the splice retains the insulation, outer sheath properties, and usage characteristics of the cord being spliced.

(iii) Flexible cords shall be connected to devices and fittings so that strain relief is provided which will prevent pull from being directly transmitted to joints or terminal screws.

(h) *Portable cables over 600 volts, nominal.* Multiconductor portable cable for use in supplying power to portable or mobile equipment at over 600 volts, nominal, shall consist of No. 8 or larger conductors employing flexible stranding. Cables operated at over 2,000 volts shall be shielded for the purpose of confining the voltage stresses to the insulation. Grounding conductors shall be provided. Connectors for these cables shall be of a locking type with provisions to prevent their opening or closing while energized. Strain relief shall be provided at connections and terminations. Portable cables may not be operated with splices unless the splices are of the permanent molded, vulcanized, or other approved type. Termination enclosures shall be suitably marked with a high voltage hazard warning, and terminations shall be accessible only to authorized and qualified personnel.

(i) *Fixture wires.*—(1) *General.* Fixture wires shall be approved for the voltage, temperature, and location of use. A fixture wire which is used as a grounded conductor shall be identified.

(2) *Uses permitted.* Fixture wires may be used:

(i) For installation in lighting fixtures and in similar equipment where enclosed or protected and not subject to bending or twisting in use; or

(ii) For connecting lighting fixtures to the branch-circuit conductors supplying the fixtures.

(3) *Uses not permitted.* Fixture wires may not be used as branch-circuit conductors except as permitted for Class 1 power limited circuits.

(j) *Equipment for general use.*—(1) *Lighting fixtures, lampholders, lamps, and receptacles.* (i) Fixtures,

lampholders, lamps, rosettes, and receptacles may have no live parts normally exposed to employee contact. However, rosettes and cleat-type lampholders and receptacles located at least 8 feet above the floor may have exposed parts.

(ii) Handlamps of the portable type supplied through flexible cords shall be equipped with a handle of molded composition or other material approved for the purpose, and a substantial guard shall be attached to the lampholder or the handle.

(iii) Lampholders of the screw-shell type shall be installed for use as lampholders only. Lampholders installed in wet or damp locations shall be of the weatherproof type.

(iv) Fixtures installed in wet or damp locations shall be approved for the purpose and shall be so constructed or installed that water cannot enter or accumulate in wireways, lampholders, or other electrical parts.

(2) *Receptacles, cord connectors, and attachment plugs (cups).* (i) Receptacles, cord connectors, and attachment plugs shall be constructed so that no receptacle or cord connector will accept an attachment plug with a different voltage or current rating than that for which the device is intended. However, a 20-ampere T-slot receptacle or cord connector may accept a 15-ampere attachment plug of the same voltage rating.

(ii) A receptacle installed in a wet or damp location shall be suitable for the location.

(3) *Appliances.*—(i) Appliances, other than those in which the current-carrying parts at high temperatures are necessarily exposed, may have no live parts normally exposed to employee contact.

(ii) A means shall be provided to disconnect each appliance.

(iii) Each appliance shall be marked with its rating in volts and amperes or volts and watts.

(4) *Motors.* This paragraph applies to motors, motor circuits, and controllers.

(i) *In sight from.* If specified that one piece of equipment shall be "in sight from" another piece of equipment, one shall be visible and not more than 50 feet from the other.

(ii) *Disconnecting means.* (a) A disconnecting means shall be located in sight from the controller location. However, a single disconnecting means may be located adjacent to a group of coordinated controllers mounted adjacent to each other on a multi-motor continuous process machine. The controller disconnecting means for motor branch circuits over 600 volts, nominal, may be out of sight of the

controller, if the controller is marked with a warning label giving the location and identification of the disconnecting means which is to be locked in the open position.

(b) The disconnecting means shall disconnect the motor and the controller from all ungrounded supply conductors and shall be so designed that no pole can be operated independently.

(c) If a motor and the driven machinery are not in sight from the controller location, the installation shall comply with one of the following conditions:

(1) The controller disconnecting means shall be capable of being locked in the open position.

(2) A manually operable switch that will disconnect the motor from its source of supply shall be placed in sight from the motor location.

(d) The disconnecting means shall plainly indicate whether it is in the open (off) or closed (on) position.

(e) The disconnecting means shall be readily accessible. If more than one disconnect is provided for the same equipment, only one need be readily accessible.

(f) An individual disconnecting means shall be provided for each motor, but a single disconnecting means may be used for a group of motors under any one of the following conditions:

(1) If a number of motors drive special parts of a single machine or piece of apparatus, such as metal and woodworking machines, cranes, and hoists;

(2) If a group of motors is under the protection of one set of branch-circuit protective devices; or

(3) If a group of motors is in a single room in sight from the location of the disconnecting means.

(iii) *Motor overload, short-circuit, and ground-fault protection.* Motors, motor-control apparatus, and motor branch-circuit conductors shall be protected against overheating due to motor overloads or failure to start, and against short-circuits or ground faults. These provisions shall not require overload protection that will stop a motor where a shutdown is likely to introduce additional or increased hazards, as in the case of fire pumps, or where continued operation of a motor is necessary for a safe shutdown of equipment or process and motor overload sensing devices are connected to a supervised alarm.

(iv) *Protection of live parts—all voltages.*—(a) Stationary motors having commutators, collectors, and brush rigging located inside of motor end brackets and not conductively connected to supply circuits operating at

more than 150 volts to ground need not have such parts guarded. Exposed live parts of motors and controllers operating at 50 volts or more between terminals shall be guarded against accidental contact by any of the following:

(1) By installation in a room or enclosure that is accessible only to qualified persons;

(2) By installation on a suitable balcony, gallery, or platform, so elevated and arranged as to exclude unqualified persons; or

(3) By elevation 8 feet or more above the floor.

(b) Where live parts of motors or controllers operating at over 150 volts to ground are guarded against accidental contact only by location, and where adjustment or other attendance may be necessary during the operation of the apparatus, suitable insulating mats or platforms shall be provided so that the attendant cannot readily touch live parts unless standing on the mats or platforms.

(5) *Transformers.*—(i) The following paragraphs cover the installation of all transformers except the following:

(a) Current transformers;

(b) Dry-type transformers installed as a component part of other apparatus;

(c) Transformers which are an integral part of an X-ray, high frequency, or electrostatic-coating apparatus;

(d) Transformers used with Class 2 and Class 3 circuits, sign and outline lighting, electric discharge lighting, and power-limited fire-protective signalling circuits; and

(e) Liquid-filled or dry-type transformers used for research, development, or testing, where effective safeguard arrangements are provided.

(ii) The operating voltage of exposed live parts of transformer installations shall be indicated by warning signs or visible markings on the equipment or structure.

(iii) Dry-type, high fire point liquid-insulated, and askarel-insulated transformers installed indoors and rated over 35kV shall be in a vault.

(iv) If they present a fire hazard to employees, oil-insulated transformers installed indoors shall be in a vault.

(v) Combustible material, combustible buildings and parts of buildings, fire escapes, and door and window openings shall be safeguarded from fires which may originate in oil-insulated transformers attached to or adjacent to a building or combustible material.

(vi) Transformer vaults shall be constructed so as to contain fire and combustible liquids within the vault and to prevent unauthorized access. Locks and latches shall be so arranged that a

vault door can be readily opened from the inside.

(vii) Any pipe or duct system foreign to the vault installation may not enter or pass through a transformer vault.

(viii) Materials may not be stored in transformer vaults.

(6) *Capacitors.* (i) All capacitors, except surge capacitors or capacitors included as a component part of other apparatus, shall be provided with an automatic means of draining the stored charge after the capacitor is disconnected from its source of supply.

(ii) Capacitors rated over 600 volts, nominal, shall comply with the following additional requirements:

(a) Isolating or disconnecting switches (with no interrupting rating) shall be interlocked with the load interrupting device or shall be provided with prominently displayed caution signs to prevent switching load current.

(b) For series capacitors (see § 1910.302(b)(3)), the proper switching shall be assured by use of at least one of the following:

(1) Mechanically sequenced isolating and bypass switches,

(2) Interlocks, or

(3) Switching procedure prominently displayed at the switching location.

(7) *Storage batteries.* Provisions shall be made for sufficient diffusion and ventilation of gases from storage batteries to prevent the accumulation of explosive mixtures.

§ 1910.306 Specific purpose equipment and installations.

(a) *Electric signs and outline lighting.*

(1) *Disconnecting means.* Signs operated by electronic or electromechanical controllers located outside the sign shall have a disconnecting means located inside the controller enclosure or within sight of the controller location, and it shall be capable of being locked in the open position. Such disconnecting means shall have no pole that can be operated independently, and it shall open all ungrounded conductors that supply the controller and sign. All other signs, except the portable type, and all outline lighting installations shall have an externally operable disconnecting means which can open all underground conductors and is within the sight of the sign or outline lighting it controls.

(2) Doors or covers giving access to uninsulated parts of indoor signs or outline lighting exceeding 600 volts and accessible to other than qualified persons shall either be provided with interlock switches to disconnect the primary circuit or shall be so fastened that the use of other than ordinary tools will be necessary to open them.

(b) *Cranes and hoists.* This paragraph applies to the installation of electric equipment and wiring used in connection with cranes, monorail hoists, hoists, and all runways.

(1) *Disconnecting means.* A readily accessible disconnecting means shall be provided between the runway contact conductors and the power supply.

(ii) Another disconnecting means, capable of being locked in the open position, shall be provided in the leads from the runway contact conductors or other power supply on any crane or monorail hoist.

(a) If this additional disconnecting means is not readily accessible from the crane or monorail hoist operating station, means shall be provided at the operating station to open the power circuit to all motors of the crane or monorail hoist.

(b) The additional disconnect may be omitted if a monorail hoist or hand-propelled crane bridge installation meets all of the following:

(1) The unit is floor controlled;

(2) The unit is within view of the power supply disconnecting means; and

(3) No fixed work platform has been provided for servicing the unit.

(2) *Control.* A limit switch or other device shall be provided to prevent the load block from passing the safe upper limit of travel of any hoisting mechanism.

(3) *Clearance.* The dimension of the working space in the direction of access to live parts which may require examination, adjustment, servicing, or maintenance while alive shall be a minimum of 2 feet 6 inches. Where controls are enclosed in cabinets, the door(s) shall either open at least 90 degrees or be removable.

(c) *Elevators, dumbwaiters, escalators, and moving walks.* (1)

Disconnecting means. Elevators, dumbwaiters, escalators, and moving walks shall have a single means for disconnecting all underground main power supply conductors for each unit.

(2) *Warning signs.* If interconnections between control panels are necessary for operation of the system on a multicar installation that remains energized from a source other than the disconnecting means, a warning sign shall be mounted on or adjacent to the disconnecting means. The sign shall be clearly legible and shall read "Warning—Parts of the control panel are not de-energized by this switch." (See § 1910.302(b)(3).)

(3) *Control panels.* If control panels are not located in the same space as the drive machine, they shall be located in cabinets with doors or panels capable of being locked closed.

(d) *Electric welders—disconnecting means.* (1) A disconnecting means shall be provided in the supply circuit for each motor-generator arc welder, and for each AC transformer and DC rectifier arc welder which is not equipped with a disconnect mounted as an integral part of the welder.

(2) A switch or circuit breaker shall be provided by which each resistance welder and its control equipment can be isolated from the supply circuit. The ampere rating of this disconnecting means may not be less than the supply conductor ampacity.

(e) *Data processing systems—disconnecting means.* A disconnecting means shall be provided to disconnect the power to all electronic equipment in data processing or computer rooms. This disconnecting means shall be controlled from locations readily accessible to the operator at the principal exit doors. There shall also be a similar disconnecting means to disconnect the air conditioning system serving this area.

(f) *X-Ray equipment.* This paragraph applies to X-ray equipment for other than medical or dental use.

(1) *Disconnecting means.* (i) A disconnecting means shall be provided in the supply circuit. The disconnecting means shall be operable from a location readily accessible from the X-ray control. For equipment connected to a 120-volt branch circuit of 30 amperes or less, a grounding-type attachment plug cap and receptacle of proper rating may serve as a disconnecting means.

(ii) If more than one piece of equipment is operated from the same high-voltage circuit, each piece or each group of equipment as a unit shall be provided with a high-voltage switch or equivalent disconnecting means. This disconnecting means shall be constructed, enclosed, or located so as to avoid contact by employees with its live parts.

(2) *Control.* (i) *Radiographic and fluoroscopic types.* Radiographic and fluoroscopic-type equipment shall be effectively enclosed or shall have interlocks that de-energize the equipment automatically to prevent ready access to live current-carrying parts.

(ii) *Diffraction and irradiation types.* Diffraction- and irradiation-type equipment shall be provided with a means to indicate when it is energized unless the equipment or installation is effectively enclosed or is provided with interlocks to prevent access to live current-carrying parts during operation.

(g) *Induction and dielectric heating equipment.* (1) *Scope.* Paragraphs (g)(2) and (g)(3) of this section cover induction

and dielectric heating equipment and accessories for industrial and scientific applications, but not for medical or dental applications or for appliances.

(2) *Guarding and grounding.* (i) *Enclosures.* The converting apparatus (including the DC line) and high-frequency electric circuits (excluding the output circuits and remote-control circuits) shall be completely contained within enclosures or noncombustible material.

(ii) *Panel controls.* All panel controls shall be of dead-front construction.

(iii) *Access to internal equipment.* Where doors are used for access to voltages from 500 to 1000 volts AC or DC, either door locks or interlocks shall be provided. Where doors are used for access to voltages of over 1000 volts AC or DC, either mechanical lockouts with a disconnecting means to prevent access until voltage is removed from the cubicle, or both door interlocking and mechanical door locks, shall be provided.

(iv) *Warning labels.* "Danger" labels shall be attached on the equipment and shall be plainly visible even when doors are open or panels are removed from compartments containing voltages of over 250 volts AC or DC.

(v) *Work applicator shielding.* Protective cages or adequate shielding shall be used to guard work applicators other than induction heating coils. Induction heating coils shall be protected by insulation and/or refractory materials. Interlock switches shall be used on all hinged access doors, sliding panels, or other such means of access to the applicator. Interlock switches shall be connected in such a manner as to remove all power from the applicator when any one of the access doors or panels is open. Interlocks on access doors or panels are not required if the applicator is an induction heating coil at DC ground potential or operating at less than 150 volts AC.

(vi) *Disconnecting means.* A readily accessible disconnecting means shall be provided by which each unit of heating equipment can be isolated from its supply circuit.

(3) *Remote control.* If remote controls are used for applying power, a selector switch shall be provided and interlocked to provide power from only one control point at a time. Switches operated by foot pressure shall be provided with a shield over the contact button to avoid accidental closing of the switch.

(h) *Electrolytic cells.* (1) *Scope.* These provisions for electrolytic cells apply to the installation of the electrical components and accessory equipment or electrolytic cells, electrolytic cell lines, and process power supply for the

production of aluminum, cadmium, chlorine, copper, fluorine, hydrogen peroxide, magnesium, sodium, sodium chlorate, and zinc. Cells used as a source of electric energy and for electroplating processes and cells used for production of hydrogen are not covered by these provisions.

(2) *Definitions applicable to this paragraph.*

Cell line: An assembly of electrically interconnected electrolytic cells supplied by a source of direct-current power.

Cell line attachments and auxiliary equipment: Cell line attachments and auxiliary equipment include, but are not limited to: auxiliary tanks; process piping; duct work; structural supports; exposed cell line conductors; conduits and other raceways; pumps; positioning equipment and cell cutout or by-pass electrical devices. Auxiliary equipment also includes tools, welding machines, crucibles, and other portable equipment used for operation and maintenance within the electrolytic cell line working zone. In the cell line working zone, auxiliary equipment includes the exposed conductive surfaces of ungrounded cranes and crane-mounted cell-servicing equipment.

Cell line working zone: The cell line working zone is the space envelope wherein operation or maintenance is normally performed on or in the vicinity of exposed energized surfaces of cell lines or their attachments.

Electrolytic Cells: A receptacle or vessel in which electrochemical reactions are caused by applying energy for the purpose of refining or producing usable materials.

(3) *Application.* Installations covered by paragraph (h) of this section shall comply with all applicable provisions of this subpart, except as follows:

(i) Overcurrent protection of electrolytic cell DC process power circuits need not comply with the requirements of § 1910.304(e).

(ii) Equipment located or used within the cell line working zone associated with the cell line DC power circuits need not comply with the provisions of § 1910.304(f).

(iii) Electrolytic cells, cell line conductors, cell line attachments, and the wiring of auxiliary equipment and devices within the cell line working zone need not comply with the provisions of §§ 1910.303, and 1910.304 (b) and (c).

(4) *Disconnecting means.* (i) If more than one DC cell line process power supply serves the same cell line, a disconnecting means shall be provided on the cell line circuit side of each power supply to disconnect it from the cell line circuit.

(ii) Removable links or removable conductors may be used as the disconnecting means.

(5) *Portable electric equipment.* (i) The frames and enclosures of portable electric equipment used within the cell line working zone may not be grounded. However, these frames and enclosures may be grounded if the cell line circuit voltage does not exceed 200 volts DC or if the frames are guarded.

(ii) Ungrounded portable electric equipment shall be distinctively marked and may not be interchangeable with grounded portable electric equipment.

(6) *Power supply circuits and receptacles for portable electric equipment.* (i) Circuits supplying power to ungrounded receptacles for hand-held, cord- and plug-connected equipment shall be electrically isolated from any distribution system supplying areas other than the cell line working zone and shall be ungrounded. Power for these circuits shall be supplied through isolating transformers.

(ii) Receptacles and their mating plugs for ungrounded equipment may not have provision for a grounding conductor and shall be of a configuration which prevents their use for equipment required to be grounded.

(iii) Receptacles on circuits supplied by an isolating transformer with an ungrounded secondary shall have a distinctive configuration, shall be distinctively marked, and may not be used in any other location in the plant.

(7) *Fixed and portable electric equipment.* (i) AC systems supplying fixed and portable electric equipment within the cell line working zone need not be grounded.

(ii) Exposed conductive surfaces, such as electric equipment housing, cabinets, boxes, motors, raceways and the like that are within the cell line working zone need not be grounded.

(iii) Auxiliary electrical devices, such as motors, transducers, sensors, control devices, and alarms, mounted on an electrolytic cell or other energized surface, shall be connected by any of the following means:

(a) Multiconductor hard usage or extra hard usage flexible cord;

(b) Wire or cable in suitable raceways; or

(c) Exposed metal conduit, cable tray, armored cable, or similar metallic systems installed with insulating breaks such that they will not cause a potentially hazardous electrical condition.

(iv) Fixed electric equipment may be bonded to the energized conductive surfaces of the cell line, its attachments, or auxiliaries. If fixed electric equipment is mounted on an energized conductive

surface, it shall be bonded to that surface.

(8) *Auxiliary nonelectric connections.* Auxiliary nonelectric connections, such as air hoses, water hoses, and the like, to an electrolytic cell, its attachments, or auxiliary equipment may not have continuous conductive reinforcing wire, armor, braids, and the like. Hoses shall be of a nonconductive material.

(9) *Cranes and hoists.* (i) The conductive surfaces of cranes and hoists that enter the cell line working zone need not be grounded. The portion of an overhead crane or hoist which contacts an energized electrolytic cell or energized attachments shall be insulated from ground.

(ii) Remote crane or hoist controls which may introduce hazardous electrical conditions into the cell line working zone shall employ one or more of the following systems:

(a) Insulated and ungrounded control circuit;

(b) Nonconductive rope operator;

(c) Pendant pushbutton with nonconductive supporting means and having nonconductive surfaces or ungrounded exposed conductive surfaces; or

(d) Radio.

(i) *Electrically driven or controlled irrigation machines.* (See § 1910.302(b)(3).)

(1) *Lightning protection.* If an electrically driven or controlled irrigation machine has a stationary point, a driven ground rod shall be connected to the machine at the stationary point for lightning protection.

(2) *Disconnecting means.* The main disconnecting means for a center pivot irrigation machine shall be located at the point of connection of electrical power to the machine and shall be readily accessible and capable of being locked in the open position. A disconnecting means shall be provided for each motor and controller.

(j) *Swimming pools, fountains, and similar installations.* (1) *Scope.* Paragraphs (j)(2) through (j)(5) of this section apply to electric wiring for and equipment in or adjacent to all swimming, wading, therapeutic, and decorative pools and fountains, whether permanently installed or storable, and to metallic auxiliary equipment, such as pumps, filters, and similar equipment. Therapeutic pools in health care facilities are exempt from these provisions.

(2) *Lighting and receptacles.* (i) *Receptacles.* A single receptacle of the locking and grounding type that provides power for a permanently installed swimming pool recirculating pump motor may be located not less

than 5 feet from the inside walls of a pool. All other receptacles on the property shall be located at least 10 feet from the inside walls of a pool. Receptacles which are located within 15 feet of the inside walls of the pool shall be protected by ground-fault circuit interrupters.

Note.—In determining these dimensions, the distance to be measured is the shortest path the supply cord of an appliance connected to the receptacle would follow without piercing a floor, wall, or ceiling of a building or other effective permanent barrier.

(ii) *Lighting fixtures and lighting outlets.* (a) Unless they are 12 feet above the maximum water level, lighting fixtures and lighting outlets may not be installed over a pool or over the area extending 5 feet horizontally from the inside walls of a pool. However, a lighting fixture or lighting outlet which has been installed before April 16, 1981 may be located less than 5 feet measured horizontally from the inside walls of a pool if it is at least 5 feet above the surface of the maximum water level and shall be rigidly attached to the existing structure. It shall also be protected by a ground-fault circuit interrupter installed in the branch circuit supplying the fixture.

(b) Unless installed 5 feet above the maximum water level and rigidly attached to the structure adjacent to or enclosing the pool, lighting fixtures and lighting outlets installed in the area extending between 5 feet and 10 feet horizontally from the inside walls of a pool shall be protected by a ground-fault circuit interrupter.

(3) *Cord- and plug-connected equipment.* Flexible cords used with the following equipment may not exceed 3 feet in length and shall have a copper equipment grounding conductor with a grounding-type attachment plug.

(i) Cord- and plug-connected lighting fixtures installed within 16 feet of the water surface of permanently installed pools.

(ii) Other cord- and plug-connected, fixed or stationary equipment used with permanently installed pools.

(4) *Underwater equipment.* (i) A ground-fault circuit interrupter shall be installed in the branch circuit supplying underwater fixtures operating at more than 15 volts. Equipment installed underwater shall be approved for the purpose.

(ii) No underwater lighting fixtures may be installed for operation at over 150 volts between conductors.

(5) *Fountains.* All electric equipment operating at more than 15 volts, including power supply cords, used with fountains shall be protected by ground-

fault circuit interrupters. (See § 1910.302(b)(3).)

§ 1910.307 Hazardous (classified) locations.

(a) *Scope.* This section covers the requirements for electric equipment and wiring in locations which are classified depending on the properties of the flammable vapors, liquids or gases, or combustible dusts or fibers which may be present therein and the likelihood that a flammable or combustible concentration or quantity is present. Hazardous (classified) locations may be found in occupancies such as, but not limited to, the following: aircraft hangars, gasoline dispensing and service stations, bulk storage plants for gasoline or other volatile flammable liquids, paint-finishing process plants, health care facilities, agricultural or other facilities where excessive combustible dusts may be present, marinas, boat yards, and petroleum and chemical processing plants. Each room, section or area shall be considered individually in determining its classification. These hazardous (classified) locations are assigned six designations as follows:

Class I, Division 1
Class I, Division 2
Class II, Division 1
Class II, Division 2
Class III, Division 1
Class III, Division 2

For definitions of these locations see § 1910.399(a). All applicable requirements in this subpart shall apply to hazardous (classified) locations, unless modified by provisions of this section.

(b) *Electrical installations.* Equipment, wiring methods, and installations of equipment in classified locations shall be intrinsically safe, approved for the hazardous (classified) location, or safe for the hazardous (classified) location. Requirements for each of these options are as follows:

(1) *Intrinsically safe.* Equipment and associated wiring approved as intrinsically safe shall be permitted in any hazardous (classified) location for which it is approved.

(2) *Approved for the hazardous (classified) location.* (i) Equipment shall be approved not only for the class of location but also for the ignitable or combustible properties of the specific gas, vapor, dust, or fiber that will be present.

Note.—NFPA 70, the National Electrical Code, lists or defines hazardous gases, vapors, and dusts by "Groups" characterized by their ignitable or combustible properties.

(ii) Equipment shall be marked to show the class, group, and operating

temperature or temperature range, based on operation in a 40 degrees C ambient, for which it is approved. The temperature marking shall not exceed the ignition temperature of the specific gas or vapor to be encountered. However, the following provisions modify this marking requirement for specific equipment:

(a) Equipment of the non-heat-producing type, such as junction boxes, conduit, and fittings, and equipment of the heat-producing type having a maximum temperature not more than 100 degrees C (212 degrees F), need not have a marked operating temperature or temperature range.

(b) Fixed lighting fixtures marked for use in Class I, Division 2 locations only, need not be marked to indicate the group.

(c) Fixed general-purpose equipment in Class I locations, other than lighting fixtures, which is acceptable for use in Class I, Division 2 locations need not be marked with the class, group, division, or operating temperature.

(d) Fixed dust-tight equipment, other than lighting fixtures, which is acceptable for use in Class II, Division 2 and Class III locations need not be marked with the class, group, division, or operating temperature.

(3) *Safe for the hazardous (classified) location.* Equipment which is safe for the location shall be of a type and design which the employer demonstrates will provide protection from the hazards arising from the combustibility and flammability of vapors, liquids, gases, dusts, or fibers.

Note.—The National Electrical Code, NFPA 70, contains guidelines for determining the type and design of equipment and installations which will meet this requirement. The guidelines of this document address electric wiring, equipment, and systems installed in hazardous (classified) locations and contain specific provisions for the following: wiring methods, wiring connections; conductor insulation, flexible cords, sealing and drainage, transformers, capacitors, switches, circuit breakers, fuses, motor controllers, receptacles, attachment plugs, meters, relays, instruments, resistors, generators, motors, lighting fixtures, storage battery charging equipment, electric cranes, electric hoists and similar equipment, utilization equipment, signaling systems, alarm systems, remote control systems, local loud speaker and communication systems, ventilation piping, live parts, lightning surge protection, and grounding. Compliance with these guidelines will constitute one means, but not the only means, of compliance with this paragraph.

(c) *Conduits.* All conduits shall be threaded and shall be made wrench-tight. Where it is impractical to make a threaded joint tight, a bonding jumper shall be utilized.

(d) *Equipment in Division 2 locations.* Equipment that has been approved for a Division 1 location may be installed in a Division 2 location of the same class and group. General-purpose equipment or equipment in general-purpose enclosures may be installed in Division 2 locations if the equipment does not constitute a source of ignition under normal operating conditions.

§ 1910.308 Special systems.

(a) *Systems over 600 volts, nominal.* Paragraphs (a)(1) through (a)(4) of this section cover the general requirements for all circuits and equipment operated at over 600 volts.

(1) *Wiring methods for fixed installations.* (i) Above-ground conductors shall be installed in rigid metal conduit, in intermediate metal conduit, in cable trays, in cablebus, in other suitable raceways, or as open runs of metal-clad cable suitable for the use and purpose. However, open runs of non-metallic-sheathed cable or of bare conductors or busbars may be installed in locations accessible only to qualified persons. Metallic shielding components, such as tapes, wires, or braids for conductors, shall be grounded. Open runs of insulated wires and cables having a bare lead sheath or a braided outer covering shall be supported in a manner designed to prevent physical damage to the braid or sheath.

(ii) Conductors emerging from the ground shall be enclosed in approved raceways. (See § 1910.302(b)(3).)

(2) *Interrupting and isolating devices.* (i) Circuit breakers located indoors shall consist of metal-enclosed or fire-resistant, cell-mounted units. In locations accessible only to qualified personnel, open mounting of circuit breakers is permitted. A means of indicating the open and closed position of circuit breakers shall be provided.

(ii) Fused cutouts installed in buildings or transformer vaults shall be of a type approved for the purpose. They shall be readily accessible for fuse replacement.

(iii) A means shall be provided to completely isolate equipment for inspection and repairs. Isolating means which are not designed to interrupt the load current of the circuit shall be either interlocked with an approved circuit interrupter or provided with a sign warning against opening them under load.

(3) *Mobile and portable equipment.* (i) *Power cable connections to mobile machines.* A metallic enclosure shall be provided on the mobile machine for enclosing the terminals of the power cable. The enclosure shall include provisions for a solid connection for the

ground wire(s) terminal to effectively ground the machine frame. The method of cable termination used shall prevent any strain or pull on the cable from stressing the electrical connections. The enclosure shall have provision for locking so only authorized qualified persons may open it and shall be marked with a sign warning of the presence of energized parts.

(ii) *Guarding live parts.* All energized switching and control parts shall be enclosed in effectively grounded metal cabinets or enclosures. Circuit breakers and protective equipment shall have the operating means projecting through the metal cabinet or enclosure so these units can be reset without locked doors being opened. Enclosures and metal cabinets shall be locked so that only authorized qualified persons have access and shall be marked with a sign warning of the presence of energized parts. Collector ring assemblies on revolving-type machines (shovels, draglines, etc.) shall be guarded.

(4) *Tunnel installations.* (i) *Application.* The provisions of this paragraph apply to installation and use of high-voltage power distribution and utilization equipment which is portable and/or mobile, such as substations, trailers, cars, mobile shovels, draglines, hoists, drills, dredges, compressors, pumps, conveyors, and underground excavators.

(ii) *Conductors.* Conductors in tunnels shall be installed in one or more of the following:

(a) Metal conduit or other metal raceway.

(b) Type MC cable, or

(c) Other approved multiconductor cable.

Conductors shall also be so located or guarded as to protect them from physical damage. Multiconductor portable cable may supply mobile equipment. An equipment grounding conductor shall be run with circuit conductors inside the metal raceway or inside the multiconductor cable jacket. The equipment grounding conductor may be insulated or bare.

(iii) *Guarding live parts.* Bare terminals of transformers, switches, motor controllers, and other equipment shall be enclosed to prevent accidental contact with energized parts. Enclosures for use in tunnels shall be drip-proof, weatherproof, or submersible as required by the environmental conditions.

(iv) *Disconnecting means.* A disconnecting means that simultaneously opens all ungrounded conductors shall be installed at each transformer or motor location.

(v) *Grounding and bonding.* All nonenergized metal parts of electric equipment and metal raceways and cable sheaths shall be effectively grounded and bonded to all metal pipes and rails at the portal and at intervals not exceeding 1000 feet throughout the tunnel.

(b) *Emergency power systems.* (1) *Scope.* The provisions for emergency systems apply to circuits, systems, and equipment intended to supply power for illumination and special loads, in the event of failure of the normal supply.

(2) *Wiring methods.* Emergency circuit wiring shall be kept entirely independent of all other wiring and equipment and may not enter the same raceway, cable, box, or cabinet with other wiring except either where common circuit elements suitable for the purpose are required, or for transferring power from the normal to the emergency source.

(3) *Emergency illumination.* Where emergency lighting is necessary, the system shall be so arranged that the failure of any individual lighting element, such as the burning out of a light bulb, cannot leave any space in total darkness.

(c) *Class 1, Class 2, and Class 3 remote control, signaling, and power-limited circuits.* (1) *Classification.* Class 1, Class 2, or Class 3 remote control, signaling, or power-limited circuits are characterized by their usage and electrical power limitation which differentiates them from light and power circuits. These circuits are classified in accordance with their respective voltage and power limitations as summarized in paragraphs (c)(1)(i) through (c)(1)(iii) of this section.

(i) *Class 1 circuits.* (a) A Class 1 power-limited circuit is supplied from a source having a rated output of not more than 30 volts and 1000 volt-amperes.

(b) A Class 1 remote control circuit or a Class 1 signaling circuit has a voltage which does not exceed 600 volts; however, the power output of the source need not be limited.

(ii) *Class 2 and Class 3 circuits.* (a) Power for Class 2 and Class 3 circuits is limited either inherently (in which no overcurrent protection is required) or by a combination of a power source and overcurrent protection.

(b) The maximum circuit voltage is 150 volts AC or DC for a Class 2 inherently limited power source, and 100 volts AC or DC for a Class 3 inherently limited power source.

(c) The maximum circuit voltage is 30 volts AC and 60 volts DC for a Class 2 power source limited by overcurrent protection, and 150 volts AC or DC for a

Class 3 power source limited by overcurrent protection.

(iii) The maximum circuit voltages in paragraphs (c)(1)(i) and (c)(1)(ii) of this section apply to sinusoidal AC or continuous DC power sources, and where wet contact occurrence is not likely.

(2) *Marking.* A Class 2 or Class 3 power supply unit shall be durably marked where plainly visible to indicate the class of supply and its electrical rating. (See § 1910.302(b)(3).)

(d) *Fire protective signaling systems.* (See § 1910.302(b)(3).)

(1) *Classifications.* Fire protective signaling circuits shall be classified either as non-power limited or power limited.

(2) *Power sources.* The power sources for use with fire protective signaling circuits shall be either power limited or nonlimited as follows:

(i) The power supply of non-power-limited fire protective signaling circuits shall have an output voltage not in excess of 600 volts.

(ii) The power for power-limited fire protective signaling circuits shall be either inherently limited, in which no overcurrent protection is required, or limited by a combination of a power source and overcurrent protection.

(3) *Non-power-limited conductor location.* Non-power-limited fire protective signaling circuits and Class 1 circuits may occupy the same enclosure, cable, or raceway provided all conductors are insulated for maximum voltage of any conductor within the enclosure, cable, or raceway. Power supply and fire protective signaling circuit conductors are permitted in the same enclosure, cable, or raceway only if connected to the same equipment.

(4) *Power-limited conductor location.* Where open conductors are installed, power-limited fire protective signaling circuits shall be separated at least 2 inches from conductors of any light, power, Class 1, and non-power-limited fire protective signaling circuits unless a special and equally protective method of conductor separation is employed. Cables and conductors of two or more power-limited fire protective signaling circuits or Class 3 circuits are permitted in the same cable, enclosure, or raceway. Conductors of one or more Class 2 circuits are permitted within the same cable, enclosure, or raceway with conductors of power-limited fire protective signaling circuits provided that the insulation of Class 2 circuit conductors in the cable, enclosure, or raceway is at least that needed for the power-limited fire protective signaling circuits.

(5) *Identification.* Fire protective signaling circuits shall be identified at terminal and junction locations in a manner which will prevent unintentional interference with the signaling circuit during testing and servicing. Power-limited fire protective signaling circuits shall be durably marked as such where plainly visible at terminations.

(e) *Communications systems.* (1) *Scope.* These provisions for communication systems apply to such systems as central-station-connected and non-central-station-connected telephone circuits, radio and television receiving and transmitting equipment, including community antenna television and radio distribution systems, telegraph, district messenger, and outside wiring for fire and burglar alarm, and similar central station systems. These installations need not comply with the provisions of §§ 1910.303 through 1910.308(d).

(2) *Protective devices.* (i) Communication circuits so located as to be exposed to accidental contact with light or power conductors operating at over 300 volts shall have each circuit so exposed provided with a protector approved for the purpose.

(ii) Each conductor of a lead-in from an outdoor antenna shall be provided with an antenna discharge unit or other suitable means that will drain static charges from the antenna system.

(3) *Conductor location.* (i) *Outside of buildings.* (a) Receiving distribution lead-in or aerial-drop cables attached to buildings and lead-in conductors to radio transmitters shall be so installed as to avoid the possibility of accidental contact with electric light or power conductors.

(b) The clearance between lead-in conductors and any lightning protection conductors may not be less than 6 feet.

(ii) *On poles.* Where practicable, communication conductors on poles shall be located below the light or power conductors. Communications conductors may not be attached to a crossarm that carries light or power conductors.

(iii) *Inside of buildings.* Indoor antennas, lead-ins, and other communication conductors attached as open conductors to the inside of buildings shall be located at least 2 inches from conductors of any light or power or Class 1 circuits unless a special and equally protective method of conductor separation, approved for the purpose, is employed.

(4) *Equipment location.* Outdoor metal structures supporting antennas, as well as self-supporting antennas such as vertical rods or dipole structures, shall be located as far away from overhead

conductors of electric light and power circuits of over 150 volts to ground as necessary to avoid the possibility of the antenna or structure falling into or making accidental contact with such circuits.

(5) *Grounding.* (i) *Lead-in conductors.* If exposed to contact with electric light and power conductors, the metal sheath of aerial cables entering buildings shall be grounded or shall be interrupted close to the entrance to the building by an insulating joint or equivalent device. Where protective devices are used, they shall be grounded in an approved manner.

(ii) *Antenna structures.* Masts and metal structures supporting antennas shall be permanently and effectively grounded without splice or connection in the grounding conductor.

(iii) *Equipment enclosures.* Transmitters shall be enclosed in a metal frame or grill or separated from the operating space by a barrier, all metallic parts of which are effectively connected to ground. All external metal handles and controls accessible to the operating personnel shall be effectively grounded. Unpowered equipment and enclosures shall be considered grounded where connected to an attached coaxial cable with an effectively grounded metallic shield.

§ 1910.309-§ 1910.330. [Reserved]

Safety-Related Work Practices

§ 1910.331-§ 1910.360. [Reserved]

Safety-Related Maintenance Requirements

§ 1910.361-§ 1910.380 [Reserved]

Safety Requirements for Special Equipment

§ 1910.381-§ 1910.398 [Reserved]

Definitions

§ 1910.399 Definitions applicable to this subpart.

(a) *Definitions applicable to §§ 1910.302 through 1910.330.*

(1) *Acceptable.* An installation or equipment is acceptable to the Assistant Secretary of Labor, and approved within the meaning of this Subpart S: (i) If it is accepted, or certified, or listed, or labeled, or otherwise determined to be safe by a nationally recognized testing laboratory, such as, but not limited to, Underwriters' Laboratories, Inc. and Factory Mutual Engineering Corp.; or (ii) with respect to an installation or equipment of a kind which no nationally recognized testing laboratory accepts, certifies, lists, labels, or determines to be safe, if it is inspected or tested by

another Federal agency, or by a State, municipal, or other local authority responsible for enforcing occupational safety provisions of the National Electrical Code, and found in compliance with the provisions of the National Electrical Code as applied in this Subpart; or (iii) with respect to custom-made equipment or related installations which are designed, fabricated for, and intended for use by a particular customer, if it is determined to be safe for its intended use by its manufacturer on the basis of test data which the employer keeps and makes available for inspection to the Assistant Secretary and his authorized representatives.

(2) *Accepted.* An installation is "accepted" if it has been inspected and found by a nationally recognized testing laboratory to conform to specified plans or to procedures of applicable codes.

(3) *Accessible.* (As applied to wiring methods.) Capable of being removed or exposed without damaging the building structure or finish, or not permanently closed in by the structure or finish of the building. (See "concealed" and "exposed.")

(4) *Accessible.* (As applied to equipment.) Admitting close approach; not guarded by locked doors, elevation, or other effective means. (See "Readily accessible.")

(5) *Ampacity.* Current-carrying capacity of electric conductors expressed in amperes.

(6) *Appliances.* Utilization equipment, generally other than industrial, normally built in standardized sizes or types, which is installed or connected as a unit to perform one or more functions such as clothes washing, air conditioning, food mixing, deep frying, etc.

(7) *Approved.* Acceptable to the authority enforcing this Subpart. The authority enforcing this Subpart is the Assistant Secretary of Labor for Occupational Safety and Health. The definition of "acceptable" indicates what is acceptable to the Assistant Secretary of Labor, and therefore approved within the meaning of this Subpart.

(8) *Approved for the purpose.* Approved for a specific purpose, environment, or application described in a particular standard requirement.

Suitability of equipment or materials for a specific purpose, environment or application may be determined by a nationally recognized testing laboratory, inspection agency or other organization concerned with product evaluation as part of its listing and labeling program. (See "Labeled" or "Listed.")

(9) *Armored cable.* Type AC armored cable is a fabricated assembly of

insulated conductors in a flexible metallic enclosure.

(10) *Askarel.* A generic term for a group of nonflammable synthetic chlorinated hydrocarbons used as electrical insulating media. Askarels of various compositional types are used. Under arcing conditions the gases produced, while consisting predominantly of noncombustible hydrogen chloride, can include varying amounts of combustible gases depending upon the askarel type.

(11) *Attachment plug (Plug cap) (Cap).* A device which, by insertion in a receptacle, establishes connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle.

(12) *Automatic.* Self-acting, operating by its own mechanism when actuated by some impersonal influence, as, for example, a change in current strength, pressure, temperature, or mechanical configuration.

(13) *Bare conductor.* See "Conductor."

(14) *Bonding.* The permanent joining of metallic parts to form an electrically conductive path which will assure electrical continuity and the capacity to conduct safely any current likely to be imposed.

(15) *Bonding jumper.* A reliable conductor to assure the required electrical conductivity between metal parts required to be electrically connected.

(16) *Branch circuit.* The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s).

(17) *Building.* A structure which stands alone or which is cut off from adjoining structures by fire walls with all openings therein protected by approved fire doors.

(18) *Cabinet.* An enclosure designed either for surface or flush mounting, and provided with a frame, mat, or trim in which a swinging door or doors are or may be hung.

(19) *Cable tray system.* A cable tray system is a unit or assembly of units or sections, and associated fittings, made of metal or other noncombustible materials forming a rigid structural system used to support cables. Cable tray systems include ladders, troughs, channels, solid bottom trays, and other similar structures.

(20) *Cablebus.* Cablebus is an approved assembly of insulated conductors with fittings and conductor terminations in a completely enclosed, ventilated, protective metal housing.

(21) *Center pivot irrigation machine.* A center pivot irrigation machine is a multi-motored irrigation machine which

revolves around a central pivot and employs alignment switches or similar devices to control individual motors.

(22) *Certified*. Equipment is "certified" if it (a) has been tested and found by a nationally recognized testing laboratory to meet nationally recognized standards or to be safe for use in a specified manner, or (b) is of a kind whose production is periodically inspected by a nationally recognized testing laboratory, and (c) it bears a label, tag, or other record of certification.

(23) *Circuit breaker*. (i) (600 volts nominal, or less). A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without injury to itself when properly applied within its rating.

(ii) (Over 600 volts, nominal). A switching device capable of making, carrying, and breaking currents under normal circuit conditions, and also making, carrying for a specified time, and breaking currents under specified abnormal circuit conditions, such as those of short circuit.

(24) *Class I locations*. Class I

locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class I locations include the following:

(i) *Class I, Division 1*. A Class I, Division 1 location is a location: (a) in which hazardous concentrations of flammable gases or vapors may exist under normal operating conditions; or (b) in which hazardous concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or (c) in which breakdown or faulty operation of equipment or processes might release hazardous concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment.

Note.—This classification usually includes locations where volatile flammable liquids or liquefied flammable gases are transferred from one container to another; interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used; locations containing open tanks or vats of volatile flammable liquids; drying rooms or compartments for the evaporation of flammable solvents; locations containing fat and oil extraction equipment using volatile flammable solvents; portions of cleaning and dyeing plants where flammable liquids are used; gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape; inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids; the interiors of refrigerators and freezers in which volatile

flammable materials are stored in open, lightly stoppered, or easily ruptured containers; and all other locations where ignitable concentrations of flammable vapors or gases are likely to occur in the course of normal operations.

(ii) *Class I, Division 2*. A Class I, Division 2 location is a location: (a) in which volatile flammable liquids or flammable gases are handled, processed, or used, but in which the hazardous liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment; or (b) in which hazardous concentrations of gases or vapors are normally prevented by positive mechanical ventilation, and which might become hazardous through failure or abnormal operations of the ventilating equipment; or (c) that is adjacent to a Class I, Division 1 location, and to which hazardous concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

Note.—This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used, but which would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors to be merit considered in determining the classification and extent of each location.

Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Locations used for the storage of flammable liquids or a liquefied or compressed gases in sealed containers would not normally be considered hazardous unless also subject to other hazardous conditions.

Electrical conduits and their associated enclosures separated from process fluids by a single seal or barrier are classed as a Division 2 location if the outside of the conduit and enclosures is a nonhazardous location.

(25) *Class II locations*. Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations include the following:

(i) *Class II, Division 1*. A Class II, Division 1 location is a location: (a) in which combustible dust is or may be in suspension in the air under normal operating conditions, in quantities

sufficient to produce explosive or ignitable mixtures; or (b) where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitable mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, operation of protection devices, or from other causes, or (c) in which combustible dusts of an electrically conductive nature may be present.

Note.—This classification may include areas of grain handling and processing plants, starch plants, sugar-pulverizing plants, malting plants, hay-grinding plants, coal pulverizing plants, areas where metal dusts and powders are produced or processed, and other similar locations which contain dust producing machinery and equipment (except where the equipment is dust-tight or vented to the outside). These areas would have combustible dust in the air, under normal operating conditions, in quantities sufficient to produce explosive or ignitable mixtures. Combustible dusts which are electrically nonconductive include dusts produced in the handling and processing of grain and grain products, pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and woodflour, oil meal from beans and seed, dried hay, and other organic materials which may produce combustible dusts when processed or handled. Dusts containing magnesium or aluminum are particularly hazardous and the use of extreme caution is necessary to avoid ignition and explosion.

(ii) *Class II, Division 2*. A Class II, Division 2 location is a location in which, (a) combustible dust will not normally be in suspension in the air in quantities sufficient to produce explosive or ignitable mixtures; and dust accumulations are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus; or (b) Dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment, and dust accumulations resulting therefrom may be ignitable by abnormal operation or failure of electrical equipment or other apparatus.

Note.—This classification includes locations where dangerous concentrations of suspended dust would not be likely but where dust accumulations might form on or in the vicinity of electric equipment. These areas may contain equipment from which appreciable quantities of dust would escape under abnormal operation conditions or be adjacent to a Class II Division 1 location, as described above, into which an explosive or ignitable concentration of dust may be put into suspension under abnormal operating conditions.

(26) *Class III locations*. Class III locations are those that are hazardous because of the presence of easily

ignitable fibers or flyings but in which such fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitable mixtures. Class III locations include the following:

(i) *Class III, Division 1.* A Class III, Division 1 location is a location in which easily ignitable fibers or materials producing combustible flyings are handled, manufactured, or used.

Note.—Such locations usually include some parts of rayon, cotton, and other textile mills; combustible fiber manufacturing and processing plants; cotton gins and cottonseed mills; flax-processing plants; clothing manufacturing plants; woodworking plants, and establishments; and industries involving similar hazardous processes or conditions.

Easily ignitable fibers and flyings include rayon, cotton (including cotton linters and cotton waste), sisal or henequen,istle, jute, hemp, tow, cocoa fiber, oakum, baled waste kapok, Spanish moss, excelsior, and other materials of similar nature.

(ii) *Class III, Division 2.* A Class III, Division 2 location is a location in which easily ignitable fibers are stored or handled, except in process of manufacture.

(27) *Collector ring.* A collector ring is an assembly of slip rings for transferring electrical energy from a stationary to a rotating member.

(28) *Concealed.* Rendered inaccessible by the structure or finish of the building. Wires in concealed raceways are considered concealed, even though they may become accessible by withdrawing them. [See "Accessible. (As applied to wiring methods)."]

(29) *Conductor.* (i) *Bare.* A conductor having no covering or electrical insulation whatsoever.

(ii) *Covered.* A conductor encased within material of composition or thickness that is not recognized as electrical insulation.

(iii) *Insulated.* A conductor encased within material of composition and thickness that is recognized as electrical insulation.

(30) *Conduit body.* A separate portion of a conduit or tubing system that provides access through a removable cover(s) to the interior of the system at a junction of two or more sections of the system or at a terminal point of the system. Boxes such as FS and FD or larger cast or sheet metal boxes are not classified as conduit bodies.

(31) *Controller.* A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

(32) *Cooking unit, counter-mounted.* A cooking appliance designed for mounting in or on a counter and consisting of one or more heating

elements, internal wiring, and built-in or separately mountable controls. (See "Oven, wall-mounted.")

(33) *Covered conductor.* See "Conductor."

(34) *Cutout.* (Over 600 volts, nominal.) An assembly of a fuse support with either a fuseholder, fuse carrier, or disconnecting blade. The fuseholder or fuse carrier may include a conducting element (fuse link), or may act as the disconnecting blade by the inclusion of a nonfusible member.

(35) *Cutout box.* An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box proper. (See "Cabinet.")

(36) *Damp location.* See "Location."

(37) *Dead front.* Without live parts exposed to a person on the operating side of the equipment.

(38) *Device.* A unit of an electrical system which is intended to carry but not utilize electric energy.

(39) *Dielectric heating.* Dielectric heating is the heating of a nominally insulating material due to its own dielectric losses when the material is placed in a varying electric field.

(40) *Disconnecting means.* A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply.

(41) *Disconnecting (or Isolating) switch.* (Over 600 volts, nominal.) A mechanical switching device used for isolating a circuit or equipment from a source of power.

(42) *Dry location.* See "Location."

(43) *Electric sign.* A fixed, stationary, or portable self-contained, electrically illuminated utilization equipment with words or symbols designed to convey information or attract attention.

(44) *Enclosed.* Surrounded by a case, housing, fence or walls which will prevent persons from accidentally contacting energized parts.

(45) *Enclosure.* The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized parts, or to protect the equipment from physical damage.

(46) *Equipment.* A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like, used as a part of, or in connection with, an electrical installation.

(47) *Equipment grounding conductor.* See "Grounding conductor, equipment."

(48) *Explosion-proof apparatus.* Apparatus enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor which may occur within it and of preventing the ignition of a specified gas or vapor

surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within, and which operates at such an external temperature that it will not ignite a surrounding flammable atmosphere.

(49) *Exposed.* (As applied to live parts.) Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated, or insulated. (See "Accessible," and "Concealed.")

(50) *Exposed.* (As applied to wiring methods.) On or attached to the surface or behind panels designed to allow access. [See "Accessible. (As applied to wiring methods)."]

(51) *Exposed.* (For the purposes of § 1910.308(e), *Communications systems*.) Where the circuit is in such a position that in case of failure of supports or insulation, contact with another circuit may result.

(52) *Externally operable.* Capable of being operated without exposing the operator to contact with live parts.

(53) *Feeder.* All circuit conductors between the service equipment, or the generator switchboard of an isolated plant, and the final branch-circuit overcurrent device.

(54) *Fitting.* An accessory such as a locknut, bushing, or other part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function.

(55) *Fuse.* (Over 600 volts, nominal.) An overcurrent protective device with a circuit opening fusible part that is heated and severed by the passage of overcurrent through it. A fuse comprises all the parts that form a unit capable of performing the prescribed functions. It may or may not be the complete device necessary to connect it into an electrical circuit.

(56) *Ground.* A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

(57) *Grounded.* Connected to earth or to some conducting body that serves in place of the earth.

(58) *Grounded, effectively.* (Over 600 volts, nominal.) Permanently connected to earth through a ground connection of sufficiently low impedance and having sufficient ampacity that ground fault current which may occur cannot build up to voltages dangerous to personnel.

(59) *Grounded conductor.* A system or circuit conductor that is intentionally grounded.

(60) *Grounding conductor.* A conductor used to connect equipment or

the grounded circuit of a wiring system to a grounding electrode or electrodes.

(61) *Grounding conductor, equipment.* The conductor used to connect the non-current-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor and/or the grounding electrode conductor at the service equipment or at the source of a separately derived system.

(62) *Grounding electrode conductor.* The conductor used to connect the grounding electrode to the equipment grounding conductor and/or to the grounded conductor of the circuit at the service equipment or at the source of a separately derived system.

(63) *Ground-fault circuit-interrupter.* A device whose function is to interrupt the electric circuit to the load when a fault current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit.

(64) *Guarded.* Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach to a point of danger or contact by persons or objects.

(65) *Health care facilities.* Buildings or portions of buildings and mobile homes that contain, but are not limited to, hospitals, nursing homes, extended care facilities, clinics, and medical and dental offices, whether fixed or mobile.

(66) *Heating equipment.* For the purposes of § 1910.306(g), the term "heating equipment" includes any equipment used for heating purposes if heat is generated by induction or dielectric methods.

(67) *Hoistway.* Any shaftway, hatchway, well hole, or other vertical opening or space in which an elevator or dumbwaiter is designed to operate.

(68) *Identified.* Identified, as used in reference to a conductor or its terminal, means that such conductor or terminal can be readily recognized as grounded.

(69) *Induction heating.* Induction heating is the heating of a nominally conductive material due to its own I²R losses when the material is placed in a varying electromagnetic field.

(70) *Insulated conductor.* See under "Conductor."

(71) *Interrupter switch.* (Over 600 volts, nominal.) A switch capable of making, carrying, and interrupting specified currents.

(72) *Irrigation machine.* An irrigation machine is an electrically driven or controlled machine, with one or more motors, not hand portable, and used primarily to transport and distribute water for agricultural purposes.

(73) *Isolated.* Not readily accessible to persons unless special means for access are used.

(74) *Isolated power system.* A system comprising an isolating transformer or its equivalent, a line isolation monitor, and its ungrounded circuit conductors.

(75) *Labeled.* Equipment is "labeled" if there is attached to it a label, symbol, or other identifying mark of a nationally recognized testing laboratory which, (a) makes periodic inspections of the production of such equipment, and (b) whose labeling indicates compliance with nationally recognized standards or tests to determine safe use in a specified manner.

(76) *Lighting outlet.* An outlet intended for the direct connection of a lampholder, a lighting fixture, or a pendant cord terminating in a lampholder.

(77) *Listed.* Equipment is "listed" if it is of a kind mentioned in a list which, (a) is published by a nationally recognized laboratory which makes periodic inspection of the production of such equipment, and (b) states such equipment meets nationally recognized standards or has been tested and found safe for use in a specified manner.

(78) *Location.* (i) *Damp location.* Partially protected locations under canopies, marquees, roofed open porches, and like locations, and interior locations subject to moderate degrees of moisture, such as some basements, some barns, and some cold-storage warehouses.

(ii) *Dry location.* A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.

(iii) *Wet location.* Installations underground or in concrete slabs or masonry in direct contact with the earth, and locations subject to saturation with water or other liquids, such as vehicle-washing areas, and locations exposed to weather and unprotected.

(79) *Medium voltage cable.* Type MV medium voltage cable is a single or multiconductor solid dielectric insulated cable rated 2000 volts or higher.

(80) *Metal-clad cable.* Type MC cable is a factory assembly of one or more conductors, each individually insulated and enclosed in a metallic sheath of interlocking tape, or a smooth or corrugated tube.

(81) *Mineral-insulated metal-sheathed cable.* Type MI mineral-insulated metal-sheathed cable is a factory assembly of one or more conductors insulated with a highly compressed refractory mineral insulation and enclosed in a liquidtight and gastight continuous copper sheath.

(82) *Mobile X-ray.* X-ray equipment mounted on a permanent base with wheels and/or casters for moving while completely assembled.

(83) *Nonmetallic-sheathed cable.* Nonmetallic-sheathed cable is a factory assembly of two or more insulated conductors having an outer sheath of moisture resistant, flame-retardant, nonmetallic material. Nonmetallic sheathed cable is manufactured in the following types:

(i) *Type NM.* The overall covering has a flame-retardant and moisture-resistant finish.

(ii) *Type NMC.* The overall covering is flame-retardant, moisture-resistant, fungus-resistant, and corrosion-resistant.

(84) *Oil (filled) cutout.* (Over 600 volts, nominal.) A cutout in which all or part of the fuse support and its fuse link or disconnecting blade are mounted in oil with complete immersion of the contacts and the fusible portion of the conducting element (fuse link), so that arc interruption by severing of the fuse link or by opening of the contacts will occur under oil.

(85) *Open wiring on insulators.* Open wiring on insulators is an exposed wiring method using cleats, knobs, tubes, and flexible tubing for the protection and support of single insulated conductors run in or on buildings, and not concealed by the building structure.

(86) *Outlet.* A point on the wiring system at which current is taken to supply utilization equipment.

(87) *Outline lighting.* An arrangement of incandescent lamps or electric discharge tubing to outline or call attention to certain features such as the shape of a building or the decoration of a window.

(88) *Oven, wall-mounted.* An oven for cooking purposes designed for mounting in or on a wall or other surface and consisting of one or more heating elements, internal wiring, and built-in or separately mountable controls. (See "Cooking unit, counter-mounted.")

(89) *Overcurrent.* Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload (see definition), short circuit, or ground fault. A current in excess of rating may be accommodated by certain equipment and conductors for a given set of conditions. Hence the rules for overcurrent protection are specific for particular situations.

(90) *Overload.* Operation of equipment in excess of normal, full load rating, or of a conductor in excess of rated ampacity which, when it persists for a sufficient length of time, would

cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload. (See "Overcurrent.")

(91) *Panelboard*. A single panel or group of panel units designed for assembly in the form of a single panel; including buses, automatic overcurrent devices, and with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall or partition and accessible only from the front. (See "Switchboard.")

(92) *Permanently installed decorative fountains and reflection pools*. Those that are constructed in the ground, on the ground, or in a building in such a manner that the pool cannot be readily disassembled for storage and are served by electrical circuits of any nature. These units are primarily constructed for their aesthetic value and not intended for swimming or wading.

(93) *Permanently installed swimming pools, wading and therapeutic pools*. Those that are constructed in the ground, on the ground, or in a building in such a manner that the pool cannot be readily disassembled for storage whether or not served by electrical circuits of any nature.

(94) *Portable X-ray*. X-ray equipment designed to be hand-carried.

(95) *Power and control tray cable*. Type TC power and control tray cable is a factory assembly of two or more insulated conductors, with or without associated bare or covered grounding conductors under a nonmetallic sheath, approved for installation in cable trays, in raceways, or where supported by a messenger wire.

(96) *Power fuse*. (Over 600 volts, nominal.) See "Fuse."

(97) *Power-limited tray cable*. Type PLTC nonmetallic-sheathed power limited tray cable is a factory assembly of two or more insulated conductors under a nonmetallic jacket.

(98) *Power outlet*. An enclosed assembly which may include receptacles, circuit breakers, fuseholders, fused switches, buses and watt-hour meter mounting means; intended to supply and control power to mobile homes, recreational vehicles or boats, or to serve as a means for distributing power required to operate mobile or temporarily installed equipment.

(99) *Premises wiring system*. That interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all of its associated hardware, fittings, and wiring devices, both permanently and temporarily installed, which extends

from the load end of the service drop, or load end of the service lateral conductors to the outlet(s). Such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment.

(100) *Qualified person*. One familiar with the construction and operation of the equipment and the hazards involved.

(101) *Raceway*. A channel designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this subpart. Raceways may be of metal or insulating material, and the term includes rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquidtight flexible metal conduit, flexible metallic tubing, flexible metal conduit, electrical metallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface raceways, wireways, and busways.

(102) *Readily accessible*. Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc. (See "Accessible.")

(103) *Receptacle*. A receptacle is a contact device installed at the outlet for the connection of a single attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is a single device containing two or more receptacles.

(104) *Receptacle outlet*. An outlet where one or more receptacles are installed.

(105) *Remote-control circuit*. Any electric circuit that controls any other circuit through a relay or an equivalent device.

(106) *Sealable equipment*. Equipment enclosed in a case or cabinet that is provided with a means of sealing or locking so that live parts cannot be made accessible without opening the enclosure. The equipment may or may not be operable without opening the enclosure.

(107) *Separately derived system*. A premises wiring system whose power is derived from generator, transformer, or converter winding and has no direct electrical connection, including a solidly connected grounded circuit conductor, to supply conductors originating in another system.

(108) *Service*. The conductors and equipment for delivering energy from the electricity supply system to the wiring system of the premises served.

(109) *Service cable*. Service conductors made up in the form of a cable.

(110) *Service conductors*. The supply conductors that extend from the street main or from transformers to the service equipment of the premises supplied.

(111) *Service drop*. The overhead service conductors from the last pole or other aerial support to and including the splices, if any, connecting to the service-entrance conductors at the building or other structure.

(112) *Service-entrance cable*. Service-entrance cable is a single conductor or multiconductor assembly provided with or without an overall covering, primarily used for services and of the following types:

(i) *Type SE*, having a flame-retardant, moisture-resistant covering, but not required to have inherent protection against mechanical abuse.

(ii) *Type USE*, recognized for underground use, having a moisture-resistant covering, but not required to have a flame-retardant covering or inherent protection against mechanical abuse. Single-conductor cables having an insulation specifically approved for the purpose do not require an outer covering.

(113) *Service-entrance conductors, overhead system*. The service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop.

(114) *Service entrance conductors, underground system*. The service conductors between the terminals of the service equipment and the point of connection to the service lateral. Where service equipment is located outside the building walls, there may be no service-entrance conductors, or they may be entirely outside the building.

(115) *Service equipment*. The necessary equipment, usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise defined area, and intended to constitute the main control and means of cutoff of the supply.

(116) *Service raceway*. The raceway that encloses the service-entrance conductors.

(117) *Shielded nonmetallic-sheathed cable*. Type SNM, shielded nonmetallic-sheathed cable is a factory assembly of two or more insulated conductors in an extruded core of moisture-resistant, flame-resistant nonmetallic material, covered with an overlapping spiral metal tape and wire shield and jacketed with an extruded moisture-, flame-, oil-, corrosion-, fungus-, and sunlight-resistant nonmetallic material.

(118) *Show window.* Any window used or designed to be used for the display of goods or advertising material, whether it is fully or partly enclosed or entirely open at the rear and whether or not it has a platform raised higher than the street floor level.

(119) *Sign.* See "Electric Sign."

(120) *Signaling circuit.* Any electric circuit that energizes signaling equipment.

(121) *Special permission.* The written consent of the authority having jurisdiction.

(122) *Storable swimming or wading pool.* A pool with a maximum dimension of 15 feet and a maximum wall height of 3 feet and is so constructed that it may be readily disassembled for storage and reassembled to its original integrity.

(123) *Switchboard.* A large single panel, frame, or assembly of panels which have switches, buses, instruments, overcurrent and other protective devices mounted on the face or back or both. Switchboards are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets. (See "Panelboard.")

(124) *Switches.*

(i) *General-use switch.* A switch intended for use in general distribution and branch circuits. It is rated in amperes, and it is capable of interrupting its rated current at its rated voltage.

(ii) *General-use snap switch.* A form of general-use switch so constructed that it can be installed in flush device boxes or on outlet box covers, or otherwise used in conjunction with wiring systems recognized by this subpart.

(iii) *Isolating switch.* A switch intended for isolating an electric circuit from the source of power. It has no interrupting rating, and it is intended to be operated only after the circuit has been opened by some other means.

(iv) *Motor-circuit switch.* A switch, rated in horsepower, capable of interrupting the maximum operating overload current of a motor of the same horsepower rating as the switch at the rated voltage.

(125) *Switching devices.* (Over 600 volts, nominal.) Devices designed to close and/or open one or more electric circuits. Included in this category are circuit breakers, cutouts, disconnecting (or isolating) switches, disconnecting means, interrupter switches, and oil (filled) cutouts.

(126) *Transportable X-ray.* X-ray equipment installed in a vehicle or that may readily be disassembled for transport in a vehicle.

(127) *Utilization equipment.* Utilization equipment means equipment which utilizes electric energy for mechanical, chemical, heating, lighting, or similar useful purpose.

(128) *Utilization system.* A utilization system is a system which provides electric power and light for employee workplaces, and includes the premises wiring system and utilization equipment.

(129) *Ventilated.* Provided with a means to permit circulation of air sufficient to remove an excess of heat, fumes, or vapors.

(130) *Volatile flammable liquid.* A flammable liquid having a flash point below 38 degrees C (100 degrees F) or whose temperature is above its flash point.

(131) *Voltage (of a circuit).* The greatest root-mean-square (effective) difference of potential between any two conductors of the circuit concerned.

(132) *Voltage, nominal.* A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (as 120/240, 480Y/277, 600, etc.). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

(133) *Voltage to ground.* For grounded circuits, the voltage between the given conductor and that point or conductor of the circuit that is grounded; for ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit.

(134) *Watertight.* So constructed that moisture will not enter the enclosure.

(135) *Weatherproof.* So constructed or protected that exposure to the weather will not interfere with successful operation. Rainproof, raintight, or watertight equipment can fulfill the requirements for weatherproof where varying weather conditions other than wetness, such as snow, ice, dust, or temperature extremes, are not a factor.

(136) *Wet location.* See "Location."

(137) *Wireways.* Wireways are sheet-metal troughs with hinged or removable covers for housing and protecting electric wires and cable and in which conductors are laid in place after the wireway has been installed as a complete system.

(b) *Definitions applicable to §§ 1910.331 through 1910.360 [Reserved].*

(c) *Definitions applicable to §§ 1910.361 through 1910.380 [Reserved].*

(d) *Definitions applicable to §§ 1910.381 through 1910.398 [Reserved].*

Appendix A—Reference Documents

The following references provide information which can be helpful in understanding and complying with the requirements contained in Subpart S:

- ANSI A17.1-71 Safety Code for Elevators, Dumbwaiters, Escalators and Moving Walks.
- ANSI B9.1-71 Safety Code for Mechanical Refrigeration.
- ANSI B30.2-76 Safety Code for Overhead and Gantry Cranes.
- ANSI B30.3-75 Hammerhead Tower Cranes.
- ANSI B30.4-73 Safety Code for Portal, Tower, and Pillar Cranes.
- ANSI B30.5-68 Safety Code for Crawler, Locomotive, and Truck Cranes.
- ANSI B30.6-77 Derricks.
- ANSI B30.7-77 Base Mounted Drum Hoists.
- ANSI B30.8-71 Safety Code for Floating Cranes and Floating Derricks.
- ANSI B30.11-73 Monorail Systems and Underhung Cranes.
- ANSI B30.12-75 Handling Loads Suspended from Rotocraft.
- ANSI B30.13-77 Controlled Mechanical Storage Cranes.
- ANSI B30.15-73 Safety Code for Mobile Hydraulic Cranes.
- ANSI B30.16-73 Overhead Hoists.
- ANSI C2-77 National Electrical Safety Code.
- ANSI C33.27-74 Safety Standard for Outlet Boxes and Fittings for Use in Hazardous Locations, Class I, Groups A, B, C, and D, and Class II, Groups E, F, and G.
- ANSI K61.1-72 Safety Requirements for the Storage and Handling of Anhydrous Ammonia.
- ASTM D2155-66 Test Method for Autoignition Temperature of Liquid Petroleum Products.
- ASTM D3176-74 Method for Ultimate Analysis of Coal and Coke.
- ASTM D3180-74 Method for Calculating Coal and Coke Analyses from As Determined to Different Bases.
- IEEE 483-77 Standard for Electrical Safety Practices in Electrolytic Cell Line Working Zones.
- NFPA 20-76 Standard for the Installation of Centrifugal Fire Pumps.
- NFPA 30-76 Flammable and Combustible Liquids Code.
- NFPA 32-74 Standard for Drycleaning Plants.
- NFPA 33-73 Standard for Spray Application Using Flammable and Combustible Materials.
- NFPA 34-74 Standard for Dip Tanks Containing Flammable or Combustible Liquids.
- NFPA 35-76 Standard for the Manufacture of Organic Coatings.
- NFPA 38-74 Standard for Solvent Extraction Plants.
- NFPA 40-74 Standard for the Storage and Handling of Cellulose Nitrate Motion Picture Film.
- NFPA 56A-73 Standard for the Use of Inhalation Anesthetics (Flammable and Nonflammable).
- NFPA 56F-74 Standard for Nonflammable Medical Gas Systems.
- NFPA 58-76 Standard for the Storage and Handling of Liquefied Petroleum Gases.
- NFPA 59-76 Standard for the Storage and Handling of Liquefied Petroleum Gases at Utility Gas Plants.
- NFPA 70-78 National Electrical Code.
- NFPA 70C-74 Hazardous Locations Classification.

- NFPA 70E Standard for the Electrical Safety Requirements for Employee Workplaces.
- NFPA 71-77 Standard for the Installation, Maintenance, and Use of Central Station Signaling Systems.
- NFPA 72A-75 Standard for the Installation, Maintenance, and Use of Local Protective Signaling Systems for Watchman, Fire Alarm, and Supervisory Service.
- NFPA 72B-75 Standard for the Installation, Maintenance, and Use of Auxiliary Protective Signaling Systems for Fire Alarm Service.
- NFPA 72C-75 Standard for the Installation, Maintenance, and Use of Remote Station Protective Signaling Systems.
- NFPA 72D-75 Standard for the Installation, Maintenance, and Use of Proprietary Protective Signaling Systems for Watchman, Fire Alarm, and Supervisory Service.
- NFPA 72E-74 Standard for Automatic Fire Detectors.
- NFPA 74-75 Standard for Installation, Maintenance, and Use of Household Fire Warning Equipment.
- NFPA 76A-73 Standard for Essential Electrical Systems for Health Care Facilities.
- NFPA 77-72 Recommended Practice on Static Electricity.
- NFPA 80-77 Standard for Fire Doors and Windows.
- NFPA 86A-73 Standard for Ovens and Furnaces; Design, Location and Equipment.
- NFPA 88A-73 Standard for Parking Structures.
- NFPA 88B-73 Standard for Repair Garages.
- NFPA 91-73 Standard for the Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal, or Conveying.
- NFPA 101-78 Code for Safety to Life from Fire in Buildings and Structures. (Life Safety Code.)
- NFPA 325M-69 Fire-Hazard Properties of Flammable Liquids, Gases, and Volatile Solids.
- NFPA 493-75 Standard for Intrinsically Safe Apparatus for Use in Class I Hazardous Locations and Its Associated Apparatus.
- NFPA 496-74 Standard for Purged and Pressurized Enclosures for Electrical Equipment in Hazardous Locations.
- NFPA 497-75 Recommended Practice for Classification of Class I Hazardous Locations for Electrical Installations in Chemical Plants.
- NFPA 505-75 Fire Safety Standard for Powered Industrial Trucks Including Type Designations and Areas of Use.
- NMAB 353-1-79 Matrix of Combustion-Relevant Properties and Classification of Gases, Vapors, and Selected Solids.
- NMAB 353-2-79 Test Equipment for Use in Determining Classifications of Combustible Dusts.
- NMAB 353-3-80 Classification of Combustible Dusts in Accordance with the National Electrical Code.

Appendix B—Explanatory Data [Reserved]

Appendix C—Tables, Notes, and Charts [Reserved]

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Part III

Department of Labor

**Occupational Safety and Health
Administration**

**Occupational Noise Exposure; Hearing
Conservation Amendment**

DEPARTMENT OF LABOR

29 CFR Part 1910

Occupational Noise Exposure; Hearing Conservation Amendment

AGENCY: The Occupational Safety and Health Administration (OSHA) of the United States Department of Labor.

ACTION: Final rule.

SUMMARY: This final rule establishes a hearing conservation program, including exposure monitoring, audiometric testing, and training, for all employees who have occupational noise exposures equal to or exceeding an 8-hour time-weighted average of 85 dBA. This amendment covers all employees except those engaged in construction or agriculture. This rule is the outgrowth of the proposed revision of the occupational noise exposure standard which was proposed in 1974. By its action today, OSHA is deferring final action on two issues raised in the 1974 proposal: the permissible exposure level for occupational noise and the appropriate method of compliance with the permissible exposure level. These two issues will continue to be governed by the existing standard.

OSHA plans to study these two issues further and will in the near future reopen the record for the submission of new evidence on these issues.

EFFECTIVE DATE: This standard will become effective April 15, 1981. Start-up dates: Employee exposure monitoring shall be completed by October 15, 1981. Dosimeters used to measure employee exposures must meet the specifications in the standard by April 15, 1983. Baseline audiograms shall be completed by April 15, 1982.

FOR FURTHER INFORMATION CONTACT: Dr. Alice Suter, Office of Physical Agents Standards, Occupational Safety and Health Administration, Room N-3718, U.S. Department of Labor, 200 Constitution Avenue NW., Washington, D.C. 20210, Telephone (202) 523-7151.

Copies of any portion of the record including the Final Environmental Impact Statement and Regulatory Analysis may be obtained by contacting: Docket Officer, Docket No. OSH-11, Room S-6212, U.S. Department of Labor, 200 Constitution Avenue, N.W., Washington, D.C. 20210, Telephone (202) 523-7894.

I. Introduction

Rationale for Amendment

Noise is one of the most pervasive occupational health problems. It is a by-product of many industrial processes.

Exposure to high levels of noise causes temporary or permanent hearing loss and may cause other harmful health effects as well. The extent of damage depends primarily on the intensity of the noise and the duration of the exposure.

There is an abundance of epidemiological and laboratory evidence that protracted noise exposure above 90 decibels (dB) causes hearing loss in a substantial portion of the exposed population, and that more susceptible individuals will incur hearing loss at levels below 90 dB (Ex. 11; Ex. 12; Ex. 17; Ex. 26-2). This is discussed more fully in the Health Effects section below. Noise-induced hearing loss in an irreversible condition that progresses with increased exposure, and is exacerbated by the normal aging process. Although such a loss may be slight at first, continued exposure may result in a loss that is severe enough to affect seriously an individual's ability to understand speech. In some cases, even slight losses in the audiometric frequencies that are critical for the understanding of speech can adversely affect an individual's ability to earn a living and to function in society in general. It constitutes a serious physical, psychological, and social handicap. Such impairment of a critical functional capacity clearly is the type of material impairment of health, which Congress, in Section 6(b)(5) of the Act, directed the Secretary to prevent.

Noise can also cause other adverse effects, such as degraded job performance, increases in accidents and absenteeism, job dissatisfaction, headaches, fatigue, sleeplessness, stress-related illnesses, and other effects that are more difficult to quantify and identify as noise-related than is hearing loss (Ex. 2C-108, p. 2; Ex. 2C-111, p. 1; Ex. 96, pp. 277-281; Ex. 189-8, p. 2; Ex. 28A, pp. 18-24, 27-28, 41-44, 46-49; Ex. 32, App. B, Gulian, pp. 6-11; Ex. 79, p. 2; Ex. 173, pp. 1-2, 7-8; Ex. 84, attach. 2, pp. 1-2).

OSHA's existing standard for occupational exposure to noise (29 CFR 1910.95) specifies a maximum permissible noise exposure level of 90 dB for a duration of 8 hours, with higher levels allowed for shorter durations. (This level is called a time-weighted average sound level, abbreviated TWA.) Employers must use feasible engineering or administrative controls, or combinations of both, whenever employee exposure to noise in the workplace exceeds the permissible exposure level. Personal protective equipment may be used to supplement the engineering and administrative controls where such controls are not

able to reduce the employee exposures to within permissible limits. The standard also requires employers to administer a "continuing, effective hearing conservation program" for overexposed employees, but the standard does not define such a program.

OSHA proposed a revised noise standard in 1974, which maintained the current standard's 90 dB time-weighted average exposure limit, but required exposure monitoring, and articulated the requirements for hearing conservation programs. There was a great deal of controversy in the rulemaking proceedings about alternative permissible exposure limits and their technical and economic feasibility, but few challenged the concept or the appropriateness of a hearing conservation program. (Tr. 551-553; Tr. 210; Ex. 308, Secs. J2C, J1C, J4C; Ex. 305; Ex. 2C-16A; Ex. 2C-16B)

Analysis of the hearing record reveals information gaps in the area of extra-auditory physiological effects of noise (adverse health effects other than loss of hearing, such as high blood pressure), and also in the areas of economic and technological feasibility of noise control. The Agency needs to obtain additional material and to perform additional impact analyses before issuing a comprehensive new regulation. Therefore, for the present, OSHA will leave the permissible exposure level and compliance mechanisms of the current noise standard unchanged and continue its enforcement. The Agency will defer the final decision on methods of compliance and the permissible exposure level until it has obtained and evaluated the necessary information. The decision to implement a hearing conservation program is separate and severable from the remaining issues.

While such information is being obtained, employees must be afforded additional protection against the effects of noise. Information in the record indicates that many employees are not receiving the benefits of engineering controls to reduce their exposures to within the permissible exposure limits. In fact, there are some 2.9 million workers in American production industries with TWAs in excess of 90 dB, and an additional 2.3 million whose exposure levels exceed 85 dB. These workers, who face a significant risk of material impairment of health or functional capacity, will receive greatly increased protection from the promulgation and enforcement of these hearing conservation requirements, which amend certain provisions of the present noise standard. The provision of

this protection in the form of a well-defined hearing conservation program does not depend upon a determination of an appropriate exposure level or compliance strategy. These issues were treated separately in the proposal and the decision to implement a hearing conservation program first is consistent with the mandate of the Act that, insofar as possible, workers be protected from any material impairment of health or functional capacity.

Hearing conservation programs constitute commonly accepted industrial hygiene practice. Many companies already have instituted programs for their noise-exposed workforce (Ex. 306; Ex. 147A; Ex. 147C). This amendment clarifies what a hearing conservation program must be, and gives direction to the implementation of such a program.

Hearing conservation includes noise exposure monitoring, audiometric testing, the use of hearing protective devices where necessary, and employee education. All of these elements are reasonably necessary and appropriate for a continuing effective hearing conservation program. These procedures will result in considerable benefits for more than 5.2 million employees. Hearing protective devices will reduce the incidence of noise-induced hearing loss and also the various extra-auditory effects described below. Audiometric tests will enable employers and employees to take proper precautions to prevent further deterioration of hearing. Monitoring and educational programs will increase general awareness of noise problems, and promote the effective use of ear protectors. Another benefit, which was suggested by a National Institute for Occupational Safety and Health study, is a reduction in workplace accidents and absenteeism (Ex. 26-11, pp. ii, 5-2).

At this time the Agency does not believe that a hearing conservation program alone is the solution to the problem of workplace noise. The Agency continues to support the policy, reflected in the existing standard and not affected by this amendment, that engineering control of noise is preferable to the use of personal protective devices. The record contains considerable evidence that hearing protectors do not always provide as much attenuation in practice as the manufacturer indicates (Ex. 319, B-12, p. 4; Ex. 300A, p. 91; Ex. 301, p. 33), that many workers dislike using hearing protectors (Ex. 79, pp. 7-8; Ex. 94, pp. 9-10; Ex. 78, p. 14), and that protectors can be very uncomfortable (Ex. 73, Attach. 4, p. 1; Ex. 79, p. 7; Ex. 321-45A, pp. 1-11; Ex. 94, p. 10; Ex. 78, p. 14). In fact the

degree of protection provided by such devices is questionable since they may become unseated through talking or chewing during the course of the workday.

When hearing protectors are relied upon, the adequacy of protection will depend upon the quality of the hearing protector, the tightness of the fit, and its use by employees. Permanent hearing loss can occur before it is identified by audiometric testing and, of course, extra-auditory effects cannot be detected by audiometry. Thus, none of these measures are as effective as controlling the hazard at the source.

Physical Properties of Sound

Sound consists of pressure changes in a medium (usually air), caused by vibration or turbulence. These pressure changes take the form of alternating compression and rarefaction of molecules, producing waves that propagate away from a vibrating or turbulent source. The magnitude and the type of effect on humans depend on three physical parameters of sound: level, frequency, and duration. Sound pressure level is a logarithmic measure of the magnitude of the pressure change, which is perceived as loudness. Sound pressure level is expressed in decibels, abbreviated dB. The magnitude, or intensity, of sound is perceived as loudness. The entire range of audible sound pressure (for individuals with normal hearing a range of more than ten million to one), can be compressed into a practical scale of 0 to 140 dB. Because of the logarithmic scale, a small increase in decibels represents a large increase in sound energy. Technically, each increase of 3 dB represents a doubling of sound energy, an increase of 10 dB represents a tenfold increase, and a 20-dB increase represents a 100-fold increase in sound energy.

The frequency of a sound is the number of times that a complete cycle of compressions and rarefactions occurs in a second. The descriptor, which used to be "cycles per second," is now hertz, abbreviated Hz. Frequency is perceived as pitch. The audible range of frequencies for humans with good hearing is 20 Hz to 20,000 Hz. Most everyday sounds contain a mixture of frequencies generated by a variety of sources. A sound's frequency composition is referred to as the spectrum. Frequency spectrum can be a determinant of the annoyance caused by noise, with high frequency noise being generally more annoying than low frequency noise. Also, narrow frequency bands or pure tones (single frequencies) can be somewhat more harmful to hearing than is broad band noise.

The third important parameter is the way a sound level varies over time. The duration of a sound can be measured in microseconds (the duration of a gunshot) to indefinitely long periods (typical of the hum of an electrical transformer). Industrial noise is usually described as continuous, fluctuating, intermittent, or impulsive. Continuous noise, like the sound of a fan or a motor, remains relatively constant for a long period of time. Fluctuating noise, such as the sound of a vehicle in different gears, rises and falls in intensity over a period of time. Intermittent noise ceases or falls to low levels between "on-times," or periods of much higher levels. Drilling or sawing operations are examples of intermittent noise. Impulse noise is characterized by a sharp rise in sound pressure level to a high peak, followed by a rapid decay. Impulses can occur in quiet conditions, or they can be superimposed on a background of continuous or fluctuating noise, which is typical of the production industries. Sometimes a distinction is made between impulse noise, which is non-reverberant, and impact noise, which is reverberant. Since impulsive noise in industry can be either reverberant or non-reverberant, and since the relevant parameter is pulse duration, only one term, "impulse noise," will be used.

Sound levels are relevant under this standard only as they affect employees. If the employee is not present while high sound levels are being generated, OSHA is not concerned. The Agency is concerned with employee *exposures*, which is the accumulation of noise levels experienced by employees, as these levels are distributed over the workshift. This distinction is important because some comments in the record reflected a misunderstanding of the difference between workplace sound levels and employee levels (Ex. 14-96, p. 1; Ex. 14-79, p. 1). Although the frequency spectrum of a sound may have some effect on hearing loss, it is primarily the combination of level and duration that determines the degree to which noise will cause hearing loss and extra-auditory health effects. The manner in which level and duration are combined, for purposes of predicting adverse effects or calculating noise "dose" or 8-hour time-weighted average sound level, depends upon the "exchange rate." This combination is sometimes referred to as the "doubling rate," or the "time-intensity" tradeoff. A 5-dB exchange rate is used in 29 CFR 1910.95 and in this amendment. Specifically, a 5-dB increase in level is permitted for each halving of duration,

or conversely, a doubling of duration necessitates a 5-dB decrease in level.

Noise exposure can be described either in terms of an 8-hour time-weighted average sound level or a noise dose. For purposes of Section 29 CFR 1910.95 and this amendment the integration is performed according to a 5-dB exchange rate, referenced to a "criterion" level of 90 dB and a criterion duration of 8 hours. A worker's 8-hour time-weighted average sound level (TWA) is obtained from the time integral of the various noise levels experienced over the entire workshift. For example, for purposes of the hearing conservation amendment, the exposure of an individual who works 12 hours in continuous noise of 90 dB would correspond to a TWA of 93 dB.

Noise dose is the same concept expressed in percent. A dose of 50 percent means that one-half of the permitted TWA has been experienced. It could represent 8 hours at 85 dB, 4 hours at 90 dB, 16 hours at 80 dB, or other such combinations.

Hearing and Hearing Loss

The auditory system has three primary components: the outer ear serves to direct sound into the ear, the middle ear mechanically transmits the sound waves from the air to the fluid-filled inner ear, and the inner ear changes the sound waves from mechanical to neural energy. This last process is done in a small organ known as the cochlea, where sensory cells respond to the mechanical vibrations, change them into electrical energy, and transmit the message to the brain via the auditory nerve.

Noise-induced hearing loss can be temporary or permanent. Temporary hearing loss results from short-term exposures to noise, with normal hearing returning after a period of rest. This temporary decrease in hearing ability is called temporary threshold shift (TTS), a person's hearing threshold being the level of sound that he or she can just barely hear. For example, if a person with normal hearing works all day in a noisy environment, measurements at the end of the day would show that he or she could not hear as well as at the beginning of the day. But by the next morning, after a period of quiet, this person's hearing would have returned to normal. Generally, prolonged exposure to noise over a period of several years causes permanent damage to the sensory cells of the cochlea. A person who regularly sustains TTS will eventually suffer permanent hearing loss, which will occur gradually over time. The occurrence of TTS shows that a worker has been affected by noise,

and if that individual continues to be exposed to the same levels of noise, it will result in a noise-induced permanent threshold shift (NIPTS).

The ability to hear sounds with clarity is a distinct attribute of normal hearing. Damage to the outer or middle ear can produce a problem with the perception of sound intensity. Damage to the cochlea or the auditory nerve is termed "sensori-neural," and causes impaired perception of intelligibility as well as intensity. Even if sounds are amplified, they still seem indistinct. Sensori-neural hearing loss is irreversible. People with noise-induced hearing loss sometimes can benefit from the use of a hearing aid, but the aid can never "correct" a hearing loss the way eyeglasses usually can correct for impaired vision (Ex. 231, written testimony, p. 5). Hearing aids merely amplify sound, but they do not make it clearer, or less distorted. Also, they amplify the unwanted noise as well as the wanted speech signals.

Noise-induced hearing loss is sensori-neural. It is a permanent condition, and cannot be treated medically. It is characterized by a declining sensitivity to high frequency sounds, usually to frequencies above 2000 Hz. The loss usually appears first and is most severe for the 4000-Hz frequency; the "4000-Hz notch" in the audiogram is typical of noise-induced hearing loss. With continued exposure, the loss spreads to the other audiometric frequencies, 500 through 6000 Hz. This phenomenon results in difficulties in the perception of speech. Most of the sound energy of speech is in the vowel sounds, and yet most of the intelligibility lies in the consonants. People with noise-induced, high-frequency hearing loss typically have difficulty hearing consonant sounds, and therefore have difficulty understanding speech (Ex. 9, p. 18). These problems will be discussed more fully in the Health Effects section below.

The hearing-impaired person is often frustrated by missing information that is vital for social or vocational functioning. Not only will people have to speak louder, but they must speak more clearly in order to be understood. In addition, background noise, such as radio, TV, or other people talking, has a much more disruptive effect on hearing-impaired individuals than on the normal listener because these individuals are less able to differentiate between the wanted signal and the unwanted background noise (Ex. 50, p. 6; Ex. 321-16 B, pp. 9, 10, 14, 49-50). People with noise-induced hearing impairments may be lost when trying to communicate in a group or on a noisy street.

Studies in the record show that some individuals suffer severe hearing losses

as a result of noise exposure (Ex. 12, p. 158; Ex. 310, p. 22; Ex. 279, 11-13, p. 443; Ex. 26-2, p. 51). These individuals would rate themselves as hearing very poorly, or even as deaf (Ex. 29, p. 85).

Social relationships become increasingly difficult as the hearing impairment becomes more severe. Audiologist Dr. W. Grady Thomas of the University of North Carolina explains some of the difficulties experienced by the hearing impaired as follows:

depression, isolation, suspicion and withdrawal from social contacts . . . can be expected in some individuals with moderate hearing loss. . . . Adjustment problems in adults who lose hearing are difficult because habit patterns are firmly established. . . . Also, the evaluation of self, to a great extent is affected by the individual's perceptions of the evaluation of himself by others. Having to continually ask people to repeat misunderstood speech messages can contribute to feelings of inadequacy and insecurity. (Tr. 815-816)

Other Adverse Effects

In addition to hearing loss, noise can cause other harmful effects. Noise can interfere with conversation to the extent that communication is virtually impossible, causing a feeling of isolation among workers. High levels of noise, even though they may be of relatively short duration, can mask warning shouts or signals. Injuries and even fatalities have been reported in conditions where the noise masked danger signals or cries for help (Ex. 26-1, p. 7; Ex. 78, p. 20).

There is increasing evidence that noise can cause adverse effects on general health. Laboratory and field studies implicate noise as a causative factor in stress-related illnesses, such as hypertension, ulcers, and neurological disorders. These effects, as well as more details on noise-induced hearing loss, will be discussed in subsequent sections of this preamble.

Measurement of Noise and Hearing Loss

There are two major types of instruments that are used to measure occupational noise. These are the noise dosimeter and the sound level meter. Noise dosimeters measure noise dose by directly integrating a function of the various sound levels over the entire workshift. For this reason they are quite useful in workplaces where noise levels vary throughout the workshift. The dosimeter gives a reading in terms of percentage of allowable exposure. The person being monitored wears the dosimeter throughout the workshift. Results of the monitoring are obtained after the dosimeter is taken off, either by pressing a button on the dosimeter or by plugging it into a master unit which then

gives a "readout." Since employee noise exposure is expressed either as percentage of allowable dose, or as a TWA, OSHA has included a chart in Appendix A, which presents the relationship between these forms of measurement.

A sound level meter registers the level of sound that occurs at a particular time. It is useful for measuring the noise level due to a given process, or for measuring a worker's exposure to sound that fluctuates relatively little. Sound level meters contain a microphone, an amplifier with a calibrated attenuator, a set of frequency response networks, and an indicator meter.

Most sound level meters and dosimeters are small, "general purpose" (Type 2) instruments, equipped with "weighting networks," which adjust the meter response to predetermined frequency portions of the measured sounds. The A-weighting network is most commonly used in the measurement of industrial and environmental noise. The A-weighting network discriminates against low-frequency sound and, to a lesser extent, against high-frequency sound. The rationale behind A-weighting is that low frequency sound, and some fairly high-frequency sound, is not as damaging or as irritating as sound in the mid-frequency range. Thus, A-weighted sound level appears to be a good predictor of human response to noise. A-weighted sound levels will be assumed throughout the amendment and preamble unless otherwise specified. Most general purpose sound level meters also have a C-weighting network, which basically reflects sound as it occurs in the environment, without any adjustment for human response. The C-weighting network is useful in determining the effectiveness of hearing protectors for particular noise conditions, since it does not discount the presence of low-frequency sound.

The frequency range is sometimes divided into octave bands. By measuring the sound level in each octave-band one can determine the spectrum of the noise. Each band is identified by its center frequency, such as 125, 250, 500, 1000, 2000, 4000 and 8000 Hz. Octave band measurements are necessary when selecting a room in which to perform audiometric testing, and in certain audiometer calibrations. They can also be helpful for assessing engineering control strategies. To determine the level of noise in different frequency bands, a sound level meter with an octave-band filter set is needed. This instrument is somewhat larger and more complex than the general purpose sound

level meter that is used for measuring A-weighted and C-weighted sound levels.

The instrument that is used to test hearing is the audiometer. Audiometers produce pure tones at specific frequencies (e.g., 250, 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz) and at specific sound levels. OSHA has required that employee hearing be tested at the frequencies 500 through 6000 Hz, since these are the most important frequencies for understanding speech, and since they are useful for determining the cause of the hearing loss.

The record of a given individual's hearing sensitivity is an audiogram. An audiogram shows hearing threshold level measured in decibels as a function of frequency in hertz. It indicates how intense or loud a sound at a given frequency must be before it can be perceived, thereby providing a graphic representation of the status of the individual's hearing. With periodic audiometric testing it is possible to trace and document hearing loss, and by doing so, to prevent further loss from occurring. The audiogram is an important indicator of early hearing loss, since losses can occur so gradually that a person may not realize that he or she is becoming impaired until a substantial amount of hearing is lost.

There are two principal types of audiometers, manual and self-recording. When a manual audiometer is used the technician adjusts the level of the tone to the point where the individual being tested can just hear it, and the technician records the level as hearing threshold. A self-recording audiometer allows the test subject to adjust the level of the tone, and the intensity of the tone is constantly recorded by a stylus, which records the results on a moving card.

Hearing threshold levels, as they are recorded from the audiometer, are given in decibels above audiometric zero. Audiometric zero is not the same as 0 dB sound pressure level, the zero reference level to which sound level meters are set. Audiometric zero deviates somewhat from 0 dB sound pressure level at each test frequency. (For example, the deviation is 10 dB at 1000 Hz, and 8.5 dB at 2000 Hz.) Audiometric zero represents the median hearing threshold level of young people with normal hearing. While some individuals may have unusually good hearing sensitivity (as good as -10 dB), others may have hearing thresholds of 10 or 15 dB and still be considered within the range of normal. Therefore, audiometric zero (as opposed to 0 dB sound pressure level) reflects an adjustment to represent normal baseline hearing.

Audiometric zero has been standardized for the U.S. population in American National Standard Specification for Audiometers S3.6-1969. This zero reference level is assumed throughout the amendment and preamble unless otherwise specified.

II. Health Effects

The effects of occupational noise can be divided into two principal categories: auditory effects and extra-auditory effects. There is a wealth of information on the relationship between noise exposure and hearing loss. Dose-response relationships have been well established. Numerous studies are available which describe the effects of noise on hearing as a function of level and duration. The effects are stated in terms of the audiometric frequencies at which the loss occurs, degree of hearing loss, anatomical changes (in animal experiments), and differential changes in hearing as variables such as age and sex interact with noise exposure.

The extra-auditory effects of noise involve complex physiological and psychosocial reactions, which are much more difficult to document. Although stress-related illnesses have been associated with noise exposure, isolating all of the factors which contribute to stress confounds efforts to provide a direct "cause and effect" relationship between noise and such stress-related conditions as hypertension or ulcers. Although precise dose-response relationships are lacking at this time, information on the extra-auditory effects is included in this discussion because the data are highly suggestive of adverse effects, and therefore provide added incentive for protecting noise exposed workers.

A. Hearing Loss.

There is no doubt that noise exposure causes hearing loss, which grows more severe as exposure continues over the years. Many witnesses spoke with first-hand knowledge of the effect of noise exposure on their hearing, and consequently, on their lives. Ruth Knowles, President of Local 1716 of the Textile Workers Union, testified as follows about her noise-induced hearing loss:

It has been a gradual loss of hearing for me, so gradual that I never really realized it until a few years ago, when a relative asked me if I did not hear well. After then I started noticing that it was getting worse and that I was having to strain more to hear clearly. I became alarmed and consulted a specialist, only to be told that nothing could be done and that the hearing loss had been caused by high noise exposure.

It is truly a sad, helpless feeling that you have been told that you have lost a significant part of your second most

important sensor. As time has passed, I have been embarrassed because I was not able to hear well enough to know what was going on. I have even given an affirmative nod only to find out later that it should have been a negative answer. Socially speaking, there have been many, many instances that because of my hearing impairment, I would rather have stayed at home. It is difficult for me to hear and understand most waitresses in restaurants and a few times I have even had to tell them that I did not hear well, after which they speak so loudly that everyone around turns to look. My family has come to realize this problem and usually volunteers their help.

Also, I am never able to hear sales persons in grocery stores or bank tellers. At times it has become so disturbing that I have actually sat down and cried when I would get home. Persons who do not suffer any loss of hearing can't possibly realize the humiliation those of us who have impaired hearing go through. (Tr. 2021-2022).

Material Impairment

Section 6(b)(5) of the Occupational Safety and Health Act indicates that when dealing with a harmful physical agent the Secretary should set a standard which guards against material impairment of health or functional capacity, even if the worker is exposed for a working lifetime. As discussed below, noise is a harmful physical agent. The hearing conservation amendment is reasonably necessary to mitigate the significant risk of noise, which is present in most workplaces. This amendment is necessary to prevent large numbers of workers from suffering material impairment of health and functional capacity resulting from exposure to noise. As shown below, even assuming compliance with the current occupational noise exposure standard, many workers will still be at increased risk of suffering material impairment of functional capacity from noise in the workplace. The hearing conservation program prescribed in this amendment will save at least 189,000 workers from suffering material impairment after the program is fully effective. Accordingly OSHA finds that this amendment is reasonably necessary and appropriate, not only to provide healthful, but to provide safe places of employment.

OSHA defines material impairment of hearing as an average hearing level, with respect to audiometric zero, that exceeds 25 dB for the frequencies 1000, 2000, and 3000 Hz. This hearing level is sometimes called a "fence" in that it provides a demarcation point along the continuum of hearing levels, above which a hearing loss is considered, in the language of the Occupational Safety and Health Act, a "material impairment of health or functional capacity." Most audiologists and acousticians will agree

that small amounts of hearing loss can be tolerated. If more than a small amount of loss is suffered, a person cannot function as well as a normally hearing individual. The selection of the point or "fence" beyond which an individual person cannot function as well becomes the definition of material impairment of hearing.

OSHA believes that the capacity to hear and understand speech is the most critical function of human hearing. Therefore the definition of material impairment of hearing is directly related to people's ability to understand speech as it is spoken in everyday social conditions. Assessing this ability can be done by a variety of speech audiometric tests. Since speech audiometry is not well standardized, researchers and administrators have used pure-tone thresholds to estimate hearing for speech. As explained in the introductory section, these thresholds are the lowest levels at which a listener can just barely hear discrete frequency tones.

There is very little debate about the usefulness of pure tones to assess hearing impairment, but there is some disagreement about the hearing level, or fence, at which material impairment begins, and about which audiometric frequencies to use in the assessment. Setting the fence at a high hearing level means that workers are allowed to lose quite a lot of hearing before the loss is considered to be a material impairment to be prevented. Setting the fence at a low hearing level means that relatively little hearing is lost before the loss or impairment is considered material. The lower the fence, the larger will be the number of workers identified as materially impaired. The selection of audiometric frequencies also has an effect on the number of workers that will be identified. Since noise-induced hearing loss affects the high frequencies earlier and more severely than the low frequencies, more workers will be identified as crossing the fence or suffering material impairment when high frequencies are used in the definition. It should be noted that the use of high frequencies in the definition of material impairment more accurately portrays a worker's actual hearing loss, since those frequencies are more severely affected by noise.

The hearing levels and audiometric frequencies that constitute the definition of material impairment of hearing have been identified through studies of the ability to communicate in everyday listening conditions. Some of these studies were submitted to the record, and the issue of material impairment received considerable attention.

Until now, the Agency had not conclusively defined material impairment of hearing. For purposes of the proposal, OSHA had used the definition of hearing handicap developed in 1959 by the American Academy of Ophthalmology and Otolaryngology (AAOO), a subgroup of the American Medical Association (Ex. 3, p. 44; Ex. 6, p. 12337). The AAOO definition, which has been used primarily for workers' compensation purposes, uses a 25-dB fence for average hearing levels at the frequencies 500, 1000, and 2000 Hz. Some comments to the record (Ex. 35, p. 1; Ex. 26-3, p. 5-24; Ex. 26-4, p. 1) favored this definition, because it was thought to describe an individual's ability to communicate under everyday conditions. However, several commenters pointed out that it would not be appropriate to use the same formula for prevention and compensation (Ex. 47, p. 5; Ex. 46, pp. 364-365; Ex. 51, p. 4; Ex. 57, pp. 9-10). Dr. H. E. von Gierke of the U.S. Air Force commented on this subject on behalf of the EPA. He states that: "Formulas developed for assessing hearing handicap for compensation purposes were never intended to be used for purposes of preventive criteria." (Ex. 47, p. 5).

In its criteria document NIOSH recommended that the definition of material impairment be expanded to include the ability to hear and to understand speech in noisy or difficult listening conditions. NIOSH used an average loss of 1000, 2000, and 3000 Hz in the frequency averaging, still using a 25-dB fence (Ex. 1, pp. VI-11 through VI-14). Various studies and comments supported the 1000, 2000, and 3000 Hz definition as being more realistic than the 500, 1000, and 2000 Hz AAOO definition, because good hearing in the higher frequencies (2000 and 3000 Hz) is very important for understanding speech especially when there is noise in the background, or when speech is not clear. It was also noted that everyday listening conditions are noisy at least part of the time rather than being completely quiet (Ex. 1, p. VI-13; Ex. 50, p. 16; Ex. 321-16B, pp. 9-10, 61; Ex. 5, p. 43803), which is the assumption in the AAOO formula.

Dr. Aage Moller, Professor of Physiological Acoustics at the Karolinska Institute in Stockholm, commented on the severity of the AAOO definition in his testimony for the AFL-CIO:

The 26 dB hearing loss average value for frequencies 500, 1000 and 2000 Hz is (by AAOO) assumed to correspond to a beginning loss of ability to understand speech in the quiet. Historically this definition originates from the limit where workmen's

compensation was to be paid for loss of hearing power. Such a hearing loss will no doubt by most people be regarded as a rather severe handicap in normal social life. It will with most people make it impossible or at least very difficult to participate in parties where more than one person speaks at a time. People with that degree of hearing loss will also have difficulties to understand novel words and numbers. It is thus somewhat surprising that this "limit of a handicap" at present has been accepted as "the limit of a tolerable" impairment of the hearing. It has been suggested to exchange 500 Hz with 3000 Hz to give more realistic estimates of beginning loss of intelligibility of speech. (Ex. 88, pp. 3-4).

William C. Sperry, a private individual whose hearing impairment was very close to the AAOO-identified point of beginning handicap, filed a comment (Ex. 184). He believed that his hearing loss was sufficient to warrant buying a hearing aid. Although the hearing aid sometimes helped, there were other times when hearing was extremely difficult. He stated:

In a situation where there is a high ambient noise level, such as parties, I might as well leave my hearing aid at home, and very often, I go home after a short while since the multitude of speakers and all of the noise frequently makes it impossible to follow conversations. In any situation, where there is background noise, such as an air-conditioner, I find that communication is difficult, with or without the hearing aid. . . . I submit to you that people with my hearing loss are considerably more than just barely impaired. A standard that allows an average of 25 dB hearing loss at 500, 1000 and 2000 Hz very definitely allows material impairment to occur, and does not prevent people from losing one of their most valuable abilities, namely the ability to communicate effectively with each other. (Ex. 184, pp. 4-5).

Finally it was pointed out that the AAOO formula does not distinguish between a person who has a noise-induced hearing loss and a person who has a conductive hearing loss since it includes 500 Hz and excludes the frequencies above 2000 Hz (Ex. 1, pp. VI-12 and VI-13). Conductive hearing loss (which can be the result of many nonoccupational factors such as ear infections) tends to be of the same magnitude across all frequencies so that the loss has a flat appearance on the audiogram. Noise-induced hearing loss produces a sloping configuration, the loss being much more severe in the high frequencies than in the low frequencies, especially in the early stages. Since 500 Hz is the last and least severely affected of the test frequencies, it is not nearly so important as 3000 Hz in characterizing the audiogram of the individual with noise-induced hearing loss.

In 1979 the American Medical Association (AMA) (Ex. 321-10, p. 2058)

changed its formula for hearing handicap, and now advocates a low fence of 25 dB for hearing levels averaged at the frequencies 500, 1000, 2000, and 3000 Hz. The AMA has chosen to include 3000 Hz because it now recognizes the value of high-frequency hearing in more realistic listening situations (Ex. 321-10, p. 2058). However, the primary use of the AMA formula for "medico-legal" (compensation) purposes remains unchanged.

Another method for describing material impairment, developed by the Committee on Hearing, Bioacoustics and Biomechanics of the National Academy of Sciences (CHABA), was discussed by Dr. W. Dixon Ward (Ex. 222C, pp. 12-13) and Dr. Thomas (Ex. 51, pp. 7, 8). The CHABA report specified that a fence of 35 dB should be used if hearing levels at 1000, 2000, and 3000 Hz were averaged (Ex. 222C, pp. 12-13). CHABA's charge was to find a low fence for the frequencies 1000, 2000, and 3000 Hz that would yield the same compensation as a 25-dB fence at 500, 1000, and 2000 Hz (Ex. 51, pp. 7-8). Since this formula was specifically concerned with compensation, rather than with prevention, OSHA does not consider it appropriate for use in a standard to prevent material impairment of hearing. The CHABA committee made no attempt to define material impairment of hearing by examining research results on the ability to understand speech and to function in everyday life.

EPA (Ex. 189-5, p. 11) recommended a 25-dB fence for hearing levels averaged at the frequencies 1000, 2000, and 4000 Hz, and later submitted a study (Ex. 321-16B, pp. 60, 61) to support the same frequencies but using an even lower fence.

Other witnesses also recommended lower fences or higher frequencies than those employed by the AAOO. Dr. Karl Kryter of the Stanford Research Institute, testifying on behalf of EPA (Ex. 50, p. 8; Tr. 776-778) criticized the AAOO formula, and suggested a fence at least as low as 15 dB if the frequencies 500, 1000, and 2000 Hz were used. Joseph Hafkenschiel of the Communications Workers of America, recommended a 15-dB fence for the frequencies 500, 1000, and 2000 Hz (Ex. 82, p. 4), and others also argued that a 25-dB fence allows too much hearing loss (Ex. 189-5, p. 7; Ex. 184, p. 5; Ex. 50, p. 4). A fence of 15 dB at 500, 1000, and 2000 Hz would be equivalent to a hearing level of 25 dB if the frequencies 1000, 2000, and 3000 Hz were used (Ex. 50, p. 19).

A report submitted by the Center for Policy Alternatives at the Massachusetts

Institute of Technology (Ex. 138A, pp. 2-2 to 2-3) recommended using a variety of fences to describe different degrees of hearing loss experienced by a noise exposed population.

Dr. William Burns, professor of physiology at the University of London, pointed out (Tr. 851) that the British Standard, Method of Test for Estimating the Risk of Hearing Handicap due to Noise Exposure (in draft form at the time of his testimony), estimated risk data for the frequencies 1000, 2000, and 3000 Hz, although the standard used a fence of 30 dB. This fence and frequency combination were also recommended by the British to the International Organization for Standardization (Proposal from the UK-Member Body of ISO/TC 43/SC 1 for a revision of ISO 1999—Acoustics—Assessment of Occupational Noise Exposure for Hearing Conservation Purposes). These two documents later were submitted to the record by EPA as Exhibits 286E (p. 15) and 279, 11-10 (p. 1).

Following the original recommendation of NIOSH, OSHA will consider as material impairment a 25-dB fence for the frequencies 1000, 2000, and 3000 Hz. The agency agrees with the many comments and studies cited to show that high-frequency hearing is critically important for the understanding of speech (Ex. 46, p. 363; Ex. 26-1, p. 3; Ex. 26-6, p. 830; Ex. 228, p. 8; Ex. 5, p. 43803; Ex. 51, pp. 6-7), and that everyday speech is sometimes distorted and often takes place in noisy conditions. Therefore, the Agency believes that 3000 Hz should be included in the definition of material impairment, and 500 Hz, since it is not so important for understanding speech (Ex. 1, p. VI-16; Ex. 26-6, p. 830; Ex. 26-7, p. 1217; Ex. 321-16B, pp. 42-44) and since it is last and least affected by noise, should be excluded from the definition.

OSHA has considered including the 4000-Hz frequency in the definition of material impairment as recommended by EPA, since hearing at this frequency appears to be particularly valuable at times when listening conditions are noisy and distorted (Ex. 26-6, p. 830; Ex. 26-7, p. 1217; Ex. 321-16B, pp. 34-45). However, OSHA recognizes that listening conditions are favorable at least part of the time, and until data become available to show the typical proportion of favorable to unfavorable listening conditions, or the average amount of distortion that occurs in everyday speech, OSHA will continue to use the 25-dB fence at 1000, 2000, and 3000 Hz as recommended by NIOSH (Ex. 1, p. VI-11) and others (Ex. 88, pp. 3-4, Ex. 26-7, pp. 1217, 1223; Ex. 50, pp. 6,

19). This is not to say that the 4000-Hz frequency has no importance for the understanding of speech and that unlimited loss should be allowed in that frequency, but only that it is not included in the definition of material impairment at this time. In the typical noise-induced hearing loss pattern, severe losses at 4000 Hz are almost always accompanied by losses at 3000 Hz which are nearly as severe (Ex. 12, p. 136, fig. 10.19; Ex. 26-2, pp. 36-47; Ex. 1, fig. 7). Therefore, losses at 4000 Hz would not be unaccounted for.

The Agency has accepted the recommendation of the Center for Policy Alternatives to examine the effects of noise on hearing by means of a variety of fences. In the discussion of the anticipated benefits of hearing conservation programs, the Agency uses fences at 15 dB, 25 dB, and 40 dB for the frequencies 1000, 2000, and 3000 Hz. The 25-dB fence, however, is considered the point at which impairment may be considered material.

Quantifying the Effects of Noise

The two most useful concepts for describing dose-response relationships for noise-induced hearing loss are the "percentage risk" and the "noise-induced permanent threshold shift" (NIPTS) concepts. The first concept involves predicting the percentage of a population that will develop material impairment of hearing as a result of given levels and durations of noise. The second concept is used to predict the amount of hearing loss in decibels that will occur as a result of given levels and durations of noise after subtracting for presbycusis (hearing loss from aging).

In order to better understand the methods of describing the effects of noise, the concept of presbycusis should first be discussed. Presbycusis is a natural phenomenon that affects most individuals if they live to be old enough. Some people will lose some hearing by the age of 40 or 50, while others will have normal hearing well into their 70s. Mature adults will seldom have hearing levels as low as 0 dB for all audiometric frequencies. As people age, their hearing levels become higher, and most individuals accept some hearing loss as a natural occurrence (Ex. 29, p. 84). However, when even a minor noise-induced hearing loss is added to presbycusis, the resulting loss can be sufficient to cross the fence into material impairment. Whether a hearing loss is one-third presbycusis and two-thirds noise-induced, or the other way around, the loss of functional capacity is the same. In most cases, people will not be materially impaired by presbycusis alone unless they live to be very old.

When noise exposure is added, usually from an occupational source, many will become materially impaired when they are young or middle-aged, and the impairments will grow more severe as age increases. In addition, occupational noise exposures have the effect of making some people suffer more hearing loss at a younger age than they would if not exposed to occupational noise.

Since presbycusis, when it occurs, is a natural and inevitable condition, it is only reasonable to examine the impact of noise exposure on a population that includes some amount of presbycusis. After a working lifetime most individuals will be at least 60 years old, and will have experienced some amount of presbycusis. It is also useful to know the extent of damage produced by noise alone, so as to judge the magnitude of the effect at each audiometric frequency as a function of exposure level and duration. Therefore the Agency has quantified the effects of noise on hearing using both the percentage risk and the NIPTS methods.

The percentage risk method allows the inclusion of presbycusis in that the procedure estimates numbers of people whose hearing levels (including presbycusis or any other impairment) will exceed a certain fence due to noise exposure. It does not include people who will exceed a certain fence because of a hearing loss *only* from aging, since the calculation subtracts the percentage of a non-noise-exposed population who would cross the fence anyway from "natural" causes. The remainder is the population at risk of developing material impairment of hearing due to noise exposure.

OSHA believes that the data in Table 1 provide reliable and consistent estimates of the percentages of the population at risk of developing material impairment due to exposure to daily average noise levels of 80, 85 and 90 dB for a working lifetime.

Table 1

[Estimated percentages of the population at risk of exceeding a 25-dB fence at 500, 1000, and 2000 Hz as a function of average noise exposure level for 40 years. (EPA, Ex. 5, p. 43805)]

Organization	Noise exposure in dB	Risk (percent)
ISO	90	21
	85	10
	80	0
EPA	90	22
	85	12
	80	5
NIOSH	90	29
	85	15
	80	3

This table, which was submitted by EPA (Ex. 5, p. 43805), shows the percentage of the exposed population

expected to exceed a 25-dB fence at the frequencies 500, 1000, and 2000 Hz. The risk figures were developed by the International Organization for Standardization (ISO) (based on the data for Baughn), EPA, and NIOSH. These organizations estimated percentage risk for the 500, 1000, and 2000 Hz combination since the AAOO definition of hearing handicap still was used widely at the time these percentage risk estimates were developed (ISO in 1975, Ex. 26-4; EPA in 1973, Ex. 31; and NIOSH in 1972, Ex. 1). Two of the three organizations have now advocated the inclusion of frequencies above 2000 Hz in the definition of material impairment (Ex. 5, pp. 43803, 43805; Ex. 1, pp. VI-11, VI-14). The ISO-1980 proposal, which still is in draft form at this time, does not prescribe a specific formula for risk assessment but provides an array of formulas that can be used for predictive purposes (Ex. 321-43A, p. 3).

It can be seen that the risk of material impairment at an average exposure level of 90 dB is a substantial 21 to 29 percent. The risk of incurring material impairment after a working lifetime of 85 dB is 10 to 15 percent, and at 80 dB is 0 to 5 percent. The inclusion of 3000 or 4000 Hz in the definition of material impairment would tend to make the percentages at risk somewhat higher, since hearing loss at these frequencies from noise exposure is almost always greater than it is at 500 and 1000 Hz.

Because these risk figures were developed virtually independently¹ by the three organizations, the percentages for each exposure level are slightly different. These differences are to be expected when using the percentage risk concept because the estimates can be influenced by the extent to which a noise-exposed population is screened to exclude people with nonoccupational hearing loss, and also by the extent to which the population includes hearing loss from aging (Ex. 5, p. 43806). For example, NIOSH suggested that its percentage risk estimates might be slightly higher than those derived from the "severely" screened population (Ex. 1, p. VI-31). (An exposed population that includes some amount of nonoccupational hearing loss and some presbycusis would be representative of the U.S. population, and thus the risk figures should not be unrealistic.)

¹ As mentioned above, the ISO risk estimates were derived from data collected by Dr. W. L. Baughn. The EPA also used Baughn's data, and averaged them with data collected by Drs. Burns and Robinson, and Dr. Passchier-Vermeer. All of these studies will be discussed in further detail below. Since EPA's estimates are based in part on the same data that were used by ISO, the relationship between the EPA and ISO risk estimates is not entirely independent.

Although Table 1 shows small differences, the risk estimates for the same exposure level are very similar.

The percentage risk concept, while easy to understand, is in some ways a limited descriptor of noise-induced hearing loss (Ex. 5, p. 43806; Ex. 47, pp. 9-10; Ex. 231, written testimony, p. 1). First, the use of a single fence such as 25 dB does not adequately describe the effects of noise on all of the impaired workers in that it does not quantify the amount of loss (Ex. 5, p. 43805; Ex. 231, p. 7). Everyone whose hearing threshold has exceeded the 25-dB fence is considered to have the same amount of hearing loss. The single fence conveys nothing about the people who start with excellent hearing and lose up to 25 dB from noise exposure, nor does it indicate how many people suffer severe losses, greater than 40 or 50 dB, for example (Ex. 5, p. 43806; Ex. 231, p. 7; Ex. 47, pp. 9-10). In an attempt to overcome these limitations, OSHA uses three fences to discuss the benefits anticipated from hearing conservation programs.

Noise-induced permanent threshold shift (NIPTS) is the actual shift in hearing level due to noise exposure, after corrections have been made for aging. NIPTS values may be designated for combinations of frequencies, but they are usually given for each audiometric frequency separately, and it can be helpful to examine hearing loss at individual frequencies. (The percentage risk method nearly always averages hearing levels at three or more frequencies.) The NIPTS method allows examination of the effects of noise on hearing level at 4000 and 6000 Hz, which, although they are not usually included in the definition of material impairment, are the frequencies where hearing is earliest and most severely affected by noise. NIPTS usually is presented for certain percentages of the exposed population, such as the median, the 90th and the 10th percentiles, the lower percentiles representing the more severely affected members.

The disadvantage in presenting the data only as NIPTS is that the full impact of noise exposure is not as easily comprehended as it is with percentage risk. Since NIPTS values do not include any hearing loss from nonoccupational causes, they do not reflect actual hearing levels. However, for comparing the effects of one exposure level against another they are very useful.

Table 2 shows NIPTS as a function of exposure level and exposure duration in years (see Johnson's Table 3, Ex. 310, pp. 27-28). NIPTS values are given for each audiometric frequency from 500 Hz to 6000 Hz, and are shown for the less sensitive 90th percentile, the median,

and the more sensitive 10th percentile. When added to presbycusis values from a "normal" non-noise exposed population, these resulting hearing levels would reflect realistic hearing levels to be expected in noise exposed populations.

Table 2 is taken from a report by Col. Daniel Johnson of the U.S. Air Force, entitled "Derivation of Presbycusis and Noise Induced Permanent Threshold Shift (NIPTS) to be used for the Basis of a Standard on the Effects of Noise on Hearing" (Ex. 310, pp. 27-28). As in a previous report, which Col. Johnson had prepared for the EPA (Ex. 17), he averaged the hearing loss data from some well-known studies. While in the earlier report Col. Johnson used the data of Baughn, Burns and Robinson, and Passchier-Vermeer, in the more recent report he combined only the data of Burns and Robinson with those of Passchier-Vermeer. Details of these studies will be discussed further below.

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TABLE 2

Noise-induced permanent threshold shift in decibels as a function of audiometric frequency, resulting from 8-hour daily average sound levels of 75 dB to 100 dB, for durations of 10 to 40 years. Data are presented for the 90th, 50th and 10th population centiles. From Johnson, Ex. 310, pp. 27-28, using the combined data of Burns/Robinson and Passchier-Vermeer.

Sound Level [dB]	Freq. [Hz]	10 yrs.			20 yrs.			30 yrs.			40 yrs.		
		.9	.5	.1	.9	.5	.1	.9	.5	.1	.9	.5	.1
75	500	0	0	0	0	0	0	0	0	0	0	0	0
80	500	0	.1	.6	.1	.1	.3	.4	.1	.4	.8	.2	.4
85	500	.1	.2	1.4	.1	.3	1.2	.5	.7	1.5	.9	.4	1.1
90	500	.2	.5	2.3	.2	.7	2.4	.6	.8	2.5	1.1	1.0	2.4
95	500	.3	.9	3.5	.5	1.3	4.0	.6	1.7	4.5	1.0	1.9	4.6
100	500	1.7	3.9	7.6	2.8	5.1	9.2	3.9	6.2	10.6	4.9	7.2	11.4

Sound Level [dB]	Freq. [Hz]	10 yrs.			20 yrs.			30 yrs.			40 yrs.		
		.9	.5	.1	.9	.5	.1	.9	.5	.1	.9	.5	.1
75	1000	0	0	0	0	0	0	0	0	0	0	0	0
80	1000	.1	.1	.7	.1	.2	.4	.4	.2	.6	.8	.2	.6
85	1000	.1	.3	2.0	.2	.5	1.9	.5	.6	1.9	.9	.7	1.7
90	1000	.3	.7	2.9	.4	1.0	3.3	.8	1.3	3.6	1.3	1.5	3.6
95	1000	.5	2.7	5.9	.8	3.7	7.2	3.3	4.6	8.4	4.3	5.3	8.9
100	1000	3.1	6.1	11.0	4.8	8.1	13.5	6.4	9.9	15.6	8.3	11.3	16.9

Sound Level [dB]	Freq. [Hz]	10 yrs.			20 yrs.			30 yrs.			40 yrs.		
		.9	.5	.1	.9	.5	.1	.9	.5	.1	.9	.5	.1
75	2000	0	0	0	0	0	0	0	0	0	0	0	0
80	2000	.1	.3	1.6	.1	.4	.9	1.1	.5	1.2	1.8	.6	1.3
85	2000	.3	.9	4.9	.7	1.3	4.8	1.8	1.8	4.6	2.8	2.1	3.9
90	2000	.6	2.4	8.0	1.6	3.9	9.3	3.6	5.4	11.8	5.3	6.6	10.6
95	2000	1.2	5.5	14.2	3.7	8.7	17.4	7.4	12.0	20.1	10.6	14.8	21.9
100	2000	2.3	9.2	21.5	6.5	14.6	26.6	12.0	19.9	35.9	16.7	24.1	33.9

Sound Level [dB]	Freq. [Hz]	10 yrs.			20 yrs.			30 yrs.			40 yrs.		
		.9	.5	.1	.9	.5	.1	.9	.5	.1	.9	.5	.1
75	3000	0	0	0	0	0	0	0	0	0	0	0	0
80	3000	.2	2.0	4.1	1.9	2.4	3.4	3.5	2.7	2.7	5.1	3.0	2.3
85	3000	1.6	4.4	7.7	3.6	5.3	7.8	5.5	6.2	7.6	7.4	6.7	7.2
90	3000	3.9	9.2	16.9	6.6	11.0	17.9	8.5	12.6	18.4	11.3	13.7	18.4
95	3000	8.1	16.0	26.8	11.6	18.9	29.1	14.9	21.4	30.1	17.8	23.1	30.5
100	3000	15.8	25.4	37.5	20.6	29.5	39.7	24.8	32.7	41.0	28.6	35.0	41.6

Sound Level [dB]	Freq. [Hz]	10 yrs.			20 yrs.			30 yrs.			40 yrs.		
		.9	.5	.1	.9	.5	.1	.9	.5	.1	.9	.5	.1
75	4000	0	0	0	0	0	0	0	0	0	0	0	0
80	4000	.3	3.1	1.9	.3	3.4	2.1	1.8	3.7	6.3	3.3	3.8	5.3
85	4000	1.6	6.7	12.3	3.4	7.4	12.2	5.0	8.0	11.9	6.7	8.3	11.0
90	4000	6.3	11.9	19.1	8.4	13.3	19.5	10.3	14.4	19.4	12.1	14.9	18.6
95	4000	13.7	20.4	28.2	16.4	22.5	28.7	18.7	23.9	28.5	20.7	24.6	27.6
100	4000	22.3	30.2	37.8	25.6	32.6	37.8	28.4	34.1	37.2	30.6	34.8	36.1

Sound Level [dB]	Freq. [Hz]	10 yrs.			20 yrs.			30 yrs.			40 yrs.		
		.9	.5	.1	.9	.5	.1	.9	.5	.1	.9	.5	.1
75	6000	0	0	0	0	0	0	0	0	0	0	0	0
80	6000	.3	2.0	4.0	1.8	2.2	3.1	3.2	2.4	2.2	4.6	2.5	2.1
85	6000	1.1	4.8	8.9	2.8	5.3	8.6	4.3	5.8	8.2	5.8	6.1	7.3
90	6000	1.9	8.5	15.6	3.8	9.5	16.0	5.6	10.4	16.0	7.3	10.9	15.3
95	6000	4.3	13.7	23.5	6.7	15.5	24.4	8.9	16.8	24.5	10.8	17.6	23.8
100	6000	9.2	20.3	32.2	13.3	23.7	33.9	17.0	26.5	34.9	20.2	28.4	35.1

Studies of Noise and Hearing Loss

Numerous studies of the effects of noise on hearing were submitted to the record. For purposes of this discussion, the studies have been divided into the categories of continuous and impulsive noise. The word "continuous" refers here to time-varying exposures as well, since in most of the studies noise levels varied somewhat throughout the day (Ex. 11, p. 2-3; Ex. 12, pp. 93-99; Ex. 26-2, p. 10).

Exposure to intermittent (on and off) noise will not be treated separately since the same methods for predicting hearing loss from continuous noise apply to losses resulting from intermittent noise (Ex. 279, 11-3, p. 447; Ex. 54, pp. 16-17; Ex. 29, p. 217). There was some disagreement as to whether the 5-dB or the 3-dB exchange rate should be used in calculating the time-weighted average exposure level from noncontinuous noise. But since the current noise standard (29 CFR 1910.95) uses the 5-dB exchange rate, and since the permissible exposure level remains unchanged at this time, the debate over the exchange rate will not be treated extensively at this time.

OSHA has examined the many studies and reports in the record that describe the effects of continuous noise on hearing (Ex. 11; Ex. 17; Ex. 310; Ex. 12; Ex. 26-2; Ex. 36; Ex. 266 A; Ex. 304), and the Agency believes that they comprise the best available data on the subject. The results of the various studies are relatively consistent, both in terms of the population at risk, and the extent of NIPTS as a function of noise exposure. The various studies, if considered together, contain data on more than 10,000 subjects.

As stated above, Col. Johnson averaged the data of different researchers in the preparation of a report for EPA. Later, the EPA used Col. Johnson's analysis of those data in the development of criteria for the effects of noise (Ex. 31, p. 5-17) and for the identification of safe levels of noise (Ex. 30, p. C-5). The three studies that were used in the EPA reports were the subject of much discussion during the hearings. Although some criticisms were raised, they were also widely supported (Tr. 734, 738, 779, 785, 834). The three studies were the following:

"Relationship between Daily Noise Exposure and hearing loss based on the evaluation of 6,835 industrial noise exposure cases" by W. L. Baughn (Ex. 11).

"Hearing and Noise in Industry" by W. Burns and D. W. Robinson (Ex. 12).

"Hearing Loss Due to Exposure to Steady-state Broadband Noise" by W. Passchier-Vermeer (as displayed and used in "Prediction of NIPTS due to continuous noise exposure" by D. L. Johnson (Ex. 17).

The study by Dr. William L. Baughn of the General Motors Corporation was performed between 1960 and 1985 (Ex. 11). These data have been used in the development of the Air Force report "Hazardous Noise Exposure" (Ex. 48) and for the current ISO standard 1999, "Assessment of Occupational Noise Exposure for Hearing Conservation Purposes" (Ex. 11, p. iii). The data were published in 1973 as an Air Force technical report (Ex. 11). Dr. Baughn studied the effects of average noise exposures of 78 dB, 86 dB, and 92 dB on 6,835 industrial workers employed in midwestern plants producing automobile parts. Approximately 20,000 subjects had been excluded from the study because there was insufficient information about their exposure histories, or because they had "mixed" exposures (including nonoccupational sources). Subjects with anatomical abnormalities (such as ear infections) were not screened from the noise-exposed or control groups. Noise measurements had been taken over a period of 14 years, and through interviews, exposure histories were estimated as far back as 40 years (Ex. 11, p. 2. Dr. Baughn "smoothed" the data and presented families of curves showing the numbers of people exceeding a 15-dB fence at 500, 1000, and 2000 Hz referenced to the ASA 1951 audiometric zero, which is the equivalent of a 25-dB fence referenced to the ANSI 1969 zero level. He also provided data for fences of 5 dB to 40 dB (ASA), which would translate to 15 dB to 50 dB (ANSI). Since the exposure categories were for 78 dB, 86 dB and 92 dB, Dr. Baughn interpolated so as to provide estimates for exposures to 80 dB, 85 dB and 92 dB. He also extrapolated to exposure levels up to 115 dB, but the data above 95 dB were not used in Col. Johnson's report or the comparisons shown earlier.

Figure 1 shows Baughn's estimates of the percentages of the exposed population that will cross a 25-dB fence as a result of exposure to daily average noise levels of 80 dB to 115 dB. Since these estimates use the frequencies 500, 1000, and 2000 Hz, the numbers of people crossing a 25-dB fence at 1000, 2000, and 3000 Hz would be expected to be greater.

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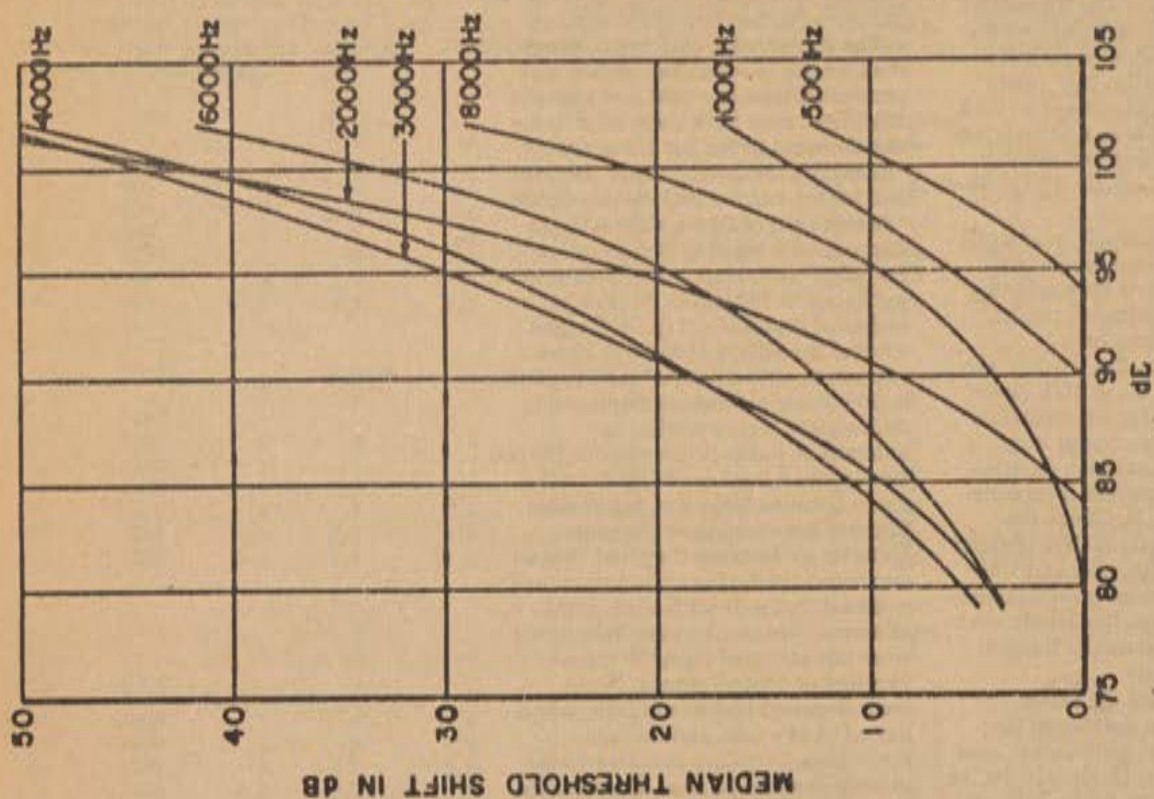


Figure 2. Median noise-induced threshold shift for various audiometric frequencies as a function of average daily noise exposure level for 10 years. Data are from Passchier-Vermeer (in Ex. 5, p. 43803).

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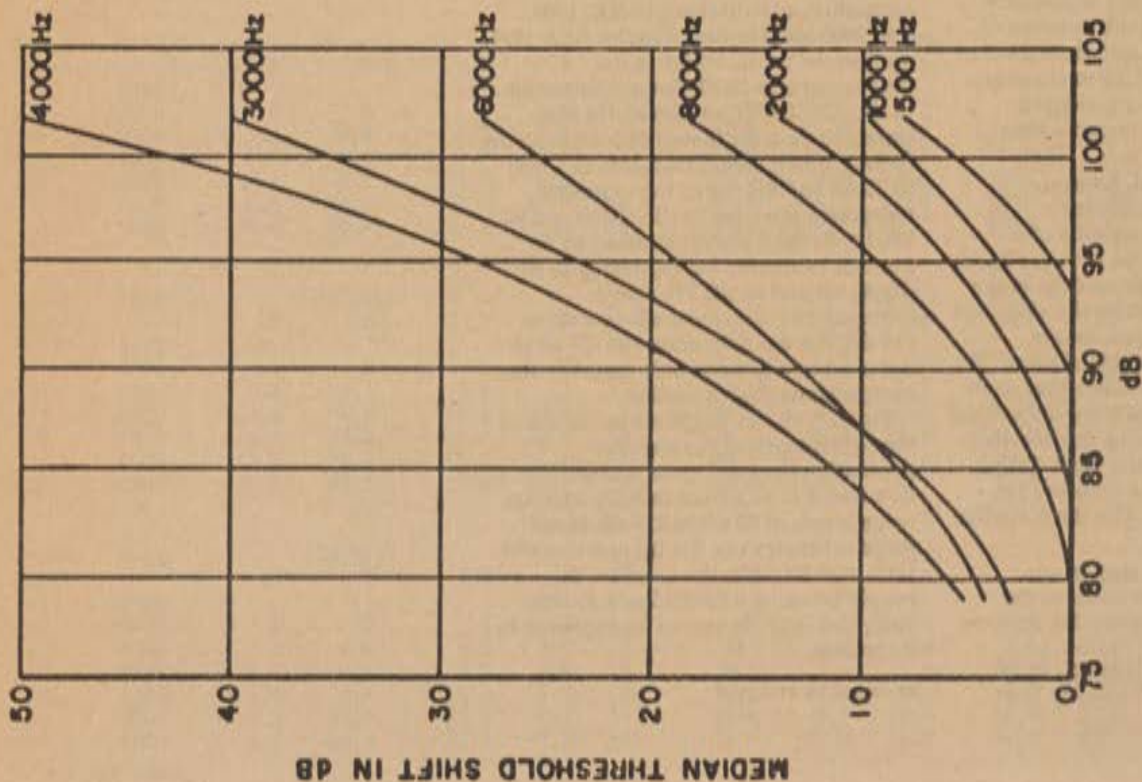


Figure 3. Median noise-induced threshold shift for various audiometric frequencies as a function of average daily noise exposure level for 40 years. Data are from Passchier-Vermeer (in Ex. 5, p. 43803).

Baughn's study was criticized because in some cases as little as 20 minutes of recovery time was allowed prior to audiometric testing (Ex. 17, p. 2; Ex. 3, p. 39; Ex. 26-3, p. 5-15; Ex. 138A, p. 2-17). As a result the data may have been influenced to some extent by temporary threshold shift, which would have the effect of making the noise-exposed group's hearing threshold levels appear worse than they should. The study was also criticized because the control group may have had average exposures as high as 78 dB so that they may also have had a small amount of occupational hearing loss (Ex. 17, p. 2; Ex. 138A, p. 2-17). If the control group's hearing levels were slightly inflated, this would tend to reduce the difference between the hearing levels of the exposed and control groups. These potential flaws would have the tendency to offset each other when NIPTS is calculated. In addition, Dr. Kryter (Ex. 50, pp. 9-12) pointed out that any residual TTS after 20 minutes would be quite small (only 1 to 2 dB) for those subjects who had already incurred a noise-induced hearing loss. (TTS tends to become smaller after significant permanent loss is incurred.)

One practical limitation of the Baughn study is that the author did not provide hearing loss data at separate frequencies, but only at the combined frequencies of 50, 1000, and 2000 Hz, and then separately for 4000 Hz (Ex. 11, pp. 4, 30; Ex. 5, p. 43804). Thus, it is not possible to estimate hearing loss, for example, at only 2000 Hz, or for the combined frequencies 1000, 2000, and 3000 Hz. While this may result in some procedural problems for researchers and administrators, it does not detract from the validity of the study. The sample size appears to be the largest in any single hearing loss study, and the study has received support from other scientists and organizations. The results are not incompatible with other data in the record. Therefore, OSHA believes that the Baughn study represents a valuable contribution to the public record.

Dr. W. Passchier-Vermeer's data on steady-state noise exposure do not appear in the hearing record except as they are presented by Col. Johnson (Ex. 17 and Ex. 310). Dr. Passchier-Vermeer presented in 1968 an exhaustive review of hearing loss as a function of exposure to average noise levels of about 80 dB to 102 dB, having summed, analyzed, and correlated data from any sources (Ex. 17, pp. 2, 3, 12-14). The data consisted of laboratory and field studies conducted by British, Dutch, Swedish, and U.S. investigators.

Figure 2 shows median NIPTS at various frequencies as a function of noise exposure for a period of 10 years. Figure 3 shows median NIPTS after 40 years of noise exposure. These figures, which were submitted by EPA (Ex. 5, p. 43803), are taken from Dr. Passchier-Vermeer's reports. Of course the noise-induced permanent threshold shift would be expected to be more severe for the more susceptible individuals in the higher centiles of the population, such as the 19th or the 95th centiles.

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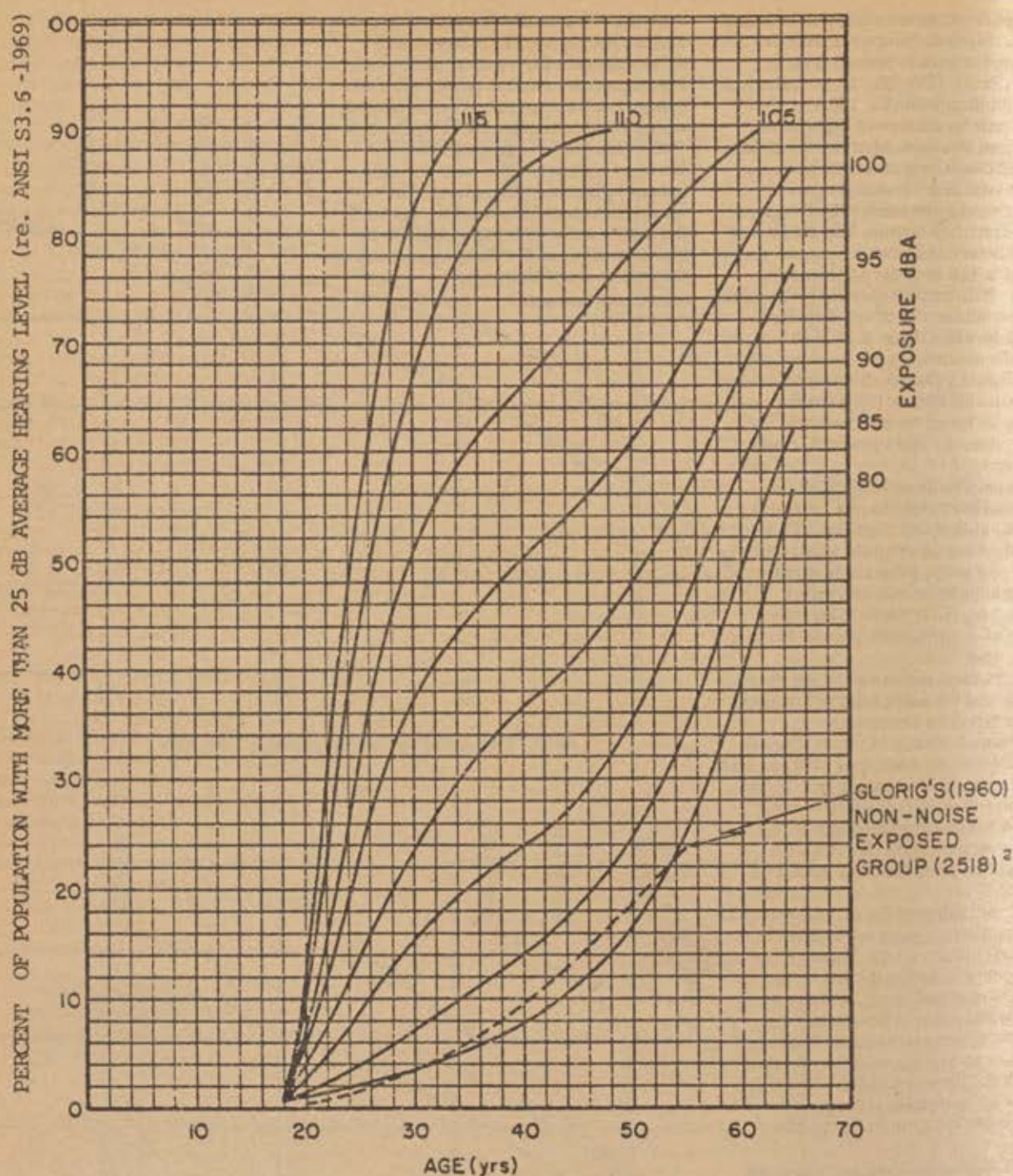


Figure 1. Percent of the population with more than 25 dB average hearing level for the frequencies 500, 1000, and 2000 Hz as a function of noise exposure level. From Baughn (Ex. 11, p. 41).

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Four of the 10 studies analyzed by Dr. Passchier-Vermeer were discussed briefly in documents prepared by NIOSH (Ex. 1), EPA (Ex. 31), and Drs. Burns and Robinson (Ex. 12). The NIOSH criteria document reported that Drs. Taylor, Pearson, Mair, and Burns studied 251 working and retired jute weavers who were exposed to average overall sound pressure levels of 99 to 102 dB. The investigators found the greatest deterioration of hearing occurred in the first 10 to 15 years of exposure (Ex. 1, p. 5 Table IV). NIOSH also reported on a study by Drs. Burns, Hinchcliffe, and Littler of 174 textile spinners and weavers exposed to average overall (unweighted) sound pressure levels of 100 to 101 dB. Hearing losses were found to be greater for the weavers than the spinners (Ex. 1, p. 6 of Table IV).

EPA's document entitled Public Health and Welfare Criteria for Noise described a study by Gallo and Glorig, which also was used by Dr. Passchier-Vermeer, as well as the study by Taylor et al., mentioned above. According to EPA (Ex. 31, p. 5-5), Drs. Gallo and Glorig measured the hearing levels of 400 men aged 18-65, and 90 women, aged 18-35, exposed to an average overall sound pressure level of 102 dB. The population had been screened to exclude nonoccupational noise exposure and otological abnormalities. The results showed that high-frequency hearing loss rose rapidly during the first 15 years of exposure, but that hearing loss in the mid-frequencies continued to rise in a linear manner up to 40 years of exposure.

Drs. Burns and Robinson (Ex. 12, pp. 220-228) also discussed the studies of Gallo and Glorig, and Taylor et al. In addition, they described a study by Dr. B. Kylin, which also was used by Dr. Passchier-Vermeer, of 89 men exposed for durations of 10 to 15 years, and 29 male controls. Neither population was screened for military noise exposure or for ear disease. (These factors should not have influenced the actual NIPTS since they were distributed evenly among the noise exposed and control populations (Ex. 12, p. 226).) Drs. Burns and Robinson compared the results of their study with those of the three selected studies (Gallo and Glorig, Taylor et al., and Kylin), and with the results predicted by Dr. Passchier-Vermeer on the basis of all of the studies she analyzed. They found, using median hearing loss values, that agreement among all of the results was good for the mid-frequencies (500, 1000, and 2000 Hz), but that their own data and method of prediction showed

somewhat lower values (less hearing loss) for the higher frequencies (3000, 4000, and 6000 Hz) (Ex. 12, p. 227). The authors suggested that this finding might be due to differences in noise monitoring and subject selection techniques used by the various investigators (Ex. 12, p. 228).

Because the Passchier-Vermeer data resulted from a synthesis of many studies, some people argued that their quality was difficult to judge (Ex. 50, p. 8). Others noted that the original report only presented data for quartile groups (25th, 50th and 75th centiles) and neglected to address the more variant hearing levels found in the extremes of the population (Ex. 3, p. 39; Ex. 17, p. 2; Ex. 26-3, p. 5-14). Col. Johnson has extrapolated the data to the 10th and 90th centiles so that it would be averaged with those of the other studies (Ex. 17, p. 14 and Ex. 310, p. 7). Col. Johnson reported (Ex. 17, p. 14) that in a paper published in 1971, Dr. Passchier-Vermeer did publish the data for the 10th and 90th centiles, and these data were in agreement with Johnson's extrapolations.

The Passchier-Vermeer data are useful in that hearing levels are given for the discrete audiometric frequencies 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz, resulting from exposure levels of 80 dB, 85 dB, and 90 dB. Also, the Agency believes that averaging the results from a number of studies may be considered an advantage in that it ought to minimize any anomalies that might occur as a result of any one study. The Passchier-Vermeer data also were supported by various witnesses and comments to the record, (Ex. 47, p. 8; Ex. 216 A, p. 5).

Dr. W. Burns (Ex. 54) reported on a study of British factory workers that he and Dr. D. W. Robinson conducted between 1963 and 1968. The complete study was submitted to the record by OSHA as Exhibit 12. The study's population consisted of 759 subjects exposed to average noise levels between 75 dB and 120 dB and 97 non-noise exposed control subjects. The range of exposure durations was one month to 50 years. Exposure levels were taken in octave bands from 63 to 8000 Hz, and A-weighted measurements also were taken. Approximately 4000 audiograms were performed. Subjects were screened thoroughly to exclude exposure histories that were not readily quantifiable (to some extent unknown), exposure to gunfire, ear disease or abnormality, and language difficulties (Ex. 12, p. 12). The investigators found that hearing levels of people exposed to certain noise levels for certain durations

were much the same as those of others exposed to higher levels for shorter times (Ex. 12, p. 17). They found that this relationship held for relatively short durations as well as for many years of exposure (Ex. 12, pp. 17-18). Consequently, they developed a mathematical formula to predict hearing levels in the frequencies 500 through 6000 Hz in various percentages of the exposed population due to specific levels and durations of noise (Ex. 12, pp. 100-151). Data from the Burns and Robinson study are shown combined with those of Dr. Passchier-Vermeer in Table 2 above.

The Burns and Robinson study has been criticized on the grounds that eliminating all workers with any form of nonoccupational hearing loss by extensive screening (which appeared to be more rigorous than in the other studies) would cause the resulting hearing levels to be an underestimate of the total "real-life" hearing loss picture (Ex. 40, p. 7; Ex. 50, p. 17). This problem has been eliminated in the analyses performed by Col. Johnson (Ex. 17 and 310) and by OSHA in the Benefits section, by using only the NIPTS data from Burns and Robinson and adding values for presbycusis from a normal, unscreened population (such as the U.S. Public Health Survey data).

The Burns and Robinson study was also criticized by Terrence Dear of the DuPont Company for including subjects exposed to impulse noise (Tr. 864-866), although the authors maintained that they tried to minimize such exposures, and that impulse noise exposures only would have occurred in a relatively small number of cases where subjects were exposed to high levels of continuous noise (Tr. 864-866; Ex. 12, p. 97).

On the whole, OSHA believes that the study by Burns and Robinson represents a very thorough, well-controlled study, with results that are extremely useful in predicting the effect of noise exposure on hearing.

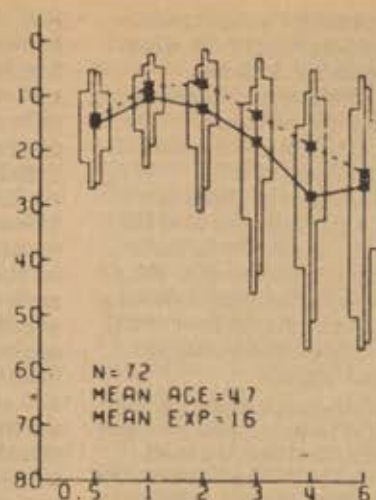
NIOSH submitted to the record a report entitled "Occupational Noise and Hearing", 1968-1972 (Ex. 26-2). The dose-response relationships described in this report had been used by NIOSH in making the recommendations in its criteria document (Ex. 1). The report (Ex. 26-2, p. vi) presented background information about the study, and statistical analyses that were meant to complement the analyses that had already been published in the criteria document. NIOSH studied a population of 792 industrial workers exposed to average noise levels of 85 dB, 90 dB, and 95 dB, and a control population of 380 subjects who were exposed to average

levels below 80 dB. (Since the control population was exposed to levels as high as 80 dB, a few members of the group may have incurred some amount of occupational hearing loss, and therefore the study would be subject to the same criticism as the study of Dr. Baughn.) Although the exposures were primarily to steady-state noise, exposure levels fluctuated slightly within each category. The total population was screened to exclude subjects who had been exposed to noise from gunfire, and who showed some sign of ear disease or audiometric irregularity (Ex. 26-2, pp. 6-7). Subjects ranged in age from 17 to 65 years. Data were presented for hearing levels of the 10th, 25th, 50th, 75th, and 90th centiles for various age groups and exposure durations, resulting from average exposures to 85 dB, 90 dB, and 95 dB. The authors concluded that the data substantiated the results of other similar investigations, but that they pertained only to simple or "ordinary" noise environments, as opposed to complex environments such as lengthened exposures, seasonal exposures, impact or impulsive noise, and high frequency noise (Ex. 26-2, p. 15).

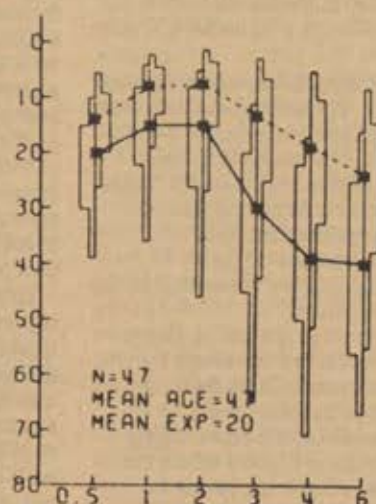
Data from the NIOSH study have not been used in the prediction of benefits from the hearing conservation amendment. Col. Johnson stated in his report (Ex. 17, p. 10) that he did not use the NIOSH data in the analysis performed for EPA because the data had not yet been "smoothed," which would make it difficult to make predictions. Also, the NIOSH data were limited to exposures of 85, 90 and 95 dB, thus preventing hearing loss estimates for exposures to 80 dB and 100 dB. Nevertheless, the data are generally consistent with the results of the other studies discussed above.

85dB

Hearing Level in dB (thresholds re: ANSI-1969)



90dB



95dB

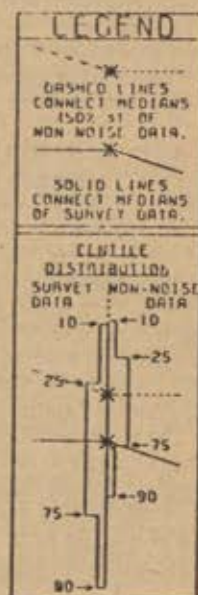
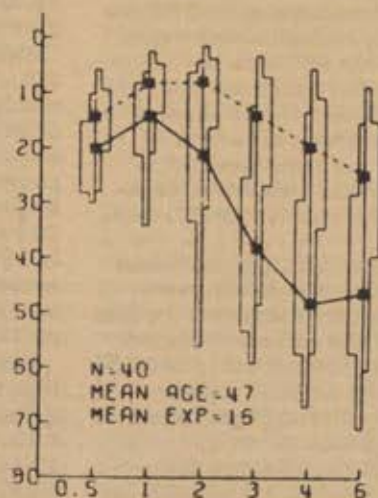


Figure 4. Hearing level distribution for workers aged 43 to 51 years exposed to daily average noise levels of 85dB, 90dB, and 95dB, and for non-noise-exposed workers.

Results of the NIOSH study are shown in Figure 4 (Ex. 26-2, p. 41). This figure shows hearing level by audiometric frequency as a function of noise exposure to levels of 85, 90, and 95 dB. Population distributions are shown for the least sensitive (labeled in this case the 10th centile) to the most sensitive (the 90th centile) groups, and are compared to the non-noise-exposed control group. This study shows that differences between median hearing levels increase with exposure level, duration, and age. Also, more importantly, the distribution of hearing levels becomes considerably greater as exposure level, duration, and age increase.

In another study, Dr. R. H. Martin, Dr. E. S. Gibson, and J. N. Lockington (Ex. 36) related the degree of employee hearing loss to average noise levels of 85 and 90 dB in industrial plants. The population consisted of 228 Canadian industrial workers ranging from 18 to 65 years of age who were screened to exclude non-occupational hearing loss. The control group consisted of 143 subjects with minimal occupational noise exposure. The study concluded that the risk of hearing loss at 500, 1000, and 2000 Hz increases significantly between 85 and 90 dB, leaving a portion of the population at risk (up to 22 percent) by a noise exposure standard of 90 dB.

Elliott Berger, with Drs. Royster and Thomas (Ex. 266A) examined a North Carolina industrial population that had been exposed for 10 to 12 years to daily average noise levels of 88 to 89 dB. The population consisted of 42 men working in one location of the plant and 58 women working in another location. Control subjects were drawn from the same geographical area, and were screened to exclude any occupational noise exposure. Because of the relatively short exposure duration and the moderate exposure levels, the investigators analyzed only the losses at 4000 Hz, where they found hearing levels somewhat worse for men than for women (Ex. 266A, pp. 82-83). They concluded that the observed hearing losses were compatible with the data of Baughn, Passchier-Vermeer, Burns and Robinson, and NIOSH, with compatibility being greater for the male than for the female subjects (Ex. 266A, pp. 81-85).

In the Inter-Industry Noise Study (IINS) (Ex. 304) the authors measured noise exposure and hearing levels of 348 industrial subjects. Daily average noise exposure levels were between 82 and 92 dB for durations ranging from 3 years to greater than 30 years. There were 228

matched control subjects whose noise exposures were less than 75 dB. After analyzing the data the authors concluded that differences in hearing levels between the control and experimental populations were not statistically significant at the frequencies 500, 1000, and 2000 Hz. Differences at 3000, 4000, and 6000 Hz were statistically significant for male subjects, but not for females (Ex. 304, p. 8). In an editorial immediately following the IINS Research Report in the Journal of Occupational Medicine (JOM), Dr. Robert O'Connor stated:

From this study it appears that 90 dB is as protective as 85, as far as women's hearing is concerned. In the case of men, if a small amount of hearing loss in frequencies that are well beyond the speech range is considered unacceptable, then this study supports a standard of 85. (Ex. 304, p. 8) [in JOM, 17: 760-770, 1975, p. 770].

The Environmental Protection Agency (Ex. 321-16A, p. 2) stated that there were major technical problems in the design, administration, and analysis of the Inter-Industry Noise Study which "raise serious questions concerning the technical appropriateness and usefulness of a number of the conclusions which were presented in the 1978 JOM publication."

A NIOSH report prepared by Barry Lempert also criticized the study by stating that the results included only mean or average hearing level comparisons while much more highly significant effects are found when the full distribution of hearing levels is presented (Ex. 321-36A, p. 1). After reviewing and reanalyzing the IINS raw data, and using evaluation techniques developed for the 1972 criteria document, NIOSH reaffirmed that "exposure to 85 dBA should allow no more than an increase of 10 to 15 percentage points in the incidence of hearing impairment" relative to a non-noise exposed population (Ex. 321-36A, p. 4).

Col. Johnson and Dr. Thomas Schori also analyzed the raw data from the IINS, and submitted a review of the data (Ex. 321-21A). The authors concluded that the hearing levels found in the IINS were essentially the same as those found in other noise and hearing loss studies (Ex. 321-22A, p. 16).

Having reviewed the study, the critiques (Ex. 321-16A; Ex. 321-36A; Ex. 321-21A), and a critique of a critique (Motor Vehicle Manufacturers Assoc., Ex. 321-8A), OSHA has determined that the findings of the IINS do not contradict those of the studies described earlier. The Agency disagrees with the conclusions of Dr. O'Connor that 90 dB is as protective as 85 dB. Although the

IINS did not find the differences between mean hearing levels of the female experimental and control groups statistically significant, there were differences at every frequency, showing greater hearing loss for noise-exposed than for control subjects (Ex. 804, p. 4). As Lempert pointed out, these differences would have been much larger if the full distribution of hearing levels had been presented, showing the more susceptible elements of the population. The same argument would apply to the differences between mean hearing levels of the male experimental and control groups, where systematic differences are shown. The fact that the standard deviations were greater for noise-exposed than for non-noise-exposed groups at nearly every frequency (Ex. 304, p. 4) supports this argument. In addition, OSHA disagrees with Dr. O'Connor that the frequencies above 2000 Hz "are well beyond the speech range," on the basis of the many studies and comments cited earlier, showing the importance of high-frequency hearing for understanding speech in everyday conditions (Ex. 46, p. 363; Ex. 26-1; p. 3; Ex. 26-6, p. 830; Ex. 228, p. 8; Ex. 5, p. 43803; Ex. 51, pp. 6-7).

Dr. Royster submitted a series of reports to the record (Ex. 321-22 A through H). Some of these reports discussed recent findings by Dr. Royster and his colleagues that differences in sex and race are evident in the growth of NIPTS (Ex. 321-22A, pp. 18-19), as well as in the growth of presbycusis (Ex. 321-22B, p. 510; Ex. 321-22C, pp. 116-118; Ex. 321-22D, pp. 1-2). After examining the audiograms of a large North Carolina industrial population (Ex. 321-22A), Drs. Royster and Thomas concluded that hearing threshold levels differ significantly according to race and sex and that these differences are greater for the higher audiometric frequencies and increase with age. In their subject population, black women had the best hearing, followed by white women, black men, and finally, white men after noise exposure (Ex. 321-22A, pp. 15, 18-19).

Sex differences in hearing levels have been noted in numerous studies of non-noise-exposed populations (Ex. 31, p. 4-4; Ex. 321-22, p. 7; Ex. 279, pp. 11-8, pp. 41-44). OSHA has incorporated the NIOSH presbycusis data (Ex. 1, pp. 1-16 to 1-17) for men and women separately in Appendix F of the amendment. Also, the Agency has calculated the benefits anticipated from hearing conservation programs using separate presbycusis data for men and for women. Actual NIPTS values have not been differentiated according to sex because

data for men and women shown separately were not available for the major studies mentioned above (Burns and Robinson, Passchier-Vermeer, Baughn, and NIOSH).

Drs. Burns and Robinson (Ex. 12, pp. 145-147) found small but persistent sex differences in noise-induced hearing loss, suggesting that NIPTS developed slightly more rapidly in men than in women. However, they did not present separate data for men and women. The IINS also showed slightly larger NIPTS values for men than for women both in the control and in the experimental populations (Ex. 304, pp. 4-8). Col. Johnson (Ex. 17 and Ex. 310) did not display NIPTS values separately for men and women, but he did show different data for certain non-noise-exposed populations, and therefore for certain estimates of the percentage at risk (Ex. 310). The studies by Baughn (Ex. 11), NIOSH (Ex. 26-2), Passchier-Vermeer (as reported by Johnson in Ex. 17), and Martin et al. (Ex. 36) did not present different NIPTS data for male and female subjects. OSHA believes that there is relatively little evidence available at this time to show that the hearing of men and women is differently affected by noise exposure, but that there is considerable evidence that differences exist in non-noise-exposed populations. Therefore, for estimating the benefits of hearing conservation programs, the Agency has used Col. Johnson's analysis of the Burns and Robinson and Passchier-Vermeer data, which shows sex differences for presbycusis but not for NIPTS. For any additional breakdown by sex or race the Agency will await further experimental evidence.

OSHA believes that the above studies are meritorious and are sufficient to make good estimates of the benefits to be derived from hearing conservation programs, despite any criticisms raised. Dr. von Gierke stated that "in spite of some uncertainties and everybody's desire for the 'perfect' study, there is adequate information available to predict with reasonable confidence the hearing impairment produced in the general population by a lifetime's exposure to continuous noise" (Tr. 705-706).

Discussion

Having established a definition of material impairment of hearing and discussed the various studies, some attention must be given to the various interpretations of the noise exposure and hearing loss data. Not all of the commenters interpreted the data in a similar manner.

Generally the argument for protecting workers above 85 dB is made on two grounds: analysis of NIPTS and of the percentage at risk showed that not only is the amount of hearing loss significantly greater at an average daily exposure level of 90 dB than at 85 dB, but also considerably more people are at risk of incurring material impairment (Ex. 40, p. 3; Ex. 47, p. 19; Ex. 57, p. 8; Ex. 82, pp. 1-4; Ex. 6, p. 12337; Ex. 26-1, p. 2).

Using the data of Baughn, Passchier-Vermeer, and Burns and Robinson, the Environmental Protection Agency found that half as many people are at risk of impairment at a daily average noise level of 85 dB as at 90 dB (Ex. 138A, pp. 1-4; Ex. 5, p. 43805; Ex. 189-5, p. 6). In addition, the amount of NIPTS doubles between 85 dB and 90 dB, especially for the frequencies 1000, 2000, and 3000 Hz (Ex. 5, p. 43804). In order to prevent any measurable hearing loss over a 40-year period the EPA identified a maximum 8-hour average daily noise exposure level of 75 dB (Ex. 5, p. 43803; Ex. 30, p. 4).

NIOSH also found that the population at risk due to lifetime exposures to average daily levels of 90 dB would be twice the size of the population at risk from 85 dB. The estimates were 29 percent and 15 percent, respectively (Ex. 1, Tables XV and XVII). Dr. Moller also noted that the number of impaired people doubles when average levels are increased from 85 to 90 dB (Ex. 88, p. 33).

There were numerous comments in the record concerning the amount of protection afforded by an average daily exposure level of 90 dB. Estimates of the percentage of unprotected workers ranged from 1 percent to 30 percent. Many commenters supported the 90-dB level based on OSHA's estimate that 98 percent of the population would be protected (Ex. 14-11, p. 1; Ex. 14-45, p. 1; Ex. 14-81, p. 1; Ex. 14-157, p. 2; Ex. 14-189, p. 1).

In OSHA's draft Environmental Impact Statement (Ex. 3, App. D, p. 12337) the Agency incorrectly stated that an exposure level of 90 dB would protect 98 percent of the exposed population. This estimate was based on the data and method of Burns and Robinson, using a 25-dB fence for the frequencies 500, 1000, and 2000 Hz, and a 30-year exposure duration. Later, an EPA representative (Ex. 40) pointed out that OSHA had neglected to perform one of the steps in the Burns and Robinson method, (step 7 on p. 132 of Ex. 12). Using the same data and method, the risk would actually be much greater than 2 percent (Ex. 40, pp. 5-6). Dr. Burns clarified the matter by explaining the distinction between hearing level, which includes presbycusis, and hearing loss, which does not (Ex. 54-2, pp. 1, 2).

Dr. Ward (Ex. 222C, p. 7) based his recommendation exclusively on Passchier-Vermeer's data, which, he claimed, showed that no workers would exceed a 25-dB hearing loss at the frequencies 500, 1000, or 2000 Hz due to exposure between 85 and 90 dB. For this reason Dr. Ward concluded that 90 dB protects workers from a "noticeable" hearing loss (Ex. 64, p. 3). This interpretation of Passchier-Vermeer's data is at variance with the interpretation of EPA and Col. Johnson. EPA submitted a graph of Passchier-Vermeer's data showing hearing loss as a function of noise exposure (Ex. 5, p. 43803). Although the median NIPTS from a 40-year exposure to 90 dB is essentially zero at 500 and 1000 Hz, it is nearly 10 dB at 2000 Hz. While the resulting average hearing levels would be quite small when added to the hearing loss from aging, they would be sufficient to ensure that some members of the exposed population would cross a 25-dB fence. Considering that nearly 3 million workers are exposed to daily average noise levels of 90 dB and above, 50 percent of the population, or 1.5 million workers, would be expected to have at least this much NIPTS. Also, the NIPTS values would be expected to be larger for more sensitive individuals. Median NIPTS data say very little about actual hearing levels in the more susceptible members of the exposed population. As described above, when Johnson and EPA combined the data of Passchier-Vermeer with those of Baughn, and Burns and Robinson, the risk of crossing a 25-dB fence at 500, 1000, and 2000 Hz was 12 percent from exposure to 85 dB, and 22 percent from exposure to 90 dB (Ex. 5, p. 43805). Finally, as mentioned earlier, both the NIPTS and the risk are greater when 3000 Hz is included in the averaging and 500 Hz is eliminated.

OSHA has considered the definition of material impairment as it relates to hearing loss in light of a large body of data on the effects of noise on hearing. The Agency has determined that many workers will be at risk of material impairment of hearing, and possibly incur other kinds of physiological damage, when they are exposed to daily average sound levels above 90 dB over a working lifetime. Some workers will be expected to develop a material impairment of hearing if they are exposed to daily average sound levels between 85 and 90 dB, and a few will even develop a material impairment from average levels between 80 and 85 dB. Since it is possible to incur noise-induced hearing loss as a result of exposure to daily average levels less

than 90 dB, OSHA has determined that it is necessary to initiate audiometric testing and other aspects of the hearing conservation program at a time-weighted average sound level of 85 dB. The practice of requiring an "action level," a point well below the permissible exposure level at which protective action is taken, is consistent with OSHA's policy of protecting workers before they are overexposed. Moreover, the final standard will identify those in the exposed population that might be more sensitive to noise, and protect them before they suffer further adverse effects. In keeping with this policy, employers may wish to provide audiometric testing for employees whose TWAs are between 80 and 85 dB, so that the few most susceptible workers might be identified and protected.

B. Effects of Impulse Noise on Hearing

The fact that impulse noise can be extremely damaging to hearing is widely supported in studies submitted to the record (Ex. 29, pp. 211-216, pp. 219-228, pp. 229-234; Ex. 30, App. G; Ex. 37 or Ex. 26-12(B); Ex. 279, 11-3 and 11-5). Although these studies suggest that there is no uniformly accepted definition of impulse noise, everyone agrees on certain of its characteristics. Impulse noise is characterized by a rapid rise time, high peak value of short duration, and a rapid decay. These sounds may be divided into two general categories: "A-duration" impulses are of very short duration (usually measured in microseconds) and are non-reverberant, in that they usually occur outside or in a sound-deadening environment. An example would be gunfire outdoors or in a sound-treated firing range. "B-duration" impulses are of longer duration (usually measured in milliseconds), and are reverberant mainly because they occur inside where the sound is augmented by reflective surfaces. B-duration impulses are more typical of industrial conditions where the sounds of metal impacting on metal, or short, high-level bursts of compressed air, are quite common. B-duration impulses are considerably more damaging to hearing than A-duration impulses of the same level because of the increased duration (Ex. 30, App. G, p. G-4).

There were a number of comments and exhibits in the record concerning impulse noise. Some were reports of studies, others were reviews of research on impulse noise, and others were discussions and recommendations for the standard.

In contrast to the studies of continuous noise mentioned above,

dose-response relationships for impulse noise are not so easily defined. This may be due in part to the fact that the different studies of impulse noise varied considerably in such parameters as the subject (human or animal), the effect (TTS or NIFTS) and the stimulus (level, rise time, A-duration, B-duration, etc.). Also, there appears to be more individual variability associated with response to impulse noise than there is with response to continuous noise (Ex. 29, p. 227).

Many of the investigators and witnesses concluded that the best way to describe the effects of impulse noise was an approach called the "equal energy" method or rule (Ex. 54, pp. 16, 17; Ex. 279, 11-3, pp. 444, 449; Ex. 29, pp. 213-214; Ex. 321-21E, pp. 1-9; Ex. 80, App. B, p. 3, Ex. 81A, p. 3). According to this approach, equal amounts of sound energy produce equal effects on hearing, even though they are distributed differently in time. As explained in the introduction, sound energy is represented logarithmically by the decibel scale, an increase or decrease of 3 dB representing a doubling or halving of sound energy, and an increase or decrease of 10 dB representing a tenfold change in sound energy. Therefore, this approach is also called the 3-dB rule or the 3-dB exchange rate. It is somewhat more conservative than the 5-dB exchange rate presently used in OSHA's noise standard, 29 CFR 1910.95, and in this amendment.

Studies

In an article that OSHA had used to support the impulse requirements in the proposal, Dr. D. H. McRobert and Dr. Ward (Ex. 13) discussed their laboratory study of TTS due to short-duration impulses. The purpose of the study was to determine the appropriate trading relationship between sound level and number of impulses. Drs. McRobert and Ward used impulses with peak sound pressure levels of about 146 to 155 dB and about 2 milliseconds in duration. After establishing an individual's "critical level" (the level that produced a 20-dB TTS), the investigators lowered the level and increased the numbers of impulses. They found that subjects could tolerate greater numbers of lower-level impulses than would have been predicted by the equal energy rule (Ex. 13, p. 1299). On the basis of their experiment, Drs. McRobert and Ward recommended a 5-dB decrease in peak level for every tenfold increase permitted in number of impulses. However, they cautioned that this relationship would only be correct for non-reverberant impulses, not for reverberant impulses. In fact, they

stated that it is probably erroneous to have a single dose-response curve for both reverberant and non-reverberant impulses (Ex. 13, p. 1300).

In a document submitted by EPA (Ex. 29, pp. 219-228), Drs. T. Ceypek, J. Kuzniarz, and A. Lipowczan reported on their field study of 213 drop-forge workers. The noise environment consisted of impulses with peak sound pressure levels of 127 to 134 dB and durations of 100 to 200 milliseconds repeated 3,000 to 10,000 times per day, superimposed on a background noise of about 110 dB. Subjects had been exposed to these conditions for one to 30 years. The results showed large hearing losses even after fairly short durations, such as two years (Ex. 29, pp. 221, 227). The authors concluded that impulses combined with continuous noise produced a more rapid development of permanent hearing loss than would continuous noise alone and that the loss observed after five years was the same as that which would be expected after 10 years of exposure to continuous noise (Ex. 29, pp. 221, 227). They also concluded that the criteria developed for gunfire (non-reverberant impulses) were inappropriate for such industrial conditions as dropforging (Ex. 29, pp. 221, 227).

In another chapter of the document submitted by EPA (Ex. 29, pp. 229-234), Dr. H. G. Dieroff described a laboratory study that he had conducted of the effects of impulse noise on guinea pigs. In an attempt to discover a mechanism causing the hearing loss that is different from the one involved in continuous noise-induced hearing loss, he studied the effects of impulse noise on the cochlear microphonic potential (MP), and on the secretion of succinylcholinesterase (SDH) activity in the cochlear. In so doing he compared a mechanical and a histochemical response to sound stimuli. He found that when guinea pigs were exposed to peak sound pressure levels of 162 dB for durations of 200 to 400 milliseconds the MP was very rapidly adversely affected, whereas any adverse SDH changes were not detected until much longer after they would have been predicted to appear with exposure to equivalent levels of continuous noise (Ex. 29, pp. 232-233). These seemingly conflicting results were not easily explained.

NIOSH submitted to the hearing record three studies on the effects of impulse noise (Ex. 26-12 (A) (B) and (C)), which had been performed at the Upstate Medical Center of the State University of New York by Drs. Roger Hamernik and Donald Henderson and their colleagues. In the experiments

chinchillas were used, a practice that is not unusual for laboratory studies of permanent hearing loss. In the first of these studies (Ex. 26-12(A), pp. 1-20), Dr. C. R. Perkins, with Drs. Hamernik and Henderson, explored the effects of the time interval between impulses on the magnitude of hearing loss. They exposed five chinchillas to 50 A-duration impulses with a peak sound pressure level of 155 dB and an interval between sound stimuli of one minute. Five more chinchillas were exposed to impulses of the same number and level, but with an interval between stimuli of only 10 seconds. The results showed that the group with the shorter interval between stimuli (and hence less recovery time) had much more temporary and permanent hearing loss than the group with the longer recovery interval (Ex. 26-12(A), pp. 6-7).

In the second study, Drs. Hamernik, Henderson, J. Crossley, and R. Salvi (Ex. 26-12(B), and Ex. 37) reported on a laboratory experiment on the interaction of continuous and impulsive noise. As justification for the experiment, the authors cited the high incidence of serious hearing losses among army personnel in the armored branch, where exposure to a combination of continuous and impulsive noise is common (Ex. 26-12(B), p. 117). Groups of chinchillas were exposed to 50 impulses having a 40-millisecond A-duration with peak sound pressure levels of 158 dB and 175 dB, a 2000 to 4000 Hz band of continuous noise of 95 dB, and two combination exposures of impulsive noise at 158 dB with continuous noise at 95 dB. Results showed that the combination of impulsive and continuous noise produced sizeable permanent hearing losses, whereas the TTS from the exposures to continuous noise alone and impulsive noise alone recovered fully with time (Ex. 26-12(B), pp. 118-119). The exposure to impulsive noise of 175 dB proved to be less damaging than the combined exposure (of 90 dB plus 175 dB), even though the impulse was 17 dB higher in level (Ex. 26-12(B), p. 119). When the combined exposure was interrupted with quiet periods of approximately 2 seconds, the damage was less severe even though the total sound energy was the same (Ex. 26-12(B), p. 120). Dr. Hamernik and his co-workers concluded that since the addition of the background noise to the impulses added very little to the total sound energy, the large increase in damage must be due to something else, such as "metabolic insufficiency" in the cochlea (Ex. 26-12(B), p. 120). The authors suggested that the interactive effect of impulsive and continuous noise

might be similar to the drug-noise interaction, where damage due to the interaction can be two to four times greater than the damage expected from each stimulus alone (Ex. 26-12(B), p. 120).

In the third study (Ex. 26-12(C)) Drs. Hamernik and Henderson and Charles M. Woodford attempted to determine a safe level of B-duration impulses and to explore the trading relation between impulse intensity and duration. They exposed a total of 23 chinchillas to 50 impulses with the same duration (200 milliseconds) and interval between stimuli (one per minute), but with differing peak sound pressure levels. The investigators found that 50 impulses at the 140-dB level produced no permanent hearing loss or cochlear destruction, and was presumed safe for chinchillas, whereas the 155-dB level produced profound changes in hearing and cochlear structure, and was presumed hazardous (Ex. 26-12(C), pp. 2-3). In the group exposed to 150 dB some animals were severely affected, and others appeared to be nearly normal. The authors concluded that 150 dB may be close to a critical level at least for the number and temporal pattern of impulses that were used in the experiment (Ex. 26-12(C), p. 4).

Reviews

In a publication submitted by the Environmental Protection Agency, Drs. R. Coles, C. Rice, and A. Martin reviewed research on the effects of impulse noise performed before 1973 (Ex. 29, pp. 211-217). According to the authors (Ex. 29, p. 212), the first comprehensive set of recommendations for impulse noise was published in 1968 by Coles, Garinther, Hodge, and Rice. These recommendations were based on gunfire-induced TTS (Ex. 29, p. 212), and assumed that a similar amount of permanent hearing loss would occur after years of habitual exposure (Ex. 29, p. 214). They were applicable to military situations where about 10 to 20 exposures per year would occur (Ex. 29, p. 214). These criteria allowed A-duration impulses with peak levels up to about 175 dB, so long as the duration was extremely short (only a few microseconds). Peak levels must be reduced as duration increases. The authors also described (Ex. 29, p. 213) the attempt in 1970 of Coles and Rice to extend the criteria (previously based on gunfire-type impulses) to longer duration impulses, which would be typical of industrial conditions. Coles and Rice added data points to the criteria, indicating that the peak level should be considerably lower for B-duration than for A-duration impulses in order to

produce the same amount of hearing loss. According to Coles et al. (Ex. 29, p. 213), this extension was based on TTS studies by Cohen, Kylin, and LaBenz in 1966, and Walker in 1969.

Another document (Ex. 279, 11-3), a report by Dr. Alan Martin entitled "The Equal Energy Concept Applied to Impulse Noise," presented an extensive review of research conducted before 1978 on the effects of impulse noise. In addition to some of the studies mentioned above, he discussed his own field study (Ex. 279, 11-3, p. 432) of 77 dropforge workers exposed to peak sound pressure levels of 65 to 448 Pascals (130 to 147 dB) with a repetition rate of 0.2 to 0.7 per second. Dr. Martin combined noise levels and duration according to the method advocated by Robinson (Ex. 12, App. 10, and Ex. 17, p. 14). His experiment supported the use of the equal energy (or 3 dB) rule for predicting the amount of permanent hearing loss resulting from all kinds and combinations of noise (Ex. 279, 11-3, pp. 437, 449). Instead of starting with critical peak levels and progressing to lower levels with increases of duration (like Coles et al. in Ex. 29, p. 212), Dr. Martin advocated building on the existing criteria for continuous noise, decreasing the duration as the level became higher (Ex. 279, 11-3, pp. 444-449).

Using the data from other impulse noise investigations, Dr. Martin combined level and duration of exposure according to the equal energy rule, and compared the results to studies of continuous noise. A study of 70 dropforgers by Guberan, Fernandez, Cardinet, and Terrier was supported by Dr. Burns (Ex. 54, pp. 9,11) as well as by Dr. Martin (Ex. 279, 11-3, p. 439) as supporting the equal energy rule for predicting hearing levels resulting from impulse noise. Dr. Martin also used Ceypek's data (Ex. 279, 11-3, p. 440) on dropforgers and achieved the same results. In addition he cited a study by Atherly (Ex. 279, 11-3, p. 443) of 50 trimmers who used pneumatic chisels on manganese bronze castings. Once again the observed hearing levels agreed very closely with predicted levels according to the equal energy rule, even in the extremes of the population distribution (at the first and 99th percentiles) (Ex. 279, 11-3, pp. 443-444). Dr. Martin concluded that these studies provided ample proof that the equal energy concept may be extended to include exposures to industrial impulse noises (Ex. 279, 11-3, p. 444).

Dr. Martin believed that the preponderance of the evidence indicated that the equal energy concept should be extended from steady-state noise

exposure to include industrial impulse noise. He concluded by stating:

It is somewhat surprising that, in the past and in the context of injury to hearing, impulse noise has been treated as a special type of noise having different properties than steady-state noise. It is now apparent from research, as perhaps has been from a logical viewpoint for some time, that it merely forms part of a "temporal" continuum of noise, and therefore should be treated in a similar manner to the rest of that continuum. (Ex. 279, 11-3, p. 449).

Criteria and Standards

The current noise standard, 29 CFR 1910.95, limits impulse noise to a peak sound pressure level of 140 dB.

OSHA's proposal maintained the maximum allowable level for impulses at a peak sound pressure level of 140 dB but specified a maximum of 100 impulses at that level with a 10-dB decrease in level for each tenfold increase in number (39 FR 37775, October 24, 1974), (an equal energy approach). According to the proposal's preamble, this requirement was based on the study by Drs. McRobert and Ward (Ex. 13), discussed above. In addition the proposal defined "impulse or impact noise" as "a sound with a rise time of not more than 35 milliseconds to peak intensity and a duration of not more than 500 milliseconds to the time when the level is 20 dB below the peak." If impulses occurred more often than once every half second they were to be considered as continuous noise.

Certain other standards and criteria for impulse noise were submitted to the record. In a report entitled "Proposed Damage-Risk Criterion for Impulse Noise (Gunfire)" (Ex. 16), the Committee on Hearing, Bioacoustics, and Biomechanics (CHABA) modified the criteria of Coles et al. (Ex. 29, pp. 212-214; Ex. 279, 11-3, p. 421), making it about 10 dB more stringent (Ex. 16, p. 5) in order to protect a higher percentage (95 percent) of the exposed population (Ex. 16, p. 2). Even so, the criteria were designed to permit NIPTS of 10 dB at 1000 Hz, 15 dB at 2000 Hz, and 20 dB at 3000 Hz and above in a small percentage of the population (Ex. 16, p. 1). The criteria specified a maximum peak sound pressure level of 164 dB for the short pulses (25 microsecond or less), with a 2-dB decrease for each doubling of duration, dropping to a plateau of 152 dB for A-duration impulses or 138 dB for B-duration impulses (200 to 1000 milliseconds) (Ex. 16, pp. 2, 4-5).

The authors of the CHABA report cautioned that it was only a first attempt at reasonable damage risk criteria for impulses, and it rested heavily on the assumption of a constant relation

between TTS and NIPTS, and that this assumption might be incorrect (Ex. 16, p. 6). However, they believed that the report designated "reasonable limits for the type of impulse noise to which most service personnel will be exposed: rifle and pistol reports from his own and his fellows' weapons, and single rounds fired by higher caliber armament in both reverberant and non-reverberant conditions." (Ex. 16, p. 6).

The NIOSH criteria document (Ex. 1) made very little mention of impulse noise, except to say that the provisions in the recommended standard were "intended to apply for all noise even though additional controls may be necessary for certain specific types of noise, such as some impact and impulsive noise." (Ex. 1, p. 1-1). However, no specific recommendations were given for the measurement of impulse noise, or for calculating its contribution to the daily dose. In the supporting text NIOSH stated that industrial noise and hearing surveys dealing with this kind of exposure were just beginning at that time (1972) (Ex. 1, p. IV-9).

EPA submitted to the record a document entitled "Information on Levels of Environmental Noise Requisite To Protect the Public Health and Welfare With an Adequate Margin of Safety" (Ex. 30). This document contained a section on impulse noise (Appendix G), which modified the CHABA criteria so that the allowable levels would prevent 90 percent of the exposed population from incurring more than a 5-dB hearing loss at 4000 Hz (Ex. 30, App. G, pp. G-4, p. G-10). The allowable levels became accordingly more stringent. A peak sound pressure level of 152 dB was the maximum allowable level for impulses of 25 microseconds or less, with plateaus of 140 dB for A-duration impulses and 126 dB for B-duration impulses (Ex. 30, Appendix G, p. G-6). Unlike the CHABA criteria EPA recommended changes in peak level of 10 dB for every tenfold change in number of impulses based on a limit of 100 impulses (Ex. 30, App. G, p. G-4). The EPA "Levels" document indicated growing support for the extension of the equal energy rule to include impulsive as well as continuous noise exposure (Ex. 30, App. G, p. G-9). However, the authors recommended evaluating impulsive and continuous noise separately, "each according to its own criterion," until combining them according to the equal energy rule had been further justified by more research (Ex. 30, Appendix G, pp. G-8, G-9).

Recently Col. Johnson submitted to the hearing record a preliminary draft

ANSI standard entitled "The Evaluation of the Effect on Human Hearing of Sounds with a Peak A-Weighted Sound Pressure Level Above 120 Decibels and a Peak C-Weighted Sound Pressure Level Below 140 Decibels" (Ex. 321-21E). Although the draft ANSI standard is intended to cover impulse noise, the committee decided against unequivocally defining impulse noise, impact noise, or types of non-impulsive noise (Ex. 321-21E, p. 1), and instead refers to "intense" sound (Ex. 321-21E, p. 3). The basic measurement used to assess the effect of intense sound on hearing is the A-weighted equivalent continuous level (calculated by the equal energy rule), and all sound between the levels specified in the title is to be included in the assessment (Ex. 321-21E, p. 1). The measuring system must be able to integrate properly the energy of very short impulses, and the sound environment must be sampled at least every 25 microseconds (Ex. 321-21E, p. 6).

Although the ANSI standard still is in the preliminary draft stages, the intent of integrating impulsive with continuous noise according to the equal energy rule appears to be quite clear.

Discussion

The topic of the maximum permissible peak sound pressure level of 140 dB will not be addressed in this discussion since the requirement is present in the existing standard, 29 CFR 1910.95, and remains unchanged at this time. However, the method with which impulses are to be included in employee dose is germane to the calculation of dose or TWA for purposes of the hearing conservation amendment.

Walter Nowikas, late president of Donley, Miller and Nowikas, Inc. (Ex. 161, 9 B; Tr. 3222), pointed out that OSHA's criteria were derived from studies of short duration impulses, and therefore were not appropriate for longer duration industrial impulses. He believed that the proposed limit of 100 impulses at 140 dB was excessive since it could exceed the allowable exposure for continuous noise when the sound energy was summed. To prevent this discrepancy, he suggested reducing the number of impulses by a factor of 10 (Ex. 14-42, p. 6). Mr. Nowikas recommended changing the criteria "to conform at least with the RMS equivalent" (the equivalent for continuous noise) (Ex. 161, p. 31).

Some comments favored integrating impulses in the manner suggested above by Dr. Martin (Ex. 279, 11-3) and later by Col. Johnson (Ex. 321-21E). Dr. Loren Kerr, Medical Director of the United Mine Workers (Ex. 80, App. B, p. 3),

suggested that the standard should read, "Impulse noise, when integrated by the equal energy rule, shall not produce equivalent levels in excess of Table G-16(a)." Dr. Burns (Ex. 54, p. 16) testified that he was "satisfied that impulse noise, suitably handled, is also amenable to a simple energy method of exposure."

In order to be sufficiently protective, Drs. Richard Bolt and Edgar Shaw, speaking for the Acoustical Society of America, recommended the equal energy rule until such time as more definitive criteria could be developed. They stated:

It is regrettable that no simple but valid damage risk criterion covering all kinds of impulse and impact noise exposure has yet been found or appears within sight. In these circumstances, it may be wise to consider limits based strictly on the A-weighted daily total acoustic energy, i.e. the eight hour energy equivalent level *Leq*. Such a measure might prove overprotective by as much as 10 decibels in some circumstances, but would have the merit of simplicity with respect to interpretation and instrumentation. (Ex. 14-303, p. 2).

Other commenters pointed out that OSHA had proposed a standard that seemed to allow two separate doses—one for continuous noise, and one for impulse noise (Ex. 79, p. 7; Ex. 80, App. B, p. 3). On this subject Wookcock stated (Ex. 79, p. 7):

* * * I would like to point out that OSHA has proposed a noise standard which, in effect, sets two separate levels—one for continuous noise and one for impulse and impact noise. Conceivably, the standard allows for a double exposure. This should be corrected so that both hazards are not permitted to exist at the same time.

Dr. Ward must have recognized this problem when he recommended using a combination of the 5-dB and 3-dB trading relations. He suggested using the 5-dB trading relation when calculating noise dose for exposures from 85 dB to 105 dB and the 3-dB trading relation for high level exposures above 105 dB (Tr. 1042-1043). He felt that this combination would bridge the gap between steady and impulsive noise (Ex. 64, Statement by W. Dixon Ward on behalf of AISI—July 1, 1975, pp. 10-11).

Conclusions

It is clear from examining the studies, reviews, standards and comments discussed above that the early criteria for impulse noise were developed using assumptions that are not generally applicable to industrial conditions. The studies on which they were based used A-duration (gunfire) impulses, even though they have been extrapolated to cover B-duration impulses (Ex. 29, pp.

212-213; Ex. 16, p. 6; Ex. 30, App. G, p. G-8). In addition, the early studies of gunfire noise did not include moderate or high levels of continuous noise in the background, which is typical of the industrial situation (Ex. 294, p. 1; Ex. 26-12(B), p. 117). Since the early criteria were meant to apply to the military situation they assumed only 10 to 20 exposures per year (Ex. 29, p. 214), whereas workers in industry often are exposed to impulsive noise on a daily basis.

When impulsive noise was combined with continuous noise, the studies and reports submitted to the hearing record showed fairly clearly that the hazard increased (Ex. 26-12(B), p. 119; Ex. 29, pp. 221, 227). The study by Hamernik et al. (Ex. 26-12(B), p. 119) showed an effect that was not just additive but synergistic. Field studies where impulses were superimposed on background noise indicated that hearing loss was exacerbated. Ceypek et al. (Ex. 29, p. 221) found considerably more damage than would be expected from continuous noise. Dr. Martin (Ex. 279, pp. 449, 432-444), through the results of his own investigation and by evaluating the data from studies by Guberan et al., Ceypek et al., and Atherly, found that the best way to predict hearing loss was to extend the equal energy rule from continuous through impulsive noise. The draft ANSI standard submitted by Col. Johnson (Ex. 321-21 E, p. 1) supports this method for use in the U.S.

Therefore, OSHA has determined that, for purposes of the hearing conservation program, impulse noise should be combined with continuous noise for purposes of calculating employee noise exposure. Since industrial impulses are almost always superimposed on a background of moderate-to-high levels of continuous noise (Ex. 6, p. 12338; Ex. 26-12(B), p. 117; Ex. 29, p. 229; Ex. 29, p. 227; Ex. 30, p. G-8), and since both may be harmful, it is only reasonable to consider their effect together, rather than to treat each separately. There is ample justification for this approach in the studies and comments submitted to the hearing record (Ex. 26-12(B), pp. 117, 121; Ex. 279, 11-3, p. 449; Ex. 29, p. 213; Ex. 60, App. B, p. 3; Ex. 81A, p. 3; Ex. 54, p. 16). However, since there are still some uncertainties as to the ameliorative effects of certain temporal patterns (Ex. 26-12(A), pp. 6-7, 10; Tr. 1051; Ex. 26-12(B), p. 120), and since there usually are some quiet periods (or less noisy periods) during the work day (Ex. 64-5, p. 2; Ex. 64-6, p. 6; Ex. 6, p. 12338; Ex. 114, p. 7), the Agency cannot determine the precise effects of industrial impulses

at this time, and therefore OSHA has chosen to retain the 5-dB exchange rate for purposes of the hearing conservation amendment. Until such time as another method, such as the equal energy rule (the 3-dB exchange rate), or a combination of the 3-dB and 5-dB exchange rate (as suggested by Dr. Ward, Tr. 1042-1043), is borne out by laboratory and field research, OSHA will continue to require the integration of all sound, including impulse noise, according to the 5-dB exchange rate in the computation of dose or TWA.

While the hearing conservation amendment does nothing to change the PEL or methods of compliance required by 29 CFR 1910.95(a) and (b)(1), it does require that all noise exposures above 80 dB, whether impulsive or steady state, be considered in determining whether an employee is included in the hearing conservation program. The decision to measure all noise exposures for purposes of the hearing conservation program is a pragmatic approach to the whole problem of impulse noise. For, while there is some dispute as to the precise definition and effect of impulse noise, there is general agreement that impulse noise is damaging. The hearing conservation program is designed to identify and protect those who show an increased susceptibility to the effects of noise. Accordingly, in computing an employee's noise dose or TWA for purposes of inclusion in the hearing conservation program, the impulsive component of the noise exposure is included. Moreover, there have been many technological advances in the capabilities of measuring instruments, and equipment now exists that can integrate impulse noise into the dose. Therefore, OSHA has determined that it is appropriate to include impulse noise in the dose computation for hearing conservation in order to provide employees exposed to significant amounts of this type of noise the protection of the amendment.

C. Extra-Auditory Effects of Noise

The most obvious physiological effect of noise is damage to the auditory system. However, depending upon the level, type, and duration of the noise, a variety of extra-auditory effects have been observed, which will be discussed in the following paragraphs. In addition, it should be noted that people who are exposed to noise at work may also be exposed to noise during their non-working hours. For example, many workers live in areas where there is highway and aircraft noise as well as noise from industrial plants. Industrial workers who live in the urban settings are sometimes stressed by noise 24

hours a day without respite, and without adequate opportunity to recover, either physiologically or psychologically. Thus, effects that might otherwise have been temporary would tend to become chronic.

Although there is a substantial body of data suggesting a wide variety of noise-induced physiological responses, specific responses to specific noise doses have not yet been identified. The evidence of noise-induced health effects is not conclusive for 8-hour exposures of 85 dB, or 90 dB, or even higher levels experienced over a working lifetime. However, to ignore this large body of data is to undervalue the significance of the adverse effects (Ex. 5, p. 43806; Ex. 138A, p. 2-31). Both testimony and written exhibits, including subjective and experimental evidence, indicate that noise can be harmful to human health (Ex. 2C-106, p. 2; Ex. 2C-111, p. 1; Ex. 2C-4, p. 1; Ex. 96, pp. 277-281; Ex. 189-8, p. 2; Ex. 28A, pp. 18-24, 27-28, 41-44, 46-49; Ex. 32, App. B, pp. 6-11; Ex. 79, p. 2; Ex. 173, pp. 1-2, 7-8; Ex. 84, Attach. 2, pp. 1-2).

During the 1975 and 1976 public hearings most of the evidence that was submitted was anecdotal, although some studies were submitted by individuals (Ex. 28A), unions (Ex. 88, Ex. 95, Ex. 96, Ex. 97, Ex. 98), and government agencies (Ex. 26-9; Ex. 26-10; Ex. 26-3; Ex. 26-11; Ex. 32; Ex. 40). Leonard Woodcock, then president of the United Auto Workers, stated:

I am sure that there are many limitations to these studies, as there always seems to be in this sort of work. But we think there is truth to these studies since it matches our subjective experience. We expect that future research into this important area will offer more definitive data. (Ex. 79, p. 5)

According to Ruth Knowles, then president of Local 1716 of the Textile Workers Union (Tr. 2024), "Some workers have been forced to retire long before retirement age because of hypertension." She goes on to state that in her opinion the high noise exposure in the weave department could have been a factor in those instances.

The major concern over extra-auditory health effects from noise arises from the fact that noise has the ability to act as a general, non-specific, biological stressor (Ex. 138A, p. 2-31). Evidence suggests that the stress reaction produced by noise is not unlike that produced by other stressors; that is, a generalized reaction governed by sympathetic activation of the autonomic nervous system.

The concept of biological stress, first introduced by Dr. Hans Selye, has been described as "the nonspecific response of the body to any demand made upon

it; a stereotyped, phylogenetically old adaptation pattern primarily preparing the organism for physical activity, e.g., fight or flight." (Ex. 138A, p. 2-32).

This stress reaction produces a widespread change in bodily activity. There is a rise in blood pressure, a rise in pressure inside the head and an increase in sweating. The heart rate increases, there are changes in breathing and there may be a sharp constriction of the muscles over the whole body (Ex. 26-9, p. 10-8). These changes are likely to be mediated by increased adrenal secretion of the catecholamine hormones, epinephrine and norepinephrine (Ex. 138A, p. 2-32).

In the hearing record two theories were proposed to explain mechanisms by which these stress-related physiological changes can have an impact on human health. Two conceivable damage pathways were developed:

1. Abnormalities in blood pressure regulation that lead to hypertension.

2. Increased blood platelet adhesiveness that accelerates the development of atherosclerotic plaques in the walls of the arteries.

Each of these stress-related damage pathways is discussed in turn.

1. The theory that noise stress can result in hypertension is supported by Dr. Bruce Welch (Ex. 321-16E, pp. 1-11) and Dr. Ernest Peterson (Ex. 321-16D, pp. 1, 4, 10) as well as by numerous other researchers, referred to in these and other exhibits (Ex. 88, p. 6; Ex. 96, p. 279). Intense industrial sound impairs the regulation of blood pressure, the most distinct manifestation of which is an increased prevalence of hypertension (Ex. 321-16E, p. 2).

According to Dr. Welch, hypotension, or reduced blood pressure levels, also can result from noise stress (Ex. 321-16E, pp. 3-4). Both hyper- and hypotension fundamentally are disorders of circulatory regulation. They are characterized by exaggerated and inappropriate cardiac and vasomotor response to changes in body position or physical and psychological stimuli (Ex. 321-16E, p. 8). This increase in vascular lability (or changeability) under noise stress affects the circulatory adjustments that must normally be made during the course of a working day (Ex. 321-16E, p. 9). For those who already have impaired circulation, excessive vascular lability can lead to congestive heart failure, cardiac ischemia, or cardiovascular stroke. In fact it has been established that hypertension, even at moderate elevations, is associated with increased risk of coronary and cerebrovascular disease (Ex. 321-16E, p. 3).

2. In a report submitted by EPA (Ex. 138A, p. 2-40) Hattis et al. proposed another pathway theory, which involves an increase in the adhesiveness of blood platelets. Increased platelet adhesiveness has clear potential for negative side effects, due to an increased tendency for the formation of thrombi, small aggregates of platelets and other blood components involved in the clotting process. These thrombi contribute to the buildup of atherosclerotic plaques, which gradually narrow the arteries and reduce the oxygen supply to vital tissues. A heart attack can occur when there is complete blockage of an artery to the heart muscle, or when the demand for blood oxygen is greater than that which can be supplied through a narrowed coronary artery. These effects can be cumulative, for the same thrombi that contributed to a gradual narrowing of the arteries can complete the sequence by forming the final occlusion leading to tissue death in the heart.

Two epidemiological studies that were submitted to the record are of particular importance. In a classic study of German iron and steel workers (Ex. 98, p. 219), Dr. Gerd Jansen found that 62 percent of the workers chronically exposed to noise levels above 90 dB had "peripheral circulatory symptoms", compared to 48 percent of those exposed to lower levels. Physiological and psychological examinations were performed to determine the extent to which the difference could be caused by non-occupational factors. Dr. Jansen concluded that noise interferes with involuntary bodily functions, and as such could be a serious health risk.

A NIOSH-sponsored study (Ex. 29, pp. 441-452) performed by the Raytheon Service Company lends further support to these findings. The medical records of factory workers routinely exposed to high noise levels (at or above 95 dB) were compared to those of a population exposed to lower noise levels (at or below 80 dB). Statistically significant differences in the number of cardiovascular and circulatory disorders as well as other health problems and complaints were found between the two groups. In a follow-up study the Raytheon Service Company compared medical records of workers exposed to high noise levels (prior to the implementation of a hearing conservation program) with records of the same workers after a hearing conservation program has been put into effect. The overall results indicated fewer accidents, diagnosed medical disorders, and absences during the period when workers were involved in a

hearing protection program. The Raytheon report summarizes: "In general, the results were interpreted as adding strong support to the hypothesis that prolonged exposure to high intensity noise increases the incidence of various medical, accident and attendance problems." (Ex. 26-11, pp. 5-1 and 5-2).

In an experimental study (Ex. 28A, pp. 42, 46-50) on the effects of prolonged exposure to tonal pulses, Dr. Robert Cantrell found statistically significant increases in plasma cortisol and blood cholesterol levels when compared with the pre-exposure levels of his experimental subjects. Significant increases were noted at noise levels of 80 and 85 dB, and were pronounced at 90 dB.

However, there was skepticism during the hearings about the importance of extra-auditory effects. The Edison Electric Institute maintained that:

since there is no clear evidence on non-auditory noise impact, an occupational noise standard should not consider this area. We recommend that the federal government undertake additional long-term research as provided for in the OSH Act before promulgating standards for non-auditory noise effects (Ex. 73, p. 2).

According to Dr. Bruce Karth of DuPont:

I know of no significant report of extra-auditory physiological effects for persons with noise exposure levels below 115 dBA. We have not conducted a controlled scientific study on non-auditory effects of noise at our plants because of our experience with our hearing conservation program has not indicated a need for such a study (Ex. 114, p. 14).

In May of 1973 three Swedish researchers (Carlestam, Karlsson, and Levi in Ex. 29, p. 485) pointed out that "the evidence in favor of noise as a major pathogenetic environmental agent is rather shaky."

Between the 1975 hearings and the recent reopening of the record (April 1980), considerable research activity has occurred, and new and more persuasive evidence has been submitted to the record.

The EPA submitted an analysis by Dr. Welch (Ex. 321-16E) of over forty studies from European and Soviet bloc nations of the effects of noise exposure on the cardiovascular system. Dr. Welch found evidence of noise-induced structural changes in the heart, increased cardiac morbidity, cerebrovascular and peripheral vascular disorders, and hypertension (Ex. 321-16E, pp. 2-21). Dr. Welch admits that many of these studies suffered from methodological problems, although approximately half of them presented

data in a statistically verifiable manner. Viewed as a whole, these studies represent a consistent body of data containing significant evidence that noise levels greater than 90 to 95 dB may increase the risk of cardiovascular disease in exposed workers. He concludes:

In a practical sense, the available evidence now demands that prolonged exposure to high intensity sound be viewed in a much broader sense than heretofore as a serious threat to general human health. The evidence for associating long-term sound exposure with cardiovascular disease, in particular, is comparable to that for associating it with loss of hearing (Ex. 321-16E, p. 37).

In another report submitted by EPA (Ex. 321-16D, pp. 1-2), Dr. Peterson also discusses recent developments in research on the extra-auditory effects of noise. He finds that by far the largest body of evidence centers about the relationship between prolonged exposure to intense noise and cardiovascular performance. The most common occurrence is one of impaired regulation of blood pressure, which may be manifested either as hypotension or hypertension. Other signs and symptoms that occur more frequently in noise-exposed workers are abnormalities in cardiac pacing, reducing stroke volume, various ECG abnormalities, and narrowing of retinal arteries. Dr. Peterson also reported on his own work (Ex. 321-16D, pp. 6-10), a laboratory study of the effects of protracted noise exposure on rhesus monkeys. Monkeys were chosen as an animal model so as to closely approximate human response. As a result of life-like exposure scenarios (averaging 85 dB) for 9 months, the monkeys showed significant alterations in blood pressure that were sustained even after cessation of the stimulus.

A third submission by EPA (Ex. 321-16F) is a study of German brewery workers by Dr. H. Ising et al., who attempted to quantify the risk to the cardiovascular system associated with exposure to noise levels averaging 95 dB. Dr. Ising used each individual as his own control by comparing various cardiovascular indicators with and without the use of hearing protectors. In so doing he overcame some of the methodological problems discussed by Dr. Peterson (Ex. 321-16D, pp. 2-4) and Dr. Welch (Ex. 321-16E, pp. 35-37). Dr. Ising found that on days when people worked without hearing protection, there was a significant elevation in systolic blood pressure, changes in arterial wall elasticity, and increased levels of catecholamine hormones excreted in the urine. (The catecholamines are characteristically

secreted in response to stress, and have been associated with increased blood platelet adhesiveness and with increases in blood pressure (Ex. 138A, pp. 2-32 and 2-33)).

Despite the quantity of evidence in the studies discussed above, clear dose-response relationships do not yet exist for the cardiovascular effects of noise. However, if, as the evidence suggests, there is a cause-effect relationship between noise and hypertension, the health implications would be widespread and serious (Ex. 79, p. 5; Ex. 266B, pp. 2, 13, 14-15; Ex. 138A, p. 2-31; Ex. 321-16E, p. 37; Ex. 29, p. 485). Therefore the Agency urges caution on the part of employers. OSHA has included the above evidence as a qualitative, if not a quantitative, argument for requiring hearing conservation programs.

Other extra-auditory effects are also discussed in the record. The report of the initial Raytheon study, mentioned above, described other possible effects of noise (Ex. 29, pp. 449, 451). In addition to cardiovascular effects, the investigators found evidence of digestive, respiratory, allergenic, and musculo-skeletal disorders. Over a period of 5 years the number of diagnosed disorders in every category was significantly higher for workers exposed to high noise levels than it was for those exposed to lower noise levels.

In his report (Ex. 321-16E, p. 31), Dr. Welch discusses neurological changes associated with long-term exposure to occupational noise. After reviewing the scientific literature, he finds that the sense of balance can be altered, that reaction time is impaired, and that there is decreased tactile sensitivity in the hands and feet. Dr. Cohen and Dr. Joseph Anticaglia (Ex. 96, pp. 277) suggest that noise-induced neurological changes may occur as a result of overstimulation of the brain's reticular formation, leading to a state of reflex hyperactivity and abnormal EEG response. The authors noticed that laboratory subjects complained about feelings of disorientation after exposure to high levels of noise (Ex. 96, p. 278). Studies cited by Dr. Edith Gulian (Ex. 97, pp. 38-39) support this observation with factory workers as well. It has also been suggested that high levels of noise reduce the eye's ability to focus clearly, and narrow the visual field (Ex. 97, p. 35; Ex. 96, p. 278). These effects can be significant from the standpoint of potential accidents and injuries (Ex. 96, p. 279).

There was information on the effects of noise on worker performance submitted to the hearing record. According to EPA's Public Health and

Welfare Criteria for Noise (Ex. 31, p. 8-2), a variety of effects have been observed in the literature. EPA cites research by Dr. D. O. Hebb to explain these effects. To paraphrase: Changes in stimulation (such as intense noise) produce arousal activity which originates in the reticular formation. An individual's level of arousal affects the performance of a task. Too little arousal produces inadequate performance whereas too much arousal interferes with performance. The optimum is somewhere at the top of an inverted U-shaped curve. Thus, noise can enhance, interfere with, or fail to affect the performance of certain tasks. The EPA concludes that:

Continuous noise levels above 90 dBA appear to have potentially detrimental effects on human performance, especially on what have been described as noise-sensitive tasks such as vigilance tasks, information gathering and analytical processes. Effects of noise on more routine tasks appear to be much less important, although cumulative degrading effects have been demonstrated by researchers. Noise levels of less than 90 dBA can be disruptive, especially if they have predominantly high frequency components, are intermittent, unexpected, or uncontrollable. The amount of disruption is highly dependent on the type of task, the state of the human organism, and the state of morale and motivation (Ex. 31, pp. 8-6 and 8-7).

Noise can degrade job safety in some of the same ways that it degrades performance. It is logical to conclude that the same parameters that disrupt job performance (high noise levels, or noise that is high in frequency, intermittent, unexpected, or uncontrollable) can jeopardize job safety. In addition, there are other reasons why noise can be a safety hazard. Noise can effectively mask alarm signals and warning shouts. This includes signals from malfunctioning machines and the sound of approaching vehicles.

I.W. Abel, former president of the Steelworkers Union, reported the following:

A recent study of the causes of 25 fatalities in railroad accidents by the Federal Railroad Administration showed the common factor was the workers' unawareness of the approach of the railroad cars or equipment that struck them. Many of these workers, the study pointed out, were working under exposure to a high level of noise (Ex. 78, p. 20).

Howard Pemberton, safety committeeman from Local 588 of the UAW, describes the workers' condition: "They cannot escape the noise. They also tell us—and we know from our own experience—that they cannot hear instructions from the foremen, and that

they must scream to carry on necessary communication" (Ex. 2C-74, p. 2).

Another way in which noise can lead to accidents (although the cause and effect relationship is less direct), is through workers' aversion to the noise. Dr. John Finklea, then Director of NIOSH, related the following incident:

Several weeks ago, a worker fatality was reported in a power plant in the Cincinnati area. An investigation revealed that the accident victim and his fellow workers, irritated by the screeching sounds from a pulley drive in a conveyor system, had resorted to repeated "soaping" of the pulley unit to quiet the sound. Gaining access to the pulley for this purpose involved certain risks that were contrary to company work policy. Despite this, a worker in the course of soaping the pulley evidently became caught, was pulled into the moving conveyor and was killed. It is doubtful that even an 85 dBA noise limit would have prevented this accidental death. Yet the case deserves mention if only to show that non-auditory problems of noise cannot be ignored. Indeed, it should motivate more conservative approaches in specifying noise limits meeting both health and safety needs (Ex. 29-1, p. 7).

Finally, the general effect of worker absenteeism should be mentioned. Whether from psychological aversion to noise or the physiological consequences of noise stress, absenteeism appears to be higher among workers in noisy industries. According to anecdotal evidence from union witnesses, both fatigue and absenteeism are higher (Ex. 2C-74, p. 2; Ex. 79, p. 2). Studies in the record supported this contention. The Raytheon study mentioned earlier (Ex. 26-11, p. 3-172), found significant differences in absenteeism between groups of workers exposed to average noise levels above 95 dB and below 80 dB. Absenteeism in the high noise group was significantly decreased after the institution of a hearing conservation program.

A study by Schmidt, Royster, and Pearson (Ex. 321-22F, p. 28) found significant differences in absenteeism as well in accident records. The report by Dr. Gulian cites a study by Odescalchi of 50 noisy Italian companies (such as textile, steel and metal fabrication), where the annual number of absences is about 15 percent higher than in quieter ones (Ex. 97, p. 80). Other studies cited by Dr. Gulian are inconclusive on this issue, but enough data exist to be strongly indicative of increased absenteeism, which can be very costly to industry.

III. History of the Regulation

The occupational noise exposure standard, which is found at 29 CFR 1910.95, was originally promulgated as a standard under the Walsh-Healey Public

Contracts Act, 41 U.S.C. 35 *et seq.* (See 34 FR 7946, May 20, 1965; 35 FR 1015, January 24, 1970). The Walsh-Healey occupational noise standard (41 CFR 50-204.10) was adopted under § 6(a) of the Occupational Safety and Health Act, 84 Stat. 1590, 29 U.S.C. 651 *et seq.* which, within two years of the effective date of the Act, allowed the Secretary to promulgate without regard to rulemaking any established Federal standard. (See also § 4(b)(2) of the Act).

The present noise standard limits an employee's noise exposure to 90 dB as an 8-hour time-weighted average (TWA). Employee exposure to noise above the permissible exposure level (PEL) must be reduced to within permissible limits by feasible engineering controls or administrative controls. Where such controls cannot reduce employee exposure to within permissible limits, they are to be supplemented with personal protective equipment. The OSHA noise standard also requires that the employer must administer a continuing effective hearing conservation program if exposures exceed the PEL. OSHA has interpreted this to require employers to provide audiometric testing for those employees exposed above the PEL without regard to the use of personal protective equipment. (See Industrial Hygiene Field Operations Manual, Chapter IV, pp. 9-16, OSHA Instruction CPL 2-2.20, April 2, 1979).

On August 14, 1972, the National Institute for Occupational Safety and Health (NIOSH) transmitted to the Department of Labor a criteria document, "Occupational Exposure to Noise" (HSM 73-11001) (Ex. 1), in accordance with section 20(a) and 22(d) of the Occupational Safety and Health Act, (29 U.S.C. 669(a), 671(d)), which authorizes the Secretary of Health, Education and Welfare to conduct research to develop criteria for dealing with harmful physical agents and to make recommendations to the Secretary of Labor concerning new or improved occupational safety and health standards. The criteria document recommended that employee noise exposures be limited to an 8-hour TWA of 85 dB in new installations and that the Secretary should study the feasibility of reducing the PEL in all facilities to an 8-hour TWA of 85 dB. In addition, the criteria document recommended audiometric testing not only for employees whose exposures exceeded the PEL but also for those employees whose exposures were reduced to within the PEL by the use of personal protective equipment.

On January 26, 1973 the Assistant Secretary of Labor for Occupational Safety and Health appointed an Advisory Committee on Noise pursuant to section 7(b) of the Act (29 U.S.C. 656). The Committee consisted of 15 members, representing a broad cross-section of individuals knowledgeable about noise hazards in the industrial environment. The Committee included representatives of employers and employees, as well as representatives of the public and the occupational safety and health professions. The purpose of this committee was to obtain and evaluate additional recommendations from labor, management, government, and independent experts. In its deliberations the Committee considered approximately 135 comments submitted to it by various interested parties (see Ex. 2(c)), as well as numerous oral presentations (see Ex. 2(a)). The Committee held meetings periodically during an eight-month period and on December 20, 1973 it transmitted its recommendations for a revised occupational noise exposure standard (see Ex. 2(b)) to the Occupational Safety and Health Administration (39 FR 6647, February 21, 1974).

Briefly, the Advisory Committee recommended that the permissible exposure level for occupational noise be an 8-hour time-weighted average of 90 dB, with exposures down to 85 dB integrated into the computation. Exposures to steady-state noise were not to exceed 115 dB at any time. In addition, the Advisory Committee recommended audiometric testing be done annually for all employees whose exposures equalled or exceeded 85 dB or would equal or exceed 85 dB but for the use of personal protective equipment.

OSHA considered the information and recommendations contained in the NIOSH Criteria document (Ex. 1), the Advisory Committee's recommendations (Ex. 2(b)), and other available information. On October 24, 1974, OSHA proposed a revision to its occupational noise exposure standard and solicited comments and objections to it from interested persons (39 FR 37773-37778). OSHA proposed to retain an 8-hour TWA of 90 dB as the PEL, with exposures down to 85 dB integrated into the time-weighted average. In addition, the suggested ceiling of 140 dB for impact noise exposure contained in the old standard (see 29 CFR 1910.95, Table G-16, note) was proposed to be modified to a mandatory ceiling of no more than 100 impulses of 140 dB per day, with a tenfold increase in the permissible number of impulses to which employees could be exposed for each 10 dB

decrease in the peak pressure of the impulse. The proposal also required the employer to determine if any employees were exposed to an 8-hour time-weighted average of 85 dB or above and to measure the exposure of any employees so identified. Additional exposure monitoring was required within 30 days of any change of equipment or process which would affect the noise level. Employee exposures to impact or impulse noise were also required to be monitored.

Under the proposal, audiometric testing was to be required for all employees who had noise exposures equal to or exceeding 85 dB as an 8-hour TWA and for all employees who were using personal protective equipment to reduce their exposures to an 8-hour TWA of 90 dB. If the employee's audiogram showed a significant threshold shift (STS) when compared to the employee's first or baseline audiogram, the employee had to be retested within one month. If the diminution of hearing was confirmed on retest, then the employee had to be informed of the change in the hearing level, and had to be provided and fitted with, and instructed in, the use of hearing protectors. Employees whose audiograms showed that they had a significant threshold shift were required to wear hearing protectors under the proposal even if they were not exposed over the PEL.

The preference for engineering controls over personal protective equipment as a method of compliance was retained and clarified and a limited exception was proposed that would have allowed personal protective equipment to be used even where engineering or administrative controls were feasible if the employee overexposure occurred on no more than one day a week. Various other provisions in the proposal required the employer to keep records of employee exposure monitoring, audiometric tests, calibration of audiometers, and notifications of employee overexposures.

On December 18, 1974, the Administrator of the U.S. Environmental Protection Agency (EPA), acting under the authority of section 4(c)(2) of the Noise Control Act of 1972 (86 Stat. 1236, 42 U.S.C. 4903), published a notice in the Federal Register requesting that the Secretary of Labor review the proposed occupational noise exposure regulation and report to the Administrator within 90 days on the advisability of revising the proposed regulation (39 FR 43802). Briefly, EPA contended that the proposal "does not protect the public health and

welfare to the extent required and feasible." EPA objected to the proposal's permissible exposure limit, including the use of a 5 dB time-intensity trade-off (doubling rate) in computing the PEL, and to the definition of significant threshold shift which was used in the proposal. On March 18, 1975, OSHA published in the Federal Register the Review and Report Requested by EPA (40 FR 12336). In its response, OSHA reviewed and explained the reasoning underlying its proposed regulation. OSHA noted that the document to which EPA objected was merely a proposal upon which the public had been invited to comment. The Assistant Secretary concluded that "no changes should be made in the proposal at this stage," since the proposal by its very nature did not represent a final agency position and EPA's objections would be aired along with objections raised by concerned persons at an informal public hearing. In addition, OSHA promised to consider EPA's request and the evidence contained therein along with the rest of the evidence in developing its final standard. To the extent that the final hearing conservation rule promulgated today deals with issues raised in the Request for Review and Report, they are discussed below under the appropriate topic headings.

In the notice of proposed rulemaking, interested persons were given approximately 45 days to submit written data, views and arguments on the proposal and to file objections and request a hearing thereon. The comment period was subsequently extended two more times (until March 21, 1975) because of the complexity of the issues raised in the proposal and in response to a number of requests for additional time in which to prepare responses. (See 39 FR 42929, 12/9/74; 40 FR 2822, 1/16/75). Thus, the public was given almost five months in which to file comments and objections on the proposal. OSHA received approximately 1000 written comments on the proposal (Ex. 14).

Section 6(b)(3) of the Act provides for informal public hearings on objections to a proposal. Many persons requested that hearings be held on the proposed occupational noise exposure standard and an informal public hearing was scheduled (40 FR 16336, 4/11/75). The rulemaking hearing was convened by Administrative Law Judge Milton Kramer on June 23, 1975. The hearing lasted through July 30, 1975. Over 90 parties, many of them represented by multi-witness panels, participated in the hearing. In addition, during the course of the hearing approximately 188 exhibits, many containing numerous documents,

were submitted to the record. Testimony at the hearing addressed every issue raised by the proposal, as well as environmental issues and economic issues. At the close of the hearing, a 45-day period for the receipt of post-hearing comments was authorized by Judge Kramer. The hearing record also remained open for receipt of an economic impact analysis.

On June 18, 1976, OSHA published a notice of availability of an economic impact analysis which had been prepared for the agency by Bolt, Beranek and Newman, Inc. (BBN) of Cambridge, Massachusetts (41 FR 24718). The economic impact analysis considered the possible inflationary impact and economic feasibility not only of the proposed noise exposure regulation, but of several alternatives such as a standard with a PEL of 85, and various compliance periods. Benefits to be derived from the alternatives were also considered. Basically the economic impact analysis was modeled after the guidelines for implementing Executive Order 11821 (see 39 FR 41501) although the proposal predated the Executive Order (see Ex. 192, p. iii). According to the BBN study noise exposure monitoring was estimated to cost approximately \$12 per production worker, while audiometric testing for all workers exposed to an 8-hour TWA of 85 dB or above was estimated to cost about \$20 per worker (Ex. 192, p. iv). The cost of keeping the PEL at 90 dB and instituting a hearing conservation program including audiometric testing was estimated to be approximately \$241 million per year (Ex. 192, p. iv). BBN also estimated the relative probability of workers experiencing material impairment after 20 and 40 years of exposure at 85 dB as opposed to 90 dB (Ex. 192, pp. 2-26-2-36) and estimated the benefits of including hearing conservation requirements at or below the PEL (Ex. 192, pp. 2-34-2-36).

Interested persons were given an opportunity to comment on the BBN study and a second informal public hearing was scheduled to begin on August 24, 1976 (41 FR 24718). The notice also invited the submission of any new information that might be available on the issue of economic feasibility of the proposed standard and on any of the other issues discussed in the economic impact analysis itself. OSHA subsequently extended the period in which to file comments and rescheduled the public hearing in response to a number of requests for extensions of time (41 FR 32912, 8/6/76). OSHA received approximately 108 comments

on the economic impact analysis (Ex. 193).

The economic impact hearing was convened on September 21, 1976 with Administrative Law Judge Jean F. Greene presiding. Approximately 70 parties were scheduled to appear at the hearing (Ex. 196), and approximately 69 exhibits were submitted to the record during the hearing. The hearing lasted through October 8, 1976. Those participating at the hearing were given 60 days from the close of the hearing in which to submit post-hearing comments.

During the hearing OSHA received many requests for information that was not contained in the economic impact analysis itself, but which was related to its preparation. OSHA, through arrangements with BBN, made available that portion of the requested information which had not been obtained under a pledge of confidentiality. BBN prepared a document (Ex. 278) which included some of the data requested at the hearing. In addition, BBN discussed and clarified many of the issues raised at the hearing. On January 28, 1977, OSHA published in the Federal Register a notice of the availability of the BBN post-hearing comment and additional information on the economic impact analysis (42 FR 5374). Those who participated at the hearing were given additional time in which to comment on the BBN submission. OSHA received approximately 18 comments on the BBN submission (Ex. 279).

Although the proposal was published before any of the Executive Orders requiring the preparation of Inflationary or Economic Impact Statements or Regulatory Analyses (Executive Orders 11821, 11949 and 12044), OSHA has prepared a Final Regulatory Analysis for this hearing conservation amendment which is generally consistent with the requirements of the most recent Executive Order on the subject. This analysis was based on information and methodologies contained in the noise record and uses standard techniques of economic and scientific analysis. In addition publicly available population and employment data, such as that published by the Bureau of Labor Statistics (*Employment and Earnings*) was used. Similarly, the estimates of the costs of compliance as well as benefits of the amendment were made using information from the record and publicly available data. The expected economic impact was developed using costs estimated by OSHA, on the basis of record information, publicly available data and standard techniques of economic analysis. OSHA has used the latest available data. Interested persons

may request copies of the Final Regulatory Analysis through the Docket Office.

On April 18, 1980, OSHA again opened the record to introduce additional comments, letters and reports that had been sent to the agency since the last time the record had been open (45 FR 26366). Some corrected transcripts from the second hearing were submitted to the record as an exhibit and some updated cost data on hearing conservation programs were also submitted. Interested persons were given over 45 days in which to submit comments. The Agency subsequently extended the comment period until July 3, 1980 in response to requests for additional time (45 FR 40166, 6/13/80). Thus the public was given 11 weeks in which to submit comments on this information.

OSHA received a number of objections to its April 18, 1980, Federal Register notice. Some of these objections, as noted, requested additional time in which to comment, and some raised certain procedural objections (see Ex. 321-15A, 321-11, 321-14). Several comments expressed the belief that OSHA had selectively introduced exhibits into the record (Ex. 321-15A, p. 2, 321-11, p. 2). However, OSHA made no attempt to "select" correspondence to be submitted to the record or correspondence to be withheld. Rather, all the substantive comments on noise which the Agency had on file were submitted to the record. Any comments which may have been inadvertently omitted could have been resubmitted in response to the Federal Register notice.

The Federal Register notice invited comments "on the above materials only," and went on to explain that because of the length and repetition of the existing record the public was asked to refrain from resubmitting material already submitted. The record in this proceeding could be characterized as voluminous, verbose, redundant, and since it contains approximately 38,000 pages, unwieldy. The Agency has tried in every manner consistent with the statutory mandate to accommodate the reasonable demands and concerns of interested persons. However, some few persons apparently interpreted the Federal Register notice to mean that relevant new data would not be allowed into the record. (See Ex. 321-15A, 321-11, p. 2). The vast majority of commenters, however, construed the sentence correctly and did not resubmit evidence but instead confined their comments to the general subject matter of the additional submissions. A number

of the comments received in response to the Federal Register notice (see, for example, Ex. 323) did in fact constitute new evidence or studies on the subject matter of the new submissions. (See, for example, Ex. 321-44, 321-53D, 321-17, 321-19, 321-20A, 321-21, 321-22, 321-14D, 321-35, 321-13, 321-10).

In misconstruing the notice, several persons mentioned that they should be given a chance to submit new evidence showing the effectiveness of hearing conservation programs and new updated cost estimates on engineering controls (Ex. 321-15A, 321-12A, p. 4; 321-11, p. 2-4; 321-53A, p. 2). As discussed above, the final rule here merely articulates hearing conservation requirements. Several issues, including the appropriate permissible exposure level and priorities among compliance strategies, have not been decided at this time. Both issues have been deferred for further study.

The Agency contemplates further economic studies and another hearing on these and other remaining issues. The record will be reopened to receive any new evidence on the relevant issues, including overall effectiveness of personal protective equipment as opposed to engineering controls in preventing material impairment, the permissible exposure level and the correct doubling rate, economic costs and consequences of various alternative strategies, benefits of the various strategies, and technological advances in engineering controls. Anyone wishing to do so may submit new evidence when the record is reopened.

Certain other participants requested that OSHA repropose the standard in view of advances in technology (Ex. 321-12A, p. 2; 321-11, p. 2). At the present time it is not contemplated that re-proposal will be necessary. The original proposal as well as the EPA Request for Review and Report and the OSHA response, all of which were printed in the Federal Register and actively debated at the hearing, gives the public ample notice of the wide range of regulatory alternatives that are being considered within the general parameters of the permissible exposure level and the method-of-compliance issues. Such alternatives include industry-by-industry standards, different compliance schedules, and a performance standard allowing the employer to choose the best method of compliance.

Another commenter (see Ex. 321-12A, p. 3) objected to a meeting with several audiologists which was held in August 1979. The meeting which was the subject of this objection had been held primarily to discuss various problems with the

instructions contained in the Industrial Hygiene Field Operations Manual on audiometric testing as part of an effective hearing conservation program. Since some of the issues discussed at the meeting could have possible relevance to the hearing conservation amendment, OSHA included a detailed summary of the meeting in a group of noise-related materials submitted to the record of April 18, 1980 (see Ex. 317). Interested persons were given an ample amount of time in which to comment upon this material. Clearly, then, the business community as well as other interested persons were permitted "a further opportunity for input" (see Ex. 321-12A, p. 4) on the subject of the meeting.

A few other commenters objected that a new hearing was not being scheduled to discuss the new record submissions. (See Ex. 321-15, 321-15A, p. 2). Section 6(b)(3) of the Act does not indicate a "right" to a hearing every time something new is submitted to the record. Such an interpretation of section 6(b)(3) might even, for example, require a hearing in response to post-hearing comments, a procedure which could easily result in needlessly drawn-out rulemakings.

As stated above, the Agency has tried at every point in the proceeding to accommodate all reasonable demands and concerns of the public. This has been done by according more time to respond at numerous junctures in the proceeding, clarifying ambiguities and considering numerous alternative approaches suggested by the public as well as by other government agencies. The public dialogue on the various issues raised during the course of this proceeding has been extensive and helpful. The record has been carefully reviewed and all opinions, comments and evidence therein have been considered in reaching the final decisions reflected in the hearing conservation amendment. The Agency believes this provides workers with adequate protection without undue burden on employers.

IV. Benefits

Summary and Conclusions

The primary purpose of this hearing conservation amendment is to prevent occupationally related cases of hearing impairment. Hearing impairment is a serious obstacle to a person's effectiveness as an employee and in the other aspects of life as discussed elsewhere in this preamble. Occupationally related hearing loss cannot be cured by hearing aids.

The noise record includes extensive evidence indicating that hearing conservation programs can reduce the number of cases of hearing impairment. Based on that record OSHA has made estimates of the number of hearing impairments prevented by the hearing conservation program prescribed herein. Evidence in the record amply demonstrates that many workplaces are not safe from hazards posed by noise. Present noise exposures pose a significant risk of harm to workers and can be lessened or reduced by instituting hearing conservation programs for workers exposed at or above a TWA of 85 dB.

OSHA estimates that hearing conservation programs for all employees exposed above 85 dB will eliminate 212,000 cases of material impairment of hearing after 10 years, 690,000 after 30 years and 898,000 cases at equilibrium. Even assuming full compliance with the present standard which requires hearing conservation programs for all employees exposed over 90 dB, this amendment would prevent 38,000 additional impairments within 10 years, 143,000 within 30 years, and 189,000 at equilibrium. Therefore the standard will significantly reduce the risk of hearing impairment present in many workplaces. Unfortunately this standard will not completely succeed in eliminating occupationally related hearing impairment. Approximately 162,000 cases of impairment will remain at equilibrium after the implementation of this standard.

OSHA anticipates that employers and employees will carefully and conscientiously carry out the provisions of this standard. However, even if only 50% of employees receive protection, there will be a reduction of 381,000 cases of impairment at equilibrium. This is still a very substantial benefit.

The OSHA estimates are based on the methodology of CPA, the exposure estimates of BEN and the scientific data contained in the record. OSHA has utilized its judgment based on the record to choose what it believes are the better methodologies, assumptions and data and has updated the estimates to take into account more recent, publicly available population data. Therefore, as discussed below, OSHA believes that its estimates improve upon the earlier estimates.

The Supreme Court in *Industrial Union Department, AFL-CIO v. American Petroleum Institute*, 65 L. Ed. 2d 1010, 100 S. Ct. 2844 (July 2, 1980) indicated that in promulgating a standard dealing with toxic materials or harmful physical agents, the Act "requires the Secretary to find, as a

threshold matter, that the toxic substance or harmful physical agent in question poses a significant health risk in the workplace and that a new lower standard is therefore reasonably necessary or appropriate to provide safe or healthful employment." (slip op., p. 5).

The record in this proceeding clearly demonstrates and OSHA therefore concludes that all these tests have been met. OSHA finds that employee exposure to noise at existing workplace levels poses a significant health risk in the workplace. Even assuming full compliance with the current occupational noise exposure standard, some employees face a significant risk of material impairment of hearing. Accordingly a new and more protective standard is reasonably necessary and appropriate to provide healthful employment. Indeed OSHA would reach this same conclusion even if the risk of hearing impairment had been substantially less than is the case.

These conclusions have been reached without reliance on the further benefits of reduced absenteeism, improved workplace safety, and reduced extra-auditory health effects also resulting from the standard. But, of course, those benefits provide additional justification for the standard.

Finally, workplace noise, and the resulting occupationally related hearing loss, is perhaps the most widespread hazard faced by workers. As Leonard Woodcock, then President of the United Auto Workers stated, "noise is probably the most pervasive of the many job hazards which our members face today. We have had no health and safety problem about which our members complain more" (Tr. p. 1388).

The hearing conservation standard will go a substantial way towards alleviating the worst aspect of the hazard, hearing loss, though it will not achieve the ideal solution, eliminating the hazard at its source. The Agency finds that eliminating noise exposure utilizing engineering controls would create substantial additional benefits of reduced discomfort and more effective hearing conservation.

The existing level of risk in absolute numbers and the amount of risk reduced by this standard is great. Clearly, even if the level of risk were lower and the reduction of risk were not as great, OSHA would still be able to make a valid threshold finding of significant risk. While in this instance detailed data were available to estimate the hearing impairment benefits of this noise regulation, it should be recognized that in many circumstances much less evidence will be available, especially

for relatively new substances which may create life threatening risks. As the Supreme Court noted, OSHA may make a finding of significant risk even when much less evidence is available upon which to base such judgments. "OSHA is not required to support its findings that significant risk exists with anything approaching scientific certainty . . . this provision requires a reviewing court to give OSHA some leeway where its findings must be made on the frontiers of scientific knowledge . . ." (slip op., p. 45).

The rest of this section sets forth, in depth, the basis for OSHA's estimates of hearing impairment and analyzes the relevant portions of the record. To make its estimates as current and exact as possible, OSHA made use of some publicly available census and labor statistics data, such as employment by SIC code, which is not physically in the noise record. The limited amount of data in this category that has been utilized is not controversial and is publicly available.

It is relatively complicated to present data on the number of noise-related cases of hearing impairment because it occurs at varying ages and lasts a varying number of years before death. The approach selected here is the "snapshot" approach. This estimates in a given year, the absolute number of cases of impairments existing if there were no regulation, the number eliminated by the standard or an alternative, and the number of impairments remaining. It is not appropriate to add the number of impairments in the 10th year to those in the 20th year, for example, since that would double-count the persons who were impaired in both years. On the other hand, the actual number of impaired individuals over periods of time greater than a year are greater than the number present in a given year. Over time persons die and then are subtracted from the totals while others enter into the totals for the first time.

For example, OSHA estimated that hearing conservation programs for all employees exposed above 85 dB would prevent 696,000 material hearing impairments in the 30th year and 799,000 in the 40th year. The total number of individuals saved from impairment by these programs during the decade is less than the sum of 696,000 + 799,000, because some individuals lived through that period and would have been counted as saved from impairment at each of those timepoints. On the other hand, the number of individuals saved from impairment prior to the 40th year is much greater than 799,000 since many who will be saved from impairment by

these programs will die before the 40th year and were therefore not counted in the 40th year totals. OSHA has also presented data on the number of person-years of hearing impairment prevented. This data does not present the same problems, but does not indicate how many individuals will suffer impairment.

Much of the data presented is for the equilibrium year. Hearing impairment develops gradually over time from the accumulation of noise the employee is subject to in each year of employment. In addition, hearing impairment once developed lasts beyond age 65 and through the entire time of retirement until death. Clearly hearing impairment is a substantial loss to retired persons as well. Many people live well into their 80's. (For example, the average life expectancy of males at age 65 is 14 years and females 19 years. Of course a substantial portion of the population lives longer than these averages.) Therefore, the full effects of hearing conservation programs will not be achieved until the entire population has been replaced by a population who have spent their entire working lives covered by these programs. This does not occur for at least 70 years, the time from age 18 until when most retirees have died by age 88. However, benefits are also presented at the 10th, 20th, 30th and 40th years after the implementation of hearing conservation programs. It can be seen that by the 30th year, about 1/4 of the number of employees who will ultimately be protected will receive the full benefits of hearing conservation programs.

Introduction

Workers will derive substantial benefits from the hearing conservation amendment. The primary benefit of the amendment will be a sizable reduction in the incidence of occupational hearing impairment for U.S. workers. This reduction will substantially improve the health and quality of life of these workers. In addition, there will be possible declines in the number of workplace accidents and in the incidence of cardiovascular disease following the implementation of the amendment. The hearing conservation amendment will also create financial benefits stemming from reductions in worker absenteeism and medical costs, which will partially offset the costs of the amendment. Employers will profit by the decline in workers' absences, while workers will benefit from the reduction in medical costs. Consumers and taxpayers as a whole will gain from a reduction in the societal subsidy to medical costs. These financial benefits

furnish additional support for the amendment.

Occupational hearing loss damages the social relationships of impaired workers by hindering their ability to communicate with other workers, their families, and their friends. OSHA's hearing conservation amendment, by substantially reducing the incidence of occupational hearing loss, will improve the quality of life for these individuals since they will no longer need to endure the difficulties and hardships experienced by those who associate with impaired workers. These improvements are also benefits of this amendment.

In addition, other indirect benefits will occur. For example, audiometric testing will indicate that there are workers with non-occupationally caused hearing difficulties, thereby enabling their referral to otologists for treatment. (For an example, see Ex. 321-1, p. 2.) Monitoring will provide information on workplace noise levels that may be used by workers and their union representatives in collective bargaining negotiations concerning work conditions. However, these informational benefits are not easily quantified, and the following discussion will focus on the benefits resulting from the increased use of personal hearing protectors as required by the amendment.

The hearing conservation amendment will also lead to a more equitable distribution of the costs and benefits of industrial production. Currently, one undesirable side effect of industrial production is the loss of hearing ability among a substantial number of workers. Although workers bear this cost of industrial production, the benefits of this production are shared by firms, stockholders, and consumers, as well as by workers. One traditional principle of distributional equity is that those who benefit from an activity should share in its costs. In order to prevent occupational hearing loss, implementation of the hearing conservation amendment will impose compliance costs on firms. Depending on the particular economic circumstances of these firms, these costs may be passed on to consumers or borne by stockholders. In both cases, most workers will no longer bear the cost of occupational hearing loss, while those who share the benefits of industrial production will share the costs of preventing that loss.

Moreover, the benefits of the reduced incidence of occupational hearing loss will be experienced to a greater extent by poorer and lesser educated workers who often have little choice except to

work in the noisiest and least healthful jobs. Evidence derived from a U.S. Public Health Service Survey shows that for every age group, those of lower educational attainment have a higher risk of hearing impairment than those with higher levels of education (Center for Policy Alternatives, "Some Considerations," Ex. 138A, 3-2 to 3-3). Thus, the reduced incidence of occupational hearing impairment will more than proportionately benefit those with fewer material resources.

In this section, the various benefits of the hearing conservation amendment are discussed. The primary benefit of the amendment—the prevention of occupational hearing impairment—is treated extensively by including first, an examination of the major studies in the record, second, a description of OSHA's methodology for updating the estimates of the benefits and third, a presentation of the results of OSHA's calculations. Several other effects of the amendment, including improved workplace safety, and possible reductions in cardiovascular illness, absenteeism, medical costs, and workers' compensation payments, are also discussed. Finally, although the current record lacks the information needed for a final evaluation, two possible benefits are analyzed: reduced annoyance and improved productivity.

Material Impairment of Hearing Prevented

Previous Estimates

Four major studies present in the record estimate the number of hearing impairments that would be prevented by an OSHA standard regulating occupational noise exposure. Although each has certain inadequacies, taken together they reveal that occupational noise >85 dB impairs a substantial number of workers. Based on these studies and OSHA's own calculations and analysis, presented below, the Agency has concluded that regulatory action is necessary.

Bolt, Beranek, and Newman, Inc. (BBN), a consulting firm under contract to OSHA, prepared a report entitled "Impact of Noise Control at the Workplace" (Ex. 7), which was dated January 1, 1974. They estimated, based on "informal discussions with industry spokesmen", their extensive experience conducting noise surveys, and 1973 employment data, that 8,524,000 workers (59.3 percent of the 14,382,000 production workers in 19 two-digit industries) were exposed to noise levels > 85 dB, while 3,755,000 workers (26.1 percent) were exposed to levels > 90 dB (BBN, Ex. 7, p. C-2). For demonstration purposes

they assumed that 30 percent of production workers were exposed to levels > 90 dB and an additional 40 percent were exposed between 85 and 90 dB. (Ex. 7, p. D-3). Then using the risk data of Baughn, they calculated that maximum compliance with a 90 dB Permissible Exposure Limit (PEL), which they referred to as "the present standard," would reduce the number handicapped at retirement by 700,000 (25 dB fence at 500, 1000, and 2000 Hz); and that compliance with an 85 dB PEL would reduce this number by an additional 770,000.

This study formed the basis for BBN's testimony at the 1975 hearings. After those hearings, OSHA contracted with BBN for a more extensive study of workplace noise and the impact of 85 and 90 dB PEL's. The resulting study, entitled "Economic Impact Analysis of Proposed Noise Control Regulation" (Ex. 192), was released by OSHA in 1976. In it, BBN estimated that 4,468,400 workers (34.5 percent of the 12,939,300 production workers in the 19 industries studied) were exposed to noise levels > 85 dB, while 2,393,200 workers (19.3 percent) were exposed to levels > 90 dB (BBN, Ex. 192, p. 2-7).

Using dose-response relationships for noise exposure and hearing impairment developed by Baughn and the team of Burns and Robinson, BBN estimated the number of hearing impairments that would occur under a number of alternative regulations, definitions of material impairment, and assumptions concerning job mobility. They estimated that after implementation of a 90 dB PEL, between 86,400 and 875,100 workers would still be impaired (25 dB fence at 500, 1000, and 2000 Hz) while an 85 dB PEL would reduce this to between 44,400 and 631,200. Therefore, the additional impairments prevented by an 85 dB PEL would be between 42,000 and 243,900 (BBN, Ex. 192, p. 2-35). (The range of estimates was due to the use of two measures of the risk of impairment: the Burns and Robinson data for the lower bound and the Baughn data for the upper bound.)

In addition, BBN made estimates of the benefits of requiring hearing protector use in combination with the 90 and 85 dB PEL's. They did this using three different assumptions concerning hearing protector use. First, that all workers required would wear hearing protectors and three-fourths of them would wear them correctly. Second, that three-fourths of the workers required to do so would wear hearing protectors and three-fourths of them would wear their hearing protectors correctly. Third, that one-half of the workers required to

do so would wear hearing protectors and one-half of them would wear them correctly. In all cases, correct use of hearing protectors was assumed to yield a 30 dB attenuation.

Using these assumptions, BBN calculated that a 90 dB PEL for engineering controls, with hearing protector use for those exposed above 85 dB, would leave between 10,800 and 324,200 impairments after 20 years of exposure if everyone who required hearing protectors wore them. The number of impairments remaining in the workforce was larger under the second and third assumptions. For these two assumptions, the estimates of impairments remaining in the population were between 30,000 and 488,400 impairments (second assumption), and 32,900 and 634,900 impairments (third assumption) (BBN, Ex. 192, p. 2-35). Compared to the effects of a 90 dB PEL, the use of hearing protectors by those exposed above 85 dB was therefore estimated to prevent at least an additional 53,500 to 75,600 impairments (lower bound estimate based on the Burns and Robinson data) or an additional 240,200 to 550,900 impairments (upper bound estimate based on the Baughn data).

The estimates provided by BBN require updating for several reasons. First, the production work force of 12,939,300 for the 19 industries studied by BBN was based on employment data for 1975. Second, BBN calculated the benefits of noise control assuming a workforce composed entirely of 20-year-olds who would be exposed to noise for 20 years. This inaccurately depicts the effects of noise on a real work force that also contains older workers and retirees who have been exposed for more than 20 years. Third, in most cases, the number of hearing impairments was calculated for hearing thresholds greater than or equal to a 25 dB average of 500, 1000, and 2000 Hz. For reasons discussed in the Health Effects section, OSHA believes that this combination of frequencies is not the most appropriate measure of material hearing impairment and that a 25 dB average of hearing threshold levels at the frequencies of 1000, 2000, and 3000 Hz is preferable.

A third benefits estimate was performed by the Center for Policy Alternatives (CPA) under contract to the Environmental Protection Agency (EPA). Entitled "Some Considerations in Choosing an Occupational Noise Exposure Regulation," it was presented at the first hearings. Using the risk data of Baughn throughout their report, CPA estimated that present noise exposures (based on the estimates in BBN's first

report and assuming no job mobility) would lead to 1,649,000 impairments (25 dB at 500, 1000, and 2000 Hz) after 40 years of exposure. They calculated that if noise exposures for all workers above 90 dB were brought down to 90 dB, the number of impairments could be reduced to 1,106,000, while if all exposures above 85 dB were brought down to 85 dB, the number of impairments could be reduced to 710,000 (CPA, Ex. 138A, p. 2-26). Thus a 90 dB PEL could prevent 543,000 hearing impairments while an 85 dB PEL could prevent an additional 396,000 impairments.

A fourth estimate of the impairments prevented by the proposed noise regulation that was submitted to the record and subjected to examination at the 1976 hearings was also performed by CPA under contract to EPA. ("Economic/Social Impact of Occupational Noise Exposure Regulations," Ex. 232). This report continued the earlier research CPA had performed for EPA (Ex. 138A). The noise exposure profile used in the second CPA report was based on the same raw exposure data that BBN had collected for their second report (Ex. 192), although the data were modified by CPA. CPA estimated that after the establishment of equilibrium, compliance with a 90 dB PEL would prevent 770,000 workers from impairment (25 dB fence at 500, 1000, and 2000 Hz) while an 85 dB PEL would prevent 1,350,000 impairments (CPA, Ex. 232, p. 5p7). Thus the additional impairments prevented by the 85 dB PEL would total 580,000.

For various reasons the CPA estimates also require updating. First, the estimates were based on 1974 employment levels rather than on the latest available data. Second, although CPA used an age distribution of the exposed population, they excluded retirees and did not distinguish between men and women. OSHA has determined that these calculations should include future retirees because they will also benefit from hearing conservation programs. In addition the calculations must distinguish between men and women because of the presbycusis differences between the sexes. Third, CPA used the frequencies 500, 1000, and 2000 Hz instead of the more appropriate 1000, 2000, and 3000 Hz. Fourth, the CPA study discussed the benefits of engineering control strategies to reduce noise levels to 90 and 85 dB, but not the benefits of hearing conservation programs that require the issuance and use of hearing protectors.

OSHA's Methodology

In order to improve upon the estimates of BBN and CPA, OSHA has decided to revise and update the calculation of the benefits of the hearing conservation amendment. The principal benefit of the hearing conservation amendment will be to prevent occupational hearing impairments through the inter-related aspects of effective hearing conservation programs. For example, monitoring provides information on the need for hearing protection and the type of protectors required. The use of these hearing protectors will reduce worker exposures. Training sessions will instruct workers in properly fitting, maintaining, and using hearing protectors. Audiometric testing detects temporary and permanent shifts in hearing ability, thereby detecting workers who are susceptible to hearing loss, identifying workers who may be wearing their hearing protectors improperly, and motivating those who would not otherwise wear them.

OSHA's estimates of the benefits of hearing conservation programs were calculated by comparing the number of hearing impairments that would occur if no hearing conservation programs exist with the number that will occur after they are established. The methodology used to estimate the benefits is derived from the studies summarized above as well as from other evidence contained in the record. Specifically, OSHA has determined that the methodology of the CPA report is more appropriate than the simpler methodology followed by BBN. BBN's methodology was based on a hypothetical work force composed of 20-year-olds, while CPA's methodology used the actual age distribution of the noise-exposed population. OSHA's calculations do, however, use the noise exposure distribution developed by BBN since it is the best available evidence on occupational noise exposures.

The benefits of preventing hearing impairment are described here by presenting (1) the number of persons prevented by hearing conservation programs from incurring material impairment of hearing after the full effects of these programs are realized, (2) the number of persons prevented from incurring material impairment of hearing at years selected from the interim time period before the full effects are realized, and (3) the accumulated person-years of impairment prevented over that time period.

People in the current workforce will only gain a limited benefit from the hearing conservation programs

established by this hearing conservation amendment since many of these workers have already suffered noise-induced hearing loss. The full benefits of the amendment will be realized only by workers who spend their entire working lives covered by its provisions. It will take a number of years for the current worker population to be completely replaced by people who have been covered by hearing conservation programs for all of their working lives. Over time, the number of people prevented from incurring a material impairment will rise until an equilibrium is reached after the entire pre-hearing conservation work force has been replaced. With the continued provision of hearing protectors and hearing conservation programs, this equilibrium level of impairments prevented should continue for the years following the establishment of equilibrium.

Although the benefits of preventing occupational hearing impairment are not fully realized until equilibrium is reached, benefits will accrue during the period prior to equilibrium. As the years advance, the number of workers prevented, at any one time, from having a material impairment of hearing will increase. In order to describe this progression, the number of material impairments prevented during the 10th, 20th, 30th, and 40th years following implementation were calculated and are referred to as the interim benefits of the hearing conservation programs.

These first two descriptions, the number of impairments prevented at equilibrium and the number prevented at 4 interim years, provide only views of the benefits at particular time points. These "snapshot" views fail to capture the differences in the number of impairment-free years each person has enjoyed. For example, the number of impairments prevented at the 40th interim year will include some people who have been free from impairment for 40 years, as well as some people free from impairment for as short as 1 year. In fact, as time passes after implementation, the average number of impairment-free years per impairment prevented increases.

In order to describe this pattern, OSHA has calculated the accumulated number of person-years of impairment prevented over the interim time period. The number of person-years of impairment prevented is derived by multiplying the number of impairments prevented by the number of years each individual was kept free from impairment. For example, 2 people prevented from incurring a material impairment of hearing for 10 years

apiece equals 20 person-years of impairment prevented. This would also be equal to 1 person for 20 years or 4 people for 5 years.

The accumulated person-years of impairment prevented were estimated from the interim benefits using the procedures suggested and used by CPA (Ex. 232, p. B-21), and described in Appendix A of OSHA's Final Regulatory Analysis. Estimates of the accumulated number of person-years of impairment prevented were calculated for 10, 20, 30, 40, and 70 years after the implementation of hearing conservation programs. Seventy years was chosen to approximate the length of time required for equilibrium to be reached. Since these calculations were based on a population that included retirees, and since many retirees live well into their 80's, it will take at least 70 years for people in the existing workforce, who have spent some of their working lives without the benefits of hearing conservation programs, to be replaced by people who have had those benefits.

Noise Exposure Distribution. These updated hearing impairment calculations are based on the same set of 19 industries and the same noise exposure data used by BBN for their second study of the proposed regulation. (CPA used the same set of industries, but modified the exposure data.) BBN, in their economic impact analysis, presented a noise exposure distribution based on surveys of 68 different establishments in 19 two-digit standard industrial classification (SIC) industries. The industries selected by BBN were the ones believed to contain most of the noisy workplaces in the U.S. (BBN, Ex. 192, p. 2-1). These industries and the number of production workers in them during 1979 are listed in Table 3.

Note.—That the total number of workers in these industries today is about 2 million greater than BBN's 1976 estimate.

The selection of industries and establishments was based on BBN's extensive experience with industrial noise and its control. During the survey, BBN estimated the number of workers exposed to various noise levels within 5 dB ranges. Because of uncertainty in the classification of workers by exposure level, BBN adjusted the raw data by distributing one-fourth of the workers in each 5 dB range to the next highest 5 dB range and one-fourth to the next lowest 5 dB range. Although CPA judged this adjustment to be inappropriate (See Ex. 232, p. B-4), OSHA has retained it because BBN was more familiar with the raw data and its peculiarities.

Table 3.—Industries Studied

SIC code ¹	Industry title ²	Production workers ³ (thousands)
20	Food	1,176.2
21	Tobacco	52.5
22	Textiles	777.0
23	Apparel	1,122.2
24	Lumber and wood	648.3
25	Furniture and fixtures	398.0
26	Paper	541.5
27	Printing and publishing	702.2
28	Chemicals	636.9
29	Petroleum and coal	139.7
30	Rubber and plastics	801.1
31	Leather	267.4
32	Stone, clay, and glass	562.5
33	Primary metals	978.3
34	Fabricated metals	1,305.9
35	Machinery, except electrical	1,816.2
36	Electrical machinery	1,378.6
37	Transportation equipment	1,404.2
48	Utilities	659.3
Total		14,904.0

¹ Executive Office of the President, Office of Management and Budget, *Standard Industrial Classification Manual*, 1972.

² Average number of production workers in 1979.

Source: U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, 27, (March 1980): 58-66, Table B-2.

These exposure estimates, which were published in the 1976 BBN report (BBN, Ex. 192, pp. 2-4 and 2-7) and discussed at the hearings, have been recalculated to correct minor errors in the original profile. Thus, the noise exposure profile used here differs slightly from the profile published by BBN as Table 2.1 of their report. These differences are small—no more than one-half of one percentage point for any 5 dB exposure range. This recalculation has also corrected the inconsistency of Tables 2.1 and 2.2 of the 1976 BBN report (BBN, Ex. 192, pp. 2-4 and 2-7). Except for the total percentage exposed above 85 dB, the exposure profile used here is consistent with BBN's Table 2.2. The total percentage above 85 dB differs by only one-tenth of one percentage point. (See also Table 11 in the Cost of Compliance section below.) Table 4 presents the corrected noise exposure distribution for the 19 industries.

Table 4.—Noise Exposure Distribution

Exposure Level (dB)	Percent
Less than 80	46.88
80-85	19.74
85-90	15.06
90-95	10.58
95-100	5.47
100+	2.87
Total	100.00

Source: Bolt, Beranek, and Newman. This is a corrected version of Table 2.1 from "Economic Impact of Proposed Noise Control Regulation," Ex. 192, p. 2-4.

OSHA has chosen to use the BBN exposure estimates because they remain the most comprehensive and detailed estimates of occupational noise exposures in U.S. industry. Although these estimates were briefly criticized at the hearings (see Hearing Transcript,

Sept. 21, 1976, pp. 139-43; Sept. 22, 1976, pp. 237-42, 360-1) as well as in the post-hearing comments (Ex. 279-8, pp. 37-8, 69-72), no one came forward with another set of exposure estimates that includes both the full range of industries and the detailed exposure levels of the BBN estimates. The American Road Builders Association (Ex. 186B) and the Motor Vehicle Manufacturing Association (Ex. 242D) presented estimates limited to the specific industries in which their member companies operate. Evidence, based on samples drawn from a wider range of industries, is included in surveys by Hearing Conservation Noise Control (Ex. 240B) and NIOSH (Ex. 321-14B and Ex. 321-14D). These surveys present the number of workers exposed above either 90 or 85 dB but do not provide a detailed classification of employees by 5 dB exposure level ranges as do the BBN estimates. This classification is necessary for the matching of the exposure distribution with the risk matrices to estimate the number of hearing impairments prevented by hearing conservation programs.

OSHA has concluded that three simplifying assumptions were necessary in order to use the BBN noise exposure distribution to estimate the number of hearing impairments prevented. First, that BBN's noise exposure distribution adequately describes the occupational noise environment in the 19 industries studied, and that the 19 industries encompass all substantial occupational noise exposure. Second, that the noise exposure distribution and the size of the work force in the 19 industries will remain unchanged for the 70-year period used to calculate benefits. If there are changes in the noise distribution and the size of the work force which increase the number of persons exposed to harmful noise levels, this assumption will lead to an understatement of the number of hearing impairments prevented. On the other hand, if these changes decrease the number of persons exposed, then there will be an overstatement of the number of impairments prevented. Third, in industries with fluctuating noise levels, it was assumed that a 5 dB exchange rate adequately represents time-weighted exposure levels. The BBN data are based on a 5 dB exchange rate. The CPA report argued that these data should be adjusted to take into account a 3 dB exchange rate (CPA, Ex. 232, p. B-5).

The exchange rate or the "doubling rate" is a way of either averaging or comparing exposure levels and durations. Under a 5 dB exchange rate,

for a 5 dB increase in the exposure level the exposure duration must be halved to obtain an equivalent time-weighted exposure. Thus, 8 hours of exposure to a level of 90 dB is equal to 4 hours at 95 dB. Similarly, under a 3 dB rate, an increase of 3 dB necessitates halving the duration—e.g., 8 hours at 90 dB equals 4 hours at 93 dB. Since OSHA is currently retaining the 5dB exchange rate used in 29 CFR 1910.95, and since the procedure used by CPA to adjust the BBN data does not appear to be based on actual exposure data, the Agency did not adjust the noise exposure distribution to account for a 3 dB exchange rate. This adjustment would have increased the effective exposure level of the work force and would have increased the estimated number of hearing impairments. By not performing this adjustment, OSHA may be understating the number of hearing impairments prevented by the final amendment.

Fences. The methodology used to estimate the number of people suffering impairments of hearing continues the standard practice of drawing fences to demarcate "normal" from "materially impaired" and then calculating the number of persons with hearing abilities worse than the level of that fence. An important issue is the choice of appropriate fences, both in terms of the levels used as well as the frequencies to be examined or averaged. BBN did most of their calculations using a 25 dB average of hearing threshold levels at the frequencies of 500, 1000, and 2000 Hz. However, BBN also examined the effects of choosing other levels, 15 and 35 dB, as well as an average of the frequencies of 1000, 2000, and 3000 Hz (BBN, Ex. 192, pp. 2-27, 2-28). CPA correctly pointed out that the effect of noise on a population of workers is to cause a change from one population distribution to another. They state:

Essentially the entire population of workers has worse hearing because of the influence of noise. Those which, without noise, might have had excellent hearing are shifted so that they have less than excellent hearing. Those which without noise, would have had only fair or poor hearing have their hearing handicaps increased. (CPA, Ex. 232, p. 5-2)

Thus, the usual practice of drawing a single fence does not adequately describe the shift of the entire distribution of workers. Therefore, CPA suggested that a series of fences be employed (CPA, Ex. 232, p. 5-3). There were many other comments submitted to the record concerning the choice of appropriate fences, both for the determination of the number of workers suffering material impairment as well as for workers' compensation purposes.

(For a discussion of these comments, see the Health Effects Section.) After a thorough review of these comments, OSHA has concluded that the number of hearing impairments prevented by the final amendment should be measured using the fences of 15, 25, and 40 dB. These fences are defined as the average of a person's hearing threshold levels for the frequencies 1000, 2000, and 3000 Hz. As described in the discussion on health effects, these frequencies were chosen as those most appropriate to describe the ability of persons to understand human speech under everyday conditions. The levels were chosen to describe the number of persons with various degrees of hearing loss: mild hearing loss, material impairment, and moderate to severe impairment.

Dose-Response Relationship. A person's hearing ability can be estimated by analyzing two components: the loss in hearing ability due to noise and the loss in hearing ability due to the effects of aging (presbycusis). The following discussion will focus on these two components, presenting OSHA's arguments concerning the best available and most appropriate evidence for each.

The change in hearing ability due to noise exposure is measured in terms of the permanent decibel shift in hearing thresholds caused by noise. This change, the amount of lost hearing ability, is more commonly called the Noise-Induced Permanent Threshold Shift or NIPTS. An examination of the hearing loss studies cited in the Health Effects section reveals a fair degree of consistency in their basic findings concerning the amount of NIPTS caused by various combinations of exposure levels and durations. One way to incorporate all of the information in these studies is to average the results. Col. Daniel Johnson has recommended such an approach (Ex. 17, p. 2) and EPA has applied it to the data of Baughn, Burns and Robinson, and Passchier-Vermeer both for establishing criteria for noise regulation (Ex. 28-3) and for identifying safe levels of noise exposure (Ex. 30, p. C-5). Recently Col. Johnson published a variety of calculations, based on averaging the data of Burns and Robinson (referred to only as "Robinson" by Johnson) and Passchier-Vermeer (Ex. 310).

OSHA has chosen to use the studies of Burns and Robinson and Passchier-Vermeer because of the completeness of their data for describing the NIPTS at frequencies from 500 to 6000 Hz for various population percentiles, noise levels, and exposure durations. Baughn's data (Ex. 11) were not available for individual frequencies, thus preventing

the averaging of hearing threshold levels at 1000, 2000, and 3000 Hz. The NIOSH data (Ex. 26-2) were limited to exposures of 85, 90, and 95 dB, thus preventing the estimation of hearing loss for exposures to 80 and 100 dB.

OSHA has determined that the results of the Burns and Robinson and Passchier-Vermeer studies can be strengthened by averaging the NIPTS values from each. Because Johnson's recent publication, *Derivation of Presbycusis and Noise Induced Permanent Threshold Shift* (Ex. 310), provides a convenient presentation of this data, OSHA has used it as the basis for the calculation of the number of occupational hearing impairments. Table A.7 in Appendix A of OSHA's Final Regulatory Analysis presents the NIPTS values, derived from the Johnson publication, which were used by OSHA.

The second component that determines a person's hearing ability is calculated by observing the hearing ability of a "normal" population, and making adjustments to account for the effects of aging (presbycusis) on hearing ability. For this study, OSHA has used a presbycusis base developed by Johnson from the data of the U.S. Public Health Survey conducted in 1960-62. In this survey, 6,672 persons aged 18-79, drawn from the civilian, non-institutional population of the U.S., were given audiometric examinations. Thus, the survey gives a detailed picture of the actual hearing ability of the U.S. population. Other researchers, most notably Burns and Robinson, have screened their populations quite severely in order to eliminate all individuals who have been exposed to gunfire, or had ear disease, or other ear abnormalities. These screening techniques were designed to create a population that is otologically "normal."

But the actual work force is not otologically "normal." Some workers have been exposed to gunfire, both from sport shooting and from service in the armed forces. Other workers have or have had ear disease or other ear abnormalities. OSHA has therefore decided that the presbycusis base to use in calculating the number of hearing impairments in the work force should reflect, as closely as possible, the real world hearing ability of the U.S. population. The Public Health Survey represents the best available description of this hearing ability. An examination of the aging curves in Baughn (Ex. 12, p. 26) and Berger, Royster, and Thomas (Ex. 266A, pp. 42, 43, and 57) reveals that the data of the Public Health Survey are consistent with other major presbycusis bases.

The two components, the NIPTS and the presbycusis, may then be added together to find the total hearing loss for populations of given ages and sexes exposed to specified levels and durations (See Johnson's discussion, Ex. 310, p. 16). Johnson has provided a convenient computer program (Ex. 310, pp. 43-47) which was used to generate dose-response relationships. A simple linear interpolation was used to match the exposure distribution with these dose-response relationships to create the risk matrices (Tables A.9, A.10, A.11 in Appendix A of OSHA's Final Regulatory Analysis) used in the calculation of the number of hearing impairments.

Hearing Protector Use and Attenuation. Under the current noise standard, hearing protector use is mandatory for workers exposed above the PEL (90 dB TWA) where there are no feasible engineering or administrative controls. Under the amendment hearing protectors must also be provided to all workers exposed to noise levels between 85 and 90 dB, but of these workers only those who have experienced a significant threshold shift are required to wear hearing protectors. It is impossible to project accurately the number of workers exposed to noise between 85 and 90 dB who would voluntarily choose or be required to wear hearing protectors, but it is probable that the annual audiometric test will identify, by showing significant threshold shifts, the employees most vulnerable to occupational hearing loss. These employees will then be required to use hearing protectors, which should prevent most of them from incurring a material impairment of hearing. Thus, the following calculations are based on the assumption that following the implementation of this amendment, all workers who are vulnerable to occupational hearing loss will wear hearing protectors when exposed to noise >85 dB.

The CPA report did not present any assumptions concerning hearing protector use or attenuation. BBN assumed for correct usage, an attenuation value of 30 dB (BBN, Ex. 192, p. 2-34). As the following studies indicate, this is an attenuation that is generally achieved only in laboratory settings.

In a NIOSH-sponsored study (*A Field Investigation of Noise Reduction Afforded by Insert-Type Hearing Protectors*, Ex. 308), a team of researchers investigated the attenuation received by workers using various types of hearing protectors in actual industrial settings. The three earplugs tested had

median attenuation values of 7.5, 10.0, and 12.8 dB (Ex. 308, p. 26). Padilla's study revealed an overall mean attenuation of 12 dB at 500 Hz for the earplugs he tested. He estimated that this was equal to approximately 7 dB over the frequencies 125-8000 Hz. ("Ear Plug Performance in Industrial Field Conditions," Ex. 301, p. 34). Regan found mean attenuation values of 25.11 and 19.74 dB for two types of earplugs and 33.04 dB for one type of earmuff (*Real Ear Attenuation of Ear Protective Devices Worn in Industry*, Ex. 300A, pp. 67-71). In addition, Berger presents information from the National Acoustic Laboratories (Australia) for four different earplugs. For these earplugs, the Noise Reduction Rating with a correction of two standard deviations ranged from 0-14 dB, while with a correction of one standard deviation the range was 9-19 dB ("Laboratory Estimates of the Real World Performance of Hearing Protectors," Ex. 321-35E).

The results of these studies reveal, for the earplugs tested, a mean attenuation of approximately 10-15 dB in industrial settings. It is reasonable to assume that the training and audiometric testing provisions of the hearing conservation amendment will improve industrial hearing conservation programs to at least maintain the upper bound of this average attenuation range. Moreover, those exposed to very loud workplace noise can use earmuffs or a combination of earmuffs and earplugs. These two options appear to have a higher attenuation rating than the earplugs tested in the studies mentioned. Accordingly, for the purposes of these calculations, OSHA has concluded that a reasonable assumption is that workers using personal hearing protection will receive an attenuation of 15 dB.

Mobility. The OSHA calculations were based on the assumption that workers do not move between jobs with harmful noise exposures and jobs without such exposures. Both BBN and CPA generally assumed such mobility to calculate the number of material hearing impairments. However, they used different procedures and assumptions concerning the effect of mobility on the number of material impairments in the population and the number that would benefit from reduced occupational noise exposure. BBN's calculations suggest that assuming mobility reduces the number of additional workers protected by controlling noise levels to 85 dB. (BBN, Ex. 192, Table 2.11, p. 2-30). CPA, on the other hand, argued that an assumption of mobility dramatically increases both the estimated number of

material impairments in the pre-regulation population and the number of impairments that would be prevented by regulatory action (Ex. 232, p. 5-8. See also discussion at the hearings by CPA: Hearing Transcript, Oct. 8, 1976, pp. 2286-82, 2343-9, 2354-8 and BBN's reply in their Post-Hearing Comments, Ex. 278, pp. 60-65).

Occupational mobility has two separate, contradictory effects. First, mobility from jobs with harmful noise exposures to jobs without such exposures means that each individual worker will be exposed to harmful levels of noise for a shorter length of time because he or she will not have spent an entire lifetime exposed to harmful levels of occupational noise. This shortened duration of exposure lowers a worker's chance of suffering an occupational hearing impairment as well as the amount of lost hearing ability, and thus would tend to reduce the number of impairments in the entire population. The second effect of mobility, however, is to increase the population exposed to harmful noise levels, even though for shorter periods of time. This increase in the population at risk will tend to increase the number of occupational hearing impairments.

CPA has calculated that, on the average, workers hold three different jobs during their lifetimes. If one assumes that during one of these jobs they will be exposed to harmful occupational noise levels and that the other two jobs have no such noise exposure, then the total population at risk will be increased threefold. (The noise exposure distribution indicates that approximately one-third of the jobs in the 19 industries have noise exposures >85 dB; while two-thirds have exposures less than this. See Table 4.) In order for there to be no difference in the estimated number of hearing impairments when comparing the assumptions of mobility and no mobility, this threefold increase in the number of workers must be matched by a two-thirds decrease for each worker in the percentage risk of crossing a fence. If the decrease is less than two-thirds, then mobility will increase the number of impairments. If it is more than two-thirds, then mobility will decrease the number of impairments.

CPA calculated, using the equal energy rule (the 3 dB exchange rate), equivalent lifetime exposure levels for workers holding one job with harmful noise exposures and two jobs without such exposures during a working lifetime. This calculation reveals that the maximum reduction in a worker's lifetime exposure level with an

assumption of three jobs per worker is about 5 dB for exposures >90 dB, 4 dB for exposures of 85-90 dB, and 3 dB for exposures of 80-85 dB (CPA, Ex. 232, Table B-6, p. B-14). An examination of the risk matrices (Tables A.9, A.10, A.11 in Appendix A of OSHA's Final Regulatory Analysis) shows that these reductions in lifetime exposure levels lead to a decrease of less than two-thirds in the percentage risk. Therefore, the decrease in the percentage risk is more than matched by the increase in the population at risk due to mobility. Thus, even though an individual's risk of impairment declines from the shortened exposure duration, the increase in the number of persons at risk leads to an increase in the total number of impairments in the population.

Accordingly, the Agency concurs with the judgment of CPA that an assumption of mobility will increase the estimated number of material impairments in the noise-exposed population and therefore will increase the estimated number of impairments prevented by the regulation. As CPA also argued, this effect occurs whenever workers move between jobs with and jobs without harmful noise levels and is intensified by increasing the assumed number of jobs per worker (CPA, Ex. 232, p. 5-8). This effect follows from the shape of the dose-response curve for noise, which is such that the first exposure to noise is more damaging than successive increments of exposure (Hearing Transcript, Oct. 8, 1976, p. 2357).

However, the current record does not contain sufficient information on the current pattern of occupational mobility for the industries under study to enable OSHA to update the hearing impairment calculations using a specific mobility rate. Therefore, OSHA has assumed that no mobility occurs. Since such mobility does take place, this assumption will lead to an understatement of the estimated number of material impairments in the population as well as to an understatement of the number of hearing impairments prevented by the final hearing conservation amendment.

Results of OSHA's Calculations

Occupational hearing impairment is a function of age, sex, exposure level, and exposure duration. OSHA's methodology for calculating the number of material impairments incorporates these functional relationships.

The six basic steps used to calculate the number of material impairments prevented by the hearing conservation amendment were:

1. Develop an age distribution,
2. Develop an age by exposure level distribution,

3. Adjust exposure levels for the use of hearing protectors,

4. Develop a sex distribution and combine with the age by exposure level distribution,

5. Calculate the number of hearing impairments from all causes,

6. Determine the number of occupational hearing impairments.

These six steps, as well as the procedure used to estimate the interim benefits of the regulation, are described in detail in Appendix A of OSHA's Final Regulatory Analysis. It should be noted that OSHA's procedure uses an age distribution that includes retired workers, as well as incorporating a distribution of the work force by sex, thus improving upon two deficiencies of previous studies.

The benefits of the hearing conservation amendment will accrue primarily to future populations of workers, slowly reducing the number of material impairments in these populations until an equilibrium is reached. The results of these calculations show that 1,060,000 individuals currently have crossed a 25 dB fence (1000, 2000, and 3000 Hz) due to occupational noise. Hearing conservation programs are expected to reduce this number to 848,000 persons 10 years after implementation; 583,000 in 20 years; 384,000 in 30 years; 261,000 in 40 years; and 162,000 at equilibrium (See Appendix A of OSHA's Final Regulatory Analysis, Table A.15). In each of these years, the number of hearing impairments which would have existed in the absence of hearing conservation programs remains constant at 1,060,000.² Consequently, the number of hearing impairments prevented by hearing conservation programs can be calculated by subtracting the number that will exist in any of the years from the 1,060,000 impairments that would have existed. Hearing conservation programs, therefore, are expected to reduce the number of hearing impairments (25 dB fence) by at least 212,000 in the 10th year after implementation; 477,000 in the 20th year; 696,000 in the 30th year; 799,000 in the 40th year; and 898,000 at equilibrium (See Table 5). The reduction of 898,000 impairments at any one time after the establishment of equilibrium represents 84.7 percent of the occupational impairments that would have occurred without hearing conservation programs.

In addition, OSHA has calculated the number of individuals with hearing impairments at any one time after the

²This is based on the assumption of a constant size for the work force exposed to noise, as discussed above.

establishment of equilibrium for two other fences—15 dB and 40 dB at 1000, 2000, and 3000 Hz. These calculations reveal that without hearing conservation programs, 1,624,000 people will be across a 15 dB fence, and 473,000 will be across the 40 dB fence due to occupational noise exposure. Hearing conservation programs for those exposed to levels >85 dB are expected to reduce this to 321,000 across the 15 dB

fence, and 59,000 across the 40 dB fence (Table A.13 of OSHA's Final Regulatory Analysis). Thus after the establishment of equilibrium, these programs can be expected to reduce the number of persons across the fences by 1,303,000 for the 15 dB fence, and 412,000 for the 40 dB fence (See Table 5), reductions of 80.2 percent, and 87.1 percent, respectively.

Table 5.—Hearing Impairments Prevented by the Hearing Conservation Amendment

	Years after implementation				Equilibrium
	10	20	30	40	
Number of impairments prevented:					
15 dB Fence					1,303,000
25 dB Fence	212,000	477,000	696,000	799,000	896,000
40 dB Fence					412,000
Accumulated person-years of impairment prevented:					
25 dB Fence	1,060,000	4,505,000	10,370,000	17,848,000	43,300,000

Source: OSHA, Office of Regulatory Analysis.

Finally, the number of person-years of impairment prevented can be calculated. (The procedure used follows that of CPA, Ex. 232, and is described in Appendix A of OSHA's Final Regulatory Analysis.) In the 70 years following implementation of the amendment, the total accumulated person-years of prevented impairment is 43.3 million. The pattern of this accumulation is presented in Table 5.

Two conclusions follow from these data: First, without hearing conservation programs, a large number of workers will suffer hearing impairment and reduced hearing ability. Therefore, OSHA has determined that workers who are exposed to occupational noise >85 dB (TWA) face a significant risk of material impairment. Second, hearing conservation programs for all workers exposed to >85 dB (TWA) will substantially reduce that risk.

Full Compliance Assumptions

In keeping with past practice concerning the preparation of economic analyses of OSHA regulations, full compliance with the hearing conservation amendment, including 100 percent usage of hearing protectors, has been assumed. For a variety of reasons, this may not occur. Many workers cannot or will not wear hearing protectors. Workers with irregularly shaped or infected ear canals cannot wear ear inserts. Similarly, persons needing to wear either prescription or safety glasses often cannot wear ear muffs because the frames of the glasses will break the seal the muff makes

around the ear. More often, hearing protectors will not be worn because they are uncomfortable. Workers have complained about headaches, claustrophobia, and general discomfort from the use of ear protectors. In addition, the use of earplugs may lead to ear infections, especially in dirty workplaces.

Full compliance with this amendment will have substantial benefits. Partial compliance will also provide benefits, although not to the same extent. Moreover, the estimated attenuation of 15 dB after regulation may also be an overestimate of the benefit achieved from the use of hearing protectors. In order to provide this attenuation, hearing protectors must be fitted carefully, worn properly, maintained conscientiously, and replaced in a timely fashion. As illustrated in Table 6, if all workers who are required to do so wear hearing protectors, if they receive a 15 dB attenuation, and if they wear their hearing protection every day that they are exposed to noise, then the total pool of material hearing impairment from occupational causes (at equilibrium) will be reduced by 898,000 persons. If only 10 dB of attenuation is achieved, the number of material impairments prevented falls to 759,000. However, if only 50 percent of workers exposed above 85 dB receive 10 dB attenuation and the remaining 50 percent do not wear ear protection, then the reduction in the number of impairments declines to 381,000. The effectiveness of hearing conservation

programs is therefore very dependent on the attenuation that hearing protectors provide and their daily use by all workers.

Table 6.—Sensitivity Analysis for Assumptions on Hearing Protector Use and Attenuation

Assumption	Number of occupational impairments prevented ¹
100% of workers required ² wear hearing protectors and receive 15 dB attenuation	898,000
100% of workers required ² wear hearing protectors and receive 10 dB attenuation	759,000
50% of workers required ² wear hearing protectors and receive 10 dB attenuation	381,000
No hearing protector use	0

¹ Hearing threshold levels >25 dB average of 1000, 2000, and 3000 Hz. Data are for equilibrium.
² All workers exposed to levels >90 dB after feasible engineering and administrative controls have been implemented and all workers exposed >85 dB who have shown a permanent significant threshold shift.

Source: OSHA, Office of Regulatory Analysis.

These calculations of the number of impairments prevented are also based on the assumption that workers exposed above 85 dB do not currently use hearing protectors. However, the current OSHA standard for noise does require the use of hearing protectors by workers exposed to levels above the PEL of 90 dB (TWA) and the establishment by each employer of a "continuing, effective hearing conservation program" for these employees (29 CFR 1910.95(b)(3)). Moreover, there is evidence in the record to suggest that some employees currently do wear hearing protection and that some companies have established hearing conservation programs. (The BBN exposure estimates were based solely on the use of non-use of engineering controls. The use of personal hearing protectors was not factored into their estimates.)

But the effectiveness of these programs and the length of time they have been in operation is less clear. Submissions by Newport News Shipbuilding (Ex. 131), Dupont (Ex. 273A), and Burlington Industries (Ex. 175) describe hearing conservation programs for three large companies that appear to be effective. But one cannot reasonably conclude that all companies with workers exposed to levels greater than 90 dB are maintaining such programs. A NIOSH study revealed that only 29 percent of the manufacturing respondents had such programs, while another 20.1 percent were planning such programs. Most of those without

programs or plans claimed no noise problems (Ex. 321-14B, p. B-3). This study also included the testing of equipment used by 85 companies with hearing conservation programs. These tests revealed that 80 percent of these companies were not in compliance with at least one of the then existing ANSI specifications for audiometers and audiometric test booths (Ex. 321-14B, p. 55).

Based on data from NIOSH's National Occupational Hazard Survey (Ex. 321-14D), it is reasonable to conclude that up to 20 percent of those exposed to greater than 90 dB currently wear hearing protectors. The lack of adequate audiometric testing, monitoring, and training activities, however, make it less likely that a 15 dB attenuation would be achieved. A more reasonable estimate of the current attenuation would be 10 dB, which is the lower bound of the average attenuation range revealed in several studies on the real world attenuation of hearing protectors. (See discussion above.) OSHA has calculated, using the procedures and assumptions detailed in this section and in Appendix A of OSHA's Final Regulatory Analysis, that the effect of this current hearing protector use would ultimately be a reduction of 120,000 material impairments (25 dB fence) from the 1,060,000 that would continue to exist at any one time in the absence of hearing protector use.

OSHA anticipates that fully effective hearing conservation programs for all workers exposed to levels greater than 85 dB would prevent 898,000 impairments after the entire population has worked with hearing conservation programs in effect. Thus, the incremental or additional benefits due to the hearing conservation amendment will be the difference between these benefits and the 120,000 impairments expected to be prevented by existing programs. The final hearing conservation amendment, therefore, is estimated to prevent 778,000 material impairments over and above the number expected to be prevented by current hearing conservation programs. (These 778,000 impairments prevented consist both of workers exposed to levels >90 dB who are not currently receiving hearing protection as well as those exposed between 85 and 90 dB who will benefit from hearing conservation programs for the first time.)

This discussion on the benefits of preventing hearing impairment has shown that there are substantial benefits to be gained from reducing workplace noise exposure by 15 dB for those exposed above 85 dB. It was

assumed in this discussion that the reduction of noise exposures would be achieved through the use of personal hearing protectors. However, that reduction could also be achieved by engineering controls, including the redesign of machinery and the construction of baffles to impede the transmission of sound energy. Engineering controls provide more consistent and dependable protection to worker hearing than personal hearing protectors and are still preferred by OSHA.

Improved Workplace Safety

A second benefit of the hearing conservation amendment is improved workplace safety. The presence of untreated workplace noise can increase the number of accidents because (1) noise can mask warning signals or shouts, and (2) noise exposure might lead to inattentiveness and fatigue, both of which may precipitate accidents. Edith Gulian's summary of studies in the European literature revealed no clear consensus on the relationship between noise and accidents. One study found no relationship, while two others concluded that noise may have contributed to accidents (Gulian, Ex. 97, p. 60). Two other studies in the record, by examining the job safety records of workers before and after the institution of hearing conservation programs, showed a statistically significant reduction in the number of accidents and injuries occurring after the initiation of hearing conservation programs.

Schmidt, Royster, and Pearson (Ex. 321-22F) studied a cotton yarn plant where a hearing conservation program requiring the use of hearing protectors was instituted in 1972. Using a statistical technique by which each worker serves as his or her own control, the researchers compared the mean number of injuries in the 4-year period prior to the hearing conservation program to the 4-year period following institution of the hearing conservation program for two groups of employees exposed to noise levels of 92-96 dB. The results showed a statistically significant reduction in reported injuries.⁸ For one group, the reduction in the mean injury rate was from 0.4 to 0.2 injuries per year, or by about 50 percent; for the other group, the reduction was from 0.5 to 0.3 injuries per year, or by about 40 percent (Schmidt, et al., Ex. 321-22F, p. 22).

A second study was performed by the Raytheon Service Company under

contract to NIOSH (Ex. 26-11). The researchers studied the records of a boiler fabrication plant for the 2-year period before the initiation of a hearing conservation program and the 2-year period after program initiation. The results of this study showed a statistically significant reduction in the number of accidents among workers exposed to noise levels >95 dB after the initiation of the hearing conservation program. The median frequency of accidents was reduced from 3.8 to 2.3 accidents per worker per year, or by 39.5 percent (Raytheon, Ex. 26-11, pp. 3-5 to 3-6).

Information from the Bureau of Labor Statistics shows that annually there are about 2,474,000 reported occupational injuries in the 19 industries in this noise study, of which about 1,052,900 are lost workday cases (Bureau of Labor Statistics, *Occupational Injuries and Illnesses in 1978: Summary*, March 1980, Report 586, Table 3, pp. 12-13). If these accidents are distributed evenly among all workers in these industries without regard to noise exposure, then approximately 851,000 total cases and 362,000 lost workday cases could occur each year for those exposed above 85 dB (TWA) [2,474,000 injuries $\times$ 34.4 percent (workers exposed >85 dB) = 851,056; 1,052,900 lost workday cases $\times$ 34.4 percent = 362,198]. Similarly, there are 477,000 total cases and 203,000 lost workday cases among those exposed above 90 dB (TWA) [2,474,000 injuries $\times$ 19.3 percent = 477,482; 1,052,900 lost workday cases $\times$ 19.3 percent = 203,210]. The Schmidt, Royster, and Pearson study, and the Raytheon study together reveal that the initiation of hearing conservation programs may reduce this yearly toll of accidents.

The reduction in the number of accidents, beside improving the quality of worker lives, may also provide financial benefits to employers by reducing the costs of accidents. These costs include administrative and legal fees, safety administration, damage to equipment, loss of productivity, supplements to workers' compensation payments, and lost income due to inefficiency of replacement personnel. Robert Sharkey, Safety Administrator for Alcoa, estimates that these costs total \$14,000 per lost-workday case. (See Peter J. Sheridan, "What Are Accidents Really Costing You?" *Occupational Hazards*, March 1979, pp. 41-43.)

Extra-Auditory Health Benefits

As described in the Health Effects section, there is a wealth of evidence suggesting a link between noise

⁸ Statistical significance refers to the probability or confidence, based on laws of probability and statistics, that the decline in the number of accidents was not due solely to chance. In this case, the confidence level was 99.9 percent.

⁹ 99 percent confidence level.

exposure and ill effects, including cardiovascular, respiratory, allergenic, musculo-skeletal, and glandular disorders. However, because precise dose-response relationships have not yet been developed OSHA has not attempted to quantify these benefits. One example does reveal the magnitude of the occurrence of cardiac disease in the U.S. today. The current rate for deaths due to heart disease for those between 45 and 64 years old is 536.7 per 100,000 (Bureau of the Census, *Statistical Abstract of the United States*, 1979, p. 77, Table 111). If this rate applies to the 4,984,000 workers aged 45-64 in the 19 industries, then approximately 27,000 will die of heart disease annually. By reducing noise exposure, the hearing conservation amendment may help to prevent some of these premature deaths.

Reduced Absenteeism

The reduction in noise exposures due to hearing protector use should reduce the number of noise-induced illnesses and could also lead to better worker attitudes towards their jobs, thus improving both attendance records and job performance. In both cases, employers, firms, and consumers would benefit from increased output and reduced costs. The Raytheon study (Raytheon, Ex. 20-11) found that the median number of absences for the group exposed to >95 dB fell by 12.4 days per year after initiation of a hearing conservation program. This was a reduction of about 83 percent from the preconservation program level of absences (Raytheon, Ex. 26-11, p. 3-177).

Several studies of the economic impact of the proposed regulation placed a monetary value on the expected reduction in absenteeism. CPA, in their first study, assumed a reduction in absenteeism of 1 day per year per worker exposed over 85 dB. This was calculated to provide an estimated benefit of \$2 billion per year (CPA, "Some Considerations," Ex. 138A, p. 2-55). In their second study, CPA used a more complex methodology based on information from the Raytheon report concerning the reduction in the average number of days absent. CPA calculated the value of lost production based on lower and upper bounds—i.e., average production worker wages and value added per production worker. Based on 1975 dollars, CPA estimated that the value of improved worker attendance for an 85 dB PEL would be between \$341.04 million and \$1.2484 billion per year (CPA, "Economic/Social Impact," Ex. 232, p. 5-28). A third estimate of the value of absenteeism savings was performed by the Council on Wage and

Price Stability (COWPS). Although not based on any empirical studies, COWPS assumed that an 85 dB PEL would reduce absenteeism by 1 day for those previously exposed to 85-90 dB and by 2 days for those exposed above 90 dB. COWPS calculated the savings by multiplying the number of person-days saved by the average daily wages of manufacturing workers, including an estimate of the costs for turnover and new worker training. Finally, COWPS concluded that controlling noise exposures to 85 dB would produce a benefit of \$271.7 million per year (COWPS, Ex. 208, p. 19).

After a review of these estimates, OSHA has concluded that the best estimates are provided by the methodology used by CPA in their September 1976 report, which was based on information from the Raytheon study. OSHA has chosen to reestimate the absenteeism benefits by updating the CPA calculations for the increase in the size in the labor force and changes in wage rates since 1976. For this update, OSHA has used only the wage rate to estimate the value of production lost from absenteeism. These calculations, which assume that hearing conservation programs will reduce exposures to below 85 dB for those exposed at 90 dB and above, follow the CPA methodology. First the total number of worker-days of absenteeism prevented were calculated by using the number of workers exposed to noise >90 dB and the number of days of absenteeism saved according to the CPA presentation of the Raytheon data (See CPA, Ex. 232, p. 5-25). The equation used was: 1.243 million workers exposed >95 dB $\times$ 3.9 days saved per worker + 1.836 million workers exposed to 90-95 dB $\times$ 1.55 days saved per worker = 7.384 million worker-days saved. The value of the production gain from reduced absenteeism was then estimated using the 1979 average wage rate in the 19 industries (See *Employment and Earnings*, 27, 3, March 1980, Table C-2). Thus, 7.384 million worker-days saved $\times$ 8 hours per day $\times$ \$6.76 per hour = \$399.3 million. This gain of about \$400 million per year from reduced absenteeism will benefit employers by partially offsetting the costs of hearing conservation programs and feasible engineering and administrative controls.

Reduced Medical Costs

Workers, and also society, indirectly through third party medical payments, will benefit financially through reduced medical costs. Although in most cases noise-induced hearing loss is untreatable and irreversible, there still

is a drain on medical resources—principally professional time—used to reach those diagnoses. In addition, there is the purchase of prescribed hearing aids in the minority of cases for which hearing aids can help, as well as the hearing aids purchased by workers vainly hoping for a cure. In all three cases, social resources are consumed. The prevention of occupational hearing impairments will free those resources for other uses.

Ideally, the magnitude of this loss could be quantified. However, the current noise record does not include either estimates of this loss or information from which estimates could be calculated. Because of this lack of information, OSHA has not attempted to quantify these savings, although preventing 898,000 hearing impairments should lead to a substantial reduction in medical costs.

Reduced Workers' Compensation Payments

Two estimates of the anticipated reduction in workers' compensation payments for occupational hearing loss are contained in the record. BBN estimated that the additional workers' compensation liability saved by reducing noise exposures to 85 dB would be \$16.097 million (BBN, Ex. 192, p. 2-38). This is the additional savings, comparing a 90 dB with an 85 dB PEL, not the total reduction expected from the implementation of hearing conservation programs. CPA made an estimate of the total potential workers' compensation payments that a noise regulation might save. They calculated that the present value of the stream of potential savings for an 85 dB PEL over the next 40 years would be \$530 million (CPA, Ex. 232, p. 5-34).

But any of these estimates is speculative since hearing impairment is often not compensated. Over 70 percent of manufacturing workers in the U.S. live in states that pay few or no hearing impairment claims (EPA, *Occupational Hearing Loss: Workers' Compensation under State and Federal Programs*, Ex. 321-16C, p. viii). EPA estimates that in 1977, 8,095 claims totalling approximately \$13 million were paid for occupational hearing loss. This figure could change considerably in the future because the number of claims filed has been increasing dramatically (EPA, Ex. 321-16C, pp. 14-15).

It has been pointed out that an estimate of reduced workers' compensation payments cannot be directly added to the other benefits described in this section. As COWPS testified:

Although a reduction in workmen's compensation payments is a benefit to employers who no longer have to pay workmen's compensation premiums, it represents an almost equal and offsetting cost to workers who no longer receive such payments. (COWPS, Ex. 208, pp. 7-8)

In other words, workers' compensation payments are transfer payments from employers to impaired workers. The true social cost is the incidence of occupational hearing impairment and the various other ill effects of noise; the true social benefit is the reduction in the number of hearing impairments and ill effects.

Annoyance

Several of the studies in the record quantified the benefit of reduced annoyance from noise exposures. (See CPA, "Some Considerations," Ex. 138A, pp. 2-55 to 2-59; Smith *The Occupational Safety and Health Act*, Ex. 261A, pp. 46-52; COWPS, Ex. 208, pp. 17-18.) Although these calculations provide interesting information, they primarily apply to the benefits of using engineering controls to reduce noise exposures. The use of hearing protectors to achieve noise reductions will not create the full value of these benefits, because hearing protectors also create disutilities, especially worker discomfort, for those who must wear them. Thus, the benefits of less annoyance due to lowered noise levels are likely to be considerably reduced by this disutility although there are no data in the record enabling OSHA to make a more precise determination.

Worker Productivity

The hearing conservation amendment may also improve the productivity of workers exposed to high levels of noise. There are two possible mechanisms for this: (1) through improvements in conscious worker attitudes towards their jobs, and (2) through subconscious reductions in psychological and physiological stress. The hearing conservation amendment will improve the quality of worker lives by preventing occupational hearing loss and by reducing the incidence of other noise-induced illnesses. These improvements in the quality of life may improve worker attitudes towards their jobs, thus leading to increases in the quantity and the quality of goods and services they produce. The reduction of noise exposures through the issuance and use of hearing protectors may also improve worker performance even if it does not improve conscious worker morale. In particular, workers may still hold the same attitudes towards their jobs, but may be more productive because of a

reduction in the subconscious psychological and physiological stress experienced by workers exposed to workplace noise.

In both cases, employers, workers, and consumers would benefit financially. The increased production and improved product quality would benefit employers by offsetting, at least partially, the cost of the amendment. To the extent that the increases in output and improvements in quality increase the productivity of labor inputs, workers could be able to gain improvements in wages and fringe benefits. Finally, consumers would benefit from the increase in the quantity and quality of output. This increase would enable them to purchase an increased quantity at existing prices or continue to purchase the existing quantity but at reduced prices.

Thus, one can reasonably believe that reductions in noise exposure with the use of hearing protectors could, through improved worker morale and reduced subconscious stress, improve worker productivity and lead to financial benefits for employers, workers, and consumers. However, the empirical literature summarized in submissions to the noise record does not provide enough data to confirm or reject this.

In their criteria document on occupational exposure to noise, NIOSH reviewed some of the literature on the effect of noise on job performance (NIOSH, *Criteria for a Recommended Standard*, Ex. 1). NIOSH discovered that the effect of noise appears to be quite variable depending on the type of noise, the nature of the job, and the attitudes of the person affected. It also appeared that impulsive noise (recurring bursts of noise of high intensity) and intermittent noise (on and off exposures) create greater performance losses than continuous noise. The nature of the job is also important—jobs which require "unremitting attention" or "which place extreme mental demands on the employee" appear to be the most vulnerable to decrements in employee performance under noise exposures. For simple, repetitive tasks, performance may be enhanced by the presence of low to moderate levels of noise. Finally, it appears that certain attitudes and personality factors influence the effect noise has on task performance. Tense, anxious individuals, as well as those already dissatisfied with their jobs may be less able to perform productively under noisy conditions than other persons (NIOSH, *Criteria for a Recommended Standard*, Ex. 1, pp. IV-13 to IV-16).

EPA and Edith Gulian drew similar conclusions from their reviews of the

literature. EPA concluded that continuous noise levels above 90 dB can impair job performance for "noise sensitive tasks," such as vigilance, information gathering, and analytical tasks. Noise levels of less than 90 dB can be disruptive, especially if the noise is composed of high frequencies, or if it is "intermittent, unexpected, or uncontrollable." The amount of this disruption is a function of the nature of the task, and the psychological and physiological state of the individual. The studies surveyed showed that noise does not usually affect the total quantity which a person produces, but may increase the variability of the work rate and reduce the accuracy of the work (EPA, *Public Health and Welfare Criteria for Noise*, Ex. 31, pp. 8-1 to 8-7). Gulian's survey of the European literature found several studies which indicated increased production with reduced noise exposures, but concluded that the literature was inconclusive on the effects when noise levels were lower than 100 dB, although under certain conditions lower levels have shown adverse effects on productivity (Gulian, Ex. 97, pp. 18-20).

Many of these studies involved testing the ability of persons to perform certain experimental tasks under laboratory conditions and not actual jobs under industrial working conditions. Moreover, the studies mentioned above investigated primarily the effects of noise on performance. They did not examine what effect the issuance and use of hearing protectors might have on job performance.

One study that did examine the effect of hearing protectors indicates that the issuance and use of hearing protectors may have an adverse effect on productivity. This study, by L. R. Hartley (cited by CPA, "Some Considerations," Ex. 138A, pp. 2-45 to 2-46), examined the ability of test subjects to perform a laboratory task under four conditions: quiet, quiet while wearing hearing protectors, noisy, and noisy while wearing hearing protectors. Under quiet conditions, subjects were exposed to broad-band noise at a C-weighted sound level of 70 dB; for noisy conditions exposures were at a C-weighted sound level of 95 dB. The researcher used two measures of subject performance—the number of gaps (pauses of 1½ seconds) and errors. The results revealed that without hearing protectors, exposure to noisy conditions increased both the number of gaps and the number of errors compared to the quiet conditions. When the subjects were exposed to conditions of quiet, the use of hearing protectors increased the number of gaps and

errors. Finally, under noise conditions, the use of hearing protectors decreased the number of gaps, but increased the number of errors. CPA concluded their discussion of this study by suggesting that these results:

... tend to give added support to the preference of OSHA, NIOSH, and EPA for engineering solutions to noise, rather than personal ear protection. The widely-observed resistance of workers to the discomfort and annoyance of at least some ear protectors increases the probability that their imposition may sometimes have negative effects on the quality, if not the quantity of industrially-produced goods (CPA, "Some Considerations," p. 2-46).

A final determination of the effect of noise and hearing protector use on productivity awaits the completion of further research. Therefore, OSHA has not based its justification of the hearing conservation amendment on possible gains in worker productivity.

Conclusion

In this section, the benefits of the hearing conservation amendment were delineated and discussed. The primary benefit will, of course, be a substantial reduction in the incidence of occupational hearing impairment in the population exposed to workplace noise. The additional benefits to be gained include improved workplace safety, reduced absenteeism, reduced medical costs, and a possible reduction in cardiovascular and certain other illness. The range of health, safety, and financial benefits, and the magnitude of their favorable impact on the quality of life for U.S. workers serve to justify this amendment.

V. Cost and Feasibility Considerations

Summary and Conclusions

The following three sections analyze in depth the costs of the final standard, its economic feasibility and its technical feasibility. This subsection briefly summarizes that analysis.

The cost of the hearing conservation amendment will average \$53 per year for each of the 5.1 million employees estimated to be covered by the amendment. This comes to \$270 million in total annual costs for the 19 sectors of the economy (2-digit SIC codes) which have significant noise exposures. Approximately \$15.7 million is already being spent on hearing conservation programs, so the additional costs generated by the standard are \$254.3 million. As explained in the cost section, OSHA believes these costs are somewhat overestimated because of the methodology used.

The industry with the largest compliance costs is lumber and wood

with annual costs of \$30.9 million. Other industries with annual costs between \$20 and \$25 million are printing and publishing, primary metals, fabricated metals, machinery except electric, and utilities. The food and textile industries have costs of \$17 million. No other industry has costs over \$13 million per year.

The only other comprehensive cost estimates were submitted by BBN. They estimated a cost of \$65 per employee included in hearing conservation programs. Certain changes in the standard, as well as the use of more timely cost data, account for the differences between the BBN and OSHA estimates.

The section on economic impact discusses in detail the impacts of the costs of the standard. These impacts are small. If the total costs of the regulation are passed on to consumers, prices would increase 0.0148%. Even in the segment most impacted, lumber and wood, prices would increase only 0.0776%.

Even in the unlikely event that firms would be forced to absorb the costs of the amendment, these costs represent only 0.1932% of the profits of the 19 industries. It should be noted that even in the industry most affected, lumber and wood, costs represent slightly under 1% of profits. It is inappropriate to present the increased price and decreased profit data as cumulative when analyzing impacts. The two maximum effects will not occur simultaneously. The greater the increase in prices, the smaller the reduction in profits. Similarly, the greater the reduction in profits, the smaller the increase in prices. The price and profit impacts are both likely to be less than the maximums presented here.

Section 6(b)(5) of the Occupational Safety and Health Act requires standards to be feasible and this includes economic as well as technical considerations. The D.C. Circuit explored this requirement in *Industrial Union Dept., AFL-CIO v. Hodgson*, 499 F.2d 467 (1975). It states,

There can be no question that OSHA represents a decision to require safeguards for the health of employees even if such measures substantially increase production costs. This is not, however, the same thing as saying that Congress intended to require immediate implementation of all protective measures technologically achievable without regard for their economic impact. To the contrary, it would comport with common usage to say that a standard that is prohibitively expensive is not "feasible." . . . practical considerations can temper protective requirements. Congress does not appear to have intended to protect employees by putting their employers out of business—

either by requiring protective devices unavailable under existing technology or by making financial viability generally impossible.

This qualification is not intended to provide a route by which recalcitrant employers or industries may avoid the reforms contemplated by the Act. Standards may be economically feasible even though, from the standpoint of employers, they are financially burdensome and affect profit margins adversely. Nor does the concept of economic feasibility necessarily guarantee the continued existence of individual employers. It would appear to be consistent with the purposes of the Act to envisage the economic demise of an employer who has lagged behind the rest of the industry in protecting the health and safety of employees and is consequently financially unable to comply with new standards as quickly as other employers. As the effect becomes more widespread within an industry, the problem of economic feasibility becomes more pressing. (pp. 447-8).

As shown in the economic impact section, the cost impacts of the final hearing conservation amendment will not lead to economic dislocation. The costs are tiny relative to sales (averaging 0.0148%) and small relative to profits.

The worst case is 1% of profits while the average is 0.2%. In reality the costs as a percentage of profits will be less because some costs will be passed forward to consumers. These costs are easily affordable and no economic disruption or anything approaching it will be caused in any industry. Even employers who have a high percentage of employees affected by the amendment should be able to afford the \$53 per employee cost. Therefore OSHA finds that the standard is without doubt economically feasible.

Technological feasibility is analyzed in the resource availability section. No difficult engineering problems, or indeed any engineering problems, are created by the standard. The hearing protection devices are already available on the market. The measuring and testing equipment needed (dosimeters, audiometers, etc.) is also available for purchase. In those areas where short-term production may not be adequate to meet immediate demand, a 2-year delayed starting date is provided by the standard. There also are adequate numbers of trained personnel, audiologists, physicians, etc., to meet the needs of employers resulting from the standard.

OSHA therefore finds the hearing conservation amendment is clearly technologically feasible.

VI. Costs of Compliance

Introduction

Many industry groups strongly recommended to OSHA that hearing conservation programs are a cost-effective and affordable means of reducing noise induced hearing impairment among workers. Bolt Beranek and Newman, (BBN), in their 1976 report for OSHA, "Economic Impact Analysis of Proposed Noise Control Regulation," Ex. 192] estimated that the hearing conservation provisions of the proposed standard would cost the manufacturing and utilities sectors of the U.S. economy a total of \$289.3 million per year in 1975 prices. This amounted to an annual cost of \$65 per worker included in the program. The monitoring, recordkeeping, and associated tasks were estimated at \$155.2 million annually, (p. 3-9) and were based on the assumption that a typical plant had 50 production workers and could be surveyed by a noise engineer for \$600. The annual cost for audiometric testing was calculated at \$20 per production worker for \$89.1 million, and hearing protectors were estimated at \$10 per worker for a total of \$45 million per year (Ex. 192, p. 3-33). None of these cost estimates were adjusted to reflect the existence of hearing conservation programs already established by industry.

The BBN estimates of these provisions were not widely criticized. However, certain differences between the proposed standard and the final rule, as well as the availability of more timely cost data, have convinced OSHA to update these estimates of the expected compliance costs. The current estimation procedures, which are based on a thorough review and analysis of the entire record, are presented below for each major provision of the final regulation (Appendix B of OSHA's Final Regulatory Analysis provides the detailed calculations for a sample SIC industry). Overall these new calculations show that the total annual cost of the regulation will average about \$53 for each of the 5.1 million workers estimated to be covered by the hearing conservation amendment. Thus, the total cost of complying with all of the provisions of the amendment are estimated at about \$270 million a year. After accounting for some of the compliance activities already taking place, OSHA estimates that the new compliance costs will not exceed about \$254.3 million a year and most likely will fall well below this amount (see Table 7).

Table 7.—Estimated New Annual Compliance Costs of the Hearing Conservation Amendment

Monitoring	\$73,731,000
Audiometric Testing	87,199,000
Hearing Protectors	45,534,000
Training	40,029,000
Warning Signs	1,795,000
Recordkeeping	6,033,000
Total	254,321,000

Source: OSHA, Office of Regulatory Analysis.

Monitoring

The proposed standard directed employers to monitor worker exposure to noise on an annual basis. The final amendment will be less costly because in most cases, it requires monitoring to be performed only every other year. Although the final hearing conservation amendment requires that a new representative exposure be obtained whenever there is a change in noise levels that would render the employee's hearing protection inadequate, in practice, the general availability of hearing protectors rated to reduce high noise levels should make these occurrences infrequent.

A number of consultants have submitted documents to the record listing their fees for noise measurement services. For example, Exhibit 319 B-8 lists \$440 plus expenses as the daily charge for a noise engineer and \$360 plus expenses as the daily fee for a technician. Exhibit 319 B-11 indicates fees from \$250 to \$350 for an engineer and from \$180 to \$240 for a technician, while Exhibit 319 B-16 reported between \$229 and \$465 plus expenses for an engineer and between \$175 and \$255 plus expenses for a noise technician. The average of these daily fees is about \$362 for an engineer and \$262 for a technician. Travel expenses will vary according to each firm's location relative to the consultant. However, as the demand for these services grows, economies of scale will operate to reduce costs below current market charges. For example, the expanded market for consultant services within a region will stimulate the supply of monitoring consultants in the area, thereby minimizing travel expenses. Also, noise engineers should find it increasingly profitable to combine resources with audiometric testing firms to provide industrial clients with a complete range of hearing conservation services. A growing number of firms already market these comprehensive consulting programs (Ex. 305; 319 B-12), and this one-stop approach to satisfying monitoring, testing and training requirements should substantially

reduce the costs of these services over time.

Based on its survey experience, OSHA has estimated the average time it would take noise experts to take measurements in plants of varying sizes. Table 8 shows OSHA's estimate of the cost of hiring a noise consultant, based on the daily fee of \$362 for an engineer, \$262 for a technician, and a \$50 average travel expense.

Table 8.—Cost of Monitoring by Consultant

Number of employees measured	Days in the field		Days in office—Eng- neer	Cost
	Engi- neer	Techni- cian		
1 to 10	1			\$412
11 to 20	1		5	500
21 to 40	1	1	5	850
41 to 60	1.5	2	5	1,298
61 to 80	2	2	1	1,600
81 to 100	2.5	3	1.5	2,264
101 to 120	2	4	2	2,546
121 to 140	2	5	2	2,908

Source: OSHA, Office of Regulatory Analysis.

The monitoring provision of the amendment requires the reporting of representative exposures of all workers exposed to a time weighted average (TWA) of noise above 85 dB, rather than an actual measurement of each such employee. Thus, a measure of the exposure of one employee may be used to represent similarly exposed employees. Since the data shown in Table 8 correspond to measured workers (as opposed to others who are represented by the measured workers), an estimate of the number of employees who would be individually measured is necessary to assess the total monitoring cost. However, there is no data base available to identify statistically the determinants of the number of employees who would actually have to be measured according to the final rule. This number will vary due to the nature of the industrial process and the diversity of the work areas and tasks. For instance, in workplaces where noise levels are fairly uniform throughout the shop, fewer employees will need to be monitored than in workplaces where the noise exposure vary extensively among workers. Nevertheless, it can be assumed that, in general, the percent of the work force to be measured would vary inversely with the size of the plant. (See Ex. 309, p. 35, Table 3.1 for an example of how the percentage of workers to be sampled within a group of similarly exposed workers might decline as the group grows larger.) Table 9 gives estimates of the percentage of employees who would have to be measured individually to provide representative exposures of workplace noise for all exposed workers. These estimates were developed by OSHA.

based on its broad experience with noise surveys for numerous industrial establishments, and are consistent with the final monitoring requirement as they are predicted on a sampling strategy designed to place employees within 5 dB ranges.

source of data on TWA exposures in typical noisy industrial surroundings.

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Table 9.—Percent of Employees Measured To Provide Representative Exposures

Number of employees	Employees measured (percent)
1 to 19	100
20 to 49	60
50 to 99	50
100 to 249	40
250 and over	30

Source: OSHA, Office of Regulatory Analysis.

To refine the estimate of the cost of using consulting services to conduct industrial noise measurements, it was necessary to construct a statistical distribution of the number of production workers in manufacturing establishments of different sizes. The U.S. Bureau of the Census provides 1977 data on the total number of employees in five establishment size categories (*County Business Patterns*, CBP-77-1). The conversion of this size distribution from total employees to one limited to production workers was accomplished by combining these data with information from the U.S. Bureau of Labor Statistics (BLS) (*Employment and Earnings*, 1909-1976) to obtain a 15-year average ratio of the number of production workers to the total number of employees. When multiplied by the 1977 Census estimates of total employment by industry and establishment size, this procedure yields estimates of 1977 production worker employment by industry and establishment size. These data are shown in Table 10.

OSHA believes that the best estimates of the total number of workers affected by this hearing conservation program are obtained from the BBN data on the percentage of workers exposed to various levels of noise in those industrial sectors which include most manufacturing and public utility firms (Ex. 192, p. 2-7). BBN's industry-wide estimates, as presented in Table 11, were developed from surveys of 68 firms representing 19 two-digit SIC categories, were based on years of extensive experience and expertise in noise control surveys, and were the most comprehensive and detailed noise exposure estimates submitted to the record. Thus, they remain the best

Table 10
Number of Production Workers and Establishments by Industry and Establishment Size

SIC	1-19 Employees		20-49 Employees		50-99 Employees		100-249 Employees		Over 250 Employees	
	Production Workers	Establishments	Production Workers	Establishments	Production Workers	Establishments	Production Workers	Establishments	Production Workers	Establishments
20	75,583	13,118	122,613	4,783	158,034	2,813	292,110	2,332	527,859	1,248
21	431	102	817	30	1,402	22	5,487	37	44,363	42
22	17,182	2,647	36,791	1,238	53,828	825	143,386	1,007	525,811	985
23	73,714	12,301	150,593	4,490	180,224	2,810	314,631	2,257	403,037	1,020
24	131,794	25,577	108,400	3,550	117,628	1,697	159,885	1,103	128,894	319
25	33,894	5,762	45,134	1,527	52,706	819	91,521	647	174,745	373
26	15,173	2,204	38,254	1,360	61,079	983	149,706	1,146	277,289	538
27	126,470	35,518	101,748	5,199	89,263	2,042	117,751	1,251	266,969	641
28	33,186	6,812	48,072	2,091	54,695	1,082	94,984	841	405,953	687
29	8,380	1,379	9,271	286	9,988	137	23,737	142	88,264	123
30	33,391	5,590	62,459	2,230	82,901	1,353	134,120	989	288,230	498
31	8,275	1,410	13,413	467	20,528	332	48,213	341	116,962	325
32	74,668	11,639	80,305	2,810	65,780	998	107,929	750	231,819	422
33	20,304	3,003	41,908	1,475	54,945	893	138,046	945	731,098	795
34	117,675	19,020	169,809	6,154	170,975	2,815	274,821	2,041	572,619	1,088
35	163,075	32,304	155,393	6,406	135,719	2,502	219,331	1,783	942,683	1,468
36	38,208	7,192	59,430	2,212	80,189	1,338	179,628	1,383	1,021,145	1,394
37	27,347	5,379	34,035	1,318	44,954	801	92,414	751	1,204,450	898
49	67,188	10,593	66,942	2,179	79,232	1,156	110,509	744	335,430	421
Total	1,065,937	201,550	1,343,368	50,310	1,514,071	25,459	2,640,979	20,450	8,287,626	13,285

Source: Estimated as described in text from the U.S. Bureau of the Census, County Business Patterns, CSP-77-1; and the U.S. Bureau of Labor Statistics, Employment and Earnings, 1909-1978.

Table 11.—Percentage of Production Workers Exposed to Noise

SIC	90 dB	85 dB	80 dB	75 dB
20	16	28	47	
21	6.6	9.7	28	
22	52	75	87	
23	0	1	20	
24	72	94	97	
25	12	30	53	
26	21	40	59	
27	19	45	66	
28	20	37	55	
29	52	76	82	
30	13.9	20	40	
31	0	1	20	
32	4.8	16	42	
33	28	63	81	
34	19	34	56	
35	13	28	48	
36	2.5	7	27	
37	13	23	42	
48	30	74	89	
Total	19.3	34.4	53.1	71.5

Source: Bell, Beranek, and Newman. "Economic Impact Analysis of Proposed Noise Control Regulation," (Ex. 192, p. 2-7, and BSN worksheets).

Technically, representative exposures are only required for workers with a TWA exposure to noise of 85 dB or above. However, it seems probable that many employees exposed to noise below a TWA of 85 dB would be surveyed also. This is because, at least initially, employers would not know which workers were exposed to 85 dB without monitoring representatives of most of the workers stationed in fairly noisy work areas. Consequently, all workers exposed above a TWA of 80 dB were assumed to be surveyed for cost estimation purposes despite the fact that, as employers become more knowledgeable about the exposures, this adjustment will overestimate monitoring costs.

Therefore, the number of measurements for each establishment size category in each SIC industry studied can be estimated by the following equation:

$$(1) M = (PM/100)(PW/E)(N)$$

where:

M = the number of measurements

PM = the percent of workers actually measured (Table 9)

PW = the number of production workers (Table 10)

E = the number of establishments (Table 10)

N = the percentage of workers exposed to >80 dB (Table 11)

This formula simply multiplies: (the percent of workers that the sampling strategy would require to be actually measured) $\times$ (the average number of production workers per establishment) $\times$ (the percentage of workers exposed to >80 dB). When the number of measurements for each establishment size are matched to estimates of the corresponding consultant charge (Table 8) this provides estimates of the average cost for a firm using a noise consultant.

Since monitoring will usually be required biennially, the annual consultant cost is one-half of the values listed in Table 8.

However, employers may elect to monitor with in-house personnel. An acceptable dosimeter, readout and calibrator, such as described in Exhibit 319 A-7, costs \$1,230. The standard capital recovery formula with a 10 percent interest rate and a 10-year equipment lifetime gives an annualized capital cost of about \$200. Periodic calibration costs could add another \$60 a year. In addition, it might take an employer about an hour per measured employee to select representative workers, make daily calibrations of the dosimeter, and place and remove the dosimeters from the individual workers. Since this task may be performed by the employer or by supervisory employees earning more than the average industry production worker wage, an average cost of \$10 per hour was used to account for the time required to complete this task. Thus, the average annual cost for each establishment can be calculated as $\$200 + (\$10 \times \text{the number of measured workers}/2 \text{ years})$. The resulting values imply that monitoring would usually be done by in-house staff only in the largest plants where the average cost of \$755^{*} is substantially below the \$1,142^{*} average consultant cost. However, for the smallest establishments, the annual consultant fee of \$206 is significantly less than the cost of developing an in-house program by purchasing the required equipment.

Alternatively, sound level meters and calibrators may be purchased for \$810 (Ex. 319 A-7). Since these meters are expected to last at least 10 years (Ex. 319 A-7; Ex. 319 A-72), a 10 percent interest rate yields an annualized equipment cost of \$99.27. Biennial calibration would add an additional \$30 per year (Ex. 319 A-7). However, the time employers would need to make TWA exposure measurements with a sound level meter would often exceed the time required using a dosimeter because sound level meter measurements often require following employees through various phases of the work process. For this reason, the following calculations assume the use of dosimeters for in-house monitoring.

It was assumed that employers would select the least expensive mode of complying with the provision. Therefore, for each SIC sector, multiplying the

^{*} $\$200 + (10 \times M/2) = \755 , where M is defined as in equation (1) and equals, on average, $(.30 \times 8,287,629/13,285 \times .531)$ which is 99.

^{*} Table 8 indicates that the consultants fee for measuring 99 workers was estimated at \$2,234. If performed biennially, the annual cost is \$1,142.

number of establishments in each size class by the average consultant cost where consultant services would be more efficient (generally the first three or four establishment size categories), and the average in-house cost using dosimeters for the larger size categories where in-house programs are more efficient, provides an estimate of the industry's monitoring cost. Summing these costs over all the SIC's gives total costs of \$78,427,000 to initiate monitoring programs in all establishments in the studied industries.

However, many firms already have extensive monitoring programs. Although precise estimates are not available, a survey of hearing conservation programs conducted by The National Institute for Occupational Safety and Health (NIOSH) (Ex. 321-14B) evaluated responses from 1,410 manufacturing firms (p. 7). Twenty-nine percent stated that their firm had a program concerned with hearing conservation (p. B-3), and 90 percent of those firms, or 26 percent of the respondents, reported that they currently monitor workplace noise (p. B-7). Since the survey sample was heavily weighted with firms of over 100 employees, the results may apply primarily to these larger firms. Table 10 indicates that there are about 33,775 establishments with more than 100 employees in the industries studied. Based on the NIOSH study, it is reasonable to conclude that 26 percent of the firms with more than 100 employees already have monitoring programs. Thus, the new annual cost of this monitoring provision falls to about \$73,731,000 for the 19 SIC sectors (See Appendix B in OSHA's Final Regulatory Analysis for a detailed example of the computational procedure).

Even more important, however, is the implausibility of the assumption that every single establishment in the industries studied would have workers exposed to a TWA of 85 dB or greater. The only large-scale survey that presents estimates of the number of plants with noise levels above 85 dB is the National Occupational Hazard Survey (NOHS) prepared by the NIOSH (Ex. 321-14D). The Center of Policy Alternatives (CPA), Massachusetts Institute of Technology, presented a preliminary summary of these data, stating that "NIOSH has collected extensive data on noise exposures in workplaces representative of American industry . . ." (Ex. 138A, p. 2-6). Since NIOSH directed its staff to note "Any continuous noise in worker's normal environment equal to or exceeding 85 dBA . . . regardless of exposure

duration. . . ." (NOHS, vol. 1, p. 15), it is clear that these estimates of the number of noisy firms would exceed projections made on a TWA basis. Table 12 displays the results of this survey, which indicate that only about 49 percent of the plants in the studied industries have workers exposed to noise levels of 85 dB or greater as measured by NOHS. If this survey is accurate, the monitoring costs estimated above are substantially overstated.

Table 12.—Number of Plants With Continuous Noise Above 85dB in the National Occupational Hazard Survey

Industry sector	Total plants ¹	Number of plants with workers exposed to continuous noise ²	Percent of plants with continuous noise
Manufacturing.....	141,397	68,949	48.8
19.....	113	72	63.7
20.....	16,173	7,711	47.7
21.....	196	48	24.5
22.....	3,225	1,580	48.4
23.....	15,565	4,115	26.4
24.....	3,091	2,214	71.6
25.....	4,618	3,132	67.8
26.....	4,859	3,673	75.6
27.....	13,609	5,248	38.6
28.....	6,743	2,423	35.9
29.....	993	599	60.3
30.....	5,640	2,967	52.6
31.....	1,653	798	48.3
32.....	7,955	4,425	55.6
33.....	5,040	3,716	73.7
34.....	19,615	12,658	64.5
35.....	14,190	6,949	49.0
36.....	5,073	1,337	26.2
37.....	3,457	1,849	53.5
49.....			*45.8

¹NIOSH, Table, pp. 42-43.

²NIOSH, Table 49, p. 290.

*Preliminary NOHS estimate reported in Exhibit 138A, p. 2-8.

Source: National Institute of Occupational Safety and Health, *National Occupational Hazard Survey*, Vol. III (Ex. 321-14D).

Moreover, the current record does not adequately indicate the widespread current or future availability of rental markets for dosimeters or sound level meters. An informal telephone survey reveals that even the relatively more expensive dosimeters can generally be leased for under \$100 per month. On a biennial basis this is less than \$50 per year for most of the 311,094 establishments in the industries studied, for a total yearly equipment charge of only \$15.6 million. Alternatively, some firms will share noise monitoring meters rather than purchase them. Thus, the true new monitoring costs attributable to this hearing conservation amendment may be substantially below OSHA's \$73.7 million estimate which was based solely on data in the noise record.

BBN's economic impact analysis (Ex. 192, p. 3-9) projected annual costs of \$155.2 million for the proposed monitoring provision. This estimate overstates the cost of the final provision for several reasons. First, the BBN analysis was based on the proposed

requirement for annual monitoring, whereas the final rule will generally require only biennial monitoring. Second, BBN's methodology assumed that all industrial firms employed 50 production workers and would hire noise consultants to conduct the monitoring requirements. OSHA has determined that larger firms will find it substantially more economical to obtain noise measuring instruments and to perform the monitoring themselves. Third, BBN's estimate includes the cost of recordkeeping which OSHA treats as a separate cost category. Fourth, the BBN estimates do not reflect the current monitoring activities which are already taking place. OSHA believes that these factors taken together more than offset the price increases which may have occurred since BBN's 1976 report and consequently account for the divergent estimates.

Audiometric Testing

An analysis of the record indicates that the cost of audiometric testing will vary with the size of the establishment. Very small plants are likely to send production workers who require testing to a clinic or doctor. Somewhat larger plants will contract with audiometric testing firms for the actual exam and review. Still larger plants will find it cost effective to purchase the equipment for audiometric testing, to train the industrial nurse or safety director to give the test, and to use an outside firm of doctor to review the audiograms. The largest firms will perform the entire service in-house.

Commercial specialists who evaluate worker's hearing have submitted the following per employee costs for audiometric testing, review and reporting: \$7.50 to \$10.65 (Ex. 317); \$10.00 (Ex. 319 B-6); \$3.00 or less for more than 100 (Ex. 319 B-12); \$7.00 to \$20.00 (Ex. 319 B-5); and \$12.00 (Ex. 293). These firms generally provide this service by transporting an audiometric test booth in a mobile van directly to the commercial establishment that has contracted for the testing. Employees of the smallest firms, however, will often be sent to a clinic or doctor's office to be tested. These fees will vary greatly and some are rather high (Ex. 2C-71-3, p. 50 reported \$20). However, many clinic or physician fees should ultimately be comparable to those charged by mobile units because (1) negotiated fees are a traditional practice in industrial medicine, (2) employers of small firms may group together to gain scale economies, and (3) stationary medical facilities do not bear the substantial transportation costs borne by the operators of mobile vans. (For example,

the Washington Speech and Hearing Society currently charges \$120 plus \$10 per exam for their central mobile unit but only \$7.50 per test at their facility.)

Because the current market for audiometric services is small relative to the demand that would follow the promulgation of this regulation, it is not possible to make precise estimates of the cost to all firms that would purchase these services. However, in order to estimate the regulatory cost, it is reasonable to assume that the average firm sending workers to a clinic would lose about 2 hours in lost production time plus about \$15 per worker for test fees and travel expenses. For firms large enough to take advantage of mobile units, the estimated lost production time per worker would be about one-half hour, and the submissions cited above imply an average test fee of about \$12.00.

For large firms, in-house programs will be substantially less expensive. A comment to the Advisory Committee (Ex. 102, Sec. 9, p. 15) estimated the cost of providing audiometric testing programs for firms with 200, 300, and 500 employees at about \$6.00, \$5.00, and \$4.00 per audiogram, respectively. Numerous submissions in the record itemize the specific components of these costs. For example, audiometric test booths sell for about \$1,700 (Ex. 319 A-44; Ex. 319 A-51; Ex. 2C-71-3, p. 47), and installation could add about \$300. Audiometer price quotes average about \$500 (Ex. 319 A-51; Ex. 319 A-53; Ex. 319 A-60; Ex. 319 A-62; Ex. 319 A-66; Ex. 319 A-67) and are expected to operate for 10 years (Ex. 319 A-90; Ex. 319 A-60). The calibration procedures require a coupler which costs about \$130 (Ex. 319 A-16; Ex. 319 A-11) and a sound level meter with an octave filter set which costs about \$1,000. The operator's certification course is good for 5 years and costs \$250 plus 3 days of an employee's time (Ex. 319 B-4) which amounts to \$240 at \$10 per hour. The cost of calibrating the audiometer could be another \$100 every other year (Ex. 102, Sec. 9, p. 16). Thus, the total capital outlay is about \$4,200. Assuming that the test booths last for 20 years, the other equipment lasts for 10 years, the certification course is given every 5 years, and the interest charge is 10 percent, the total annualized cost amounts to about \$650.

Since one exam takes about 10 minutes of time (Ex. 306-J5C, p. 9; Ex. 319 B-6), approximately 48 workers can be tested by a technician earning a daily rate of about \$80. Thus, the cost to the firm of the technician's time amounts to \$1.67 per worker tested. The cost of

reviewing audiograms and reporting the findings is also dependent upon whether this service is contracted out or done in-house. Contractor fees for reviewing audiograms are reported at \$2.25, \$2.50, \$3.00, and \$4.00 per audiogram (Ex. 317; Ex. 319 B-12), whereas the in-house review by a physician or audiologist was estimated to cost only \$0.25 each (Ex. 102, sec. 9, Audiometric Testing, p. 16). Thus, using \$2.50 as a reasonable average cost to review the audiogram, a typical cost for administering the tests as well as reviewing the audiograms would amount to \$4.17 per unit (\$1.67 + \$2.50). Finally, a cost for one-half hour of lost production for each worker during the test procedure adds an additional one-half of the hourly wage per worker tested. In summary, the annual cost of the in-house audiometric program is estimated at about \$650 per establishment for equipment and certification-related charges, and about \$4.17 plus one-half of the industry hourly wage for each employee tested.

The Can Manufacturers Institute, Inc., (Ex. 2C-71-3, p. 50) stated that it would become cost-effective for a firm to develop its own audiometric testing capability when the number of audiograms it required reached about 100 per year. Dr. W. G. Thomas, (Ex. 102, sec. 9) put the break-even point between in-house and contracted audiometric testing at about 300 employees. To estimate the number of firms that would develop their own testing facilities, it is appropriate to use the Table 10 estimates of the number of production workers in the five establishment size categories for the 19 industries studied. The data in Table 10 imply that if the BBN estimate of 34.4 percent of production workers exposed to a TWA >85 dB remains constant across establishment sizes, the average number of workers per establishment in the hearing conservation program will be less than 2 employees for the smallest size category and 9, 21, 46, and 213 employees, respectively, in the larger establishment size categories.

It is likely that workers in the two smallest establishment size classes (1-19, and 20-49 employees) would travel to facilities outside the firm to take the audiometric exam. As explained above, the estimated annual cost for these establishments in each SIC sector would be the number of workers exposed to noise at or above a TWA of 85 dB $\times$ (2 hours at the industry hourly wage + \$15 per test). For workers in the third and fourth largest size categories (50-99, 100-249 employees), the best assumption is that hearing conservation firms with mobile vans will service the employees.

Since each employee would miss only about a half-hour or work time, the annual cost per industry for these intermediate-sized firms is the number of workers exposed to noise at or above a TWA of 85 dB $\times$ (.5 hours at the industry hourly wage + \$12 per test).

Most firms in the over 250 employee size group would choose in-house audiometric programs. The annual cost for these firms, as detailed above, is estimated at (\$650 $\times$ the number of establishments) + [(the number of workers exposed to a TWA of 85 dB or greater in these establishments $\times$ (\$4.17 + .5 hours at the industry hourly wage))].

The data needed to complete the above calculations include the percent of workers exposed to a TWA of >85 dB as shown in Table 11, the number of production workers and plants by establishment size in each industry as presented in Table 10, and the 1979 industry average hourly wage as reported by BLS (*Employment and Earnings*, March 1980). However, workers employed for less than 120 days with one firm are exempt from this provision. Employment data from the BLS as well as submissions to the record (Ex. 14-279; Ex. 14-512) indicate that SIC's 20 and 21 hire a substantial number of seasonal employees. In fact, the 1979 BLS average monthly employment estimate would fall by 17,100 and 1,400 in SIC's 20 and 21, respectively, if employment in each industry's 120-day peak employment period were adjusted downward to the level of the following month. The data from Table 10 were revised to reflect this exemption in order to estimate the cost of audiometric testing. Temporary workers in other industries will also take advantage of the exclusion, but the lack of appropriate data have prevented further adjustments to these calculations.

In addition to the annual audiogram, some workers will need to be retested during the year owing to threshold shifts, operator errors, or inconsistent test results. A number of workers will exhibit temporary threshold shifts if they are tested toward the end of the workday after being exposed to excessive noise. Wearing effective and properly inserted hearing protectors prior to the test would lower the incidence of temporary threshold shifts, whereas testing at the start of the day would substantially eliminate their detection. The number of permanent threshold shifts recorded will depend upon the intensity of the noise exposures, the worker turnover rates, and the effectiveness of the hearing protectors. In addition, the requirement

for a recheck is waived if the annual test is conducted after 14 hours free from workplace noise. If as many as 20 percent of the workers require rechecks, the overall cost of audiometric testing would total \$92,352,000 or about \$18 per worker tested.

This discussion has assumed that no audiometric testing is currently provided. The noise record, however, indicates that many industrial establishments already offer audiometric testing to their employees. For example, a survey by the Forging Industry Association revealed that 82 percent of the 151 member firms responding do periodic testing, (Ex. 321-25), while Table 90 of the NOHS (Ex. 321-14D) shows that in their sample, 40 percent of the manufacturing workers exposed to continuous noise above 85 dB received audiometric exams. Table 13 of this same exhibit indicates that primarily the largest-sized establishments provide this service for their workers. Still another NIOSH hearing conservation survey shows that annual and biannual audiometric tests account for about 23 percent and 13 percent, respectively, of current industry testing programs, with retesting periods in other programs ranging from 6 months to every 5 years (Ex. 321-14B, p. 30). For cost estimating purposes, it seems reasonable to assume that on average, these tests are already provided on a biennial basis to 40 percent, or on an annual basis to 20 percent of the workers in plants with more than 250 employees. Since the number of establishments providing these services is unknown, an accurate accounting of the costs already accepted by industry is not possible. Reducing only the labor-related cost of the largest firms by 20 percent to reflect current practice brings the total cost of this provision to \$87,199,000 a year (See Appendix B in OSHA's Final Regulatory Analysis for an example of the calculations). This estimate is not significantly different from BBN's 1976 estimate of 89.1 million even though BBN did not adjust their data to acknowledge current programs and simply used a \$20 per worker cost (Ex. 192, p. 3-33).

Hearing Protectors

Hearing protectors used in industry include ear muffs, disposable ear plugs, molded plugs, and custom-molded plugs. Unfortunately, there is no survey information on the percentage of workers who wear each type of protector. In hot, humid environments, workers are likely to choose plugs. It is probable that plugs will be chosen in more than a majority of instances as

they are often associated with a lesser degree of discomfort.

Substantial data on the price of ear protectors have been collected for the record. For example, disposable foam ear plugs can be purchased for \$0.15 a pair (Ex. 319 A-41) and are reusable. If employees use two pair a week, the yearly cost is \$15.00. Disposable non-foam ear plugs cost only from \$0.06 to \$0.07 a pair (Ex. 319 A-30; Ex. 319 A-37). For a new set of plugs each day, these costs would average about \$16.50 a year per employee. Molded ear plug prices are quoted at about \$1.50 (Ex. 319 A-30; Ex. 319 A-37), and would cost \$6.00 a year if workers used 4 pair per year. Custom molded plugs can be purchased in a kit that makes up to 50 pair of ear plugs at \$3.10 a pair (Ex. 319 A-35). These plugs, with minimum care, will last 2 or 3 years (Ex. 319 A-36). Ear muff prices are listed at \$9.50 (Ex. 319 A-30), \$7.60 (Ex. 319 A-31), and \$8.40 (Ex. 319 A-37). The estimated cost of about \$10 per year per employee reported by the Industrial Fasteners Institute (Tr. 1611), Bethlehem Steel Corporation (Ex. 145), and BBN (Ex. 192, p. 3-33) appear consistent with these rates. Based on a cost of \$10 per year per employee, if hearing protectors were provided to all employees exposed to noise at or above a TWA of 85 dB, the cost of this provision would be \$51,296,000.

The NIOSH NOHS survey also indicates that about 20 percent of the workers exposed to continuous noise at or above 85 dB are subject to attempts to reduce exposures (See Vol. III, Table 51). Moreover, the data in Table 90 of the NOHS study show that hearing protectors are almost always the method selected to accomplish this reduction. Since the data show that 20 percent of the workers exposed above 85 dB are provided hearing protectors, this implies that more than 20 percent of those exposed above 90 dB have them. This is because it is probable that most of the current worker use of hearing protectors takes place among workers whose exposures exceed 90 dB. However, if we assume that just 20 percent of the workers exposed to noise above a TWA of 90 dB are already supplied with hearing protectors, the total cost of this provision is \$45,534,000. This may be an overestimate of the cost to the extent that not all workers exposed between 85 and 90 dB are required to use the hearing protectors.

Training Program

The major cost elements for the training program will be the cost of the production lost while the workers are being trained, and the cost for the individuals providing the training.

Because the training session may last about an hour, the cost for production time lost while training takes place can be estimated by multiplying the industry average hourly wage times the number of workers trained. The cost for the people conducting the training will vary with the size of the establishment. The data from Tables 10 and 11 imply that establishments with under 100 employees average less than 21 workers exposed to noise at or above a TWA of 85 dB. A training program consisting of one hour per year per establishment seems appropriate for these size classes. For establishments with more than 100 employees, it is reasonable to assume that one individual could train 30 people in one session.

Consequently, the cost of training can be estimated at (the average production worker hourly wage $\times$ the number of workers exposed to noise $>$ a TWA of 85 dB) $+$ (the number of establishments with less than 100 employees $\times$ the cost of providing one hour of training) $+$ (the number of employees exposed at $>$ 85 dB in establishments larger than 100 employees divided by 30 workers per session $\times$ the cost of providing one hour of training). If we assume that the cost for the person providing the training is \$10 an hour, the cost estimating equation for each SIC is:

$$\$Tr = (W)(PW)(P) + \$10e + \$10/30(PWE)(P)$$

were:

\$Tr = the cost of training

W = the hourly production worker wage

PW = the number of production workers (Table 10)

P = the fraction of workers exposed to $>$ 85 dB (Table 11)

e = the number of establishments with less than 100 employees (Table 10)

PWE = the number of production workers in establishments with over 100 employees (Table 10)

Summing over all SIC's, the total cost of training for the 19 industry sectors is estimated at \$40,029,000. Although a number of comments described well organized training programs already in operation (Ex. 307, J2C, p. 11; Ex. 147C, p. 335; Ex. 147A, p. 6), and it is likely that many firms do some training, no estimates were available of the total number of such programs currently in existence. Therefore, the above estimate for the cost of this regulatory provision is overstated by the extent that industry already provides this instruction.

Warning Signs

The cost for noise warning signs will vary with the plant layout and the number of entrances into the noisy area. Signs are available for slightly over a

dollar (Bilsom International, Inc., Product Order Form, etc.). If, on the average, one sign accommodates ten workers and takes 15 minutes to install, the cost to a firm for placing one sign would be about \$3.50 at a \$10 hourly wage, and the total cost of the provision would be \$1,795,000. Although OSHA's calculations treat this estimate as an annual cost, it is probable that most signs will last for considerably longer than one year.

Recordkeeping

Updating records of noise exposure should take no longer than 10 minutes per worker measured. This amounts to 5 minutes per worker per year. Recordkeeping of audiograms, could also take about 5 minutes per employee per year. The cost of this lost work time would equal $1/6$ of an hour $\times$ the industry hourly wage $\times$ the number of workers exposed to noise at a TWA of $>$ 85 dB.

In addition, recordkeeping of periodic calibration of audiometers could take 20 minutes per year. If every establishment with over 250 employees in the SIC's studied maintained an audiometer, the total cost for the activity would be $2/6$ of an hour $\times$ the industry hourly wage $\times$ the number of establishments. It can reasonably be assumed that most firms that market hearing conservation services already keep these records so that their additional costs would be negligible. Thus, the total recordkeeping costs are estimated to amount to \$6,033,000.

Conclusion

Overall, the above calculations show that the annual cost of compliance with all of the provisions of this regulation would amount to about \$53 for each of the more than five million workers protected by the program. The total cost of hearing conservation programs, as measured in current dollars, is about \$270 million a year. After adjustment for some of the compliance activities already taking place, the total new costs fall to \$254 million per year.

OSHA's estimates do not appear inconsistent with industry statements. For example, testimony from the Industrial Fasteners Institute implies an annual cost of \$50 per employee (Tr. 1611, 1612), and the American Boiler Manufacturers Association commented that \$35 per production worker is a conservative estimate (Tr. 1573). Dupont stated that its comprehensive program cost the firm between \$10 and \$20 per worker per year (Ex. 306-J5c). Moreover, a study submitted by the American Textile Manufacturers Institute estimated an annual cost of \$14.16 per

employee (Ex. 275 B, Attachment I). BBN offered the only industry-wide calculation. However, as described above, their cost estimate of \$65 per worker does not reflect significant changes from the proposal to the final rule.

Table 13 displays the new compliance costs attributable to this amendment as estimated by OSHA for each industry sector. To the extent that many establishments in the industries studied are not affected by noise, or already comply with most of the requirements, or that rental equipment is easily available for monitoring purposes, actual costs would be substantially below the estimates provided.

Table 13.—Estimated New Annual Compliance Cost of Hearing Conservation Amendment

SIC	Industry	Estimated cost
20	Food	\$17,319,440
21	Tobacco	224,058
22	Textiles	17,756,670
23	Apparel	6,134,562
24	Lumber & Wood	30,864,350
25	Furniture & Fixtures	6,117,161
26	Paper	9,076,951
27	Printing & Publishing	22,264,030
28	Chemicals	10,944,270
29	Petroleum & Coal	4,454,059
30	Rubber & Plastics	6,721,314
31	Leather	909,841
32	Stone, Clay & Glass	7,348,522
33	Primary Metals	23,072,240
34	Fabricated Metals	23,505,250
35	Machinery, Except Electrical	25,519,890
36	Electrical Machinery	6,843,939
37	Transportation Equipment	12,914,530
49	Utilities	22,310,000
Total		254,321,000

Source: OSHA, Office of Regulatory Analysis.

VII. Economic Impact

Introduction

The cost of the hearing conservation amendment will generate a series of economic effects on those industries that expose their employees to significant amounts of noise. It is difficult to forecast precisely the magnitude of the specific impacts that will occur because they depend in part upon decisions by individual employers on how best to respond to the costs of the amendment. However, the economic framework within which the decisions will be made can be described, and the potential range of subsequent impacts can be identified. For example, compliance costs will exert upward pressure on the prices of the products produced in those industries. Conversely, profits and employment may decline if sales cannot be maintained at the higher price levels. However, the analysis presented below indicates that the economically adverse effects of the program will be

exceedingly small compared to each industry's ability to finance them. Moreover, it is shown that the most severe of these impacts will hardly influence the various financial indexes used to assess each industry's economic well-being.

The analysis that follows is based upon the assumption that the cost of production in each affected industry will rise by the full extent of the compliance costs as estimated in the previous section. However, even if these compliance cost estimates are approximately correct, it is probable that the accounting ledgers of the impacted industries will not reflect the full burden of these costs. In fact, studies cited in the Benefits section above support the view that the amendment may cause significant cost savings due to decreased rates of industrial accidents, absenteeism, and worker's compensation premiums. To the extent that dollar outlays for these business expenses are reduced following the implementation of the amendment, the net regulatory cost to industry will diminish. However, to demonstrate conclusively the economic feasibility of the amendment, this section does not adjust the above compliance cost estimates for these potentially important cost reductions.

Price Impact

Economic reasoning indicates that firms will attempt to pass on higher production costs by increasing the selling price of their products. If an industry faces a perfectly inelastic demand for its output, the manufacturers would shift the entire cost of complying with the amendment to their customers through a price increase without a contraction of industry sales. This market condition, however, is seldom the case. On the other hand, if the industry supply curve is perfectly elastic, product prices will rise by the full amount of the cost increase, but industry output will fall to the extent that sales are inversely related to price. Except for over very long time periods, this industry response would also be considered unusual.

In general, firms will try to pass on cost increases by raising product prices, and consumers will respond by reducing their purchases of the industry's products. Most firms, therefore, will find that they cannot quickly recoup all of their profits through price hikes, but must settle for price increases allowing less than a full cost passthrough. If firms could pass on their entire cost increase, however, the maximum expected price rise can be calculated by dividing the estimated compliance cost for each

industry by the sales of that industry, and expressing the result as a percentage. Table 14 presents the percentage price increase that would be attributable to the amendment if the entire cost is passed on solely and exclusively in the form of price increases.

Table 14.—Maximum Price Increase

[In millions of dollars]

SIC	Industry	Estimated cost of amendment	1979 total shipments	Maximum price increase (percent)
20	Food	\$17.32	\$234,828	0.0074
21	Tobacco	0.22	12,173	.0018
22	Textiles	17.76	46,992	.0376
23	Apparel	6.13	40,080	.0153
24	Lumber and wood	30.86	39,781	.0776
25	Furniture and fixtures	6.12	16,853	.0363
26	Paper	9.08	66,033	.0136
27	Printing and publishing	22.28	49,527	.0450
28	Chemicals	10.94	149,181	.0073
29	Petroleum and coal	4.45	134,041	.0033
30	Rubber and plastics	6.72	44,742	.0150
31	Leather	0.91	7,508	.0121
32	Stone, clay, glass	7.35	48,185	.0153
33	Primary metals	23.07	140,122	.0164
34	Fabricated metals	23.51	109,463	.0215
35	Machinery, except electrical	25.52	157,695	.0162
36	Electrical machinery	6.84	110,713	.0062
37	Transportation equipment	12.91	194,461	.0066
49	Utilities	22.31	117,024	.0191
Total		254.32	1,719,402	.0148

¹ Data for 1977. See U.S. Department of Commerce, Bureau of the Census, *Preliminary Report, 1977 Census of Manufactures*, Table 2, p. 4-23.

² Revenues from sales to customers for electric power and gas utilities. See U.S. Department of Commerce, *Survey of Current Business* (July 1980): S-23. This figure slightly understates total revenues for the entire SIC 49 because it does not include revenues from sanitary services.

Source: OSHA, Office of Regulatory Analysis. U.S. Department of Commerce, *Survey of Current Business* (July 1980): S-4.

The table shows that the overall impact of the proposed amendment, if all of the costs were passed on, would be to increase prices by 0.01 percent, i.e., one hundredth of a percent in the 19 industrial sectors studied. This clearly implies a negligible change to any of the nation's more aggregated price index series. While there is variation among industries, in only a few cases are the estimated price increases greater than a few hundredths of a percent. The largest increase in price, 0.078 percent, is recorded for the lumber and wood sector, an industry estimated to have over 94 percent of its production workers exposed to noise levels above 85 dB. However, even this price increase is of such a small magnitude that its effect would be hardly noticeable among all of the other cyclical factors affecting the industry product prices.

Financial Impact

The discussion above illustrates the impact on prices if the costs of the amendment were shifted entirely to industry customers through higher prices. Alternatively, the entries in Table 15 show the impact upon profits if the costs were solely and exclusively absorbed from profits. The percentage decrease in profits was calculated by dividing the cost of the amendment for each industry by its estimated 1979 profit level. Table 15 indicates that even in the highly unlikely event of no price change, overall profits would decrease by only 0.19 percent. Profits would fall by under 1 percent in all industry sectors, and in the great majority of cases, the anticipated decline is less than one-half of one percent. Moreover, to the extent that output prices rise at all, profits will fall by a smaller amount than listed. Thus, even these fractional values must be considered estimates of the maximum reduction in industry profits.

Table 15.—Maximum Profit Reduction
(In millions of dollars)

SIC	Industry	Estimated cost of amendment	1979 pre-tax profits	Profit reduction (percent)
20	Food	\$17.32	\$10,061	0.1718
21	Tobacco	0.22	2,237	.0098
22	Textiles	17.76	2,291	.7752
23	Apparel	6.13	2,033	.3015
24	Lumber and wood	30.86	*3,140	.9828
25	Furniture and fixtures	6.12	*883	.6931
26	Paper	9.08	4,614	.1966
27	Printing and publishing	22.28	6,077	.3686
28	Chemicals	10.94	13,372	.0818
29	Petroleum and coal	4.45	25,239	.0176
30	Rubber and plastics	6.72	1,929	.3484
31	Leather	0.91	647	.1406
32	Stone, clay, glass	7.35	3,650	.2014
33	Primary metals	23.07	6,215	.3712
34	Fabricated metals	23.51	6,830	.3442
35	Machinery, except electrical	25.52	15,484	.1648
36	Electrical machinery	6.84	10,884	.0628
37	Transportation equipment	12.91	6,685	.1930
49	Utilities	22.31	*7,138	.3126
	Total	254.32	131,609	.1932

¹The Quarterly Financial Report aggregates income for "Other Nondurables" (SIC's 23 and 31). The pre-tax income of \$2,660 million was allocated to the respective SIC's on the basis of the 1976 Internal Revenue Service (IRS) data. The IRS survey gives 75.84 percent of "Net income (less deficit)" to SIC 23 and 24.16 percent to SIC 31. See Internal Revenue Service, *Preliminary Report, Statistics of Income—1976, Corporation Income Tax Returns*, (Washington, D.C., 1979), p. 6.

²The Quarterly Financial Report lists income for "Other Durable Manufacturing Products" which is composed of SIC's 24, 25, and 39. The pre-tax income of \$5,934 million was also allocated on the basis of the 1976 IRS data (see ¹ above). The distribution was 52.91 percent for SIC 24, 14.88 percent for SIC 25, and 32.21 percent for SIC 39. Since 39 was not included in this study, the profits from that industry are excluded from this table.

³This amount is also based upon the 1976 IRS data (see ¹ above). The 1976 profit rate was calculated by dividing Net Income (less deficit) by total receipts. This profit rate, 6.1

percent, was then multiplied by the total 1979 revenues presented in Table 14.

Source: OSHA, Office of Regulatory Analysis, U.S. Federal Trade Commission, *Quarterly Financial Report, First Quarter 1980*, pp. 19-53.

The ability of the affected industries to raise sufficient compliance funds through normal commercial channels is another relevant consideration. Table 16 presents several financial indicators for U.S. manufacturing industries as presented in the *Quarterly Financial Reports* published by the U.S. Federal Trade Commission. The three indicators—cash on hand, outstanding short term loans, and net working capital—have been chosen because each helps to establish the ability of an industry to finance the costs of the amendment. Comparing the magnitude of these variables to the volume of required funds indicates whether the dollar outlays would be disruptive to the traditional financial operations of the affected industries.

Table 16 shows that for the 19 industries studied, the cost of the amendment is only about 0.6 percent of current cash on hand. The table also indicates that for those industries where data are available, compliance costs average only about 0.7 percent of the short-term debt, and 0.1 percent of the net working capital. Although some industry-to-industry variation exists, none of these ratios is above 2.66 percent. This clearly demonstrates that the cost of compliance will be small relative to each industry's ability to comply with the regulation. On this basis, the record indicates that the regulatory burden would not be an undue financial hardship for each of these sectors.

Table 16.—Compliance Cost as a Percent of Selected Financial Indicators (1979)

SIC	Industry	Cost as a percent of cash on hand	Cost as a percent of short-term loans	Cost as a percent of net working capital
20	Food	0.57	0.37	0.09
21	Tobacco	.12	.10	.01
22	Textiles	2.40	2.32	.23
31	Leather	.58 ¹	.34 ¹	.06 ¹
23	Apparel	.58 ¹	.34 ¹	.06 ¹
24	Lumber and wood	2.66 ²	NA	NA
25	Furniture and fixtures	2.66 ²	NA	NA
26	Paper	.60	1.92	.12
27	Printing and publishing	1.04	2.61	.26
28	Chemicals	.33	.68	.04
29	Petroleum and coal	.08	.15	.03
30	Rubber and plastics	.99	.65	.11
32	Stone, clay, glass	.58	1.59	.11
33	Primary metals	1.04	1.13	.14
34	Fabricated metals	.99	1.04	.15
35	Machinery, except electrical	.62	.57	.08

Table 16.—Compliance Cost as a Percent of Selected Financial Indicators (1979)—Continued

SIC	Industry	Cost as a percent of cash on hand	Cost as a percent of short-term loans	Cost as a percent of net working capital
36	Electrical machinery	.18	.36	.03
37	Transportation equipment	.21	.84	.08
49	Utilities	*.66	NA	NA
	Total	.60	*.70	*.10

¹FTC reports only aggregated data for the non-durables group which consists of SIC's 23 and 31.

²FTC reports aggregated data of \$2,105 million for the Durables group consisting of SIC's 24, 25, and 39. This value was allocated according to IRS data indicating that SIC 24 had 50 percent and SIC 25 about 16 percent of the "Cash" balances reported by firms in these industries in 1975. See U.S. Department of the Treasury, Internal Revenue Service, *Source Book, Statistics of Income—1975, Corporation Income Tax Returns* (Washington, D.C., 1976), p. 52.

*"Cash" as defined by the IRS for tax purposes, and thus not strictly comparable to the FTC definition. See IRS, *Id.*, p. 52.

⁴Excludes SIC's 24, 25, and 49.

Source: OSHA, Office of Regulatory Analysis, U.S. Federal Trade Commission, *Quarterly Financial Report, First Quarter 1980*, pp. 16-53.

Other Sectors

The 19 industrial sectors for which detailed feasibility data were presented above include almost all manufacturing and utility industries. These sectors were initially selected by BBN (see their "Economic Impact Analysis of Proposed Noise Control Regulation," Ex. 192 p. 2-1) because they were believed to be the areas under OSHA's jurisdiction which were most likely to have occupational noise problems. However, industrial noise may also be found in some service-oriented industries. Nevertheless, there is no reason to believe that firms in other industries could not also provide adequate hearing conservation programs for the estimated average cost of \$53 per exposed worker. Therefore, there is no reason to expect other major adverse economic impacts.

In addition, the industries covered by OSHA's vertical standards for the maritime industries may also be affected by this hearing conservation amendment. These industries include shipbuilding, ship repair, shipbreaking, and longshoring. Shipbuilding and ship repair are included in SIC 37 (Transportation Equipment) for which cost estimates were presented above. Shipbreaking (or the disassembly of ships) and longshoring are included in SIC 44 (Water Transportation) which was not among the 19 two-digit SIC's studied by OSHA. According to the Bureau of Labor Statistics, in 1979, there were 225,300 total employees in SIC 44.¹ Using the \$53 per worker cost, even if all of these employees are exposed to noise

¹U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, 27 (March 1980): 63.

levels ≥ 85 dB (TWA), the total cost of the hearing conservation amendment for this industry would be \$11.9 million. Since this amounts to less than 0.2 percent of total business receipts and only 2.1 percent of net income,* it is clear that the hearing conservation amendment would have a minor economic impact on this industry. Moreover, this estimated cost and economic impact are substantially overstated because the total employment figure used includes white collar workers as well as those production workers who are exposed to noise levels below 85 dB (TWA). Since, for the most part, the number of workers exposed to severe noise in the nonmanufacturing sectors is small compared to the number in heavy manufacturing, it is even less probable that compliance costs in these industries would be the cause of major economic disruption.

Small business

OSHA has always attempted to minimize the regulatory burden on small business as long as it would not jeopardize worker safety and health. To conform with this practice, as well as to comply with the spirit of the Regulatory Flexibility Act, the Agency has made a concerted effort to analyze the special problems that small business might face in complying with this amendment. (The requirement for a Regulatory Flexibility Analysis applies only to proposed regulations issued after January 1, 1981, not to final regulations issued after that date.) Where possible, the proposed regulation was modified to ameliorate potential hardships. For example, the requirement for monitoring may affect smaller businesses disproportionately because they will often rely on consultants, whereas it is easier for larger firms to develop an in-house monitoring capability. After analyzing the record, OSHA drafted the present provision to allow the obligation to recur every other year in most situations, rather than at least annually as was originally proposed. Also, the proposal required that a worker repeat the audiometric exam if a significant threshold shift was detected. The final amendment deletes this requirement for workers who were tested after 14 hours away from workplace noise. Although it may not be practicable for large firms to schedule morning tests for all of their exposed workers, small businesses

should be able to take full advantage of this exemption.

Despite these efforts, small business firms may find compliance more of a burden than large firms. Table 10 in the Cost of Compliance section shows that there are only 1-19 employees in almost two-thirds of the 311,094 establishments in those industries primarily affected by noise. The table implies that a firm classified in this size group hires an average of five production workers. Based on the BBN exposure data (see Table 11) an average of 34.4 percent, or only about 2 workers, would be exposed to noise at or above 85 dB in these small establishments.

Small firms will often find ways to reduce monitoring costs by working together to share equipment or by renting monitoring equipment to measure noise exposures. However, following the cost estimation procedures developed above, if these firms do hire consultants to satisfy their monitoring requirements, the annual monitoring cost would average \$206 per firm. Using BLS data to calculate a weighted average hourly earnings of \$6.76 for production workers in these industries, the estimated cost of sending two workers for audiometric testing is \$68 per year. Annual costs for these small firms to provide training and hearing protectors come to about \$24 and \$20 respectively, while costs for recordkeeping and the posting of signs add \$6.00 per firm. Thus, compliance costs for establishments in the smallest size category may average about \$324 per year.

Costs of this magnitude are obviously significant to the smallest firms. However, except for the most marginal of these establishments, they are not likely to affect the economic viability of an otherwise profitable operation. Moreover, these costs may be substantially offset by the potential financial benefits of reduced worker absenteeism and workplace accidents. In addition, OSHA offers free onsite consultation in every state, funded under Section 7(c)(1) of the OSHA Act. This service is delivered by State governments or private sector contractors using trained and qualified professional staff. To the extent that these resources allow, OSHA will make a special effort to respond to requests from employers for professional advice and assistance. Also, OSHA is in the process of developing printed pamphlets that will assist employers in providing appropriate training to their workers. The availability of these additional resources should significantly enhance the ability of small business to comply

with the provisions of the hearing conservation amendment.

VIII. Resource Availability

For the compliance activities of the hearing conservation amendment to be feasible, industry must have the specialized equipment and personnel essential to an acceptable program. As documented in the following paragraphs, the noise record indicates that industry need not develop new technologies to implement hearing conservation programs since the equipment required by the new rule is already being manufactured and sold to industrial purchasers.

A substantive issue that remains to be addressed, however, is the general accessibility of the necessary human and material resources. An assessment of the present availability of equipment and personnel would be useful but it would not provide a realistic indication of the future availability of these resources following the promulgation of the amendment. In the absence of a detailed requirement for hearing conservation programs, many employers have not felt obligated to protect workers from hearing loss. As a result, there has been little incentive for manufacturers to step up the production of appropriate equipment. Similarly, the number of properly trained hearing professionals has been limited by the demand for their services. As industry begins to implement the hearing conservation activities mandated under this rule, it is anticipated that the supply of these resources would rapidly expand to satisfy the new requirements.

Monitoring

The feasibility of the monitoring provision, which requires the determination of a representative noise exposure for each worker exposed to an 8 hour TWA of 85 dB or more, depends on the availability of appropriate instrumentation for firms performing in-house monitoring or of qualified monitoring consultants for firms that choose not to obtain the necessary noise measuring equipment. Comments to the noise record indicate that currently at least 6,000 dosimeters are manufactured each year (Ex. 319 A-1; Ex. 319 A-7; Ex. 319 A-12; Ex. 319 A-20; Ex. 319 A-69; Ex. 319 A-72). Although not all of these dosimeters meet the specifications of the final rule, some appear to comply with the amendment by meeting the range and lower threshold requirements as well as the specifications of ANSI § 1.25-1978 (Ex. 319 A-8; and OSHA telephone survey to dosimeter manufacturers). Kampman (Ex. 321-32) has tested one of these instruments

* In 1974, receipts for SIC 44 totalled \$6,958,289,000 while net income was \$370,287,000. See U.S. Department of the Treasury, Internal Revenue Service, *Statistics of Income—1974, Corporation Income Tax Returns*, (Washington, D.C., 1976), p. 12.

and found that it meets a test OSHA believes to be more rigorous than the one this amendment requires. Other manufacturers should also have little difficulty building units that comply with the amendment as the technology is available to both domestic and foreign firms. In addition, there are at least 5,300 sound level meters manufactured each year that can be used to measure worker exposures (Ex. 319 A-1; Ex. 319 A-7; Ex. 319 A-12; Ex. 319 A-72).

The analysis described in the Cost of Compliance section concludes that only the larger industrial establishments are likely to purchase monitoring equipment. In the 19 industrial sectors studied, there are less than 34,000 establishments with over 100 employees (see table 10). It is not known how many of these firms already possess acceptable monitoring instruments. However, the rates of production listed above for units that will last a number of years imply that a substantial amount of equipment is already available. Further, because many of the smaller establishments will opt to rent or share equipment, each instrument will frequently be used by numerous employers.

The significant increase in the demand for monitoring instruments which will follow the implementation of the hearing conservation programs will provide a sharp stimulus to their production. Of the 12 companies currently manufacturing dosimeters, only 2 manufactured acoustical measurement equipment prior to the passage of the 1969 noise standard. Since that time, the remaining companies either expanded their product lines to include sound level meters and dosimeters or were established in response to the anticipated demand for noise measurement equipment. In similar fashion, existing manufacturers and new firms will be able to supply dosimeters and sound level meters to meet the new demand. To provide adequate time for this increased scale of production, OSHA is allowing a 2-year period before the more stringent specification requirements for dosimeters become effective.

In addition, the widespread occurrence of industrial noise has fostered the establishment of numerous acoustical consulting firms that will be available to accommodate those employers who choose to rely on specialized acoustical technicians to measure worker exposures (Ex. 319 B-8; Ex. 319 B-9; Ex. 319 B-11; Ex. 319 B-15). Audiometric testing firms also frequently offer monitoring services (Ex.

319 B-9; Ex. 319 B-12; Ex. 305; Ex. 321-7). This approach is acceptable as long as employers ensure that the consultants use qualified personnel and appropriate equipment and that they follow the requirements of the amendment. Each consulting firm can provide monitoring services to numerous industrial clients as the surveys do not always require a substantial degree of technical expertise (especially where dosimeters are used), and the smaller establishments can be surveyed in no more than one day (see Table 8). Although the record does not indicate the number of consulting firms that currently have the capability to conduct noise measurement surveys, the capacity of such firms would be expected to expand accordingly if the current supply of these services proves to be insufficient.

Audiometric Testing

The data developed in the cost of compliance section indicate that there will be about 5,126,000 workers in audiometric testing programs. The amendment requires that an otolaryngologist, an audiologist, or in their absence, a qualified physician oversee each program. In addition, the audiometric examination must be administered by one of these professionals or a certified technician trained in a course that contains material equivalent to that approved by the Council for Accreditation in Occupational Hearing Conservation, or The Guidelines of the Inter-Society Committee on Audiometric Technician Training.

In 1975, the American Speech and Hearing Association (ASHA) reported that course work in industrial hearing conservation was offered by 100 university and college programs. The ASHA estimated that there were 3,500 audiologists at that time and that this number would probably double in the next five years. (Ex. 15-30, p. 4). Indeed, by 1980, the American Speech-Language-Hearing Association (ASLHA) reported that there were currently 6,052 audiologists who are members of ASLHA, another 2,000 who are licensed, and an additional 1,600 students who were about to receive masters' or doctoral degrees (Ex. 319 B-7). Thus, within the near future, there will be about 9,652 audiologists who can supervise audiometric programs. Although it is unlikely since many firms will have a medical doctor to oversee the program, if only these audiologists supervised audiometric testing for all 5,126,000 workers, they would see an average of 531 workers each. The number of workers tested per

audiologist, therefore, is about 2 per day, which is clearly a manageable task.

In addition to audiologists, otolaryngologists and other qualified physicians can oversee audiometric testing programs. The American Council of Otolaryngology (ACO) estimated that there were almost 5,000 practicing otolaryngologists in 1973 (Ex. 321-5, p. 17). According to the ACO, by 1985 there will be a surplus of 253 otolaryngologists (Ex. 321-5, p. 94). Moreover, in 1977 there were 382,000 professionally active M.D.'s in the U.S. (Statistical Abstract of the U.S., 1979, p. 106), and a major study recently submitted to the U.S. Department of Health and Human Services concludes that the U.S. will have an oversupply of 70,000 physicians by 1990 (Report of the Graduate Medical Education National Advisory Committee, Vol. I, GMENAC Summary Report, Sept. 1980, p. 3).

Currently, the Council for Accreditation in Occupational Hearing Conservation (CAOHC) indicates that they have certified about 6,700 audiometric technicians (Ex. 319 B-4), and there are about 700 course directors approved by the CAOHC to provide training for 20-30 technicians per course. If each course director teaches only one course per year to 20 people, this represents an additional 14,000 technicians. Thus, within a year, about 21,000 technicians could be available to perform audiometric tests, which averages to about one technician per 244 workers. However, many technicians have received training and certification by institutions and professionals other than the CAOHC, and audiologists and physicians other than those certified as instructors by the CAOHC will be able to train additional technicians. Thus, the supply of technicians is likely to be even larger than the 21,000 estimated here.

As explained in the previous section on the cost of compliance, about 829,000 workers will receive audiometric tests supervised by physicians or audiologists at clinics and in private practices. The 253 excess otolaryngologists that the ACO predicted to be available in 1985, alone, could provide 1,170,000 office visits (Ex. 321-5, p. 94). Thus, there is no indication that the total supply of otolaryngologists, audiologists, and physicians could not meet this demand.

About 1,447,000 workers were estimated to receive audiometric tests from mobile vans which can travel to virtually any plant facility. At a testing rate of 48 persons per day (Ex. 319 B-8 suggests 56 per 8-hour day), the workers could be tested in 180 days by 167 mobile vans. The use of these vans is already a common practice for many hearing conservation firms. Although the

number of vans presently equipped to provide audiometric services was not submitted to the record, it is reasonable to expect that the existing audiometric firms, along with new firms entering the market will be able to supply these mobile services.

Approximately 2,850,000 workers were estimated to have their hearing tested at in-house programs in 13,285 of the largest industrial establishments. Many of these firms already offer audiometric tests to their employees. Moreover, additional audiometric technicians can be readily trained by sending employees at each facility to an appropriate institution for training. Thus, it is unlikely that these large firms will have difficulty finding appropriately qualified personnel.

In general, the trained personnel are widely disseminated throughout the nation. For example, there are about 2.1 otolaryngologists per 100,000 people in the U.S., with a range from 1.7 in the east south central region to 2.5 in the pacific region (Ex. 321-5, p. 21). By federal geographical region, the distribution of audiologists listed on the ASLHA mailing list ranges from 285 ASLHA audiologists in Region 8 to 1,188 ASLHA audiologists in Region 5. Nevertheless, one objection raised against audiometric testing was that some commercial activities, such as logging operations, would not be accessible to qualified personnel (Ex. 14-264; Ex. 14-260). However, OSHA believes the record shows that in almost all cases, the widespread availability of professional and technical personnel supplying mobile audiometric services should be adequate for even outlying industrial sites.

The major equipment required to perform audiometric examinations are audiometers and audiometric test booths. Based on 2,000 hours of use per year and a 10-minute examination period, each audiometer can potentially be used to provide 12,000 tests. If the audiometers are operated at only half this rate, it would take about 1,000 audiometers to test 5,120,000 workers. The current production of this equipment, each unit of which is expected to operate for about 10 years, is at least 5000 per year. (Ex. 319 A-51; Ex. 319 A-60; Ex. 319 A-64; Ex. 319 A-67). Moreover, all of the manufacturers who commented indicated that they could meet an increased demand, and it is likely that most of the existing audiometers currently used by industry are acceptable under the amendment.

There are three major manufacturers of audiometric test booths in the U.S. Although there is no information in the record about the number of units

produced each year, manufacturers could increase their production fairly rapidly by adding second and third shifts if the current supply proves to be inadequate to meet an increased demand. In addition, other firms could expand into this area. However, some users of audiometric test booths may have difficulty complying with the maximum octave band sound pressure levels allowed in the booth during audiometric testing. This may be particularly difficult in the 500 Hz octave band. In an effort to alleviate this difficulty, OSHA has chosen to use 27 dB as the maximum sound pressure level in the 500 Hz octave band rather than the more stringent level of 21.5 dB specified in the ANSI S3.1-1977 standard. Although there is evidence on the record that the levels specified by ANSI S3.1-1977, with the adjustment at 500 Hz, can be met during industrial audiometry (Ex. 266A, p. 73; Ex. 295), some users may have to relocate their booths to a quieter location in order to comply with this provision. Since only the largest industrial establishments will develop in-house audiometric facilities, quieter enclosed areas should be generally available. Nevertheless, barrier walls could be constructed or double-walled booths purchased where a problem persists. Since this part of the requirement does not become effective until 2 years after the effective date of the amendment, most users should have sufficient time to make the necessary adjustments.

Other Provisions

The resources required to comply with the use of hearing protectors, training, the posting of warning signs, and the keeping of records will not be difficult for companies to find. The general availability of hearing protectors is amply demonstrated by the list of 175 models of hearing protectors from 46 different manufacturers or suppliers published by NIOSH in 1975 (Ex. 321-14A). Training materials, warning signs, and record forms also can be readily purchased from many safety supply houses.

IX. Additional Matters

It has been shown that this standard will result in a significant reduction of a significant risk of hearing impairment. Indeed, even assuming full compliance with the present hearing conservation requirements set forth in § 1910.95(b)(3), the new standard is reasonably necessary and appropriate to reduce a significant risk, in that it will result in 38,000 fewer cases after 10 years, 143,000 after 30 years, and 189,000 at equilibrium. It has also been shown that

the costs of the standard, \$53 per employee covered, and the total new costs, averaging 0.0148% of sales and less than .2% of profits, are economically feasible and that the amendment is technologically feasible. Hearing impairment reduces a worker's effectiveness on the job, makes life much more difficult and when noise-induced, is essentially nonreversible and cannot be cured through use of hearing aids. OSHA has issued this standard because of these reasons and findings. Thus, in accordance with the Agency's traditional interpretation of Sections 3(8) and 6(b)(5) of the Act, and its legislative history, the Secretary is issuing this standard to reduce a significant risk of material impairment.

OSHA rejects the view that the Agency should weigh costs and benefits in issuing this standard. OSHA believes such a course would contravene its statutory mandate. We note, however, that the question of whether OSHA must balance costs and benefits is presently pending before the Supreme Court in *American Textile Mfgs. Institute, Inc. v. Marshall*, U.S. Nos 79-1429, 79-1583. If required to do so as a formal finding, OSHA would find that the prevention of a year of hearing impairment is worth many times more than the cost of this standard in preventing that impairment. Losses of workplace effectiveness, inability to hear safety warnings on the job, inability to communicate with family and friends, and inability to enjoy many of the benefits of a media oriented society are very real and very substantial losses, even if exceedingly difficult to quantify in dollars. The basis for this alternative cost-benefit finding are contained in the Final Regulatory Analysis (Section VII) which contains several evaluations of the comparison between costs and benefits. That discussion is incorporated here by reference. However, we briefly summarize it below.

Some of the financial savings created by this amendment, such as reductions in absenteeism and worker's compensation payments have been estimated above. However, the value of preventing the serious hardship of hearing impairment, though large, cannot be quantified in dollars.

The data available in the noise record are much more extensive than can normally be expected to be available in the health area. It is possible to make a reasonable estimate that hearing conservation programs over the next 70 years will prevent 43.3 million person-years of hearing impairment at a cost of \$436 per year of hearing impairment

prevented (discounting neither costs nor benefits).

OSHA has placed a detailed numerical analysis of the benefits of the standard in the preamble because the data available permits it. But in most cases of health regulation, such detailed analysis cannot be done because data are not available. As the Supreme Court pointed out, the inability to do such detailed analysis does not inhibit the agency from issuing appropriate regulations (*I.U.D. v. API, supra*, slip. op. p. 45).

As discussed above, this standard creates massive benefits, has a low cost per employee covered and creates no feasibility problems. In fact, it would even be appropriate for health and safety regulations to be issued and fully justified by the OSH Act though the reduction in risk were much less and the economic impact greater.

X. Environmental Impact

On February 19, 1974 OSHA announced in the *Federal Register* its intention to prepare an Environmental Impact Statement assessing the impact of a standard that would be proposed for occupational noise exposure (See 39 FR 6119). Information was solicited from the public on a variety of environmentally related issues including possible environmental impacts of the recommended standard and any irreversible commitments of resources which would be involved if the standard should be implemented.

A draft Environmental Impact Statement was made available to the public on June 16, 1975 (40 FR 25525) and environmental impact was specifically an issue at the first hearing held in 1975. Approximately 29 comments were received on the environmental impact of the proposal.

A Final Environmental Impact Statement has been prepared in accordance with the Council on Environmental Quality (CEQ) Guidelines (40 CFR § 1500 et seq.) and the Department of Labor's regulations setting out procedures to be used by Department of Labor agencies to insure compliance with the National Environmental Policy Act (29 CFR Part 11). The Final Environmental Impact Statement concluded that the hearing conservation amendment will beneficially impact the workplace environment by reducing both the incidence and the degree of hearing loss among workers. The incidence of other adverse health effects associated with noise exposure may also be reduced. In addition, the environment outside the workplace should not be significantly affected.

The Final Environmental Impact Statement discussed a number of alternatives including:

- (1) Revision of the permissible exposure level for noise.
- (2) Initiation of a hearing conservation program at 85 dB.
- (3) Initiation of a hearing conservation program at 80 dB, and 90 dB.
- (4) Revision of the monitoring, testing, and training provisions in the proposal.
- (5) No regulatory action.

The alternative which would be the most preferable environmentally is the one which would result in the greatest reduction in hearing loss and other adverse non-auditory health effects associated with noise exposure in the workplace without resulting in any significant adverse environmental impact. Theoretically at least the most preferable alternative would have been to revise the permissible exposure level downward; this would have the effect of protecting more employees from suffering material impairments of hearing and of lessening the severity of the impairments that might be suffered anyway. At the other end of the continuum was the alternative of no regulatory action. This would result in approximately 5.4% of employees and retirees (940,000) suffering material impairments of hearing due to occupational noise exposure. The Agency felt that more information was needed before it could make a decision to reduce the permissible exposure level. The decision as to the appropriate permissible exposure level was deferred pending the acquisition and evaluation of the necessary data.

Various alternative monitoring, testing and training provisions were generally considered. Many of these were suggested by interested persons in comments and were discussed at the rulemaking hearing. For example, the appropriate frequency of monitoring and audiometric testing was the subject of somewhat varying opinions. While it is not possible to isolate the contribution of any particular element to the overall efficacy of an employee hearing conservation program, OSHA has endeavored to select a combination of provisions which together will provide adequate protection to employees while minimizing the burden on employers. The hearing conservation program prescribed in the final standard is consistent with the advice and recommendations of numerous experts in the field of hearing conservation.

Initiation of hearing conservation programs at employee exposure levels of both 90 dB and 80 dB was also considered. Initiation of a hearing conservation program at 90 dB was

rejected because it was not considered adequate to reduce the significant risk of material impairment faced by many employees at this level. Implementation of this alternative, even assuming perfect compliance, would still result in approximately 351,000 occupationally-exposed persons suffering material impairment of hearing. Initiation of a hearing conservation program for all employees exposed to 80 dB, although it would have provided a substantial reduction in the number of hearing impairments resulting from noise exposure, was deferred. Lowering the initiation level for hearing conservation programs to 80 dB would greatly increase the number of workers and establishments included in these programs. This would increase the demand for the various resources needed to implement effective hearing conservation programs including individuals trained in the evaluation of hearing and persons trained in conducting audiometric examinations, as well as increase the demand for the equipment and supplies used in such programs. The current record does not contain enough information to enable OSHA to determine if the resources available are adequate to meet this increased demand.

After considering the various alternatives the Agency decided to mandate hearing conservation programs when workers are exposed to TWAs of 85 dB. This is an environmentally pragmatic decision and should result in preventing 898,000 persons from suffering a material impairment of hearing as a result of occupational noise exposure. This represents an additional 778,000 material impairments over the estimated number of material impairments that are being prevented by hearing conservation programs currently in effect.

The alternative selected by the Agency will not eliminate all environmental harm due to occupational noise exposure since some persons will continue to suffer material impairment of hearing even after implementation of the hearing conservation program required by the amendment. However it was chosen by the Agency because it will extend the benefits of hearing conservation programs to approximately 5.1 million U.S. workers while the Agency resolves various feasibility issues surrounding the permissible exposure level and priority of various methods of compliance. By its action in promulgating the hearing conservation amendment, the Agency has taken all practicable means to minimize

environmental harm within these feasibility constraints.

This action will help to preserve the nation's human resources by protecting workers from occupational noise exposure. It has been designed to minimize the irretrievable commitments of human and physical resources needed in order to implement hearing conservation programs.

Summary and Explanation of the Standard

Exposure Monitoring

Noise monitoring is necessary for the following reasons:

(1) to identify employees who should be given audiometric tests and the other benefits of the hearing conservation program;

(2) to identify those employees for whom hearing protection is mandatory under the provisions of this amendment;

(3) to determine the amount of attenuation that hearing protectors need to provide; and

(4) to instruct both employers and employees in the degree of the noise hazard.

The monitoring requirements of this amendment are imposed pursuant to section 6(b)(7) of the Act, which mandates that standards promulgated under section 6(b) shall, where appropriate, "provide for monitoring or measuring of employee exposure at such locations and intervals, and in such a manner as may be necessary for the protection of employees." In this amendment the word "measurement" is used to mean the quantification of an employee's noise exposure. Monitoring refers to a program that includes calibration, measurement, and calculation of dose or noise exposure. Although the current standard requires noise exposures to be controlled to within specific limits, it does not explicitly require the collection of personal noise exposure data. This amendment makes monitoring requirements explicit for purposes of the hearing conservation program.

Briefly, the amendment requires employers initially to determine if any employee's exposure equals or exceeds a TWA of 85 dB. This determination must be based on the employer's good faith inquiry into any factors which would tend to indicate that noise exposures in the workplace are in the vicinity of an 8-hour TWA of 85 dB. Factors meriting a positive determination include any employee complaints about noise, any difficulties in communication at a distance of about 2 feet, or any measurements made with a sound level meter or dosimeter. If the

employer's determination indicates any employees are or may be exposed to a TWA at or above 85 dB, then employers must obtain noise exposure measurements which are representative of all such employees.

This initial determination/monitoring cycle must be repeated every 2 years. Of course, the employer may, at his own option, skip the initial determination procedure entirely, and simply measure employee exposures.

Where employees have a TWA of 85 dB or more, measurements must be made at least every 2 years. Measurements must also be taken within 60 days of any change in process, equipment, or personnel assignment which increases employee exposure to the extent that some employees may be newly exposed to a TWA of 85 dB or above, or increases exposure to the extent that any personal protective equipment being used no longer provides enough attenuation. Rather than measure every worker, in such cases, employers have the option of measuring the exposure of only one member of an employee group so long as the other members are engaged in a similar kind of work and are reasonably expected to have approximately the same noise exposure. In this case the employer must select for measurement the employee in the group whom he reasonably believes has the highest exposure. The exposure of the measured employee is then attributed to the other members of the group. Measurements of new employees must be taken (or exposures must be attributed to them) within 60 days of their exposures to a TWA of 85 dB or above. Workers must be notified of their exposures in writing within 21 days of the measurement.

Expression of Noise Exposure

In the proposal, an employee's noise exposure was expressed in terms of a fraction of allowable exposure or dose, often expressed as a percentage. Noise dose is a measure of the total noise to which an employee is exposed during a workshift. It is measured directly by a noise dosimeter or it can be computed from sound levels and the amount of time of exposure to each level. In this amendment, the concept of an "8-hour time-weighted average sound level," abbreviated TWA, is used as an alternative descriptor of noise exposure. The TWA as a single numerical value is the sound level which, if experienced continuously for an 8-hour workshift, would lead to the same noise dose as was measured or calculated, even if the duration was shorter or longer than 8-hours. Since noise exposure levels vary throughout the day in most industrial

establishments, the TWA represents the integration of these levels (according to the 5-dB exchange rate), referenced to a duration of 8 hours and an exposure level of 90 dB. OSHA believes that since TWA is an exposure level expressed in decibels, it may be more easily understood by workers, management, the public, and others who are not familiar with the field of acoustics. To summarize, for purposes of the hearing conservation amendment, a dose of 0.5, or 50 percent, is equal to a TWA of 85 dB, computed in accordance with Appendix A of the amended noise standard.⁶

Since noise dose and TWA are equivalent in that one can be calculated from the other, since there does not appear to be much possibility of confusion between the two terms, and since one or the other may be preferred under different circumstances, both terms are defined in this amendment and either may be used by employers. Table A-1 in Appendix A has been added as a convenience so that where the value of one descriptor is known, the value of the other may easily be found.

There were relatively few comments in the record that addressed the issue of whether to describe noise exposure in terms of dose or TWA. There were, however, some instances where witnesses and commenters seemed to confuse noise levels with noise exposures (for example Ex. 14-96, p. 1; Ex. 14-79 p.

(1) OSHA wishes to clarify the fact that both "dose" and "8-hour, time-weighted, average sound level" are descriptors of employee noise exposure. Noise levels are addressed by this amendment only to the extent that they are experienced by employees. Even then, it is the time integration of noise levels that is of importance.

When To Implement the Program

The hearing conservation program must be implemented when any employee's noise exposure equals or exceeds an 8-hour TWA of 85 dB,¹⁰ or when the dose equals or exceeds 50 percent (0.5). The final standard requires the initiation of a hearing conservation program at this point because as explained earlier, a substantial

⁶ Technically TWA is not a true average, either arithmetic or exponential, since it represents a theoretical value derived from an accumulated dose. To be more precise, TWA should stand for "time-weighted accumulation." However, the Agency has chosen to use the word "average" so as to be consistent with other OSHA standards, such as the asbestos standard (29 CFR 1910.1002) and the acrylonitrile standard (29 CFR 1910.1045), as well as to be more easily understood.

¹⁰ Unless otherwise noted, where the term TWA is used in the preamble an 8-hour duration is assumed.

percentage of the population whose exposures exceed this level over a working lifetime will incur noise-induced hearing loss constituting material impairment unless preventive measures are applied. This is similar to setting an "action level" of 85 dB. Setting an action level for noise monitoring at approximately one-half the permissible exposure level (PEL) is consistent with other OSHA health standards (for example the standards on Arsenic (29 CFR 1910.1018) and Acrylonitrile (29 CFR 1910.1045)). This is done primarily because of uncertainties that can affect the employer's measuring program. The employer may not be absolutely certain that the day on which he or she measures is representative of the employee's actual exposure throughout the year. Therefore, requiring noise exposure measurements and other elements of the hearing conservation program at an action level the PEL safeguards employers against exceeding the permissible level, as well as identifies the more susceptible workers so that steps may be taken to protect their hearing. Many comments in the record supported initiating noise monitoring at a TWA of 85 dB (Ex. 162, p. 48; Ex. 189-6, p. 25; Ex. 114, p. 5; Ex. 23, p. 4; Ex. 2B, p. 6; Ex. 2C-128, p. 1). In fact, many people who opposed a PEL of 85 dB supported the idea of initiating monitoring and audiometric testing at 85 dB (Ex. 114, pp. 4-5; Ex. 175, pp. 10-11).

Dose Computation

The amendment requires noise dose to be computed in accordance with Table G-16a and the formula $D=100 C/T$. In cases where the measured levels are not specified in the table, noise dose may be computed using the equation given in the footnote to Table G-16a.

The sound levels to be included in the calculation of the noise dose, whether one uses a sound level meter or a dosimeter, extend from 80 to 130 dB. A-weighted sound levels are assumed throughout the standard and preamble unless otherwise specified. The term "dBA" is not used because it is technically incorrect to do so. (It is the sound level that is weighted, not the decibel). According to acoustician Dr. Robert W. Young (Ex. 2C-121, p. 1) "The decibel is not A-weighted. The quantity . . . is A-weighted sound level (dB)."

Noise dose is relatively simple to compute when the sound level is constant throughout the workshift. The dose in percent, D, is given by $D=100 C/T$, where C is the total length of the workshift in hours and T is the reference duration corresponding to the measured sound level L, as given in Table G-16a of the amendment.

For example, consider a worker who is exposed to a continuous sound level of 96 dB for a 7-hour workshift. As specified in Table G-16a, the reference duration for 96 dB is 3.5 hours. Entering this reference duration into the previous formula: $D=100(7/3.5)=100(2)=200\%$. Two hundred percent is the dose for a 7-hour day's exposure to 96 dB.

When the employee's noise exposure level fluctuates, or consists of two or more levels, the total noise dose is computed as follows: $D=100(C_1/T_1 + C_2/T_2 + \dots + C_n/T_n)$, where C_n represents the total time of exposure at a specific level, and T_n represents the reference duration for that level given in Table G-16a or by the equation in the footnote to that table.

For example, if a worker is exposed for 5 hours to 85 dB, 2 hours to 87 dB, 15 minutes (0.25 hour) at 95 dB, and 45 minutes (0.75 hour) at 97 dB, the total noise dose would be:

$$D=100 (5/16 + 2/12.1 + .25/4 + .75/3)$$

$$D=100 (0.31 + 0.17 + 0.06 + 0.25)$$

$$D=100 (0.79)=79\%$$

The 8-hour time-weighted average sound level (TWA) can be computed from the employee's dose by use of the formula: $TWA=16.61 \log_{10} (D/100) + 90$ where the dose, D, is given in percent. Conversely, the dose may be computed from TWA using: $D=100 \times 10^{(TWA-90)/16.61}$.

Values of TWA corresponding to various doses are tabulated in Appendix A, II. For the two examples given above, the TWA for a dose of 200 percent is approximately 95 dB, and that for a dose of 79 percent is approximately 88 dB. Since Table A-2 in Appendix A does not provide values above a dose of 999 percent or above a TWA of 106.6 dB, the formula must be used to convert from dose to TWA, or from TWA to dose in cases where exposures exceed these values.

Note that TWA is the sound level that would produce a given noise dose if an employee were exposed to that sound level continuously over an 8-hour workday. This is true regardless of the length of the actual workshift. OSHA requires the initiation of monitoring at a noise dose of 0.5, or 50 percent. This corresponds to a TWA of 85 dB. It is important to understand that the exposure is to be averaged over 8 hours. Thus, if an employee only works for 5 or 6 hours, the exposure can be higher during those hours than if the employee works for 8 hours. For example, for purposes of the hearing conservation amendment a 4-hour workday at a steady sound level of 90 dB, an 8-hour workday at 85 dB, and a 12-hour workday at 82 dB all correspond to a

noise dose of 50 percent and to a TWA of 85 dB.

Table G-16a is essentially the same as the table presented in the proposal except that levels above 115 dB and below 85 dB are included so as to help clarify the fact that they are to be included in the determination of noise dose.

There are several reasons for the extension of Table G-16a. The current standard does not permit exposures above 115 dB, regardless of duration. This provision was not intended to preclude such levels, where they actually exist, from being included in the computation of an employee's actual total exposure. Indeed, it would be patently unreasonable to exclude the highest levels which are the most damaging (Kamperman, Ex. 321-32, p. 1; Ex. 321-21E, p. 5). The extension of the table above that level has been done to make explicit the requirement that, for purposes of the hearing conservation program, exposures above 115 are to be included in the dose. This is important so that where noise exposure levels exceed 115 dB, the actual exposures above that level are assessed accurately, so that employees will know that they need to select hearing protection with maximum attenuation capabilities, and to take steps to ensure that protectors are effectively fitted and worn. To avoid giving the impression that levels above 115 dB are permitted, values above that level in Table 16a have been added in italics.

Similarly, Table G-16a gives values below 85 dB so that such levels also can be included in the dose for purposes of the hearing conservation program. These values are primarily relevant for those employees with workshifts longer than 8 hours. To ensure that exposure measurements taken with a dosimeter are equivalent to those obtained using a standard sound level meter, and to those in Table G-16a, an operating range of 80 to 120 dB is required for dosimeters. The upper limit of 120 dB ensures that levels above 115 are included in the dose. The lower limit of 80 dB is consistent with accepted measuring techniques for dosimeters. It is generally accepted that the lower threshold of a dosimeter should be 5 dB below the level for which measurements are being taken. Evidence in the record supports this requirement.

Dr. George C. Maling, Jr., representing the Institute of Noise Control Engineering, commented that selection of the same level as the point at which integration (or accumulation of noise dose) begins may lead to serious measurement errors. He recommended setting the threshold 3 to 5 dB below the lowest "action point" (Ex. 14-334, p. 2).

Kenneth Eldred, as Chairman of the ANSI Sound Level Meter Standards Working Group, also supported this concept. He stated that should a sound level of 85 dB for 8 hours trigger the hearing conservation program, there might be considerable measurement error unless the threshold level of the dosimeter is required to be at a lower level, such as 80 dB (Ex. 321-19, p. 2). For example, with continuous noise levels that fluctuate between 84 dB and 86 dB, instruments with lower thresholds of 84.5 dB, 84.8 dB, or 85 dB could read anything from zero percent to more than 100 percent dose in exactly the same noise conditions. Setting the threshold well below 85 dB would prevent this confusing situation, and would ensure that the appropriate employees receive the benefits of the hearing conservation program.

There were some comments during the hearings that by initiating the hearing conservation program at a TWA of 85 dB, OSHA was, in effect, lowering the permissible exposure limit, thereby making new requirements for engineering controls (Ex. 14-341, p. 1; Ex. 14-288, p. 2). However, the Agency has made it clear throughout this preamble that the PEL remains unchanged at this time, and that an action level of 85 dB, calculated as set forth in the amendment, is an appropriate action level to trigger monitoring and other hearing conservation measures. The lower threshold of 80 dB for measurements merely facilitates the proper identification of employees to be included in the hearing conservation program, and does not change the requirements for engineering controls.

Monitoring Requirements

The proposal stated that employers have an obligation to determine if any employee is exposed to a daily noise dose of 0.5 or above (50 percent or above). The American Trucking Association (Ex. 14-878, p. 3) suggested that the proposal gave insufficient guidance on when monitoring is required. In order to ensure that monitoring will be conducted when necessary, OSHA has stated conditions upon which employers must base their determinations.

In order to comply with this amendment employers must determine whether or not they need to monitor workers' noise exposures. The initial determination is based on any information, observation, calculations, or exposure measurements that indicate exposures are or may be at or above 85 dB. This includes personal noise exposure surveys, area noise surveys,

and other information such as manufacturer's information about noise emitted from specific machines. The employer must also consider other factors which may tend to suggest noise exposures at or above a TWA of 85 dB. Such factors include employee complaints about noise, indications that employees are losing their hearing, or are finding that normal conversation between two people is very difficult when those attempting to communicate are facing each other in the work area at a distance of 2 feet (Ex. 1, Table 5; Ex. 31, Fig. 6-1). Employers shall make this determination at least every two years so as to identify any new employees in need of periodic noise monitoring.

The Agency received a number of comments favoring an initial determination as a practical approach to monitoring. Dr. Robert Benson, representing the American Iron and Steel Institute (Ex. 64-10, p. 11), stated that a preliminary screening method should be used to determine whether or not extensive measurements must be applied. S.E. Cyc for the Timken Co. (Ex. 14-978, p. 3) suggested that employers establish "noise centers" where noise samples could be made on a regular basis to see if certain areas need further investigation. The Evaporated Milk Association (Ex. 14-295, p. 2) suggested that Type III sound level meters could be used to make cursory measurements for such determinations. OSHA agrees that all of these methods could be appropriate.

John J. Ahern of General Motors Corp. (Ex. 14-883, pp. 8-9), as well as H. Grady Gatlin of the Air Transport Association (Ex. 14-860, p. 3), recommended area monitoring as a way to estimate employee exposure. Area monitoring is a good way to determine the need for further monitoring, and it is useful for planning engineering control strategies. However, since employees move around within the workplace, and since area measurements are not made at the worker's ear, area monitoring is not sufficient to describe actual worker exposures. Area monitoring would constitute compliance with the requirement for an initial determination, but not with the actual monitoring requirement.

It is intended that the initial determination direct the employer's attention to the workplace noise exposures. Because of the ubiquity of noise, it is contemplated that all employers covered by the standard will have to make initial determinations, yet only a small fraction of them will actually have to monitor their employees' noise exposures. The initial

determination is essentially a screening device which balances the need to protect employees by measuring their exposures against the undue burden on employers if the standard were to require measurement of every employee's exposure. Such a requirement would result in the monitoring of many employees who do not have significant noise exposures. The final standard does not require the initial determination to be written. While it is thought that a written initial determination might force the employer to focus more on the rationale for deciding not to monitor, it was felt that in this case imposing such a requirement would result in an extremely large amount of paperwork due to the ubiquity of noise. It should be noted, however, that initial determinations which are incorrect do not protect an employer from a citation for failure to monitor employee exposures. There is little to gain from incorrect initial determinations and it is expected that initial determinations will be carefully done.

The proposed standard required annual monitoring. However, some commenters suggested less frequent monitoring. The J.I. Case Company (Ex. 189-1, p. 3) suggested every 2 years, and John Stenmark of the American Iron and Steel Institute recommended every 3 years (Ex. 2C-126, p. 4). In the final amendment the proposed annual monitoring requirement has been relaxed to every 2 years. The Agency believes that monitoring every 2 years is sufficient, as long as additional monitoring is conducted whenever the employer has reason to believe that employees' exposures may have increased so that those not in the hearing conservation program would need to be included or that the attenuation provided by hearing protectors already in use is insufficient. Therefore the amendment requires employers to remonitor whenever there is an increase in the level or time of exposure sufficient to render an employee's hearing protectors inadequate. Monitoring more often than every 2 years will probably be unnecessary in industries where production processes change relatively little.

Some commenters opposed a requirement for periodic monitoring at all, especially in conditions where noise levels tend to be uniform over long periods of time. Groups such as the Air Transport Association (Ex. 142, p. 4-5), the American Iron and Steel Institute (Ex. 64-4, p. 3-4), and the Can Manufacturers Institute (Ex. 14-862, p.

12) believed that periodic monitoring was unnecessary unless there was a significant change in production process.

After considering these arguments OSHA has, in this amendment, required periodic monitoring for all industries, where initial determinations indicate exposures may equal or exceed a TWA of 85 dB, but has substantially reduced the frequency of the required monitoring. Periodic monitoring is necessary because noise levels tend to increase as equipment ages and wears, and in the absence of actual measurement employers are often unaware of these changes. Changes in noise level may cause workers whose exposures have been below a TWA of 85 dB to exceed that level, and therefore these workers would need the benefits of the hearing conservation program. Workers who have been exposed to a TWA between 85 and 90 dB may exceed the permissible exposure limit (PEL) and at this point the employer has an obligation to implement feasible engineering controls (or hearing protection whenever engineering controls are infeasible). Workers exposed above the PEL and whose exposures have increased may need additional hearing protection, such as an earplug with greater attenuation, or a change in type of protector. In addition, periodic monitoring is expected to serve an informational purpose since the amendment requires employers to inform employees of their exposures. Therefore workers will be reminded of the nature and extent of their exposures and will be better motivated to participate cooperatively in the hearing conservation program, and to wear properly fitted hearing protectors. (Ex. 147C, p. 335).

The monitoring procedure outlined in the final standard requires that once every 2 years the employer make an initial determination as to whether any of the employees may be exposed to a TWA of 85 dB. Even in the case of a negative initial determination, a new initial determination must be conducted every 2 years. If the initial determination is positive, then the employer must determine actual exposure through measurement.

In order to minimize the employer's burden while affording adequate protection to employees, the final amendment allows employers to measure fewer than all noise-exposed employees. The employer must select a group of employees who are engaged in a similar kind of work, and whose noise exposures are expected to be similar. The employer must then select for monitoring the worker within this group

whom he or she reasonably believes has the highest noise exposure. When this employee has been monitored, his or her noise exposure is attributed to and written on the record of each member of the group. If the employer finds that the monitored employee's noise exposure is so high that it does not accurately reflect the exposure of other members of the group the employer may, of course, divide the group into smaller subgroups and pick an employee within that subgroup to monitor. This employee's exposure may be attributed to the rest of the employees in the subgroup. Of course nothing in the amendment prevents the employer from monitoring the exposures of all employees.

The proposal required additional monitoring with 30 days of any change or modification of equipment or process, or other workplace or work practice modifications affecting the noise level. There was considerable debate about this requirement. Some companies, such as the Outboard Marine Corporation. (Ex. 14-242, p. 4), pointed out that noise levels in their facilities were constantly changing from day to day. Others agreed (Air Transport Association, Ex. 14-860, Attach 2, p. 3; National Concrete Masonry Association, Ex. 14-247, p. 4; Oklahoma General Contractors, Ex. 14-306, p. 1) and stated that remonitoring should not have to occur unless there was a "significant" or "substantial" change in exposure levels. The Can Manufacturers Institute (Ex. 14-862, p. 12) equated a "significant increase" with an increase in level of 5 dB or greater. Many witnesses supported the 30-day "grace period" in which to remonitor when a significant change had occurred (Ex. 14-287, p. 2; Ex. 14-306, p. 1), but some recommended longer periods. Bill Johnson, representing Keystone Steel and Wire (Ex. 14-232, p. 1), suggested that 30 days was insufficient due to limited personnel and time constraints. William Hughes, representing the Composite Can and Tube Institute (Ex. 14-984, p. 4), supported monitoring within 90 days of a change in process so that employers could be sure that new conditions were not temporary, and that they had stabilized.

In response to these arguments the Agency has relaxed the proposed requirements for additional measurements. OSHA agrees that it is unreasonable and unnecessary for purposes of deciding who should be included in the hearing conservation program to require employers to remonitor with any change in exposure level since work environments will often change from day to day. The Agency does not intend employers to have to

monitor workers' exposures continuously, but to monitor whenever changes in exposures are sufficiently great to require new hearing protectors or, for those employees who are not already in the hearing conservation program, to require training, audiometric testing, and the availability of hearing protectors. To minimize the need for interim monitoring, employers should take the periodic noise measurements on days when workplace conditions are noisiest, and plan the hearing conservation program accordingly. Due to potential feasibility problems, the time period for interim monitoring has been lengthened to 60 days. The Agency recognizes that employers who use consultants may have a scheduling problem and thus has provided this longer period. However, employers are urged to remonitor sooner than 60 days whenever possible, in order to minimize the time during which employees might be subjected to higher noise exposures without adequate protection.

This option of representative sampling is consistent with many comments in the record, and was generally supported by General Motors and Alcoa. Mr. Ahern of General Motors Corporation (Ex. 14-883, pp. 8-9) said that monitoring every employee was costly and unnecessary. Mr. Cyc. (Ex. 14-978, p. 3) suggested that employers could sample the noise exposures of certain groups of employees in an area and use the average of those samples. Thomas Bonney of Alcoa Corporation (Ex. 14-969, p. 2) suggested that monitoring a representative sample of employees be allowed when noise dosimeters are used. The draft California Noise Standard (Ex. 321-50A, pp. 5-6) recommended the following: "Where several employees work at the same job, the daily noise dose may be measured for a representative sample of employees and the highest noise dose thus determined shall be considered representative of all such employees in the group." OSHA believes that the provisions of the final standard are responsive to these suggestions and that a method such as this effectively reduces the monitoring burden but still provides adequate protection for employees.

The proposal did not explicitly provide how soon a new employee should be monitored. The Agency recognizes a need for such an explicit requirement so as to identify employees who need audiometric testing and ear protection. If employers wait until the regular biannual monitoring employees might not be identified for up to two years. Therefore the amendment

requires new employees to be monitored within 60 days of their first exposure to noise at or above a TWA of 85 dB.

The need for actually monitoring new employee exposures would depend upon the circumstances. If the new employee replaces an employee who did the same job, the old employee's noise exposure measurement may represent the new employee's measurement until the next biannual monitoring. If the new employee is assigned to a work activity for which employee exposure measurements have been made, that exposure would then be attributed to the new employee. If the new employee does not replace anyone, and does not become part of a group with a measured representative, the employer must do an initial determination and, where the determination is positive, must measure the exposure of the new employee. In either case the new employee must be apprised of his or her noise exposure, (which is actually the representative noise exposure) within 21 days of the determination.

Initial monitoring of all employees exposed to a TWA above 85 dB shall be completed within 180 days after the effective date of the amendment. This extra time has been provided because the Agency recognizes that a great many employees will need to be monitored. Although many employers already possess noise measuring equipment, and have an ongoing monitoring program, most of the 2 million employees exposed to TWAs between 85 and 90 dB (Ex. 192, pp. 2-7) will not have been monitored previously. Those employers who have not monitored before will need to purchase or rent equipment, or engage consultants to perform the monitoring. It is felt that this extra time, when added to the delayed effective date of the standard, will not result in an undue burden on employers or tax available equipment and services. Initially OSHA will accept previous monitoring results done within the past two years if they are done in accordance with this amendment.

Employee Notification

The hearing conservation amendment requires employers to notify workers of their noise exposure individually and in writing within 21 days of the monitoring. Each worker shall be notified of his or her own exposure, or of the exposure of the measured employee who represents the group.

The proposal required the employer to notify employees within 5 days of the time the employer discovers overexposure. Comments to the hearing record generally favored longer time periods because of administrative

difficulties (Ex. 105, p. 8; Ex. 145, Comments p. 5; Ex. 14-215, p. 3; Ex. 14-223, p. 8; Ex. 14-308, p. 4). Therefore the Agency has relaxed the requirement to 21 days from the time of monitoring. It is the Agency's belief that the additional time will minimize administrative difficulties without significantly lessening employee protection. For example, in the event that a consultant takes the measurements the longer period will allow for communications between the consultant and the employer. Also, this period should allow the employer sufficient time to include the written notice in the employee's pay envelope. Periods longer than 21 days are not satisfactory since employees need to know the nature and extent of the hazard as quickly as possible in order to carry out their responsibilities in the prevention of adverse effects. The grace period now extends from the time of the monitoring rather than the time the employer discovers "overexposure" so as to discourage long delays or lapses of communication between employers and their technical staffs or consultants.

The proposal required employees whose exposures exceeded the prescribed noise levels to be notified "of such excessive exposure." Employers were required to keep a record of each employee's noise dose, which would be accessible to the employee. The proposal did not specifically require that employers notify employees of their actual exposures, but the accessibility of the record partly fulfilled that function. The final amendment modifies this requirement in that the employer must notify each employee of his or her actual exposure, or of the exposure of the employee who is representative of his or her exposure.

The amendment clarifies the proposal's requirement for employee notification since it is important for workers to know more than merely whether or not they are overexposed. This is especially true for purposes of a hearing conservation program where much of the burden of protection falls on the employee. By informing workers of their actual exposures, employees will have a better understanding of the extent of the hazard, and in many cases will be better motivated to wear their hearing protectors effectively. A worker who is told that his or her TWA is 103 dB will have a better sense of the need for protection than will a worker who is only told that he or she is exposed above the permissible level (90 dB) or the action level (85 dB). Since the field use of hearing protectors shows significantly lower average attenuation values than laboratory tests would

indicate (Ex. 308, p. 27; Ex. 301, p. 35; Ex. 300A, p. 91), and since the worker is the only one who can know on a continuous basis whether the protector fits snugly, it is very important that the worker be properly apprised of the hazard.

Method and Accuracy of Measurement

In order to evaluate employee noise exposure accurately, OSHA has established specific requirements for instruments and techniques to be employed in measuring noise. In some instances the amendment requires that measuring instruments adhere to, and calibrations be performed according to, consensus standards developed by the American National Standards Institute (ANSI). In other instances the amendment specifies exactly the steps that employers must follow in order to meet a certain requirement. These specifications are considered necessary in order to standardize and evaluate the measurement results.

By specifying minimum requirements for noise measuring instruments the Agency believes that it will better identify those workers needing audiometric testing and will help ensure that those workers requiring hearing protectors because of a significant threshold shift will be given protectors with proper attenuation to afford them adequate protection. Other elements of the program are also dependent upon accurate noise measuring instruments, namely measurements of sound levels inside audiometric test rooms, audiometer calibration, and the calculation of hearing protector attenuation. Moreover, it should be noted that these specifications merely provide a floor, or a minimum level of compliance. Employers are always free to use instruments that are more precise or more sophisticated than the ones specified in the amendment.

The use of consensus standards, such as those of ANSI, is supported by section 6(b)(6) of the Occupational Safety and Health Act, which calls for the Secretary of Labor to explain the reasons why any rule adopted by OSHA differs from any existing national consensus standard. Although the Agency recognizes that ANSI standards are revised periodically, the amendment refers to specific standards by number and year. In the event that a referenced ANSI standard is revised, the Agency will consider proposing a revision to the noise standard whenever the Agency believes that the revision is necessary and feasible for industry.

The hearing conservation amendment permits noise exposure measurements to be made either with a noise dosimeter or a sound level meter. Sound level

meters must meet the Type 2 requirements of the American National Standard Specification for Sound Level Meters (ANSI S1.4-1971) (R1976)), and they must be set to the A-weighting network and the "slow" meter response. An appropriate sampling strategy must be used in order to measure accurately the employee noise exposure. Appendix B has been provided to advise employers of an acceptable strategy. Appendix B is intended as a guideline; reasonable alternatives that will ensure sufficient numbers of measurements for the range of sound levels encountered may also be used. All sound levels between 80 dB and 130 dB must be included, as specified in Table G-16a, in computing noise dose or TWA from measured sound levels.

The amendment also permits the use of dosimeters to measure the noise exposure of employees. The use of dosimeters is preferred in situations where there is a significant component of impulse noise, because the dosimeter can integrate all noise levels automatically, whereas individuals who use a sound level meter and a stopwatch are likely to miss certain transient sounds. Therefore, in situations where there is a significant impulse noise component, a dosimeter can be expected to result in more accurate exposure data than can be obtained using a sound level meter. It is also important to note that, in most industrial settings where the noise levels are not constant, the use of a dosimeter will be less burdensome than the use of a sound level meter. Nevertheless, employers have the option of using a sound level meter providing it is used in a manner which, like the procedures suggested in Appendix B, ensures the maximum accuracy.

Two years after the effective date of this amendment dosimeters must meet the requirements for Class 2A-90/80-5 according to the American National Standard Specifications for Personal Noise Dosimeters (ANSI S1.25-1978) (Ex. 313). "Class 2" corresponds to Type 2 tolerances of ANSI S1.4-1971 for sound level meters; "A" refers to the A-weighting network; "90" refers to the 90 dB level at which an 8-hour exposure yields 100 percent of the allowable dose; 80 refers to the lower cutoff or threshold below which the dosimeter does not respond, and "5" refers to the exchange rate between noise level and duration. Dosimeters must have an "operating range," as defined in ANSI S1.25-1978, from 80 to at least 120 dB, and in addition they must meet the requirements of section 7.5 of ANSI S1.25-1978 for a test signal at an average sound level of 90 dB, when the signal

has a "crest factor," also as defined in ANSI S1.25-1978, of 30 dB.

Crest factor is the ratio of the peak sound pressure to the average sound over a specific time period. The "crest factor capability" of an instrument indicates the maximum crest factor for which the instrument meets specified tolerances. Since section 7.5 of the ANSI standard requires a crest factor of approximately 10 dB above the upper limit of the operating range (which must be at least 120 dB), such instruments will be capable of including short-duration sounds up to 130 dB in the integration. The final standard requires that dosimeters meet an additional test beyond that required by section 7.5 of the ANSI dosimeter standard. The additional test using a signal with a 90-dB average sound level and a 30-dB crest factor has been included to ensure the proper integration of short duration sounds having peak levels that are considerably higher than the average sound level. Because not all existing dosimeters can be adjusted to meet these specifications, the requirement for a lower threshold of 80 dB and a crest factor capability of 30 dB are not mandatory for 2 years. Until that time, employers may conduct monitoring with existing dosimeters using a lower threshold setting as low as the instrument permits. In addition, during this interim period dosimeters without a crest factor capability of 30 dB may be used.

The proposal permitted the use of dosimeters with accuracy and precision equivalent to that of a sound level meter, but specific performance requirements were not given, chiefly because no performance standard existed at that time. This led the Can Manufacturers Institute to point out (Ex. 14-962, p. 13) that dosimeter performance was suspect in the absence of a performance standard.

In 1978 the Acoustical Society of America completed and published an American National Standard Specification for Personal Noise Dosimeters, ANSI S1.25-1978 (Ex. 313). The standard was submitted to the public record, and the public was invited to comment on it. There were no adverse comments on the document. The existence of this consensus standard greatly facilitates the specification of noise dosimeter performance for use in conjunction with this amendment.

Considerable general support for the use of dosimeters is found in the record (Ex. 2A, p. 252, 9-25-73; Ex. 14-969, p. 2; Ex. 14-952, p. 2; Ex. 2C-117-1, p. 4; Ex. 14-247, p. 4; Ex. 315, p. 3730; Ex. 316, 40760). Dr. Floyd Van Atta (Ex. 2A, p.

2,5-9-73) pointed out the advantages of dosimeters when sound levels vary throughout the workshift. There is also specific support in the record for incorporation of the performance requirements of ANSI S1.25-1978 (Ex. 321-15, p. 3; Ex. 321-17, pp. 1, 2; Ex. 321-19, p. 1).

The American National Standard Specification for Personal Noise Dosimeters, S1.25-1978 (Ex. 313, p. 4) in itself, does not sufficiently define dosimeter performance since several operational parameters are left for the user to define. For example, the operating range can be quite different for purposes of community noise as opposed to industrial noise measurement, (such as 40-90 dB or 80-130 dB respectively). For measurements to be made in conjunction with this amendment, a Class 2A-90/80-5 dosimeter is required; this corresponds to the accuracy requirements of a Type 2 sound level meter, and to A-weighted response, and thus is consistent with the performance requirements for a sound level meter in the proposal. Similarly, the 90-dB level for 100 percent dose and the 5-dB exchange rate are consistent with the proposal. The class designation defines tolerances, frequency weighting, criterion sound level (meaning the 100 percent dose level), threshold level, and exchange rate. It is also necessary to designate the operating range—the range between the threshold level and an upper sound level within which the dosimeter operates within stated tolerances.

Noise dosimeters designed in the past few years, and particularly those designed since S1.25-1978 became available, have an operating range that extends, at least, from 90 to 115 dB if those dosimeters were intended for monitoring compliance with 29 CFR 1910.95 (a) (Ex. 319A-8, p. 22; Ex. 319A-2, p. 2).

The proposed standard did not specify a lower threshold. However, the 80-dB requirement is included in the amendment to permit reliable measurement of noise doses down to 50 percent (a TWA of 85 dB).

There are several suggestions in the record that support upper limits for dosimeters that are well in excess of 115 dB. The draft California noise standard (Ex. 321-50A, p. 6) recommends an upper limit of at least 130 dB. Mr. Eldred, as chairman of the working group that is responsible for the ANSI standards for both sound level meters and dosimeters, suggests (Ex. 321-19, p. 3) an upper limit "in the region of 115 to 140 dB." Col. Johnson introduced (Ex. 321-21E, p. 1) a draft ANSI standard on the effect on human hearing of intense (impulse or

impact) noise, that considers average A-weighted sound levels of up to 142 dB. Kamperman (Ex. 321-32, p. 1) advocated a dynamic response from 80 dB to "greater than 140 dB and preferably greater than 150 dB."

OSHA has considered all of the factors and recommendations cited above. Because of the known adverse effects of high-level noise on human hearing, it would be very desirable to require dosimeters to integrate sound levels accurately up to 140 dB or higher. However, an informal survey of dosimeter manufacturers indicated that many of the instruments currently on the market could not easily be modified to operate accurately over a dynamic range from 80 to 140 dB. In order not to rule out the use of existing dosimeter designs, OSHA has decided to require dosimeters that meet the performance requirements of ANSI S1.25-1978 only over an operating range from 80 to 120 dB. (As discussed above, a dosimeter that accurately integrates average sound levels up to 120 dB should be able to handle peak instantaneous sound levels up to approximately 130 dB.) In the purchase of new dosimeters, employers are encouraged to consider instruments that have a larger operating range than that which is required by this amendment. OSHA intends to follow closely the availability of instruments having a larger operating range (e.g., 80 to 140 or 150 dB) and will consider amending the standard to require a larger operating range when such instruments become more readily available.

T. A. Rockwell (Ex. 321-47, p. 1) correctly pointed out that noise dose will, in some cases, be significantly higher when impulses are included in the calculation. He contrasts sound level meter measurements using the "fast" response mode with those using the "slow" response mode. By using the "fast" mode one is able to ignore the contribution of impulses and report only the level of the background noise. The hearing conservation amendment requires that noise exposures be measured with a standard sound level meter set to the slow response or a dosimeter with a crest factor capability of at least 30 dB.

¹¹ The current standard indicates that employee exposure should be measured with a standard sound level meter "at slow response." Thus the PEL under 29 CFR 1910.95(a) is, by definition, that total amount of noise that is reflected by measurement with a standard sound level meter set to the slow response. A recent revision of the Industrial Hygiene Field Operations Manual directing compliance officers to use the "fast" mode to measure noise where there is both continuous and impulse noise present is clearly at variance with the present standard and is being deleted.

Use of this instrumentation will, as Mr. Rockwell asserts, include the impulsive component of the total noise exposure in the calculation of the dose. This result is intended. As stated above (see discussion of impulse noise), for purposes of determining which employees should be included in the hearing conservation program it is important to consider the employees' total noise exposure: continuous, intermittent, and impulsive. The dosimeter specified in the final standard is capable of integrating impulse noise accurately into the total dose. Appendix B provides guidance to employers on an appropriate sampling strategy when using a sound level meter to measure exposure even where impulse noise is present.

John Stenmark, for the American Iron and Steel Institute (Ex. 321-15, p. 2) and Mr. Kamperman (Ex. 296, p. 1) suggested that public hearings be held to permit consideration of the exposure requirements for impulse noise. As discussed above, the final decision has not been made on the PEL, which includes the exchange rate and any specific requirements for impulse noise. Until that time, the Agency does see the necessity of including impulses in the computation of dose for purposes of the hearing conservation program.

The evidence submitted to the record supports OSHA's conviction that impulsive noise must not be ignored—that it is as harmful to hearing as continuous noise of equivalent sound energy, and that it is especially harmful when it is combined with high levels of continuous noise. Dr. Van Lee (Ex. 294, p. 1) points out that the superposition of impulsive or impact noise is very common in industrial noise environments. Dr. Lee recommends extending Table G-16 to include the computation of impulsive noise. The evidence also supports the conclusion that instrumentation that will include impulses in the noise dose is currently available. Kamperman (Ex. 321-32, p. 2) found that several units of one dosimeter model could meet a fairly rigorous test to incorporate the energy from impulses. Although he conducted the test on one model only, he stated that engineers employed by other manufacturers believed that his "dynamic response test requirement was reasonable and meaningful although they had not actually performed the test on (their) dosimeters."

In the present amendment, the total noise dose must include intermittent and impulsive contributions, as well as continuous sound levels.

Instrumentation requirements must be consistent with this intent and therefore noise dosimeters and sound level meters must be capable of handling intermittent and impulsive signals with proper accuracy. Although the scope of the American National Standard Specification for Personal Noise Dosimeters, S1.25-1978, states that this standard is not intended for use with noises that are "predominantly" impulsive, the Agency recognizes, based on its experience, that most industrial impulses are superimposed on a background of continuous noise, and therefore, would not be considered *predominantly* impulsive. However, there are many industrial situations where impulses exceed the continuous background noise by more than a few decibels. Therefore, there is a need for instrumentation with crest factor capability sufficient to measure these impulses. Since such a test is not available in ANSI S1.25-1978, this amendment includes a crest factor test that is conducted according to the method described in section 7.5 of the ANSI standard. This test is necessary to ensure that dosimeters used to measure employee exposure meet the needs of the standard.

Section 7.5 of ANSI S1.25 requires that the dosimeter respond with an accuracy of ± 1.5 dB to a tone burst having a crest factor of approximately 3 (which, being a ratio, translates to approximately 10 dB). For a dosimeter with an operating range of 80 to 120 dB, this test signal would be applied at an average level corresponding to 85 dB and also at 119 dB. Such a test should assure that the instrument functions properly for an average sound level of 85 dB with instantaneous peak levels up to 95 dB and for an average level of 119 dB with peaks up to 129 dB. For many instrument designs, these tests would assure proper operation for an average level of 85 dB with peak levels up to 129 dB, thus yielding reliable readings for continuous sound levels with high crest factors due to impulsive content. However, some dosimeter designs could result in an instrument that could not record a rapidly increasing sound level (such as that commonly associated with impulse noise), thus resulting in erroneously low dose readings, or an instrument that could not record the rapid decrease in sound level after an impulsive event and therefore would yield erroneously high doses. To preclude such possibilities, OSHA has added an additional test using a test method from the ANSI standard. The Agency is requiring a dosimeter that is capable of performing the function required by the standard:

namely, the integration of sound levels from 80 to 130 dB. Thus, the amendment requires that the test included in Section 7.5 of S1.25-1978 also be carried out with a signal corresponding to an average sound level of 90 dB but having a crest factor of 30 (approximately 30 dB). The instrument reading must be correct to within ± 1.5 dB, which is the tolerance stated by the ANSI standard. OSHA anticipates that most instrument manufacturers will conduct the test and specify in their brochures whether the instrument meets it. According to Kamperman (Ex. 321-32, p. 2) there is currently available at least one dosimeter that meets a similar test which OSHA believes is more stringent than the test which is being required herein.

Although there are some instruments currently available that meet the new provisions, (e.g. Ex. 319A-8, p. 22), there are others where adjustments would have to be made, and still others that would not be usable for compliance with this amendment after the end of the 2-year period. OSHA advises employers who already own noise dosimeters to consult the specifications and, if necessary, the distributor or manufacturer, to learn the extent to which their dosimeter complies with the new regulations. The amendment allows employers up to 2 years in which to check their existing instruments, have them adjusted if appropriate, or obtain new ones. The Agency has provided this 2-year grace period also for the sake of manufacturers, who may need to alter the design of their instrument and manufacture new models.

There were some comments in the record that questioned the accuracy and reliability of noise dosimeter measurements (Ex. 14-46, pp. 1-3; Ex. 14-161, p. 3; Ex. 14-978, p. 3; Ex. 321-15, pp. 3, 4; Ex. 321-28A, section 18, pp. 1, 2). Stenmark cited a number of articles that describe in detail the problems of erroneous results from noise exposure evaluations using personal dosimeters (Ex. 321-15, pp. 3, 4). However, all but one of these articles were published before 1978, the date of the ANSI dosimeter standard. In fact, two of the authors cited were members of the ANSI work group that drafted the dosimeter standard. The introduction to ANSI S1.25 states that the standard should "help minimize variations between results obtained with various makes and models . . . (of dosimeters)" (Ex. 313, p. 1). Moreover, the employer has the option of using sound level meters to measure employee noise exposure, although, where noise levels fluctuate, they are admittedly more difficult to use.

In addition, NIOSH made a strong case for the use of dosimeters, which will be discussed below.

OSHA believes that some of the problems experienced in the past may have been due to the fact that different models of dosimeters had slightly different lower thresholds, crest factors, and ranges. The Agency has determined that OSHA's new requirements for the 80-dB lower threshold and the 30-dB crest factor capability should minimize discrepancies among these instruments.

The DuPont Company expressed a number of concerns about the use of dosimeters (Ex. 321-28A, Section 18, pp. 1, 2). Among their concerns was the fact that dosimeters are not identical to sound level meters in such respects as meter ballistics, microphonics, and system diffraction characteristics. Naturally the two instruments are different in some ways because the dosimeter carries out a function automatically that must be done by the measurer when a sound level meter is used. Also the dosimeter is worn on the body of the individual whose exposure is to be measured, whereas the sound level meter is carried by the measurer. Therefore, the measurement locations would be slightly different with respect to the sound source. OSHA does not believe that these kinds of differences should cause significant differences in measurement results, so long as measurements with each instrument are taken properly.

DuPont was also concerned (Ex. 321-28A, Section 18, p. 1) that none of the existing hearing loss criteria are based on studies correlating dosimeter measurements with audiometric test results. Only sound level meters were used. OSHA believes that this fact should not detract from the use of dosimeters for compliance purposes since dosimeters and sound level meters are expected to produce the same results when properly used. Moreover, record evidence indicates that the company already uses dosimeters as part of their hearing conservation program (Ex. 306, Section J2B, p. 4). The company manufactures and sells dosimeters as well, claiming that their product "is designed to accurately measure and record personal noise exposure . . ." (Ex. 319, A-21, cover).

Many of the concerns about the use of dosimeters have been addressed by NIOSH in its "Findings of Fact on Use of Noise Dosimeters" (43 FR 3729 (1978)) (Ex. 315). NIOSH supported the use of dosimeters for making noise exposure measurements in coal mines. On the basis of evidence presented at its hearing, and on other available information, NIOSH made certain

significant findings, which are summarized below:

1. Field and laboratory comparisons of personal noise dosimeters with other noise survey instruments or systems meeting ANSI S1.4-1971 tolerances for Type I or Type II instruments, indicate that noise dosimeters will yield comparable results to these other noise measurement instruments.

2. Inadvertent and extraneous noise may be integrated by personal noise dosimeters, thus, affecting dosimeter readings; however, this problem can be minimized by spot checking of noise levels with sound level meters, or by full-shift observation of the measurement by a "qualified" person.

3. Instrument errors (including calibrator error) are less than 1 dB, and these errors combined with other possible errors associated with microphone placement and calibration drift will be within the ± 2 dBA tolerance permitted by the Mining Enforcement and Safety Administration for purposes of citing noise violations (Ex. 315, pp. 3730, 3731).

OSHA recognizes that some people will prefer to use a sound level meter and a timing device, rather than a noise dosimeter, to determine employee noise dose. For continuous sound levels and relatively immobile workers, this is an acceptable procedure. Hess, Reed, Jensen, and Jokel (Ex. 303, p. 717) report that careful sampling techniques used in conjunction with a sound level meter can yield noise exposure data with an accuracy that approaches that of a dosimeter. However, such techniques, which involve following a worker around with a sound level meter held near his ear, taking many measurements, and making involved calculations, may necessitate expertise and time that many employers will not want to provide.

If a sound level meter is used, an appropriate sampling strategy must be used in order to determine the noise dose with adequate accuracy (Ex. 303, pp. 718-719). Appendix B has been provided to advise employers of an acceptable strategy. Since Appendix B is intended as a guideline, reasonable alternatives may be used. The number of necessary measurements will depend primarily upon the range of sound levels. In most circumstances, the greater the range, the more measurements will be needed. It is the employer's obligation to assure that the sampling procedure is adequate. The sampling procedure detailed in Appendix B is a simplification of a procedure developed by Hess, Reed, Jensen, and Jokel (Ex. 303). Except for the inclusion of impulsive sounds, Appendix B is similar to the sound level meter measurement method found in the proposed revision to the ISO standard 1999 (Ex. 321-43, pp. 11-20).

It has been stated (Ex. 321-47, pp. 1-2) that in certain conditions a noise dosimeter overestimates the noise dose relative to that which would be obtained using a sound level meter and timing device. OSHA believes that this situation should not occur for the following reasons: A dosimeter essentially consists of a sound level meter followed by a circuit that integrates the proper function of the A-weighted sound level. When only a sound level meter is used, sufficient data as to the temporal distribution of sound levels must be taken so as to enable the integration to be done numerically. Assuming that each instrument performs accurately and that the microphone positions are the same, the noise dose obtained with a dosimeter and that obtained using a sound level meter and a timing device should agree when the daily noise exposure is the result of several essentially constant sound levels, each experienced for an easily determined duration. OSHA has observed this kind of agreement in its compliance experience. In such cases, the noise dose can easily be obtained with a sound level meter using Table G-16a and the procedures given in Appendix A.1. However, if the sound level varies over a range of more than a few decibels and, particularly, if the sound level undergoes rather rapid excursions due to intermittent or impulse noises, it can be very difficult to obtain accurate noise doses using a sound level meter and a timing device. If the sound level is fluctuating more or less randomly, without sudden rapid excursions, a sampling strategy and calculation procedure such as that described in Appendix B can result in reliable determinations of noise dose.

OSHA therefore concludes that a properly calibrated dosimeter reads the correct dose but that the use of a sound level meter, for intermittent noise or noise with significant impulse content, may lead to an underestimate of the correct dose.

Microphone Placement

There are three popular methods for positioning a microphone to monitor noise:

(1) The microphone (typically on a dosimeter) is located near one of the employee's ears (on the shoulder), usually occupying that position for the entire workday.

(2) The microphone is maintained near the employee's head, with the measuring instrument (typically a sound level meter) usually held by an individual who follows the employee during a portion of the workshift.

(3) The microphone is placed at a fixed location in the workplace.

OSHA requires that the microphone be placed according to either Method 1 or Method 2. As mentioned earlier in this preamble, Method 3, area monitoring, cannot be used to determine personal exposure. While Method 3 may be useful for planning engineering control strategies, area monitoring alone is not sufficient to assess employees' personal exposure. Workers move around too much for this method to be accurate.

The use of either Method 1 or Method 2 requires consideration as to whether or not it is necessary to specify more precisely the actual microphone location and orientation. The NIOSH criteria document (Ex. 1, pp. 1-5) required measurement at the "appropriate head position," and the Advisory Committee (Ex. 2B, p. 1) required the microphone to be located at the point that most closely approximates the noise levels at the employee's head. The proposal required the noise to be measured at the employee's point of exposure. Comments in the record suggested a more specific location and microphone orientation than was stated in the proposal. One, for example (Ex. 2C-72, p. 1), wanted the microphone placed on the head using a free-field microphone and a random incidence corrector with the axis of the microphone perpendicular to the floor. Another (Ex. 14-231, p. 2) stated that the microphone should be positioned 12-18 inches from the head. The American Speech and Hearing Association (Ex. 2C-14, p. 3) recommended that a free-field microphone and random incidence corrector be used, and that the microphone be held at various angles of incidence and an average taken. Other comments called for OSHA to specify a standardized microphone position (for example, Ex. 186, p. 5).

In the noise exposure standard for surface and underground coal mines, (30 CFR Part 70 and Part 71; 43 FR 40760-40762 (1978)) (Ex. 318, p. 40761), the Department of Labor's Mine Safety and Health Administration (MSHA) requires dosimeter microphones to be positioned as follows:

For the miner whose noise exposure is under consideration, noise exposure measurements shall be made with the personal noise dosimeter microphone located at the top of the shoulder, midway between the neck and the end of the shoulder with the microphone pointing in a vertical upward direction. . . .

MSHA's standard shows a diagram to facilitate compliance with the requirement. The standard's preamble justifies the requirement by citing

studies that show the importance of exact and standardized microphone positioning for "limiting measurement errors associated with body baffle and absorption effects."

OSHA agrees that uniform placement of the dosimeter microphone is good measurement practice in order to minimize error. However, the Agency is aware that different kinds of microphones need to be placed at different angles of incidence with respect to the sound source. Also, the advent of newer, smaller microphones ($\frac{1}{2}$ inch and $\frac{1}{4}$ inch in diameter) may tend to reduce errors caused by microphone directionality, and positioning may become less critical. Miniaturization of dosimeters in the future may lead to their placement on the ear or on the top of the head (positioned on a helmet or a headband). OSHA does not want to preclude the development of more advantageous positioning techniques by requiring microphone placement only on the shoulder. However, the Agency does recognize the need for uniformity of placement of most 1-inch microphones. Therefore, unless the dosimeter manufacturer specifies otherwise, the Agency strongly recommends positioning the 1-inch microphone midway between the neck and the end of the shoulder with the microphone pointing vertically upward, as required by MSHA. In order to retain some flexibility to respond to technological advances, the amendment only requires the dosimeter microphone to be placed somewhere on the employee's shoulder or head.

In addition, because of the diversity of working situations, OSHA has decided not to specify an exact location for the microphone of the sound level meter. Instead the amendment only requires employers to position the sound level meter microphone not less than 2 inches nor more than 2 feet from the worker's ear. Care must be taken to be close enough so that the measurements are representative of what the worker actually hears, but not so close that the body acts as a baffle or a reflector. Again, OSHA advises the employer to follow the manufacturer's instructions concerning the microphone's angle of incidence with respect to the sound source.

There was some discussion in the record as to whether measurements should be made with or without the worker present. The Institute of Noise Control Engineering (Ex. 14-334, p. 2) stated that the measurements should be made without the worker. The proposal was unclear on this point but could be

interpreted to mean either with or without the worker present.

Whenever an object (a worker) is placed in a sound field, it distorts the field to some extent and the measured sound level will be different from that which would be measured if the object were not there. Measuring the noise in the worker's absence may be preferred for the development of engineering solutions to the noise problem of a particular machine. However, since actual exposure takes place in the worker's presence, OSHA requires measuring the noise in the presence of the worker for purposes of the hearing conservation amendment.

Calibration

To check the calibration of a sound level meter or noise dosimeter an acoustical calibrator, of known frequency and sound pressure level output, is connected to the sound measuring instrument, and a test is made at least at a single frequency and sound level. The appropriate controls, such as amplifier gain, on the instrument are then adjusted, if necessary, so that the instrument reads correctly, within certain tolerances, for that test signal. This procedure is often called "field calibration."

The proposal required such calibration before and after each day's use. Also, the MSHA amendments to 30 CFR Part 70 state that dosimeters "shall be acoustically calibrated in accordance with the manufacturer's instructions before and after each shift on which the meter is used" (Ex. 316, p. 40761). There was some discussion in the record of the proposal's requirement for daily field calibration.

Some commentators, such as the International Paper Company (Ex. 14-345, p. 2) and the California Manufacturers Association (Ex. 14-169, p. 2) believed that daily field calibration would take too long. Others such as Clayton Ruyle of Aerospace Industries Association of America, (Ex. 105A, p. 7) said that it was impractical to calibrate a dosimeter before and after daily use. However, OSHA's requirement was supported in comments by Dr. Bruce Karrh on behalf of the American Occupational Medicine Association (Ex. 321-34A, p. 1), and the Motor Vehicle Manufacturers Association (Ex. 2C-1, p. 6). Washington Occupational Health Associates, Inc. (Ex. 321-49, p. 1) stated: "We encourage the application of uniform calibration procedures which will work to the advantage of all parties involved." It has been the experience of OSHA personnel that field calibration of a sound level meter can be done in a

matter of seconds, and that a dosimeter can be calibrated in a few minutes.

The Agency has determined that the advantages of daily field calibration warrant any inconvenience that might be experienced. Such calibrations are necessary to assure any degree of accuracy or uniformity in employee noise exposure measurements, which are a crucial and integral part of the entire hearing conservation program. Therefore, the amendment requires that an acoustical calibrator shall be used to verify the calibration of all equipment used to measure employee noise exposure prior to and after each day's measurements. In establishing this requirement OSHA believes that:

1. the accuracy of the instrument will be less subject to question when it is field calibrated at least before and after each day's measurement;
2. if meter/dosimeter performance does drift over the time between field calibrations, only one day's data will be lost;
3. it is good acoustical practice to check instrument performance as often as practical.

Although the amendment does not require calibration *immediately* prior to and following each day's use, it is good measurement practice to calibrate as close as possible to the time of instrument use.

In the broadest technical sense, the "calibration" of noise-measuring equipment involves precise evaluation of instrument performance relative to the specified ideal performance. Such calibration is a complex procedure that should be carried out in a sophisticated laboratory with specialized facilities by skilled people knowledgeable in acoustics and electronics. The amendment requires that instruments used to measure employee noise exposure—the noise dosimeter and the sound level meter—conform to ANSI S1.25-1978 for noise dosimeters, or ANSI S1.4-1971 for sound level meters. In order to ensure that instruments continue to meet the ANSI standard, it may be necessary for them to be calibrated in a laboratory.

The amendment does not specify how often the laboratory calibration should take place. Prudent practice requires that instruments, should be kept well maintained, that the manufacturer's instructions concerning maintenance and upkeep should be carefully followed, and that instruments should be carefully tested at appropriate intervals by the manufacturer or by a qualified laboratory to ascertain that their performance meets specifications. The intervals between laboratory calibration would depend upon the

amount of usage. Based on the Agency's estimates of the frequency of monitoring according to the size and type of the company, OSHA estimates that employers will send noise measuring equipment for laboratory calibration approximately every 2 years. Instruments that are used often, or are inadvertently bumped or dropped, should be calibrated more frequently, as should instruments that require frequent and extensive adjustment as a result of the field calibration.

NIOSH presents support for this type of requirement in its "Findings of Fact on Use of Noise Dosimeters" (43 FR 3729 (1978)) (Ex. 315, p. 3730).

Most failures are attributable to microphone interferences resulting in an inability of the instrument to achieve calibration tolerances. Thus, there is a need for annual recalibration of personal noise dosimeters including as a minimum frequency response testing and visual inspection of the microphone for any foreign matter or defects.

Another Federal agency, the U.S. Department of Transportation, Federal Highway Administration, recommends that "The Equipment should be checked annually by its manufacturers or other certified laboratory to verify its accuracy." (Ex. 321-42A, p. 7).

Although the proposed standard was silent on the subject, OSHA agrees with MSHA, NIOSH, and the Department of Transportation, on the merits of periodic recalibration of noise-measuring instruments. However, the Agency does not require that these tests be conducted at any particular time interval because the appropriate intervals between calibrations are highly dependent upon instrument usage. Some businesses will use the instruments only occasionally, and store them in between uses. These instruments may maintain their calibration for longer periods of time if they are cared for according to the manufacturer's instruction.

Although the proposal required acoustical calibrations to be accurate to within plus or minus 1 dB, the amendment has not made this 1-dB precision and accuracy mandatory. However, a draft American National Standard Specification for the Performance and Use of Acoustical Calibrations has been prepared (Ex. 321-17B), and when this standard is issued, employers are encouraged to use acoustical calibrators that conform to it.

Audiometric Testing Program

Audiometric testing is an integral part of hearing conservation. Since the hearing loss process tends to occur gradually, a worker often does not realize that he or she is developing a hearing loss until quite a bit of damage

has occurred. Because noise-induced permanent threshold shift is not reversible, it is very important to identify it as early as possible in order to prevent further deterioration. If it is not identified, the hearing loss will continue and the resulting impairment will be even more debilitating. Audiometric testing, to identify employees who are losing their hearing and to try to prevent further hearing loss, is therefore necessary to reduce the risk of material impairment.

Not only does audiometric testing establish a baseline and a continuing record of hearing acuity, but it provides the employer a tool with which to educate employees about the importance of hearing conservation (Ex. 2A, p. 1-101 8-9-73). It also provides workers with information about their hearing acuity and the need for protection. A well run audiometric testing program will document the extent to which the entire hearing conservation program is effective.

In the words of Dr. John Fletcher, professor at the University of Tennessee Medical School:

Another essential in hearing conservation programs is monitoring audiograms. To restate the obvious, these are periodic hearing tests after the worker has begun work or after he has started this program. These are important because they give us some feedback about the effectiveness of the program. They are necessary, we need that effectiveness. (Tr. 210).

Dr. Norman Righthand went on to say:

The effectiveness of an industrial hearing conservation program is dependent upon proper assessment by audiometric testing. The accuracy of such testing is a function of many factors, including the training and experience of the audiometric technician, background noise levels, and the cooperation and attention of the persons being tested. Of equal importance is the state of calibration of the audiometer. (Ex. 281, attach 1, p. 1).

This amendment requires testing of employees who are exposed to an 8-hour time-weighted average sound level of 85 dB (or equivalently a dose of 50 percent) or more. Baseline audiometric tests must be administered, then retests must be performed annually. Employees who experience significant shifts of hearing thresholds with respect to the baseline test must be retested within 60 days. Baseline and retest audiograms must be preceded by at least 14 hours free from workplace noise. Follow-up procedures are required in cases where a significant threshold shift is permanent. Medical or audiological referral is required in cases where the test results are ambiguous, or where medical problems are suspected. Requirements for personnel, audiometric

testing, follow-up procedures, audiometric test rooms, test frequencies, instrument specifications and calibration are specified. These requirements are addressed in the following paragraphs.

Personnel

The hearing conservation amendment requires that certain functions be performed by a licensed or certified audiologist or otolaryngologist, or in the absence of one of these specialists, a qualified physician. This professional is responsible for administering the audiometric tests or supervising the conduct of the tests by technicians, for ensuring that the audiometer is properly calibrated and that the tests are conducted in a room that is sufficiently quiet, and for reviewing audiograms, making a determination as to whether a hearing loss is work related, and determining the need to refer employees for further evaluation. Under certain circumstances employees will need to be evaluated more thoroughly than can be done on-site. Sometimes resources may not be available through the industrial audiometric program, and employees must be sent to a physician or an audiology clinic in the community. For example, although the supervising professional may be an audiologist, he or she may determine that the employee needs an otological evaluation by a physician. On the other hand, the professional supervisor may be an otolaryngologist, who may determine that the employee needs further audiological evaluation in a facility where more sophisticated audiological equipment is available.

The proposed standard did not require that an audiologist or otolaryngologist supervise the program. A wide range of opinion about this issue was expressed. Some recommended that licensed or certified otologists or audiologists supervise audiometric testing as opposed to technicians (Ex. 14-172, p. 2; Ex. 14-68, p. 4; Ex. 14-243, p. 4; Ex. 129, p. 4; Ex. 147, p. 7; Ex. 81A, p. 9). Others who regarded audiometric testing as a medical program said that only a physician should supervise (Ex. 14-158, p. 1; Ex. 2C-113, p. 1; Ex. 2A, p. 154, 5-30-73). Dr. Robert McLaughlin, of the American Speech and Hearing Association (ASHA) recommended that only audiologists supervise audiometric testing because of their extensive knowledge of audiometric testing (Ex. 2C-83, p. 3).

Either licensed or certified audiologists or otolaryngologists should supervise the audiometric testing program since these professionals are highly trained in hearing loss and are

familiar with audiometric protocol. Individuals who are knowledgeable of audiometric configurations and the associated causes, are in the best position to assess the validity of audiograms and the need for medical referral, and to assess work relatedness by interpreting the results of the audiometric test. Although other physicians also may supervise the audiometric testing, it is recommended that audiologists and otolaryngologists be used because they are likely to be more knowledgeable of audiometric procedures and the patterns of hearing loss.

The amendment requires that these individuals review the audiograms to determine the existence of threshold shifts and to determine whether the shifts are due to occupational noise exposure. Since many large companies and consulting firms may wish to computerize the audiometric test results, the supervising professional does not need to review actual audiograms, so long as a professional is involved in preparing the computer program. In this way the professional will be able to determine what kinds of audiograms need to be identified for review, and review the results on a selective basis. For example, audiograms that show large losses at 500 Hz, or audiograms where there is a substantial difference in hearing thresholds between ears may need to be reviewed, as well as audiograms that show significant threshold shift, as defined below.

OSHA advises employers to see that the audiometric testing program is well supervised by either an audiologist or otolaryngologist, although the professional does not need to be present at the time of testing. Although technicians may actually conduct the audiometric tests, they must be under the direction of the professional who is responsible for the proper conduct of the tests, and the calibration of equipment. In cases where the validity of the audiogram is in question, or when problems of a medical nature are suspected, the professional must decide whether another test, or referral is necessary. Examples of cases where medical referral would be appropriate are audiograms that show large differences in hearing thresholds between the two ears, or predominantly low-frequency hearing losses. Examples of cases where retesting would be indicated would be unusual hearing loss configurations, thresholds that are not repeatable, and invalid results on self-recording audiometers. Another good use of the audiologist, otolaryngologist, or other qualified physician supervising

the testing would be in the training and counseling of employees with significant hearing threshold shifts, because they will be able to answer employee questions.

The hearing conservation amendment requires that appropriate professionals or trained audiometric technicians administer the audiometric tests. This is similar to the proposal's requirement for certified audiometric technicians or individuals with at least equivalent training and experience. There was some discussion in the record concerning the qualifications of the person actually administering the test. Most commenters, such as Dr. McLaughlin (Ex. 129, p. 4) and others (Ex. 2C-22, p. 1 and attach., p. 2; Ex. 2C-31-1, p. 2; Ex. 2A, 157, 5-30-73, Ex. 2B, p. 6) stated that the tests should be conducted by physicians, audiologists, or trained audiometric technicians. OSHA's decision to require appropriate professionals or trained audiometric technicians to administer the tests is consistent with the proposal and the above comments. While OSHA believes that the quality of testing should be as professional as possible, the Agency recognizes that a well-trained technician can do a satisfactory job. Aside from the actual test procedures, the tester must recognize when the audiometer is not working properly and know what to do about it, and should be familiar with the proper testing conditions. The tester must be able to check the functional operation of the audiometer, although he or she is not necessarily required to perform an acoustical calibration.

Employers must be able to show that technicians are competent in the administration of hearing tests and in the care and use of audiometers. One of the best ways for technicians to achieve this competence is to successfully complete a course that is especially designed for the training and certification of audiometric technicians. Such courses usually will include sessions in the anatomy and physiology of the ear, the hearing mechanism, causes of hearing problems, different types of audiometric configurations, care and use of the audiometer, daily checking of the audiometer's functioning, administration of valid audiometric tests, selection and fitting of ear protection, and recordkeeping. These topics are covered by courses that are specified by the Council of Accreditation of Occupational Hearing Conservation (CAOHC) (1619 Chestnut Ave., Haddon Heights, N.J. 08035) (Ex. 319-B4) or the Guidelines of the Inter-Society Committee on Audiometric Technician Training, (see American

Industrial Hygiene Association Journal, Vol. 27: 303, May-June 1966) (Ex. 4, p. 37775). The Agency recognizes that more extensive training courses are available, and therefore, that the CAOHC and Inter-Society courses should be considered minimum curricula. The Agency strongly advises that technicians be given a refresher course at least every 5 years. The frequency of retraining necessary would be dependent upon the degree of supervision provided by audiologists or otolaryngologists, with technicians who are more closely supervised needing less retraining. Professionals with advanced degrees, such as audiologists and physicians, need not be certified as technicians.

The Agency advises (but does not require) that an otoscopic examination be conducted before audiometry as well as before the fitting of hearing protectors. This examination can be conducted by a professional supervisor or a trained technician. This practice, suggested by Dr. Thomas (Ex. 102 sec. 9 pp. 28-29), is helpful to ensure that the ear canal is not blocked with excessive wax which would preclude accurate results on the hearing test and accurate fitting of hearing protectors.

Employees To Be Included in the Program

All employees who are exposed to an 8-hour time-weighted average sound level of 85 dB or greater must be included in the audiometric test program, except for those who work less than 4 months (120 days) for one employer. This 120-day delay means the length of time from the start to the termination of employment; it is not variable or dependent upon duration of exposure, that is, the number of days or hours within the 4-month period actually worked. All employees who are subject to the noise standard, including those engaged in part-time work for less than 35 hours a week, as well as temporary workers who work for a given employer for more than 4 months are required to be tested if their TWAs exceed 85 dB.

There was considerable concern over the proposal's requirement to test within 90 days, which would have required the audiometric testing of all seasonal employees (the Larsen Company, Ex. 2C-8, p. 1; the Michigan Canners and Freezers Association, Ex. 14-279, p. 1; the American Frozen Food Institute, Ex. 14-512, p. 2; and other organizations (Ex. 2C-11-1, pp. 2-4; Ex. 2C-15, p. 3; Ex. 14-867, p. 2; Ex. 15-36, p. 2; Ex. 164, p. 3; Ex. 186-4, pp. 1-2)). Commenters stated that audiometric testing for seasonal employees would not be useful or protective, because these workers are

located at several job sites in a season or over the year which makes monitoring their hearing very difficult. The decision in the final amendment to allow 120 days for the baseline audiogram is in response, at least in part, to the comments and objections raised by the above groups.

The Agency believes that allowing employers 4 months in which to perform the baseline audiogram, will have the effect of excluding most temporary and seasonal employees. OSHA has allowed the 4-month period, at least in part, as an administrative convenience so that employers who use distant consulting services for audiometric testing need only schedule the mobile van three times a year or less. Also, the Agency believes that it would be fruitless to require a testing program for workers who move from job to job because follow-up testing would be difficult or impossible.

However, OSHA does not believe these workers should be unprotected merely by virtue of the relatively short tenure of their employment. Therefore, all workers exposed to a TWA of 85 dB or above must be offered a variety of personal protective equipment and encouraged to use it, and must be educated in the hazards of noise.

Audiometric Testing

Audiometric testing consists of measuring an individual's hearing level at various frequencies in both ears. An audiogram, which is a graph showing hearing sensitivity at each frequency, provides a record of the status of that individual's hearing. When new audiograms are compared to previous audiograms, a picture of an individual's hearing sensitivity over the course of years emerges. It is important that employers observe all of the standard's requirements concerning the various components of the testing program to ensure that the test results are valid and can be compared in a meaningful manner.

There are three types of audiograms. The first is the baseline against which all other audiograms will be compared. The second is the annual audiogram, which serves to identify individuals who are developing hearing loss, and to track the effectiveness of hearing protectors and other hearing conservation measures. The third is the retest audiogram, which is required when there appears to be a significant threshold shift, or if there is any doubt about the accuracy of an audiogram.

Baseline Audiograms

The baseline audiogram is extremely important since it is the reference

against which future audiograms are compared in order to determine the extent to which an employee's hearing is deteriorating. If the baseline audiometric test is not conducted properly, it will not reflect the employee's true thresholds, and any real changes between baseline and future tests may be masked. For example, if the baseline audiogram is not taken after at least 14 hours of relative quiet, it may include some temporary threshold shift (Ex. 102, sec. 9, p. 5; Tr. 2340-2341), and hearing thresholds would be somewhat inflated. Consequently, differences between the baseline and subsequent annual audiograms would appear to be less than if the baseline had been accurate. This process would mask the true amount of hearing loss. Therefore, employers must follow the requirements of the amendment to ensure the accuracy of the baseline audiogram. OSHA requires that workers must have been away from workplace noise for at least 14 hours before the baseline audiometric test is conducted so that the baseline will accurately reflect the employee's hearing thresholds.

The hearing conservation amendment requires baseline audiograms to be established for new employees within 4 months of an employee's first exposure to noise at or above a TWA of 85 dB. The proposal required baseline audiograms to be established within 90 days for all employees. NIOSH (Ex. 1, p. 1-5) and Dr. Larry Royster (Ex. 102, sec. 4, p. 12) suggested that less time be allowed before the baseline. As explained above, OSHA has chosen the 4-month grace period, which gives employers an opportunity to exclude seasonal employees. OSHA has determined that to delay audiometric testing of employees longer than 4 months, as suggested by the American Frozen Food Institute (Ex. 164, pp. 3-4) and General Foods Corporation (Ex. 2C-105, p. 2) would not be appropriate since employees might begin to incur hearing loss. To safeguard the purity of the baseline audiogram as much as possible, employers are advised to encourage all employees exposed to a TWA at or of 85 dB to wear hearing protectors until the baseline test has been performed. (All employees exposed over the PEL must already be wearing ear protectors, if engineering and administrative controls are not sufficient to reduce their exposure). Employers are encouraged to conduct pre-employment baseline audiogram where possible. Both employers as well as employees may benefit in the long run from this practice. Early testing would probably provide the employer with a more accurate

indication of the effectiveness of the hearing conservation program. Early testing also will identify, at a stage where there can be no question, individuals whose hearing losses are not attributable to noise exposures within that particular workplace.

For employees presently exposed to a TWA of 85 dB or above a baseline audiogram must be obtained within 1 year of the effective date of this amendment. The Agency has allowed this amount of time because many employers will be initiating hearing conservation programs for the first time, and will need additional time to make preparations. Employers whose audiometric testing programs already meet the requirements of this standard may use audiograms taken before the effective date of the amendment to fulfill this requirement.

There are two circumstances recognized in the amendment in which the baseline audiogram must be revised. This is a change from the proposal, which had no provision for revising the baseline. Comments submitted by Dr. Royster (Ex. 321-22D, pp. 5, 47; Ex. 321-22E, p. 40), and by R. V. Durham, director of Health and Safety for the International Brotherhood of Teamsters (Ex. 81A, p. 1), discussed cases where subsequent audiograms reveal better thresholds than the original baseline. It was suggested that this might be due to a "learning effect" where an individual becomes slightly more skillful at taking the test. Or it can be caused by a reduction in temporary threshold shift due to the beneficial effects of hearing protection. The amendment requires that when a subsequent audiogram shows improved thresholds in at least two test frequencies with respect to the baseline, this later audiogram becomes the new baseline audiogram, and subsequent audiograms must be compared to it. The Agency believes that the audiogram with improved thresholds must more closely resemble an employee's true, non-noise-exposed baseline, and that significant threshold shifts would be detected that might otherwise have been overlooked by using this audiogram from as the revised baseline. Of course the old baseline audiogram must be retained, according to the recordkeeping requirements to be discussed later in the preamble.

Where the retest or annual audiogram is considered to be free of TTS, e.g., when it is conducted after 14 hours free from noise, the audiogram may show a deterioration in thresholds with respect to the baseline due to the harmful effects of noise exposure. If the change in threshold is "significant" (as defined

in the amendment and discussed later in this section) the audiogram with the reduced thresholds shall become the baseline audiogram and subsequent audiograms will be compared to it. This provision is in response to a number of comments, which pointed out the futility of identifying the same significant threshold shift year after year, even though the hearing loss may have stabilized, an unintended result of the way the proposal was worded (Ex. 317, p. 3; Ex. 321-1, p. 2; Ex. 321-24A, p. 9; Ex. 321-38, p. 3). Revising the baseline each time a new significant threshold shift occurs should prevent this problem.

Annual Audiograms

The annual audiometric test has a number of purposes. It detects shifts in hearing level, indicates the need for followup procedures identifies employees who are particularly susceptible to noise-induced hearing loss, monitors the effectiveness of hearing protectors, and detects medical problems.

OSHA proposed that employers test their employees' hearing annually. Dr. McLaughlin (Ex. 2A, p. 1-101, 8-9-73), the Architectural Woodwork Institute (Ex. 127, p. 2), and many other organizations and witnesses supported annual testing (Ex. 2C-2, p. 2; Ex. 2C-31-1, p. 2; Ex. 81, p. 9; Ex. 14-166, p. 1; Ex. 102, sec. 4, p. 12; Ex. 29-2, p. 3; Ex. 110, p. 3; Ex. 321-50, p. 9). NIOSH (Ex. 1, p. 1-6) and some others (Ex. 130, p. 5; Tr. 2138) favored testing every 2 years since it was postulated that a period of this length is needed to identify shifts that are truly significant.

OSHA has chosen to retain the annual audiometric test requirement because of the potential seriousness of the hearing damage that can occur within a 2-year period. For employees exposed to high levels of noise, a 2-year period between audiograms might allow too much hearing loss to occur before identifying the loss and taking remedial steps. Annual audiometric tests can aid employers and workers in detecting temporary threshold shifts before they become permanent, and they can also detect minor threshold shifts before they become significant. In both cases increased awareness of the hazard reflected by the audiometric test results will lead to more prompt protective action, and as a result more hearing will be saved.

The proposal required that all audiograms be conducted after 14 hours of quiet. This provision has been modified in the final rule to allow annual audiograms to be taken anytime during the workshift. This is consistent with the recommendation of Jeffrey

Morrill, President of Impact Hearing Conservation, Inc. (Ex. 293, p. 1), and may result in increased employee protection in that audiograms taken during the workshift are likely to show TTS. Since TTS is a harbinger of permanent threshold shift (Ex. 188-27, sec. 11, attach., p. 730), it is an important symptom or warning sign, and protective measures can then be taken before the change in threshold becomes permanent. Some employers may find this procedure more convenient than testing before the beginning of the workshift. Employers are encouraged to conduct annual audiometric tests during the workshift since the early identification of TTS can result in the prevention of permanent hearing loss.

Retest Audiograms

In cases where the annual audiogram reveals a significant threshold shift, the employee must be retested within 60 days. The retest must be performed after at least 14 hours free from workplace noise. The purpose of the retest after 14 hours of relative quiet is to determine the extent to which the significant threshold shift is permanent. Hearing protection and educational steps may be taken to prevent a temporary loss from becoming permanent, and to prevent a permanent loss from progressing. Also, the Agency recommends that a medical history be taken at the time of the retest. This may be in the form of a simple questionnaire that should contain questions relevant to the employee's work and auditory history. The purpose of the history is to aid the professional reviewer in making determinations of work relatedness, and the need for medical or audiological referral.

Although NIOSH (Ex. 1, p. 1-6) had recommended a retest within 60 days, the Advisory Committee (Ex. 2B, p. 8) and the proposal required the retest within 30 days. However, OSHA received some negative comments on the 30-day retest provision. Individuals such as Dr. J. Ronald Bailey of North Carolina State University (Ex. 2C-33, p. 6) recommended a period of 60 days within which to retest employees. Companies such as the International Paper Co. (Ex. 14-344, p. 3) maintained that a 30-day retest period is impractical since it creates a hardship for employers who must rely on mobile audiometric test vans, which may not always be available. OSHA had decided that 60 days is an appropriate period within which to require retests. Professionals who must review the audiograms, might not be available within a shorter time frame; time would therefore be needed to send the audiograms to the professional, have them reviewed, and

then reschedule the mobile van for any necessary retests. While some employers may choose to send employees to a local hospital or audiology clinic instead of rescheduling a mobile van, this may not always be possible in small towns or rural locations. In any event, to provide the employer maximum flexibility, 60 days are allowed for the retest audiogram.

A retest audiogram is not required if the annual audiogram is conducted after 14 hours free from workplace noise, because recovery from TTS would have occurred and the threshold shift can be presumed to be permanent under these circumstances. Although the Agency recommends the two-stage procedure, OSHA does not require annual testing during the workshift and retest in the event of significant threshold shift in order to distinguish temporary shifts from permanent shifts, since scheduling large numbers of retests may pose a feasibility problem in some cases, and employers may choose to perform all audiometric tests before the workshift. Employers may be able to use this two stage approach by scheduling the retest for the next morning before workers are exposed to noise.

Significant Threshold Shift

A definition and an understanding of what OSHA considers to be a significant shift of hearing threshold is very important in the proper implementation of the amendment's requirements. Without such a definition workers and employers are unable to know the seriousness of the noise-induced hearing loss.

Identifying a threshold shift as significant means that it is outside the range of audiometric error (± 5 dB), and it is serious enough to warrant prompt attention because it is a precursor to material impairment of hearing. When threshold shifts are significant, employers must provide and fit hearing protection, and take other remedial actions depending upon whether or not the shift is permanent.

The definition of the term "significant" is critical to the effective operation of the hearing conservation program. If the definition is too stringent, spurious threshold shifts may occur and workers will be identified because of audiometer or technician error. If the definition is not stringent enough, workers will be allowed to lose too much hearing before protective actions are taken. Correctly identifying significant threshold shifts of hearing is particularly important for workers who have already begun to lose their hearing, so that the progression may be stopped

before the hearing loss becomes handicapping.

OSHA's proposed standard defined significant threshold shift as an average shift of more than 10 dB at the frequencies 2000, 3000, and 4000 Hz in either ear, relative to the baseline audiogram. These frequencies were selected with the understanding that hearing loss occurs earliest and most severely in the higher audiometric frequencies.

However, a number of witnesses criticized the leniency of the proposal's definition of significant threshold shift. The Environmental Protection Agency (Ex. 9, pp. 37, 41, 51; Ex. 5, p. 43802) and others (Ex. 51, pp. 10-11; Ex. 80, p. 2; Ex. 82, attach. 1, p. 2) pointed out that under certain circumstances the proposal's definition would allow shifts of up to 30 dB at single frequencies.

According to Dr. McLauchlin:

Workers should be identified when the first signs of noise induced threshold shift occur. With a more rigid criteria the risk of allowing workers to develop compensable hearing impairments is lessened. Further, a more stringent interpretation of "significant threshold shift" provides more adequate means for evaluating the performance of ear protective devices. (Ex. 129, p. 3).

Support for a more stringent definition of significant threshold shift is provided in the NIOSH Criteria Document (Ex. 1, p. 1-6), which defined it as a shift that equals or exceeds 10 dB at 500, 1000, 2000, or 3000 Hz, or 15 dB at 4000 or 6000 Hz when that audiogram is compared to the most recent age-corrected audiogram. Some commentators such as John R. Franks of the Department of Audiology and Speech Services, Purdue University (Ex. 14-68, p. 3), and Donna Dickman, director of the Industrial Hearing Conservation Program at the Washington Hearing and Speech Society (Ex. 14-320, p. 2), suggested a very stringent definition, which was a 10-dB shift at any frequency from 500 to 4000 Hz. The Armstrong Rubber Company (Ex. 14-50, p. 1), Dupont Company (Ex. 308, sec. 12C, p. 8), and others (Ex. 2B, pp. 7-8; Ex. 14-289, p. 4), suggested more stringent threshold shift criteria (10 dB) at the lower frequencies of 500, 1000 and 2000 Hz, and larger values (up to 25 dB) at the higher frequencies of 3000, 4000 and 6000 Hz.

The Agency has chosen to use the more protective approach suggested by McLauchlin, Dickman, and Franks for workers who already have a hearing loss, while allowing a less stringent criterion for those with normal hearing. Thus, the amendment's definition of significant threshold shift reflects a "sliding scale" approach, with the amount of hearing loss constituting a

significant threshold shift becoming smaller as the worker's hearing loss becomes greater. The use of a "sliding scale" for determining hearing loss was the result of suggestions to OSHA (Ex. 2B, pp. 7-8; Ex. 14-289, p. 4; Ex. 48, p. 16; Ex. 321-38, p. 2; Ex. 317, pp. 3-4) from various audiologists and others who were concerned about workers who have a pre-existing hearing loss or workers who have already demonstrated threshold shifts. Also, the Advisory Committee recognized the need for such an approach (Ex. 2B, pp. 7-8), by recommending a more stringent definition of significant threshold shift for employees whose hearing levels at any test frequency were worse than 25 dB.

Thus, the amendment requires that for employees whose hearing is within 25 dB of audiometric zero and who have not previously suffered a significant threshold shift, the significant threshold shift criterion is a fairly lenient one—a 20-dB shift at any frequency. For employees who have lost some hearing (more than 25 dB at any test frequency), the criterion is more strict—10 dB or greater at 1000 and 2000 Hz, 15 dB at 3000 and 4000 Hz, and 20 dB at 6000 Hz. For employees who already have a mild to moderate hearing loss (worse than 25 dB average at 1000, 2000, and 3000 Hz) or who have previously incurred a significant threshold shift, the criterion is a more stringent 10 dB at any test frequency.

OSHA believes that this more complex definition of significant threshold shift will be more efficient, and more protective. Identification of spurious threshold shifts would be minimized by a fairly lenient (20-dB) criterion for workers whose hearing was within normal limits. Yet workers whose hearing had begun to deteriorate, in other words, those with less hearing left to lose, would be watched more closely as a result of the stricter criteria. In these cases employers would need to take protective measures. Making the criteria more stringent for workers who have lost some hearing would minimize the possibility of allowing progressive deterioration to go unnoticed in workers who change jobs frequently and may have constantly worsening baseline audiograms against which annual audiograms are compared.

Unlike the proposal, the amendment includes 1000 Hz in the definition of significant threshold shift because of its importance in the understanding of speech, and the amendment also includes 6000 Hz in the definition because of its importance as an early indicator of noise-induced hearing loss.

The amendment addresses each frequency separately instead of averaging them so as to avoid the situation where a worker might lose up to 30 dB at one frequency before the shift is considered "significant".

Like the proposal, the final hearing conservation amendment excludes the 500 Hz frequency from the definition of significant threshold shift. OSHA agrees with certain industrial audiologists (Ex. 317, p. 4), that the 500 Hz frequency does not need to be included in the criteria for significant threshold shift because hearing at 500 Hz is the last and least affected of any of the test frequencies (500 through 6000 Hz) as a result of noise exposure. By the time the hearing level at 500 Hz has shifted, all of the higher frequencies will have been affected more severely, and the worker would have suffered considerable hearing loss. Noise-induced hearing loss at 500 Hz alone is very unlikely to occur, even in workers who are exposed to predominantly low-frequency noise.

Aging

The hearing conservation amendment permits the application of an age (presbycusis) correction to the audiometric test results in order to discount the results of aging in determining whether a significant threshold shift has occurred. When applying an age correction, the most recent audiogram is corrected according to the procedures outlined in Appendix F. In this appendix, OSHA has adopted the procedures and the age correction tables used by NIOSH in the criteria document (Ex. 1, pp. I-14 to I-17).

Although the proposal does not address the issue, the record contains a substantial number of comments recommending the use of an age correction, many of which stated that hearing loss can occur from aging, nonoccupational noise, and other factors, and such hearing loss should not be considered part of a significant threshold shift within the context of the OSHA standard (Ex. 14-110, p. 2; Ex. 14-150, p. 2; Ex. 14-160, p. 2; Ex. 14-188, p. 1; Ex. 14-200, p. 1; Ex. 14-215, p. 3; Ex. 14-248, p. 3). Lawrence Hodge of the J. I. Case Company told OSHA that an analysis of approximately 40,000 audiograms from over 10,000 employees revealed that the proposed criterion for significant threshold shift was not appropriate without addressing presbycusis. He urged OSHA to adjust audiograms accordingly (Ex. 321-24A, p. 1).

The NIOSH criteria document (Ex. 1, pp. I-14 to I-17, III-6) recommended adjusting the baseline audiogram for hearing loss that occurs naturally due to

the aging process. The adjusted baseline could then be subtracted from the most recent annual audiogram in order to determine whether or not a significant threshold shift had occurred. If employers wish to correct for aging, the amendment directs them to make the adjustment to the annual audiogram rather than to the baseline, so that the baseline will not be changed (and remain changed) by mistake. The NIOSH presbycusis values are similar to those of other well known presbycusis data bases. Although there may be slight variations at individual frequencies, the NIOSH values are generally consistent with other presbycusis data such as the U.S. Public Health Service data, and those used by Robinson and Burns, and by Passchier-Vermeer (found in "Derivation of Presbycusis and Noise Induced Permanent Threshold Shift (NIPTS) To Be Used for the Basis of a Standard on the Effects of Noise on Hearing", (Ex. 310, p. 31)). It is the differences in hearing level between age groups that actually form the age corrections.

OSHA is responding to employer's concerns that if a stringent significant threshold shift criterion is not coupled with an age correction, many people would be referred unnecessarily for follow-up. Employers need not use these corrections if they choose not to.

The Agency recognizes that many workers will be exposed to nonoccupational noise that could result in some amount of hearing loss. Most presbycusis data bases include some amount of nonoccupational hearing loss, although these populations usually are screened to avoid such cases to the extent possible. It would not be appropriate to include more than a small value for nonoccupational hearing loss in the age correction since these noise exposures vary greatly among individuals.

Follow-Up Procedures

When a significant threshold shift has been identified, the employee must be provided with and required to wear adequate hearing protection and be trained in how to use and care for this protection. If the threshold shift is shown to be temporary as a result of a retest audiogram, employees exposed to TWAs between 85 and 90 dB may discontinue the use of the hearing protection. However, OSHA advises such employees to continue to wear protectors as the fact that they have suffered TTS may indicate an increased susceptibility to noise. If the threshold shift is found to be permanent, employers must require workers to wear hearing protection. Workers exhibiting

significant threshold shift have shown an increased susceptibility to noise; the permissible exposure limit is not sufficiently protective for them, and additional measures, such as ear protectors are needed to protect these individuals. In addition, the worker must be informed in writing of a permanent, significant threshold shift within 21 calendar days of the determination. Although the proposal did not require that notification be made in writing, Durham (Ex. 321-18, pp. 2-3), and those who prepared the draft California noise standard (Ex. 321-50, p. 9) recommended it. Durham stated that workers should be notified in writing "to prevent any misunderstandings or ambiguities . . ." (Ex. 321-18, pp. 2-3). A period of 21 days was chosen in order to give the professional reviewer time to interpret the test results and review previous audiograms. A period of 21 days should allow the employer the convenience of enclosing the notice with the employee's paycheck.

So as to make the notification more meaningful to employees Dr. McLaughlin (Ex. 2A, p. 103, 8-9-73) and others (Ex. 2C-83, p. 4; Ex. 81A, p. 8) urged that OSHA require employees to be informed of their hearing levels at the time of audiometric testing. Dr. Thomas (Ex. 102, sec. 9, p. 31) asserted that "this is the best time for a good individualized education program on a one-to-one basis and companies which fail to take advantage of this time are missing an excellent opportunity." At this time the employees are interested in their test results and can be shown a graphic display of their hearing sensitivity. Workers should be informed at the time of testing of any change in hearing level that is discovered, even if the threshold shift is not yet "significant." However, the Agency does not require this procedure in the final amendment because the individual giving the test may not have the employee's previous records available at the time.

The company must refer the employee for an audiological or otological examination under certain circumstances. The determination for this referral will usually be made on the advice of the professional reviewer. Follow-up examinations were not required by the proposal. However, the Agency agrees with suggestions from interested persons that such examinations are necessary under certain limited conditions. Employees must be referred under the following circumstances:

a. Sometimes an employee is unable to take a hearing test on a self-recording audiometer. He or she may not

understand the directions, or may not be able to produce an audiogram that meets the requirement in section (ii)(E) of Appendix C, that at least six tracings or excursions must be made at each frequency for the audiogram to be considered valid. Fewer tracings would be indicative of very slow or uncertain responses, and the determination of hearing threshold would be questionable. Since the standard requires a valid audiogram, the test would have to be administered on a manual audiometer in order to obtain a valid audiogram for such an employee (Ex. 102, sec. 9; Ex. 321-1, pp. 2-3). If a manual audiometer is not available to the employer, the employee must be sent to a clinical audiologist or otolaryngologist for further testing.

b. In other cases the employee may not respond reliably to a test given on a manual audiometer (Ex. 321, p. 3). In such cases the employee must be retested. This may happen in situations where the employee has a language problem and has not understood the directions, or where an employee may have tinnitus (ringing sounds in the ears) that can interfere with taking the test, or occasionally where an employee may exaggerate the hearing loss. If upon retesting satisfactory results are not obtained, the employee must be referred to a clinical audiologist or an otolaryngologist for a diagnostic evaluation.

c. The supervising professional may feel that the audiogram is valid, but may suspect that the loss is due to a nonoccupational cause (such as ear infection or illness) (Ex. 321-1, p. 2); these suspicions may be based on an audiogram that reveals large amounts of low frequency hearing loss, large hearing threshold differences between ears, or some other audiometric configuration that is not typical of noise-induced hearing loss. Unless the employer is willing to enter the hearing loss as work related on the OSHA Form 200, the employee must be sent to an otolaryngologist or audiologist for further evaluation to attempt to ascertain whether the hearing loss is occupationally related.

OSHA recognizes that noise-induced hearing loss may not always be due to occupational exposure. Many people raised this point at the hearing (E. 14-160, p. 2; Ex. 14-188, p. 1; Ex. 14-248, p. 3; Ex. 144, pp. 2-3). However, since this amendment covers workers who are occupationally exposed to significant amounts of noise, the occupational loss can be expected to be the dominating component in most cases. Even though people may hunt or engage in noisy

hobbies, most workers' NIPTS will be work related because the average person spends infinitely more time on a routine basis at work than in recreational activities.

d. A problem may arise where the employer or the supervising professional suspects that hearing protectors are either causing or aggravating an irritation or infection of the ear canal. The symptoms may include pain upon insertion of the ear plug, visible irritation of the ear canal, or draining ear, etc. The possibility of such conditions was reported by labor union witnesses (Tr. 2026-2027; Ex. 79, p. 7; Ex. 88, p. 7; Ex. 73, attach 4, p. 1). In this case the employer must refer the worker for an otological examination so that medical treatment will enable the worker to wear ear protectors comfortably and without any adverse medical consequences.

In some circumstances a medical pathology of the ear may be suspected that is clearly unrelated to the wearing of ear protectors. Examples could be infection or irritation prior to the fitting and wearing of protectors, or an otoscopically abnormal ear drum related to a cold or allergy. Regardless of the amount or kind of hearing loss, if the employer feels that an employee needs medical treatment, the employee should be informed of the need. In these cases the amendment does not require medical or audiological referral, but employers are advised to inform workers of the need for examination or treatment. (Ex. 321-1, p. 1).

Quiet periods

The amendment requires 14 hours free from workplace noise prior to conducting baseline and retest audiograms. Ear protection is not permitted as a substitute for this quiet period.

The proposed standard specified that audiometric tests (of any kind) must be preceded by at least 14 hours during which there was no exposure to workplace sound levels in excess of 80 dB. The requirement could be met by wearing hearing protectors.

OSHA received many comments favorable to requiring a quiet period prior to taking audiograms (Ex. 2A, pp. 51-54, 5-31-73; Tr. 2340-2341; Ex. 321-34, p. 2; Ex. 321-51, p. 10). Since the baseline and retest audiograms must not be influenced by temporary threshold shift, some time away from noise is necessary in order to allow the ear to recover. Therefore, baseline and retest audiograms will have to be conducted before the workshift. Morrill (Ex. 293, p. 1) supported the option of the using hearing protectors under controlled

conditions to achieve the necessary quiet period. The draft California noise standard (Ex. 312-50, p. 10) also included this option. However, this amendment does not permit the use of hearing protections to fulfill the 14-hour quiet requirement since studies have shown (Ex. 300, p. 2; Ex. 300A, p. 91; Ex. 308, p. 27) that common fitting and wearing practices can greatly reduce hearing protector effectiveness. This reduction in effectiveness would contribute to the risk of contaminating the baseline and retest audiograms by temporary threshold shift, so that neither would reflect the employee's true hearing threshold levels.

The proposal specified a maximum workplace noise exposure level of 80 dB immediately preceding the baseline audiogram. The amendment does not specify any maximum noise exposure level for the 14-hour quiet period, since employers cannot be responsible for their employees' noise exposures away from work, if employees are in the hearing conservation program to begin with, their workplace noise levels would not meet an 80-dB exposure level without the use of hearing protectors, and therefore the testing would have to be performed before work. Employers should explain to workers why the audiometric tests must be performed after 14 hours of quiet and counsel them that it is in their best interest to avoid recreational noise exposures before baseline or retest audiometric tests.

There was some dispute about the appropriate length of quiet time necessary before the baseline and retest audiograms. The New York State Department of Labor (Ex. 2C-118, p. 2) recommended 48 hours, while most others stated that 14 hours was sufficient (Ex. 2B, p. 6; Ex. 321-34, p. 2; Tr. 2340; Ex. 2A, p. 51, 5-31-73). While OSHA recognizes that workers with greater exposures will need longer periods of time to recover from TTS than will those who are exposed to more moderate levels, it has also been shown that the major portion of TTS disappears in the first few hours after cessation of exposure (Ex. 279, 11-6, pp. 987-990; Ex. 29, pp. 288-289; Ex. 183-27, sec. 11, p. 735). However, since it is not possible to specify an appropriate recovery time for each individual, OSHA has selected 14 hours as the most appropriate and protective period that is practical. The Agency recognized that some employees exposed to high levels of noise currently are wearing hearing protectors, and therefore they should have minimal TTS if the protectors are being worn properly. Since it is very difficult for employers to know if the ear protectors

are being worn properly, and since it is very important for the baseline audiogram to be free of TTS, the amendment requires all employees to be away from workplace noise for at least 14 hours before the baseline and retest audiograms are taken.

The Agency has chosen the 14-hour period as an administrative convenience, since there are usually at least that many hours between the end of an employee's workshift and the beginning of the next shift. Employers who are unable to meet the 14-hour minimum quiet period between shifts (due to overtime or irregular schedules) may prefer to schedule the baseline or retest audiogram before work on the first day of the work week.

Audiometric Test Frequencies

This amendment requires that pure tone air conduction audiometric tests be performed for each ear at the frequencies 500, 1000, 2000, 3000, 4000, and 6000 Hz. This is consistent with the proposal, the NIOSH criteria document (Ex. 1, p. 1-6) and the Advisory Committee (Ex. 2B, p. 8) recommendations.

While 500 Hz is not included in the definition of significant threshold shift, this frequency still is included among the required test frequencies in order to provide a more complete audiometric profile. The hearing threshold level at 500 Hz can be very helpful in assessing the validity of the audiogram as a whole since an unusual loss at this frequency can signal the need for a retest. Also, OSHA believes that the hearing threshold level at this frequency can provide important information about the health of employees, even though it is usually the last of the test frequencies to be affected by noise. Hearing loss at 500 Hz may be indicative of job related conductive hearing loss, which could possibly result from an adverse reaction to hearing protection, or from upper respiratory infections due to inhalation of irritating dust. Dr. Gene Del Polito of the American Speech-Language-Hearing Association explained why testing should include 500 Hz:

500 Hertz can add information that is useful in detecting most medical problems affecting the function of the outer and middle ears. Detecting these problems by way of hearing measurement could provide an additional measure for assuring the safety and health of the worker. Also, industrial accidents resulting in trauma to the auditory mechanism, such as punctured eardrums or disarticulated ossicles, may affect hearing more in the low frequency range than in the higher frequencies. (Ex. 291, pp. 1-2).

Dr. Joseph Sataloff (Ex. 2A, pp. 35-36, 5-10-73)) recommended the inclusion of

8000 Hz in the required audiometric test frequencies in order to more clearly delineate the characteristic noise-induced "notch," (where hearing levels at 8000 Hz are sometimes less severe than at 4000 or 6000 Hz). A number of comments to the Advisory Committee recommended against any requirement to test at 8000 Hz (Ex. 2C-41, p. 1; Ex. 2C-42, p. 1; Ex. 2C-46, p. 1; Ex. 2C-51, p. 1; Ex. 2C-52, p. 1). OSHA did not accept Dr. Sataloff's recommendation for two reasons. First, the calibration of 8000 Hz is often less stable than it is for other frequencies, and spurious results are likely to occur. Also, there are some audiometers that are incapable of testing at 8000 Hz, and the inclusion of this frequency would preclude their use under this amendment.

Audiometer Specifications

The amendment calls for equipment that meets the specifications of, and is maintained and used in accordance with the American National Standard Specification for Audiometers (ANSI S3.6-1969). Since the ANSI standard does not contain requirements for pulsed-tone and self-recording audiometers these requirements are found in Appendix C of the amendment. (Pulsed-tone and self-recording audiometers interrupt the tone signal automatically, whereas with other audiometers the interruption is performed manually). The requirements in Appendix C are essentially unchanged from those of the proposal.

The ANSI standard contains performance specifications for audiometers. It also contains calibration requirements, and specifications for audiometric zero with respect to sound pressure level at the different test frequencies. OSHA understands that microprocessor audiometers, which computerize the audiometric test are increasingly used by consultants and large companies. They are allowed by this amendment so long as they meet the performance specifications of ANSI S3.6-1969.

The proposal required that audiometers meet the specifications of ANSI S3.6-1969. There was some discussion in the record about the use of older audiometers that fail to meet the 1969 standard, but instead were calibrated to an earlier zero reference level established by the American Standard Association in 1951. Comments by Stenmark (Ex. 2C-134, p. 1) and Edwin Toothman (Ex. 145, attach 1, p. 8) expressed the opinion that industry should be allowed to continue to use existing audiometers conforming to the 1951 standard. Others, such as the American Speech and Hearing

Association (Ex. 129, attach 1, p. 2), the Environmental Defense Fund (Ex. 2C-125-1, p. 7), the Motor Vehicle Manufacturers Association (Ex. 2C-1, p. 9) and the Advisory Committee (Ex. 2B, pp. 8-9) supported adherence to the 1969 standard.

There is an average difference of 10 dB between the 1951 and the 1969 audiometric zero reference levels, the 1969 levels being lower (closer to 0 dB sound pressure level). Because the differences between the older and newer standards vary according to frequency (for example 9.5 dB at 1000 Hz and 5.5 dB at 4000 Hz), allowing both zero reference levels to be used would make it very difficult to compare an individual's audiograms that had been performed on different audiometers. It would also be very confusing for anyone wishing to assess the effectiveness of a hearing conservation program, especially since the criteria for significant threshold shift would have to be adjusted for each frequency. Since the 1969 ANSI standard has been in effect for 11 years, and since OSHA has estimated the average life of an audiometer to be about 10 years (Ex. 319A-60, p. 1; Ex. 319A-90, p. 1), the Agency assumes that there are very few audiometers in existence that are calibrated to the 1951 zero reference level. To the extent that audiometers calibrated to the 1951 zero reference level are still in use, some probably can be recalibrated to the 1969 zero reference level (Ex. 306, p. 15C-3). Therefore, the amendment requires that audiometers be calibrated to the zero reference level specified in ANSI S3.6-1969.

There was some discussion about the use of less common audiometric features, such as sweep-frequency and pulsed-tone types. Comments favored the proposal's requirements for discrete-frequency (as opposed to sweep-frequency) audiometers where the tone is presented in octave or half-octave intervals (Ex. 1, p. 1-7; Ex. 2C-1, p. 9). Comments also supported the proposal's requirement that with pulsed-tone audiometers, the on-time of the test tone is at least 200 milliseconds (Ex. 1, p. 1-7; Ex. 2C-1, p. 9). There was consensus that self-recording audiometers should be allowed in addition to the manual type, (Ex. 1, p. 1-7; Ex. 2B, p. 9; Ex. 48, p. 12; Ex. 102, sec. 9, pp. 25-26, 51; Ex. 306, p. 11C-11; Ex. 2C-26, p. 2; Ex. 2C-30, p. 1; Ex. 2C-125-1, pp. 7-8).

NIOSH (Ex. 1, p. 1-7) and the Advisory Committee (Ex. 2B, p. 9) recommended and the proposal required that self-recording audiometers should

be subject to the requirements found in Appendix C. These requirements are necessary to ensure the validity of audiograms taken with self-recording audiometers.

Audiometer Rooms

Background sound levels in audiometer rooms must be quiet enough to permit valid measurements of audiometric thresholds. Too much noise can "mask" or artificially shift a subject's hearing threshold level. In other words, the tone would have to be significantly louder before the person could distinguish it from the background noise, making it seem as though the individual hears less well than he or she actually does. While this is not a good practice for any type of hearing test, it is especially serious with respect to the baseline audiogram. For example, a worker might enter a company with hearing as good as 0 dB at 1000 Hz. But background noise could mask this worker's hearing level at 1000 Hz by 15 dB, and cause the baseline to read 15 dB rather than 0 dB hearing level. In subsequent years the worker might actually lose some ability to hear at various frequencies, including 1000 Hz. Not until the worker had already lost more than 15 dB of hearing would any changes begin to show up on the audiogram. Then, the worker would have to have a hearing level of 35 dB (signifying a loss of 20 dB more), before the shift would be considered significant, under the amendment, and protective actions would be taken.

The Agency has determined that background levels in audiometer test rooms should be quiet enough to allow threshold testing to 0 dB hearing level. This is especially important in order to describe accurately the hearing levels of individuals who enter the workforce with hearing as good as 0 dB. According to the DuPont Company (Ex. 306, sect. 11C, pp. 8-9) "most young subjects will have extremely good hearing and will respond to the tone while the hearing dial is still at 0 dB threshold. In these cases it is good practice to obtain . . . responses . . . at these low levels." "Screening" audiometry, (merely registering positive responses at a specific level across frequencies) does not satisfy the requirements of this regulation because actual thresholds, and therefore valid threshold shifts, cannot be identified by this process. Baseline and periodic audiograms should reflect testing to the lowest audible level. These views have also been supported by industrial audiologists (Ex. 317, p. 2; Ex. 319B-2, p. 1; Ex. 319B-3, p. 3), and constitute good

industrial audiometric practice, necessary to preserve workers' hearing.

In the proposed standard OSHA required that background levels in audiometric test rooms levels not exceed the following:

40 dB at 500 Hz
40 dB at 1000 Hz
47 dB at 2000 Hz
57 dB at 4000 Hz
62 dB at 8000 Hz

These levels, referenced to 0 dB sound pressure level, were taken from the American National Standard, Criteria for Background Noise in Audiometer Rooms, S3.1-1960.

The amendment retains the background levels specified in the proposal (as Table D-2 of Appendix D) for 2 years, and then imposes a more stringent background noise requirement for audiometric test rooms. After 2 years, background levels shall not exceed the following.

27 dB at 500 Hz
30 dB at 1000 Hz
35 dB at 2000 Hz
42 dB at 4000 Hz
41 dB at 8000 Hz

So that the professional reviewer will know that testing has been conducted in sufficiently quiet conditions, employers must record on employees' audiograms whether the test room meets the requirements of Table D-1 or Table D-2.

These background levels (with the exception of the 27-dB level at 500 Hz) are specified in the American National Standard for Permissible Ambient Noise During Audiometric Testing, S3.1-1977. This standard was submitted to the record as Exhibit 312 and public comment was invited on it (see 45 FR 26366, 4/18/80).

OSHA has required the more stringent background levels in audiometric test rooms which are outlined above to be as consistent as possible with the newer ANSI standard. In previous years, the older (1960) ANSI standard for background levels was presumed to be sufficient for allowing threshold testing to audiometric zero, based on the 1951 audiometric zero (ANSI S3.1-1960, p. 7). However, as mentioned above, audiometric zero was changed (made more stringent) in 1969, and therefore the old ANSI standard for background levels was no longer stringent enough to allow threshold testing to 0 dB. ANSI began revising the standard for background levels, but the new standard was not published until 1977. It is logical for this amendment to require the more stringent background levels so that workers may be tested to the 1969 0-dB hearing threshold level, which is now the nationally accepted norm for

audiometric zero. (In fact, the proposal required the use of audiometers meeting the ANSI S3.6-1969 standard, which includes the 1969 zero reference level).

Although the 1977 ANSI standard for background levels specifies a maximum level of 21.5 dB at the 500-Hz frequency, OSHA has modified this requirement to 27 dB. This change was based in part on a number of recent submissions to the record by audiometric booth manufacturers, employers, and industrial audiologists, who maintained that they were unable to meet the new ANSI requirement of 21.5 dB at 500 Hz with existing equipment (Ex. 287, p. 2, Attach. 1, p. 1, Attach. 3, p. 1; Ex. 291, p. 2; Ex. 295, p. 1, Ex. 319-B1; Ex. 319-B2, pp. 1, 2; Ex. 321-15, pp. 1, 2). Alan Eckel, president of Noise Control Products and Materials Association (Ex. 287, p. 2) stated that ANSI S3.1-1977 was "a clinical research standard and . . . not intended for industrial hearing conservation purposes." However, there is no such distinction made by the ANSI standard (Ex. 312). While the ANSI standard maintains that the exclusion of all ambient noise is not necessary, the levels in the standard will permit measurement of hearing threshold levels as low as those specified in ANSI S3.6-1969, (as explained above) (Ex. 312, p. 1).

Also, the Agency realizes that since 500 Hz is not included in the definition of significant threshold shift, audiometric precision at this frequency is not as important as it is at the other test frequencies. However, is not appropriate to allow background noise up to 40 dB at 500 Hz, (as allowed by the older ANSI standard) since this amount of noise would be capable of masking thresholds at 1000 Hz. The decision to allow a sound pressure level of 27 dB is based on a study by Dr. James Jerger (Ex. 321-20, p. 387), which shows that background levels at 500 Hz may be raised approximately 5 dB without interfering with threshold testing at 1000 Hz.

William Vanke (Ex. 285, p. 2) referred to the statement in ANSI S3.1-1977 (Ex. 312, p. 1) to the effect that some testing programs may be met by measurements at test signal sound pressure levels higher than 0 dB referenced to ANSI S3.6-1969. The objectives of the audiometric testing program required by OSHA can be met by slightly higher levels at 500 Hz, but they cannot be met at higher levels for the test frequencies 1000 through 6000 Hz because these frequencies are used in the definition of significant threshold shift. Testing to 0 dB hearing threshold level is critical to the proper characterization of hearing level for persons with acute hearing, so

as to correctly identify significant threshold shift, with the goal of preventing material impairment of hearing.

The amendment does not incorporate the entirety of ANSI S3.1-1977 by reference since the octave band levels at 500 through 8000 Hz stated above are the only ones necessary for the amendment's audiometric testing requirements (frequencies such as 125, 250, and 750 Hz are not included since testing is not required at these frequencies). Also, the amendment has rounded the levels stated in the ANSI standard to the next highest whole number, (e.g., at 1000 Hz the amendment requires 30 dB instead of 29.5 dB). Since the remainder of the ANSI standard consists mainly of appendices, which are not actually part of the standard, only the pertinent allowable levels as modified are included in the final standard.

Although the amendment does not require testing at 8000 Hz, (nor did the proposal), this frequency is included instead of 6000 Hz in the requirements for background sound levels. This is because ordinary sound level meters are not capable of measuring sound pressure levels for the octave band surrounding 6000 Hz. Therefore OSHA has listed the levels to permit testing at the 6000-Hz frequency even though they must be measured with the octave band filter set for 8000 Hz. This procedure was assumed in the proposal, since a 62-dB maximum level was required for audiometric testing at 6000 Hz, although the 8000 Hz frequency was specified for measurement with the sound level meter. The same rationale applies to the 41-dB maximum level to be measured at 8000 Hz setting after the initial 2-year period. Since most background noise tends to be predominantly low frequency, and also since high frequency sound is more efficiently attenuated by typical audiometric test booths (Ex. 312, p. 7), the amendment's requirement for maximum levels of high frequency noise are not expected to pose a feasibility problem.

Since some employers or consultants may need to retrofit their present audiometer rooms, (Ex. 319B-2, p. 2) or move them to a quieter location, the Agency has allowed them 2 years in which to make these changes. There may be cases where employers need to purchase new test booths, but OSHA believes that these cases will be rare because of the modification of allowable background noise made at 500 Hz.

Quieter booths of the double-walled variety are available but they should not usually be necessary since most factories have some kind of office space,

where background noise levels are relatively low. Because none of the comments in the record mentioned difficulties at frequencies above 500 Hz, OSHA concludes that the 1977 ANSI requirements at these frequencies do not present significant problems.

Measurements of background levels submitted by audiologist Sue Riggs (Ex. 295, p. 1 and Attachment) indicated some difficulties at 500 Hz, but the 1977 ANSI levels were met at other frequencies. Alan Eckel of Eckel Industries stated that "almost all audiometric booths currently used in industrial hearing conservation programs meet the requirements of the new ANSI standard at 1000 Hz and above. The lower frequencies are difficult to achieve". (Ex. 319 B-1, p. 1).

Measurements by Riggs (Ex. 295, Attachment) indicated that the 27-dB levels at 500 Hz could be met in many of the cases she cited, although the 21.5-dB level specified in ANSI S1.3-1977 could not. Reports by Berger et al. (Ex. 286A, p. 38) and NIOSH (Ex. 28-2, p. 23), showed that the 27-dB level usually was met in the conditions in which these investigators tested. The mobile audiometric van used by Burns and Robinson had a mean attenuation of 79 dB at 500 Hz from outside the vehicle to inside the booth (Ex. 12, p. 71), which when added to the 27-dB allowable level at 500 Hz, must have provided ample attenuation for any ordinary circumstances.

Audiometer Calibration

This amendment requires three types of audiometer calibration. First, the functional calibration of the audiometer must be checked before each day's use. Second, the audiometer's calibration must be checked acoustically with a sound level meter and earphone coupler at least every year. Finally, the audiometer must receive an exhaustive calibration at least every 2 years. In the first two instances the word "calibration" refers to a procedure by which the audiometer is checked to make sure that it is producing the correct level of pure tones at specific frequencies, and that the signals are free from distortion or unwanted sounds, which might lead to invalid audiograms. In the third type of calibration the instrument is thoroughly checked, and adjusted if necessary, so that it meets the ANSI specifications described below. In most cases this type of calibration must be performed in a laboratory or at the manufacturer's factory.

So as to ensure accurate audiograms, OSHA advises employers to measure the background sound pressure levels in

audiometric test rooms periodically. Since the sound levels inside the room are greatly dependent upon the sound levels outside, employers should measure the room levels whenever there is an increase in outside sound levels that might adversely affect compliance with Appendix D. For example, Dr. Thomas (Ex. 102, Sect. 9, pp. 53-56) recommends making these measurements whenever a test room is relocated, or when noisy equipment is moved into the area of the test room.

Audiometer calibration is necessary in order to obtain valid audiograms, which in turn are critical since changes in hearing level initiate a number of different actions. There were many comments in the record supporting required audiometer calibrations. According to William Reich of Gen Rad Corporation, "An accurate and reliable audiometric testing program involves more than the simple purchase of a good audiometer. Periodic calibrations are an essential part of the audiometer program . . ." (Ex. 281, attach. 2, p. 86, Electro-Acoustic Audiometer Calibration). There are several studies that show that audiometers can often malfunction, and this malfunctioning can be undetected by the individual who is using the instrument (Ex. 321-51A, Ex. 281, attach. 2, p. 86). As a consequence, the audiograms that have been produced are of questionable accuracy and value. According to a study by Thomas, Preslar, Summers, and Stewart (Ex. 321-51A, p. 326), of 98 audiometers checked, none was "in condition to do satisfactorily the testing for which it was manufactured. The most frequent defect was incorrect sound level output." This study and also a study performed by the U.S. Air Force School of Aerospace Medicine (Ex. 281, attach., p. 86) indicate that a high percentage (50 percent to 100 percent) of audiometers failed to perform according to ANSI requirements when these instruments were left uncalibrated. It is for these reasons that calibration is mandatory.

The hearing conservation amendment requires that the functional operation of the audiometer be checked before each day's use. The process involves testing a person whose hearing levels are stable and do not exceed 25 dB at any test frequency. This person may be the tester himself or herself, or any other person with normal hearing. The process also includes checking the general function of the audiometer for unwanted sounds, such as clicks, static, and distortion. This functional check is quite simple, and can be done in a few minutes. If the test reveals significant deviations (greater than 5 dB), in hearing level from

the subject's known audiogram or unwanted or distorted sounds, a more thorough calibration is warranted. In this case OSHA requires an acoustic calibration. In order to be sure that the audiometer's output is deviating rather than the subject's hearing level (the subject may have a headcold), the tester is advised to test additional subjects (with known stable hearing levels that do not exceed 25 dB). If these subjects confirm the deviation, use of this audiometer for testing must be discontinued until a periodic or exhaustive calibration can be performed since all of the audiograms taken that day would be suspect.

The proposal also required that the functional operation of the audiometer be checked prior to each period of use to ensure that it was in proper operating order. In addition, the proposal required a "biological" calibration at least once a month, which consisted of testing a person having known, stable audiometric thresholds. If the results of the biological calibration indicated hearing level differences greater than 5 dB, the audiometer was to be subjected to a "periodic" calibration. In the final amendment the Agency has combined the functional check and the biological calibration into the same requirement, to be performed before each day's use of the audiometer. This approach has been taken because it is extremely important to ensure that the audiometer produces correct sound pressure levels each time it is used. The process of testing one person's hearing can be done quickly, especially if the individual performing the test tests himself or herself.

This type of calibration check was supported by comments and articles submitted to the record. Even a new audiometer from the factory can lose its calibration especially if it was bumped in transit, and a functional check before each day's use would alert the operator to any malfunctions that might invalidate the test results (Ex. 102, sec. 9, p. 55-56; Ex. 306, p. J5C-8). This type of calibration appears to be accepted audiological practice, and was recommended in many comments to the record (Ex. 2C-14, p. 4; Ex. 2C-31-1, p. 2; Ex. 48, p. 14; Ex. 58, p. 2; Ex. 159, p. 6; Ex. 281, attach. 2, p. 88; Ex. 306, pp. J5C-6, J1C-4, J1C-12).

Like the proposal, the amendment requires an acoustic calibration at least once a year, in order to check the audiometer's output with calibrated measuring equipment. This calibration is specified in Appendix E, and must be performed with a sound level meter and octave-band filter set, and a National Bureau of Standards 9-A coupler. The

amendment's requirements are the same as those of the proposal, except that the listening test and the functional check are not included since they must now be performed before each day's use. The name has been changed from "periodic" to "acoustic" to more accurately characterize this particular calibration.

The amendment's requirements for acoustic calibration are given in Section 4.1.4.3 of ANSI § 3.6-1969, but the actual calibration procedures are given more explicitly in Appendix E, as they were in the proposal. Also, Appendix E gives reference sound pressure levels for both the Telephonics TDH-39 and TDH-49 earphones, which are in popular use today. (Reference levels for the TDH-49 earphone were not included in ANSI § 3.6-1969).

For the acoustic calibration, measurements must be taken acoustically at a reading of 70 dB on the audiometer's hearing threshold dial at all test frequencies (500, 1000, 2000, 3000, 4000, and 6000 Hz). Measurements must then be taken at the 1000-Hz frequency in decreasing steps of 10 dB from 70 dB to 10 dB hearing level. These latter measurements may be taken acoustically with the sound level meter or electrically with a voltmeter. The purpose of these measurements is to check the sound pressure level output at all frequencies, and to check the linearity of the attenuator, to make sure that the audiometer is producing the correct sound pressure level output at all hearing levels. Appendix E gives the following tolerances, which also are stated in Section 4.1.4.3 of ANSI § 3.6-1969:

3 dB at 500 through 3000 Hz
4 dB at 4000 Hz
5 dB at 6000 Hz

Whenever the audiometric output deviates by more than the above levels, OSHA advises an exhaustive calibration. Until such time as the exhaustive calibration is performed, deviations that exceed these tolerances should be posted on the audiometer, so that the operator can correct the audiograms accordingly. When manual audiometers are used, deviations of 3 or 4 dB should be rounded to 5 dB when adjusting the audiogram. The amendment advises, but does not require an exhaustive calibration when small tolerances are exceeded, because posting deviations and correcting audiograms should serve as a satisfactory interim measure. However, when the deviations exceed 10 dB, an exhaustive calibration is mandatory.

This portion of the amendment reflects a slight departure from the proposal, which specified additional

listening checks. The amendment limits the requirement to an assessment of sound pressure level output, since sound pressure level output is the audiometric function most frequently found to be incorrect (Ex. 321-51A, p. 326).

Comments in the hearing record supported a periodic calibration and some even specified its performance quarterly (Ex. 2C-14, p. 4; Ex. 2C-31-1, p. 2; Ex. 48, p. 14). Since not all audiometers will be in constant service and since an acoustic calibration will be triggered by a functional check that shows the necessity of further calibration, the Agency believes that a regular acoustic calibration once a year should be sufficiently frequent to assure accuracy.

The hearing conservation amendment requires an exhaustive calibration every 2 years. The content of the requirement is essentially the same as that which appeared in the proposal, although the interval between calibrations has been shortened from 5 to 2 years. This calibration will usually be performed in a laboratory or by the audiometer manufacturer because of the need for specialized equipment. (Calibration of frequencies below 500 Hz and above 6000 Hz may be omitted since they are not required test frequencies). During this calibration the audiometer is actually adjusted so that it conforms to the following sections of ANSI § 3.6-1969:

Section 4.1.2 Accuracy of Tone Frequencies. The purpose of the test is to make sure that the audiometer will actually produce tones at the frequency stated on the audiometer dial. For example, the tone should be 2000 Hz, not 2100 Hz or 1900 Hz.

Section 4.1.3 Purity of Tones. In this test the audiometer is checked to make sure that harmonics of the test frequencies are not present to the extent that a test subject might respond to the harmonic rather than to the test tone.

Section 4.1.4.3 Accuracy of Sound Pressure Level. In this test the audiometer's sound pressure level output is checked in a similar manner as it is on the acoustic calibration. Reference threshold levels should be appropriate to the type of earphone, as mentioned above.

Section 4.4.1 Sound from Test Earphone. The purpose of this test is to ensure that the earphone will not emit any sound other than the test tone, which might affect the subject's threshold.

Section 4.4.2 Sound from Second Earphone. This test guards against any sound from the nontest earphone, which might affect the subject's threshold.

Section 4.4.3 Other Unwanted Sound. This test guards against any sound from the audiometer itself, which might furnish a clue to the subject being tested, thereby affecting the subject's threshold.

Section 4.5 Tone Switch. The purpose of this test is to ensure that the tone has an adequate rise and decay time, and that operation of the switch does not produce audible transient sounds or extraneous frequencies, which could influence the subject's threshold determination.

The proposal required an exhaustive calibration every 5 years. The amendment requires that the exhaustive calibration be performed every 2 years. Many comments in the hearing record supported an exhaustive (or factory) calibration every year (Dr. Righthand, Ex. 281, Attach. p. 91; Air Force Regulation Ex. 48, p. 13; Dr. Thomas, Ex. 102, Sec. 9, p. 58). Although the DuPont Company calls its yearly calibration an "acoustic" calibration, their requirements are similar to the exhaustive calibration specified in the amendment. The Company states: "This calibration shall check both frequency and intensity at each setting, rise time and overshoot and electrical and mechanical integrity." (Ex. 306, p. J5C-5). A Draft International Standard (Ex. 321-39, p. 3) suggests an exhaustive calibration every 2 years. The NIOSH criteria document (Ex. 1, p. 1-19), the Advisory Committee (Ex. 2B, p. 12), and the draft California noise standard (Ex. 321-50, p. 15) supported the 5-year period between exhaustive calibrations.

Since the validity of the audiogram is highly dependent upon the calibration of the audiometer, OSHA believes that 5 years is too long an interval between exhaustive calibrations. Even though employers may find in the acoustic calibration that the sound pressure level output is correct, other malfunctions may occur, such as inaccurate tone frequencies or harmonic distortion. These malfunctions could occur without the knowledge of the operator because they can be too difficult to detect. A shorter interval is all the more important because the exhaustive calibration is advised but not required when an acoustic calibration indicates that the audiometer is up to 10 dB out of calibration. Audiometers that are not used very often (such as only a few days a year) should not need to be thoroughly calibrated more often than every 2 years. However, employers are urged to send their audiometers for exhaustive calibration more frequently when they are heavily used, or when, as a result of periodic calibration, it becomes

apparent that they slip out of calibration fairly easily.

The amendment requires employers to record the date of the most recent acoustic or exhaustive calibration on employees' audiograms. This requirement will aid professional reviewers in making the determination that the tests have been conducted with properly calibrated equipment. In addition, employers must make complete calibration records available to professional reviewers, so that the reviewers will have better knowledge of actual function of the audiometer.

Hearing Protectors

The hearing conservation amendment requires employers to make hearing protectors available to all workers whose exposures equal or exceed an 8-hour time-weighted average sound level of 85 dB. When the PEL is exceeded, and employers are unable to reduce exposures through the use of engineering or administrative controls, hearing protectors must be provided and worn, as required by the current noise standard, 29 CFR 1910.95(b)(1). In addition, employers must assure that hearing protectors are provided to and worn by employees exposed to a TWA of 85 dB or greater if their audiograms have indicated a permanent significant threshold shift. Although workers who have not yet received a baseline audiogram are not required to wear protectors if their TWAs are between 85 and 90 dB employers are advised to encourage them to do so.

Employers must provide workers with a choice of hearing protectors. Employers are advised to give workers a choice between at least one type of ear plug and one type of ear muff (preferably more) since individuals may be much more comfortable in one type of protection than in the other. Ear protectors shall be supplied at the employer's expense. The employer is responsible for the proper initial fitting of hearing protection, and for regularly supervising its use to make sure that employees are wearing the protectors, and that they are worn correctly.

Employers must select hearing protectors that attenuate or reduce employee noise exposure at least to the PEL, and for employees who have suffered a significant threshold shift, to a TWA of 85 dB or below. Under the present standard, 29 CFR 1910.95(b)(1), an employee must wear hearing protection whenever his or her exposure exceeds the PEL and engineering controls are infeasible, in the process of being installed, or will not reduce the employee's exposure to within the PEL. The final hearing conservation

amendment requires an additional group of employees to wear hearing protection: those exposed to TWAs of 85 dB or above if they suffer a significant threshold shift of hearing level.

The results of four recent studies indicate that the way hearing protectors are worn in real life conditions significantly reduces the manufacturer's stated estimates of attenuation (Ex. 301, p. 35; Ex. 308, pp. 1, 2; Ex. 321-14C, p. 5; Ex. 321-35E, abstract). NIOSH found that the attenuation achieved in the field was only about one-third of the attenuation achieved in the laboratory (Ex. 308, p. iii). Therefore, employers are advised to underestimate hearing protector attenuation by a few decibels when selecting protectors for employees. (This underestimate may have the effect of slightly overprotecting the employee.)

A given hearing protector must always be suitable for the frequency distribution of the noise environment in which it is to be worn. Therefore employers must estimate hearing protector attenuation for each employee's noise exposure conditions in order to be sure that the attenuation provided will be adequate. Methods for estimating hearing protector attenuation are described, and instructions for their use are given in Appendix G: *Methods for Estimating the Adequacy of Hearing Protector Attenuation*. This appendix is mandatory.

As discussed above in the section on exposure monitoring, the employer must remonitor whenever there is a change in working conditions that may cause an employee's hearing protector attenuation to be insufficient. After monitoring, the employer must re-evaluate the attenuation of the hearing protector being used and provide new protectors as necessary. These measurements could be taken as a result of either a bi-annual monitoring or monitoring due to a change in noise conditions.

The proposal required hearing protectors to be provided to and used by employees exposed to a TWA between 85 and 90 dB if their audiograms showed a significant threshold shift. OSHA has retained this very important requirement since these workers have demonstrated susceptibility to noise exposure (Ex. 310, p. 25; Ex. 5, pp. 43804, 43805; Ex. 138A, p. 1-4) and wearing hearing protectors may help prevent further hearing loss (Ex. 231, p. 11; Ex. 321-53D, p. 3; Tr. 2246; Tr. 755).

Unlike the proposed standard, the amendment also requires employers to make protectors available to all employees exposed to a TWA above 85 dB on a voluntary basis. The fundamental reason for this requirement

is the fact that hearing loss can occur above 85 dB, as was explained earlier. A significant percentage of workers exposed to 85 dB over a working lifetime will suffer material impairment of hearing (Ex. 138A, p. 1-4; Ex. 5, p. 43805; Ex. 189-5, p. 6; Ex. 88, p. 33). These workers should not have to incur significant threshold shifts or any work related diminution of hearing, for that matter, before they have access to hearing protection. Workers should be able to wear protection voluntarily, even where the use of hearing protection is not mandatory. This is fully consistent with the purposes of the Occupational Safety and Health Act (see section 2(b)(1) and 2(b)(4) of the Act).

Generally the amendment does not make the wearing of hearing protectors mandatory until exposure levels exceed the PEL since the permissible exposure level listed in 29 CFR 1910.95(a), Table G-16 has not been changed. This requirement is contained in the present noise standard and the amendment does nothing to change it. Moreover, workers sometimes find hearing protectors particularly oppressive at the more moderate exposure levels where they can cause interference with speech communication to be more noticeable. (More speech communication is likely to occur in moderate levels, especially if the noise is intermittent, allowing speech to take place in the quiet intervals (Ex. 321-35G, p. 3; Ex. 231, p. 12).) Therefore the Agency has decided to require employers to provide ear protectors to employees exposed between 85 and 90 dB, but not to make the use of these devices mandatory for those employees without significant threshold shift until the PEL is exceeded. Since the Agency recognizes that many employees dislike hearing protectors, mandatory use of protectors has been limited to those cases where they are absolutely necessary.

Acceptability of Hearing Protectors

A major issue that was addressed in the record is worker refusal to wear ear plugs because they cause discomfort (Ex. 75-5, p. 22; Ex. 321-45A, pp. 1, 11; Ex. 94, p. 9). Complaints about ear muffs included headaches, claustrophobia, excessive warmth, perspiration, interference with safety glasses and hardhats, and bulk in and around the ear (Tr. 576, 603, Tr. 1371; Ex. 94, p. 9; Ex. 2C-16B, p. 25). Hearing protectors also have been criticized because their effectiveness is so heavily dependent upon individual worker's compliance, rather than on the more consistent protection afforded by engineering controls (Tr. 794). The use of hearing protectors can be more difficult to

supervise because their effectiveness depends upon many people (all employees who wear them) rather than on one or two machines (Tr. 1465). Also, supervision is difficult because it is impossible to know whether a hearing protector is being effectively worn just by looking at each employee. Finally, some stated that hearing protectors can be unacceptable for hygienic reasons (i.e., they lead to ear infections) (Ex. 79, p. 7; Ex. 94, p. 9; Ex. 88, p. 7; Tr. 2026-2027).

Leonard Woodcock, former president of the United Auto Workers Union, revealed many potential problems with ear protection:

The effect of using ear protection shifts the burden and responsibility for compliance from the employer to employee. Ear protection is uncomfortable and irritating. Some workers easily get ear infections or drainage problems from wearing them.

Moreover, experience teaches us that management often selectively enforces the wearing of ear protection. (Ex. 79, p. 7).

Joseph Hafkenschiel of the Communication Workers of America went on to say that:

Personal protective equipment, cannot be regarded . . . as anything more than an interim control measure. Even in these temporary situations, many people cannot wear this type of protection because of medical problems of the ear. Other individuals find the effective deafness enforced by ear protectors psychologically disturbing. Finally, ear protection may mask shouts or signals and, thus, contribute to industrial accidents. (Ex. 82, p. 8).

In response to these problems many commentators pointed out the necessity to fit hearing protectors correctly and to allow for personal preference in order to assure comfort and acceptance (Tr. 3463-3464; Ex. 14-245, p. 2; Ex. 308, p. 1; Ex. 321-14A, p. 2; Ex. 321-14B, p. 2; Ex. 14-894, sec. 3, p. 6; Ex. 75-2, p. 123; Ex. 321-34A, p. 2; Ex. 321-53D, p. 3). Workers who develop ear infections or have significant amounts of wax in the ears should use muffs, if possible, instead of insert type hearing protectors (Ex. 102, sec. 8, p. 15; Tr. 1803, 1805).

In a program developed for the North Carolina Department of Labor (Ex. 2C-16B, pp. IV-6, 7), Dr. Royster provided an example of a program which emphasized that workers should be able to receive help when protectors are not satisfactory. A supervisor, a nurse, or even a health and safety committee can provide guidance "on the job." OSHA believes that if, after a trial period, (Ex. 75-2, p. 122) the discomfort associated with the use of a particular hearing protector is so great that it cannot be worn successfully, then an alternative protector should be used. The company

must make a concerted effort to find the right protector for each worker—one that offers the appropriate amount of attenuation, is accepted in terms of comfort, and is used by the employee. The Agency requires workers to wear hearing protectors as part of the total hearing conservation program. If the protectors do not fit properly will not provide the estimated amount of protection.

There are several reasons why OSHA mandates that employers provide a variety of protectors (Ex. 147C, pp. 336-337). Plant conditions such as dust, temperature, and humidity can cause one type of protector to be more suitable than another (Ex. 102, sec. 5, p. 18). For example, ear plugs can be more comfortable in a hot, humid environment, than ear muffs. Also, individual ear canals come in all shapes and sizes. For people with unusually shaped ear canals, fitting may be difficult, and commonly-used insert protectors may be very uncomfortable (Ex. 2C-16B, p. V-3).

In a survey of industrial hearing conservation programs NIOSH found that:

Another factor which seemed to affect the willingness of the employee to wear ear protectors was the variety of items offered to him. Many companies supplied a wide range of personal ear protector devices and permitted the employee a trial period to select the one he liked. (Ex. 321-14B, p. 2).

This finding was also supported by Dr. M. Thomas Summar (Ex. 147C, p. 335) and others (Ex. 321-14A, p. 2; Ex. 321-14B, p. 2; Tr. 3464; Ex. 321-34A, p. 2).

Another aspect of worker rejection of ear protectors is safety. The United Auto Workers, for example (Ex. 79, p. 8; Ex. 94, p. 10; Ex. 91C, p. 3), stated that hearing protectors create unsafe conditions in the workplace by reducing the audibility of shouts and warning signals. It is possible that a worker might not hear noises that indicate that machinery is malfunctioning. The Environmental Protection Agency (Ex. 231, p. 12) pointed out that hearing protectors can impede speech communication, especially in situations where the noise is highly intermittent, or in cases where the wearer has a high-frequency hearing loss. Interference with speech communication can cause a safety hazard. This issue is complex, since, in some situations protectors can actually improve hearing of speech in noisy backgrounds (Ex. 14-295, p. 1; Ex. 14-886, p. 1; Ex. 14-907, p. 21). On the basis of this evidence, OSHA concludes that although hearing protectors may in some circumstances pose a safety hazard, this is insufficient reason to

abandon their use when workers are exposed to potentially damaging levels of noise and there are no other feasible means of reducing the noise exposure.

There is also some evidence that protectors provide other advantages beyond protection against NIPTS. Studies by the Raytheon Company (Ex. 26-11, p. 5-2) and another by Schmidt, Royster, and Pearson (Ex. 321-22, p. 27) showed that after the institution of a hearing protector program not only was hearing loss reduced, but lower injury rates and higher attendance rates were observed.

Administrative and Financial Responsibility

Another important issue that was raised at the hearings was the placement of administrative responsibility for this part of the program. The American Newspaper Publishers Association (Ex. 14-268, p. 2) and others (Ex. 14-173, p. 2; Ex. 14-290, p. 2; Ex. 14-276, p. 2) stated that it should be the worker's responsibility to use ear protectors. Going one step further, the Air Transport Association of America (Ex. 144, p. 10), and Dr. Raymond J. LeZak (Ex. 14-276, p. 2) felt that each worker should decide whether or not to use protection. Based on this reasoning, if the employee is not diligent in the use of protection, then any hearing loss that is incurred cannot be blamed on the company.

The Occupational Safety and Health Act does not include the concept of "assumption of risk" which would permit workers to decide which rules merit compliance. On the contrary, the Act requires employees to comply with all rules and employers have the responsibility of enforcing all of OSHA's requirements.

The proposal did not specify who should bear the expense of hearing protectors. Some comments in the record, such as those submitted by the Environmental Protection Agency (Ex. 9, p. 5) and others (Ex. 321-18, p. 2; Ex. 321-50A, p. 8; Ex. 103A, p. 4), recommended that ear protectors be provided at the employer's expense. For example, R. V. Durham, director of the Safety and Health Department of the International Brotherhood of Teamsters stated:

A point we must raise, the burden of cost for personal ear protective devices, is one that is vital although often overlooked. Labor and most employers recognize the responsibility of the employer to provide a safe and healthful working environment for its employees. Where, in certain circumstances, personal protective equipment is necessary to afford such an environment, it is again almost universally accepted that its

purchase is the responsibility of the employer. If personal ear protective devices are necessary to the success of a hearing conservation program, it is vital that the employer provide appropriate ear protectors and maintain control over the proper issuance, maintenance, and use.

An employer's attempt to require its employees to purchase their own personal ear protective devices would cause resentment among the workers and clearly demonstrate to them the lack of commitment on the part of their employer in preventing hearing loss. Such a requirement would discourage the use of ear protective devices and would create an adversarial atmosphere in regard to the hearing conservation program. Finally, requiring workers to buy their own hearing protective devices risks losing the necessary control over the organized and consistent selection, issuance, maintenance, and use of such equipment (Ex. 321-18, pp. 1-2).

On the basis of arguments such as the above, and because ear protectors are vital to the prevention of noise-induced hearing loss, the Agency has determined that employers must bear the expense of providing employees with hearing protectors, including the cost of replacing protectors that wear out.

Hearing protectors do wear out, and lose some of their ability to attenuate noise. Malleable inserts eventually become inflexible and unable to attenuate properly. Premolded plugs also can lose their elasticity, and custom molded plugs may shrink. Ear muffs also wear out eventually—the soft seals surrounding the ear cup can become inflexible, and the headband can lose its tension. Employers must replace all types of protectors as often as necessary so as to ensure the necessary amount of attenuation. Certain types of protectors, such as disposable plugs, may need to be replaced daily.

Dr. Royster mentioned that workers might damage or lose their protectors or just want an extra set, presumably to take home (Ex. 2C-16B, pp. IV-3, IV-6). The final standard's requirement that the employer pay for hearing protectors does not go this far. The Agency believes that employers should not have to pay for an unlimited supply of protectors or replace protectors lost due to employee negligence. The issue of how many replacement protectors to supply is up to the individual company as it is with other necessary work items, such as tools. However, if the employer refuses to replace worn out ear protectors, the employer may be subject to citation. On the other hand, the employer should not have to bear the expense if an employee has been irresponsible.

The Agency is aware that many industrialists are concerned about being held responsible for nonoccupationally-

induced hearing loss (Ex. 14-8, p. 2; Ex. 14-86, p. 1 and Ex. 14-288, pp. 3-4). To the extent that an employee's noisy hobby can contribute to noise-induced hearing loss, wearing protectors at home should diminish the loss. Therefore, OSHA suggests that employers urge workers to use protectors at home during noisy activities.

Attenuation

The value of hearing protectors lies in their ability to attenuate or reduce the noise that reaches the ear. Although the proposed standard did not specify requirements for estimating hearing protector attenuation, adequate attenuation is fundamental to worker protection, and for this reason it was suggested that OSHA make its requirements explicit (Ex. 1, pp. I-11 through I-13, III-7, III-8; Ex. 2B, pp. 13-15).

The amendment requires employers to evaluate the effectiveness of particular ear protectors in specific noise environments, since the capabilities of the protectors need to be matched to the characteristics of the noise. For example, workers who are exposed to predominantly low-frequency noise levels of approximately 100 dB may need protectors that provide more attenuation in the low frequencies than those needed by workers who are exposed to predominantly high-frequency noise of the same A-weighted level.

Since hearing protectors generally provide greater attenuation in the high frequencies than in the low frequencies, (see Ex. 321-14A, pp. 4-16) and since industrial noise tends to be predominantly low-frequency, (Ex. 26-2, pp. 34-35; Ex. 266A, pp. 77-78) it is important to assess the relative contribution of low-frequency noise in order to select an appropriate hearing protector. As explained in the Introduction, the sound level meter's C-weighting network does not discriminate against (filter out) low-frequency noise, whereas the A-weighting network discriminates strongly against low-frequency noise. Thus, taking the difference between C-weighted and A-weighted sound levels is a simple method of assessing the relative contribution of low frequencies in a given noise spectrum. This method was advocated in a study submitted by DuPont Company (Ex. 188-27, part 4, p. 447) in which Dr. R. Waugh pointed out that the same ear protector could provide 20 dB more attenuation of noise with one frequency spectrum than with another. Dr. Waugh recommended selecting ear protectors according to the difference obtained by subtracting the

A-weighted noise level from the C-weighted level.

NIOSH and EPA also found the difference between C-weighted and A-weighted noise levels to be useful for purposes of hearing protector selection (Ex. 321-14A, p. 28; Ex. 314, p. 561B). OSHA also recognizes the value of this approach, and recommends a method that incorporates it, which is EPA's Noise Reduction Rating (NRR) (Ex. 314). EPA requires all manufacturers of hearing protectors to label the package with the appropriate NRR for that protector. The regulation, 40 CFR Part 211, became effective Sept. 27, 1980 (44 FR 56130, 1979).

Appendix G requires the use of the NRR or one of three NIOSH methods. OSHA recommends the NRR since it is simple to use, and it appears to have been reasonably and thoughtfully developed (see NIOSH Ex. 321-14A, and EPA Ex. 314). The NRR concept has been adopted by another Federal agency (the EPA), and the NRR will appear on the label of all hearing protectors manufactured in the United States. Once the NRR of a protector is known, the employer needs to relate the NRR (or a reduction factor determined by one of the NIOSH methods), to an individual worker's exposure to assess the adequacy of the hearing protector for that individual.

Use of the NRR to predict the sound level at the ear drum is dependent upon knowledge of the C-weighted sound level to which the worker is exposed. The NRR is to be subtracted from the C-weighted sound level in the employee's environment. Since sound levels usually fluctuate throughout the day, it is necessary to obtain a C-weighted TWA so that employers can estimate the A-weighted sound level under the protector. The simplest and most efficient way to accomplish this would be to obtain a C-weighted noise dose with a dosimeter. Since contemporary dosimeters do not have C-weighting networks, this method will not be possible unless or until such dosimeters are manufactured and marketed. However, such a method has been included in Appendix G in the event that dosimeters with C-weighting networks become available. In the meantime employers may use the guidelines in Appendix B to calculate C-weighted noise dose, or they may make a correction to the A-weighted dose or TWA to allow for the uncertainty of not knowing the C-weighted exposure level.

OSHA has selected a 7 dB correction factor for cases where the difference between the C-weighted and A-weighted TWA is not known. This correction factor was suggested by

NIOSH for use when information about the spectral distribution of a worker's noise environment was not available. However, the NIOSH report stated that a certain amount of caution should be exercised in using this method in workplaces where the difference between C-weighted and A-weighted sound levels might be greater than 7 dB (Ex. 321-14A, p. 31). Thus, when employers are aware of significant amounts of low-frequency noise, they are advised to take C-weighted measurements to make sure that the 7 dB correction factor is sufficient. To make the correction, 7 dB is subtracted from the NRR, and the remaining NRR value is subtracted from the A-weighted TWA in order to estimate the A-weighted sound level under the ear protector. When dosimeters are used, dose must be converted to TWA before the subtraction can be made. Appendix A, II, provides tables with which this conversion can easily be made.

As an alternative, employers may actually measure the employee's C-weighted exposure levels. They are advised to take these measurements whenever the noise is predominantly low-frequency, or whenever exposure levels are fairly high (i.e., above 95 dB). Employers should use temporal sampling procedures such as those described in Appendix B, but they may not need to take as many samples. If employers already have taken the required number of A-weighted measurements with a sound level meter, it is usually necessary only to take a few C-weighted measurements in order to obtain a good estimate of the average C-weighted sound level in each time segment. If employers have not already taken A-weighted measurements with a sound level meter, (in other words if they have used an A-weighted dosimeter), more measurements may be necessary in order to obtain a good estimate of the C-weighted TWA. Then the 8-hour time-weighted average of each segment's C-weighted sound levels must be computed using Figure B-5 in Appendix B and Table G-16a, or an equivalent method. Finally, the NRR is subtracted from the C-weighted TWA to obtain the estimated A-weighted TWA under the employee's ear protector. OSHA has not specified the exact number of measurements needed in order to estimate the level under the ear protector. However, the Agency believes that employers should attempt to assess the C-weighted exposure levels as accurately as possible.

In some instances employers may choose to use a method other than the NRR. For example, an employer may

want to use a protector that is not manufactured in the United States, or a protector that for some reason does not bear the NRR label on the package. Or the noise may have an unusual spectrum, which the employer wants to evaluate by octave-band analysis. In these cases employers may use any of the three methods developed by NIOSH described in the "List of Personal Hearing Protectors and Attenuation Data," by Kroes, Fleming and Lempert, HEW Publication No. 76-120, 1975 (Ex. 321-14A). The NIOSH method #1 is the most complex, but is likely to be the most accurate method since it uses the largest amount of information from the frequency spectrum of the worker's environment.¹² It requires data for each octave band. As with the use of the NRR, employers should be careful to take enough measurements so that a representative sample is obtained for each identified time segment. When using the NIOSH methods the reduction factor, or "R" factor needs to be calculated. Since this "R" factor is already included in the NRR, use of the NRR should be more convenient. Also, OSHA recommends the NRR for the sake of uniformity as well as for simplicity.

Elliot Berger, manager of Acoustical Engineering at the E-A-R Corporation, noted that the real world performance of hearing protectors is significantly overrated by the manufacturer's laboratory data, reflected by the NRR (Ex. 321-35, p. 1). Mr. Berger noted that the NRR incorporates certain corrections that are intended to ensure that 98 percent of the population who "correctly" wear the device in 98 percent of the industrial noise environments will achieve the protection indicated by the NRR (Ex. 321-35D, p. 3). However, Berger cited studies by NIOSH (Ex. 308), Padilla (Ex. 301), Regan (Ex. 300A), and the National Acoustic Laboratory of Australia (Ex. 321-35F), which show that the NRR value is not usually realized in actual use. This occurs because the NRR does not make allowances for improper fitting, for unusually shaped ear canals, or for highly unusual noise spectra.

OSHA recognizes that the NRR is based on laboratory data taken according to standardized procedures in standardized conditions (Ex. 311). At the time of testing the plugs and muffs are new, and they are fitted carefully. Unfortunately, hearing protectors are used in conditions that are less

favorable than laboratories. Field tests have revealed that workers receive far less attenuation from several types of earplugs than is predicted by the laboratory test methods. A NIOSH report, for example, found that "half of the workers tested were receiving less than one-third of the potential attenuation of the hearing protectors in terms of noise reduction in dBA" (Ex. 308, p. iii). The report attributed the reduced protection to workers wearing the wrong size plugs and inserting their plugs improperly. In a similar study, Padilla (Ex. 301, p. 35) also concluded that the average earplug was worn incorrectly and suggested a test by which employers could monitor the attenuation of plugs in field use.

A study submitted by Dr. Donald Regan also found that devices worn in the occupational setting showed significantly less attenuation than the manufacturers estimated. Dr. Regan concludes: "The results of this investigation emphasize the 'false sense of safety' that management, industrial consultants, and particularly the individual who is wearing the device is assuming, if they conclude they are being adequately protected from the possibility of hearing loss." (Ex. 300A, p. 91).

As a result of this information OSHA urges employers to use extra caution in the initial selection and fitting of ear protectors so that protectors will fit comfortably, yet snugly, and so that workers will be skilled in refitting and caring for them.

Fitting

The fitting of hearing protectors must be done very carefully. Workers shall be trained in the care and fitting of the protectors, and employers must supervise their use.

Suggestions for proper fitting procedures were offered to the hearing record. Dr. Harold R. Imbus, medical director of Burlington Industries stated:

It is often little understood that ear canal size can vary on the same individual. We have often found it necessary to use two different sizes of plugs in order to get the proper fit in each ear. We instruct the employee to return to the nurse's office immediately should any unusual soreness develop, because a refitting with a different type of plug may be necessary. (Tr. 3463-3464).

According to Dr. Royster:

It is not sufficient to simply make available ear protection; the company must make sure that the fitting is done by someone trained in the issuing of ear protectors. This individual, nurse, technician, etc., should be under the supervision of the company doctor, local doctor, (or) audiologist. (Ex. 2C-16B, p. 27).

There was a great deal of comment recommending that trained persons fit hearing protective devices, especially if the protector is custom molded (Ex. 2C-16B, p. 27; Ex. 58, p. 3; Ex. 321-28A-2, p. 12; Ex. 75-5, p. 24). The Agency believes that any trained person, such as most nurses and technicians, will be able to fit ear protection adequately, so long as training on the subject has been included in their short courses, and they are well acquainted with the relevant audiological and/or industrial hygiene literature.

If proper precautions are taken, and if workers and management approach the problem in a spirit of cooperation, noise induced hearing loss should be greatly reduced. Comment and testimony by Dr. Karh of DuPont Corp. (Tr. 2237; Ex. 306, p. 1), Dr. Sataloff (Ex. 321-53, pp. 5-6), Dr. von Gierke (Tr. 755), and Dr. Kryter (Tr. 794), indicated that well managed hearing protector programs can be extremely effective in conserving workers' hearing. However, employers should not lose sight of the fact that the current standard, 29 CFR 1910.95 (a), requires them to control noise by engineering or administrative means whenever feasible. True cooperation between labor and management is most likely to occur when workers know that management is making every attempt to eliminate the hazard, and that personal protective equipment is a temporary rather than a long term solution.

Observation of Monitoring

Section 8(c)(3) of the Occupational Safety and Health Act requires OSHA to issue regulations for keeping records on employee exposures to toxic materials or harmful physical agents, "which are required to be monitored or measured under section 6." The Act goes on to say, "Such regulations shall provide employees or their representatives with an opportunity to observe such monitoring and measuring, and to have access to the records thereof." Since the hearing conservation amendment requires some monitoring of employee noise exposure, the amendment requires employers to provide workers with an opportunity to observe the process of noise exposure monitoring. The Agency believes that workers who observe the monitoring of their exposures will gain insight into the nature and extent of the noise hazard, and will become more involved in the hearing conservation program. This involvement should increase the motivation for the proper use of ear protection, and thereby increase the effectiveness of the program.

The hearing conservation amendment requires employers to provide monitored

¹² NIOSH developed two additional methods. NIOSH method #2 is very similar to the NRR and method #3 is similar to the NRR plus correction factor, which is described above.

employees or their representatives an opportunity to observe any noise exposure measurements that are conducted for compliance with the amendment. Employees may desire to have someone else observe the monitoring, such as a union health and safety representative. Under certain circumstances, an outside professional may be allowed to observe. Although employers are not obligated to notify workers of the intention to monitor in advance, the Agency recommends that they do so whenever possible.

Without interfering with the monitoring, observers are entitled to receive an explanation of the procedures, observe all the steps related to the noise measurements (with the exception of any calculations made away from the workplace), and record the results.

OSHA received some comments objecting to the observation of monitoring provisions in the proposal. For example, John Harris of the J. I. Case Company (Tr. 2611), stated that observation of monitoring would not prevent occupational hearing loss, but on the contrary would take time, manpower, and money away from the hearing conservation efforts. However, many commenters favored the concept of employee observation. Mr. Ahern of General Motors Corp. (Ex. 14-883, p. 10) said, "We recognize of course, that under 8(c)(3) of the Occupational Safety and Health Act an employee or his duly authorized representative has the right to observe monitoring under certain circumstances." Mr. Bonney of Alcoa (Ex. 14-969, p. 2) stated that "under the OSH Act employees were given the right to observe measuring or monitoring. We certainly cannot take exception to this."

Most of the objections implied that the requirements would be burdensome or disruptive. In response to these comments OSHA has made certain changes to the proposed standard that should make the requirements somewhat easier for employers to implement.

The proposal required employers to give written notice of scheduled monitoring at least 3 days before the event was to occur by posting a notice to this effect in a place regularly visited by employees. One reason why the Agency had proposed this requirement was that in certain circumstances the employees might have a desire to have someone with knowledge of noise measurement present to observe the monitoring. However, such a person might not be on the premises and it might take some time to get there. The proposal also allowed employers to require employees to give written

notification of their intent to observe the monitoring. This was an attempt to eliminate any disruption that might ensue in the event that a number of employees decided spontaneously to exercise their right to observe the monitoring.

Many commenters objected to the requirement for advance notification. Seymour Epstein of the Aluminum Association stated:

We cannot take exception to the employees' right to observe monitoring. However, we strongly object to the requirement for posting notice of opportunity to observe the monitoring at least three working days before this is scheduled to occur and listing the time and place where the monitoring will occur. We feel this is unrealistic, will unnecessarily restrict the activities of industrial hygienists in the plant and will place an undue burden on their efforts. (Ex. 14-952, p. 2)

Mr. Harris (Tr. 2613) agreed, and described the conditions that might make advance notification impractical or even impossible: changes in production, breakdowns, shutdowns, failures of measurement equipment, or other such factors might suddenly alter the monitoring schedule. Other commenters suggested that only one day's advance notification should suffice (Ex. 14-169, p. 2; Ex. 59, p. 5; Ex. 14-290, p. 5).

On the basis of the argument presented by Mr. Harris and others, OSHA has decided that advance notification might be difficult for some employers. Therefore the Agency recommends rather than requires advance notice. In addition, the Agency recognizes that such requirements as posting advance notice and allowing the employer to require a response in writing from employees may constitute unnecessary paperwork, and employers may need to retain some flexibility in how best to inform employees of monitoring plans. OSHA does believe that it is helpful for workers or their representatives to know about the monitoring in advance so that they may plan their schedules accordingly.

A number of comments suggested that the observation provisions would be disruptive to the production process and to the monitoring itself.

Mr. Cornell of the Gypsum Association (Tr. 2664) suggested that all workers might exercise their rights to observe, and in that case no one would be available to operate the machinery in question. David Anderson of the Bethlehem Steel Corp. (Ex. 14-347, p. 3) suggested that employees might actually interfere with the monitoring process by stopping work. M. V. Truss of the Vulcan Materials Co. (Ex. 14-58, p. 3)

believed that if employees stopped work and watched the monitoring it would be too expensive for the company. For these reasons some industry spokesman suggested that only employee representatives (and not employees) be allowed to observe the monitoring process (Ex. 14-58, p. 3; Ex. 14-290, p. 4).

The Agency understands that in some circumstances a cessation of work might cause the noise levels to change, and it would not be in the interest of either the worker or the employer to take measurements under conditions that did not reflect the employee's true exposure. For reasons such as these, the amendment (as did the proposal) specifies that observation shall be permitted so long as it does not interfere with the monitoring process.

OSHA does not expect that employee observation of monitoring will be disruptive of the production process or the monitoring itself. While the precise method in which this employee right is exercised will vary from workplace to workplace, it is expected that, in most cases, employees will select a single representative to act as an observer. This observer will receive the explanation of the process, observe the calibration of equipment, its placement, and the actual sampling, and report to other employees. The observer may also record the results of the monitoring. It has been OSHA's experience in the context of other health standards that the observation of monitoring by a representative employee successfully implements this provision without undue disruption. In any event, the employee right to observe monitoring must be tempered with "standard of reasonableness," and observation which seriously disrupts production or the sampling itself is not permitted.

Training Program

Section 6(b)(7) of the Occupational Safety and Health Act indicates that standards shall prescribe appropriate forms of warning to insure that employees are apprised of all hazards to which they are exposed. The final standard requires that employers provide workers whose exposures equal or exceed a TWA of 85 dB with a training program that explains the purposes and major components of the hearing conservation program. As part of employee training, the employer also has the responsibility of making certain materials and information, such as the hearing conservation amendment, available to employees.

The proposal required employers to train workers initially in the use of hearing protectors, and to reinstruct employees in the use of hearing

protectors whenever employees incurred a significant threshold shift in hearing. Also the requirement for warning signs and for notification of exposure, which were included in the proposal, are considered elements of worker training. The amendment retains and clarifies these provisions (see discussion under specific subject headings). In addition, the final rule includes a separate training section with more detailed guidance than was found in the proposal. Employees must be trained according to these new requirements at least once a year, so that they will be reminded on a regular basis of the hazardous effects of noise, and the respective roles of management and workers in preventing these effects. Annual audiometric tests should be an opportune time to conduct such training programs.

It should be noted that the entire training program does not have to be accomplished at one session. For example, employers who have safety meetings biweekly may wish to work some elements of the training requirements into general safety meetings. Workers may have been given a brief overview before starting a job, with supplementary information provided later. It is not the intention of this amendment to impose a rigid and formal training program on employers. Rather, the amendment gathers in one place all of the elements deemed necessary for a good training program and allows the employer maximum flexibility in deciding how best to impart the information to the noise-exposed workers.

The new training requirements are in direct response to the many comments in the record emphasizing the importance of training and education to the success of the hearing conservation program (Ex. 75-10, p. 3; Ex. 102, Attach. 4, pp. 4-6, and Attach. 5, p. 3; Ex. 321-1, Attach. 1, p. 3; Ex. 75, p. 11; Ex. 75-2, p. 125; Ex. 306, pp. 2-3 and p. J 2 C; Ex. 307, p. 1; Ex. 2C-16A, p. 6; Ex. 305, p. 7; Ex. 147C, p. 335; Ex. 147A, p. 6; Tr. 3269, 3140; Tr. 3504-3505; Tr. 2528-2529). For example, an article submitted by Dr. M. Thomas Summar (Ex. 147A, p. 4) states that, "Personal counseling with employees and visits to work areas are necessary and important parts of the program. Some of these visits coincide with the yearly monitoring hearing tests . . ." C. Edward Scott and Dr. Royster (Ex. 102, p. 12) maintain that "continuing education should be used as a means for improving the quality of the program whenever it is found necessary."

Although the amendment does not dictate the content of employers'

training programs, certain subject areas must be included. First, workers must be informed of the requirements of the noise standard and the hearing conservation amendment. So that they are aware of the extent of the hazard, workers must be told about the effects of noise on hearing. Workers must be told to report any symptoms of TTS, such as not being able to hear very well after the end of the workshift. This is so that employers can identify TTS and implement prompt protective measures. Workers must also be told about other effects, such as speech and signal masking, which may cause a safety hazard.

So that employees can better understand the nature of their own particular noise exposures, the training program must include a discussion of specific machinery at the job site that causes hazardous exposures, including information on any noise control compliance plan in effect. An integral part of the training program is a complete discussion of hearing protectors, the advantages and disadvantages of various types, and clear instructions on the selection, fitting, use, and care of the protectors. Finally, so that employees are motivated to take the hearing test and to refrain from non-occupational noise exposure before baseline and recheck audiograms, the program must include an explanation of the purpose of audiometric testing, and of the test procedure.

Employers must post a copy of the standard and amendment in a location where employee notices are customarily posted, and they must make a copy of the standard and amendment available to employees exposed to a TWA of 85 dB or above, if they should ask for it. This requirement gives workers an opportunity to be fully informed of specific aspects of the amendment, and should provide workers with access to this information in cases where they might be afraid or reluctant to ask management for a copy. Employers must also provide these employees with any informational materials supplied by OSHA, which are meant to be distributed to affected employees. Lastly, employers must provide copies of their training materials to OSHA if they are requested to do so. This is intended to provide an objective check of compliance with the requirements of this section of the amendment.

Many comments to the record supported the concept of training programs, and emphasized the importance of motivating employees to play an active role in the hearing

conservation program. As Dr. Karrh of DuPont pointed out:

Our experience has shown that maximum effectiveness of hearing conservation results when employees understand the reasons for the program and cooperate and take initiative in its implementation and conduct on a daily basis. This cooperation is accomplished by educating them regarding the potential effects of exposure to high noise levels whether encountered at work or during leisure hours. (Ex. 306, p. 3).

Training programs are also important at the supervisory level. Personnel who conduct the training program must be well versed in all aspects of the company's hearing conservation program, so that they are prepared to answer employees' questions (Ex. 102, Sec. 5, pp. 9, 27-29). Involvement of first-line supervisors would be particularly effective. As stated by Scott and Royster, "the success of the hearing conservation program in each working area will in the end depend upon the willingness of the local supervisor to support the program and enforce its requirements." (Ex. 102, Sec. 5, p. 9). DuPont and several other companies have demonstrated that imagination, discipline, and commitment from the highest levels of management are qualities that will promote successful programs (Ex. 75-5, p. 21; Ex. 75, p. 122; Ex. 307, p. 1; Ex. 102, Sec. 5, pp. 10, 15). Simply informing workers to use hearing protectors so they "won't go deaf" is not enough.

Morrill (Ex. 305, p. 7) stressed the importance of worker education in overcoming workers' objections to wearing hearing protectors. A number of comments indicated that workers are reluctant to appear weak or ridiculous as a result of wearing personal protection (Ex. 321-13C, p. 738; Ex. 75-7, p. 20; Ex. 75-5, p. 22; Ex. 75-12, p. 24). According to Dr. Roger Maas (Ex. 75-2, p. 2) "Supervisors must sell employees on the need and value of hearing protection devices. When employees understand what the protective measure is for, it will be accepted because the employee realizes it is for his own good." Labor leadership, such as union health and safety committees, can also play an active, supportive role in answering on-the-job questions, seeing that their members are fitted satisfactorily, and encouraging workers to wear protectors.

Employers are advised to use audiologists, otolaryngologists, or industrial hygienists to aid in the training of employees. They are not required to do so because these personnel may not always be available. However, the instructor should be capable of addressing any questions on

the technical, procedural, or health aspects of hearing conservation. Also, the instructor should be well versed in all aspects of hearing protectors since employees are likely to have many questions on the subject. One person does not have to perform all of the training. Different aspects of the training may be done by a variety of people with knowledge of various aspects of the hearing conservation program.

The employer is free to structure the training program any way he or she pleases as long as it contains the specific topics discussed above. Several commenters (Ex. 102, Attach. 3, p. 5, and Attach. 4, pp. 6, 12; Ex. 2C-16B, p. 17; Ex. 75-2, p. 125; Ex. 75-3, p. 6; Ex. 75-10, p. 3) offered suggestions. They recommended that companies (and also unions) regularly distribute informative literature to employees, provide periodic audiovisual presentations, hang posters and use bulletin board displays, and put articles on noise hazards and hearing protection in the company or union magazine. Audiovisual materials can often be obtained from Federal and State health agencies, insurance companies, trade union and professional associations, hearing protector and audiometric equipment suppliers, educational institutions, individual medical practitioners, and audiological consulting firms.

To summarize, good training means clear content, well presented by an informed and sympathetic person, who is willing to spend the time and effort to motivate employees to participate actively in the hearing conservation program. The final element is the behavior, and implicitly the attitude, of management. According to Dr. Thomas, who submitted extensive materials to the record:

Several companies have gone to considerable expense in developing and implementing a hearing conservation program only to end up with what can properly be called a second rate program. Why? . . . Lack of support by top management . . . Why spend several thousand dollars implementing the program if MR. BIG is going to walk through the plant without wearing his protective equipment. Even if the amount of exposure expected is insignificant the attitude given is what counts. MR. BIG, regardless of his position in the company, must also abide by the rules and by example educate the employees. (Ex. 2C-16, pp. IV-5).

Warning Signs

The proposal required that clearly worded warning signs be posted at the entrances to or on the periphery of areas where employees' exposures exceed the prescribed limits. These signs were to be large enough so as to be easily read by employees working in this area. The

warning sign was to indicate that the area is a high noise area, and it was to specify the protective actions (usually ear protectors) that are necessary.

The final standard requires warning signs in those areas where exposures equal or exceed a TWA of 85 dB. This represents the action level for the initiation of the hearing conservation programs, and it is consistent with the concept to have warning signs in such environments.

Most entries to the hearing record favored the use of warning signs (Ex. 105, p. 8; Ex. 132, p. 6; Ex. 58, p. 2; Ex. 2C-1, p. 11 and 12; Ex. 2C-125-1, p. 9; Ex. 14-984, p. 6). Some commenters believed that the requirements for notification of exposure and posting of warning signs were redundant (Ex. 14-346, p. 4; Ex. 14-333, p. 5). The Agency believes that the requirement is not redundant with the notification of employee exposure because exposure notification occurs approximately every two years, while the warning sign presents a constant reminder that a hazard exists, and that protective action may be needed.

Certain witnesses, such as Dr. Ward (Ex. 64-6, pp. 1-2), brought up the fact that warning signs are necessarily stationary and describe noise levels, whereas OSHA regulates noise exposures for workers who move around. OSHA recognizes this problem. For this reason OSHA advises employers to post signs in areas where employees' noise exposures regularly rather than occasionally meet or exceed 85 dB. Also, the Agency is aware that not all workers who are exposed to a TWA above 85 dB are required to wear hearing protectors. Therefore the Agency advises employers to specify mandatory ear protectors on the sign in locations where employees' noise exposures are routinely above 90 dB, and in areas where employee's exposures are between 85 and 90 dB employers may specify that hearing protectors are advised, or may be needed.

Some comments recommended that OSHA put specific wording for signs into the regulation (Ex. 1, p. 1-9; Ex. 48, p. 9; Ex. 110, p. 4), or provide examples of clearly worded signs (Ex. 14-152, p. 4). Although the Agency believes that employers should be free to devise their own wording, the following examples are suggested:

In work areas where employee exposure routinely exceed a TWA of 90 dB:

WARNING
HAZARDOUS NOISE AREA

Hearing Protection

Required

In work areas where employee exposures routinely exceed a TWA between 85 and 90 dB:

WARNING
HAZARDOUS NOISE AREA

Hearing Protection

May be Necessary

OSHA has not prescribed the specific wording for the warning signs. It is desirable to retain as much flexibility as possible so that employers may devise signs that are appropriate to the specific workplace environment.

Recordkeeping

Section 8(c)(1) of the Occupational Safety and Health Act gives OSHA the authority to require employers to maintain records that are: "Necessary or appropriate for the enforcement of this Act, or for developing information regarding the cause and prevention of occupational accidents and illnesses." Section 8(c)(3) requires OSHA to "issue regulations requiring employers to maintain accurate records of employee exposures to potentially toxic materials or harmful physical agents which are required to be monitored or measured under section 6."

The hearing conservation amendment requires that records of noise exposure measurements, audiometric testing and audiometer calibration be maintained. These recordkeeping requirements have been approved by the Office of Management and Budget (Approval No. 44-R 1622).

Noise exposure records require the date, location, and results of the measurements, including the number of measurements made when sound level meters are used. Although the latter requirement did not appear in the proposal, this provision provides further clarification of the proposal's requirement that the employer keep an accurate record of all noise exposure measurements. The number of sound level meter measurements is required to be recorded in order to show that the sampling procedures have been sufficient to give a reasonable estimate of the TWA for the range of noise levels encountered. The final rule also requires a description of the equipment used and the date of the most recent laboratory-type calibration. The name and job classification must be recorded for each employee measured, and for any other employees represented by the measured employee. Although not specified in the proposal, an entry for job classification (or job title) has been added so that employers and employees may see the important connection between job location and magnitude of exposure. The requirement to record the social security number has been eliminated as unnecessary paperwork unless the employer desires to keep it. Records of noise exposure monitoring must be kept for at least 2 years. This represents a relaxation of the proposal's requirement, which was to keep noise exposure records for at least 5 years. Since the employee's most recent noise exposure must be recorded on the audiometric test record, OSHA feels that it is unnecessary to keep records of noise exposure monitoring for longer than 2 years, after which they may be replaced by new monitoring records.

Records of audiometric tests must include the employee's name and job classification. They must also include the date of the audiometric test, the examiner's name and qualifications, the make and model of the audiometer, and the date of the last acoustic or exhaustive audiometer calibration. These requirements are essentially the same as those of the proposal, except for the inclusion of job classification and the deletion of social security number for the reasons stated above. The Agency has added a requirement to record the employee's most recent noise exposure (or that of the employee's representative) on the audiogram record. This will aid employers and professional reviewers in making important associations between noise exposure and hearing loss, and will permit monitoring records to be disposed of at an earlier date. Also, the amendment

requires that employers indicate on the audiometric test record whether the background noise levels in the audiometer room met the levels specified on Table D-1 or Table D-2 in Appendix D. This information will be very useful to the professional reviewer, who needs to know that the audiometric test was carried out in sufficiently quiet conditions. As required in the proposal, audiometric test records must be retained for the duration of employment plus 5 years.

OSHA recommends that employers record the type of hearing protector selected, its attenuation (usually the NRR), and the procedure used to determine its attenuation, which involves identifying the method selected from Appendix G. This entry, coupled with the exposure measurement, would be useful to employers and professional reviewers in assessing the adequacy of hearing protection. However, OSHA has not made this provision a requirement because employers must provide workers with a variety of ear protectors, and workers may want to use certain protectors on a trial basis. The Agency does not want to restrict the flexibility with which employers offer and employees choose their hearing protection by requiring employers to record the make of protector before the final choice is made.

The requirements for keeping records of audiometer calibration are the same as those specified by the proposal. The record must include information on the type of calibration, whether an acoustic or exhaustive calibration, and the date the calibration was performed. The record must also include the numerical results of the acoustical calibration, which are the results of the measurements taken. These records will provide employers and professional reviewers with evidence of the proper functioning of the audiometer, and any steps that were taken to correct improper functioning. As required in the proposal, they must be kept for a minimum of 5 years.

Although the proposal did not contain this requirement, employees must record measurements of the background sound pressure levels in the audiometric test room and the date of these measurements. The Agency believes that this information must be recorded because it is critical to the requirement that valid audiograms be made. Sound pressure level measurements of audiometric test rooms must be kept at least 5 years.

OSHA has included a new requirement for the transfer of records in case an employer should cease to do business. If a new employer takes over

the business the old employer must transfer the records to the new employer. This provision, which is added to safeguard the records, also is found in other OSHA standards.

Discussion in the hearing record centered on the usefulness of keeping records, the impact of recordkeeping on the affected businesses, the retention period, access to records, and recordkeeping procedures.

Some commenters questioned the usefulness of keeping records. M. V. Truss, Director of Engineering at the Vulcan Material Company (Ex. 14-58, p. 2) was joined by others (Ex. 14-86, p. 2; Ex. 14-35, p. 1) in saying that disruptive paper work would seem to outweigh any theoretical benefits. Others maintained that recordkeeping requirements have no bearing on the reduction of noise levels or on hearing loss (Ex. 14-129, p. 3; Ex. 14-190, p. 1; Ex. 14-246, p. 5; Ex. 14-791, pp. 1-2). Carroll Rogers Jr., President of the Feldspar Corporation (Ex. 14-28, p. 1), was among those who believed that the provisions would be too burdensome, especially for small business (Ex. 14-72, p. 1; Ex. 14-117, p. 1; Ex. 14-201, p. 1; Ex. 14-215, p. 4; Ex. 14-266, p. 2; Ex. 14-292, pp. 2-3).

OSHA understands that recordkeeping can be problematic; however, without this requirement the effectiveness of the amendment would be impaired. Professional reviewers need to make sure that the audiometric tests were carried out under proper conditions and that audiograms reflect employees' true hearing levels. Records are educational for employees because they enable employees to assess the continuing status of their hearing. In addition, they provide employers with a way of assessing the success or failure of the hearing conservation program.

Some industry spokesmen suggested that records should not have to be kept for short-term employees. The National Association of Manufacturers (Ex. 14-864, p. 20), and the Beet Sugar Development Foundation and the United States Beet Sugar Association (Ex. 14-867, p. 3, p. 34) suggested that records should only be kept for employees who have worked continuously for more than 180 days, whereas the National Canners Association (Ex. 188-4, p. 6) suggested 120 days. The Can Manufacturers Institute (Ex. 14-862, p. 23) thought that employees should have worked at least 1 year before records should be kept. Although no recordkeeping exemptions have been specified, OSHA believes that short-term employees should not present a significant recordkeeping problem. Audiometric testing of short-term workers is not required unless they remain at work longer than 4 months.

Since employers must monitor new employees within 60 days of exposure to a TWA of 85 dB or greater, they may have to keep noise exposure records of short-term employees. In most cases, as explained earlier, a new employee will assume a position occupied by a former employee, and therefore the former employee's noise exposure will be attributed to the new employee. Making and retaining the same information for the new employee should not be a difficult matter. Also, since the amendment permits employers to monitor representative employees rather than all employees, this procedure should reduce the recordkeeping burden in many cases. Employers may choose to write the exposure level, names, and jobs of the represented employees all on one record. Employers must, however, record the most recent exposure measurement on each individual's audiometric test record.

Following the recommendation of the Advisory Committee (Ex. 2 B, p. 17) the proposal required noise exposure measurements to be maintained for 5 years, audiometric records to be maintained for 5 years. Many comments to the record discussed this issue. Some, such as those of Dr. Ward (Ex. 64-9, p. 5), Robert Richards of the Consumers Power Company (Ex. 14-332, p. 5), and others (Ex. 14-348, p. 3, Ex. 14-329, p. 3), indicated that the proposed record retention periods were too long and too costly. Edwin Hood of the Shipbuilders Council of America (AC 53-1, p. 3) suggested that the employer determine the length of the retention period but that all records be kept for at least 5 years. On the other hand, Frank Fitzsimmons of the International Brotherhood of Teamsters (Ex. 81A, p. 9) advocated a longer retention period for exposure records, stating that exposure records should be kept for the same amount of time as audiometric records so that the relationship between noise exposure and hearing loss can be reviewed. NIOSH recommended a 10-year retention period for records of exposure monitoring, 20 years for audiometric records, and 20 years for audiometric calibration records. NIOSH's recommendations were supported by Raelyn Janssen of the Environmental Defense Fund (AC 125-1, p. 11) and by Dr. J. Ronald Bailey, Assistant Professor of Mechanical Engineering at the North Carolina State University (AC 33, p. 10). Dr. Victor Gladstone, Assistant Professor of Audiology at Towson State College (AC 31, p. 3) concurred with NIOSH, but recommended that if an employee remained in the same employment for a

period longer than 20 years, audiometric records should be kept for the duration of employment.

OSHA has considered these recommendations and agrees with Mr. Fitzsimmons that both noise exposure measurements and audiometric test records should be retained at least for the duration of employment to enable employers and professional reviewers to follow the employee's audiometric thresholds in relation to the employee's noise exposure levels. This procedure has been accomplished (and simplified) by the requirement to record the employee's latest noise exposure level on the audiometric test record. OSHA believes that it is not necessary to keep the details of the noise measurements, such as a description of the equipment and the date of calibration, longer than 2 years, at which time they may be replaced by new measurements. However, the Agency does see the value in keeping audiometric test records and the employee's exposure levels for the duration of employment plus 5 years in order to ascertain the employee's sensitivity to noise exposure, and to judge the effectiveness of the hearing conservation program.

A minimum of 5 years was selected for the retention of audiometric calibration records and records of the sound pressure levels in audiometric test rooms. These durations are necessary so that employers and professional reviewers may be assured that a series of audiograms was carried out under proper test conditions.

Requirements for access to records are essentially the same as those of the proposal, with the exception that the proposal required employers to furnish copies of audiometric data upon written request by employees. The amendment specifies written requests only when employees designate another person to receive the records. The Agency does not believe that written requests are necessary for direct employee access to either noise monitoring or audiometric test records. The amendment requires employers to make records available, upon request, to the Assistant Secretary of Labor and his or her respective authorized representatives, including compliance officers. Copies of records must be made available to affected (noise-exposed) employees and former employees. If an employee or former employee should present a written request, employers must also furnish the records to any person designated by the employee, such as a physician, lawyer, or union representative. Since employees are granted access to their records, OSHA advises them to take

copies with them when they leave their jobs.

OSHA's standard entitled "Access to Employee Exposure and Medical Records" (29 CFR 1910.20 (d)(i) and (ii)) requires that employee medical records be preserved and maintained for at least the duration of employment plus 30 years, that exposure records be preserved and maintained for at least 30 years, and that calibration records (which would be covered by section (d)(ii) (A), "background data") be retained for 1 year. However, the standard provides that it may be superseded by other health standards that require longer or shorter retention periods. According to the standard's preamble, the reason for the 30-year or longer retention period was the long latency periods associated with certain occupational diseases. The Agency recognizes, however, that specific substances or agents may merit longer or shorter record retention periods, in which case an individual standard's recordkeeping requirements would supersede those of 29 CFR 1910.20. This provision in the access standard is appropriate since each health standard is based on rulemaking evidence specific to the substance or agent being regulated (45 FR 35270). Since the hearing conservation amendment has undergone the rulemaking procedure on issues that are specific to noise, some provisions in the amendment are different from those in the access standard.

OSHA believes that it is unnecessary to require retention of noise exposure and audiometric test records for periods as long as 30 years. In the event that some companies and consulting firms wish to computerize these records and retain them indefinitely, the Agency would encourage this practice. However, the latency for noise-induced hearing loss is not nearly as long as it is for certain other occupational diseases, such as cancer. Although the onset of noise-induced hearing loss is gradual, its progress is not expected to continue after cessation of exposure. Therefore a long record-retention period would not aid in the diagnosis of a condition, or in the identification of a hazard that is not already recognized.

The standard also requires that employees, their designated representatives, the Assistant Secretary for Occupational Safety and Health shall have access to all records required to be maintained. In general, the employer is obliged to provide access to such records at a reasonable time, place and manner. Specifics regarding the

provision of such access are found at 29 CFR 1910.20 and 29 CFR 1913.10.

It is the Agency's belief that providing employees with access to the records is a necessary component of the hearing conservation program. Such access will serve to educate employees as to the state of their hearing and the effectiveness of the program, and will encourage their conscientious participation in it. The information in the records will be invaluable to the Assistant Secretary in the enforcement of the amendment and will be useful in research into the effects of occupational noise exposure. The Director of NIOSH will also be primarily interested in the records for research purposes.

A number of commenters, such as Moyer B. Edwards of the Alabama By-Products Corporation (Ex. 14-972, p. 6), recommended restricting access to records to the employee's physician or other medical representative (Ex. 145, p. 5). Others (Ex. 233, p. 1; Ex. 14-900, p. 9; Ex. 14-965, p. 6; Ex. 14-890, p. 5) believed that because of the technical nature of the data, lay readers might misinterpret their files. Douglass Brackett of the Southern Furniture Manufacturers Association (Ex. 14-918, p. 17) and others (Ex. 14-345, p. 4) contended that records only should be made available for some justifiable reason. Lockheed-California Company (Ex. 14-312, p. 2) suggested that records should be available for exposure studies only. Some were concerned that employee access to records might result in "misuse of records" in worker compensation cases (Ex. 14-88, p. 2; Ex. 14-107, p. 1; Ex. 14-233, p. 1; Ex. 14-262, p. 3; Ex. 14-333, p. 6), and some suggested that workers might "harass" employers after they see their records (Ex. 14-107, p. 1; Ex. 14-233, p. 1; Ex. 14-262, p. 3; Ex. 14-332, p. 5). OSHA believes that proper training and education of employees should prevent misinterpretations or "misuse" of noise exposure or audiometric data. The Agency agrees with the many witnesses who stated that informed workers are better motivated and able to protect themselves, and to effectively participate in the total hearing conservation program (Ex. 305, p. 7; Ex. 306, p. 12c-11; Ex. 321-1, Section 2, p. 3; Ex. 307, p. 1; Tr. 2907). Access to their own noise exposure and audiometric test results is a necessary step in the development of informed workers.

XII. Authority

This document was prepared under the direction of Eula Bingham, Assistant Secretary for Occupational Safety and Health, 200 Constitution Avenue, N.W., Washington D.C. 20210.

Pursuant to sections 6(b) and 8(c) of the Occupational Safety and Health Act of 1970 (84 Stat. 1593, 1599, 29 U.S.C. 655, 657), Secretary of Labor's Order No. 8-76 (41 FR 25059), and 29 CFR Part 1911, Part 1910 of Title 29, Code of Federal Regulations is hereby amended by deleting paragraph (b)(3) of § 1910.95 and adding to § 1910.95 requirements for a hearing conservation program in new paragraphs (c) through (s) plus Appendices A through I.

The provision of the current occupational noise standard requiring employers who have employees exposed over the permissible exposure level to implement a continuing, effective hearing conservation program (§ 1910.95(b)(3)) will remain in effect until the new paragraphs contained in this document actually go into effect. Should the new paragraphs be stayed, judicially or administratively, or should the new paragraphs not sustain legal challenge under section 6(f) of the Act, paragraph (b)(3) of § 1910.95 will remain in effect.

Any petitions for administrative reconsideration of this amendment or for an administrative stay pending judicial review must be filed with the Assistant Secretary of Labor for Occupational Safety and Health within 45 days of the publication of this amendment in the Federal Register. Any petitions filed after this date will be considered to be untimely filed. This requirement is considered essential to permit the Agency to give full consideration to any petition filed and respond in advance of the effective date of the amendment.

Signed at Washington, D.C. this 8th day of January, 1981.

Eula Bingham,

Assistant Secretary of Labor.

1. Paragraph (b)(3) of § 1910.95 is removed.

2. Section 1910.95 is amended by adding new paragraphs (c) through (s) and Appendix A through I to read as follows:

§ 1910.95 Occupational noise exposure. * * * *

(c) *Hearing conservation program.* The employer shall administer a continuing, effective hearing conservation program, as described in paragraphs (c) through (s) of this section whenever employee noise exposures equal or exceed an 8-hour time-weighted average sound level (TWA) of 85 decibels measured on the A scale or, equivalently, a dose of fifty percent. For purposes of the hearing conservation program, employee noise exposures shall be computed in accordance with

Appendix A and Table G-16a, and without regard to any attenuation provided by the use of personal protective equipment.

(d) *Initial determination.* (1) Each employer shall determine if any employee's exposure may equal or exceed an 8-hour time-weighted average of 85 decibels (dB) measured on the A scale. This determination shall be based on all information, observations, or calculations which indicate that employee noise exposures may be at or above that level, including the following:

(i) Any employee exposure measurements which have been taken;

(ii) Any employee complaints which may be attributable to noise exposure;

(iii) Any difficulties in understanding normal conversation in the workplace when the speaker and the listener face each other at a distance of two feet.

(2) This initial determination shall be repeated at least every two years and within sixty days of a change in production, processes, equipment, controls, or personnel which may result in new noise exposures at or above a time-weighted average of 85 decibels.

(e) *Monitoring.* (1) When any information in the initial determination conducted pursuant to paragraph (d) of this section indicates that any employee's exposure may equal or exceed an 8-hour time-weighted average of 85 decibels, the employer shall within 60 days obtain individual or representative exposure measurements for all employees who may be exposed at or above that level.

(2) In cases where a group of employees is engaged in a similar kind of work and has approximately the same noise exposure, the employer may, in lieu of measuring the exposure of each employee, measure only one member of the group. In these cases, the employer shall select for monitoring the employee who is reasonably believed to have the greatest exposure and shall attribute the selected employee's exposure measurement to all employees in the group.

(3) Monitoring of employee noise exposures shall be repeated:

(i) Every two years unless an initial determination conducted pursuant to paragraph (d)(2) of this section or actual exposure measurements indicate that employees are not exposed to a time-weighted average of 85 decibels or greater; and

(ii) Within sixty days of a change in production, processes, equipment, controls, or personnel which may render the attenuation provided by hearing protectors in use inadequate to meet the requirements of paragraph (m) of this section.

(f) *Employee notification.* (1) Within 21 days of monitoring, the employer shall notify, in writing, each employee exposed at or above a time-weighted average of 85 decibels of the results of the monitoring.

(2) Each employee shall be notified of that employee's measured exposure or the representative exposure that is attributed to that employee.

(3) New employees shall be notified of their measured exposure or the exposure attributed to them within sixty days of their first exposure at or above a time-weighted average of 85 decibels.

(g) *Method of measurement.* (1) All employee exposure measurements required by paragraph (e) of this section shall be obtained by the use of noise dosimeters which comply with the provisions of paragraph (g)(1)(i) of this section or sound level meters which comply with the provisions of paragraph (g)(1)(ii) of this section.

(i) *Dosimeters.* Dosimeters shall meet the Class 2A-90/80-5 requirements of the American National Standard Specification for Personal Noise Dosimeters, S1.25-1978, with an operating range of at least 80 dB to 120 dB. Dosimeters shall also meet the performance requirements of Section 7.5 of ANSI S1.25-1978 for a test signal at an average A-weighted sound level of 90 dB having a crest factor of 30 dB.

(ii) *Sound level meters.* Sound level meters shall meet the Type II requirements of the American National Standard Specification for Sound Level Meters, S1.4-1971 (R1976).

(2) Exposure measurements shall accurately reflect employee exposures and shall be conducted in the following manner:

(i) *Dosimeters.* The microphone of the dosimeter shall be placed on the employee's shoulder or head.

(ii) *Sound level meters.* (a) Sound level meters shall be set to the A scale, slow response.

(b) All continuous, intermittent and impulsive sound levels from 80 dB to 130 dB shall be integrated into the computation of time-weighted average.

(c) The employer shall use an appropriate sampling strategy to ensure that accurate results are obtained. The employer may use the sampling procedures given in Appendix B: *Temporal Sampling Procedures for Use with a Sound Level Meter*, which are provided as guidelines for compliance with this provision.

(d) The microphone of a sound level meter shall be positioned not less than two inches nor more than two feet from the worker's ear.

(h) *Calibration of monitoring equipment.* Dosimeters and sound level

meters used to monitor employee noise exposure shall be calibrated as follows:

(1) Before and after each day's measurements, an acoustical calibrator shall be used to verify the accuracy of the measuring equipment.

(2) Whenever acoustical calibration and manual adjustments of the measuring equipment cannot verify the accuracy of the measuring instrument, laboratory calibration shall be performed to ensure conformance with the requirements of ANSI S1.25-1978 or S1.4-1971, as appropriate.

(i) *Observation of monitoring.* (1) The employer shall provide affected employees or their representatives with an opportunity to observe any measurements of employee noise exposure which are conducted pursuant to paragraph (e) of this section.

(2) Without interfering with the monitoring procedures, the observer shall be entitled to:

(i) Receive an explanation of the measurement procedures;

(ii) Observe all steps related to the noise exposure measurements performed at the place of exposure; and

(iii) Record the results obtained.

(i) *Audiometric testing program.* (1) The employer shall establish and maintain an audiometric testing program as provided in this paragraph by making audiometric testing available to all employees whose exposures equal or exceed an 8-hour time-weighted average of 85 decibels.

(2) The program shall be provided at no cost to employees.

(3) Audiometric tests shall be performed by a licensed or certified audiologist, otolaryngologist, or other qualified physician, or by a person who is certified by the Council of Accreditation in Occupational Hearing Conservation, or by an audiometric technician who has satisfactorily demonstrated competence in administering audiometric examinations, obtaining valid audiograms, and properly using, maintaining and calibrating audiometers. A technician who performs audiometric tests must be responsible to an audiologist, otolaryngologist or qualified physician.

(4) All audiograms obtained pursuant to this section shall meet the requirements of Appendix C: *Audiometric Measuring Instruments.*

(5) *Baseline audiogram.* (i) Within 4 months of an employee's first exposure to noise at or above a time-weighted average of 85 decibels, the employer shall establish for each employee so exposed a valid baseline audiogram against which subsequent audiograms can be compared.

(ii) Testing to establish a baseline audiogram shall be preceded by at least 14 hours without exposure to workplace noise.

(a) Hearing protectors shall not be used as a substitute for the requirement that baseline audiograms be preceded by 14 hours without exposure to workplace noise.

(b) The employer shall notify employees of the need to avoid high levels of non-occupational noise exposure during this 14-hour period.

(6) *Annual audiogram.* (i) At least annually after obtaining the baseline audiogram, the employer shall obtain a new audiogram for each employee exposed at or above a time-weighted average of 85 decibels.

(ii) Annual audiometric testing may be conducted at any time during the workshift.

(7) *Evaluation of audiogram.* (i) Each employee's annual audiogram shall be compared to that employee's baseline audiogram to determine if the audiogram is valid and if a significant threshold shift, as defined in paragraph (j)(10) of this section, has occurred.

(ii) Such evaluation shall be performed by an audiologist, otolaryngologist, or qualified physician. The employer shall provide to the person performing this evaluation the following information:

(a) A copy of the requirements for hearing conservation as set forth in paragraphs (c) through (r) of this section.

(b) The baseline audiogram and most recent audiogram of the employee to be evaluated;

(c) Measurements of background sound pressure levels in the audiometric test room as required in Appendix D: *Audiometric Test Rooms.*

(d) Records of audiometer calibrations required by paragraph (k)(5) of this section.

(iii) The audiologist, otolaryngologist, or qualified physician shall also review the audiograms to determine whether any significant threshold shift is work related or whether there is need for further evaluation.

(iv) If the comparison of the audiograms reveals a significant threshold shift as defined in paragraph (j)(10) of this section, a retest to obtain a new audiogram shall be performed within 60 days to determine if the shift is permanent.

(a) Retesting shall be preceded by at least 14 hours without exposure to workplace noise.

(b) Hearing protectors shall not be used as a substitute for the requirement that retesting be preceded by at least 14 hours without exposure to workplace noise.

(c) Retesting is not required if the annual audiogram was obtained after 14 hours without exposure to workplace noise. In this case the significant threshold shift revealed by the annual audiogram shall be considered permanent.

(d) If retesting also reveals a significant threshold shift as defined in paragraph (j)(10) of this section, the significant threshold shift shall be considered permanent.

(8) *Follow-up procedures.* If a comparison of the annual audiogram to the baseline audiogram indicates a significant threshold shift as defined in paragraph (j)(10) of this section, the employer shall ensure that the following steps are taken:

(i) Employees not using hearing protectors shall be fitted with hearing protectors, trained in their use and care, and required to use them.

(ii) Employees already using hearing protectors shall be refitted and retrained in the use of hearing protectors and provided with hearing protectors offering greater attenuation if necessary.

(iii) If retesting of an employee reveals that the significant threshold shift is not permanent, the use of hearing protectors by that employee may be discontinued, unless the employee is required to wear hearing protectors pursuant to paragraph (b)(1) of this section.

(iv) If a significant threshold shift has been determined to be permanent on the basis of a retest audiogram or an annual audiogram conducted after 14 hours without exposure to workplace noise, the employer shall:

(a) Inform the employee in writing, within 21 days of the determination, of the existence of a permanent significant threshold shift;

(b) Refer the employee for a clinical audiological evaluation or an otological examination, as appropriate, if additional testing is necessary to determine the cause of the permanent significant threshold shift, or if the employer suspects that a medical pathology of the ear (as defined in Appendix I) is caused or aggravated by the wearing of hearing protectors;

(c) Inform the employee of the need for an otological examination if a medical pathology of the ear which is unrelated to the use of hearing protectors is suspected; and

(d) Record the existence of the permanent significant threshold shift on the OSHA Form 200 when the audiologist, otolaryngologist or qualified physician who reviews the audiogram determines that the shift is work related.

(9) *Revised baseline.* An annual or retest audiogram shall be substituted for

the baseline audiogram under the following circumstances:

(i) Where the annual or retest audiogram reveals a permanent significant threshold shift as defined in paragraph (j)(10) of this section; or

(ii) Where the annual or retest audiogram reveals improved hearing thresholds with respect to the baseline at two or more test frequencies.

(10) *Significant threshold shift.* As used in this section, a significant threshold shift is:

(i) A change in hearing threshold relative to the baseline audiogram of 20 dB or greater at any test frequency other than 500 Hz in either ear, if no previous audiograms have thresholds that exceed 25 dB with reference to audiometric zero as specified by American National Standard S3.6-1969; or

(ii) A change in hearing threshold relative to the baseline audiogram of 10 dB or greater at 1000 or 2000 Hz, 15 dB at 3000 or 4000 Hz, or 20 dB at 6000 Hz, in either ear, if any previous audiogram has one or more thresholds that exceed 25 dB with reference to audiometric zero; or

(iii) A change in hearing threshold relative to the baseline audiogram of 10 dB or greater at any test frequency other than 500 Hz in either ear, if any previous audiogram has thresholds exceeding an average of 25 dB with reference to audiometric zero at the frequencies 1000, 2000, and 3000 Hz; or

(iv) A change in hearing threshold relative to the baseline audiogram of 10 dB or greater at any test frequency other than 500 Hz in either ear, if the employee has previously suffered one or more permanent significant threshold shifts.

(v) In determining whether a significant threshold shift has occurred, allowance may be made for the contribution of aging (presbycusis) to the change in hearing level by correcting the annual or retest audiogram according to the procedure described in Appendix F: *Calculation and Application of Age Correction to Audiograms.*

(k) *Audiometric test requirements.* (1) Audiometric tests shall be pure tone, air conduction, hearing threshold examinations, with test frequencies including as a minimum 500, 1000, 2000, 3000, 4000, and 6000 Hz. Tests at each frequency shall be taken separately for each ear.

(2) Audiometric tests shall be conducted with equipment that meets the specifications of, and is maintained and used in accordance with, American National Standard Specification for Audiometers, S3.6-1969.

(3) Pulsed-tone and self-recording audiometers, if used, shall meet the requirements specified in Appendix C: *Audiometric Measuring Instruments.*

(4) Audiometric examinations shall be administered in a room meeting the requirements listed in Appendix D: *Audiometric Test Rooms.*

(5) *Audiometer calibration.* (i) The functional operation of the audiometer shall be checked before each day's use by testing a person with known, stable hearing thresholds, and by listening to the audiometer's output to make sure that the output is free from distorted or unwanted sounds. Deviations of more than 5 dB shall require an acoustic calibration.

(ii) Audiometer calibration shall be checked acoustically at least annually in accordance with Appendix E: *Acoustic Calibration of Audiometers.* Test frequencies below 500 Hz and above 6000 Hz may be omitted from this check. Deviations of more than 10 dB necessitate an exhaustive calibration.

(iii) An exhaustive calibration shall be performed at least every two years in accordance with sections 4.1.2; 4.1.3; 4.1.4.3; 4.4.1; 4.4.2; 4.4.3; and 4.5 of the American National Standard Specification for Audiometers, S3.6-1969. Test frequencies below 500 Hz may be omitted from this calibration.

(l) *Hearing protectors.* (1) Employers shall make hearing protectors available to all employees exposed to a time-weighted average of 85 decibels or greater at no cost to the employees. Hearing protectors shall be replaced as necessary.

(2) Employers shall ensure that hearing protectors are worn by all employees:

(i) Who are exposed to a time-weighted average of 85 decibels or greater and who have experienced a permanent significant threshold shift; or

(ii) Who are required by paragraph (b)(1) of this section to wear personal protective equipment.

(3) Employees shall be given the opportunity to select their hearing protectors from a variety of suitable hearing protectors provided by the employer.

(4) The employer shall provide training in the use and care of all hearing protectors provided to employees.

(5) The employer shall ensure proper initial fitting and supervise the correct use of all hearing protectors.

(m) *Hearing protector attenuation.* (1) The employer shall evaluate hearing protector attenuation for the specific noise environments in which the protector will be used by one of the methods described in Appendix G:

Methods for Estimating the Adequacy of Hearing Protector Attenuation.

(2) Hearing protectors must attenuate employee exposure at least to a time-weighted average of 90 decibels as required by paragraph (b) of this section.

(3) For employees who have experienced a significant threshold shift, hearing protectors must attenuate employee exposures to a time-weighted average of 85 decibels or below.

(4) The adequacy of hearing protector attenuation shall be re-evaluated whenever employee noise exposures increase to the extent that the hearing protectors provided may no longer provide adequate attenuation. The employer shall provide more effective hearing protectors where necessary.

(n) *Training program.* (1) The employer shall institute a training program for all employees who are exposed to noise at or above a TWA of 85 dB, and shall ensure employee participation in such program.

(2) The training program shall be repeated annually for each employee included in the hearing conservation program. Information provided in the training program shall be updated to be consistent with changes in protective equipment and work processes.

(3) The employer shall ensure that each employee is informed of the following:

(i) The contents of the noise standard including the hearing conservation program;

(ii) The effects of noise on hearing;

(iii) Specific machinery at the jobsite that could produce hazardous noise exposures;

(iv) The role of engineering and administrative controls in the reduction of noise exposure;

(v) The contents of any noise control compliance plan in effect;

(vi) The purpose of hearing protectors, the advantages, disadvantages, and attenuation of various types, and instructions on selection, fitting, use, and care; and

(vii) The purpose of audiometric testing, and an explanation of the test procedures.

(o) *Access to information and training materials.* (1) The employer shall make available to affected employees or their representatives copies of this standard and shall also post a copy in the workplace.

(2) The employer shall provide to affected employees any informational materials pertaining to this standard that are supplied to the employer by the Assistant Secretary.

(3) The employer shall provide, upon request, all materials related to the

employer's training and education program pertaining to this standard to the Assistant Secretary and the Director.

(p) *Warning signs.* (1) Signs shall be posted at entrances to or on the periphery of all well-defined work areas in which employees may be exposed at or above a TWA of 85 dB.

(2) Warning signs shall clearly indicate that the area is a high noise area and shall indicate that hearing protectors may be required.

(q) *Recordkeeping.* (1) *Exposure measurements.* (i) The employer shall maintain an accurate record of all employee exposure measurements required by paragraph (e) of this section.

(ii) This exposure record shall include:

(a) Name and job classification of the employee measured and of all other employees whose exposure the measurement represents;

(b) The date, location and result of each measurement taken, and the number of measurements where sound level meters are used;

(c) A description of the noise measurement equipment used and the date of its last laboratory calibration.

(2) *Audiometric tests.* (i) The employer shall retain all employee audiograms obtained pursuant to paragraph (j) of this section;

(ii) This record shall include:

(a) Name and job classification of the employee;

(b) Date of the audiogram;

(c) The examiner's name and qualifications;

(d) Manufacturer and model of the audiometer;

(e) Date of the last acoustic or exhaustive calibration of the audiometer;

(f) Employee's most recent noise exposure assessment;

(g) Statement of whether the sound pressure levels in the test room in which the audiogram was taken meet the levels specified in Table D-1 or Table D-2 of Appendix D: *Audiometric Test Rooms.*

(3) *Audiometric test rooms.* (i) The employer shall maintain accurate records of the measurements of the background sound pressure levels in audiometric test rooms.

(ii) This record shall include:

(a) Background sound pressure level measurements at each of the following octave bands: 500, 1000, 2000, 4000, and 8000 Hz; and

(b) Date of measurement.

(4) *Calibration of audiometers.* (i) The employer shall maintain accurate records of all acoustical and exhaustive calibrations of audiometers required to be made pursuant to paragraph (k) of this section;

(ii) This record shall include:

(a) Type of calibration;

(b) Date performed; and

(c) Numerical results of the acoustical calibration.

(5) *Record retention.* The employer shall retain records required in this paragraph (q) for at least the following periods:

(i) Noise exposure measurement records shall be retained for 2 years.

(ii) Audiometric test records shall be retained for the duration of the affected employee's employment plus 5 years.

(iii) Records of background sound pressure levels in audiometric test rooms shall be retained for a period of 5 years.

(iv) Records of audiometer calibrations shall be retained for a period of 5 years.

(6) *Access to records.* All records required by this section shall be provided upon request to employees, former employees, representatives designated by the individual employee and the Assistant Secretary. The provisions of 29 CFR 1910.20(a)-(e) and (g)-(i) apply to access to records under this section.

(7) *Transfer of records.* If the employer ceases to do business, the employer shall transfer to the successor employer all records required to be maintained by this section, and the successor employer shall retain them for the remainder of the period prescribed in paragraph (q)(5) of this section.

(r) *Appendices.* (1) Appendices A, C, D, E, G, and I to this section are incorporated as part of this section and the contents of these Appendices are mandatory.

(2) Appendices B, F and H to this section are informational and are not intended to create any additional obligations not otherwise imposed or to detract from any existing obligations.

(s) *Effective dates.* (1) Paragraphs (c)-(r) of this section shall become effective April 15, 1981 unless otherwise noted below.

(2) Initial determinations and subsequent monitoring conducted pursuant to paragraphs (d) and (e) of this section shall be completed by October 15, 1981.

(3) Baseline audiograms required by paragraph (j) of this section shall be completed by April 15, 1982.

(4) In lieu of Table D-1 of Appendix D, background sound pressure levels in audiometric test rooms may conform to Table D-2 of Appendix D until April 15, 1983. After April 15, 1983, background sound pressure levels in audiometric test rooms shall comply with Table D-1 of Appendix D.

(5) Dosimeters used for employee exposure monitoring conducted pursuant to paragraph (e) of this section shall meet the requirements of paragraph (g)(1)(i) of this section by April 15, 1983.

Appendix A: Noise Exposure Computation

This Appendix is Mandatory

I. Computation of Employee Noise Exposure

(1) Noise dose is computed using Table G-16a as follows:

(i) When the sound level, L , is constant over the entire work shift, the noise dose, D , in percent, is given by: $D=100 C/T$ where C is the total length of the work day, in hours, and T is the reference duration corresponding to the measured sound level, L , as given in Table G-16a or by the formula shown as a footnote to that table.

(ii) When the workshift noise exposure is composed of two or more periods of noise at different levels, the total noise dose over the work day is given by: $D=100 (C_1/T_1 + C_2/T_2 + \dots + C_n/T_n)$, where C_n indicates the total time of exposure at a specific noise level, and T_n indicates the reference duration for that level as given by Table G-16a.

(2) The eight-hour time-weighted average sound level (TWA), in decibels, may be computed from the dose, in percent, by means of the formula: $TWA = 16.61 \log_{10} (D/100) + 90$. For an eight-hour workshift with the noise level constant over the entire shift, the TWA is equal to the measured sound level.

(3) A table relating dose and TWA is given in Section II.

Table G-16a

A-weighted sound level, L (decibel)	Reference duration, T (hour)
80	32
81	27.9
82	24.3
83	21.1
84	18.4
85	16
86	13.9
87	12.1
88	10.6
89	9.2
90	8
91	7.0
92	6.2
93	5.3
94	4.6
95	4
96	3.5
97	3.0
98	2.6
99	2.3
100	2
101	1.7
102	1.5
103	1.4
104	1.3
105	1
106	0.87

Table G-16a—Continued

A-weighted sound level, L (decibel)	Reference duration, T (hour)
107	0.76
108	0.66
109	0.57
110	0.5
111	0.44
112	0.38
113	0.33
114	0.29
115	0.25
116	0.22
117	0.19
118	0.16
119	0.14
120	0.125
121	0.11
122	0.095
123	0.082
124	0.072
125	0.063
126	0.054
127	0.047
128	0.041
129	0.036
130	0.031

In the above table the reference duration, T , is computed by

$$T = \frac{8}{2^{(L-90)/5}}$$

where L is the measured A-weighted sound level.

II. Conversion Between "Dose" and "8-Hour Time-Weighted Average" Sound Level

Compliance with paragraphs (c)-(r) of this regulation is determined by the amount of exposure to noise in the workplace. The amount of such exposure is usually measured with an audiodosimeter which gives a readout in terms of "dose." In order to better understand the requirements of the amendment, dosimeter readings can be converted to an "8-hour time-weighted average (TWA) sound level".

In order to convert the reading of a dosimeter into TWA, see Table A-1, below. This table applies to dosimeters that are set by the manufacturer to calculate dose or percent exposure according to the relationships in Table G-16a. So, for example, a dose of 91 percent over an eight hour day results in a TWA of 89.3 dB, and, a dose of 50 percent corresponds to a TWA of 85 dB.

If the dose as read on the dosimeter is less than or greater than the values found in Table A-1, the TWA may be calculated by using the formula: $TWA = 16.61 \log_{10} (D/100) + 90$ where TWA = 8-hour time-weighted average

sound level and D = accumulated dose in percent exposure.

Table A-1.—Conversion From "Percent Noise Exposure" or "Dose" to "8-Hour Time-Weighted Average Sound Level" (TWA)

Dose or percent noise exposure	TWA
10	73.4
15	76.3
20	78.4
25	80.0
30	81.3
35	82.4
40	83.4
45	84.2
50	85.0
55	85.7
60	86.3
65	86.9
70	87.4
75	87.9
80	88.4
81	88.5
82	88.6
83	88.7
84	88.7
85	88.8
86	88.9
87	89.0
88	89.1
89	89.2
90	89.2
91	89.3
92	89.4
93	89.5
94	89.6
95	89.6
96	89.7
97	89.8
98	89.9
99	89.9
100	90.0
101	90.1
102	90.1
103	90.2
104	90.3
105	90.4
106	90.4
107	90.5
108	90.6
109	90.6
110	90.7
111	90.8
112	90.8
113	90.9
114	90.9
115	91.1
116	91.1
117	91.1
118	91.2
119	91.3
120	91.3
125	91.6
130	91.9
135	92.2
140	92.4
145	92.7
150	92.9
155	93.2
160	93.4
165	93.6
170	93.8
175	94.0
180	94.2
185	94.4
190	94.6
195	94.8
200	95.0
210	95.4
220	95.7
230	96.0
240	96.3
250	96.6
260	96.9
270	97.2
280	97.4
290	97.7
300	97.9
310	98.2
320	98.4
330	98.6
340	98.8
350	99.0

Table A-1.—Conversion From "Percent Noise Exposure" or "Dose" to "8-Hour Time-Weighted Average Sound Level" (TWA)—Continued

Dose or percent noise exposure	TWA
360	99.2
370	99.4
380	99.6
390	99.8
400	100.0
410	100.2
420	100.4
430	100.5
440	100.7
450	100.8
460	101.0
470	101.2
480	101.3
490	101.5
500	101.6
510	101.8
520	101.9
530	102.0
540	102.2
550	102.3
560	102.4
570	102.6
580	102.7
590	102.8
600	102.9
610	103.0
620	103.2
630	103.3
640	103.4
650	103.5
660	103.6
670	103.7
680	103.8
690	103.9
700	104.0
710	104.1
720	104.2
730	104.3
740	104.4
750	104.5
760	104.6
770	104.7
780	104.8
790	104.9
800	105.0
810	105.1
820	105.2
830	105.3
840	105.4
850	105.4
860	105.5
870	105.6
880	105.7
890	105.8
900	105.8
910	105.9
920	106.0
930	106.1
940	106.2
950	106.2
960	106.3
970	106.4
980	106.5
990	106.5
999	106.6

Appendix B: Temporal Sampling Procedures for Use With a Sound Level Meter

This Appendix Is Non-Mandatory

Two basic types of equipment permitted are to measure noise exposure for the purposes of paragraphs (c) through (r) of 29 CFR 1910.95: the noise dosimeter and the sound level meter. The sampling procedure for using a sound level meter described below is intended to yield accuracy comparable to that obtained by using a dosimeter meeting the requirements of paragraph

(g)(1)(i) of 29 CFR 1910.95. This accuracy will only be possible when the sampled sound levels are truly representative of the total exposure. 1. Based on the nature of the workplace operations to which the employee is exposed, identify each time period for which the noise exposure is to be determined.

This identification is done by dividing the entire workday into a number of time segments, each having workplace operations where the noise environment is relatively uniform. The noise may vary with time in each time segment but except for periodic variations in sound level associated with the cyclic nature of specific machinery, there is no reason to expect consistently different sound levels in one part of this time segment as opposed to another part.

For example, in a machine shop a worker may spend the early part of the day preparing his particular machine for production and the remainder of the day actually running it. The sound level at the worker's location might exceed 80 dB during the setting up process because of nearby machines already in operation. When his own machine is running, the sound level to which he is exposed could be much greater. During each period the sound levels vary in a characteristic manner. Each of these two time periods (see Figure B-1) would be an identified time segment during which measurements should be made.

As another example, consider a factory where intermittent noise due to operation of a particular machine is superimposed on a fairly steady background noise, so that the sound level varies with time as shown in Figure B-2. The total time that the machine is on can be considered to be one time segment and the total time that the machine is off would be another time segment. The procedure described in Section 2, below, can be used in conjunction with such intermittent noise provided that the times spent in each operating cycle are sufficiently long that the duration of each on-cycle or off-cycle can be easily measured.

As a third example, consider a situation where impulsive sounds due, for example, to mechanical impacts are superimposed on continuous noise as indicated in Figure B-3. The total time that the impulses are well in excess of the general ambient noise can be considered as one time segment and the remainder of the time as another time segment. The procedure described in Section 3, below, can be used in conjunction with impulsive noises or very short bursts of noise.

2. For each time segment for which the noise is essentially continuous,

determine the average sound level in the following manner:

(a) Carry out any necessary calibration to ensure proper and accurate operation of the sound level meter.

(b) Set the controls of the sound level meter for A-weighted SLOW response.

(c) Adjust the controls of the sound level meter so that the highest sound level readings that occur during the time segment will be readable on the meter scale.

(d) With the microphone located in the desired position, read the sound level at intervals and place a checkmark in the appropriate box on the data sheet (Figure B-4). The sound levels should be read to the nearest decibel. The readings may be made at any time interval of 5 seconds or longer. The readings should be instantaneous, i.e., the person taking the data should glance at the indicator of the sound level meter and read it "on the fly" rather than look for maximum or minimum levels or wait for fairly steady levels. If the noise-producing operation is cyclic, care should be taken to avoid reading sound levels at consistent times relative to the cycles in sound level; this may require taking observations at random, rather than at regular time intervals.

(e) If the time interval is not sufficiently long to take 25 readings at intervals of 5 seconds or longer, readings should be taken at 5-second intervals throughout the entire time period and steps (f), (g), and (h) may be omitted.

(f) If, after 25 sound level readings have been taken, the total range of sound levels does not exceed 3 dB, the highest reading obtained may be taken as the effective sound level, and steps (g), (h), and (i) may be omitted.

(g) If, after 25 readings have been taken, the total range of sound levels exceeds 3 dB, the total number of readings that are required is estimated as follows:

(1) On the data sheet (Figure B-4), count down four checkmarks from the top. Draw a horizontal arrow (as shown in the example on Figure B-6) from the ordinate scale marked "A-weighted sound level" to the center of the row in which the fourth checkmark appears.

(2) Count up four checkmarks from the bottom and draw an arrow in line with the center of the row in which the fourth checkmark appears.

(3) Take the difference, in decibels, between the two sound levels (rows) so identified. This is the "spread of levels" to be used below. If the spread of levels from the fourth lowest to the fourth highest exceeds 12 decibels, the identified time segment should be

divided into two or more smaller time segments such that the spread of levels in each time segment will not exceed 12 decibels. If this is not possible, the use of a sound level meter to determine the noise exposure is probably not advisable and a noise dosimeter should be used. (However, see Section 3, below, for circumstances under which transient or impulsive noises may be ignored).

(4) Locate the estimated duration of the time segment on the ordinate scale to the far left on the data sheet. Draw a straight line from this point to the point where the upper arrow (step (1) above) intersects the scale labeled "A-weighted sound level." Draw a second straight line from the point labeled 8 hr on the time segment scale through the intersection of the first line with the "pivot line" located midway between the two scales, extend it to the sound level scale and then draw a horizontal arrow to the right to find the "adjusted upper level."

(5) The total number of sound level readings required is given by the table at the bottom of the worksheet. The columns in this table correspond to different values of the spread of levels (from the fourth lowest to the fourth highest). The three rows correspond, respectively, to the adjusted upper level being less than 85 decibels, between 85 and 90 decibels, and greater than 90 decibels.

(h) If the "adjusted upper level" is less than 80 decibels, the contribution due to the particular time segment may be ignored and no further measurements or calculations for that time segment are required.

(i) If the required number of sound level meter readings is equal to 25, no further sound levels need be read. If the required number is greater than 25, take additional measurements, in accordance with (d), above, until the total number of readings, including the 25 original readings, exceeds the required number. (The checkmarks can be added onto the original data sheet).

(j) Compute the effective sound level using the worksheet (Figure B-5) as follows:

(1) Enter the number of counts per sound level (frequency of occurrence) in Column B. Add them to get Sum B.

(2) Multiply the counts in Column B by the number in Column C and enter the results in Column D.

(3) Add all values in Column D to determine Sum D.

(4) Divide Sum D by Sum B.

(5) Locate the value in Column C that is approximately equal to Sum D/Sum B. The corresponding value in Column A is equal to the effective sound level.

Note.—It may be desirable to use a (pre-programmed) calculator to carry out these steps rather than to use the worksheet. This is quite acceptable so long as the calculation procedure is checked to ensure correctness.

(k) Proceed to carry out steps (a) through (g) as necessary for any other identified time segments.

3. When impulsive noise or short bursts of continuous noise result in large (e.g., 10 decibels or more) increases of short duration in the sound level, care must be taken to determine properly the effective duration of the higher noise level. When such discrete events occur, with a resultant time variation of sound levels such as that shown in Figure B-3, the following procedure may be followed:

(a) Carry out steps (a), (b), and (c) of Section 2, above.

(b) With the microphone located in the desired position, read the maximum sound level indicated on the sound level meter during occurrence of one of the discrete events of interest and place a checkmark in the appropriate box on a data sheet (Figure B-4). The maximum sound levels should be read to the nearest decibel.

(c) Repeat step 3(b) for 25 readings of the maximum sound level.

(d) Compute the maximum effective sound level for these 25 readings using the worksheet (Figure B-5) and the procedures described in Section 2(j), above.

(e) Calculate the sound level that is 6 decibels less than the maximum effective sound level determined in step 3(d); this is designated as the "6-decibel down level."

(f) Determine the effective duration of a transient event as follows: For a minimum of 10 events, use a stop watch or other timing device to measure the time that the sound level is greater than the "6-decibel down level" that was determined in step 3(e). This can be done by noting the 6-decibel down level on the sound level meter and then, for at least 10 events, starting the stop watch when the sound level increases to the 6-decibel down level, allowing the stop watch to run while the sound level is above the 6-decibel down level, and stopping the watch when the sound level falls below the 6-decibel down level. The effective duration of a single event is the arithmetic average of at least 10 durations thereby obtained, rounded up to the next larger integer second.

(g) The duration of the time segment for all similar single events is simply the number of such events multiplied by the effective duration of a single event.

(h) Follow the procedures described in Section 2(g) to determine the total

required number of sound level meter readings, using the duration of the time segment as determined in step 3(g) to enter the left-hand scale of the data sheet (Figure B-4).

(i) If the "adjusted upper level" is less than 80 decibels, the contribution due to the particular time segment may be ignored and no further measurements or calculations for that time segment are required.

(j) If the required number of sound level meter readings is equal to 25, no further readings of the maximum sound level need be taken. If the required number of readings is greater than 25, take additional measurements, in accordance with 3(b), above, until the total number of readings, including the 25 original readings, exceeds the required number.

(k) Compute the effective sound level, using the worksheet (Figure B-5) and the procedure described in Section 2(j), above.

4. The average sound levels thus determined, and the durations for each time segment, should be entered into Table G-16a to compute the total noise dose, and subsequently the 8-hour time-weighted average sound level according to the procedures required by 29 CFR 1910.95(c).

Example for Continuous Noise

(a) Twenty-five sound levels are measured and entered on a data sheet with the results shown in Figure B-6.

(b) Counting down four checkmarks from the top, the number corresponding to the row in which the fourth checkmark appears is 97 decibels. An arrow is placed in line with that row and a dot is drawn where the tail of the arrow intersects the scale labeled "A-weighted sound level."

(c) The duration of the time segment is estimated as 5 hours; a corresponding dot is placed on the (left-hand) time scale on the data sheet.

(d) A straight line is drawn connecting the dot at 5 hours on the time scale and the dot at 97 dB on the sound level scale. A dot is placed where this line intersects the "pivot line" that is parallel to and midway between the two scales.

(e) A straight line (shown dashed in Figure B-8) is drawn from the mark at 8 hours on the time scale through the dot on the pivot line and extended to intersect the sound level meter scale. An arrow (also shown dashed) is drawn from this intersection point to the right—the "adjusted upper level" is found to lie between 93 and 94 decibels.

(f) Counting up four checkmarks from the bottom of the worksheet, the number corresponding to the row in which the fourth checkmark appears is 92 dB.

(g) The difference between this lower level and the (unadjusted) upper level is 5 decibels; from the table at the bottom of the worksheet, it is found that at least 75 sound level readings are required.

(h) Fifty additional sound levels are read and entered onto the data sheet with the results show in Figure B-7; the number of checkmarks in each row is summed and entered in the right hand column.

(i) The sums from the data sheet are transferred to a worksheet and the required calculations are carried out as shown in Figure B-8; the resultant average sound level for the selected time period is found to be 95 dB.

Example for Impulsive Noise

(a) Twenty-five maximum sound levels are measured and entered on a

data sheet with the results shown in Figure B-9.

(b) The sums from this data sheet are transferred to a worksheet as shown in Figure B-10 and the required calculations are carried out. The resultant maximum effective sound level for these impulsive events is found to be 103 dB.

(c) The "6-decibel down level" is thus 97 decibels. Using a stop watch, the time that the sound level exceeds 97 decibels is measured for 10 events; the average effective duration is found to be 3.4 seconds, which is rounded up to 4 seconds.

(d) It is estimated that there are approximately 50 such events during a typical workshift. Thus the duration of the time segment is estimated to be 200 seconds (or 3.3 minutes).

(e) A dot is placed on the time axis on the worksheet at 3.3 minutes and a dot is placed on the sound level axis at 103 decibels. A straight line is drawn between these two dots and a dot is placed where that line intersects the pivot line. A second line (shown dashed in Figure B-9) is drawn from the mark at 8 hours on the time axis through the mark on the pivot line. It is seen that this line would intersect the sound level scale at a location well below 80 decibels. Thus the noise exposure due to the 50 impulse sounds can be ignored and no further measurements or calculations are required. (Note: If the adjusted level had exceeded 80 decibels, the remaining procedure for the impulsive noises would have been the same as for the continuous noise example given above.)

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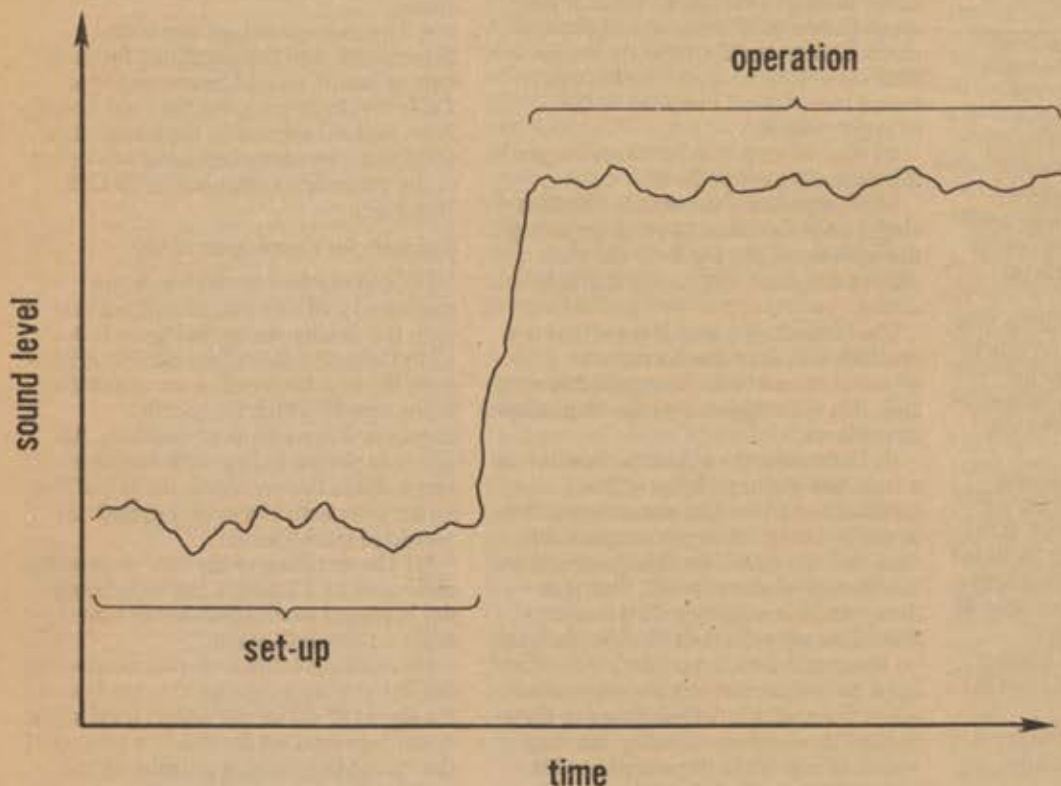


Figure B-1. Example of two discrete time segments.

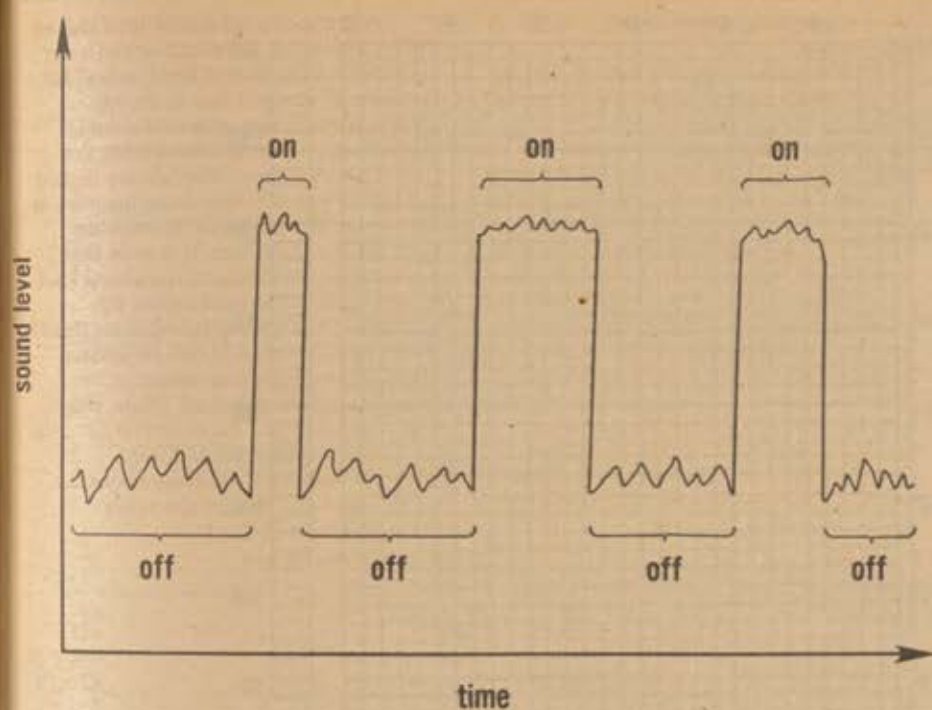


Figure B-2. Example of intermittent noise time segments.

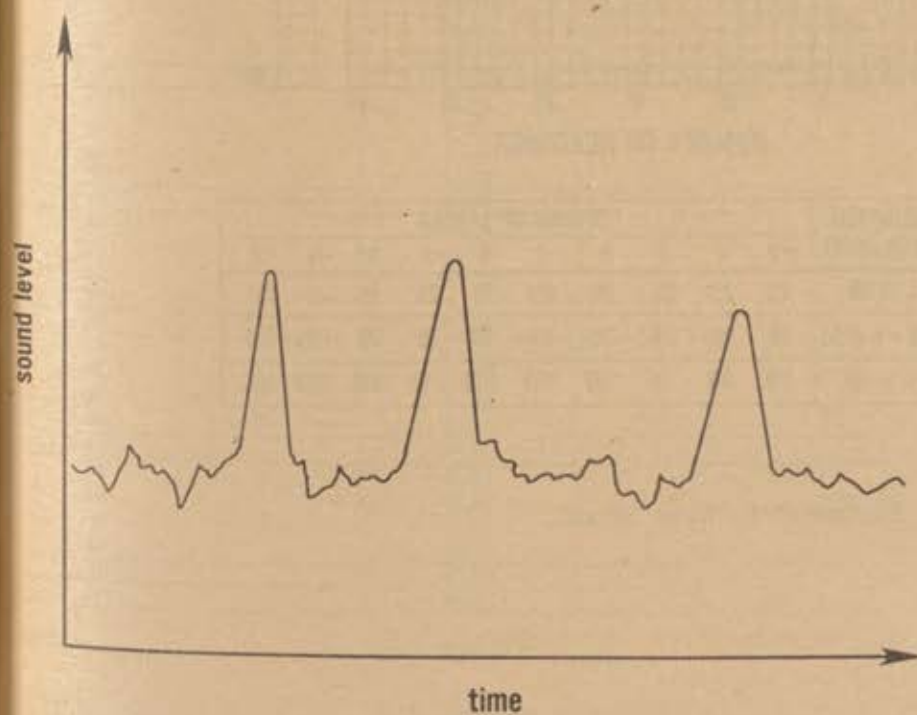


Figure B-3. Example of impulses superimposed on continuous noise.

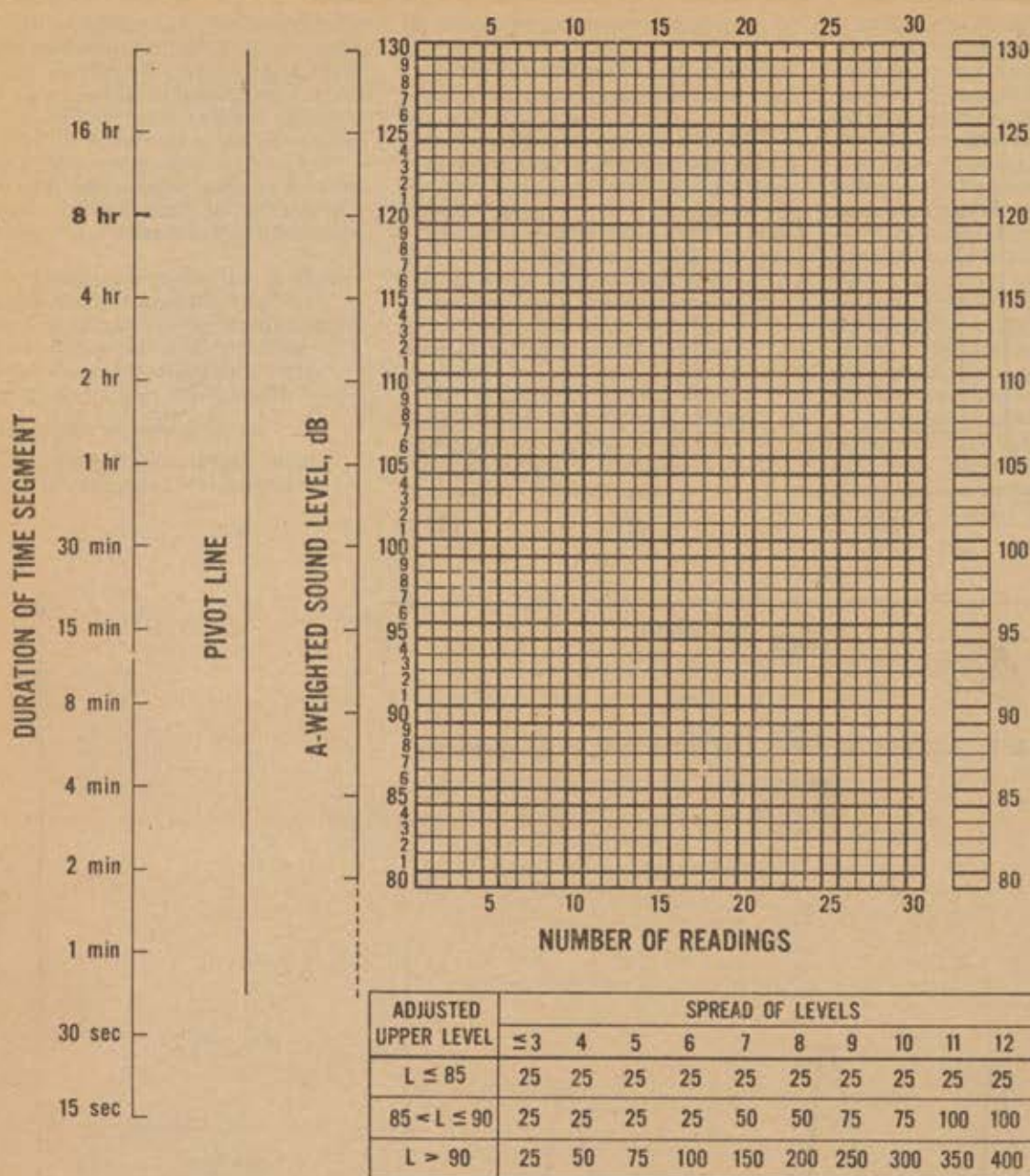


Figure B-4. Data Sheet.

A	B	C	D
SOUND LEVEL dB	COUNT	RELATIVE WEIGHTING	RELATIVE TOTAL WEIGHTING
130 or above	x	256.00	=
129	x	222.86	=
128	x	194.01	=
127	x	168.91	=
126	x	147.03	=
125	x	128.00	=
124	x	111.43	=
123	x	97.01	=
122	x	84.45	=
121	x	73.52	=
120	x	64.00	=
119	x	55.72	=
118	x	48.50	=
117	x	42.22	=
116	x	36.76	=
115	x	32.00	=
114	x	27.86	=
113	x	24.25	=
112	x	21.11	=
111	x	18.38	=
110	x	16.00	=
109	x	13.93	=
108	x	12.13	=
107	x	10.56	=
106	x	9.19	=
105	x	8.00	=
104	x	6.96	=
103	x	6.06	=
102	x	5.28	=
101	x	4.59	=
100	x	4.00	=
99	x	3.48	=
98	x	3.03	=
97	x	2.64	=
96	x	2.30	=
95	x	2.00	=
94	x	1.74	=
93	x	1.52	=
92	x	1.32	=
91	x	1.15	=
90	x	1.00	=
89	x	0.87	=
88	x	0.76	=
87	x	0.66	=
86	x	0.57	=
85	x	0.50	=
84	x	0.44	=
83	x	0.38	=
82	x	0.33	=
81	x	0.29	=
80	x	0.25	=
below 80	x	0.00	= 0.00

Sum B = _____

Sum D = _____

Sum D
Sum B = _____

Average Sound Level = _____

Figure B-5. Worksheet for computing average sound level.

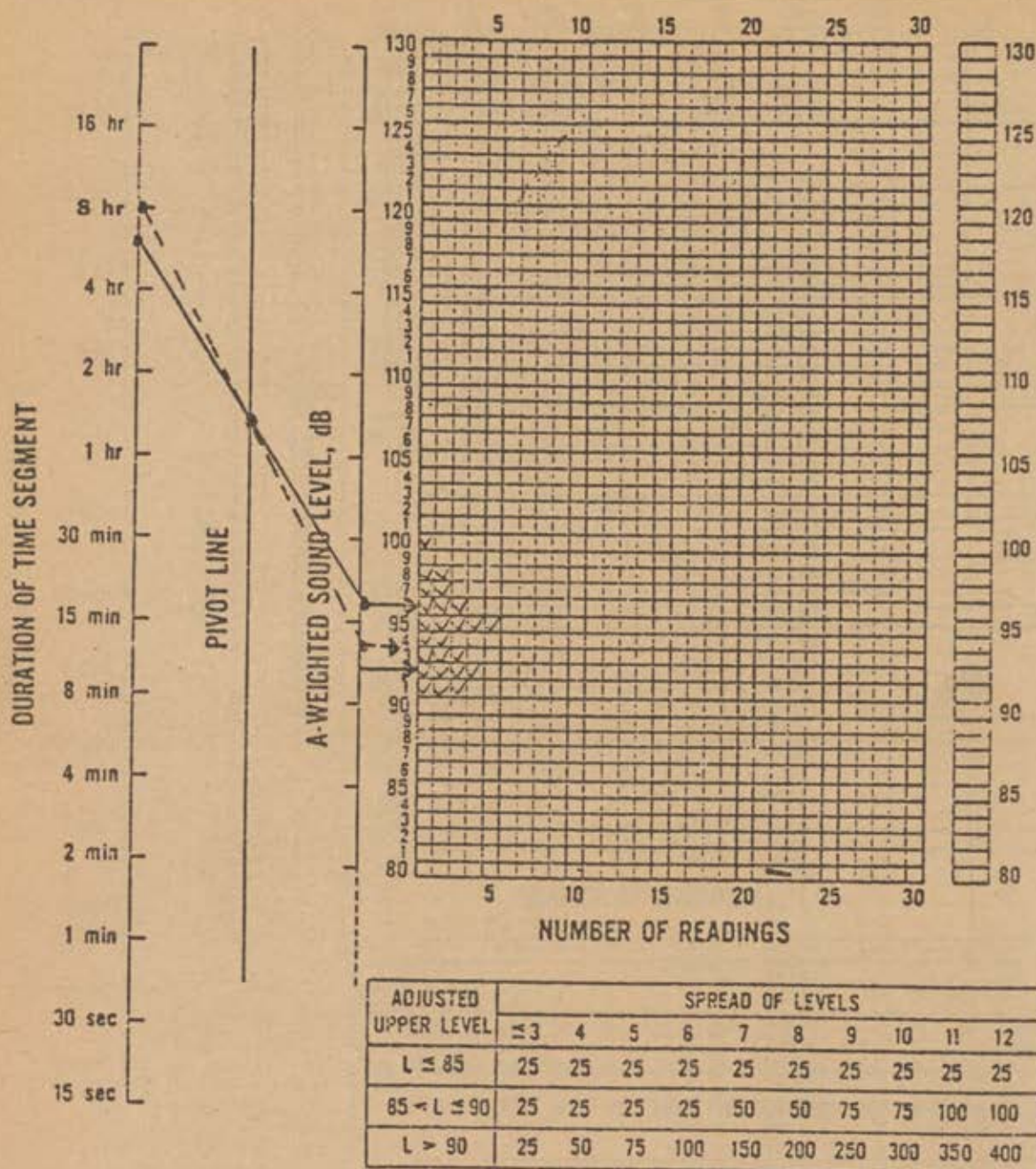


Figure B-6. Sample data sheet.

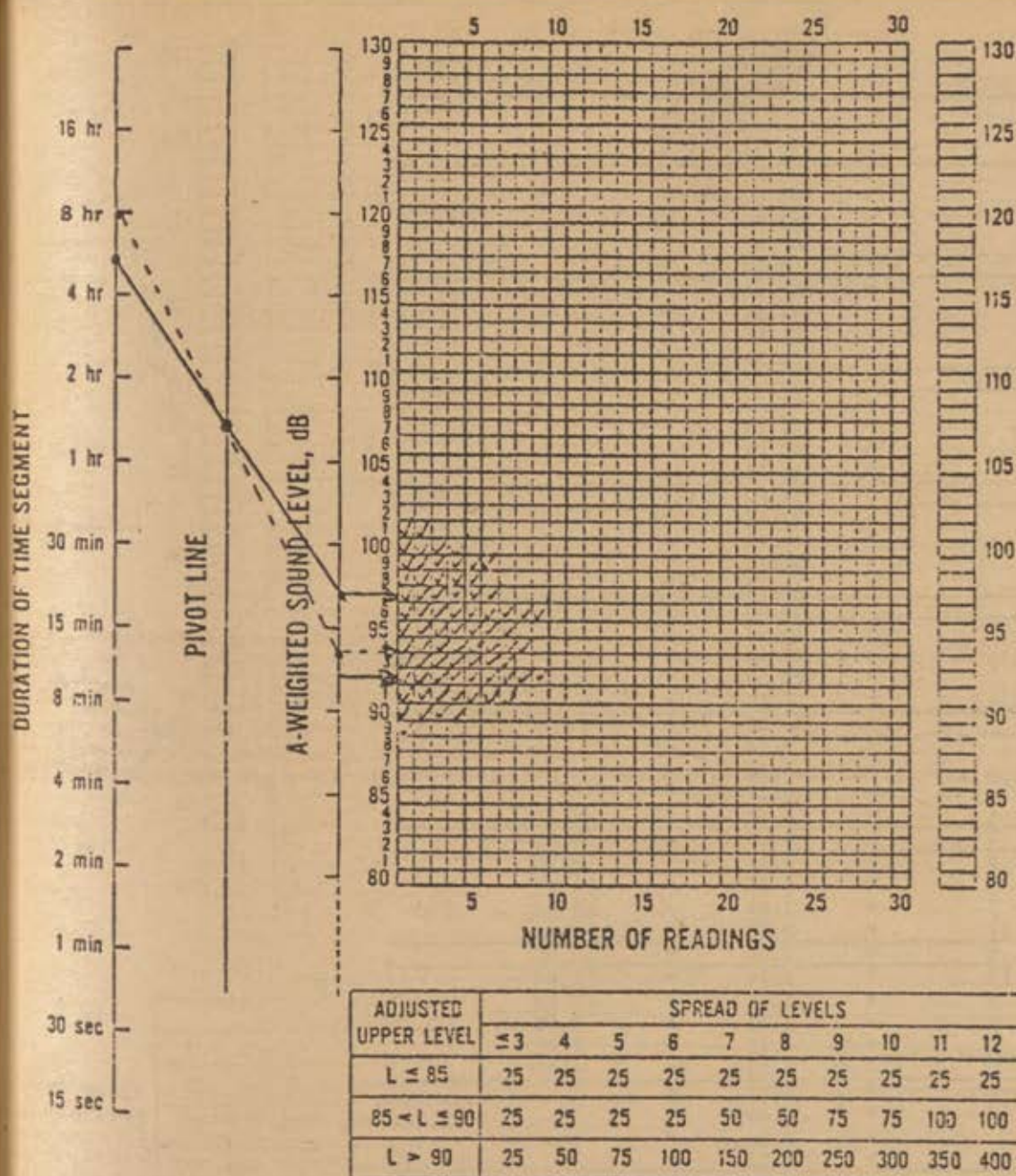


Figure B-7. Sample data sheet.

SOUND LEVEL dB	COUNT	RELATIVE WEIGHTING	RELATIVE TOTAL WEIGHTING
130 or above		x 256.00	=
129		x 222.86	=
128		x 194.01	=
127		x 168.91	=
126		x 147.03	=
125		x 128.00	=
124		x 111.41	=
123		x 97.01	=
122		x 84.48	=
121		x 73.52	=
120		x 64.00	=
119		x 55.72	=
118		x 48.30	=
117		x 42.22	=
116		x 36.76	=
115		x 32.00	=
114		x 27.86	=
113		x 24.25	=
112		x 21.11	=
111		x 18.38	=
110		x 16.00	=
109		x 13.93	=
108		x 12.13	=
107		x 10.56	=
106		x 9.19	=
105		x 8.00	=
104		x 6.96	=
103		x 6.06	=
102		x 5.28	=
101	1	x 4.59	= 4.59
100	2	x 4.00	= 8.00
99	4	x 3.48	= 13.92
98	5	x 3.03	= 15.15
97	7	x 2.64	= 18.48
96	11	x 2.30	= 25.30
95	9	x 2.00	= 18.00
94	12	x 1.74	= 20.88
93	7	x 1.52	= 10.64
92	7	x 1.32	= 9.24
91	6	x 1.15	= 6.90
90	4	x 1.00	= 4.00
89		x 0.87	=
88		x 0.76	=
87		x 0.66	=
86		x 0.57	=
85		x 0.50	=
84		x 0.44	=
83		x 0.38	=
82		x 0.33	=
81		x 0.29	=
80		x 0.25	=
Below 80		x 0.20	= 0.00

Sum B = 75Sum D = 155.00Sum D
Sum B = 2.07Average Sound Level = 95⁺ dB

Figure B-8. Sample worksheet for computing average sound level.

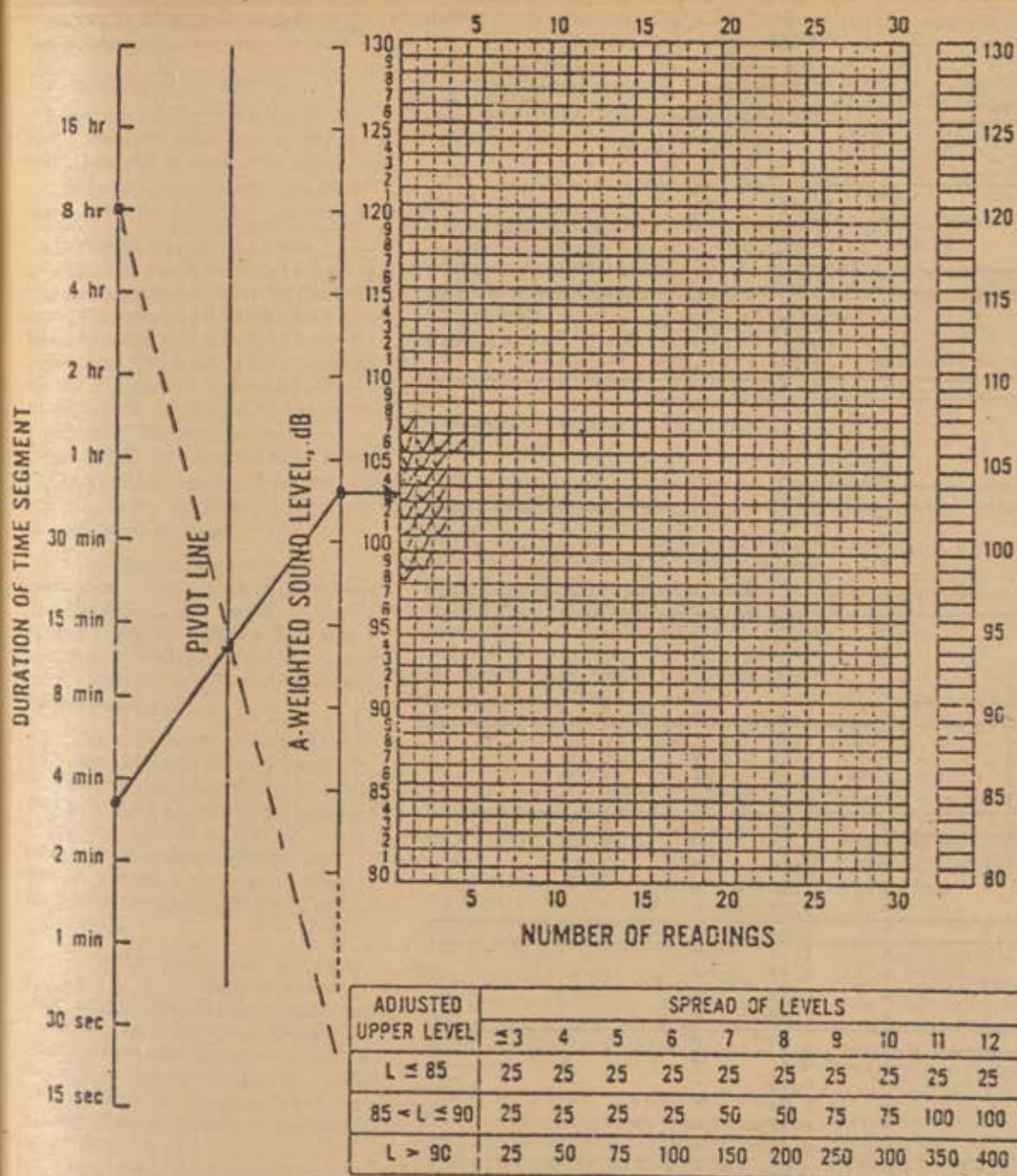


Figure B-9. Sample data sheet.

A	B	C	D
SOUND LEVEL dB	COUNT	RELATIVE WEIGHTING	RELATIVE TOTAL WEIGHTING
130 or above		* 255.00	*
129		* 222.86	*
128		* 194.01	*
127		* 168.91	*
126		* 147.03	*
125		* 128.00	*
124		* 111.43	*
123		* 97.01	*
122		* 84.43	*
121		* 73.52	*
120		* 64.00	*
119		* 55.72	*
118		* 48.50	*
117		* 42.22	*
116		* 36.76	*
115		* 32.00	*
114		* 27.86	*
113		* 24.25	*
112		* 21.11	*
111		* 18.38	*
110		* 16.00	*
109		* 13.93	*
108		* 12.13	*
107	1	* 10.56	10.56
106	4	* 9.19	36.76
105	3	* 8.00	24.00
104	3	* 6.96	20.88
103	3	* 6.06	18.18
102	3	* 5.28	15.84
101	3	* 4.59	13.77
100	2	* 4.00	8.00
99	2	* 3.48	6.96
98	1	* 3.03	3.03
97		* 2.64	*
96		* 2.30	*
95		* 2.00	*
94		* 1.74	*
93		* 1.52	*
92		* 1.32	*
91		* 1.15	*
90		* 1.00	*
89		* 0.87	*
88		* 0.76	*
87		* 0.66	*
86		* 0.57	*
85		* 0.50	*
84		* 0.44	*
83		* 0.38	*
82		* 0.33	*
81		* 0.29	*
80		* 0.25	*
Below 80		* 0.00	0.00

Sum B = 25

Sum D = 157.98

Sum D
Sum B = 6.32Average Sound Level = 103⁺ dB

Figure B-10. Sample worksheet for computing average sound level.

Appendix C: Audiometric Measuring Instruments

This Appendix is Mandatory

1. In the event that pulsed-tone audiometers are used, they shall have a tone on-time of at least 200 milliseconds.

2. Self-recording audiometers shall comply with the following requirements:

(A) The chart upon which the audiogram is traced shall have lines at positions corresponding to all multiples of 10 dB hearing level within the intensity range spanned by the audiometer. The lines shall be equally spaced and shall be separated by at least 1/4 inch. Additional increments are optional. The audiogram pen tracings shall not exceed 2 dB in width.

(B) It shall be possible to set the stylus manually at the 10-dB increment lines for calibration purposes.

(C) The slewing rate for the audiometer attenuator shall not be more than 6 dB/sec except that an initial slewing rate greater than 6 dB/sec is permitted at the beginning of each new test frequency, but only until the second subject response.

(D) The audiometer shall remain at each required test frequency for 30 seconds (± 3 seconds). The audiogram shall be clearly marked at each change of frequency and the actual frequency change of the audiometer shall not deviate from the frequency boundaries marked on the audiogram by more than ± 3 seconds.

(E) It must be possible at each test frequency to place a horizontal line segment parallel to the time axis on the audiogram, such that the audiometric tracing crosses the line segment at least six times at that test frequency. At each test frequency the threshold shall be the average of the midpoints of the tracing excursions.

Appendix D: Audiometric Test Rooms

This Appendix is Mandatory

After April 15, 1983, rooms used for audiometric testing shall not have background sound pressure levels exceeding those in Table D-1 when measured by equipment conforming at least to the Type 2 requirements of American National Standard Specification for Sound Level Meters, S1.4-1971 (R1976), and to the Class II requirements of American National Standard Specification for Octave, Half-Octave, and Third-Octave Band Filter Sets, S1.11-1971 (R1976). Table D-2 may be used until April 15, 1983.

Table D-1.—Maximum Allowable Octave-Band Sound Pressure Levels for Audiometric Test Rooms

Octave-band center frequency (Hz)	500	1000	2000	4000	8000
Sound pressure level (dB)	27	30	35	42	41

Table D-2.—Maximum Allowable Octave-Band Sound Pressure Levels for Audiometric Test Rooms (May be used in lieu of Table D-1 until Apr. 15, 1983)

Octave-band center frequency (Hz)	500	1000	2000	4000	8000
Sound pressure level (dB)	40	40	47	57	62

Appendix E: Acoustic Calibration of Audiometers

This Appendix is Mandatory

Audiometer calibration shall be checked acoustically, at least annually, according to the procedures described in this Appendix. The equipment necessary to perform these measurements is a sound level meter, octave-band filter set, and a National Bureau of Standards 9A coupler. In making these measurements, the accuracy of the calibrating equipment shall be sufficient to determine that the audiometer is within the tolerances permitted by American National Standard Specification for Audiometers, S3.6-1969.

(1) Sound Pressure Output Check

A. Place the earphone coupler over the microphone of the sound level meter and place the earphone on the coupler.

B. Set the audiometer's hearing threshold level (HTL) dial to 70 dB.

C. Measure the sound pressure level of the tones at each test frequency from 500 Hz through 6000 Hz for each earphone.

D. At each frequency the readout on the sound level meter should correspond to the levels in Table E-1 or Table E-2, as appropriate, for the type of earphone, in the column entitled "sound level meter reading."

(2) Linearity Check

A. With the earphone in place, set the frequency to 1000 Hz and the HTL dial on the audiometer to 70 dB.

B. Measure the sound levels in the coupler at each 10-dB decrement from 70 dB to 10 dB, noting the sound level meter reading at each setting.

C. For each 10-dB decrement on the audiometer the sound level meter should indicate a corresponding 10 dB decrease.

D. This measurement may be made electrically with a voltmeter connected to the earphone terminals.

(3) Tolerances

When any of the measured sound levels deviate from the levels in Table E-1 or Table E-2 by ± 3 dB at any test frequency between 500 and 3000 Hz, 4 dB at 4000 Hz, or 5 dB at 6000 Hz, an exhaustive calibration is advised. An exhaustive calibration is required if the deviations are greater than 10 dB at any test frequency.

Table E-1.—Reference Threshold Levels for Telephonics—TDH-39 Earphones

Frequency, Hz	Reference threshold level for TDH-39 earphones, dB	Sound level meter reading, dB
500	11.5	81.5
1000	7	77
2000	9	79
3000	10	80
4000	9.5	79.5
6000	15.5	85.5

Table E-2.—Reference Threshold Levels for Telephonics—TDH-49 Earphones

Frequency, Hz	Reference threshold level for TDH-49 earphones, dB	Sound level meter reading, dB
500	13.5	83.5
1000	7.5	77.5
2000	11	81.0
3000	9.5	79.5
4000	10.5	80.5
6000	13.5	83.5

Appendix F: Calculations and Application of Age Corrections to Audiograms

This Appendix is Non-Mandatory

In determining whether a significant threshold shift has occurred, allowance may be made for the contribution of aging to the change in hearing level by adjusting the most recent audiogram. If the employer chooses to adjust the audiogram, the employer shall follow the procedure described below. This procedure and the age correction tables were developed by the National Institute for Occupational Safety and Health in the criteria document entitled "Criteria for a Recommended Standard . . . Occupational Exposure to Noise," (HSM-11001).

For each audiometric test frequency;

(i) Determine from Table F-1 or F-2 the age correction values for the employee by:

(A) finding the age at which the most recent audiogram was taken and recording the corresponding values of age corrections at 1000 Hz through 6000 Hz;

(B) finding the age at which the baseline audiogram was taken and recording the corresponding values of

age corrections at 1000 Hz through 6000 Hz.

(ii) Subtract the values found in step (i)(A) from the value found in step (i)(B).

(iii) The differences calculated in step (ii) represented that portion of the change in hearing that may be due to aging.

Example: Employee is a 32-year-old male. The audiometric history for his right ear is shown in decibels below.

Employee's age	Audiometric test frequency (Hz)				
	1000	2000	3000	4000	6000
26	10	5	5	10	5
*27	0	0	0	5	5
28	0	0	0	10	5
29	5	0	5	15	5
30	0	5	10	20	10
31	5	10	20	15	15
*32	5	10	10	25	20

The audiogram at age 27 is considered the baseline since it shows the best hearing threshold levels. Asterisks have been used to identify the baseline and most recent audiogram. A threshold shift of 20 dB exists at 4000 Hz between the audiograms taken at ages 27 and 32. (The threshold shift is computed by subtracting the hearing threshold at age 27, which was 5, from the hearing threshold at age 32, which is 25). A retest audiogram has confirmed this shift. The contribution of aging to this change in hearing may be estimated in the following manner:

Go to Table F-1 and find the age correction values (in dB) for 4000 Hz at age 27 and age 32.

	Frequency (Hz)				
	1000	2000	3000	4000	6000
Age 32	6	5	7	10	14
Age 27	5	4	6	7	11
Difference	1	1	1	3	3

The difference represents the amount of hearing loss that may be attributed to aging in the time period between the baseline audiogram and the most recent audiogram. In this example, the difference at 4000 Hz is 3 dB. This value is subtracted from the hearing level at 4000 Hz, which in the most recent audiogram is 25, yielding 22 after adjustment. Then the hearing threshold in the baseline audiogram at 4000 Hz (5) is subtracted from the adjusted annual audiogram hearing threshold at 4000 Hz (22). Thus the age-corrected threshold shift would be 17 dB (as opposed to a threshold shift of 20 dB without age correction).

Table F-1.—Age Correction Values in Decibels for Males

Years	Audiometric Test Frequencies (Hz)				
	1000	2000	3000	4000	6000
20 or younger	5	3	4	5	8
21	5	3	4	5	8
22	5	3	4	5	8
23	5	3	4	6	9
24	5	3	5	6	9
25	5	3	5	7	10
26	5	4	5	7	10
27	5	4	6	7	11
28	6	4	6	8	11
29	6	4	6	8	12
30	6	4	6	9	12
31	6	4	7	9	13
32	6	5	7	10	14
33	6	5	7	10	14
34	6	5	8	11	15
35	7	5	8	11	15
36	7	5	9	12	16
37	7	6	9	12	17
38	7	6	9	13	17
39	7	6	10	14	18
40	7	6	10	14	19
41	7	6	10	14	20
42	8	7	11	15	20
43	8	7	12	16	21
44	8	7	12	17	22
45	8	7	13	18	23
46	8	8	13	19	24
47	8	8	14	19	24
48	9	8	14	20	25
49	9	9	15	21	26
50	9	9	16	22	27
51	9	9	16	23	28
52	9	10	17	24	29
53	9	10	18	25	30
54	10	10	18	26	31
55	10	11	19	27	32
56	10	11	20	28	34
57	10	11	21	29	35
58	10	12	22	31	36
59	11	12	22	32	37
60 or older	11	13	23	33	38

Table F-2.—Age Correction Values in Decibels for Females

Years	Audiometric test frequencies (Hz)				
	1000	2000	3000	4000	6000
20 or younger	7	4	3	3	6
21	7	4	4	3	6
22	7	4	4	4	6
23	7	5	4	4	7
24	7	5	4	4	7
25	8	5	4	4	7
26	8	5	5	4	8
27	8	5	5	5	8
28	8	5	5	5	8
29	8	5	5	5	9
30	8	6	5	5	9
31	8	6	6	5	9
32	9	6	6	6	10
33	9	6	6	6	10
34	9	6	6	6	10
35	9	6	7	7	11
36	9	7	7	7	11
37	9	7	7	7	12
38	10	7	7	7	12
39	10	7	8	8	12
40	10	7	8	8	13
41	10	8	8	8	13
42	10	8	9	9	13
43	11	8	9	9	14
44	11	8	9	9	14
45	11	8	10	10	15
46	11	9	10	10	15
47	11	9	10	11	16
48	12	9	11	11	16
49	12	9	11	11	16
50	12	10	11	12	17
51	12	10	12	12	17
52	12	10	12	13	18
53	13	10	13	13	18
54	13	11	13	14	19
55	13	11	14	14	19
56	13	11	14	15	20
57	13	11	15	15	20
58	14	12	15	16	21

Table F-2.—Age Correction Values in Decibels for Females—Continued

Years	Audiometric test frequencies (Hz)				
	1000	2000	3000	4000	6000
59	14	12	16	16	21
60 or older	14	12	18	17	22

Appendix G: Methods for Estimating the Adequacy of Hearing Protector Attenuation

This Appendix is Mandatory

For employees who have experienced a significant threshold shift, hearing protector attenuation must be sufficient to reduce employee exposure to a TWA of 85 dB. Employers must select one of the following methods by which to estimate the adequacy of hearing protector attenuation.

The most convenient method is the Noise Reduction Rating (NRR) developed by the Environmental Protection Agency (EPA). According to EPA regulation, the NRR must be shown on the hearing protector package. The NRR is then related to an individual worker's noise environment in order to assess the adequacy of the attenuation of a given hearing protector. This Appendix describes four methods of using the NRR to determine whether a particular hearing protector provides adequate protection within a given exposure environment. Selection among the four procedures is dependent upon the employer's noise measuring instruments.

Instead of using the NRR, employers may evaluate the adequacy of hearing protector attenuation by using one of the three methods developed by the National Institute for Occupational Safety and Health (NIOSH), which are described in the "List of Personal Hearing Protectors and Attenuation Data," HEW Publication No. 76-120, 1975, pages 21-37. These methods are known as NIOSH methods #1, #2 and #3. The NRR described below is a simplification of NIOSH method #2. The most complex method is NIOSH method #1, which is probably the most accurate method since it uses the largest amount of spectral information from the individual employee's noise environment. As in the case of the NRR method described below, if one of the NIOSH methods is used, the selected method must be applied to an individual's noise environment to assess the adequacy of the attenuation. Employers should be careful to take a sufficient number of measurements in order to achieve a representative sample for each time segment.

Note.—The employer must remember that calculated attenuation values reflect realistic values only to the extent that the protectors are properly fitted and worn.

When using the NRR to assess hearing protector adequacy, one of the following methods must be used:

(i) When using a dosimeter that is capable of C-weighted measurements:

(A) Obtain the employee's C-weighted dose for the entire workshift, and convert to TWA (see Appendix A, II).

(B) Subtract the NRR from the C-weighted TWA to obtain the estimated A-weighted TWA under the ear protector.

(ii) When using a dosimeter that is not capable of C-weighted measurements, the following method may be used:

(A) Convert the A-weighted dose to TWA (see Appendix A).

(B) Subtract 7 dB from the NRR.

(C) Subtract the remainder from the A-weighted TWA to obtain the estimated A-weighted TWA under the ear protector.

(iii) When using a sound level meter set to the A-weighting network:

(A) Obtain the employee's A-weighted TWA in accordance with a procedure such as the one recommended in Appendix B.

(B) Subtract 7 dB from the NRR, and subtract the remainder from the A-weighted TWA to obtain the estimated A-weighted TWA under the ear protector.

(iv) When using a sound level meter set on the C-weighting network:

(A) Obtain a representative sample of the C-weighted sound levels in the employee's environment for each identified time segment.¹

(B) If there is more than one identified time segment, compute the 8-hour time-weighted average of the C-weighted sound levels using Figure B-5 and Table G-16a or an equivalent method.

(C) Subtract the NRR from the C-weighted average sound level to obtain the estimated A-weighted TWA under the ear protector.

Appendix H: Availability of Referenced Documents

Paragraphs (c) through (s) of 29 CFR 1910.95 and the accompanying appendices contain provisions which incorporate publications by reference. Generally, the publications provide criteria for instruments to be used in monitoring and audiometric testing. These criteria are intended to be mandatory when so indicated in the

¹ Time segments should be identified according to a procedure such as the one recommended in Appendix B, but the same number of measurements may not be necessary to achieve a representative sample.

applicable paragraphs of Section 1910.95 and appendices.

It should be noted that OSHA does not require that employers purchase a copy of the referenced publications. Employers, however, may desire to

obtain a copy of the referenced publications for their own information.

The designation of the paragraph of the standard in which the referenced publications appear, the titles of the publications, and the availability of the publications are as follows:

Paragraph designation	Referenced publication	Available from—
§ 1910.95(g)(1)(i)	"Specification for Personal Noise Dosimeters," ANSI S1.25-1978, (ASA 25-1978).	Back Numbers Department, Dept. STD, American Institute of Physics 333 E. 45th St., New York, NY 10017; American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018.
§ 1910.95(g)(1)(ii)	"Specification for Sound Level Meters," S1.4-1971 (R 1976).	American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.
§ 1910.95(k)(2), appendix E	"Specifications for Audiometers," S3.6-1969.	Back Numbers Department, Dept. STD, American Institute of Physics 333 E. 45th St., New York, NY 10017; American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018.
Appendix D	"Specification for Octave, Half-Octave and Third-Octave Band Filter Sets," S1.11-1971 (R1975).	Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20404.
Appendix G	"List of Personal Hearing Protectors and Attenuation Data," HEW Pub. No. 76-120, 1975.	

The referenced publications (or a microfiche of the publications) are available for review at many universities and public libraries throughout the country. These publications may also be examined at the OSHA Technical Data Center, Room N2439, United States Department of Labor, 200 Constitution Avenue N.W., Washington, D.C. 20210, (202) 523-9700 or at any OSHA Regional Office (see telephone directories under United States Government—Labor Department).

Appendix I: Definitions

These definitions apply to the following terms as used in paragraphs (c) through (r) of 29 CFR 1910.95.

Audiogram—A chart, graph, or table resulting from an audiometric test showing an individual's hearing threshold levels as a function of frequency.

Audiologist—A professional, specializing in the study and habilitation of hearing, who is certified by the American Speech, Hearing, and Language Association or licensed by a state board of examiners.

Baseline audiogram—The audiogram against which future audiograms are compared.

Crest factor—Absolute value of the ratio of the peak value and the root-mean-square value measured over a specified time interval where both values are measured in reference to the arithmetic mean value of the wave.

Criterion sound level—A sound level of 90 decibels.

Decibel (dB)—Unit of measurement of sound level.

Hertz (Hz)—Unit of measurement of frequency, numerically equal to cycles per second.

Medical pathology—A disorder or disease.

For purposes of this regulation, a condition or disease affecting the ear, which should be treated by a physician specialist.

Noise dose—The ratio, expressed as a percentage, of (1) the time integral, over a stated time or event, of the 0.6 power of the measured SLOW exponential time-averaged, squared A-weighted sound pressure and (2) the product of the criterion duration (8 hours) and the 0.6 power of the squared sound pressure corresponding to the criterion sound level (90 dB).

Noise dosimeter—An instrument that integrates a function of sound pressure over a period of time in such a manner that it directly indicates a noise dose.

Otolaryngologist—A physician specializing in diagnosis and treatment of disorders of the ear, nose and throat.

Representative exposure—Measurements of an employee's noise dose or 8-hour time-weighted average sound level that the employers deems to be representative of the exposures of other employees in the workplace.

Sound level—Ten times the common logarithm of the ratio of the square of the measured A-weighted sound pressure to the square of the standard reference pressure of 20 micropascals. Unit: decibels (dB). For use with this regulation, SLOW time response, in accordance with ANSI S1.4-1971 (R1976), is required.

Sound level meter—An instrument for the measurement of sound level.

Time-weighted average sound level—That sound level, which if constant over an 8-hour exposure, would result in the same noise dose as is measured.

(Sec. 4, 6, 8, 84 Stat. 1592, 1593, 1599, (29 U.S.C. 653, 655, 657); Secretary of Labor's Order No. 8-76 (41 FR 25059); 29 CFR Part 1911)

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