[AC–41: OTS No. 3748]

Tri-County Federal Savings & Loan Association, Torrington, WY; Approval of Conversion Application

Notice is hereby given that on August 13, 1993, the Deputy Assistant Director, Corporate Activities Division, Office of Thrift Supervision, or her designee, acting pursuant to delegated authority, approved the application of Tri-County Federal Savings and Loan Association, Torrington, Wyoming to convert to the stock form of organization. Copies of the application are available for inspection at the Information Services Division, Office of Thrift Supervision, 1776 G Street, NW., Washington, DC 20552, and the West Regional Office, Office of Thrift Supervision, 1 Montgomery Drive, suite 400, San Francisco, California 94120.

Dated: August 17, 1993.

By the Office of Thrift Supervision.

Nadine Y. Washington,

Corporate Secretary.

[FR Doc. 93–20271 Filed 8–20–93; 8:45 am]

BILLING CODE 6720–01–M

DEPARTMENT OF VETERANS AFFAIRS

Information Collection Under OMB Review

AGENCY: Department of Veterans Affairs.

ACTION: Notice.

The Department of Veterans Affairs has submitted to OMB the following proposal for the collection of information under the provisions of the Paperwork Reduction Act (44 U.S.C. chapter 35). This document lists the following information: (1) The title of the information collection, and the Department form number(s), if applicable; (2) a description of the need and its use; (3) who will be required or asked to respond; (4) an estimate of the total annual reporting hours, and recordkeeping burden, if applicable; (5) the estimated average burden hours per respondent; (6) the frequency of response; and (7) an estimated number of respondents.

ADDRESSES: Copies of the proposed information collection and supporting documents may be obtained from Janet G. Byers, Veterans Benefits Administration (20A5), Department of Veterans Affairs, 810 Vermont Avenue, NW., Washington, DC 20420 (202) 233–3021.

Comments and questions about the items on the list should be directed to VA's OMB Desk Officer, Joseph Lackey, NEOB, room 3002, Washington, DC 20503, (202) 395–7316. Do not send requests for benefits to this address.

DATES: Comments on the information collection should be directed to the OMB Desk Officer by September 22, 1993.

Dated: August 12, 1993.

By direction of the Secretary.

B. Michael Berger,

Director, Records Management Service.

New Collection

1. Report of Medical, Legal, and Other Expenses Incident to Recovery for Injury or Death, VA Form 21–8416b.

2. The form is used to report expenses incurred by a beneficiary incident to recovery of benefits resulting from an award of compensation for injury or death. The information will be used to determined the correct rate of income-based VA benefits.

3. Individuals or households.

4. 7,500 hours.

5. 45 minutes.

6. On occasion.

7. 10,000 respondents.

[FR Doc. 93–20278 Filed 8–20–93; 8:45 am]

BILLING CODE 8320–01–M

Sunshine Act Meetings

Federal Register
Vol. 58, No. 161
Monday, August 23, 1993

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).

FARM CREDIT ADMINISTRATION

Farm Credit Administration Board; Amendment to Sunshine Act Meeting

SUMMARY: Pursuant to the Government in the Sunshine Act (5 U.S.C. 552b(e)(3)), the Farm Credit Administration gave notice on August 12, 1993 (58 FR 43015) of the regular meeting of the Farm Credit Administration Board (Board) scheduled for August 12, 1993. This notice is to amend the agenda to add an item to the open session of that meeting.

FOR FURTHER INFORMATION CONTACT: Curtis M. Anderson, Secretary to the Farm Credit Administration Board, (703) 883–4003, TDD (703) 883–4444.

ADDRESSES: Farm Credit Administration, 1501 Farm Credit Drive, McLean, Virginia 22102-5090.

SUPPLEMENTARY INFORMATION: Parts of this meeting of the Board were open to the public (limited space available), and parts of this meeting were closed to the public. The agenda for August 12, 1993, is amended by adding the following item to the open session:

OPEN SESSION

B. New Business

2. Other

a. Sole Source Contract for IRM Operations.

Dated: August 19, 1993.

Curtis M. Anderson,

Secretary, Farm Credit Administration Board.

[FR Doc. 93–20493 Filed 8–19–93; 3:12 pm]

BILLING CODE 6705–01–P

SECURITIES AND EXCHANGE COMMISSION

Notice is hereby given, pursuant to the provisions of the Government in the Sunshine Act, Pub. L. 94–409, that the Securities and Exchange Commission will hold the following meetings during the week of August 23, 1993.

Closed meetings will be held on Wednesday, August 25, 1993, at 10:00 a.m. and on Thursday, August 26, 1993, at 10:00 a.m.

Commissioners, Counsel to the Commissioners, the Secretary to the Commission, and recording secretaries will attend the closed meetings. Certain staff members who have an interest in the matters may also be present.

The General Counsel of the Commission, or his designee, has certified that, in his opinion, one or more of the exemptions set forth in 5 U.S.C. 552b(c)(4), (8), (9)(A), and (10) and 17 CFR 200.402(a) (4), (8), (9)(i) and (10), permit consideration of the scheduled matters at closed meetings.

Commissioner Roberts, as duty officer, voted to consider the items listed for the closed meetings in closed session.

The subject matter of the closed meeting scheduled for Wednesday, August 25, 1993, at 10:00 a.m., will be:

Institution of injunctive actions.
Institution of administrative proceedings of an enforcement nature.
Formal order of investigation.
Regulatory matters regarding financial institutions.
Opinion.
Settlement of injunctive action.
Settlement of administrative proceeding of an enforcement nature.

The subject matter of the closed meeting scheduled for Thursday, August 26, 1993, at 10:00 a.m., will be:

Institution of injunctive actions.
Institution of administrative proceedings of an enforcement nature.
Formal order of investigation.
Settlement of injunctive actions.
Settlement of administrative proceeding of an enforcement nature.
Opinions.

At times, changes in Commission priorities require alterations in the scheduling of meeting items. For further information and to ascertain what, if any, matters have been added, deleted or postponed, please contact: Bruce Rosenblum at (202) 272–2300.

Dated: August 19, 1993.

Margaret H. McFarland,

Deputy Secretary.

[FR Doc. 93–20422 Filed 8–19–93; 12:56 pm]

BILLING CODE 8010–01–M

Corrections

Federal Register
Vol. 58, No. 161
Monday, August 23, 1993

This section of the FEDERAL REGISTER contains editorial corrections of previously published Presidential, Rule, Proposed Rule, and Notice documents. These corrections are prepared by the Office of the Federal Register. Agency prepared corrections are issued as signed documents and appear in the appropriate document categories elsewhere in the issue.

DEPARTMENT OF EDUCATION

Advisory Council on Education Statistics; Meeting

Correction

In notice document 93-18881 appearing on page 42056 in the issue of Friday, August 6, 1993, in the second column, under **DATES**, in the first line, "a.m." should read "9 a.m.".

BILLING CODE 1505-01-D

DEPARTMENT OF HEALTH AND HUMAN SERVICES

Health Care Financing Administration

42 CFR Part 433

[MB-062-F]
RIN 0938-AF99

Medicaid Program; Limitations on Provider-Related Donations and Health Care-Related Taxes; Limitations on Payments to Disproportionate Share Hospitals

Correction

In rule document 93-19246 beginning on page 43156 in the issue of Friday, August 13, 1993, make the following corrections.

§ 433.68 [Corrected]

1. On page 43181, in the second column, in § 433.68 (e)(1)(i)(C)(iii), in the second line, " [publication date of this final rule]," should read "August 13, 1993".

2. On the same page, in the second column, in § 433.68 (e)(1)(iii)(B)(*8*)(iv), in the second line, "[publication date of this final rule]," should read "August 13, 1993".

3. On page 43182, in the first column, in § 433.68 (f)(3)(i), in the fourth line, "[30 days after date of publication of this final rule], should read "September 13, 1993".

4. On the same page, in the first column, in § 433.68 (f)(3)(ii), in the first line, "[publication date of this final rule]", should read "August 13, 1993", in the same paragraph, in the second and third lines from the bottom of the page, "[30 days after date of publication of this final rule]", should read "September 13, 1993". In the the second column in the same paragraph, in the first and second lines, "[30 days after date of publication of this final rule]", should read "September 13, 1993".

§ 433.72 [Corrected]

5. On the same page, in the second column, in § 433.72 (c)(1) in the third line, and in (c)(2), in the second line, "[publication date of this final rule]", should read "August 13, 1993".

BILLING CODE 1505-01-D

DEPARTMENT OF THE INTERIOR

Bureau of Land Management

43 CFR Public Land Order 6990

[OR-943-4210-06; GP3-230; OR-48136

Withdrawal of National Forest System Lands to Protect the Rehabilitation Work on the White King and Lucky Lass Uranium Mines; Oregon

Correction

In rule document 93-19012 appearing on page 42245 in the issue of Monday, August 9, 1993 in the second column, in the land description, under T. 37 S., in the first line, "NE¼NE¼." should read "NW ¼NE¼."

BILLING CODE 1505-01-D

Federal Register

Monday
August 23, 1993

Part II

Department of Energy

Office of Energy Efficiency and Renewable Energy

10 CFR Part 430

Energy Conservation Program for Consumer Products; Proposed Rule

DEPARTMENT OF ENERGY

Office of Energy Efficiency and Renewable Energy

10 CFR Part 430

[Docket No. EE–RM–93–501]

Energy Conservation Program for Consumer Products: Test Procedures for Furnaces/Boilers, Vented Home Heating Equipment, and Pool Heaters

AGENCY: Office of Energy Efficiency and Renewable Energy, Department of Energy.

ACTION: Proposed Rule and Public Hearing.

SUMMARY: The Energy Policy and Conservation Act, as amended, requires the Department of Energy (DOE or the Department) to administer an energy conservation program for certain major household appliances and commercial equipments. Among other program elements, the Act requires that standard methods of testing be prescribed for each covered product. The purpose of today's notice of proposed rulemaking is to update references, request data, comments, and information on proposed amendments to the furnaces and boilers, vented home heating equipment, and pool heater test procedures.

DATES: Written comments in response to this document must be received by November 22, 1993.

Oral views, data, and arguments may be presented at the public hearing to be held on Monday, September 20, 1993. Requests to speak at the hearing must be received by the Department no later than 5 p.m., Friday, September 10, 1993. Ten (10) Copies of statements to be given at the public hearing must be received by the Department no later than 5 p.m., Wednesday, September 15, 1993.

ADDRESSES: Written comments and requests to speak at the public hearing are to be submitted to: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Hearings and Dockets, "Test Procedures for Furnaces/Boilers, Vented Home Heating Equipment, and Pool Heaters," (Docket No. EE–RM–93–501), Forrestal Building, 1000 Independence Avenue SW., Washington, DC 20585, (202) 586–0561.

The hearing will begin at 9:30 a.m., and will be held at the U.S. Department of Energy, Forrestal Building, Room 1E–245, 1000 Independence Avenue, SW., Washington, D.C.

Requests may be hand delivered to such address between the hours of 8 a.m. and 4 p.m., Monday through Friday, except Federal holidays. Requests should be labeled "Furnaces, Vented Home Heating Equipment, and Pool Heaters Test Procedures," (Docket No. EE–RM–93–501), both on the document and on the envelope.

Copies of the transcript of the public hearing and public comments received may be read and/or photocopied at the DOE Freedom of Information Reading Room, U.S. Department of Energy, Forrestal Building, Room 1E–190, 1000 Independence Avenue SW., Washington, DC 20585, (202) 586–6020, between the hours of 9 a.m. and 4 p.m., Monday through Friday, except Federal holidays.

For more information concerning public participation in this rulemaking proceeding, see section VIII of the "SUPPLEMENTARY INFORMATION."

FOR FURTHER INFORMATION CONTACT:

Cyrus H. Nasseri, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Mail Station EE–431, Forrestal Building, 1000 Independence Avenue, SW., Washington, DC 20585, (202) 586–9127.

Eugene Margolis, Esq., U.S. Department of Energy, Office of General Counsel, Mail Station GC–41, Forrestal Building, 1000 Independence Avenue, SW., Washington, DC 20585, (202) 586–9507.

SUPPLEMENTARY INFORMATION:

I. Introduction

A. Authority

Part B of Title III of the Energy Policy and Conservation Act, Public Law 94–163, as amended by the National Energy Conservation Policy Act, Public Law 95–619, the National Appliance Energy Conservation Act of 1987, Public Law 100–12, the National Appliance Energy Conservation Amendments of 1988, Public Law 100–357 and the Energy Policy Act of 1992, Public Law 102–486, created the Energy Conservation Program for Consumer Products other than Automobiles (Program).[1] The 13 consumer household products currently subject to this Program (often referred to hereafter as "covered products") include furnaces/boilers, vented home heating equipment, and pool heaters, the subject of today's document.

Under the Act, the Program consists essentially of three parts: testing, labeling, and Federal energy conservation standards. The Department, in consultation with the National Institute of Standards and Technology (formerly the National Bureau of Standards), is required to amend or establish new test procedures as appropriate for each of the covered products. Section 323. The purpose of the test procedures is to produce test results which measure energy efficiency, energy use, or estimated annual operating cost of a covered product during a representative average use cycle or period of use and must not be unduly burdensome to conduct. Section 323(b)(3). A test procedure is not required if DOE determines by rule that one cannot be developed. Section 323(d)(1). One hundred and eighty days after a test procedure for a product is adopted, no manufacturer may represent the energy consumption of, or the cost of energy consumed by, the product except as reflected in tests conducted according to the DOE procedure. Section 323(c)(2). Test procedures appear at 10 Code of Federal Regulations, part 430, subpart B.

However, the 180-day period referred to in section 323(c)(2) may be extended for a period of up to an additional 180 days if the Secretary determines that the requirements of section 323(c)(2) would impose undue burden. Section 323(c)(3). Labeling requirements for major household appliances are administered by the Federal Trade Commission.

Section 323(e) of the Act requires DOE to determine to what extent, if any, a proposed test procedure would alter the measured energy efficiency or measured energy use of any covered product as determined under the existing test procedure. If DOE determines that an amended test procedure would alter the measured efficiency or measured energy use of a covered product, DOE is required to amend the related energy conservation standard accordingly. In determining the amended standard, DOE is required to measure the energy efficiency or energy use of representative samples of covered products which minimally comply with the existing standard. The average efficiency of these representative samples, tested using the amended test procedure, constitutes the amended standard. Section 323(e)(2).

B. Background

Today's document proposes to modify the test procedures for furnaces and boilers, vented home heating equipment, and pool heaters as follows: (1) DOE proposes to modify the test procedure for furnaces and boilers to incorporate waivers previously granted and to include test procedures for new product designs. The revised American

[1] Part B of title III of Energy Policy and Conservation Act, as amended, is referred to in this final rule as the "Act". Part B of Title III is codified at 42 U.S.C. 6291–6309.

National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 will be referenced, and test procedures will be included for atmospheric furnaces with burner air inlet dampers or flue dampers, jacket loss measurement for downflow furnaces, and electro-mechanical stack dampers with delayed opening and power vented units employing post purge during the off-cycle. Additionally, today's document establishes a minimum required blower delay time between the ignition of the burner and the starting of the circulation air blower, a maximum on-time for the circulation air blower after the burner shut-off, and other corrections and technical revisions to those sections of American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 incorporated into the DOE test procedure. Today's document also modifies the Energy Factor Descriptor to include the useful heat generated by the electrical consumption and establishes an additional new annual efficiency descriptor that includes the auxiliary electrical energy consumption of appliances when installed indoors and that could be used in determining the energy rating of mobile home furnaces. (2) DOE proposes to modify the test procedure for vented home heating equipment by establishing an additional new annual efficiency descriptor that includes the auxiliary electrical energy consumption in determining the energy rating of the appliance, and by including modified calculation procedures for the weighted average steady-state efficiency and Annual Fuel Utilization Efficiency for manually controlled heaters. (3) DOE proposes to modify the test procedure for pool heaters by establishing an additional new annual efficiency descriptor that includes the auxiliary electrical energy consumption in determining the energy rating of pool heaters.

The above modifications of the test procedures for furnaces and boilers, vented home heating equipment, and pool heaters will not change the related existing energy conservation standards for these appliances. However, the Department has determined that additional new energy descriptors may need to be made available when it is found that the existing descriptors do not account for all of the energy or all types of energy consumed by an appliance. Not having these new energy descriptors would result in the analyses for energy conservation standards being incomplete and could lead to standards which could be met by utilizing unaccounted for energy that might satisfy an energy descriptor but result in little or no total energy savings. Examples of unaccounted for energy are the pilot light energy of a pool heater which is not accounted for by the current energy descriptor of thermal efficiency or the electrical energy of a furnace or vented home heating equipment which is not accounted for by the current energy descriptor of Annual Fuel Utilization Efficiency. Accordingly, the Department is proposing in today's document to include new energy descriptors for vented home heating equipment, furnaces, and pool heaters.

II. Discussion

A. Furnace Test Procedure

On March 28, 1984, the Department published in the **Federal Register** a final rule amending the test procedures for furnaces, vented home heating equipment, and unvented home heating equipment. (Hereafter referred to as the 1984 Final Rule.) 49 FR 12148.

The 1984 Final Rule referenced the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1982 entitled "Methods of Testing for Heating Seasonal Efficiency of Central Furnaces and Boilers." In addition, it prescribed test procedures for furnaces and boilers that were not covered adequately by the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1982. The 1984 Final rule included provisions for modulating furnaces and boilers, condensing furnaces and boilers, units with thermal stack dampers, and other technical revisions (including oversize factors of furnaces and boilers, furnaces without draft relief or direct exhaust system, hot water boiler specifications on minimum return inlet water temperature and minimum water temperature rise, pump delay boiler controls, improved method for the determination of the steady state stack to flue mass flow factor for furnaces and boilers, and option of an assigned jacket loss value in lieu of actual measurement). Subsequently, the Standards Project Committee 103 of American Society of Heating, Refrigerating, and Air-Conditioning Engineers revised the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1982 to include DOE 1984 amendments that were not covered adequately by the Standard. The resulting Standard, "Methods of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers," was designated American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988.

Since 1984, through cooperative efforts with the furnace industry and through DOE test procedure waiver process, DOE has become aware of several additional furnace test procedure issues. DOE proposes to amend the furnace test procedure to address these issues:

1. American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988

American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 which revised the earlier 1982 standard, is being referenced in Appendix N to subpart B of part 430 with certain exceptions in the present DOE proposed test procedure for furnaces. One exception concerns furnaces and boilers that include small air passages in the flue that serve a utility other than for draft relief (see section 3.9 of the 1984 furnace test procedure and sections 8.2.1.2.2 and 8.3.1.2.1 of American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988). In DOE test procedure, the criterion for considering these units as direct exhaust systems is that air flow through the air passages shall not be in excess of 10 percent of the maximum steady-state total flue flow. In the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988, the criterion is that the area of the passage opening shall not be more than 10 percent of the cross-sectional area of the stack. The Department recognizes the difficulty and accuracy problems involved in the measurement of the air flow rate through the small air passage under the existing test procedure and is proposing to use the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 criterion.

The 1984 Final Rule and the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 also differ

with regard to the calculation procedure for units with an electro-mechanical stack damper. An error in the calculation procedure for the stack damper in American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 (discovered by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard Project Committee 103 after the standard was published) results in an overstated Annual Fuel Utilization Efficiency value. DOE is proposing to adopt a corrected calculation procedure. See Appendix N to Subpart B of part 430, Section 7.6, and 10.7.

A third difference between DOE current furnace test procedure and the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 concerns air circulation blower delay, both during the heat-up test (delay in starting after burner ignition) and during the cool-down test (delay in stopping after burner shut-off). During the heat-up test, the DOE test procedure requires a blower time delay of 1.5 minutes with two exceptions. The American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 added a third exception: if the furnace is designed to operate with an unvarying time delay, the delay shall be as designed. During the cool-down test, the DOE test procedure allows a 3-minute (1.5 minutes for condensing furnaces) delay in blower shut-off or until the supply air temperature drops below 40°F above the inlet air temperature, whichever results in the longer blower on time. The American National Standards Institute/American Society of Heating, Refrigerating, and Air- Conditioning Engineers Standard 103–1988 added the additional exception that for furnaces without adjustable fan control, the delay shall be as designed.

DOE is modifying both of these added exceptions in American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 in the proposed test procedure. See appendix N to subpart B of part 430, sections 8.4, and 8.7.

2. Furnaces and Boilers With Small Air Passage in the Flue

The Department's current test procedure prescribes the ratio of the air flow rate through the small air passage to the flue gas rate through the stack (10 percent) as the criterion in determining whether the unit is tested as a direct exhaust system. The American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 specifies the area ratio (10 percent) as the criterion. DOE recognizes the difficulty involved in measuring the air flow rate through the small passage, and is proposing to adopt the area ratio of 10 percent (tested and accepted by the National Institute of Standards and Technology) as the appropriate criterion.

3. Electro-mechanical Stack Dampers

The DOE current test procedure for furnaces evaluates the effectiveness of a stack damper by comparing the area of the damper plate to the area of the stack, assuming instantaneous damper closing and without time delay after the burner is shut off. DOE realizes, however, that this simplified evaluation method likely results in overstatements of efficiency (this has been verified by National Institute of Standards and Technology experimentally). The calculation procedure in the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 accounts for the time delay and specifies the finite length of time it takes for the damper to close. DOE is proposing to adopt this method for units with electro-mechanical stack dampers. See appendix N to subpart B of part 430, sections 7.6, and 10.7.

There was, however, an error as mentioned previously in the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 calculation procedure. In the procedure, a stack damper effectiveness factor D_o (defined as the ratio of the off-cycle sensible loss with the damper in operation to the off-cycle sensible loss without the damper) was used to calculate the stack gas draft factor D_s. The stack gas temperature measured with the damper open was used incorrectly in the numerator for the stack damper effectiveness D_o. This can result in an overstatement of the Annual Fuel Utilization Efficiency by 1 to 2 percentage points for a damper with a large leakage area and long delay time. The correct temperature should have been the calculated temperature with the damper in operation (determined by National Institute of Standards and Technology). The American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 procedure also simplifies the calculation incorrectly by applying the factor D_o to both the off-cycle sensible loss and off-cycle infiltration loss.[2] This simplification can result in an understatement of the Annual Fuel Utilization Efficiency by 0.2 to 1 percentage point, depending on the damper leakage area and delay time. The correct procedure is the application of a separate stack damper effectiveness factor for infiltration loss, defined the same way as the factor D_o for sensible loss, to the off-cycle infiltration loss calculation. DOE has included the corrected procedure to American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 in this document. See appendix N to subpart B of part 430, section 10.7.

Both DOE current test procedure and the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 require geometrical measurements for the stack damper to be the cross-sectional area of the stack and the net area of the damper (area of damper minus any cut-out or holes). However, since there are dampers that when closed will permit air to leak around the edge and shaft of the damper, this leakage area should be included as part of the data required. DOE has included this requirement in today's proposal. See appendix N to subpart B of part 430, section 7.6.

4. Thermal Stack Damper

The 1984 Final Rule has no provision for direct measurement of off-cycle heat losses by measuring the concentration of a tracer gas in the flue and in the stack during an appropriate off-cycle period. The procedure for thermal stack dampers is not included in the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988. The wide variation of performance of thermal stack dampers (such as sluggish closing time and variable leakage rate) requires a continuous measurement of the tracer gas concentration over the entire off-cycle period (or discrete time measurements with small time steps). This, however, would introduce significant measurement errors in the beginning of the off-cycle period (when losses are the greatest) because of the rapid decrease in stack gas flow rate and temperature and slow response of tracer gas sensors and analyzers. Therefore,

[2] "The Effect of a Time-Delayed Stack Damper on Off-Cycle Heat Losses for Residential Heating Equipment," American Society of Heating, Refrigerating, and Air-conditioning Engineers Transactions 1983, V.89.

DOE will continue to reserve the provision for thermal stack dampers pending development of testing details and a calculation procedure as discussed in the 1984 Final Rule. See 49 FR 12148, March 28, 1984, and appendix N to subpart B of part 430, section 10.28.

5. Air Circulation Blower Delay at Burner Ignition

The current furnace test procedure requires a 1.5-minute delay between the ignition of the burner and the start-up of the blower. Since 1984, numerous manufacturers have requested, and DOE has granted, waivers from this requirement to accommodate the unvarying time delay designed into their units. The manufacturers' waivers include: Coleman Company, 50 FR 2710, January 18, 1985; Magic Chef Company, 50 FR 41553, October 11, 1985; Rheem Manufacturing Company, 53 FR 48574, December 1, 1988, 56 FR 2920, January 25, 1991, 57 FR 10166, March 24, 1992, and 57 FR 34560, August 5, 1992; Trane Company, 54 FR 19226, May 4, 1989, 56 FR 6021, February 14, 1991, 57 FR 10167, March 24, 1992, and 57 FR 22222, May 27, 1992; Lennox Industries, 55 FR 50224, December 5, 1990; Inter-City Products Corporation, 55 FR 51487, December 14, 1990, and 56 FR 63945, December 6, 1991; DMO Industries, 56 FR 4622, February 5, 1991; Heil-Quaker Corporation, 56 FR 6019, February 14, 1991; Carrier Corporation, 56 FR 6018, February 14, 1991, and 57 FR 38830, August 27, 1992; Amana Refrigeration Inc., 56 FR 27958, June 18, 1991, 56 FR 63940, December 6, 1991, and 57 FR 23392, June 3, 1992; Snyder General Corporation, 56 FR 45960, September 9, 1991; Goodman Manufacturing Corporation, 56 FR 51713, October 15, 1991, and 57 FR 27970, June 23, 1992; Ducane Company, 56 FR 63943, December 6, 1991, and 57 FR 10163, March 24, 1992; Armstrong Air Conditioning, Inc., 57 FR 899, January 9, 1992, 57 FR 10160, March 24, 1992, 57 FR 10161, March 24, 1992, and 57 FR 39193, August 28, 1992; Thermo Products, Inc., 57 FR 903, January 9, 1992; and Consolidated Industries Corporation, 57 FR 22220, May 27, 1992. The DOE granting of the waivers permitted those manufacturers to test units with blowers having unvarying time delay designed into them. Today's document incorporates this test provision for all furnaces and boilers. See appendix N to subpart B of part 430, section 8.7.

Because the designed delay time varies among units, DOE is proposing a specified minimum blower delay time of 20 seconds during the heat-up test if the designed unvarying delay time is less than 20 seconds. A cold draft would be created in the occupied zone if the blower is started too early. The Department's objective is to adopt a provision that allows all furnaces designed to operate with unvarying time delay to be rated in a manner that provides for a reasonable level of occupant comfort. Therefore, DOE is proposing a modification of American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 (Section 9.6.1) to require a minimum blower delay of 20 seconds during the flue or stack gas temperature measurement portion of the heat-up test for furnaces designed with unvarying time delay. This requirement also would apply to the newer type of design for fan control where the time delay is adjustable by dip switch or jumper terminals. If the maximum time delay that can be selected is less than 20 seconds, the control would be bypassed and the blower started manually 20 seconds after the burner ignition for the heat-up test.

6. Air Circulation Blower Delay at Burner Shut-off

During the cool-down test, the current furnace test procedure allows a 3-minute (1.5-minute for condensing furnaces) delay in blower shut-off or until the supply air temperature drops below 40°F above the inlet air temperature, whichever results in the longer blower on time. American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 provides an additional exception (section 9.5.1.2.2) that for a furnace without adjustable fan control, the delay shall be as designed. Therefore, to increase the Annual Fuel Utilization Efficiency value (which does not include auxiliary electrical energy consumption in its calculation), some furnaces could be designed with unvarying blower time delay longer than 3 minutes and less than 40°F temperature difference, resulting in a cold draft in the occupied zone.[3]

Again, DOE objective is to adopt a provision that allows all furnaces designed to operate with unvarying time delay to be rated in a manner that provides for a reasonable level of occupant comfort. Therefore, DOE is proposing a modification of American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 (Section 9.5.1.2.2) to require furnaces with unvarying time delay that do not allow for the blower delay time specified (3 minutes for non-condensing or 1.5 minutes for condensing furnaces or until the supply air temperature drops to a temperature of 40°F above the inlet air temperature, whichever gives the longer blower on time) to be tested with the fan control bypassed and the blower manually controlled to give the delay time specified during the cool-down test. This requirement also would apply to the newer type of fan control designs where the adjustment is by dip switches or jumper terminals and the range of adjustment does not allow for the delay time specified. See appendix N to subpart B of part 430, section 8.4.

The Department also is proposing an exception to the delay time requirement, specified above, for blower start-up and shut-off of furnaces that employ a single motor to drive the power burner and the blower. In that case, the power burner and the blower would be started and stopped at the same time. The current furnace test procedure includes this type of exception for burner and blower start-up during the heat-up test.

7. Burner Box Inlet Damper and Flue Damper

For non direct vent furnaces with power burners, a value of 0.4 for the theoretical off-cycle flue draft factor (D_f) is assigned for use in the computation for off-cycle sensible and infiltration losses. For non direct vent units with atmospheric burners, the existing test procedure and the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 assign a D_f value of 1.0 and no test measurement for this factor is allowed. However, optional tracer gas procedure to determine a possible lower D_f value is allowed for direct vent units and power burner units. Since D_f is a factor in the calculation for off-cycle losses, a smaller D_f will decrease the calculated losses and thus increase the Annual Fuel Utilization Efficiency.

On August 1, 1989, Lennox Industries (Lennox) filed a "Petition for Waiver" and an "Application for Interim Waiver" seeking DOE approval to use the existing optional tracer gas method to determine a lower than assigned D_F value for its G20 and G20R series of

[3] In addition, the electrical energy consumed in running the blower for a longer time may be more than the heat energy recovered from the furnace heat exchangers. This will be true especially if the source energy used to generate the electricity is considered rather than the electrical energy at the building site.

atmospheric furnaces.[4] The design of these units included an integral draft diverter and an electro-mechanical burner box inlet damper which closes off the combustion air inlet to the heat exchanger during the off-cycle. Lennox stated that restriction to the air flow through the heat exchanger by the closed damper during the off-cycle caused the draft factor D_F to be less than 1.0, resulting in reduced off-cycle losses. Lennox claimed that absent an alternative test method for D_F the assigned value of 1.0 would result in a lower Annual Fuel Utilization Efficiency value and an unfair rating for its G20 and G20R series of atmospheric furnaces.

The optional tracer gas method requested by Lennox specified that for a unit with an integral draft diverter for draft relief, the cool-down test and the tracer gas test (which is conducted during the cool-down test) be conducted with the diverter sealed and the stack restricted.

Several comments argued that if the tracer gas method was used, the test should be conducted with the diverter open as this is the way the furnace would operate in field installations.[5] If the diverter was kept open during the test, aspiration by draft relief air flowing through the diverter opening into the stack could increase the air flow through the heat exchanger thereby reducing the inlet damper effectiveness and increasing the value of D_F. A sealed diverter would prevent this aspiration motion from happening, resulting in a lower D_F value. Another view held that for some atmospheric furnaces, the D_F value was found to be less than 1.0 when tested by the tracer gas method even when there was no inlet damper. This would automatically result in an increase in furnace Annual Fuel Utilization Efficiency caused solely by utilizing testing to obtain D_F and not by installation of an inlet damper.

The comments raised questions on the potential effect on industry product design and manufacturing. Therefore, DOE directed the National Institute of Standards and Technology to conduct efficiency tests of a Lennox G20 furnace using tracer gas tests to determine D_F. The test results showed that the Lennox furnace had lower off-cycle losses and a higher Annual Fuel Utilization Efficiency value when the inlet damper was operating as designed than when the inlet damper was held open during the off-cycle. National Institute of Standards and Technology also found air-flow entering the heat exchanger through the diverter opening when testing was conducted with the diverter open during cool-down. This air-flow went down one section of the clamshell heat exchanger and came up another section of the clamshell heat exchanger into the stack. Therefore, an open diverter provided a second air passage (in addition to the one through the closed burner box inlet port) for the cold air to enter and cool down the heat exchanger.

Based on the test results and the comments received regarding methods to test the draft factor, DOE developed a modified version of the existing tracer gas test method to obtain an off-cycle loss factor (K_L) that can be used to calculate the off-cycle losses of the Lennox furnace. The modified method has two requirements: (1) That the tracer gas test be performed with the draft diverter open; and (2) that the test be performed with the inlet damper open as well as closed to obtain a ratio of the two off-cycle losses during the off-cycle (loss with inlet damper closed to loss with inlet damper open) for use as the off-cycle loss factor. The latter requirement ensures that only the relative improvement in the D_F value is allowed.

During testing, National Institute of Standards and Technology found the tracer gas test, as specified in the current optional method, difficult to perform in the heat exchanger as was calculating an integrated off-cycle loss. National Institute of Standards and Technology reported that a continuous measurement of the tracer gas concentration over the entire off-cycle period was difficult to perform accurately due to the rapidly changing nature of the gas flow at the beginning of the off-cycle. National Institute of Standards and Technology also found that measurements conducted in the heat exchanger and in the test stack gave similar results in the off-cycle loss value. In addition, the ratio of the losses calculated over the entire off-cycle period was close to the ratio calculated by using the integrated losses over a 1-minute interval beginning 5 minutes into the off-cycle where the rate of change of the gas flow was more stable. This is the same rationale used in the current optional procedure where measurement of the tracer gas at between 5 to 6 minutes into the off-cycle is used to compute the D_F value. Therefore, the modified method requires: (1) That the tracer gas be injected and sampled in the stack instead of in the heat exchanger; and (2) that the 1-minute (between minutes 5 and 6 into the off-cycle) integrated values of the two off-cycle losses (measured with the inlet damper closed and open during the off-cycle) be used to calculate the off-cycle loss factor. The Department specified the modified tracer gas procedure in its December 1990 Decision and Order granting Lennox a waiver for its G20 and G20R series furnaces.[6]

The Department is including the modified procedure in today's proposal for the measurement of an off-cycle loss factor K_L for atmospheric furnaces requiring draft relief and designed with an electro-mechanical burner box inlet damper or an electro-mechanical flue damper installed upstream of the draft relief device. See appendix N to subpart B of part 430, sections 7.5, 8.9, and 10.16.

A large portion of the off-cycle losses occur in the first minute after the burner shuts off, and a slow closing damper will lose most of its effectiveness. Therefore, DOE also is proposing that the method be applicable only when the damper closes completely within 10 seconds after the burner shuts off.

The Department also is proposing revisions to Table 6 in American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 for system numbers because of the inclusion of the tracer gas procedure for atmospheric furnaces with inlet or flue dampers in today's proposed test procedure. These revisions consist of adding burner inlet damper or flue damper characteristics, D_F and D_S values, and are found in proposed table 1 of appendix N to subpart B of part 430, section 7.3.

8. Power Vented Systems Employing Post Purge After Burner Shut-Off

The current test procedure and the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 allow the optional tracer gas test method to be used to determine off-cycle power burner draft factor (D_P) for power vented burners. The procedure specifies that between 5 to 6 minutes into the cool-down period, a one-time measurement

[4] DOE published the Lennox petition in the **Federal Register** and solicited comments, data, and information respecting the petition and granted the requested Interim Waiver in its entirety. (54 FR 50525, December 7, 1989).

[5] Comments on the petition were received from manufacturers, trade associations, State government agencies, public interest groups, and utility companies. A complete list and a summary of the comments received are included in the DOE Decision and Order of December 5, 1990 (55 FR 50224, December 5, 1990).

[6] A detailed discussion of the NIST test results and the rationale for adopting a modified (tracer gas test procedure is included in the DOE December 1990 Decision and Order). (55 FR 50224, December 5, 1990).

be made on the concentration of the tracer gas in the flue gas and of the gas temperature, and the measured data used to calculate the off-cycle flue gas flow rate and the power burner draft factor D_P.

The assumption used to derive the calculation procedure is that the flue gas temperature decreases exponentially and smoothly by natural convective flow starting when the burner is shut off. In order to vent combustion product residue in the heat exchanger of some furnaces or boilers, the combustion blower (forced or induced draft) continues to run for a short period of time after the burner is shut off. This action is referred to as post purge. For a short post-purge period (less than 5 seconds), the additional loss caused by the forced convective flow of the flue gas is so small that it is considered negligible. When this post-purge period is long, as is the design of some units, the additional losses are large. However, such additional losses are not reflected in the current procedure. Actually, the longer the post-purge period, the smaller the calculated losses by the current tracer gas method. The off-cycle flue gas temperature $T_{F,OFF}$ measured between 5 to 6 minutes into the off-cycle decreases faster with longer post purge because of the additional cool-down effect of the forced air flow during post purge. The net effect is that units with long post-purge time receive an Annual Fuel Utilization Efficiency rating that is higher than it should be.

To correct this deficiency in the current test procedure, DOE directed National Institute of Standards and Technology to conduct tests on a power vented furnace employing post purge and to develop a correction procedure to the current tracer gas method. The test results[7] indicated that during the post-purge period, flue gas temperature decreased in an approximately linear fashion and that the mass flow rate increased from its steady-state value because the decreasing temperature increased the flue gas density. The flue gas temperature resumes the exponential decreasing pattern after the post-purge period.

Based on the test results, DOE is proposing to modify the test procedure by separating the calculations into two parts. During the post-purge period, the flue gas temperature is assumed to decrease linearly, and the volume flow rate of the combustion blower is assumed constant and equal to the value when the burner is on. The density of the flue gas is assumed to follow the Ideal Gas Law in the calculation for the mass flow rate of the flue gas. Based on these assumptions, the off-cycle losses can be determined analytically. In this way, the losses during the post-purge period can be determined by taking the flue gas temperature data at the beginning and end of the post-purge period. The first temperature is the same as the steady-state temperature, therefore, only one additional temperature is required. During the remaining period of the off-cycle (after post purge), the current tracer gas test and calculation procedures are used. The modification would require the tracer gas concentration and temperature data to be taken between 5 to 6 minutes following the end of the post-purge period. The off-cycle time for this part of the calculation is equal to the regular average burner off-time (13.3 minutes for single stage furnace, 33.26 minutes for single stage boiler, 10 minutes for modulating furnaces and 15 minutes for modulating boilers) minus the length of the post-purge period. The D_P value determined by the tracer gas method is used to calculate the off-cycle losses in percent of energy input during this period (after post purge). The losses from the two periods are totaled to arrive at the Annual Fuel Utilization Efficiency value. See appendix N to subpart B of part 430, sections 10.8, 10.10.2, and 10.11.2.

Therefore, DOE is proposing to revise the current test procedure to require that the length of the post-purge period t_P and the flue gas temperature at end of the post-purge period to be recorded. See appendix N to subpart B of part 430, sections 8.2, and 8.5.

9. Jacket Loss Test and Insulation Requirement for Downflow Furnaces

Neither the current DOE test procedure nor the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 specify a jacket loss test for downflow furnaces. In its certification program, the Gas Appliance Manufacturers Association requires that when conducting a jacket loss test on downflow furnaces, if the manufacturer has not supplied the internal section of vent pipe connecting the flue collar to the top of the unit to be tested, the appropriate piece of uninsulated vent pipe shall be installed by the testing facility. The Department accepts this approach and has included it in today's proposal. See appendix N to subpart B of part 430, section 6.4.

10. Blower Compartment Heat Loss During Jacket Loss Test

The current DOE test procedure and the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 do not specify whether the furnace air circulation blower compartment is considered part of the cabinet or part of the duct system. In 1990, SPC 103 recommended that the blower compartment be considered as part of the duct system and that no temperatures be recorded during the jacket loss test. DOE agrees with that specification and has included it in today's proposal. See appendix N to subpart B of part 430, section 7.2.

11. Sealing of Ventilation Openings During Jacket Loss Test

Neither the DOE test procedure nor the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 specifies a procedure for dealing with the heat loss of air flowing from the louvered ventilation opening on the top, front, or sides of the unit cabinet during the jacket loss test. Therefore, the heat loss is unaccounted for during the test. The measurement of this convective heat loss is difficult to perform with the current flow measurement technique because of the low air-flow rate and temperature difference. DOE believes, however, that heat loss by convective air flow through the ventilation openings may be significant. This heat loss can be reduced to a minimum during the jacket loss test by taping or sealing with aluminum tape those ventilation openings from which the ventilation air exits from the cabinet. DOE is proposing that such taped areas be divided into the normal 36 square inch grids and that thermocouples be installed in each square, over the tapes if necessary, to measure the temperatures over the taped area. A smoke test during a short steady-state test may be used to determine the openings where the ventilation air exits from the cabinet. This would prevent the blocking of the louvered openings where combustion air enters. The taping also would apply to downflow furnaces. No taping of louvers in the jacket would be required for other parts of the test procedure, and the tapes would be removed after the completion of the jacket loss test. DOE is proposing the above sealing procedure in today's document. See appendix N to subpart B of part 430, section 7.2.

[7] National Institute of Standards and Technology Interagency Report 4908, August 1992.

12. Insulation Requirement for Units With Draft Diverter

Both the current DOE test procedure and the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 require the insulation of an integral draft diverter with a minimum of R–7 insulation material for the cool-down and heat-up tests. In 1991, ETL Testing Laboratories, Inc. suggested that when testing units with integral draft diverters, which are mounted in an exposed position (not inside the overall cabinet), the diverters should be considered part of the vent pipe and be insulated to reduce heat loss (as is the test stack) before starting any test including the jacket loss test and the steady-state test. ETL Testing Laboratories, Inc. uses this process when testing furnaces for the Gas Appliance Manufacturers Association efficiency rating certification program. DOE agrees with ETL Testing Laboratories, Inc.'s recommendation and is proposing such a provision in today's document. See appendix N to subpart B of part 430, sections 6.2, 6.5, and 6.6.

13. Insulation Requirement for Flue Collector Box

Both the DOE test procedure and American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 require that the draft diverter and the flue gas collection box for units with integral draft diverter be insulated with no less than R–7 insulation material before the start of the cool-down test. This is to reduce heat loss and to obtain a more accurate flue gas temperature at the test plane, where the flue gas temperature is measured during cool-down and heat-up test.

This requirement is not specified for the flue collector box in units with power burners. The Department, however, believes that the same insulation requirement on the flue collector box should apply since the test plane for temperature measurement for power burner units is the same as for units with draft diverter. Therefore, DOE is proposing the same insulation requirement (during cool-down and heat-up tests but not during jacket loss and steady-state tests) on flue collector box for power burner units. See appendix N to subpart B of part 430, section 6.3.

14. Piping Arrangement for Hot Water Boilers

Based on data provided by the Hydronic Institute to Standard Project Committee 103, an error was identified in the schematic figure for piping arrangement for hot water boilers in the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 (Figure 6) and in the DOE test procedure. The error was in the recirculation line which was shown as connected to the return side of constant head tank instead of connection to the supply side of the tank. DOE concurs with the Hydronic Institute and is including the revised schematic for hot water boilers in today's proposed amendments. See appendix N to subpart B of part 430, section 6.7.

15. Minimum Value for D_P and D_F

The current test procedure allows the minimum value for D_P and D_F to equal 0.0 on units where no air flows through the combustion chamber and heat exchanger when the burner is off. American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 sets the minimum value at 0.00001. Current measurement techniques preclude an accurate tracer gas test on units with a low off-cycle air flow rate. Therefore, it is very difficult to verify an "absolutely no air-flow" condition (this has been confirmed by National Institute of Standards and Technology). Accordingly, DOE proposes that a value of 0.05 for D_P be assigned for any units whose D_P value, when measured by the optional tracer gas method, is less than 0.10. See appendix N to subpart B of part 430, sections 7.4.3, 8.8.3, 8.10, and 10.15.

16. Maintaining Draft During Off-Cycle

American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 requires that a draft be maintained in the flue pipe for furnaces and boilers with oil-fueled or power gas burners. The Department proposes to clarify this requirement by specifying that it applies only to oil-fueled or power gas burners that employ barometric dampers for draft control. See appendix N to subpart B of part 430, sections 6.8, 8.3, and 8.6.

17. Test Requirements for Modulating Units

The DOE current test procedure requires that testing and calculation procedures for cyclic tests (cool-down and heat-up) be conducted at both the maximum and the reduced input rates for units with two-stage modulating controls and at the reduced input rate for units with step modulating controls. American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 specifies the same calculation procedures but is unclear (in sections 11.4 and 11.5) as to the type of tests to be performed and the test results to be used in the calculations that follow. The SPC 103 has recommended limiting values for the terms T_c, $Effy_{ss,M}$ and $Q_{out,M}$ and the conditions under which these limits apply, DOE today is proposing such recommendations to the applicable sections. See appendix N to subpart B of part 430, sections 10.13, and 10.14.

The Department also is proposing to clarify the requirement for determining the draft factors D_P and D_F for units with modulating control. To be consistent with other cyclic test requirements, DOE proposes that the optional tracer gas procedure be conducted at both the maximum and the reduced input rates for units with two-stage controls and at the reduced input rate for units with step modulating controls. See appendix N to subpart B of part 430, section 8.8.4.

18. On-cycle Time Constant and Off-cycle Time Constant

In the current calculation procedure, both the on-cycle and off-cycle time constants use equations involving the logarithm of measured temperature difference at two specified time intervals. In testing some units, it is possible that the two temperatures will be close enough to cause a negative argument in the logarithm function and subsequent computation failure. To prevent this occurrence, the SPC 103 recommended a correction procedure specifying that when the temperatures difference is negative, the difference between the two temperatures be set to equal 0.1. DOE agrees with the correction procedure and is proposing it in today's document. See appendix N to subpart B of part 430, sections 10.3, and 10.4.

19. Multiplication Factor for Jacket Loss for Finned Tube Boilers for Isolated Combustion System

The Standard Project Committee 103 recommended the addition of the value C_J=0.5 as the multiplication factor jacket loss for finned tube boilers for Isolated Combustion System applications. This is consistent with the values of C_J assigned for other systems when installed as outdoor systems and as Isolated Combustion system. DOE

accepts the recommendation and is including it in today's proposal. See appendix N to subpart B of part 430, section 10.12.1.2.

20. Water Pump Energy Consumption

For hot water boilers, American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 assigns a constant value for water pump power (BE=0.13 KW) and no test measurement is required or allowed. This value is based on the average power consumption of water pumps shipped with boilers in 1978. To increase the accuracy of the energy descriptors, annual efficiency descriptors, and energy factor, which include electrical energy consumption and to capture the variability in pump efficiencies available for use with boilers, DOE today is proposing a test method which requires measuring the power consumption of the water pump used with the hot water boiler. This power consumption is used in the calculation of the energy descriptors, annual efficiency descriptors, and energy factor. See appendix N to subpart B of part 430, section 8.1.1.

21. Energy Factor

The current DOE test procedure includes a procedure for computing the annual auxiliary electrical energy consumption of fossil-fuel furnaces and boilers and an energy factor which includes both the fossil fuel and the auxiliary electrical energy consumption of the appliances. Specifically, "energy factor" is defined in the DOE test procedure as the ratio of the annual output of energy delivered to the heated space by fossil fuel to the total annual energy input to the appliance including auxiliary electrical energy.

Appendix B of American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 defines "energy factor" in equation (1). Equation (1) is defined for an energy factor term which gives credit for the electrical energy that is recovered as usable heat such as from a blower motor in the circulating air stream. In addition, a factor F, representing the ratio of the heat energy required to generate the electricity consumed to the useful heat energy delivered at the appliance by the electricity is applied to the auxiliary electrical consumption to reflect the efficiency of all energy used to run the appliance. DOE considers equation (1) in American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 to be appropriate for describing the energy factor of the appliance when both fossil fuel and auxiliary electrical energy consumption are considered together. Therefore, DOE proposes to adopt equation (1) in Appendix B of American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 and the accompanying procedure in Appendix C for isolated combustion systems as the energy factor. Three slight modifications are included in the procedure presented here. Those are: American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 equation (1) is corrected—divide Annual Fuel Utilization Efficiency term by 100 and multiply the right side of the equation by 100, the extra energy consumed by the combustion blower during post-purge is included in the calculation, and the energy consumed by the electrical intermittent or interrupted ignition device, if employed, is also included in the calculation of the energy factor. See appendix N to subpart B of part 430, Sections 10.19 and 10.21.

22. Annual Efficiency Descriptor

Since Annual Fuel Utilization Efficiency is defined in the Act in terms of an isolated combustion system, DOE believes that an additional energy descriptor, comparable to Energy Factor, is needed for those furnaces and boilers which are primarily installed indoors. For example, practically all mobile home furnaces are installed indoors and there are steps that could be taken to obtain a higher Annual Fuel Utilization Efficiency or Energy Factor, such as adding jacket insulation, which would have no impact on the actual efficiency of a furnace installed indoors. Because of the above, the Department proposes an additional new energy descriptor, annual efficiency descriptor, for those classes of furnaces which are installed indoors. See appendix N to subpart B of part 430, sections 10.20 to 10.26.

DOE proposes to adopt equation (1) in Appendix B of American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 and the accompanying procedure in Appendix C for indoor installations as the Annual Efficiency. Again three slight modifications are included in the procedure presented here. Those are: American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 equation (1) is corrected—divide Annual Fuel Utilization Efficiency term by 100 and multiply the right side of the equation by 100, the extra energy consumed by the combustion blower during post-purge is included in the calculation, and the energy consumed by the electrical intermittent or interrupted ignition device, if employed, is also included in the calculation of Annual Efficiency.

The calculation of annual efficiency descriptor involves the determination of the heating seasonal efficiency and the Annual Fuel Utilization Efficiency based on an outdoor installation for all weatherized furnaces or boilers and based on an indoor installation for all non-weatherized furnaces or boilers. This is different from the existing requirement for non-weatherized furnaces where heating seasonal efficiency and Annual Fuel Utilization Efficiency are calculated on the basis of installation as an Isolated Combustion System. In today's proposal, the Annual Fuel Utilization Efficiency for non-weatherized furnaces is still based on an Isolated Combustion System system. Since the indoor values of the heating seasonal efficiency and Annual Fuel Utilization Efficiency need to be calculated and used to determine the AE, two sets of values for heating seasonal efficiency and the Annual Fuel Utilization Efficiency (one for the rating of the system based on Annual Fuel Utilization Efficiency (Isolated Combustion System) and the other for the annual efficiency descriptor (indoor system) need to be calculated. DOE believes that, with the calculation procedure computerized,[a] the effort involved in computing the two sets of values is insignificant since the same test data are used in the calculation and no additional test is required. Specifically, the only changes between the two computer runs are the indices (codes) which specify the installation location and the system number.

The major difference between the Annual Fuel Utilization Efficiency and the Annual Efficiency will be the inclusion of the auxiliary electrical energy in the calculation for the annual efficiency term and the application of the F factor (the ratio of the energy consumed at the source of electrical generation to the electrical energy delivered at the furnace or boiler) to the electrical energy term in the denominator. Because of this, the value of the Annual Efficiency will be noticeably smaller than the corresponding Annual Fuel Utilization

[a] National Institute of Standards and Technology Annual Fuel Utilization Efficiency-BF version 4.0 computer program.

Efficiency value, which includes only fossil fuel energy in its calculation.

23. Other Minor Modifications to American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988

DOE also is proposing to adopt corrections and clarifications of several typographical errors and inconsistencies identified by Standard Project Committee 103 following publication of American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988. The following are the listing of these modifications, referring to section numbers of American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988:

1. Section 8.8.2.2.—Delete the two words "flue or" in the first line.
2. Section 9.7.3.—Delete the phrase "if draft is not maintained during the cool-down" in the second sentence.
3. Section 10.—Revise the definitions for the variables M_C and Q_C to: M_C=Mass of condensate, lb Q_C=fuel energy input during entire (3 or 6 cycles) cyclic condensate collection test, Btu
4. Section 11.2.4.—Delete the three words "oil or power" in the first sentence of the second paragraph. Also, replace the third paragraph with "For direct exhaust gas or oil furnaces and boilers, S/F=1."
5. Section 11.2.6.—Add missing right closing bracket in Table 7 for $L_{s,SS}$.
6. Section 11.2.9.9.—Correct the definitions for D_F for different systems to be consistent with the tabulated values of System No. versus D_F in Table 6. Also, correct the constant term 0.75 in the definition for D_S to 0.79 for systems 4 and 8.
7. Section 11.2.9.14.—Correct the section numbers which were referenced in the definitions for $\psi_{F,O,X}$ (corrected from 11.2.9.5. to 11.2.9.7.) and $\psi_{F,O,X}$ (corrected from 11.2.9.7. to 11.2.9.5.).
8. Section 11.2.9.16.—Change the system numbers from 9–12 to 9–10.
9. Section 11.2.10.6.—Correct the referenced section number in the definition for the variable F6 from 11.2.9.18. to 11.2.9.19.
10. Sections 11.4.8.5., 11.4.8.8., and 11.4.8.10.—Set the minimum default values for the terms T_C (if $T_C<0$, set $T_C=0$), $Effy_{SS,M}$ (if $Q_{OUT,R}>DHR$, set $Effy_{SS,M}=Effy_{SS,R}$), and $Q_{OUT,M}$ (IF $Q_{OUT,R}>DHR$, $Q_{OUT,M}=Q_{OUT,R}$) as recommended by American Society of Heating, Refrigerating, and Air-conditioning Engineers Standard Project Committee 103.
11. Section 11.7.2.—Delete equation $D_S=(D_O)(D_P)$ for system number 8 and substitute $D_S=[(0.79+D_P)/1.4]\ (D_O)$.
12. Appendix E of American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988—Correct the typographical errors in the defining equations for the variables F5, F6, and F8 where a constant term "+ 28" was missing from a term in the denominator of the equations as they appeared in Appendix E. See Section 10.27 and Table 2 of the proposed test procedure for details of the corrected terms of the equations.

B. Vented Home Heating Equipment Test Procedure

The Department published the test procedure for vented home heating equipment on May 2, 1978. 43 FR 20182. DOE amended this test procedure on March 28, 1984, 49 FR 12169, to include a simplified procedure for heaters with modulating controls, manually controlled vented heaters, vented heaters equipped with thermal stack dampers, and floor furnaces. 43 FR 20182.

DOE today proposes to amend the vented heating equipment test procedure: (1) To establish an annual efficiency descriptor to account for the auxiliary electrical energy consumed by the fan or blower in addition to the fossil fuel consumed; (2) to revise the calculation procedure for Annual Fuel Utilization Efficiency; and (3) to revise the calculation procedure for weighted average steady-state efficiency for manually controlled heaters with various input rates.

1. Annual Efficiency Descriptor

DOE determined that an additional new energy descriptor is needed to adequately address the energy used by some of the design options considered for energy standard level evaluation because the current energy descriptor, Annual Fuel Utilization Efficiency, does not include electrical consumption. For example, design options, such as adding an induced draft fan, improve thermal efficiency but, at the same time, add electrical consumption which unless accounted for in the energy descriptor could lead to higher Annual Fuel Utilization Efficiency with little or no net energy savings. Therefore, the Department is proposing a new energy descriptor, Annual Efficiency (AE). See appendix O to subpart B of part 430, section 4.6.

The Department's current test procedure for vented home heating equipment prescribes the calculation of the Annual Fuel Utilization Efficiency based on the energy consumption of fossil fuel only. Since auxiliary electrical energy is consumed by the appliances for the operation of the fan or blower, DOE believes a more appropriate term for evaluating the efficiency of the appliances would include both the fossil fuel and the auxiliary electrical energy consumption of the appliances.

American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988, appendix B and appendix C, includes calculations for energy factor which uses both the fossil fuel and the auxiliary electrical energy consumed by the appliance. It also gives credit for the electrical energy that is recovered as usable heat as is the case of a blower motor that is in the circulating air stream. In addition, a factor F, representing the ratio of the heat energy required to generate the electricity consumed to the useful heat energy delivered at the appliance by the electricity, is applied to the auxiliary electrical consumption to reflect the true amount of energy used to run the blower or pump. The resulting formula is designated as equation (1) in Appendix B of American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 which DOE considers the appropriate term to describe the Annual Efficiency of the appliance when both fossil fuel and auxiliary electrical energy consumption are considered together.

Therefore, DOE proposes to adopt equation (1) in Appendix B of American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 and the accompanying procedure in Appendix C of American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 as the basis of a new rating term called Annual Efficiency for vented home heating equipment. The Department's proposal includes some modifications to the calculation procedure contained in Appendix B and Appendix C of American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988. The DOE test procedure for vented home heating equipment does not require the recording of the blower on-time and off-time; therefore, the

operating time of the blower and the burner are assumed to be the same as the burner. This results in a simpler procedure than the one developed for the furnace test procedure discussed previously. The complete calculation procedure for the Annual Efficiency of vented home heating equipment is included in this document and may be found in appendix O to subpart B of part 430.

2. Pilot Light Energy Consumption

On September 21, 1990, Appalachian Stove and Fabricators, Inc. (Appalachian) and Valor Incorporated (Valor) each filed a "Petition for Waiver" requesting that DOE grant a waiver from the DOE vented home heating equipment test procedure regarding (a) pilot light energy consumption and (b) average weighted steady-state efficiency for their manually controlled vented home heaters.

With regard to the pilot light energy consumption, the current DOE test procedure requires the measurement of energy input to the pilot light (Q_P) and the use of this data in the calculation of Annual Fuel Utilization Efficiency for the energy consumed by the pilot light when the heater is not in operation. Each petition cites a vented heater (Appalachian's AGS–44 model and Valor's model VN–32, respectively) fitted with a piezo igniter which fires a transient pilot for smooth and safe ignition of the main burner. The user manually operates the pilot light, the igniter, and the main burner. The pilot light, which remains on during the operation of the heater at all (three) settings of operation, is automatically turned off when the heater's control knob is set to the "OFF" position. Operation of these units, according to the manufacturers' instructions, results in lower energy consumption and higher Annual Fuel Utilization Efficiency than calculated by the current DOE test procedure. Since the current DOE test procedure does not address this issue, the manufacturers each requested that the term involving the pilot energy consumption (Q_P) be deleted in the calculation of Annual Fuel Utilization Efficiency, resulting in an Annual Fuel Utilization Efficiency which is equal to the heating seasonal efficiency of the heater.

DOE granted the petitions, excluding the pilot light energy input term in the calculation of Annual Fuel Utilization Efficiency, subject to the heater having an easy-to-read label near the control knob instructing the user to turn the valve to the OFF position when the heater is not in use.[9]

Having made the above determination, DOE today is proposing to amend the test procedure accordingly for vented home heating equipment. See appendix O to subpart B of part 430, section 3.5.

3. Weighted Average Steady-State Efficiency

Appalachian and Valor also requested waivers from the current DOE test procedure for manually controlled vented heaters with various input rates where the weighted average steady-state efficiency is determined at 50 percent ±5 percent of the maximum fuel input rate.[10] The manufacturers each stated that the manual controls on their respective heaters give three fixed gas rates with the minimum rate at 65.3 percent of the maximum rate. This precluded testing units at the 50 percent ±5 percent rate as specified in the DOE test procedure. The manufacturers each requested approval for an alternate test procedure to determine the steady-state efficiency based on a weighted average of efficiencies obtained at the three fixed input settings.

The Department denied use of an alternate test procedure based on a weighted average of three different firing rates.[11] Instead, DOE required that the steady-state efficiency of the heaters be measured at their minimum fuel input rate of 65.3 percent of their maximum input rate. This minimum fuel input rate is closest to the 50 percent ±5 percent at which other manually controlled vented heaters are being rated. DOE believed that any other method would result in an unjustified higher Annual Fuel Utilization Efficiency that would be unfair to other manufacturers of similar heaters because relatively higher firing rates would generally result in higher burner efficiencies.

Accordingly, DOE is proposing today that calculation of the weighted average steady-state efficiency for manually controlled vented heaters use a minimum fuel input rate no higher than two-thirds of the maximum fuel input rate of the heater. See appendix O to subpart B of part 430, section 4.2.4.

C. Uniform Test Method for Measuring the Energy Consumption of Pool Heaters

The Department published the pool heater test procedure on February 7, 1989, 54 FR 6076, referencing American National Standards Institute Standard Z21.56–1986 for gas-fired pool heaters. DOE today proposes to amend the pool heater test procedure to include an annual efficiency descriptor which accounts for the auxiliary electrical energy consumed by the fan or pump in addition to the fossil fuel consumed and to reference the latest version of American National Standard Institute Standard, Z21.56–1990, recognizing that the sections referenced by the DOE pool heater test procedure have not changed.

1. Annual Efficiency Descriptor

DOE determined that an additional new energy descriptor is needed to adequately address the energy used by some of the design options considered for standard level evaluation because the current energy descriptor thermal efficiency does not include pilot light usage or electrical consumption. For example, to consider electronic ignition, the savings in pilot light gas consumption would have to be accounted for in the descriptor. Furthermore, design options, such as fan assisted combustion, improve thermal efficiency but, at the same time, add electrical usage which, unless accounted for in the energy descriptor, could lead to higher thermal efficiency with little or no net energy savings. Therefore, the Department is proposing a new energy descriptor, Annual Efficiency. See appendix P to subpart B of part 430, section 4.1.

The current test procedure for pool heaters prescribes a calculation of the thermal efficiency which is based on the energy consumption of fossil fuel only. Since auxiliary electrical energy is consumed by the heaters for the operation of the fan or pump, DOE believes a more appropriate term for evaluating the efficiency of the heaters would be one which includes both the fossil fuel and the auxiliary electrical energy consumption of the heaters. Specifically, this Annual Efficiency is defined as the ratio of the annual output of energy delivered to the heated pool water by fossil fuel to the total annual energy input to the heater including auxiliary electrical energy.

The annual output of energy delivered to the pool water would be the thermal efficiency of the heater multiplied by the average annual fossil fuel energy used by the pool heater minus the energy used by the continuous pilot light (if used) during the average non-pool season hours. The total annual energy input to the heater, including auxiliary electrical energy, would be the average annual fossil fuel energy to the pool heater plus the average annual

[9] 56 FR 51711 and 56 FR 51714, October 15, 1991.

[10] Appendix O to subpart B of part 430.

[11] 56 FR 51711 and 56 FR 51714, October 15, 1991.

auxiliary electrical energy consumption for the pool heater.

The latter term (auxiliary electrical energy) is multiplied by a factor F which represents the ratio of the heat energy required to generate the electricity consumed to the useful heat energy delivered at the pool heater by the electricity to reflect the true amount of energy used to run the auxiliary electrical equipment. The average season of use of the pool in hours per year and the average burner operating hours during the pool season will be obtained from survey data on the Nation's use of heated pools. At the present time, season of use is assumed to be 4,464 hours per year, and the burner on-time per year is assumed to be 104 hours. These values are based on limited survey data available as of February 15, 1991.[12] DOE, today, proposes to adopt this annual efficiency descriptor using the F=3.37, the survey data on pool season, and burner operating hours.

III. Environmental Review

Pursuant to section 7(c)(2) of the Federal Energy Administration Act of 1974 (Public Law 93–275), a copy of this document has been submitted to the Administrator of the Environmental Protection Agency for his comments concerning the impact of this proposal on the quality of the environment.

Since test procedures are used to standardize the measurement of energy usage, and will not affect the quality or distribution of energy usage, prescribing test procedures will not result in any environmental impacts. DOE, therefore, has determined that prescribing test procedures under the Program is not a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969. This Rulemaking, which amends existing part 430 of title 10, will not change the environmental effect of such regulation, and is an item which is "categorically excluded" (A5) by the Department of Energy regulations on National Environmental Policy Act Implementing Procedures (10 CFR part 1021) (57 FR 15122, 15152, April 24, 1992) (Appendix A to subpart D of part 1021, Categorical Exclusion A5.). Consequently, neither an Environmental Impact Statement nor an Environmental Assessment is required for the proposed rule.

[12] Berkeley Solar Group and Xenergy, 1990. OP. Cit. P 8–9 and California Energy Commission. Electricity Report #8, California Energy Commission, Forecasting Division, Sacramento, California, as cited in the BGS/Xenergy Report.

IV. Regulatory Review

Pursuant to the January 22, 1993, memorandum on the subject of regulatory review from the Director of the Office of Management and Budget (58 FR 6074, January 25, 1993), DOE submitted this document to the Director for appropriate review. The Director has completed his review. Separately, DOE has determined that there is no need for a regulatory impact analysis because the rule is not a major rule as that term is defined in section 1(b) of Executive Order 12291.

V. Regulatory Flexibility Act

The Regulatory Flexibility Act (Public Law 96–345) (5 U.S.C. 601–612) requires that an agency prepare an initial regulatory flexibility analysis and that it be published at the time the proposed rule is published. This requirement (which appears in 5 U.S.C. 603) does not apply if the agency "certifies that the rule will not, if promulgated, have a significant economic impact on a substantial number of small entities." The proposed rule affects manufacturers of furnaces and/boilers, vented home heating equipment, and pool heaters. As previously discussed, the test procedures would not have significant economic impact, but rather, would provide common testing methods. Therefore, DOE certifies that the proposed rule, if promulgated, would not have a "significant economic impact on a substantial number of small entities."

VI. Federalism Review

Executive Order 12612 (52 FR 41685, October 30, 1987) requires that regulations or rules be reviewed for any substantial direct effects on States, on the relationship between the Federal Government and the States, or on the distribution of power and responsibilities among various levels of Government. If there are sufficient substantial direct effects, then Executive Order 12612 requires preparation of a federalism assessment to be used in all decisions involved in promulgating and implementing a regulation or a rule.

DOE has identified a substantial direct effect that today's proposed rule would have on State governments. It would initially preempt inconsistent State regulations. However, DOE has concluded that such effect is not sufficient to warrant preparation of a federalism assessment for the following reason: the Act provided for subsequent State petitions for exemption. Thus, a determination as to whether a State law prevails must be made on a case-by-case basis using criteria set forth in the Act. When DOE receives such a petition, it will then be appropriate to consider preparing a federalism assessment consistent with the criteria in the Act.

VII. Review Under Section 32 of the Federal Energy Administration Authorization Act

The test procedures proposed today incorporate the commercial standards to measure the efficiency and capacity of furnaces and/boilers, vented home heating equipment, and pool heaters. The commercial standards are American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 and American National Standards Institute Standard Z21.56–1990.

Pursuant to section 301 of the Department of Energy Organization Act (Public Law 95–91), DOE is required to comply with section 32 of the Federal Energy Authorization Act, as amended by section 9 of the Federal Energy Administration Authorization Act of 1977 (Public Law 95–70).

The findings required of DOE by section 32 of the Act serve to alert the public and DOE regarding the use and background of commercial standards in a proposal and through the rulemaking process. They allow interested persons to make known their views regarding the appropriateness of the use of any particular commercial standard in a proposed rulemaking.

DOE has evaluated American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers Standard 103–1988 and American National Standards Institute Standard Z21.56–1990 with regard to compliance with section 32(b) of the Act. The Department is unable to conclude whether these standards fully complied with the requirements of section 32(b) of the Act, i.e., that they are developed in a manner which fully provided for public participation, comment, and review.

As required by section 32(c) of the Act, DOE will consult with the Attorney General and the Chairman of the Federal Trade Commission concerning the impact of these standards on competition, prior to prescribing final test procedures.

VIII. Public Comment

A. Written Comment Procedures

Interested persons are invited to participate in the rulemaking by submitting data, comments, or information with respect to the proposed test procedures set forth in

this document to the address indicated at the beginning of the document.

Comments should be identified both on the envelope and on the documents as "Furnaces, Vented Home Heating Equipment and Pool Heaters Test Procedures," (Docket No. EE–RM–93–501), Ten (10) copies are requested to be submitted. Additionally, the Department would appreciate an electronic copy of the comments to the extent possible. The Department is currently using WordPerfect™ 5.1. All submittals received by the date specified at the beginning of this document will be considered by DOE before final action is taken on the proposed amendments.

Pursuant to the provisions of 10 CFR 1004.11, any person submitting information which he or she believes to be confidential and exempt by law from public disclosure should submit one complete copy of the document and eight copies, if possible, from which the information believed to be confidential has been deleted. DOE will make its own determination with regard to the confidential status of the information and treat it according to its determination.

Factors of interest to DOE when evaluating requests to treat as confidential information that has been submitted include: (1) A description of the items; (2) an indication as to whether and why such items are customarily treated as confidential within the industry; (3) whether the information is generally known by, or available from, other sources; (4) whether the information has previously been made available to others without obligation concerning its confidentiality; (5) an explanation of the competitive injury to the submitting person which would result from public disclosure; (6) an indication as to when such information might lose its confidential character due to the passage of time; and (7) why disclosure of the information would be contrary to the public interest.

B. Public Hearing

1. Procedures for Submitting Requests to Speak

The time and place of the public hearing are indicated at the beginning of this document. DOE invites any person who has an interest in today's proposed rule, or who is a representative of a group or class of persons that has an interest in the proposed test procedures, to make a request for an opportunity to make an oral presentation. Such requests should be directed to the address indicated at the beginning of this document. Requests may be hand delivered to such address between the hours of 8 a.m. and 4 p.m., Monday through Friday, except Federal holidays. Requests should be labeled "Furnaces, Vented Home Heating Equipment, and Pool Heaters Test Procedures," (Docket No. EE–RM–93–501), both on the document and on the envelope.

The person making the request should briefly describe the interest concerned and state why he or she, either individually or as a representative of group or class of persons that have such an interest, is an appropriate spokesperson, and give a telephone number where he or she may be contacted.

Each person selected to be heard is requested to submit an advance copy of the statement prior to the hearing as indicated at the beginning of this document. In the event any person wishing to testify cannot meet this requirement, that person may make alternative arrangements with the Office of Hearings and Dockets in advance by so indicating in the letter requesting to make an oral presentation.

2. Conduct of Hearing

DOE reserves the right to select the persons to be heard at the hearing, to schedule the respective presentations, and to establish the procedures governing the conduct of the hearing. The length of each presentation is limited to 20 minutes.

A DOE official will be designated to preside at the hearing. The hearing will not be a judicial or an evidentiary-type hearing but will be conducted in accordance with 5 U.S.C. 533 and section 336 of the Act. At the conclusion of all initial oral statements at each day of the hearing, each person who has made an oral statement will be given the opportunity to make a rebuttal statement, subject to time limitations. The rebuttal statement will be given in the order in which the initial statements were made. The official conducting the hearing will accept additional comments or questions from those attending, as time permits. Any interested person may submit, to the presiding official, written questions to be asked of any person making a statement at the hearing. The presiding official will determine whether the question is relevant and whether time limitations permit it to be presented for answer.

Further questioning of speakers will be permitted by DOE. The presiding official will afford any interested person an opportunity to question, with respect to disputed issues of material fact, other interested persons who made oral presentations, as well as employees of the U.S. Government who have made written or oral presentations, relating to the proposed rule. This opportunity will be afforded after any rebuttal statement to the extent that the presiding official determines that such questioning is likely to result in a more timely and effective resolution of disputed issues of material fact. If the time provided is insufficient or inconvenient, DOE will consider affording an additional opportunity for questioning at a mutually convenient time. Persons interested in making use of this opportunity must submit their request to the presiding official no later than shortly after the completion of any rebuttal statements and be prepared to state specific justification including why the issue is one of disputed fact and how the proposed questions would expedite their resolution.

Any further procedural rules regarding proper conduct of the hearing will be announced by the presiding official.

A transcript of the hearing will be made, and the entire record of this rulemaking, including the transcript, will be retained by DOE and made available for inspection at the DOE Freedom of Information Reading Room as provided at the beginning of this document. Any person may purchase a copy of the transcript from the transcribing reporter.

C. Issues for Public Comment

DOE is interested in receiving comments and data concerning the accuracy and workability of these test procedures. Also, DOE welcomes discussion on improvements or alternatives to these approaches. In particular, DOE is interested in gathering comments on the following:

- The appropriateness of a new efficiency descriptor—annual efficiency descriptor—for vented home heating equipment that includes both the fossil-fuel and auxiliary electrical energy consumption;
- The appropriateness of a new efficiency descriptor—annual efficiency descriptor—for pool heaters that includes burner and pilot light usage fossil fuel and auxiliary electrical energy consumption;
- The appropriateness of a new efficiency descriptor—annual efficiency descriptor—for furnaces that includes both fossil fuel and auxiliary electrical energy for indoor installations;
- The appropriateness of a modified efficiency descriptor—energy factor—for isolated combustion installations; and
- The appropriateness of a test procedure for furnaces and boilers based

on an input/output method as opposed to the current and proposed method which measures losses only.

List of Subjects in 10 CFR Part 430

Administrative practice and procedure, Energy conservation, Household appliances.

Issued in Washington, DC, July 23, 1993.

Robert L. San Martin,

Acting Assistant Secretary, Energy Efficiency and Renewable Energy.

For the reasons set forth in the preamble, part 430 of chapter II of title 10, of the Code of Federal Regulations is proposed to be amended as set forth below:

PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

1. The authority citation for part 430 continues to read as follows:

Authority: 42 U.S.C. 6291–6309.

2. Section 430.2 is amended by adding definitions for terms "Annual Efficiency" and "Mobile Home Furnace" in alphabetical order, to read as follows:

§ 430.2 Definitions.

* * * * *

Annual Efficiency means the efficiency descriptor for fossil-fueled heating appliances that takes into account the energy consumed and the useful heat produced by the appliances from both the fossil fuel and the auxiliary electrical energy to the appliances, including a multiplication factor which represents the ratio of the energy consumed at the source of electricity generation (power plant) to the electrical energy delivered at the appliances (site), and that is calculated based on indoor installation for non-weatherized units and outdoor installation for weatherized units.

* * * * *

Mobile Home Furnace a direct vent furnace that is installed indoors and designed for use only in mobile homes.

* * * * *

3. Section 430.22 is amended as follows:

A. In § 430.22 (n)(1)(i), revise the words "Section 4.8 or 4.10" to read "Section 10.19.2 or 10.20.4" and in 430.22(n)(1)(ii), revise the words "Section 4.9" to read "Section 10.19.3" and revise the words "Section 4" to read "Section 10".

B. In § 430.22 (n)(2), revise the words "Section 4.6" to read "Sections 10.12.2, 10.13.6, and 10.14.2" and revise the words "Section 4.1 of Appendix N of this subpart" to read "Section 11.1 of ANSI/ASHRAE Standard 103–1988".

C. In § 430.22 (n)(3)(i), revise the words "Section 4.11 or 4.13" to read "Section 10.22.2 or 10.22.4" and in 430.22(n)(3)(ii), revise the words "Section 4.12" to read "Section 10.19.6.3".

D. In § 430.22 (n)(4), revise the words "Section 4.14" to read "Section 10.19".

E. In § 430.22, add paragraph (n)(6), revise paragraphs (o)(2), (o)(3), and (p)(1) and add paragraph (p)(3) to read as follows:

§ 430.22 Test procedures for measures of energy consumption.

* * * * *

(n) Furnaces

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(6) The annual efficiency for furnaces, expressed in percent, is the ratio of the sum of the annual fossil fuel output of useful energy plus the auxiliary electrical energy recovered as useful heat, to the sum of the annual energy input to the furnace (fossil fuel) plus the energy required to generate the auxiliary electrical energy delivered at the furnace, determined according to section 10.23 and 10.25 of appendix N of this subpart.

(o) Vented Home Heating Equipment

* * * * *

(2) The estimated annual operating cost for vented home heating equipment is the sum of:

(i) The product of the average annual fuel energy consumption, in Btu's per year for natural gas, propane, or oil fueled vented home heating equipment, determined according to section 4.6.2 of appendix O of this subpart, and the representative average unit cost in dollars per Btu for natural gas, propane, or oil, as appropriate, as provided pursuant to section 323(b)(2) of the Act; plus

(ii) The product of the average annual auxiliary electric energy consumption in kilowatt-hours per year determined according to section 4.6.4 of Appendix O of this subpart, and the representative average unit cost in dollars per kilowatt-hours as provided pursuant to section 323(b)(2) of the Act, the resulting sum then being rounded off to the nearest dollar per year.

(3) The annual efficiency for vented home heating equipment, expressed in percent, is the ratio of the sum of the annual fossil fuel output of useful energy plus the auxiliary electrical energy recovered as useful heat to the sum of the annual energy input to the vented home heater (fossil fuel) plus the energy required to generate the auxiliary electrical energy delivered at the vented home heater determined according to section 4.6 of Appendix O of this subpart.

* * * * *

(p) Pool Heaters

(1) The estimated annual operating cost for pool heaters is the sum of:

(i) The product of the average annual fuel energy consumption, in Btu's per year of gas, or oil fueled pool heaters, determined according to section 4.2 of Appendix P of this subpart, and the representative average unit cost in dollars per Btu for gas or oil, as appropriate, as provided pursuant to section 323(b)(2) of the Act, plus

(ii) The product of the average annual auxiliary electric energy consumption in kilowatt-hours per year determined according to section 4.3 of Appendix P of this subpart, and the representative average unit cost in dollars per kilowatt-hours as provided pursuant to section 323(b)(2) of the Act, the resulting sum then being rounded off to the nearest dollar per year.

* * * * *

(3) The annual efficiency for pool heaters, expressed in percent, is the ratio of the annual fossil fuel output of useful energy, to the sum of the annual energy input to the pool heater (fossil fuel) plus the energy required to generate the auxiliary electrical energy delivered at the pool heater, determined according to section 4.1 of appendix P of this subpart.

* * * * *

4. Appendix N to subpart B of part 430 is revised to read as follows:

Appendix N to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers

1. *Scope.* The scope of this appendix shall be as specified in section 2.0 of ANSI/ASHRAE Standard 103–1988.

2. *Definitions.* Definitions shall include the definitions specified in section 3.0 of ANSI/ASHRAE Standard 103–1988 and the following additional definitions:

2.1 *Annual efficiency* means the ratio of annual output energy to annual input energy which includes both fossil fuel and auxiliary electrical energy. The annual output energy includes the auxiliary electrical energy recovered as useful heat. The annual input energy includes any non-heating season pilot input loss and a multiplication factor to the auxiliary electrical energy input at the appliances which represents the ratio of the energy consumed at the source of electricity generation to the electrical energy delivered at the appliances.

2.2 *ANSI/ASHRAE Standard 103–1988* means the test standard published in 1988 by ASHRAE, approved by ANSI on August 28,

1988, and entitled "Methods of Testing for AFUE of Residential Central Furnaces and Boilers."

2.3 *ASHRAE* means the American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

2.4 *Inlet damper* means a type of electro-mechanical damper upstream of the burner combustion air inlet that is an integral part of the burner and which is designed to automatically open the air flow passage to the burner box combustion air inlet when the burner is on and to automatically close off the air passage and restrict the air flow through the heat exchanger when the burner is off.

2.5 *Post purge* means the design that permits the continued operation of the combustion blower in a power vented unit, power burner unit, or forced draft unit for a period of time after the main burner is shut off for the purpose of venting of residue flue gases in the heat exchanger and the venting system.

2.6 *Thermal stack damper* means a type of stack damper which is dependent for operation exclusively upon the direct conversion of thermal energy of the stack gases to open the damper.

3.0 *Classifications.* The classifications shall be as specified in section 4.0 of ANSI/ASHRAE Standard 103–1988. Substitute sections 3.1, 3.1.1, 3.1.2, 3.1.3 and 3.1.4 of this appendix for sections 4.8, 4.8.1, and 4.8.2. of ANSI/ASHRAE Standard 103–1988.

3.1 *Off-Cycle Devices.*

3.1.1 *Stack damper.*

3.1.2 *Electro-mechanical inlet damper.*

3.1.3 *Electro-mechanical flue damper.*

3.1.4 *None.*

4. *Requirements.* Requirements shall be as specified in section 5.0 of ANSI/ASHRAE Standard 103–1988.

5. *Instruments.* Instruments shall be as specified in section 6.0 of ANSI/ASHRAE Standard 103–1988.

6. *Apparatus.* The apparatus used in conjunction with the furnace or boiler during the testing shall be as specified in section 7.0 of ANSI/ASHRAE Standard 103–1988. Substitute sections 6.1, 6.2, 6.3, 6.5, 6.6 and 6.7 of this appendix, respectively, for figure 1 of sections 7.2.1.1, 7.2.2.1, 7.2.2.2, 7.2.3.1, 7.3.2.1, 7.3.2.2, 7.3.3.1 and 7.3.1, and figure 6 is substituted with figure 1 of this appendix, supplement sections 7.2.2.3 and 7.3.2.3 with additional specifications as described in section 6.8 of this appendix, and section 6.4 of this appendix which supplements the apparatus section of ANSI/ASHRAE Standard 103–1988:

6.1 Gravity central furnaces. Note 2 in figure 1 of section 7.2.1.1 of ANSI/ASHRAE Standard 103–1988 is replaced with the following: Note # 2. 2" insulation (optional) with K=0.27 Btu•in./(hr•ft^2•°F).

6.2 The following paragraphs supplement the requirements specified in sections 7.2.2.1 and 7.3.2.1 of ANSI/ASHRAE Standard 103–1988:

For units equipped with integral draft diverters which are mounted in an exposed position (not inside the overall unit cabinet), cover the diverter boxes (excluding any openings through which draft relief air flows) before the beginning of any test (including jacket loss test) with insulation having R-value of not less than 7 hr•ft^2•°F/Btu and an outer layer of aluminum foil. For units equipped with integral draft diverters which are enclosed within the overall unit cabinet, insulate the draft diverter box with insulation described above before the cool-down and the heat-up tests described in sections 9.5 and 9.6 of ANSI/ASHRAE Standard 103–1988, respectively. Do not apply the insulation for the jacket loss test (if conducted) described in section 8.6 of ANSI/ASHRAE Standard 103–1988 and the steady-state test described in section 9.1 of ANSI/ASHRAE Standard 103–1988.

For furnaces equipped with draft hood and an electro-mechanical burner box inlet damper or an electro-mechanical flue damper, cover the 5-ft test stack with insulation having R-value of not less than 7 and an outer layer of aluminum foil before conducting the tracer gas measurement for the determination of the off-cycle loss factor K_L described in section 8.9 of this appendix.

6.3 The following paragraph supplements the requirements specified in sections 7.2.2.2 and 7.3.2.2 of ANSI/ASHRAE Standard 103–1988:

For units with power burners, cover the flue collection box with insulation having R-value of not less than 7 and an outer layer of aluminum foil before the cool-down and heat-up tests described in sections 9.5 and 9.6 of ANSI/ASHRAE Standard 103–1988, respectively. However, do not apply the insulation for the jacket loss test (if conducted) described in section 7.3 of ANSI/ASHRAE Standard 103–1988 and the steady-state test described in section 9.1 of ANSI/ASHRAE Standard 103–1988. For power vented units, insulate the shroud surrounding the blower impeller with insulation having an R-value of not less than 7 hr•ft^2•°F/Btu and an outer layer of aluminum foil before the cool-down and the heat-up tests. Do not apply the insulation for the jacket loss test (if conducted) and the steady-state test. Do not insulate the blower motor or block the air flow openings whose purpose is for cooling of the combustion blower motor or bearings.

6.4 Down flow furnaces. Install the internal section of vent pipe the same size as the flue collar for connecting the flue collar to the top of the unit if not supplied by the manufacturer. Do not insulate the internal vent pipe during the jacket loss test (if conducted) described in section 8.6 of ANSI/ASHRAE Standard 103–1988 and the steady-state test described in section 9.1 of ANSI/ASHRAE Standard 103–1988. Insulate the internal vent pipe before the cool-down and heat-up tests described in sections 9.5 and 9.6, respectively, of ANSI/ASHRAE Standard 103–1988 with insulation having R-value of not less than 7 hr•ft^2•°F/Btu and an outer layer of aluminum foil. If the vent pipe is surrounded by a metal jacket, insulate the metal jacket with insulation as described for the vent pipe above. Install a 5-ft test stack of the same cross sectional area or perimeter as the vent pipe above the top of the furnace. Tape or seal around the junction connecting the vent pipe and the 5-ft test stack. Insulate the 5-ft test stack with not less than R–7 insulation and an outer layer of aluminum foil. See figure 2 of this appendix.

6.5 The following paragraphs supplement the requirements specified in section 7.2.3.1 of ANSI/ASHRAE Standard 103–1988:

For units with an integral draft diverter, cover the five feet of stack with insulation having R-value of not less than 7 hr•ft^2•°F/Btu and an outer layer of aluminum foil. For units with draft hoods, insulate the flue pipe between the outlet of the furnace and the draft hood with insulation having R-value of not less than 7 hr•ft^2•°F/Btu and an outer layer of aluminum foil.

For units with integral draft diverters which are mounted in an exposed position (not inside the overall unit cabinet), cover the diverter boxes (excluding any openings through which draft relief air flows) before the beginning of any test (including jacket loss test) with insulation having R-value of not less than 7 hr•ft^2•°F/Btu and an outer layer of aluminum foil. For units equipped with integral draft diverters which are enclosed within the overall unit cabinet, insulate the draft diverter box with insulation described above before the cool-down and the heat-up tests described in sections 9.5 and 9.6 of ANSI/ASHRAE Standard 103–1988, respectively. Do not apply the insulation for the jacket loss test (if conducted) described in section 8.6 of ASHRAE Standard 103–1988 and the steady-state test described in section 9.1 of ANSI/ASHRAE Standard 103–1988.

6.6 The following paragraph supplements the requirements specified in section 7.3.3.1 of ANSI/ASHRAE Standard 103–1988:

For units with an integral draft diverter, cover the five feet of stack with insulation having R-value of not less than 7 hr•ft^2•°F/Btu and an outer layer of aluminum foil. For units with draft hoods, insulate the flue pipe between the outlet of the furnace and the draft hood with insulation having R-value of not less than 7 hr•ft^2•°F/Btu and an outer layer of aluminum foil.

For units with integral draft diverters which are mounted in an exposed position (not inside the overall unit cabinet), cover the diverter boxes (excluding any openings through which draft relief air flows) before the beginning of any test (including jacket loss test) with insulation having R-value of not less than 7 hr•ft^2•°F/Btu and an outer layer of aluminum foil. For units equipped with integral draft diverters which are enclosed within the overall unit cabinet, insulate the draft diverter box with insulation described above before the cool-down and the heat-up tests described in sections 9.5 and 9.6 of ANSI/ASHRAE Standard 103–1988, respectively. Do not apply the insulation for the jacket loss test (if conducted) described in section 8.6 of ANSI/ASHRAE Standard 103–1988 and the steady-state test described in section 9.1 of ANSI/ASHRAE Standard 103–1988.

6.7 *Piping.* Substitute the following paragraph for section 7.3.1 of ANSI/ASHRAE Standard 103–1988:

See figure 1 of this appendix and figures 7, 8, and 9 of ANSI/ASHRAE Standard 103–1988 for typical piping arrangements for hot water and steam boilers including electric boilers.

6.8 Oil-fueled or power gas forced air central furnaces or oil-fueled or power gas

low pressure and hot water boilers. The following paragraph supplements the requirements specified in sections 7.2.2.3 and 7.3.2.3 of ANSI/ASHRAE Standard 103–1988:

Adjustment of draft is to be done only on units with barometric draft control.

7. *Testing conditions.* The testing conditions shall be as specified in section 8.0 of ANSI/ASHRAE Standard 103–1988 with the exception of sections 8.2.1.5.2, 8.6.1.1, Table 6, and sections 8.8.2.1, 8.8.2.2, 8.8.3 and 8.8.4.1 which are revised as described in sections 7.1, 7.2, 7.3, 7.4.1, 7.4.2, 7.4.3 and 7.6 of this appendix, respectively, and the inclusion of additional test conditions as described in section 7.5 of this appendix.

7.1 The following paragraph supplements the requirement specified in section 8.2.1.5.2 of ANSI/ASHRAE Standard 103–1988:

For units which employ a draft hood and equipped with an electro-mechanical burner inlet damper or an electro-mechanical flue damper upstream of the draft hood, install an additional thermocouple grid in a horizontal plane in the 5-ft test stack described in section 7.2.2.1 of ANSI/ASHRAE Standard 103–1988 and in section 6.2 of this appendix, located one foot from the test stack inlet (use figures 3A and 3B of ANSI/ASHRAE Standard 103–1988 for reference in the installation of the thermocouple grid in the test stack).

7.2 The following paragraphs supplement the requirements specified in section 8.6.1.1 of ANSI/ASHRAE Standard 103–1988:

For forced air central furnaces, the circulating air blower compartment is considered as part of the duct system and no surface temperature measurement of the blower compartment needs to be recorded for the purpose of this test.

For units with ventilation air openings on the top, front, or sides of the unit, those openings from which the ventilation air exits from the cabinet shall be taped or sealed with aluminum tape during this test. A smoke test during a steady-state test may be used to determine the openings where the ventilation air exits from the cabinet. On the taped openings, subdivide the area into the normal 36 sq. in. grids as in section 8.6.1.1 of ANSI/ASHRAE Standard 103–1988 and measure the surface temperatures in each grid with a surface thermocouple. Install the thermocouple over the aluminum tape if necessary.

For down flow furnaces, measure all cabinet surface temperatures of the heat exchanger and combustion section, including the bottom around the outlet duct and the burner door, using the 36 sq. in. thermocouple grid described in section 8.6.1.1 of ANSI/ASHRAE Standard 103–1988. If the burner door is louvered to allow for combustion air to enter, measure temperatures on the metal strips between the louvers using the normal 36 sq. in. grid. The cabinet surface temperatures around the blower section do not need to be measured (see figure 2), and the taping of the ventilation air openings shall be as described above.

7.3 *System Numbers.* Substitute table 1 of this appendix for Table 6 of ANSI/ASHRAE Standard 103–1988.

7.4 Optional tracer gas method for determining draft factors D_P, D_F, and D_S for systems equipped with power burners or direct vent.

7.4.1 The following paragraph supplements the requirements specified in section 8.8.2.1 of ANSI/ASHRAE Standard 103–1988:

For units with step modulating controls, the optional tracer gas procedure shall be conducted during the cool-down test described in section 9.7 of ANSI/ASHRAE Standard 103–1988 at the reduced input rate only. For units with two stage modulating controls, if the optional tracer gas procedure is conducted during the cool-down test described in section 9.7 of ANSI/ASHRAE Standard 103–1988 at the reduced input rate, it shall also be conducted at the maximum input rate, and vice versa.

7.4.2 Substitute the words "On systems for which the stack damper is to be closed during the cool-down test . . ." for the first sentence of section 8.8.2.2 of ANSI/ASHRAE Standard 103–1988 and remove the words "flue or" in the first line of section 8.8.2.2 of ANSI/ASHRAE Standard 103–1988.

7.4.3 The value *0.00001* at the end of section 8.8.3 of ANSI/ASHRAE Standard 103–1988 is substituted with the value *0.05*.

7.5 Method for determining off-cycle loss factor K_L for atmospheric systems with an integral draft diverter or draft hood and equipped with either an electro-mechanical inlet damper or with an electro-mechanical flue damper upstream of the draft diverter or draft hood that restricts the flow through the heat exchanger in the off-cycle. The following paragraph is an additional subsection under section 8.8 of ANSI/ASHRAE Standard 103–1988. The method shall apply only if the electro-mechanical damper (inlet damper or flue damper) closes completely within 10 seconds after the burner shuts off. Determine K_L (the ratio of off-cycle sensible heat loss tested with the electro-mechanical damper (inlet damper or flue damper) closed during the off-cycle to the off-cycle sensible heat loss tested with the electro-mechanical damper held open during the off-cycle) during two additional 10-minute duration cool-down tests. Conduct these two additional cool-down tests after the cool-down and heat-up tests described in sections 9.5 and 9.6 of ANSI/ASHRAE Standard 103–1988 are completed. During a short burner off period before the two additional cool-down tests but after the completion of the heat-up test, cover the 5-ft test stack with insulation on units equipped with draft hood as described in section 6.2 of this appendix, and, on units equipped with integral draft diverter, remove the blocking over the draft relief opening and the restriction over the test stack outlet but keep the insulation over the rest of the draft diverter surface on (see section 9.1.4 of ANSI/ASHRAE Standard 103–1988). Conduct the first additional cool-down test by first running the unit until steady-state conditions are reached (see section 9.1.2.1 of ANSI/ASHRAE Standard 103–1988) and then shutting the unit off with the electro-mechanical damper adjusted or bypassed so that the damper is held open during the resulting cool-down period. After the cool-down period, conduct the second additional cool-down test by again running the unit until steady-state conditions are reached and then shutting the unit off but with the electro-mechanical damper operating as designed during the resulting cool-down period. Measure the stack gas mass flow rate ($M_{S,OFF}$) and the stack gas temperature during the two additional cool-down periods described above at between 5 and 6 minutes into the cool-down period using tracer gas as described in section 8.9 of this appendix and compute the off-cycle sensible heat losses over this one minute interval and the loss factor K_L with the calculation procedures as described in section 10.16 of this appendix.

7.6 The following paragraph supplements the requirements as specified in section 8.8.4.1 of ANSI/ASHRAE Standard 103–1988:

Note that the area A_S is the cross sectional area of the flue pipe, not the area inside any ring that is attached to the inside of the flue pipe. Measure the area of any holes or cut outs in the stack damper plate, $A_{O,D}$, and either measure or obtain from the manufacturer of the stack damper leakage area, $A_{O,L}$, at the damper shaft and around the damper edge when the damper is at the closed position. Both areas shall be measured at the plane of the damper.

8.0 *Test procedure.* Testing and measurements shall be as specified in section 9.0 of ANSI/ASHRAE Standard 103–1988 with the exception of sections 9.5.1.1 and 9.5.1.2.1 which are substituted by sections 8.2 and 8.4 of this appendix, respectively, and sections 9.1.2., 9.1.2.2.1, 9.1.2.2.2, 9.1.2.3.1, 9.5.1.2, 9.5.1.2.1, 9.5.1.2.2, 9.5.2.1, 9.5.2.3, 9.6.1, 9.7 and 9.10 are replaced by sections 8.1, 8.3, 8.5, 8.6, 8.7 and 8.8 of this appendix, respectively, and the inclusion of the additional procedures in sections 8.9, 8.9.1 to 8.9.7 and 8.11 of this appendix, as follows:

8.1 *Steady-State Condition and Requirements.*

8.1.1 In sections 9.1.2.2.1 and 9.1.2.2.2 of ANSI/ASHRAE Standard 103–1988, in the sentence ". . . measure the steady-state electric power to the *power burner* on units so equipped.", substitute the word *burner* for the phrase *power burner*. Also in sections 9.1.2.2.1 and 9.1.2.2.2 of ANSI/ASHRAE Standard 103–1988, substitute the following for the last sentence "For hot water boilers, use a steady-state water pump power of 0.13 kW.":

"For hot water boilers, measure the steady-state electrical power to the water pump the same way as for the air blowers for furnaces. *See section 7.7, Fig. 11 of ANSI/ASHRAE Standard 103–1988.*"

8.1.2 The following paragraph supplements the requirement specified in sections 9.1.2.2.1 and 9.1.2.2.2 of ANSI/ASHRAE Standard 103–1988:

For burners equipped with an intermittent or interrupted ignition device (electric spark ignition, glow coil, or hot surface, etc.) also measure the total electric power to the burner when the device is on, PE_T. Measure and record the length of the time interval when the interrupted ignition device is on, t_{IG}, with a stop watch.

8.1.3 The following paragraph supplements the requirement specified in

section 9.1.2.3.1 of ANSI/ASHRAE Standard 103–1988:

On units employing draft hood, secure a sample of the stack gases at either a horizontal plane in the stack 12 in. downstream of the draft hood or in a horizontal plane 6 in. from the top of the test stack. Make sure that there are no holes or air leaks in the section of the stack from the draft hood up to the location where the stack gas is sampled. Determine the concentration by volume of carbon dioxide (CO_2,s) present in dry stack gas. Use figures 3A and 3B (test stack for units with draft diverter) as reference for the location of CO_2 measurement.

8.2 Gas- and oil-fueled gravity and forced air central furnaces without stack dampers—cool-down test. The following paragraphs are in place of the requirements specified in section 9.5.1.1 of ANSI/ASHRAE Standard 103–1988:

Turn off the main burner after steady-state testing is completed and measure the flue gas temperature by means of the thermocouple grid described in section 7.6 of ANSI/ASHRAE Standard 103–1988 at 1.5 ($T_{F,OFF}(t_3)$) and 9 minutes ($T_{F,OFF}(t_4)$) after burner shuts off. An integral draft diverter shall remain blocked, insulated, and the stack restriction shall remain in place. On atmospheric systems with an integral draft diverter or draft hood and equipped with either an electro-mechanical inlet damper or an electro-mechanical flue damper which closes within 10 seconds after the burner shuts off to restrict the flow through the heat exchanger in the off-cycle, bypass or adjust the control for the electro-mechanical damper so that the damper remains open during the cool-down test.

For furnaces that employ post purge, measure the length of the post purge period with a stopwatch. The time from burner off to combustion blower off (electrically de-energized) shall be recorded as t_P. Measure the flue gas temperature by means of the thermocouple grid described in section 7.6 of ANSI/ASHRAE Standard 103–1988 at the end of post purge period t_P ($T_{F,OFF}(t_P)$) and at the time (1.5+t_P) minutes ($T_{F,OFF}(t_3)$) and (9.0+t_P) minutes ($T_{F,OFF}(t_4)$) after the main burner shuts off. For the cases where the measured t_P is less than or equal to 5 seconds, it shall be tested as if there was no post purge.

8.3 In section 9.5.1.2 of ANSI/ASHRAE Standard 103–1988, substitute the following sentence for the sentence "For oil-fueled or power gas burner furnaces, maintain the draft in the flue pipe within ±0.01 in. of water gage of the average steady-state draft.":

"For oil-fueled or power gas burner furnaces employing barometric dampers for draft control, maintain the draft in the flue pipe within ±0.01 in. of water gage of the average steady-state draft."

8.4 *Gas- and oil-fueled gravity and forced air central furnaces without stack dampers—cool-down test.* The following paragraph is in place of the requirements specified in sections 9.5.1.2.1 and 9.5.1.2.2 of ANSI/ASHRAE Standard 103–1988:

For a furnace with adjustable fan control, this time delay will be 1.5-minute for condensing furnaces. For non-condensing furnaces with adjustable fan control, this delay shall be 3.0-minute or until the supply air temperature drops to a value of 40°F above the inlet air temperature whichever results in the longest fan on-time.

For a furnace without adjustable fan control or with the type of adjustable fan control whose range of adjustment does not allow for the delay times specified in the above paragraph, the control shall be bypassed and the fan manually controlled to give the delay times specified in the above paragraph.

For a furnace which employs a single motor to drive the power burner and the indoor air circulating blower, the power burner and indoor air circulating blower shall be stopped together.

For a power burner employing post purge where the post purge period is controlled by the fan control during the cool-down period, the fan control shall be adjusted to give a time as specified above and the combustion blower and the fan shall be stopped together as designed.

8.5 *Gas- and oil-fueled boilers without stack dampers.* The following paragraph supplements the requirements specified in section 9.5.2.1 of ANSI/ASHRAE Standard 103–1988:

For boilers that employ post purge, measure the length of the post purge period with a stopwatch. The time from burner off to combustion blower off (electrically de-energized) shall be recorded as t_P. Measure the flue gas temperature by means of the thermocouple grid described in section 7.6 of ANSI/ASHRAE Standard 103–1988 at the end of post purge period t_P ($T_{F,OFF}(t_P)$) and at the time (3.75 + t_P) minutes ($T_{F,OFF}(t_3)$) and (22.5 + t_P) minutes ($T_{F,OFF}(t_4)$) after the main burner shuts off. For the cases where the measured t_P is less than or equal to 5 seconds, it shall be tested as if there was no post purge.

8.6 In section 9.5.2.3 of ANSI/ASHRAE Standard 103–1988, substitute the following for the sentence "For oil-fueled or power gas burner units not equipped with stack dampers, maintain the draft in the flue within the same ranges specified in section 9.5.1.2.":

"For oil-fueled or power gas burner units employing barometric dampers for draft control and not equipped with stack dampers, maintain the draft in the flue within the same ranges specified in section 9.5.1.2."

8.7 The following paragraph supplements the requirements specified in section 9.6.1 of ANSI/ASHRAE Standard 103–1988:

For a unit designed to operate with an unvarying time delay (case 3 described in section 9.6.1 of ANSI/ASHRAE Standard 103–1988), the unit shall operate as designed except that the time delay shall be not less than 20-second. If the delay is less than 20 seconds, the blower control shall be bypassed and the blower started manually 20 seconds after the burner starts up. If the time delay is adjustable by dip switch or jumper terminals, select the time delay closest to the 1.5-minute specified except when the maximum time delay that can be selected is less than 20 seconds in which case the blower control shall be bypassed and the blower started manually 20 seconds after the burner starts up.

8.8 Optional tracer gas test procedures for determining draft factors for D_P, D_F, and D_S for systems equipped with power burners or direct vent and not equipped with stack dampers. The following are deletions and additions to sections 9.7 and 9.7.3 of ANSI/ASHRAE Standard 103–1988:

8.8.1 In section 9.7.3 of ANSI/ASHRAE Standard 103–1988, the sentence "At the same time, if draft is not maintained during the cool-down, measure the flue gas temperature, $T_{F,OFF}$, using the thermocouple grid described in section 7.6." is replaced with: At the same time, measure the flue gas temperature, $T_{F,OFF}$, using the thermocouple grid described in 7.6.

8.8.2 The following paragraph supplements the requirements specified in section 9.7.3 of ANSI/ASHRAE Standard 103–1988:

For systems employing post purge with post purge time period t_P (see sections 8.2 and 8.5 of this appendix), measure the percent volumetric concentration of the tracer gas present in the diluted flue gas sample, C_T, at between (5+t_P) and (6+t_P) minutes after the burner shuts off. During the same time period, measure the flue gas temperature, $T_{F,OFF}$, using the thermocouple grid described in section 7.6 of ANSI/ASHRAE Standard 103–1988.

8.8.3 Substitute the value 0.05 for the value 0.00001 at the end of the paragraph in section 9.7.4 of ANSI/ASHRAE Standard 103–1988.

8.8.4 For units with two stage modulating controls the optional tracer gas test shall be conducted at both the maximum and the reduced inputs. For units with step modulating controls, the optional tracer gas test shall be conducted at the reduced input only.

8.9 Tracer gas test procedures for determining off-cycle loss factor K_L for atmospheric systems with integral draft diverter or draft hood and equipped with either an electro-mechanical inlet damper or an electro-mechanical flue damper that restricts the flow through the heat exchanger in the off-cycle.

8.9.1 The tracer gas chosen for this task should have a density which is less than or approximately equal to the density of air. Use a gas that is of a different chemical species or different concentration from the flue gas to be measured and unreactive with the environment to be encountered. Obtain the concentration of tracer gas present in the flue gas sample (C_T) using an analyzer or instrument with accuracy of ±2 percent in the measured value. Determine the temperature of the tracer gas entering the flow meter (T_T) and the barometric pressure (P_B).

8.9.2 After the completion of the heat-up test in section 9.6 of ANSI/ASHRAE Standard 103–1988, turn the burner off. On units equipped with an integral draft diverter, remove the blocking over the draft diverter and the restriction in the test stack that are installed during the steady-state test (in preparation for the cool-down test) in section 9.1.4 of ANSI/ASHRAE Standard 103–1988. Do not remove the insulation covering the draft diverter surfaces. On units

equipped with draft hood, cover the 5-ft test stack with insulation material with R-value of no less than 7 hr•ft²•°F/Btu and an outer layer of aluminum foil as described in section 6.2 of this appendix. In the mean time, sample and feed the ambient air to the tracer gas analyzer and record the background concentration C_{TB} of the tracer gas to be used for the test (one data point is usually sufficient).

8.9.3 Turn the burner on until steady-state conditions are again achieved as specified in section 9.1.2.1 of ANSI/ASHRAE Standard 103–1988. Turn the burner off for a 10-minute cool-down period. Adjust or bypass the electro-mechanical damper (inlet damper or flue damper) so that it remains open during this cool-down period. Within one minute after the unit is shut off to start this cool-down test, begin feeding a tracer gas with a known, certified concentration C_{Tm} at a constant flow rate V_T into the lower part of the test stack just above the test plane where the stack thermocouple grid is located (see section 8.2.1.5.1 of ANSI/ASHRAE Standard 103–1988). Periodically measure the value of V_T with an instantaneously reading flow meter having an accuracy of ±3 percent of the quantity measured and maintain that value of tracer gas flow rate at less than one percent of the air flow rate through the test stack.

8.9.4 Within one minute after the tracer gas flow is started, connect the tracer gas sampling line to the sampling probe located at a plane inside and 6 in. below the top exit of the test stack. Measure the transport delay time which is equal to the time between the connecting of the sampling line and the initial response of the tracer gas analyzer. Add to this transport time the time required for the analyzer to reach 90 percent of its steady-state value as specified in the analyzer's operation manual. The sum of these two values is the tracer gas sample delay time needed to match the concentration measurement to the temperature measurement in the off-period loss calculation. Make sure that a well mixed sample is collected by using a multi-hole sampling probe as recommended in Appendix D, section B of ANSI/ASHRAE Standard 103–1988. Return the sample gas (after exiting the gas analyzer) to the top of the test stack downstream of the plane of collection.

8.9.5 At 5 minutes after the unit is shut off to start the cool-down test, measure and record the percent volumetric concentration of tracer gas present in the stack gas sample, C_T, at the location specified in section 8.9.4 of this appendix. At the same time, measure the stack gas temperature, $T_{S,OFF}$, using the thermocouple grid in the test plane (see section 8.2.1.5.1 of ANSI/ASHRAE Standard 103–1988). The data measurement and recording should be done at a time interval, Δt, of 5 seconds for the next 2 to 3 minutes. The exact length of time required for the tracer gas data measurement is equal to the tracer gas sample delay time (see section 8.9.4 of this appendix) plus 1 minute. (Even though only one minute of tracer gas data are required for the computation of the off-cycle loss, the longer time is needed to take into account the time delay between the concentration data and the temperature data.) Stop the tracer gas injection and sampling after the required data are measured and recorded. Disconnect the tracer gas sampling line from the sample probe and sample the ambient air to clear the line.

8.9.6 At the end of the 10-minute cool-down period, turn on the burner until steady-state conditions are again achieved as specified in section 9.1.2.1 of ANSI/ASHRAE Standard 103–1988. Turn the burner off for another 10-minute cool-down period. Let the electro-mechanical damper (inlet damper or flue damper) close the way it is designed to. Repeat the test steps of sections 8.9.3 through 8.9.5 of this appendix except that the electro-mechanical damper is to remain closed. Note that the tracer gas feeding rate, V_T, may have to be adjusted to a lower rate to keep the sample concentration within the range of the gas analyzer used.

8.9.7 The rate of the stack gas flow through the stack, the off-cycle sensible loss rate, and the loss factor K_L are calculated by the equations in section 10.16 of this appendix.

8.10 Substitute the value 0.05 for the value 0.00001 in the first sentence of section 9.10 of ANSI/ASHRAE Standard 103–1988.

8.11 *Direct measurement of off-cycle losses testing method.*

9. *Nomenclature.* Nomenclature shall include the nomenclature specified in section 10.0 of ANSI/ASHRAE Standard 103–1988 with the exception of the variables M_C,PE and Q_C which are revised in this appendix and the following additional variables:

AE=Annual Efficiency, percent

A_O=minimum opening area (including leakage) of stack damper when closed, in²
$=A_{O,D}\cos\Omega+A_{O,L}$

$A_{O,D}$=open area (holes and cut-outs) in stack damper plate, in²

$A_{O,L}$=leakage area around stack damper shaft and damper edges, in²

C_{TB}=concentration by volume of the tracer gas in the background, percent

D_{OI}=infiltration correction factor for stack damper effectiveness

K_L=off-cycle loss factor for atmospheric burner with burner inlet damper or with flue damper upstream of the integral draft diverter or draft hood

M_C=mass of condensate, lb

PE=electrical power to burner under steady-state operation, kW

PE_T=total electrical power to burner when the electrical intermittent or interrupted ignition device if employed is on, kW

$PE_{IG}=PE_T-PE$, electrical power to the electrical intermittent or interrupted ignition device, kW

Q_C=fuel energy input during entire (3 or 6 test cycles) cyclic condensate collection test, Btu

$q_{S,OFF}$=off-cycle sensible loss rate, Btu/min.

$Q_{S,OFF}$=1 minute sum of the measured $q_{S,OFF}\bullet\Delta t$, where Δt is defined below, Btu

t_{DELAY}=delay time, sum of tracer gas analyzer response time to reach 90 percent of the steady state value and the gas transport time delay, minutes

t_{IG}=electrical intermittent or interrupted ignition device on-time, minutes

t_P=power burner post purge time period, minutes

$T_{F,OFF}(t_P)$=off-cycle flue gas temperature at the end of power burner post purge period, °F

y_{IG}=ratio of electrical intermittent or interrupted ignition device on-time to average burner on-time

y_P=ratio of power burner combustion blower on-time to average burner on-time

Δt=time interval between each measurement of temperature or tracer gas concentration, seconds

10. *Calculation of derived results from test measurements.* Calculations shall be as specified in section 11.0 of ANSI/ASHRAE Standard 103–1988 with the exception of sections 11.2.4, Table 7 (of section 11.2.6), 11.2.9.4, 11.2.9.6, 11.2.9.9, 11.2.9.14, 11.2.9.16, 11.2.9.19, 11.2.9.20, 11.2.10.6, 11.2.10.8, 11.2.11, 11.2.12, 11.3.12, 11.4.8.1.2, 11.4.8.5, 11.4.8.8, 11.4.8.10, 11.4.12, 11.5.12, 11.6.4, 11.7.1, 11.7.2, 11.2.9.18, 11.4, 11.5 and Appendix E which are substituted, and the inclusion of additional calculations in sections 10.16, 10.17, 10.18, 10.19 and 10.21 of this appendix, as follows:

10.1 Remove the words "oil or power" in the first sentence of the second paragraph of section 11.2.4 of ANSI/ASHRAE Standard 103–1988 and the beginning of the sentence is substituted by "For gas furnaces and boilers requiring draft relief:". The first sentence in the fourth paragraph of section 11.2.4 (14th line from the beginning of the section) of ANSI/ASHRAE Standard 103–1988 is substituted by "For oil or gas power furnaces and boilers tested with barometric dampers but not marketed and sold with attached barometric dampers, S/F shall be 1.4". The sentence in the third paragraph of section 11.2.4 of ANSI/ASHRAE Standard 103–1988, "For gas furnaces and boilers not requiring draft relief: S/F=1" is substituted by "For direct exhaust gas and oil furnaces and boilers: S/F=1".

10.2 *Table 7.* A right closing bracelet is added at the end of the equation defining $L_{*,SS}$ in Table 7 of section 11.2.6 of ANSI/ASHRAE Standard 103–1988.

10.3 *On-cycle time constant.* The following calculations procedures supplement the procedures specified in section 11.2.9.4 of ANSI/ASHRAE Standard 103–1988:

If $T_{F,ON}(t_1)\geq T_{F,SS}$, use $T_{F,ON}(t_1)=T_{F,SS}-0.2$
If $T_{F,ON}(t_2)\geq T_{F,SS}$, use $T_{F,ON}(t_2)=T_{F,SS}-0.1$
If $T_{F,ON}(t_1)\geq T_{F,ON}(t_2)$, use
$T_{F,ON}(t_1)=T_{F,ON}(t_2)-0.1$

10.4 *Off-cycle time constant.* The following calculation procedures supplement the procedures specified in section 11.2.9.6 of ANSI/ASHRAE Standard 103–1988:

If $T_{F,OFF}(t_4)\leq T_{F,OFF}(t_5)$, use
$T_{F,OFF}(t_4)=T_{F,OFF}(t_5)+0.1$
If $T_{F,OFF}(t_3)\leq T_{F,OFF}(t_5)$, use
$T_{F,OFF}(t_3)=T_{F,OFF}(t_5)+0.2$
If $T_{F,OFF}(t_3)\leq T_{F,OFF}(t_4)$, use
$T_{F,OFF}(t_3)=T_{F,OFF}(t_4)+0.1$

For furnaces or boilers employing post purge with post purge period t_P (see sections 8.2 and 8.5 of this appendix), the time t_3, t_4, and t_5 are defined as:

For furnaces:

$t_3=(t_P+1.5)$ minutes
$t_4=(t_P+9.0)$ minutes
t_5=infinity.
For boilers:
$t_3=(t_P+3.75)$ minutes
$t_4=(t_P+22.5)$ minutes
t_5=45 minutes
where:
t_P=is as defined in 8.2 (furnaces) and 8.5 (boilers) of this appendix

10.5 Substitute the following for the definitions of D_F in section 11.2.9.9 of ANSI/ASHRAE Standard 103–1988:

D_F=off-cycle flue gas draft factor equal to:
=1.0 for units with atmospheric burners, systems 1, 5, 9 (except direct vent and atmospheric burners with either electro-mechanical inlet dampers or flue dampers).
=0.4 or D_P for units with power burners, systems 2, 3, 4, 6, 8, 10.
=1.0 or D_P for direct vent units with atmospheric burners, system 9 (direct vent only).
=1.0 or D_P for atmospheric burners with either electro-mechanical inlet dampers or flue dampers, system 1, and system 9 with units employing isolated combustion.
=0.05 for units complying with section 7.4.3 of this appendix.

In the same section (11.2.9.9), the definitions for $D_S{}^o$ for systems 4 and 8 is revised to read as:

$D_S{}^o$=0.85 or [(0.79+D_P)/1.4] for systems 4 and 8.

10.6.1 The definitions for $\psi_{F,O,X}$ and $\theta_{F,O,X}$ in section 11.2.9.14 of ANSI/ASHRAE Standard 103–1988 are revised to read as:

$\psi_{F,O,X}$=as defined in section 11.2.9.7 of ANSI/ASHRAE Standard 103–1988
$\theta_{F,O,X}$=as defined in section 11.2.9.5 of ANSI/ASHRAE Standard 103–1988

10.6.2 The phrase "9–12" in the eighth line of section 11.2.9.16 of ANSI/ASHRAE Standard 103–1988 is deleted and the beginning of the sentence is revised to read "For systems numbered 9–10:".

10.7 *Determine the off-cycle stack gas draft factor, D_S.* The following calculation procedures are in place of section 11.2.9.18 of ANSI/ASHRAE Standard 103–1988:

Determine the off-cycle stack gas draft factor, D_S, defined as:

D_S=1.0 for systems 1 and 2.
=0.4 or D_P for direct exhaust system with power burners, system 3.
=0.85 or [(0.79+D_P)/1.4] for system 4.
=D_O for systems 5 and 6.
=0.85D_O or [(0.79+D_P)/1.4]D_O for system 8.

where:

D_P=as defined in section 11.2.9.9 of ANSI/ASHRAE Standard 103–1988.
D_O=stack damper effectiveness factor defined as follows:

Stack damper effectiveness factor. For systems 5, 6, or 8, calculate the stack damper effectiveness factor, D_O, defined as:

$$D_O=\frac{\sum_{j=1}^{n} D_{S,j}\left[\left(100-\psi_{S,\infty,j}\right)\left(G1_j\right)\left(G2_j\right)+\psi_{S,\infty,j}\left(G3_j\right)\left(G4_j\right)\right]_j\cdot\left(h_j\right)}{\sum_{j=1}^{n}\left[\left(100-\psi_{S,\infty}\right)(G1)(G2)+\psi_{S,\infty}(G3)(G4)\right]_j\cdot\left(h_j\right)}$$

Infiltration correction factor for stack damper effectiveness. For systems 5, 6, or 8, calculate the infiltration correction factor D_{OI}, defined as:

$$D_{OI}=\frac{\sum_{j=1}^{n} D_{S,j}\left[\left(100-\psi_{S,\infty,j}\right)\left(G2_j\right)+\left(\psi_{S,\infty,j}\right)\left(G4_j\right)\right]_j\cdot\left(h_j\right)}{\sum_{j=1}^{n}\left[\left(100-\psi_{S,\infty}\right)(G2)+\left(\psi_{S,\infty}\right)(G4)\right]_j\cdot\left(h_j\right)}$$

where:

h_j=dimensionless time increment given by $h_j=1/n$.
n=100, number of segments between $t/t_{OFF}=0$ to $t/t_{OFF}=1.0$
$\psi_{S,\infty}=\psi_{S,\infty,X}$ as defined in section 11.2.9.9 of ANSI/ASHRAE Standard 103–1988
$G1=\psi_{S,O}\cdot\exp(-t/t_{OFF})=\psi_{S,O}\cdot\exp(-(t_{OFF}/t_{OFF})(t/t_{OFF}))$
$G2=(G1+28)^{0.56}/(G1+630)^{1.19}$
$G3=G1+100$
$G4=(G1+128)^{0.56}/(G1+630)^{1.19}$
$\psi_{S,O}$=as defined in section 11.2.9.17 of ANSI/ASHRAE Standard 103–1988
$\psi_{S,\infty,j}=(D_F)(\psi_{F,\infty})/[(S/F)(D_{S,j})(D_S{}^o)]$ for $(S/F)(D_{S,j})(D_S{}^o)>D_F$
$=\psi_{F,\infty}$ for $(S/F)(D_{S,j})(D_S{}^o)\le D_F$
$\psi_{F,\infty}$=as defined in section 11.2.9.16 of ANSI/ASHRAE Standard 103–1988
$G1_j=\psi_{S,O,j}\cdot\exp(-(t_{OFF}/\tau_{OFF})(t/t_{OFF}))$
$G2_j=(G1_j+28)^{0.56}/(G1_j+630)^{1.19}$
$G3_j=G1_j+100$
$G4_j=(G1_j+128)^{0.56}/(G1_j+630)^{1.19}$
$\psi_{S,O,j}=(D_F)(\psi_{F,O})/[(S/F)(D_{S,j})(D_S{}^o)]$ for $(S/F)(D_{S,j})(D_S{}^o)>D_F$
$=\psi_{F,O}$ for $(S/F)(D_{S,j})(D_S{}^o)\le D_F$
$\psi_{F,O}$=as defined in section 11.2.9.15 of ANSI/ASHRAE Standard 103–1988

Values of $D_{S,j}$ during the summation:
$D_{S,j}=1.0$ when $0\le t<t_s$
$D_{S,j}=D_S'$ when $t_s\le t<t_e$
$D_{S,j}=D_E$ when $t_e\le t\le t_{OFF}$

where:

$t=jh_jt_{OFF}$

and

$$D_S'=\sqrt{5}\Bigg/\left[5+\frac{2.6\left[\left(A_D/A_S\right)\sin\left[(\pi/2-\Omega)\tilde{t}\right]\right]^{1.58}}{\left[1-\left(A_D/A_S\right)\sin\left[(\pi/2-\Omega)\tilde{t}\right]\right]^{2}}\right]$$

where:

$\tilde{t}=(t-t_s)/(t_e-t_s)$ when $0 \le \tilde{t} \le 1$

t_s=time when damper start to close

t_e=time when damper finishing closing, or=t_s+t_d, when t_d=the duration of closing.

$D_E=(A_O/A_S)\cdot\{5/[5(A_O/A_S)^2+2.6(1-A_O/A_S)^{1.58}]\}^{1/2}$

where:

A_S=cross-sectional area of the stack, in^2, (see section 8.8.4 of ANSI/ASHRAE Standard 103–1988)

A_D=net area of the damper plate, in^2, (see section 8.8.4 of ANSI/ASHRAE Standard 103–1988)

A_O=minimum opening (including leakage) area of the damper when closed, $=A_{O,D}COS\Omega+A_{O,L}$, in^2

$A_{O,D}$=holes and cut-outs in damper plate as defined in 7.6 of this appendix

$A_{O,L}$=leakage area around damper shaft and edges as defined in 7.6 of this appendix

Ω=the angle the damper makes when closed, with a plane perpendicular to the axis of the stack (see section 8.8.4 of ANSI/ASHRAE Standard 103–1988), radians

10.8 *Off-cycle heat loss integration factors.* The following paragraphs are modifications to sections 11.2.9.19 and 11.2.9.20 of ANSI/ASHRAE Standard 103–1988:

10.8.1 *Off-cycle sensible heat loss integration factors.* The following paragraphs supplement the calculation procedures specified in section 11.2.9.19 of ANSI/ASHRAE Standard 103–1988:

For systems numbered 2, 3, and 4 which employ post purge after the burner is shut off, determine off-cycle sensible heat loss integration factors, F3 and F4, from Figures 14 and 15 of ANSI/ASHRAE Standard 103–1988, respectively, using values of $\Psi_{F,O}$ defined in 11.2.9.15 of ANSI/ASHRAE Standard 103–1988, and a modified R_{OFF} defined as:

$R_{OFF}=(t_{OFF}-t_P)/\tau_{OFF}$

where:

t_{OFF}=as defined in section 11.2.9.12 of ANSI/ASHRAE Standard (ANSI/ASHRAE) 103–1988

t_P=as defined in section 8.2 (furnaces) or 8.5 (boilers) of this appendix

τ_{OFF}=as defined in section 11.2.9.6 of ANSI/ASHRAE Standard 103–1988

For system number 10 which employs post purge after the burner is shut off, determine off-cycle sensible heat loss integration factors, F5 and F6, from Figures 16 and 17 of ANSI/ASHRAE Standard 103–1988, respectively, using values of $\Psi_{F,O}$ defined in section 11.2.9.15 of ANSI/ASHRAE Standard 103–1988, and the modified R_{OFF} defined above.

10.8.2 *Off-cycle infiltration heat loss integration factors.* The following paragraphs supplement the calculation procedures specified in section 11.2.9.20 of ANSI/ASHRAE Standard 103–1988:

For system numbered 2 and 4 which employ post purge after the burner is shut off, determine off-cycle infiltration heat loss integration factors, F7 and F8, from figures 18 and 19 of ANSI/ASHRAE Standard 103–1988, respectively, using values of $\Psi_{S,O}$ defined in section 11.2.9.17 of ANSI/ASHRAE Standard 103–1988, and a modified R_{OFF} defined in section 10.8 of this appendix.

For system number 3 which employs post purge after the burner is shut off, determine off-cycle infiltration heat loss integration factors, F7 and F8, from Figures 18 and 19 of ANSI/ASHRAE Standard 103–1988, respectively, using values of $\Psi_{F,O}$ defined in 11.2.9.15 of ANSI/ASHRAE Standard 103–1988, and a modified R_{OFF} defined in section 10.8 of this appendix.

10.9 Multiplication factor for infiltration loss during burner off-cycle. The following paragraphs are in place of the calculation procedure specified in section 11.2.10.4 of ANSI/ASHRAE Standard 103–1988:

Calculate a multiplication factor for infiltration loss during burner off-cycle $K_{I,OFF}$, defined as:

For systems numbered 1, 2 and 4:

$$K_{I,OFF}=\frac{\left(T_{S,SS}-T_{RA}+530\right)^{1.19}\left(K_{I,ON}\right)\left(D_S\right)}{\left(T_{S,SS}-T_{RA}+70-T_{OA}\right)^{0.56}}$$

For systems numbered 5–8:

$$K_{I,OFF}=\frac{\left(T_{S,SS}-T_{RA}+530\right)^{1.19}\left(K_{I,ON}\right)\left(D_S\right)}{\left(T_{S,SS}-T_{RA}+70-T_{OA}\right)^{0.56}}\cdot\left(\frac{D_{OI}}{D_O}\right)$$

For system number 3:

$$K_{I,OFF}=\frac{\left(T_{F,SS}-T_{RA}+530\right)^{1.19}\left(K_{I,ON}\right)\left(D_S\right)}{\left(T_{F,SS}-T_{RA}+70-T_{OA}\right)^{0.56}}$$

where:

$T_{S,SS}$=as defined in section 11.2.9.3 of ANSI/ASHRAE Standard 103–1988

$T_{F,SS}$=as defined in section 11.2.5 of ANSI/ASHRAE Standard 103–1988

530=as defined in section 11.2.10.3 of ANSI/ASHRAE Standard 103–1988

T_{OA}=as defined in section 11.2.8.4 of ANSI/ASHRAE Standard 103–1988

$K_{I,ON}$=as defined in section 11.2.9.2 of ANSI/ASHRAE Standard 103–1988

D_S=as defined in section 10.7 of this appendix

D_O=as defined in section 10.7 of this appendix

D_{OI}=as defined in section 10.7 of this appendix

70=as defined in section 11.2.10.1 of ANSI/ASHRAE Standard 103–1988

T_{RA}=as defined in section 11.2.5 of ANSI/ASHRAE Standard 103–1988

For system numbers 9 and 10:

$K_{I,OFF}=0$

10.10 *Off-cycle sensible heat loss.* The following are revision and additions to the calculation procedures specified in section 11.2.10.6 of ANSI/ASHRAE Standard 103–1988:

10.10.1 The definition for F6 in section 11.2.10.6 of ANSI/ASHRAE Standard 103–1988 is revised to read as "and F6=as defined in section 11.2.9.19."

10.10.2 The following paragraphs are additions to the calculation procedures as specified in section 11.2.10.6 of ANSI/ASHRAE Standard 103–1988:

For furnaces or boilers employing post purge after the burner is shut off, calculate

the off-cycle sensible heat loss of the system, $L_{S,OFF}$, expressed in percent and defined as:

$L_{S,OFF}=L_{S,OFF1}+L_{S,OFF2}$

Where $L_{S,OFF1}$, the off-cycle sensible heat loss during the post purge period, is defined as:

$$L_{S,OFF1}=100\cdot C_P\cdot M_{F,ON}\cdot t_P\cdot\left(T_{F,SS}+460\right)\cdot\left[1/\left(t_{ON}\cdot Q_{IN}\cdot 60\right)\right]\cdot\left[1+\frac{T_{RA}+460}{C_{TS}\left[T_{F,SS}-T_{F,OFF}\left(t_P\right)\right]}\cdot\ln\left[\frac{T_{RA}+460+C_{TS}\cdot\left[T_{F,OFF}\left(t_P\right)-T_{RA}\right]}{T_{RA}+460+C_{TS}\cdot\left[T_{F,SS}-T_{RA}\right]}\right]\right]$$

where:

$C_{TS}=C_{T,OFF}$ for systems numbered 2, 3 and 4

$=(C_S')(C_{T,OFF})$ for system number 10

$C_{T,OFF}$=as defined in section 11.2.9.14 of ANSI/ASHRAE Standard 103–1988

C_S'=as defined in section 11.2.9.15 of ANSI/ASHRAE Standard 103–1988

and where $L_{S,OFF2}$, the off-cycle sensible heat loss after the post purge period, is defined as:

For systems numbered 2, 3 and 4:

$L_{S,OFF2}=(K_{S,OFF})[(t_{OFF}-t_P)/t_{ON}]\bullet[(F3)+(\psi_{F,\infty})(F4)]$

For system number 10:

$L_{S,OFF2}=(K_{S,OFF})[(t_{OFF}-t_P)/t_{ON}]\bullet[(F5)+(\psi_{F,\infty})(F6)]$

where:

100=conversion factor to express a decimal as a percent

C_P=as defined in section 11.2.9.1 of ANSI/ASHRAE Standard 103–1988

$M_{F,ON}$=rate of flue gas mass flow during the on period, as defined in section 11.6.1 of ANSI/ASHRAE Standard 103–1988

t_P=length of post purge time, as defined in sections 8.2 and 8.5 of this appendix

$T_{F,SS}$=as defined in section 11.2.5 of ANSI/ASHRAE Standard 103–1988

Q_{IN}=as defined in section 11.2.8.1 of ANSI/ASHRAE Standard 103–1988

60=conversion factor, hour to minute

460=conversion factor, °F to °R

T_{RA}=as defined in section 11.2.5 of ANSI/ASHRAE Standard 103–1988

$T_{F,OFF}(t_P)$=off-cycle flue gas temperature at the end of power burner post purge period (see section 8.2 or 8.5 of this appendix), °F

F3, F4, F5 and F6=as defined in section 10.8.1 of this appendix for units with post purge, and in section 11.2.9.19 of ANSI/ASHRAE Standard 103–1988 for units without post purge

10.11 *Off-cycle infiltration heat loss.* The following paragraphs are revisions and additions to the calculation procedures specified in section 11.2.10.8 of ANSI/ASHRAE Standard 103–1988:

10.11.1 The equation defining K_{LOFF} and F7, F8 are revised to read as:

K_{LOFF}=as defined in section 10.9 of this appendix

F7, F8=as defined in section 11.2.9.20 of ANSI/ASHRAE Standard 103–1988 for units without post purge

10.11.2 The following paragraphs supplement the calculation procedures specified in section 11.2.10.8 of ANSI/ASHRAE Standard 103–1988:

For furnaces or boilers employing post purge after the burner is shut off, calculate the off-cycle infiltration heat loss of the system, $L_{I,OFF}$, expressed in percent and defined as:

$L_{I,OFF}=L_{I,OFF1}+L_{I,OFF2}$

Where $L_{I,OFF1}$, the off-cycle infiltration heat loss during the post purge period, is defined as, for systems numbered 2, 3, and 4:

$$L_{I,OFF1}=100\cdot C_P\cdot M_{F,ON}\cdot t_P\cdot\left(T_{F,SS}+460\right)\cdot\left[\frac{70-T_{OA}}{C_{T,OFF}\left[T_{F,SS}-T_{F,OFF}\left(t_P\right)\right]}\right]\cdot\ln\left[\frac{T_{RA}+460+C_{T,OFF}\cdot\left[T_{F,SS}-T_{RA}\right]}{T_{RA}+460+C_{T,OFF}\cdot\left[T_{F,OFF}\left(t_P\right)-T_{RA}\right]}\right]\cdot\left[\frac{1}{\left(t_{ON}\cdot Q_{IN}\cdot 60\right)}\right]$$

and

$L_{I,OFF2}$, the off-cycle infiltration heat loss after the post purge period, is defined as:

For system numbered 2 and 4:

$L_{I,OFF2}=(K_{I,OFF})(70-T_{OA})[(t_{OFF}-t_P)/t_{ON}]\bullet[(F7)+(\psi_{S,\infty})(F8)]$

For system number 3:

$L_{I,OFF2}=(K_{I,OFF})(70-T_{OA})[(t_{OFF}-t_P)/t_{ON}]\bullet[(F7)+(\psi_{F,\infty})(F8)]$

where:

100=conversion factor to express a decimal as a percent

C_P=as defined in section 11.2.9.1 of ANSI/ASHRAE Standard 103–1988

$M_{F,ON}$=rate of flue gas mass flow during the on period, as defined in section 11.6.1 of ANSI/ASHRAE Standard 103–1988

t_P=length of post purge time, as defined in 8.2 and 8.5 of this appendix

$T_{F,SS}$=as defined in section 11.2.5 of ANSI/ASHRAE Standard 103–1988

460=conversion factor, °F to °R

70=assumed average indoor air temperature, as defined in section 11.2.10.1 of ANSI/ASHRAE Standard 103–1988, °F

T_{OA}=national average outdoor air temperature, as defined in section 11.2.8.4 of ANSI/ASHRAE Standard 103–1988, °F

T_{RA}=as defined in section 11.2.5 of ANSI/ASHRAE Standard 103–1988

$C_{T,OFF}$=as defined in section 11.2.9.14 of ANSI/ASHRAE Standard 103–1988

$T_{F,OFF}(t_P)$=off-cycle flue gas temperature at the end of power burner post purge period (see section 8.2 or 8.5 of this appendix), °F

F7 and F8=as defined in section 10.8.2 of this appendix for power burners with post purge

Q_{IN}=as defined in section 11.2.8.1 of ANSI/ASHRAE Standard 103–1988

60=conversion factor, hour to minute

For system number 10:

$L_{I,OFF1}=0$

$L_{I,OFF2}=0$

10.12 *Heating seasonal efficiency and AFUE.* The following paragraphs supplement the calculation procedures as specified in sections 11.2.11 and 11.2 12 of ANSI/ASHRAE Standard 103–1988:

10.12.1 *Heating seasonal efficiency.*

10.12.1.1 For furnaces or boilers employing post purge after the burner is shut off, the definitions for $L_{S,OFF}$ and $L_{I,OFF}$ are replaced with the following in section 11.2.11 of ANSI/ASHRAE Standard 103–1988:

$L_{S,OFF}$=as defined in section 10.10 of this appendix

$L_{I,OFF}$=as defined in section 10.11 of this appendix

10.12.1.2 The following supplements the definition for the listed value of the jacket loss factor C_J in section 11.2.11 (and also referenced in section 11.3.11.3) of ANSI/ASHRAE Standard 103–1988:

C_J=0.5 for finned tube boilers intended to be installed in ICS applications

10.12.2 *Annual fuel utilization efficiency.* The AFUE is as defined in sections 11.2.12 (non-condensing systems) and 11.3.12 (condensing systems) of ANSI/ASHRAE Standard 103–1988, except with the following revision to the definition for the term $Effy_{HS}$ in the defining equation for AFUE:

$Effy_{HS}$=heating seasonal efficiency as defined in sections 11.2.11 (non-condensing systems) and 11.3.11 (condensing systems) of ANSI/ASHRAE Standard 103–1988 and sections 10.12.1.1 and 10.12.1.2 of this appendix and is based on the assumption that all weatherized warm air furnaces or boilers are located out-of-doors; warm air furnaces which are not weatherized are installed as ICS; and boilers which are not weatherized are installed indoors.

10.13 *Heating seasonal efficiency, steady-state efficiency, and AFUE for non-condensing modulating gas or oil furnaces and boilers.* The following paragraph is in place of the requirements specified in section 11.4 of ANSI/ASHRAE Standard 103–1988:

Heating Seasonal Efficiency, Steady-State Efficiency, and AFUE for Non-Condensing Modulating Gas or Oil Furnaces and Boilers. Perform the following calculations to determine the steady-state and heating seasonal efficiency, $Effy_{SS}$ and $Effy_{HS}$, and AFUE, of a gas or oil, furnace or boiler, non-condensing, and modulating. The calculations in sections 11.4.1 through 11.4.8.10 of ANSI/ASHRAE Standard 103–1988 need to be completed at both the maximum and reduced input rates for both two stage and step-modulating controls. The calculations in section 11.4.9 and 11.4.10 of ANSI/ASHRAE Standard 103–1988 need to be completed at the reduced input rate for units with step modulating controls, and at both maximum and reduced input rates for units with two stage controls. Use the calculation procedure specified in section 11.2 of ANSI/ASHRAE Standard 103–1988 including the revisions to section 11.2 as specified in sections 10.1 to 10.12 of this appendix, and the modifications as specified in sections 11.4.1 through 11.4.12 of ANSI/ASHRAE Standard 103–1988.

10.13.1 The definition for $Effy_{SS,R}$ in section 11.4.8.1.2 of ANSI/ASHRAE Standard 103–1988 is revised to read as "$Effy_{SS,R}$ = as defined in section 11.4.7 of ANSI/ASHRAE Standard 103–1988."

10.13.2 *Balance point temperature.* The following calculation procedure supplements the procedures specified in section 11.4.8.5 of ANSI/ASHRAE Standard 103–1988:

If $T_c < 0$, use T_c=0.

10.13.3 *Average steady-state efficiency for the modulating mode for furnaces and boilers equipped with step-modulating controls.* The following calculation procedures supplement the procedures specified in section 11.4.8.8 of ANSI/ASHRAE Standard 103–1988:

If $Q_{OUT,R}$ > DHR, $Effy_{SS,M}$=$Effy_{SS,R}$

10.13.4 *Average heat output rate for the modulating mode for furnaces and boilers equipped with the step-modulating controls.* The following calculation procedures supplement the procedures specified in section 11.4.8.10 of ANSI/ASHRAE Standard 103–1988:

If $Q_{OUT,R}$ > DHR, $Q_{OUT,M}$=$Q_{OUT,R}$

10.13.5 *Average part load efficiency.* The following supplements the definition for the listed value of the jacket loss factor C_J in sections 11.4.9.2.3. and 11.4.11.1 (and referenced in section 11.4.11.2) of ANSI/ASHRAE Standard 103–1988:

C_J=0.5 for finned tube boilers intended to be installed in Isolated Combustion System applications

=1.0 for finned tube boilers intended to be installed outdoors

10.13.6 *Annual fuel utilization efficiency.* The AFUE is as defined in section 11.4.12 of ANSI/ASHRAE Standard 103–1988, except with the following revision to the definition for the term $Effy_{HS}$ in the defining equation for AFUE:

$Effy_{HS}$=heating seasonal efficiency as defined in section 11.4.11 of ANSI/ASHRAE Standard 103–1988 and sections 10.12.1.1 and 10.12.1.2 of this appendix and is based on the assumption that all weatherized warm air furnaces or boilers are located out-of-doors; warm air furnaces which are not weatherized are installed as ICS; and boilers which are not weatherized are installed indoors.

10.14 *Heating Seasonal Efficiency, Steady-State Efficiency, and AFUE for Condensing Modulating Gas or Oil Furnaces and Boilers.* The following paragraph is in place of the requirements specified in section 11.5 of ANSI/ASHRAE Standard 103–1988:

Heating Seasonal Efficiency, Steady-State Efficiency, and AFUE for Condensing Modulating Gas or Oil Furnaces and Boilers. Perform the following calculations to determine the steady-state and heating seasonal efficiency, $Effy_{SS}$ and $Effy_{HS}$, and AFUE, of a gas or oil, furnace or boiler, condensing and modulating. The calculations in sections 11.5.1 through 11.5.8.10 need to be completed at both the maximum and reduced input rates for both two stage and step-modulating controls. The calculations in sections 11.5.9 and 11.5.10 need to be completed at the reduced input rate for units with step modulating controls, and at both maximum and reduced input rates for units with two stage controls. Use the calculation procedure specified in section 11.3 and 11.4 of ANSI/ASHRAE Standard 103–1988 including the revisions to section 11.4 as specified in sections 10.13.1 to 10.13.4 of this appendix, and the modifications as specified in sections 11.5.1 through 11.5.12 of ANSI/ASHRAE Standard 103–1988.

10.14.1 *Average part load efficiency.* The following supplements the definition for the listed value of the jacket loss factor C_J in section 11.5.11.1 (and referenced in section 11.5.11.2) of ANSI/ASHRAE Standard 103-1988:

C_J=0.5 for finned tube boilers intended to be installed in Isolated Combustion System applications

10.14.2 *Annual fuel utilization efficiency.* The AFUE is as defined in section 11.5.12 of ANSI/ASHRAE Standard 103–1988, except with the following revision to the definition for the term $Effy_{HS}$ in the defining equation for AFUE:

$Effy_{HS}$=heating seasonal efficiency as defined in section 11.5.11 of ANSI/ASHRAE Standard 103–1988 and sections 10.12.1.1 and 10.12.1.2 of this appendix and is based on the assumption that all weatherized warm air furnaces or boilers are located out-of-doors; warm air furnaces which are not weatherized are installed as ICS, and boilers which are not weatherized are installed indoors.

10.15 *Optional tracer gas procedure for determination of D_P for furnaces or boilers employing a power burner or direct vent.* The following supplements the calculation procedures specified in section 11.6.4 of ANSI/ASHRAE Standard 103–1988:

If the measured D_P above is less than 0.1, then use D_P=0.05 as if there is no chance of flow through the unit during the off-cycle, as specified in section 8.8.3 of this appendix.

10.16 Tracer gas procedure for determining the off-cycle loss factor K_L for atmospheric furnaces or boilers with integral draft diverter or draft hood and equipped with an electro-mechanical inlet damper or an electro-mechanical flue damper that restricts the flow through the heat exchanger during the off-cycle. Calculate the off-cycle loss factor, K_L, defined as the ratio of the off-cycle sensible heat loss with the electro-mechanical damper closed during the off-cycle to the off-cycle sensible heat loss with the electro-mechanical damper held open during the off-cycle:

K_L=($Q_{S,OFF}$ with damper closed) / ($Q_{S,OFF}$ with damper open)

where:

$$Q_{S,OFF} = \sum_{t=5}^{6}\left[\left(q_{S,OFF}\right)\cdot\left(\frac{\Delta t}{60}\right)\right]$$

=one minute sum-total of the measured $q_{S,OFF} \cdot \Delta t$ (Δt=time-step in seconds when data are recorded) over a one minute interval starting at five minutes into the cool-down period

Δt=time interval between measurement as defined in 8.9.5 of this appendix, seconds

1/60=unit conversion factor to convert time in second to minute

$q_{S,OFF} = C_P \cdot m_{S,OFF} \cdot (T_{S,OFF} - T_{RA})$

where:

$q_{S,OFF}$=off-cycle sensible loss rate, Btu/min
C_P=specific heat capacity of air, as defined in section 11.2.9.1 of ANSI/ASHRAE Standard 103–1988, Btu/lb • °F
$T_{S,OFF}$=measured stack temperature at time t as defined in section 8.9.5 of this appendix, °F
T_{RA}=room temperature as defined in section 11.2.5 of ANSI/ASHRAE Standard 103–1988, °F

$$m_{S,OFF}=[(C_{Tm}-C_T)/(C_T-C_{TB})] \bullet \rho_F \bullet V_T$$

where:
$m_{S,OFF}$=mass flow rate at time t of the stack gas during the off-cycle, lb/min
C_{Tm}=concentration by volume of measurable tracer gas in a certified standard tracer gas mixture, percent
C_T=concentration by volume of tracer gas present in the stack gas sample, measured at time $t+t_{DELAY}$, in accordance with section 8.9.5 of this appendix, percent
t_{DELAY}=tracer gas sample delay time as defined in section 8.9.4 of this appendix, seconds
C_{TB}=room background concentration by volume of the racer gas used as defined in section 8.9.2 of this appendix, percent
V_T=flow rate of tracer gas into the stack measured in accordance with section 8.9.3 of this appendix, ft^3/min
ρ_F=density of gas as defined in section 11.6.2 of ANSI/ASHRAE Standard 103–1988, lb/ft^3

10.17 *Optional procedure for determining off-cycle draft factors for furnaces or boilers employing a power burner or direct vent.* The following are revisions to sections 11.7.1 and 11.7.2 of ANSI/ASHRAE Standard 103–1988:

10.17.1 Add the word "factor" to the first sentence in section 11.7.1 of ANSI/ASHRAE Standard 103–1988 so that the beginning of the sentence read:

Calculate the off-cycle draft factor for flue gas flow, D_F, defined as:

10.17.2 The equation for D_S for system number 8 in section 11.7.2 of ANSI/ASHRAE Standard 103–1988, $D_S=(D_O)(D_P)$, is replaced with $D_S=[(0.79+D_P)/1.4](D_O)$.

10.18 Procedure for determining off-cycle draft factors for atmospheric furnaces or boilers with integral draft diverter or draft hood and equipped with either an electro-mechanical inlet damper or an electro-mechanical flue damper that restricts the flow through the heat exchanger in the off-cycle.

For atmospheric furnaces with an integral draft diverter or draft hood and equipped with either an electro-mechanical inlet damper or an electro-mechanical flue damper, and installed as an indoor system or an ICS, the System Number and the draft factor D_P are defined as:

System Number=1 for indoor system
=9 for ICS system

and

$D_P=K_L$

where:
K_L=off-cycle loss factor, as defined in section 10.16 of this appendix.

10.19 *National Average Burner Operating Hours, Average Annual Fuel Energy Consumption and Average Annual Auxiliary Electrical Energy Consumption for Gas or Oil Furnaces and Boilers.* The following sections 10.19.1 thru 10.19.3 are in place of sections 1 thru 3 of Appendix C of ANSI/ASHRAE Standard 103–1988:

10.19.1 *National average number of burner operating hours.*

For furnaces and boilers equipped with single stage controls, the national average number of burner operating hours is defined as:

$$BOH_{SS}=2080(0.77)(A)(DHR)-2080(B)$$

where:
2080=national average heating load hours
0.77=adjustment factor to adjust the calculated design heating requirement and heating load hours to the actual heating load experienced by the heating system
DHR=typical design heating requirements as listed in Table 8 (in unit of kBtu/h) of ANSI/ASHRAE Standard 103–1988, using the proper value of Q_{OUT} defined in Section 11.2.8.1 of ANSI/ASHRAE Standard 103–1988

$$A=100000/[341300(y_P \bullet PE+y_{IG} \bullet PE_{IG}+y \bullet BE)+(Q_{IN}-Q_P) \bullet Effy_{HS}]$$

$$B=2Q_P(Effy_{HS})(A)/100000$$

100000=factor that accounts for percent and kBtu
PE=burner electrical input rate at full-load steady-state operation
y_P=ratio of induced or forced draft blower on-time to average burner on-time, as follows:
1 for units without post purge
$1+(t_P/3.87)$ for single stage furnaces with post purge
$1+(t_P/10)$ for two-stage and step modulating furnaces with post purge
$1+(t_P/9.68)$ for single stage boilers with post purge
$1+(t_P/15)$ for two stage and step modulating boilers with post purge
PE_T=total electrical power to burner equipped with intermittent or interrupted ignition device when the device is on, as defined in Section 8.1.1 of this appendix
$PE_{IG}=PE_T-PE$, electrical input rate to the intermittent or interrupted ignition device on burner (if employed)
y_{IG}=ratio of burner intermittent or interrupted ignition device on time to average burner on-time, as follows:
=0 for burners not equipped with IID
$=(t_{IG}/3.87)$ for single stage furnaces
$=(t_{IG}/10)$ for two-stage and step modulating furnaces
$=(t_{IG}/9.68)$ for single stage boilers
$=(t_{IG}/15)$ for two stage and step modulating boilers
t_{IG}=on-time of the burner intermittent or interrupted ignition device, as defined in Section 8.1.1 of this appendix
t_P=post purge time as defined in Sections 8.2 and 8.5 of this appendix
y=ratio of blower or pump on-time to average burner on-time, as follows:
1, for furnaces without fan delay
1, for boilers without a pump delay
$1+(t^+-t^-)/3.87$, for single stage furnaces with fan delay
$1+(t^+-t^-)/10$, for two-stage and step modulating furnaces with fan delay
$1+(t^+/9.68)$, for single stage boilers with pump delay
$1+(t^+/15)$, for two stage and step modulating boilers with pump delay
BE=circulating air fan or water pump electrical energy input rate at full load steady-state operation
Q_{IN}=as defined in section 11.2.8.1 of ANSI/ASHRAE Standard 103–1988
Q_P=as defined in section 11.2.11 of ANSI/ASHRAE Standard 103–1988
$Effy_{HS}$=as defined in section 11.2.11 or 11.3.11.3 of ANSI/ASHRAE Standard 103–1988 and section 10.12.2 of this appendix, percent, and calculated on the basis of:
=indoor installation, for non-weatherized boilers
=ICS installation, for non-weatherized warm air furnaces
=outdoor installation, for furnaces and boilers that are weatherized
2=ratio of the average length of the heating season in hours to the average heating load hours
t^+=as defined in sections 9.5.1.2 and 9.5.2.1 of ANSI/ASHRAE Standard 103–1988
t^-=as defined in section 9.6.1 of ANSI/ASHRAE Standard 103–1988

For furnaces and boilers equipped with two stage or step modulating controls the average annual energy used during the heating season, E_M, is defined as:

$$E_M=(Q_{in}-Q_P)(BOH_{SS})+(8760-4600)(Q_P)$$

where:
Q_{IN}=as defined in section 11.4.8.1.1 of ANSI/ASHRAE Standard 103–1988
Q_P=as defined in section 11.4.12 of ANSI/ASHRAE Standard 103–1988
BOH_{SS}=as defined above, in which the weighted $Effy_{HS}$ as defined in section 11.4.11.3 or 11.5.11.3 of ANSI/ASHRAE Standard 103–1988 and section 10.13.6 or 10.14.2 of this appendix is used for calculating the values of A and B, the term DHR is based on the proper value of Q_{OUT} defined in section 11.4.8.1.1 of ANSI/ASHRAE Standard 103–1988, and the term $(y_PPE+y_{IG}PE_{IG}+yBE)$ in the factor A is increased by the factor R, which is defined as:
R=2.3 for two stage controls
=2.3 for step modulating controls when the ratio of minimum-to-maximum output is greater than or equal to 0.5
=3.0 for step modulating controls when the ratio of minimum-to-maximum output is less than 0.5

$$A=100000/[341300(y_PPE+y_{IG}PE_{IG}+yBE)(R)+(Q_{IN}Q_P)(Effy_{HS})]$$

$Effy_{HS}$=as defined in section 11.4.11.3 or 11.5.11.3 of ANSI/ASHRAE Standard 103–1988, and calculated on the basis of:
=indoor installation, for non-weatherized boilers
=ICS installation, for non-weatherized warm air furnaces
=outdoor installation, for furnaces and boilers that are weatherized
8760=total number of hours per year
4600=as defined in section 11.4.12 of ANSI/ASHRAE Standard 103–1988

For furnaces and boilers equipped with two stage or step modulating controls the national average number of burner operating

hours at the reduced operating mode is defined as:

$BOH_R = X_R E_M / Q_{IN,R}$

where:

X_R=as defined in section 11.4.8.7 of ANSI/ASHRAE Standard 103–1988

E_M=as defined above

$Q_{IN,R}$=as defined in section 11.4.8.1.2 of ANSI/ASHRAE Standard 103–1988.

For furnaces and boilers equipped with two stage controls the national average number of burner operating hours at the maximum operating mode (BOH_H) is defined as:

$BOH_H = X_H E_M / Q_{IN}$

where:

X_H=as defined in section 11.4.8.6 of ANSI/ASHRAE Standard 103–1988

E_M=as defined above

Q_{IN}=as defined in section 11.4.8.1.1 of ANSI/ASHRAE Standard 103–1988

For furnaces and boilers equipped with step modulating controls the national average number of burner operating hours at the modulating operating mode (BOH_M) is defined as:

$BOH_M = X_H E_M / Q_{IN,M}$

where:

X_H=as defined in section 11.4.8.6 of ANSI/ASHRAE Standard 103–1988

E_M=as defined above

$Q_{IN,M} = Q_{OUT,M} / (Effy_{SS,M}/100)$

$Q_{OUT,M}$=as defined in section 11.4.8.10 of ANSI/ASHRAE Standard 103–1988 and section 10.13.4 of this appendix

$Effy_{SS,M}$=as defined in section 11.4.8.8 of ANSI/ASHRAE Standard 103–1988 and section 10.13.3 of this appendix, percent

100=factor that accounts for percent

10.19.2 *Average annual fuel energy for gas or oil fueled furnaces or boilers.*

For furnaces or boilers equipped with single stage controls the average annual fuel energy consumption (E_F) is expressed in Btu per year and defined as:

$E_F = BOH_{SS}(Q_{IN} - Q_P) + 8760(Q_P)$

where:

BOH_{SS}=as defined in section 10.19.1 of this appendix

Q_{IN}=as defined in section 11.2.8.1 of ANSI/ASHRAE Standard 103–1988

Q_P=as defined in section 11.2.11 of ANSI/ASHRAE Standard 103–1988

8760=as defined in section 10.19.1 of this appendix

For furnaces or boilers equipped with either two stage or step modulating controls E_F is defined as:

$E_F = E_M + 4600(Q_P)$

where:

E_M=as defined in section 10.19.1 of this appendix

4600=as defined in section 11.4.12 of ANSI/ASHRAE Standard 103–1988

Q_P=as defined in section 11.2.11 of ANSI/ASHRAE Standard 103–1988

10.19.3 *Average annual auxiliary electrical energy consumption for gas or oil fueled furnaces or boilers.* For furnaces or boilers equipped with single stage controls the average annual auxiliary electrical consumption (E_{AE}) is expressed in kilowatt-hours and defined as:

$E_{AE} = BOH_{SS}(y_P PE + y_{IG} PE_{IG} + yBE)$

where:

BOH_{SS}=as defined in section 10.19.1 of this appendix

PE=as defined in section 9.1.2.2 of ANSI/ASHRAE Standard 103–1988

y_P=as defined in section 10.19.1 of this appendix

y_{IG}=as defined in section 10.19.1 of this appendix

PE_{IG}=as defined in section 10.19.1 of this appendix

y=as defined in section 10.19.1 of this appendix

BE=as defined in section 9.1.2.2 of ANSI/ASHRAE Standard 103–1988

For furnaces or boilers equipped with two stage controls E_{AE} is defined as:

$E_{AE} = BOH_R(y_P PE_R + y_{IG} PE_{IG} + yBE_R) + BOH_H(y_P PE_H + y_{IG} PE_{IG} + yBE_H)$

where:

BOH_R=as defined in section 10.19.1 of this appendix

y_P=as defined in section 10.19.1 of this appendix

PE_R=as defined in section 9.1.2.2 and measured at the reduced fuel input rate, of ANSI/ASHRAE Standard 103–1988

y_{IG}=as defined in section 10.19.1 of this appendix

PE_{IG}=as defined in section 10.19.1 of this appendix

y=as defined in section 10.19.1 of this appendix

BE_R=as defined in section 9.1.2.2 and measured at the reduced fuel input rate, of ANSI/ASHRAE Standard 103–1988

BOH_H=as defined in section 10.19.1 of this appendix

PE_H=as defined in section 9.1.2.2 and measured at the maximum fuel input rate, of ANSI/ASHRAE Standard 103–1988

BE_H=as defined in section 9.1.2.2 and measured at the maximum fuel input rate, of ANSI/ASHRAE Standard 103–1988

For furnaces or boilers equipped with step modulating controls E_{AE} is defined as:

$E_{AE} = BOH_R(y_P PE_R + y_{IG} PE_{IG} + yBE_R) + BOH_H(y_P PE_H + y_{IG} PE_{IG} + yBE_H)$

where:

BOH_R=as defined in section 10.19.1 of this appendix

y_P=as defined in section 10.19.1 of this appendix

PE_R=as defined above

y_{IG}=as defined in section 10.19.1 of this appendix

PE_{IG}=as defined in section 10.19.1 of this appendix

y=as defined in section 10.19.1 of this appendix

BE_R=as defined above

BOH_M=as defined in section 10.19.1 of this appendix

PE_H=as defined above

BE_H=as defined above

10.20 *Average annual electric energy consumption for electric furnaces or boilers.* For electric furnaces and boilers the average annual energy consumption (E_E) is expressed in kilowatt-hours and defined as:

$E_E = 100(2080)(0.77)(DHR) / 3.413\ (AFUE)$

where:

100=to express a percent as a decimal

2080=as defined in section 10.19.1 of this appendix

0.77=as defined in section 10.19.1 of this appendix

DHR=as defined in section 10.19.1 of this appendix

3.413=conversion to express energy in terms of watt-hours instead of Btu

AFUE=as defined in section 11.1 of ANSI/ASHRAE Standard 103–1988, percent

10.21 Energy Factor.

10.21.1 *Energy factor for gas or oil furnaces and boilers.* The energy factor for gas or oil furnaces and boilers is defined as the ratio of the sum of the useful annual fossil fuel energy delivered to the building space as heat and the auxiliary electrical energy that is recovered as usable heat, to the sum of the annual fossil fuel energy consumption and the energy needed at the power plant to generate the auxiliary electrical energy consumed by the appliance. The above definition of energy factor is based upon the term named as seasonal efficiency energy factor and defined as equation (1) in appendix B of ANSI/ASHRAE Standard 103–1988, using the average burner operating hours, average annual fuel energy for gas or oil fueled furnaces or boilers (E_F), average annual auxiliary electrical energy consumption for gas or oil fueled furnaces or boilers (E_{AE}), as defined in sections 10.19, 10.19.1, 10.19.2, and section 10.19.3, respectively, of this appendix. The following paragraphs specify the procedure for the calculation of EF and is in place of Appendix B of ANSI/ASHRAE Standard 103–1988, and include a correction of a syntax error contained in equation (1) of appendix B of ANSI/ASHRAE Standard 103–1988. The energy factor which incorporates fossil fuels and electrical energy as described in section 10.19 of this appendix, is defined as, in percent:

$$EF = \frac{E_F\ AFUE/100 + 3413\ y\ BEBOH}{E_F + 3413\ F\ E_{AE}} \times 100$$

where:
100=factor that accounts for percent
E_F=average annual fuel consumption as defined in 10.19.2 of this appendix.
E_{AE}=as defined in section 10.19.3 of this appendix.
AFUE=AFUE as defined in sections 11.2.12, 11.3.12, 11.4.12 and 11.5.12 of ANSI/ASHRAE Standard 103–1988, percent, and calculated on the basis of:
=indoor installation, for non-weatherized boilers
=ICS installation, for non-weatherized warm air furnaces
=outdoor installation, for furnaces and boilers that are weatherized
y=as defined 10.19.1 of this appendix
BEBOH=(BE)(BOH_{SS}) for units with single stage controls
=(BE_R)(BOH_R) + (BE_H)(BOH_H) for units with two stage controls
=(BE_R)(BOH_R) + (BE_H)(BOH_M) for units with step modulating controls
BOH_{SS}=as defined in section 10.19.1 of this appendix
BOH_R=as defined in section 10.19.1 of this appendix
BOH_H=as defined in section 10.19.1 of this appendix
BOH_M=as defined in section 10.19.1 of this appendix
BE=as defined in section 10.19.1 of this appendix
BE_R=as defined in section 10.19.1 of this appendix
BE_H=as defined in section 10.19.1 of this appendix
F=ratio of the energy consumed at the source of electrical generation to the electrical energy delivered at the furnace or boiler,=3.37
3413=conversion factor from kilowatt to Btu/h

10.21.2 *Energy factor for electric furnaces and boilers.* The energy factor for electric furnaces and boilers is defined as:

EF=AFUE

where:
AFUE=AFUE as defined in section 11.1 of ANSI/ASHRAE Standard 103–1988, percent, and calculated on the basis of:
=indoor installation, for nonweatherized boilers
=ICS installation, for non-weatherized warm air furnaces
=outdoor installation, for furnaces and boilers that are weatherized

10.22 Average Annual Energy Consumption for Furnaces and Boilers Located in a Different Geographic Region of the United States and in Buildings with Different Design Heating Requirements.

10.22.1 The following legend is added to Fig. C–1 of ANSI/ASHRAE Standard 103–1988:

Alaska—3500 HLH
Hawaii and Territories—0 HLH

10.22.2 *Average annual fuel energy consumption for gas or oil fueled furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements.* For gas or oil fueled furnaces and boilers the average annual fuel energy consumption for a specific geographic region and a specific typical design heating requirement (E_{FR}) is expressed in Btu per year and defined as:

$E_{FR}=[(E_F-8760\ Q_P)\ HLH / 2080]+8760\ Q_P$

where:
E_F=as defined in section 10.19.2 of this appendix
8760=as defined in section 10.19.1 of this appendix
Q_P=as defined in section 11.2.11 of ANSI/ASHRAE Standard 103–1988
HLH=heating load hours for a specific geographic region determined from the heating load hour map in Figure C–1 of ANSI/ASHRAE Standard 103–1988 and in section 10.22.1 of this appendix
2080=as defined in section 10.19.1 of this appendix

10.22.3 *Average annual auxiliary electrical energy consumption for gas or oil fueled furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements.* For gas or oil fueled furnaces and boilers the average annual auxiliary electrical energy consumption for a specific geographic region and a specific typical design heating requirement (E_{AER}) is expressed in kilowatt-hours and defined as:

$E_{AER}=E_{AE}HLH / 2080$

where:
E_{AE}=as defined in section 10.19.3 of this appendix
HLH=as defined in section 10.22.2 of this appendix
2080=as defined in section 10.19.1 of this appendix

10.22.4 *Average annual electric energy consumption for electric furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements.* For electric furnaces and boilers the average annual electric energy consumption for a specific geographic region and a specific typical design heating requirement (E_{ER}) is expressed in kilowatt-hours and defined as:

$E_{ER}=100(0.77)(DHR)(HLH)/3.413$ AFUE

where:
100 = as defined in section 10.20 of this appendix
0.77 = as defined in section 10.19.1 of this appendix
DHR = as defined in section 10.19.1 of this appendix
HLH = as defined in section 10.22.2 of this appendix
3.413 = as defined in section 10.20 of this appendix
AFUE = as defined in section 11.1 of ANSI/ASHRAE Standard 103–1988, percent

10.23 *Annual Efficiency for Gas or Oil Furnaces and Boilers other than Mobile Home Furnaces.* The Annual Efficiency is defined as the ratio of the sum of the useful annual fossil fuel energy delivered to the building space as heat and the auxiliary electrical energy that is recovered as usable heat, to the sum of the annual fossil fuel energy consumption and the energy needed at the power plant to generate the auxiliary electrical energy consumed by the appliance. (The equation defining Annual Efficiency is in section 10.23.4 of this appendix.) The above definition of Annual Efficiency is based upon the term named as seasonal efficiency, energy factor, and defined as equation (1) in appendix B of ANSI/ASHRAE Standard 103–1988, using the average burner operating hours, average annual fuel energy for gas or oil fueled furnaces or boilers (E_F), average annual auxiliary electrical energy consumption for gas or oil fueled furnaces or boilers (E_{AE}), as defined in Appendix C of ANSI/ASHRAE Standard 103–1988. The definition of Annual Efficiency is comparable to the energy factor defined in section 10.21 of this appendix, with the exception that for non-weatherized furnaces, Annual Efficiency is calculated on the basis of indoor installation. The following paragraphs specify the procedure for the calculation of Annual Efficiency and are in place of appendix B and appendix C of ANSI/ASHRAE Standard 103–1988, and include a correction of a syntax error contained in equation (1) of appendix B of ANSI/ASHRAE Standard 103–1988.

10.23.1 *National average number of burner operating hours.* Same as in section 10.19.1 of this appendix except the term $Effy_{HS}$ used in the calculations for the burner operating hours is defined as:

For furnaces and boilers equipped with single stage control:
$Effy_{HS}$=as defined in section 11.2.11 or 11.3.11.3 of ANSI/ASHRAE Standard 103–1988, percent, and calculated on the basis of:
=indoor installation, for non-weatherized units with system number 1, 2, 3, 4, 5, 6, or 8 that use indoor combustion air, and for direct vent units with system number 9 or 10
=outdoor installation, for units with system number 9 or 10 that are weatherized

For furnaces and boilers equipped with two stage or step modulating controls:
$Effy_{HS}$=as defined in section 11.4.11.3 or 11.5.11.3 of ANSI/ASHRAE Standard 103–1988, percent, and calculated on the basis of:
= indoor installation, for non-weatherized units with system number 1, 2, 3, 4, 5, 6, or 8 that use indoor combustion air, and for direct vent units with system number 9 or 10
= outdoor installation, for units with system number 9 or 10 that are weatherized

10.23.2 *Average annual fuel energy for gas or oil fueled furnaces or boilers.* Same as in section 10.19.2 of this appendix except that the burner operating hours is computed as defined in section 10.23.1 of this appendix.

10.23.3 *Average annual auxiliary electrical energy consumption for gas or oil fueled furnaces or boilers.* Same as in section 10.19.3 of this appendix except that the burner operating hours is calculated as defined in section 10.23.1 of this appendix.

10.23.4 An Annual Efficiency which incorporates fossil fuels and electrical energy as described in sections 10.23.2 and 10.23.3 of this appendix, is defined as, in percent:

$$AE = \frac{E_F\ AFUE^*/100 + 3413\ y\ BEBOH}{E_F + 3413\ F\ E_{AE}} \times 100$$

where:

100=factor that accounts for percent
E_F=average annual fuel consumption as defined in section 10.23.2 of this appendix.
E_{AE}=as defined in section 10.23.3 of this appendix.
AFUE*=AFUE as defined in sections 11.2.12, 11.3.12, 11.4.12 and in section 11.5.12 of ANSI/ASHRAE Standard 103–1988, percent, and calculated on the basis of:
=indoor installation, for non-weatherized units with system number 1, 2, 3, 4, 5, 6, or 8 that use indoor combustion air, and for direct vent units with system number 9 or 10
=outdoor installation, for units with system number 9 or 10 that are weatherized
y=as defined in section 10.19.1 of this appendix
BEBOH=(BE)(BOH_{SS}) for units with single stage controls
=(BE_R)(BOH_R) + (BE_H)(BOH_H) for units with two stage controls
=(BE_R)(BOH_R) + (BE_H)(BOH_M) for units with step modulating controls
BOH_{SS}=as defined in section 10.23.1 of this appendix
BOH_R=as defined in section 10.23.1 of this appendix
BOH_H=as defined in section 10.23.1 of this appendix
BOH_M=as defined in section 10.23.1 of this appendix
BE=as defined in section 10.19.1 of this appendix
BE_R=as defined in section 10.19.1 of this appendix
BE_H=as defined in section 10.19.1 of this appendix
F=as defined in section 10.21.1 of this appendix
3413=conversion factor from kilowatt to Btu/h

10.24 *Annual efficiency for electric furnaces and boilers.* The Annual Efficiency for electric furnaces and boilers is defined as:

AE=AFUE*

where:

AFUE*=AFUE as defined in section 11.1 of ANSI/ASHRAE Standard 103–1988, percent, and calculated on the basis of:
=indoor installation, for non-weatherized warm air furnaces and boilers
=outdoor installation, for furnaces and boilers that are weatherized

10.25 *Annual efficiency for mobile home furnaces.* The Annual Efficiency for mobile home furnaces, is defined as the ratio of the sum of the useful annual fossil fuel energy delivered to the building space as heat and the auxiliary electrical energy that is recovered as usable heat, to the sum of the annual fossil fuel energy consumption and the energy needed at the power plant to generate the auxiliary electrical energy consumed by the appliance. The above definition of Annuel Efficiency is the same as the Annual Efficiency defined and calculated in section 10.23 of this appendix, except that Annual Efficiency for mobile home furnaces is limited to those systems specifically designed for mobile homes and are installed indoors and use outside air for combustion.

10.25.1 *National average number of burner operating hours for mobile home furnaces.* Same as in section 10.19.1 of this appendix, except that the value of $Effy_{HS}$ in the calculation of the burner operating hours is calculated on the basis of a direct vent unit with system number 9 or 10 and installed indoors.

10.25.2 *Average annual fuel energy for mobile home furnaces.* Same as in section 10.23.2 of this appendix except that the burner operating hours is calculated as specified in section 10.25.1 of this appendix.

10.25.3 *Average annual auxiliary electrical energy consumption for mobile home furnaces.* Same as in section 10.23.3 of this appendix except that the burner operating hours is calculated as specified in section 10.25.1 of this appendix.

10.25.4 *Annual efficiency for mobile home furnaces.* The Annual Efficiency for mobile home furnaces, which incorporates fossil fuels and electrical energy as described in section 10.25 of this appendix, is defined as, in percent:

where:

$$AE = \frac{E_F\ AFUE^*/100 + 3413\ y\ BEBOH}{E_F + 3413\ F\ E_{AE}} \times 100$$

100=factor that accounts for percent
E_F=average annual fuel consumption as defined in section 10.25.2 of this appendix.
E_{AE}=as defined in section 10.25.3 of this appendix.
AFUE*=AFUE as defined in sections 11.2.12, 11.3.12, 11.4.12 and 11.5.12 of ANSI/ASHRAE Standard 103–1988, percent, and calculated on the basis of a direct vent unit with system number 9 or 10 and installed indoors
y=as defined in section 10.19.1 of this appendix
BEBOH=(BE)(BOH_{SS}) for units with single stage controls
=(BE_R)(BOH_R)+(BE_H)(BOH_H) for units with two stage controls
=(BE_R)(BOH_R)+(BE_H)(BOH_M) for units with step modulating controls
BOH_{SS}=as defined in section 10.24.1 of this appendix
BOH_R=as defined in section 10.24.1 of this appendix
BOH_H=as defined in section 10.24.1 of this appendix
BOH_M=as defined in section 10.24.1 of this appendix
BE=as defined in section 10.19.1 of this appendix
BE_R=as defined in section 10.19.1 of this appendix
BE_H=as defined in section 10.19.1 of this appendix
F=as defined in section 10.21.1 of this appendix
3413=conversion factor from kilowatt to Btu/h

10.26 *Calculation of sales weighted average annual energy consumption for mobile home furnaces.* In order to reflect the distribution of mobile homes to geographical regions with average HLH_{MHF} value different from 2080, adjust the annual fossil fuel and auxiliary electrical energy consumption values for mobile home furnaces using the following adjustment calculations.

10.26.1 For mobile home furnaces the sales weighted average annual fossil fuel energy consumption is expressed in Btu per year and defined as:

$E_{F,MHF}=(E_F - 8760\ Q_P)\ HLH_{MHF} / 2080 + 8760\ Q_P$

where:

E_F=as defined in section 10.25.2 of this appendix
8760=as defined in section 10.19.1 of this appendix
Q_P=as defined in section 11.2.11 of ANSI/ASHRAE Standard 103–1988
HLH_{MHF}=1880, sales weighted average heating load hours for mobile home furnaces
2080=as defined in section 10.19.1 of this appendix

10.26.2 For mobile home furnaces the sales weighted average annual auxiliary electrical energy consumption is expressed in kilowatt-hours and defined as:

$E_{AE,MHF}=(E_{AE})\ (HLH_{MHF}) / 2080$

where:

E_{AE}=as defined in section 10.25.3 of this appendix

HLH_{MHF}=as defined in section 10.26.1 of this appendix

2080=as defined in section 10.19.1 of this appendix

10.27 The functions F5, F6, and F8 in Appendix E of ANSI/ASHRAE Standard 103–1988 contain typographical errors in the equations as they appear in the ANSI/ASHRAE Standard 103–1988. The following term is substituted for $[\psi_{F,O} \cdot \exp(-t/\tau_{OFF})]^{0.56}$ (in F5 and F6) or $[\psi_{S,O} \cdot \exp(-t/\tau_{OFF})]^{0.56}$ (in F8) where the term (+ 28) is missing. The substituted term is:

$[\psi_{F,O} \cdot \exp(-t/\tau_{OFF}) + 28)]^{0.56}$ (in F5 and F6)

or

$[\psi_{S,O} \cdot \exp(-t/\tau_{OFF}) + 28)]^{0.56}$ (in F8).

The complete corrected equations for F5, F6 and F8 are presented in Table 2 of this appendix for information only.

10.28 *Direct determination of off-cycle losses for furnaces and boilers equipped with thermal stack dampers.*

Table 1 System Numbers

Locate the column where all the characteristics are applicable to the unit under test

Characteristic	1	2	3	4	5	6	8	9	10
Indoor Combustion Air	X	X	X	X	X	X	X		
Outdoor, Direct Vent or Isolated Combustion System								X	X
Direct Exhaust			X					(May or may not be present. Does not affect the results.)	
Draft Hood or Draft Diverter	X	X			X	X			
Barometric Draft Control				X			X		
Electrical/Mechanical Stack Damper					X	X	X		
Atmospheric Burner	X				X			X	
Power Burner		X	X	X		X	X		X
Burner Inlet Damper or Flue Damper**	X	X	X	X				X	X
D_P	1 or D_p‡	0.4 or D_p	0.4 or D_p	0.4 or D_p	1	0.4 or D_p	0.4 or D_p	1 or D_p‡‡	0.4 or D_p
D_S	1	1	D_F	0.85 or $\frac{0.79+D_p}{1.4}$	D_O	D_O	$0.85D_O$ or $\frac{(0.79+D_p)D_O}{1.4}$		
S/F	*	*	1	1.4 or test#	*	*	1.4 or test#		

* = Calculated from CO_2 values.

‡ = For atmospheric burner w/burner inlet damper or flue damper which closes within 10 seconds after the burner shuts off.

‡‡ = For direct vent, or atmospheric burner w/burner inlet damper or flue damper which closes within 10 seconds after the burner shuts off.

** = Power burner may or may not have an electro-mechanical inlet or flue damper.

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TABLE 2.—FORMULAS FOR THE FUNCTIONS F5, F6, AND F8

$$5\left(\psi_{F,0}, t_{OFF}/\tau_{OFF}\right) = \frac{1}{t_{OFF}/\tau_{OFF}} \int_0^{\frac{t_{OFF}}{\tau_{OFF}}} \left(\psi_{F,0} e^{-\frac{t}{\tau_{OFF}}} + 28\right)^{0.56} \frac{\left(\psi_{F,0} e^{-\frac{t}{\tau_{OFF}}}\right)}{\left(\psi_{F,0} e^{-\frac{t}{\tau_{OFF}}} + 530\right)^{1.19}} d\frac{t}{\tau_{OFF}}$$

$$6\left(\psi_{F,0}, t_{OFF}/\tau_{OFF}\right) = \frac{1}{100\left(t_{OFF}/\tau_{OFF}\right)}$$

$$\int_0^{\frac{t_{OFF}}{\tau_{OFF}}} \left[\frac{\left(\psi_{F,0} e^{-\frac{t}{\tau_{OFF}}} + 128\right)^{0.56} \left(\psi_{F,0} e^{-\frac{t}{\tau_{OFF}}} + 100\right)}{\left(\psi_{F,0} e^{-\frac{t}{\tau_{OFF}}} + 630\right)^{1.19}} - \frac{\left(\psi_{F,0} e^{-\frac{t}{\tau_{OFF}}} + 28\right)^{0.56} \psi_{F,0} e^{-\frac{t}{\tau_{OFF}}}}{\left(\psi_{F,0} e^{-\frac{t}{\tau_{OFF}}} + 530\right)^{1.19}} \right] d\frac{t}{\tau_{OFF}}$$

$$8\left(\psi_{S,0}, t_{OFF}/\tau_{OFF}\right) = \frac{1}{100\left(t_{OFF}/\tau_{OFF}\right)} \int_0^{\frac{t_{OFF}}{\tau_{OFF}}} \left[\frac{\left(\psi_{S,0} e^{-\frac{t}{\tau_{OFF}}} + 128\right)^{0.56}}{\left(\psi_{F,0} e^{-\frac{t}{\tau_{OFF}}} + 630\right)^{1.19}} - \frac{\left(\psi_{S,0} e^{-\frac{t}{\tau_{OFF}}} + 28\right)^{0.56}}{\left(\psi_{S,0} e^{-\frac{t}{\tau_{OFF}}} + 530\right)^{1.19}} \right] d\frac{t}{\tau_{OFF}}$$

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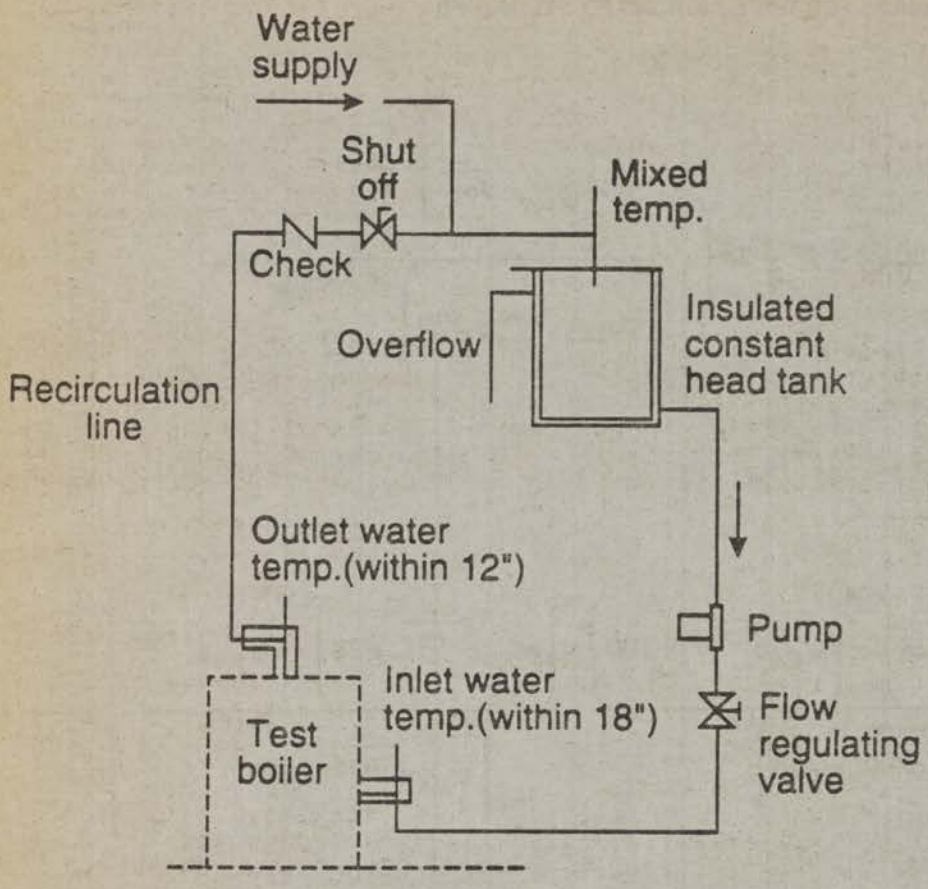

Figure 1. Suggested piping arrangement for hot water boilers

A = Inside blower door
B = Internal section of vent pipe (Uninsulated)
C = Blower access door
D = Flue collar
E = Top of unit, vent connection
F = Diverter box or inducer motor

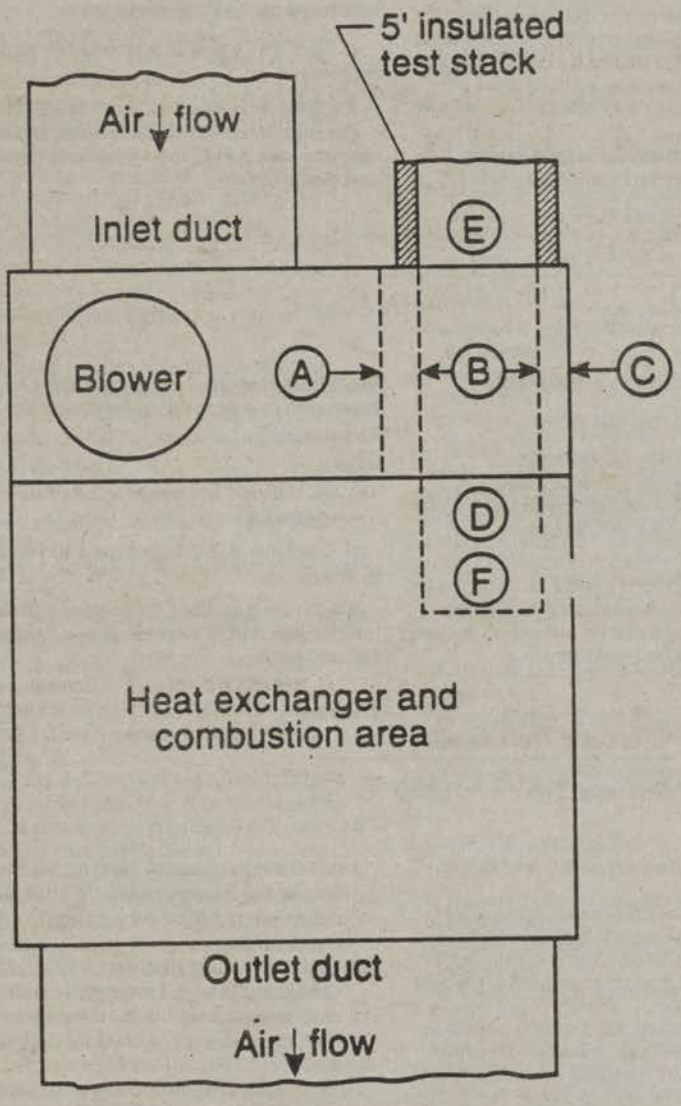

Figure 2. Jacket loss down flow unit

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5. Appendix O to Subpart B of Part 430 is amended as follows:

Appendix O to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Vented Home Heating Equipment

a. Section 3.5 is revised and sections 3.5.1 and 3.5.2 are added to read as follows:

3.5 *Pilot light measurement.*

3.5.1 Measure the energy input rate to the pilot light (Q_P) with an error no greater than 3 percent for vented heaters so equipped.

3.5.2 For manually controlled heaters where the pilot light is designed to be turned off by the user when the heater is not in use and instruction to do so is given on the heater near the gas control valve (e.g. by label) by the manufacturer, the measurement of Q_P need not be performed.

b. Section 4.2.4 is revised to read as follows:

4.2.4 *Weighted-average steady-state efficiency.*

For manually controlled heaters with various input rates the weighted average steady-state efficiency ($\eta_{SS\text{-}WT}$), is:

(1) At 50 percent of the maximum fuel input rate as measured in either section 3.1.1 to this appendix for manually controlled gas vented heaters or section 3.1.2 to this appendix for manually controlled oil vented heaters, or

(2) At the minimum fuel input rate as measured in either section 3.1.1 to this appendix for manually controlled gas vented heaters or section 3.1.2 to this appendix for manually controlled oil vented heaters if the design of the heater is such that the 50 percent of the maximum fuel input rate cannot be set, provided this minimum rate is no greater than ⅔ of maximum input rate of the heater.

For manually controlled heater with one single firing rate the weighted average steady-state efficiency is the steady-state efficiency measured at the single firing rate.

c. Section 4.2.6 is revised to read as follows:

4.2.6 *Annual fuel utilization efficiency.*

For manually controlled vented heaters, calculate the AFUE expressed as a percent and defined as:

$$AFUE = \frac{2950\,\eta_{SS} Q_{in\text{-}max}}{2950\,\eta_{SS} Q_{in\text{-}max} + 2.083(4600)\,\eta_u\,Q_P}$$

where:

2950=average number of heating degree days

η_{SS}=as defined as $\eta_{SS\text{-}WT}$ in section 4.2.4 of this appendix

η_u=as defined in section 4.2.5 of this appendix

$Q_{in\text{-}max}$=as defined as Q_{in} at the maximum fuel input rate, as defined in section 3.1 of this appendix

4600=average number of non-heating season hours per year

Q_P=as defined in section 3.5 of this appendix

2.083=(65 − 15) / 24=50/24

65=degree day base temperature, °F

15=national average outdoor design temperature for vented heaters as defined in section 4.1.10 of this appendix

24=number of hours in a day

For manually controlled vented heaters where the pilot light can be turned off by the user when the heater is not in use as described in section 3.5.2, calculate AFUE expressed as a percent and defined as:

$AFUE = \eta_u$

where:

η_u=as defined in section 4.2.5 of this appendix

d. Section 4.3.7 is revised to read as follows:

4.3.7 *Annual Fuel Utilization Efficiency.*

Calculate AFUE expressed as a percent and defined as:

$$AFUE = \frac{2950\,\eta_{SS\text{-}WT}\,\eta_u\,Q_{in\text{-}max}}{2950\,\eta_{SS\text{-}WT}\,Q_{in\text{-}max} + 2.083(4600)\,\eta_u\,Q_P}$$

where:

2950=average number of heating degree days

$\eta_{SS\text{-}WT}$=as defined in section 4.1.16 of this appendix

η_u=as defined in section 4.3.6 of this appendix

$Q_{in\text{-}max}$=as defined in section 4.2.6 of this appendix

4600=as defined in section 4.2.6 of this appendix

Q_P=as defined in section 3.5 of this appendix

2.083=as defined in section 4.2.6 of this appendix

e. Add Sections 4.6, 4.6.1, 4.6.2, 4.6.3, 4.6.4, 4.6.4.1, and 4.6.4.2 after section 4.5.3 and before the tables to read as follows:

4.6 *Annual Efficiency.*

An Annual Efficiency which incorporates fossil fuels and electrical energy, is defined as, in percent:

$AE = 100 \cdot [(E_F)(AFUE/100) + 3413(P_E)(BOH)] / [E_F + 3413(F)(E_{AE})]$

where:

E_{AE}=as defined in section 4.6.3 of this appendix

E_F=average annual fuel consumption as defined in section 4.6.2 of this appendix

AFUE=AFUE as defined in sections 4.1.17, 4.2.6, and 4.3.7 of this appendix, percent

P_E=Auxiliary electric energy input rate as defined in section 3.1.3 of this appendix

BOH=National average number of burner operating hours, defined in section 4.6.1 of this appendix as:

=(BOH_{SS}) for units with single stage or manual controls

=(BOH_R+BOH_H) for units with two stage or step modulating controls

F=the ratio of the energy consumed at the source of electrical generation to the electrical energy delivered at the vented heater, =3.37

3413=conversion factor from kilowatt to Btu/h

4.6.1 *National average number of burner operating hours.* For vented heaters equipped with single stage controls or manual controls, the national average number of burner operating hours is defined as:

$BOH_{SS} = 1416(A_F)(A)(DHR) - 1416(B)$

where:

1416=national average heating load hours for vented heaters based on 2950 degree days and 15 °F outdoor design temperature

A_F=0.6858, adjustment factor to adjust the calculated design heating requirement and heating load hours to the actual heating load experienced by the heating system

DHR=typical design heating requirements based on Q_{OUT}, from Table 4 of this appendix.

$Q_{OUT} = [(\eta_{SS}/100) - C_j(L_j/100)] \cdot (Q_{in})$

L_j=jacket loss as defined in section 4.1.5 of this appendix

C_j=2.8, adjustment factor as defined in section 4.3.6 of this appendix

η_{SS}=steady-state efficiency as defined in section 4.1.10 of this appendix, percent

Q_{in}=as defined in section 3.1 of this appendix at the maximum fuel input rate

$A = 100000/[341300(PE) + (Q_{in} - Q_P)(\eta_u)]$

$B = 2.938(Q_P)(\eta_u)(A)/100000$

100000=factor that accounts for percent and Kbtu

P_E=as defined in section 3.1.3 of this appendix

Q_P=as defined in section 3.5 of this appendix
η_u=as defined in section 4.3.6 of this appendix for vented heaters using the tracer gas method, percent
=as defined in section 4.2.5 of this appendix for manually controlled vented heaters, percent
=AFUE (2950)(η_{SS})(Q_{in})/[(2950)(η_{SS})(Q_{in}) AFUE (2.083)(4600)(QP)] for vented heaters without manual controls and without thermal stack dampers and not using the optional tracer gas method, where AFUE = as defined in section 4.1.17 of this appendix, percent
2950=average number of heating degree days as defined in section 4.2.6 of this appendix
4600=average number of non-heating season hours per year as defined in section 4.2.6 of this appendix
2.938=(4160/1416)=ratio of the average length of the heating season in hours to the average heating load hours
2.083=as defined in section 4.2.6 of this appendix

For vented heaters equipped with two stage or step modulating controls the national average number of burner operating hours at the reduced operating mode is defined as:

$BOH_R=X_1E_M/Q_{red\text{-}in}$

where:

X_1=as defined in section 4.1.14 of this appendix
$Q_{red\text{-}in}$=as defined in section 4.1.11 of this appendix
E_M=average annual energy used during the heating season
=$(Q_{in}-Q_P)(BOH_{SS})+(8760-4600)(Q_P)$
Q_{in}=as defined in section 3.1 of this appendix at the maximum fuel input rate
Q_P=as defined in section 3.5 of this appendix
BOH_{SS}=as defined above, in which the term P_E in the factor A is increased by the factor R, which is defined in section 3.1.3 of this appendix as:
R=1.3 for two stage controls
=1.4 for step modulating controls when the ratio of minimum- to-maximum fuel input is greater than or equal to 0.7
=1.7 for step modulating controls when the ratio of minimum- to-maximum fuel input is less than 0.7 and greater than or equal to 0.5
=2.2 for step modulating controls when the ratio of minimum- to-maximum fuel input is less than 0.5
$A=100000/[341300(PE)(R)+(Q_{in}-Q_P)(\eta_u)]$
8760=total number of hours per year
4600=as defined in section 4.2.6 of this appendix

For vented heaters equipped with two stage or step modulating controls the national average number of burner operating hours at the maximum operating mode (BOH_H) is defined as:

$BOH_H=X_2E_M/Q_{in}$

where:

X_2=as defined in section 4.1.15 of this appendix
E_M=as defined above
Q_{in}=as defined in section 3.1 of this appendix at the maximum fuel input rate

4.6.2 *Average annual fuel energy for gas or oil fueled vented heaters.* For vented heaters equipped with single stage controls or manual controls, the average annual fuel energy consumption (E_F) is expressed in Btu per year and defined as:

$E_F=BOH_{SS}(Q_{in}-Q_P)+8760(Q_P)$

where:

BOH_{SS}=as defined in section 4.6.1 of this appendix
Q_{in}=as defined in section 3.1 of this appendix
Q_P=as defined in section 3.5 of this appendix
8760=as defined in section 4.6.1 of this appendix

For vented heaters equipped with either two stage or step modulating controls E_F is defined as:

$E_F=E_M+4600(Q_P)$

where:

E_M=as defined in section 4.6.1 of this appendix
4600=as defined in section 4.2.6 of this appendix
Q_P=as defined in section 3.5 of this appendix

4.6.3 *Average annual auxiliary electrical energy consumption for vented heaters.*

For vented heaters with single stage controls or manual controls the average annual auxiliary electrical consumption (E_{AE}) is expressed in kilowatt-hours defined as:

$E_{AE}=BOH_{SS}(P_E)$

where:

BOH_{SS}=as defined in section 4.6.1 of this appendix
P_E=as defined in section 3.1.3 of this appendix

For vented heaters equipped with two stage or modulating controls E_{AE} is defined as:

$E_{AE}=(BOH_R+BOH_H)(P_E)$

where:

BOH_R=as defined in section 4.6.1 of this appendix
BOH_H=as defined in section 4.6.1 of this appendix
P_E=as defined in section 3.1.3 of this appendix

4.6.4 *Average annual energy consumption for vented heaters located in a different geographic region of the United States and in buildings with different design heating requirements.*

4.6.4.1 *Average annual fuel energy consumption for gas or oil fueled vented home heaters located in a different geographic region of the United States and in buildings with different design heating requirements.*

For gas or oil fueled vented heaters the average annual fuel energy consumption for a specific geographic region and a specific typical design heating requirement (E_{FR}) is expressed in Btu per year and defined as:

$E_{FR}=[(E_F-8760\ Q_P)\ HLH\ /\ 1416]+8760\ Q_P$

where:

E_F=as defined in section 4.6.2 of this appendix
8760=as defined in section 4.6.1 of this appendix
Q_P=as defined in section 3.5 of this appendix
HLH=heating load hours for a specific geographic region determined from the heating load hour map in Figure 3 of this appendix
1416=as defined in section 4.6.1 of this appendix

4.6.4.2 *Average annual auxiliary electrical energy consumption for gas or oil fueled vented home heaters located in a different geographic region of the United States and in buildings with different design heating requirements.*

For gas or oil fueled vented home heaters the average annual auxiliary electrical energy consumption for a specific geographic region and a specific typical design heating requirement (E_{AER}) is expressed in kilowatt-hours and defined as:

$E_{AER}=E_{AE}\ HLH\ /\ 1416$

where:

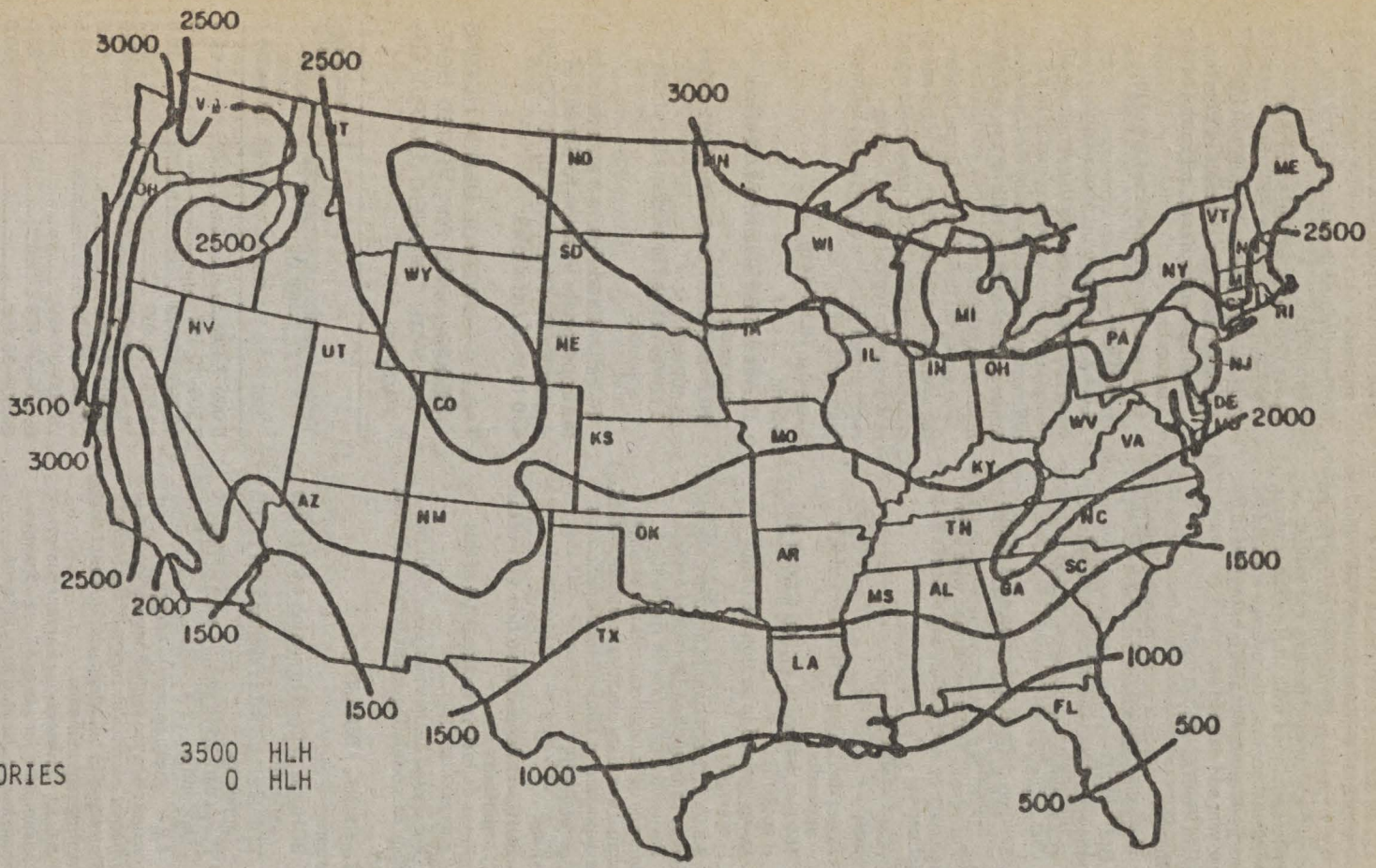
E_{AE}=as defined in section 4.6.3 of this appendix
HLH=as defined in section 4.6.4.1 of this appendix
1416=as defined in section 4.6.1 of this appendix

F. Table 4 and Figure 3 are added in the appropriate location to the end of Appendix O of Subpart B of 10 CFR part 430 to read as follows:

TABLE 4.— AVERAGE DESIGN HEATING REQUIREMENTS FOR VENTED HEATERS WITH DIFFERENT OUTPUT CAPACITIES

Vented heaters output capacity Q_{out}—(Btu/hr)	Average design heating requirements (Kbtu/hr)
5,000–7,499	5.0
7,500–10,499	7.5
10,500–13,499	10.0
13,500–16,499	12.5
16,500–19,499	15.0
19,500–22,499	17.5
22,500–26,499	20.5
26,500–30,499	23.5
30,500–34,499	26.5
34,500–38,499	30.0
38,500–42,499	33.5
42,500–46,499	36.5
46,500–51,499	40.0
51,500–56,499	44.0
56,500–61,499	48.0
61,500–66,499	52.0
66,500–71,499	56.0
71,500–76,500	60.0

Billing Code 6450-01-P



ALASKA 3500 HLH
HAWAII AND TERRITORIES 0 HLH

This map is reasonably accurate for most parts of the United States but is necessarily generalized, and consequently not too accurate in mountainous regions, particularly in the Rockies.

FIGURE 3– Heating Load Hours (HLH) for the United States and Canada

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6. Appendix P to Subpart B of Part 430 is revised to read as follows:

Appendix P to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Pool Heaters

1. *Test method.* The test method for testing gas- and oil-fired pool heaters shall be as specified in ANSI Standard for Gas-Fired Pool Heaters, Z21.56–1990.

2. *Test conditions.* Establish the test conditions specified in section 2.8 of ANSI Standard Z21.56–1990.

3. *Measurements.* Measure the quantities delineated in section 2.8 of ANSI Standard Z21.56–1990, except in the case of oil-fired heaters the measurement of energy consumption in Btu's is to be carried out in appropriate units, e.g., gallons.

4. *Calculations.* Calculate the thermal efficiency (expressed as a percent) as specified in section 2.8 of ANSI Standard Z21.56–1990, except in the case of oil-fired heaters the expression of fuel consumption shall be in Btu's.

4.1 *Annual Efficiency.* An Annual Efficiency which incorporates fossil fuels and electrical energy, is defined as the ratio of the annual output of energy delivered to the pool water (fossil fuel) to the total annual energy input to the pool heater, and is, in percent:

$AE=E_t \bullet E_{on}/(E_F+F \bullet E_{ae})$ for pool heaters with pilot light ignition

$=E_t/[1+(F-1) \bullet PE/(Q_{IN}+PE)]$ for pool heaters without pilot light ignition

where:

E_t=thermal efficiency as defined in section 2.8.1 of ANSI Standard Z21.56–1990, percent

=steady-state efficiency as defined in section 2.8.2 of ANSI Standard Z21.56–1990, percent

E_{on}=average annual energy consumption when burner is on, as defined in section 4.2 of this appendix

E_F=as defined in section 4.3 of this appendix

Q_P=energy consumption of continuously operating heater pilot light, if employed, Btu/h

E_{ae}=Average annual auxiliary electrical energy consumption for pool heaters as defined in section 4.4 of this appendix, Btu

F=the ratio of the energy consumed at the source of electrical generation to the electrical energy delivered at the pool heater,

=3.37

Q_{IN}=rated fuel energy input as defined in section 2.8.1 or 2.8.2 of ANSI Standard Z21.56–1990, Btu/h

$PE=2 \bullet E_c$ if heater tested according to section 2.8.1 of ANSI Standard Z21.56–1990

$=3.413 \bullet PE_{rated}$ if heater tested according to section 2.8.2 of ANSI Standard Z21.56–1990

E_c=measured electrical energy consumption over a 30-minute interval as defined in section 2.8.1 of ANSI Standard Z21.56–1990, Btu/(30 minutes)

2=factor converting Btu per 30-minute to Btu/h

PE_{rated}=nameplate rating of auxiliary electrical equipment of heater, Watt

3.413=factor converting Watt to Btu/h

4.2 *Average annual energy consumption when burner is on.* The average annual energy consumption when the burner is on (E_{on}) is defined as:

$E_{on}=(BOH)(Q_{IN}+PE)$

where:

BOH=average number of burner operating hours, = 104

Q_{IN}=rated fuel energy input as defined according to section 2.8.1 or 2.8.2 of ANSI Standard Z21.56–1990, Btu/h

PE=electrical input when burner is on, as defined in section 4.1 of this appendix

4.3 *Average annual fossil fuel energy for pool heaters.* The average annual fuel energy for pool heater (E_F) is defined as:

$E_F=(BOH)(Q_{IN})+(POH-BOH)(Q_P)$

where:

BOH=average number of burner operating hours as defined in section 4.2 of this appendix

POH=average number of pool operating hours, = 4464

Q_{IN}=rated fuel energy input as defined according to section 2.8.1 or 2.8.2 of ANSI Standard Z21.56–1990

Q_P=energy consumption of continuously operating pilot light if employed. It is assumed that the pilot is turned off during non-pool season of the year, Btu/h

4.4 *Average annual auxiliary electrical energy consumption for pool heaters.* The average annual auxiliary electrical energy consumption for pool heaters (E_{ae}) is expressed in Btu and defined as:

$E_{ae}=(BOH)(PE)$

where:

BOH=as defined in section 4.2 of this appendix

PE=as defined in section 4.1 of this appendix

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