BY ORDER OF THE
SECRETARY OF THE AIR FORCE

AIR FORCE MANUAL 32-1068

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CIVIL ENGINEERING

HEATING SYSTEMS AND UNFIRED PRESSURE VESSELS

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This publication implements Air Force Policy Directive (AFPD) 32-10, *Installations and Facilities*. It provides guidance and procedures on installation, operation, maintenance, and inspection of heating systems and unfired pressure vessels (UPV) throughout the Air Force. It applies to all civilian employees and uniformed members of the Regular Air Force, Air Force Reserve, and Air National Guard, except where noted otherwise. Ensure all records created as a result of processes prescribed in this publication are maintained in accordance with Air Force Manual (AFMAN) 33-363, *Management of Records*, and disposed of in accordance with the Air Force Records Disposition Schedule located in the Air Force Records Information Management System. Refer recommended changes and questions about this publication to the Office of Primary Responsibility listed above using the AF Form 847, *Recommendation for Change of Publication*; route AF Forms 847 in accordance with **Paragraph A3.2**. This publication may be supplemented at any level, but all Supplements must be routed to the OPR of this publication for coordination prior to certification and approval. The authorities to waive wing/unit level requirements in this publication are identified with a Tier ("T-0, T-1, T-2, T-3") number following the compliance statement. See Air Force Instruction (AFI) 33-360, *Publications and Forms Management*, for a description of the authorities associated with the Tier numbers. Submit requests for waivers through the chain of command to the appropriate Tier waiver approval authority. The use of the name or mark of any specific manufacturer, commercial product, commodity, or service in this publication does not imply endorsement by the Air Force.

SUMMARY OF CHANGES

This document has been substantially revised and must be completely reviewed.

This revision consolidates and supersedes AFI 32-1068, *Heating Systems And Unfired Pressure Vessels*. Chapter 1 of this AFMAN provides an overview. Chapter 2 roles and responsibilities for the individuals who support Heating Systems And Unfired Pressure Vessels. Chapter 3-7 updates and clarifies attendance for boiler/hot water generator systems, clarifies all boilers require inspection, and clarifies that boiler installation, inspection, and operational requirements also apply to organizational equipment, mobile boilers, and privately- or contractor-owned boilers.

Chapter 1

OVERVIEW

1. Overview. Air Force heating systems and UPVs must be safe, reliable, and efficient. Build and operate these systems to comply with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code and National Board Inspection Code and conform to federal law. This publication implements and adopts the use of the most recent published ASME Boiler and Pressure Vessel Code and National Board Inspection Code for the construction, inspection, and repair on Air Force installations.

1.1. Applicability. This manual applies only to pressure vessels covered by the ASME Boiler and Pressure Vessel Code. It does not apply to low-pressure boilers below 1 million British thermal units per hour (MMBtu/hr) output used only for domestic water heating, or to pressure vessels containing noncorrosive refrigerants. Air National Guard Host Installations are subject to appropriate local and state codes and laws. Installations located outside the United States are subject to these requirements only to the extent the requirements do not conflict with applicable international agreements, country-specific Final Governing Standards, and, where no Final Governing Standards exist, the Overseas Environmental Baseline Guidance Document and Real Property Installed Equipment (RPIE).

Chapter 2

ROLES AND RESPONSIBILITIES

2.1. The Assistant Secretary of the Air Force for Installations, Environment, and Energy (SAF/IE). SAF/IE shall be responsible for installation and facility policy and provides policy oversight as prescribed in AFPD 90-1, *Policy, Publications, and DoD Issuance Management.*

2.2. The Headquarters, United States Air Force, Deputy Chief of Staff for Logistics, Engineering and Force Protection, Directorate of Civil Engineers (AF/A4C) shall:

2.2.1. Be responsible for Air Force policy implementation, strategy, doctrine, oversight, directive guidance, and resource advocacy related to Air Force heating systems and unfired pressure vessels. **Note:** The National Guard Bureau Director of Installations shall maintain and approve Air National Guard policy and may provide supplemental guidance to Air National Guard installations where variance from this manual is necessary.

2.2.2. Be responsible for non-directive guidance related to the Air Force heating systems and unfired pressure vessels program.

2.3. The Air Force Installation and Mission Support Center (AFIMSC) shall:

2.3.1. Support the development of policy, strategy, doctrine, directive guidance, and oversight related to heating systems and unfired pressure vessels.

2.3.2. Be responsible for the development of non-directive publications and resource advocacy related to heating systems and unfired pressure vessels.

2.4. The Air Force Civil Engineer Center (AFCEC) shall:

2.4.1. Support the development of policy, strategy, doctrine, directive guidance, oversight, and resource advocacy related to heating systems and unfired pressure vessels.

2.4.2. Provide the Air Force's senior subject matter expert for heating systems and unfired pressure vessels.

2.4.3. Provides technical assistance and advice on proper heating system management to base civil engineer organizations.

2.4.4. Be responsible to develop, maintain, and approve non-directive guidance to implement the heating systems and unfired pressure vessels program.

2.4.5. Consult with SAF/IE and AF/A4C on all non-directive guidance and execution of the heating systems and unfired pressure vessels program.

2.4.6. Assist major command and installation heating systems and unfired pressure vessels personnel to implement an effective heating systems and unfired pressure vessels program. Provide technical support for Direct Reporting Units and small units in accordance with this AFMAN.

2.4.7. Reviews requests for boiler attendance variances.

2.4.8. Reviews and recommends approval of heating fuel or equipment conversion proposals, including the life-cycle cost analysis.

2.5. The Installation Commander. The Installation Commander as the "Responsible Official" under Title 40, Code of Federal Regulations (CFR), Part 70 and Section 71.2 to Part 71, *State Operating Permit Programs*, and 40 CFR §71.2, *Federal Operating Permit Programs*, and applicable state and local regulations, shall certify the truth, accuracy, and completeness of the content of the notifications and reports as discussed in **Attachment 3**. This duty cannot be delegated. **(T-0).**

2.6. The Base Civil Engineer shall:

2.6.1. Provide oversight and support of all installation heating systems and unfired pressure vessels in accordance with Department of Defense, federal, state, and legally applicable host nation laws, codes, regulations and final governing standards at overseas installations. **(T-0).**

2.6.2. Ensure heating systems and unfired pressure vessels are designed, constructed, installed, operated, inspected, tested, repaired, maintained and replaced in compliance with this publication and applicable laws, codes, regulations, and final governing standards at overseas installations. **(T-0).**

2.6.3. Develop and maintain installation procedures for the proper and safe operation of heating and distribution systems, and Unfired Pressure Vessel (UPV) covered by this document, that include appropriate steps, staffing and attendance requirements for systems in use. **(T-1).**

2.6.4. Determine liquid, solid, and gas utility fuel requirements and ensure safety and adequacy of fuel supplies. **(T-3).**

2.6.5. Establish and maintains a base steam trap maintenance program. **(T-2).**

2.6.6. Maintain operating logs and records of boiler repairs IAW 40 CFR. **(T-0).**

2.6.7. Ensure that inspections are conducted as scheduled and equipment is reliable and safe IAW National Board Inspection Code (NBIC). **(T-0).**

2.6.8. Ensure all boilers, pressure vessels, and trim systems are constructed, installed, tested, repaired, or replaced to meet ASME Boiler and Pressure Vessel code or equivalent host nation requirements. **(T-0).**

2.6.9. Ensure all boiler fuel piping and controls meet NFPA or equivalent host nation requirements. **(T-0).**

2.6.10. Assign only properly trained and experienced personnel to operate, inspect, and maintain heating systems. **(T-1).**

2.6.11. Establish a program to measure performance of heating systems in order to make continuous improvements, identify potential system failure points, and review metrics from this program annually. **(T-3).**

2.6.12. Establish and maintain a recurring repair work program for large heating and pressure vessel systems for maximum cost benefit. **(T-3).**

2.6.13. Ensure approved repairs or alterations are programmed and accomplished. **(T-3).**

2.6.14. Develop cost-effective alternatives for system and equipment monitoring, where feasible. **(T-3).**

2.6.15. Plan, program, and budget for routine and recurring operations, maintenance, and environmental compliance activities (e.g., tune-ups). **(T-3).**

2.6.16. Ensure efficient management of service contracts and warranty programs for maintenance and repair of heating systems. **(T-3).**

2.6.17. Maintain a boiler and unfired pressure vessel inventory using the Air Force mandated information technology or Sustainment Management Systems. **(T-2).**

2.7. The Installation Air Quality Program Manager shall:

2.7.1. Determine if facilities are either an Area or Major Source for hazardous air pollutants (HAPs). **(T-0).**

2.7.2. When applicable, ensure records documenting tune-ups and operational tests are produced and maintained for Area and Major Sources as required by 40 CFR Part 63, Subpart DDDDD, *National Emission Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters* or 40 CFR Part 63, Subpart JJJJJJ, *National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers Area Sources* **(T-0).**

2.7.3. Prior to any construction or overhaul of boilers or process heaters, identify and address any appropriate permitting and environmental impact assessment requirements in accordance with AFI 32-7001, *Environmental Management*, and 40 CFR Part 63. **(T-0).**

2.7.4. Ensure boiler tune-ups and associated reports are performed as required by 40 CFR Part 63, Subparts DDDDD (Major Source) or JJJJJJ (Area Source) as outlined in **Attachment 3. (T-0).**

Chapter 3

FUEL CONVERSION

3.1. Installations Requirements . Installations require the use of the most cost-effective fuel available in accordance with 10 CFR Part 436, *Federal Energy Management and Planning Programs*.

3.2. Life-cycle. Use life-cycle costing methods, procedures, and information when determining the most cost-effective fuel. This shall include an evaluation of fuel suitability, availability, environmental impacts, reliability, and maintainability. **(T-2).**

3.3. Analysis. The analysis will be done in accordance with National Institute of Standards and Technology (NIST) Handbook 135, *Life-Cycle Costing Manual for the Federal Energy Management Program,* and escalation factors found in the NIST *Annual Supplement: Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis*. This shall include the Department of Energy discount and implied long-term average inflation rate published in the most recent NIST Handbook. **(T-0).**

3.4. Conversions . Any conversion of a coal-fired heating facility in Europe requires SAF/IE approval per Title 10 United States Code Section 2918, *Fuel sources for heating systems; prohibition on converting certain heating facilities.*

Chapter 4

SOLID FUEL REQUISITION AND INSPECTION

4.1. Request for Coal Purchase. Prepare DD Form 416, *Purchase Request for Coal, Coke, or Briquettes*, and submit to Defense Logistics Agency (DLA) Energy, according to dates and instructions specified by DLA Energy. Requisition and acceptance procedures for overseas bases will be provided by AFIMSC. **(T-2).**

4.2. Placing Orders. The ooperations flight will submit a DD Form 1155, *Order for Supplies or Services*, according to dates and instructions specified by DLA Energy. **(T-2).**

4.3. Accepting Deliveries. Before accepting a delivery, personnel shall inspect each shipment prior to unloading and at the point of delivery. **(T-3).** Send samples to DLA Energy according to the contract for the base.

4.3.1. Heat plant personnel shall take samples according to the DLA Energy contract for the base and Military Standard (MIL-STD) 3004D, *Quality Assurance/Surveillance for Fuels, Lubricants and Related Products,* Appendix C. **(T-0).** The boiler plant shall maintain a record of the sampling and testing results. **(T-2).** Sampling and testing results should be made available to the Air Quality Program Manager. **(T-3).**

4.3.2. The coal sampler notifies the Operations Flight Chief and the Base Civil Engineer Air Quality Program Manager when a coal delivery does not meet required specifications and recommend rejection to DLA Energy. **Note:** The DLA Energy contracting officer is the final authority for rejecting a coal shipment.

4.4. Inspecting Coal Stockpiles. Heat plant personnel shall inspect coal stockpiles at least twice per week, measuring internal temperatures using a temperature probe or other proven method and investigate abnormally high temperatures or signs of combustion. **(T-3).**

Chapter 5

LIQUID FUELS

5.1. Liquid Fuel Quality. All fuels to be burned shall meet the requirements of Technical Order (T.O.) 42B-1-1, *Quality Control of Fuels and Lubricants*, Chapter 6. Submit all waivers in accordance with the T.O.

5.2. Requisitions. The Base Civil Engineer shall submit liquid fuel requirements for each fiscal year to the base fuels management office. **(T-3).**

5.3. Managing Organizational Fuel Tanks. Tanks owned or operated by the Base Civil Engineer shall meet the requirements of AFI 23-204, *Organizational Fuel Tanks,* and AFMAN 32-1067, *Water and Fuel Systems*. **(T-0).**

5.4. Sampling and Testing. Fuel sampling is the responsibility of the receiving organization. The Base Civil Engineer shall coordinate sampling and testing of fuel received in tanks with the local fuels management team to assure fuel quality per T.O. 42B-1-1. **(T-1).** The boiler plant shall maintain a record of the sampling and testing results. **(T-2).** Sampling and testing results should be made available to the Air Quality Program Manager.

5.5. Mixing and Burning Fuels. The Base Civil Engineer shall obtain AFCEC's Environmental Operations Division approval before mixing and burning waste fuel or lubricants with heating fuel. **(T-2).**

5.6. Biodiesel. Biodiesel fuel and biodiesel blends exceeding B5 (5% biodiesel) shall not be burned in boilers. **(T-2).**

Chapter 6

HEATING, DISTRIBUTION SYSTEMS, AND UNFIRED PRESSURE VESSELS (UPVS)

6.1. Design and Construction. Steam boilers, hot water generators, heating and distribution systems, unfired pressure vessels, and pressure piping systems shall comply with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code or equivalent host nation requirements and this manual. **(T-0).**

6.1.1. The code requires the design of all steam and hot water heating systems includes equipment to provide industrial water treatment (see Corrosion Control chapter of AFI 32-1001, *Civil Engineer Operations*). It also requires boilers and UPVs to have a pressure-relieving device. The Base Civil Engineer shall ensure all pressure vessels in which moisture can accumulate have automatic condensate drainage. **(T-1).**

6.1.2. Design for Process Steam. Where possible, supply process steam which wastes condensate (such as steam cleaning) from dedicated boilers.

6.2. Operating Boilers and Hot Water Generators. Boilers and hot water generators shall have qualified operating technicians on hand to detect and correctly respond to equipment malfunctions or irregularities that could disrupt service, cause a hazard, or damage equipment. **(T-1).**

6.2.1. Operating technicians shall attend assigned boilers per the minimums shown in **Table 6.1** **(T-1).** If host nation agreements or standards differ from this standard, the stricter of the two will govern. Base the frequency of checks on total heating plant capacity and operating pressure regardless of fuel sources.

6.2.2. Any variance to **Table 6.1** approved by the major command prior to 1 June 2016 will be considered valid. Variances after that date shall be routed through Air Force Installation Management Support Center (AFIMSC), to AFCEC's Operations Directorate for approval. Requests for variances should include a complete description of the boiler system, control technology, proposed operating procedures, and frequency of attendance.

6.2.3. Plants that produce high pressure steam (HPS), Medium Temperature Water (MTW), or High Temperature Water (HTW) shall have technicians present that are fully qualified for the operation of the particular system. **(T-1).** It is recommended that civilian operators be licensed in the local jurisdiction if they have a boiler operation program.

6.2.3.1. HPS boilers are those that produce steam with a pressure greater than 15 pounds per square inch gauge (psig).

6.2.3.2. MTW systems produce hot water with pressures between 30 and 160 psig (250 and 350 °F).

6.2.3.3. HTW systems produce hot water with pressures greater than 160 psig.

6.2.4. Remote monitoring is defined as a condition where boiler controls and safeties are automated and continuously monitored by a system-trained technician from a remote location, with the capability for safe shutdown of all units. It is recommended all steam boilers operating at or above 15 psig or hot water generators operating at or above 30 psig which are not required to be constantly attended, be remotely monitored.

6.2.4.1. Per National Fire Protection Agency (NFPA) 85, *Boiler and Combustion Systems Hazards Code*, remote monitoring shall not override (prevent) any boiler or hot water generator safety shutdown. **(T-0).**

6.2.4.2. Remote monitoring may be used to support a request for variance to attendance requirements.

6.2.4.3. Remote locations must have the following capabilities in order to allow remote monitoring. **(T-2).** These capabilities are:

6.2.4.3.1. Ability to safely shutdown the system.

6.2.4.3.2. A live video camera feed to view the boiler or hot water generator.

6.2.4.3.3. Ability to monitor network failure alarms.

6.2.4.3.4. Fuel flow at burner.

6.2.4.3.5. Stack temperature.

6.2.4.3.6. Feedwater flow (steam).

6.2.4.3.7. Ability to view water level (steam).

6.2.4.3.8. Steam flow/circulation flow (MTW and HTW).

6.2.4.3.9. Water pressure and temperature (MTW and HTW).

6.2.4.3.10. Make-up flow (MTW and HTW).

Table 6.1. Minimum Boiler Attendance.

Heating Medium	Total Boiler Capacity[1]	Operating Pressure and Temperature	Frequency of Attendance[2]	Log Required
Low Temp Water	Under 5,000,000 Btu/h	Under 30 psig 250 °F Max	Once per month when operating	No
Low Temp Water	5,000,000 Btu/h or greater	Under 30 psig 250 °F Max	Once per 24 hour period during operation[3]	No
Medium Temp Water	Under 5,000,000 Btu/h	30–160 psig 250–350 °F	Once per 8-hour shift during operation[3]	No
Medium Temp Water	5,000,000 Btu/h to 30,000,000 Btu/h	30–160 psig 250–350 °F	Twice per 8-hour shift during operation[3]	No
Medium Temp Water	Over 30,000,000 to 100,000,000 Btu/h	30–160 psig 250–350 °F	Constant attendance by one person per 8-hour shift[4]	No
Medium Temp Water	Over 100,000,000 Btu/h	30–160 psig 250–350 °F	Constant attendance by two people per 8-hour shift[4]	No
High Temp Water	Under 30,000,000 Btu/h	Over 160 psig Over 350 °F	Twice per 8-hour shift during operation	Yes
High Temp Water	30,000,000 Btu/h or greater	Over 160 psig Over 350 °F	Constant attendance by two people per 8-hour shift[4]	Yes
Low Pressure Steam	Under 1,000,000 Btu/h	Under 15 psig 212–250 °F	Once every week during operation	No
Low Pressure Steam	1,000,000 Btu/h to 5,000,000 Btu/h	Under 15 psig 212–250 °F	Twice per week during operation	No
Low Pressure Steam	Over 5,000,000 Btu/h	Under 15 psig 212–250 °F	Once per 24 hour period during operation[3]	Yes

Heating Medium	Total Boiler Capacity[1]	Operating Pressure and Temperature	Frequency of Attendance[2]	Log Required
High Pressure Steam	Under 5,000,000 Btu/h	Over 15 psig Over 250 °F	Once per 8-hour shift during operation[3]	Yes
High Pressure Steam	5,000,000 Btu/h to 30,000,000 Btu/h	Over 15 psig Over 250 °F	Twice per 8-hour shift during operation	Yes
High Pressure Steam	Over 30,000,000 Btu/h to 100,000,000 Btu/h	Over 15 psig Over 250 °F	Constant attendance by two people per 8-hour shift[4]	Yes
High Pressure Steam	Over 100,000,000 Btu/h	Over 15 psig Over 250 °F	Constant attendance by two people per 8-hour shift[4]	Yes

Notes:
1. The sum of the all rated capacities of boilers and hot water generators in the facility, regardless of operating status.
2. For coal-fired plants, additional operating personnel are required for coal and ash handling consistent with installed equipment.
3. Attendance can be accomplished by remote monitoring, with approved variance, and a system-trained technician with the capability for safe shutdown of all units.
4. Attendance can be reduced by one person per 8-hour shift if boiler controls and safeties are automated and continuously monitored, with the minimum items listed in **paragraph 6.2.4.** and associated subparagraphs.

6.3. Operating Logs. Heat plant logs give the plant foreman and supervisors a summary of boiler plant operations and performance. They also establish a basis for conformance with environmental air quality permits.

6.3.1. Units maintain boiler plant performance and operating logs for the following boilers:

6.3.1.1. HPS operating over 15 psig and 250 °F. **(T-3).**

6.3.1.2. HTW boiler plant operating over 160 psig. **(T-3).**

6.3.1.3. Low-pressure steam (LPS) boiler plant with minimum output capacity of 5,000,000 Btu/h. **(T-3).**

6.3.1.4. Any boiler plant the operations flight deems appropriate. **(T-3).**

6.3.2. Units use the following forms for operating logs, as applicable: **Exception:** Computer-generated printouts are acceptable if they contain all pertinent information.

6.3.2.1. AF Form 1163, *Daily High Temperature Water Plant Operating Log*. **(T-2).**

6.3.2.2. AF Form 1165, *Monthly High Temperature Water Plant Operating Log*. **(T-2).**

6.3.2.3. AF Form 1458, *Daily Steam Boiler Plant Operating Log*. **(T-2).**

6.3.2.4. AF Form 1459, *Water Treatment Operating Log for Steam and Hot Temperature Water Boilers*. **(T-2).**

6.3.2.5. AF Form 1464, *Monthly Steam Boiler Plant Operating Log*. **(T-2).**

6.4. Boiler and Hot Water Generator System Maintenance.

6.4.1. At dual-fuel plants, fire boilers at least bimonthly with standby fuel to confirm reliability. **(T-2).**

6.4.2. Schedule, plan, and resource to complete equipment overhaul and accomplish other major maintenance during short off-peak periods. **(T-2).**

6.4.3. Annually calibrate boiler instrumentation. At a minimum all gages, indicators, and boiler trim shall be checked to be operating and indicating proper measurements. **(T-2).**

6.4.4. Ensure that replacement materials and parts comply with boiler code safety standards and maintain equipment ASME code stamps and labels in legible condition. **(T-0).**

6.4.5. Ensure scheduled maintenance of boilers, heating equipment, and steam traps is performed at least annually. **(T-2).**

6.4.6. The ASME *Boiler and Pressure Vessel Code*, Section IX, "Welding and Brazing Qualifications," contains welding procedural specifications and welder qualification requirements. Base Civil Engineer shall not allow welding or brazing of pressure components of steam-jacketed cooking equipment or UPV. **(T-0).** Owning organization must replace failed parts **(T-0).**

6.4.7. Distribution Systems. Perform maintenance according to the manufacturer's recommendations and appropriate repair codes.

6.4.7.1. The operations flight shall annually check distribution systems for leaks using thermograph, or other approved testing methods as recommended by the manufacturer. **(T-3).** Additionally, check for damage and loss of insulation and repair damaged lines as necessary to maintain insulating qualities. **(T-3).**

6.4.7.2. Make temporary repairs to failed lines as soon as conditions permit. The Base Civil Engineer shall program the replacement of failed sections as soon as the extent of failure is known. **(T-2).**

6.4.7.3. Temporary repairs to direct buried systems using piping other than prefabricated conduit systems are permitted but are limited to 500 feet per repair. **(T-3)**. Repair material shall be suitable for use under the pressure and temperature conditions of the distribution system being repaired. The Base Civil Engineer shall replace these repairs within 18 months with an approved system and materials. **(T-3).**

6.4.7.4. Where cathodic protection is installed, the operations flight shall inspect, test, and maintain the system in accordance with AFI 32-1001 and Unified Facilities Criteria (UFC) 3-570-06, *Operation and Maintenance: Cathodic Protection Systems*. **(T-0).**

6.5. Replacing or Installing New Distribution Lines.

6.5.1. Route Selection. The system route should be coordinated with the Installation Development Plan. The selected route has considerable impact on system type selection. For example, aboveground systems usually are not acceptable if they create obstructions to traffic or are unsightly, while large numbers of obstructions along the system profile greatly increase the cost of underground systems. Attention should be given to any severe or complex installation conditions that adversely affect the cost of the system. The final route selected should minimize the system life-cycle cost.

6.5.2. System Type Selection. The Base Civil Engineer shall evaluate potential heat distribution system types according to the following order of preference: (1) aboveground; (2) shallow concrete trench; (3) direct buried prefabricated conduit; (4) poured-in-place

underground insulation system. **(T-2).** Calculate heat loss for each system under consideration by using standard American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) methods. **(T-2).** Evaluate life-cycle costs of the alternatives by using the building life-cycle cost program available at the Federal Energy Management Program web site. **(T-0).** Select the most cost-effective system based on the results of a life- cycle cost analysis. **(T-0).**

6.5.3. System Design and Construction of New or Replacement Distribution Systems. The Base Civil Engineer shall design and construct new and replacement distribution systems to meet the requirements of UFC 3-430-01FA, *Heating and Cooling Distribution Systems*, and applicable Unified Facilities Guide Specifications (UFGS). **(T-0).** UFCs and UFGS are available at the Whole Building Design Guide (**www.wbdg.org**).

6.5.4. Installation of Repair Sections. When not otherwise designed, the Base Civil Engineer shall install and test new system components per the UFGS, manufacturer's requirements, or by other approved methods. Complete all tests and correct deficiencies prior to insulating or covering connections, joints, welds, or fittings. **(T-1).** An authorized factory representative is recommended during installation and testing of systems.

6.6. Inspections and Testing.

6.6.1. Installations in the United States shall inspect boilers and unfired pressure vessels according to the National Board Inspection Code (NBIC). **(T-0). Exception:** Air National Guard will inspect boilers and unfired pressure vessels according to state, local, and NBIC inspection criteria on Air National Guard installations. **(T-0).**

6.6.2. Installations in foreign countries shall inspect boilers and unfired pressure vessels according to host nation standards, host nation agreement, or the NBIC, whichever is more stringent. **(T-2).**

6.6.3. Boilers and Fired Pressure Vessel Inspections.

6.6.3.1. All HPS boilers and HTW generators and expansion tanks in active use shall be inspected by NBIC certified inspectors. **(T-0)**. Air Force Installation and Mission Support Center (AFIMSC) Detachments shall use the NBIC standards for bases in foreign countries if the host country does not have NBIC-equivalent standards. See **Attachment 2** for descriptions of inspection types, frequency of inspection, and scheduling guidelines.

6.6.3.1.1. HPS boilers operate above 15 psig.

6.6.3.1.2. HTW generators operate above 160 psig or 350°F.

6.6.3.2. Inspection and evaluation of low pressure heating boilers in active use shall be performed by properly qualified personnel, as determined by the Base Civil Engineer or contracted boiler owner or operator. **(T-1).** These include:

6.6.3.2.1. Steam boilers with safety valves set at 15 psig or less. **(T-1).**

6.6.3.2.2. Hot water boilers with safety valves set at 45 psig or less. **(T-1).**

6.6.3.2.3. Pressure vessels of less than 33,500 Btu/h specially constructed for laboratory purposes. **(T-1).**

6.6.4. Steam-Jacketed Cooking Equipment Inspections. **(T-1).**

6.6.4.1. To comply with NBIC, inspect steam kettles and other steam-jacketed cooking equipment according to the manufacturer's instructions or perform a Type VB inspection (see **Attachment 2**) with hydrostatic test, excluding internal inspection, once every three years. **(T-0).** The hydrostatic test pressure should equal the safety valve set pressure.

6.6.4.2. If steam-jacketed cooking equipment is not coded as RPIE, it is organizational equipment and not maintained by civil engineer personnel and must be maintained per requirements of Chapter 7. **(T-0).**

6.6.5. Unfired Pressure Vessels Inspections.

6.6.5.1. Every three years, the operations flight shall perform internal and external inspections of all unfired pressure vessels that meeting the criteria illustrated in **Figure 6.1**. **(T-0).** The criteria includes**.**

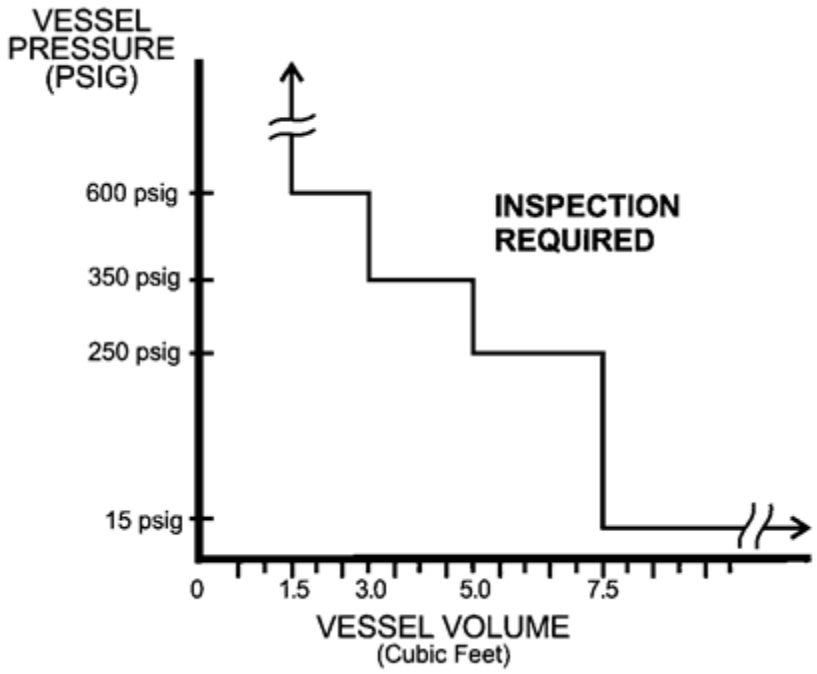
6.6.5.1.1. Unfired pressure vessels greater than 1.5 cubic feet in volume and greater than 600 psig design pressure.

6.6.5.1.2. Unfired pressure vessels greater than 3 cubic feet in volume and greater than 350 psig design pressure.

6.6.5.1.3. Unfired pressure vessels greater than 5 cubic feet in volume and greater than 250 psig design pressure.

6.6.5.1.4. Unfired pressure vessels greater than 7.5 cubic feet in volume and greater than 15 psig design pressure.

Figure 6.1. Unfired Pressure Vessel (UPV) Inspection Requirements.



6.6.5.2. An NBIC certified inspector shall perform a hydrostatic test to 1.5 times working pressure every three years on vessels operating above 200 psig that cannot be inspected internally and externally. **(T-0).**

6.6.5.3. A NBIC certified inspector shall inspect unfired steam pressure vessels which operate at pressures above 15 psig every three years or more frequently as determined by procedures in the NBIC. **(T-0).** Perform a Type VB inspection with a hydrostatic test to 1.5 times working pressure every three years on vessels operating above 200 psig that cannot be inspected internally and externally. **(T-0).** Pressure vessels without access for internal inspections shall be inspected by non-destructive testing procedures. **(T-0).**

6.6.5.4. The following categories of unfired pressure vessels are excluded from the specific inspection requirements:

6.6.5.4.1. Unfired pressure vessels with an inside diameter, width, height, or cross-section diagonal not exceeding 6 inches regardless of length or pressure.

6.6.5.4.2. Pressure vessels for human occupancy.

6.6.5.4.3. Fired process tubular heaters.

6.6.5.4.4. Unfired pressure vessels with an internal or external operating pressure not exceeding 15 psig regardless of size.

6.6.5.4.5. Hot water storage tanks when the following limitations are not exceeded: a nominal water-containing capacity of 120 gallons; a water temperature of 210 °F; and heat input of 200,000 Btu/hr.

6.6.5.4.6. Unfired pressure vessels for containing water under pressure, including vessels containing air, the compression of which serves only as a cushion, when the following limitations are not exceeded: a design pressure of 300 psig and a design temperature of 210 °F.

6.6.5.4.7. Any structure whose primary function is transporting fluids from one location to another within a system of which it is an integral part (e.g. piping systems).

6.6.6. Reporting Inspections.

6.6.6.1. Inspectors shall document all boiler and pressure vessel inspection using AF Form 1222, *Boiler or Pressure Vessel Inspection Report*. **(T-3).**

6.6.6.2. Inspectors shall promptly notify the Operations Flight Commander, base safety office, and AFIMSC Detachment, in turn, when a boiler or pressure vessel is unsafe to operate or has a serious defect. **(T-3).**

6.6.6.3. The inspector shall post one copy of the inspection report in a conspicuous location near the boiler or pressure vessel, send one copy to the Operations Flight Commander, and place one copy in the inspection file. **(T-1).**

6.6.7. Post-Inspection Repairs.

6.6.7.1. Before leaving the base the inspector will report any serious defects to the operations flight. Take corrective actions requested by the inspector or listed on the inspection reports. Per NBIC, if a boiler or pressure vessel is unsafe to operate, proper repairs shall be made before placing it back in service. **(T-0).**

6.6.7.2. All repairs to pressure components of boilers, unfired pressure vessels, or safety pressure-relief devices shall be performed by an organization holding the appropriate NBIC certification in accordance with ASME Boiler and Pressure Vessel Code. **(T-0).**

6.6.8. Reporting Repairs**.**

6.6.8.1. After inspecting the repairs (**paragraph A2.2.4**), the Base Civil Engineer shall post one copy of the inspection report describing repair actions (under a transparent protective cover with the original inspection report), send one copy to the operations flight, and place one copy in the file. **(T-1).**

6.6.9. Boiler Tune-ups.

6.6.9.1. Tune-ups are routinely required for all operational boilers depending on the boiler's input capacity, fuel type, and the facility's hazardous air pollutant (HAP) classification. The Major Source and Area Source tune-up requirements are listed in 40 CFR Part 63, Subpart JJJJJJ (Area Source) and Subpart DDDDD (Major Source) and summarized in **Attachment 3**.

6.6.9.2. The minimum tune-up requirement is adjusting the combustion air to ensure it is within the limits prescribed by the manufacturer and the requirements in **Tables A3.1**, **A3.2**, **A3.3** and **A3.4**. If automatic trim controls are not installed, a portable flue gas analyzer may be used. Follow the sampling procedures prescribed in ASME Code PTC 19.10-1981, *Flue and Exhaust Gas Analyses, Appendix 4*. **(T-0).** Include all other manufacturer-identified maintenance actions that are due or recommended to be performed on an annual basis.

6.6.9.3. Documentation of tune-ups shall be maintained in the boilers inspection record per 40 CFR Part 63 Subpart JJJJJJ and Subpart DDDDD. **(T-0).** For further guidance, refer to **Attachment 3**.

6.6.9.4. All boilers not covered by the requirements of **paragraph 6.6.9.1 through paragraph 6.6.9.3**, regardless of size or fuel type, shall be trimmed and receive all manufacturer-identified recommended maintenance actions annually. **(T-3).** Follow the sampling procedures prescribed in ASME Code PTC 19.10-1981, with a calibrated portable flue gas analyzer to determine combustion efficiency. No combustion analysis is required if an oxygen trim system is installed on a boiler.

6.6.10. Combustion Efficiency. All boilers shall be operated within the manufacturer's specified range for excess combustion air (or excess O2). **(T-3).** This ensures that boilers operate within a narrow range of optimal combustion efficiencies. **Attachment 4** lists combustion efficiency tables that can be used to identify the expected combustion efficiencies for natural gas and oil-fired boilers operating within various operating parameters.

Chapter 7

ORGANIZATIONAL EQUIPMENT, MOBILE BOILER, AND PRIVATELY OR CONTRACTOR-OWNED EQUIPMENT

7.1. Boilers. All boilers not classified as RPIE, located on Air Force installations shall be operated safely and comply with the provisions of **Chapter 6** of this AFMAN and 40 CFR Part 63 Subpart JJJJJJ and Subpart DDDDD. The owning unit, organization, or contractor shall monitor these boilers and unfired pressure vessels to ensure the operator or owner:

7.1.1. Complies with basic safety practices similar to those required for government boilers and unfired pressure vessels. **(T-2).**

7.1.2. Arranges for periodic safety inspections. **(T-2).**

7.1.3. Schedules an authorized inspection agency to perform inspections at the same intervals required for government boilers and unfired pressure vessels. **(T-2).**

7.1.4. Posts inspection reports as specified for government-operated boilers and unfired pressure vessels. **(T-2).**

7.1.5. In accordance with NBIC, the equipment owner shall:

7.1.5.1. Make repairs that the inspector recommends. **(T-0)**

7.1.5.2. Pay for all inspections and repairs. **(T-0)**

7.1.5.3. Not operate equipment before repairing it if the inspector declares it unsafe. Repairs shall be according to the NBIC or host country code, as applicable. **(T-0)**

WARREN D. BERRY, Lieutenant General, USAF
DCS/Logistics, Engineering & Force Protection

Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

References

10 USC § 2918, *Fuel sources for heating systems; prohibition on converting certain heating facilities*

42 USC §7412 (Clean Air Act §112), *Hazardous Air Pollutants*

10 CFR Part 436, *Federal Energy Management and Planning Programs*

40 CFR Part 63, Subpart DDDDD, *National Emission Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters*

40 CFR Part 63, Subpart JJJJJJ, *National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers Area Sources*

40 CFR Part 63, Subpart X, *National Emission Standards for Hazardous Air Pollutants From Secondary Lead Smelting*

40 CFR Part 63, Subpart MM, *National Emission Standards for Hazardous Air Pollutants for Chemical Recovery Combustion Sources at Kraft, Soda, Sulfite, and Stand-Alone Semichemical Pulp Mills*

40 CFR Part 63, Subpart YY, *National Emission Standards for Hazardous Air Pollutants for Source Categories: Generic Maximum Achievable Control Technology Standards*

40 CFR § 70.2, *State Operating Permit Programs; Definitions*

40 CFR Part 71.2, *Federal Operating Permit Programs; Definitions*

EPA-453/R-01-005, *National Emission Standards for Hazardous Air Pollutants (NESHAP) for Integrated Iron and Steel Plants - Background Information for Proposed Standards*, January 2001

AFPD 32-10, *Installations and Facilities*, 3 March 2010

AFPD 90-1, *Policy, Publications, and DoD Issuance Management*, 7 March 2018

AFI 23-204, *Organizational Fuel Tanks*, 3 July 2012

AFI 32-1001, *Civil Engineer Operations*, 4 October 2019

AFI 32-7001, *Environmental Management*, 23 August 2019

AFI 33-360, *Publications and Forms Management*, 1 December 2015

AFMAN 32-1067, *Water and Fuel Systems*, DD MMM YYYY (AWAITING PUBLICATION)

AFMAN 33-363, *Management of Records*, 1 March 2008

AFMAN 32-7002, *Environmental Compliance and Pollution Prevention*, 4 February 2020

MIL-STD-3004D, *Quality Assurance/Surveillance for Fuels, Lubricants and Related Products*, 28 March 2016

T.O. 42B-1-1, *Quality Control of Fuels and Lubricants*, 15 June 2011

UFC 3-430-01FA, *Heating and Cooling Distribution Systems*, 25 July 2003

UFC 3-570-06, *Operation and Maintenance: Cathodic Protection Systems*, 15 July 2019

Prescribed Forms

AF Form 1163, *Daily High Temperature Water Plant Operating Log*

AF Form 1165, *Monthly High Temperature Water Plant Operating Log*

AF Form 1222, *Boiler or Pressure Vessel Inspection Report*

AF Form 1458, *Daily Steam Boiler Plant Operating Log*

AF Form 1459, *Water Treatment Operating Log for Steam and High Temperature Water Boilers*

AF Form 1464, *Monthly Steam Boiler Plant Operating Log*

Adopted Forms

AF Form 847, *Recommendation for Change of Publication*

DD Form 416, *Purchase Request for Coal, Coke, or Briquettes*

DD Form 1155, *Order for Supplies or Services*

EPA Forms

Tune-up Information, **https://www.epa.gov/sites/production/files/2016-09/area_tuneup_info_only-1.docx**

Abbreviations and Acronyms

°F—degrees Fahrenheit

Δ**T**—change in temperature/ambient

AFCEC—Air Force Civil Engineer Center

AF—Air Force Form

AFI—Air Force Instruction

AFIMSC—Air Force Installation and Mission Support Center

AFMAN—Air Force Manual

AFPD—Air Force Policy Directive

APIMS—Air Program Information Management System

ASME—American Society of Mechanical Engineers

Btu—British thermal unit

Btu/h—British thermal units per hour

CEDRI—Compliance and Emissions Data Reporting Interface

CFR—Code of Federal Regulations

DD—Department of Defense Form

DLA—Defense Logistics Agency

EPA—Environmental Protection Agency

HAP—hazardous air pollutant

HHV—higher heating value

HPS—high-pressure steam

HTW—high-temperature water

ISO—International Organization for Standardization

LPS—low-pressure steam

LTW—low-temperature water

MBtu/h—thousand British thermal units per hour

MIL-STD—military standard

MMBtu/hr—million British thermal units per hour (Roman numeral M = 1000)

MTW—medium-temperature water

NBIC—National Board Inspection Code

NESHAP—National Emission Standards for Hazardous Air Pollutants

NFPA—National Fire Protection Association

NIST—National Institute of Standards and Technology

NOC—Notification of Compliance (Status Report)

OPR—Office of Primary Responsibility

psia—pounds per square inch absolute

psig—pounds per square inch gauge

RPIE—real property installed equipment

SAF/IE—The Assistant Secretary of the Air Force for Installations, Environment, and Energy

T.O.—Technical Order

UFC—Unified Facilities Criteria

UFGS—Unified Facilities Guide Specification

UPV—unfired pressure vessel

USC—United States Code

Terms

Affected Boiler (or Affected Source)—An affected boiler (and process heater for a Major Source) is any non-residential or non-exempt boiler (refer to **A3.3.** for list of exemptions). For an Area Source, affected boilers include boilers which combust coal, biomass, or oil. For a Major Source, an affected boiler or process heater combusts gas, oil, coal, or biomass.

Area Source—A Clean Air Act (CAA) designation identified by an installation's Base Civil Engineer Environmental function's Air Quality Program Manager. Defined as any contiguous area under common control (such as an Air Force installation) that is not a Major Source (i.e., that emits, or has the potential to emit, less than 10 tons per year of any single hazardous air pollutant (HAP) and less than 25 tons per year of any combination of HAPs).

Biomass—Any organically-based solid fuel that is not solid waste. This includes, but is not limited to, wood residue and wood products (e.g., trees, tree stumps, tree limbs, saw dust, chips, and shavings), animal manure, vegetative agricultural and silvicultural materials (e.g., logging residues, nut and grain hulls, chaff, corn stalks).

Blast furnace gas fuel-fired boiler or process heater—An industrial, commercial, institutional boiler or process heater that receives 90 percent or more of its total annual gas volume from blast furnace gas.

Boiler—An enclosed device using controlled flame combustion and having the primary purpose of recovering thermal energy in the form of steam or hot water.

Boiler System—The boiler and associated components, such as the feed water system, the combustion air system, the fuel system (including burners), blowdown systems, combustion control system, and energy consuming systems.

Electric Boiler—A boiler in which electric heating serves as the source of heat. Electric boilers that burn gaseous or liquid fuel during periods of electrical power curtailment or failure are included in this definition.

Energy Use System—Systems located on-site that use energy (steam, hot water, or electricity) provided by an affected boiler. Includes, but is not limited to, process heating, compressed air systems, machine drive (motors, pumps, fans), process cooling; facility heating, ventilation, and air-conditioning systems, hot water systems, building envelope, and lighting.

Existing Boiler—Boilers (and process heaters for a Major Source) constructed or reconstructed on or before 4 June 2010.

Gaseous Fuel (Gas 1 and Gas 2)—Includes, but is not limited to, natural gas, propane, process gas, landfill gas, coal derived gas, refinery gas, and biogas.

Gas-fired Boiler—Includes any boiler that burns gaseous fuels not combined with any solid fuels and burns liquid fuel only during periods of gas curtailment, gas supply interruption, startups, or for periodic testing, maintenance, or operator training on liquid fuel. Periodic testing, maintenance, or operator training on liquid fuel shall not exceed a combined total of 48 hours during any calendar year.

Hazardous Air Pollutant (HAP)—HAPs are air pollutants which are known or probable human carcinogens and/or linked to heath conditions affecting the lungs, skin, and central nervous system, particularly for people in vulnerable groups such as children and the elderly. Specific HAPs are defined in 42 USC § 7412.

Heavy liquid—Includes residual oil and any other liquid fuel not classified as a light liquid (residual oils such as #4, #5 & #6 oil).

High Pressure Steam—HPS operates at system pressures greater than 15 psig.

High Temperature Water—High temperature water operates at system pressures greater than 160 psig.

Hot Water Heater—A closed vessel with a capacity of no more than 120 U.S. gallons in which water is heated by combustion of fuel and hot water is withdrawn for use external to the vessel. Hot water boilers (i.e., boilers not generating steam) with a heat input capacity of less than 1.6 million Btu per hour are included in this definition (**Note:** The 120 gallon capacity threshold does not apply to hot water boilers.) Hot water heater also means a tankless unit that provides on-demand hot water.

Light Liquid—Includes distillate oil, biodiesel, or vegetable oil. Distillate oil refers to fuel oils that contain 0.05 weight percent nitrogen or less and comply with the specifications for fuel oil numbers 1 and 2 (distillate oil such as #1, #2 oil, biodiesel, vegetable oils).

Limited-use Boiler/Process Heater—Any boiler (and process heater for a Major Source) that burns any amount of solid, liquid, or gaseous fuels and has a federally enforceable average annual capacity factor of no more than 10 percent. The annual capacity factor is the ratio between the actual heat input to a boiler or process heater from the fuels burned during a calendar year and the potential heat input to the boiler or process heater had it been operated for 8,760 hours during a year at the maximum steady state design heat input capacity.

Low Pressure Boiler—A boiler in which steam or vapor is generated at a pressure less than or equal to 15 psig.

Low Temperature Water—Low temperature water operates system pressures below 30 psig and temperatures below 250 °F.

Major Source—A Clean Air Act designation identified by an installation's Base Civil Engineer Environmental function's Air Quality Program Manager. Defined as any contiguous area under common control (such as an Air Force installation) that emits or has the potential to emit, considering controls, in the aggregate, 10 tons per year or more of any single HAP or 25 tons per year or more of any combination of HAPs, unless the EPA administrator establishes a lesser quantity, or, in the case of radionuclides, different criteria from those specified in this paragraph.

Medium Temperature Water—Medium temperature water operates system pressures between 30 and 160 psig and temperatures in excess of 250 °F.

New Boiler/Process Heater—A boiler (and process heater for a Major Source) is new if construction or reconstruction of the boiler or process heater began after 4 June 2010 and the boiler or process heater meets the applicability criteria at the time construction commenced.

Oxygen Trim System—A system of monitors that is used to maintain excess air at the desired level in a combustion device. A typical system consists of a flue gas oxygen and/or carbon monoxide monitor that automatically provides a feedback signal to the combustion air controller.

Period of gas curtailment or supply interruption—A period of time during which the supply of gaseous fuel to an affected boiler is restricted or halted for reasons beyond the control of the facility. The act of entering into a contractual agreement with a supplier of natural gas established for curtailment purposes does not constitute a reason that is under the control of a facility for the purposes of this definition. An increase in the cost or unit price of natural gas due to normal market fluctuations not during periods of supplier delivery restriction does not constitute a period of natural gas curtailment or supply interruption. On-site gaseous fuel system emergencies or

equipment failures qualify as periods of supply interruption when the emergency or failure is beyond the control of the facility.

Process Heater—An enclosed device using a controlled flame with a primary purpose of transferring heat indirectly to a process material (liquid, gas, or solid) or to a heat transfer material (e.g., glycol or a mixture of glycol and water) for use in a process unit, instead of generating steam.

Reconstructed Boiler and Process Heater—The boiler (and process heater for a Major Source) is a reconstructed source if reconstruction of the boiler or process heater commenced after 4 June 2010, and met the applicability criteria at the time reconstruction commenced. Reconstruction is the replacement of components such that the total, fixed capital cost of the replacement is greater than 50% or more than the fixed capital cost of constructing a comparable, new unit**.**

Residential Boiler—A boiler used to provide heat and/or hot water and/or as part of a residential combined heat and power system. This definition includes a boiler located at an institutional facility (e.g., military base) or commercial/industrial facility if the boiler is used primarily to provide heat and/or hot water for: (1) a dwelling containing four or fewer families; or (2) a single unit residence dwelling that has since been converted or subdivided into condominiums or apartments.

Responsible Official—The Installation/Center Commander as defined by 40 CFR Part 63 and AFI 32-7002, *Environmental Compliance and Pollution Prevention Air Quality, Compliance and Resource Management* as applicable*;* this individual shall sign Initial Notice of Compliance Status reports.

Seasonal Boiler—A boiler that undergoes a shutdown for a period of at least seven (7) consecutive months (or 210 consecutive days) each twelve-month period due to seasonal conditions, except for periodic testing. Periodic testing shall not exceed a combined total of fifteen (15) days during the seven-month shutdown. This definition applies only to boilers that would otherwise be included in the biomass subcategory or the oil subcategory under the Area Source Rule.

Temporary Boiler or Process Heater—Include any gaseous or liquid fuel boiler (and process heater for a Major Source) that is designed to, and is capable of, being carried or moved from one location to another (for example by wheels, skids, carrying handles, dollies, trailers, or platforms). A boiler or process heater is NOT a temporary if any one of the following conditions exists:

(1) The equipment is attached to a foundation.
(2) The boiler or a replacement remains at a location within the facility and performs the same or similar function for more than 12 consecutive months, unless the appropriate regulatory authority grants an extension. Any temporary boiler that replaces a temporary boiler at a location and performs the same or similar function shall be included in calculating the consecutive time period.
(3) The equipment is located at a seasonal facility and operates during the full annual operating period of the seasonal facility, remains at the facility for at least 2 years, and operates at that facility for at least 3 months each year.
(4) The equipment is moved from one location to another in an attempt to circumvent the residence time requirements of this definition.

Tune-up—Adjustments made to a boiler (and process heater for a Major Source) in accordance with the procedures outlined in 40 CFR § 63.7540 (for Area Sources) or 40 CFR Part § 63.7540 (for Major Sources).

Attachment 2

INSPECTION REQUIREMENTS

A2.1. Types of Inspections.

A2.1.1. **Boilers:**

A2.1.1.1. **Type BA:** Internal and external inspection.

A2.1.1.2. **Type BB:** Internal and external inspection followed or preceded by external inspection while boiler is under a hydrostatic test.

A2.1.1.3. **Type BC:** Operational inspection while under steam pressure or filled with water. This inspection also includes verifying that safety devices perform as intended in accordance with ASME CSD-1 or NFPA 85, as applicable.

A2.1.1.4. **Type BD:** External inspection while under hydrostatic test.

A2.1.1.5. **Type BE:** Internal and external inspection of expansion tanks with HTW boilers.

A2.1.2. **UPVs:**

A2.1.2.1. **Type VA:** Internal and external inspection.

A2.1.2.2. **Type VB:** Internal and external inspection followed or preceded by external inspection while pressure vessel is under hydrostatic test.

A2.1.2.3. **Type VC:** External inspection while under operating conditions and pressure.

A2.1.2.4. **Type VD:** External inspection while under hydrostatic test.

A2.1.2.5. **Type VE:** Internal and external inspection with an ultrasonic thickness test of the pressure shell.

A2.2. Requirements per NBIC.

A2.2.1. **HPS Boilers:**

A2.2.1.1. Perform a Type BA inspection, including an internal and external inspection, annually. **(T-0).**

A2.2.1.2. Perform a Type BB inspection, which includes a hydrostatic test, every three years. **(T-0).** This replaces the Type BA inspection for that year.

A2.2.1.3. Accomplish a secondary inspection (Type BC) annually, approximately six months after the Type BA or BB. **(T-0).**

A2.2.2. **HTW Boilers:**

A2.2.2.1. Perform an external (Type BC) inspection once a year. **(T-0).**

A2.2.2.2. Perform an internal inspection (Type BA) after the first and second year of operation. **(T-0).**

A2.2.2.3. Perform a Type VE inspection on each expansion tank every two years. Perform a Type VC inspection during alternating years. **(T-0).**

A2.2.3. **Frequency of HTW Boiler Internal Inspections After Two Years.** After operating and inspecting the boiler for two years, the frequency of internal inspection can increase to three years if only after meeting specific conditions. **(T-0).** Those conditions are:

A2.2.3.1. No adverse conditions such as scale or corrosion are present.

A2.2.3.2. The amount of makeup water is negligible.

A2.2.3.3. Effective chemical treatment is under strict control.

A2.2.4. **Questionable Steam and HTW Boilers.** Perform a Type BB inspection when: (1) a boiler has been reinstalled; or (2) a boiler had major repairs (as defined in the NBIC). Inspect before returning the boiler to normal operation. Perform a Type BA inspection six months after resuming operation. Ensure an NBIC inspector performs a preliminary Type BA or Type BB inspection before initiating a major repair. **(T-0).**

A2.2.5. **Low/Medium Temperature Water (LTW/MTW) and LPS Heating Boilers.** Perform a Type BC inspection on: (1) hot water (LTW/MTW) heating boilers annually that operate at or below 250 °F and at or below 160 psig; or (2) low-pressure steam boilers (below 15 psig) biannually. Only boilers less than 1 MBtu/h output that produce domestic hot water are exempt from this inspection requirement. Inspections do not require a certified inspector and shall be accomplished by experienced, qualified base personnel, as determined by the Base Civil Engineer. **(T-1).**

A2.2.6. **Compressed Air Receivers and Other UPVs.** Perform a Type VE inspection every three years, except for liquefied petroleum (propane) tanks, which require a Type VC inspection every five years. **(T-0).** When questionable conditions or inspection indicates that a safety problem exists:

A2.2.6.1. Conduct hydrostatic tests.

A2.2.6.2. Notify the AFIMSC Detachment by telephone, followed by e-mail detailing the pressure vessel safety problem and provide a copy of the UPV inspection.

A2.2.6.3. Perform repairs as required.

A2.2.6.4. Perform a Type VE inspection annually until all problems are corrected.

A2.2.6.5. After the inspection indicates that problems are corrected, perform an inspection every three years or five years, as required. **Note:** For pressure vessels that operate over 200 psig and cannot be inspected internally and externally, perform hydrostatic test to 1.5 times working pressure every three years.

A2.2.7. **New Boilers.** Perform a Type BB inspection on all new steam or HTW boilers before operation. **(T-0).**

A2.2.8. **Inspector Qualifications.** The NBIC establishes basic qualifications for boiler inspectors in the United States, its territories, and possessions. Inspectors shall hold a current National Board Commission. **(T-0).** AFIMSC Detachments shall use the NBIC standards for bases in foreign countries if the host country does not have NBIC-equivalent standards. **(T-0).**

A2.2.9. **Hydrostatic Testing of Boilers.**

A2.2.9.1. **Establishing Test Conditions.** During hydrostatic tests to determine tightness under Type BB or BD inspections: **(T-0).**

A2.2.9.1.1. Remove safety valves before testing or hold down each disc with a test clamp or plug device designed for this purpose.

A2.2.9.1.2. Ensure water temperature is not less than ambient and between 70 °F and 120 °F.

A2.2.9.1.3. Ensure test pressure is equal to boiler working pressure but not greater than the set pressure of the safety device with the lowest setting. **Note:** For tests under a Type BB inspection, externally inspect the boiler during the safety test at the pressure described above. Set test pressure for inspections of new boilers and existing boilers before and after repairs at 1.5 times the maximum allowable working pressure.

A2.2.9.2. **When to Hydrostatically Test High-Pressure Boilers.** Subject high-pressure boilers to hydrostatic tests only under specific conditions:

A2.2.9.2.1. Upon completion of installation. (Include this requirement in the construction contract as a contractor's responsibility.) **(T-0).**

A2.2.9.2.2. After completing major repairs to any boiler component subject to steam or water pressure. **(T-0).**

A2.2.9.2.3. Before returning boilers to service in reactivated plants. **(T-0).**

A2.2.9.2.4. When the boiler inspector or the facility engineer recommends the test. **(T-0).**

A2.2.9.2.5. At the frequency required in paragraph A2.2. **(T-0).**

Attachment 3

IMPLEMENTATION OF MAJOR AND AREA SOURCE RULES: AS APPLIED TO BOILER TUNE-UPS FOR THE BOILER NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAP) RULES

A3.1. Purpose. This attachment provides guidance to AFIMSC Detachments, Base Civil Engineer, Air Force boiler owners, operators, and Air Force Environmental Management offices for meeting the regulatory requirements for boiler tune-ups of (40 CFR Part 63 Subpart JJJJJJ and Subpart DDDDD.

A3.1.1. It is the responsibility of the Base Civil Engineer and the owners or operators of Air Force boilers to become familiar with the provisions of 40 CFR Part 63 as it pertains to their boiler systems.

A3.1.2. For further reference and details on tune-ups, the AFCEC/CZTQ Air Quality Subject Matter Expert provides a boiler NESHAP guide for Area Sources and a boiler (and process heater) guide for Major Sources as comprehensive guidance for compliance with 40 CFR 63 Subpart JJJJJJ and Subpart DDDDD.

A3.2. Point of Contact. Recommendations for improvements to this guidance are encouraged. Refer recommended changes and questions regarding this AFMAN to the Air Force Air Quality Subject Matter Expert at AFCEC/CZTQ, 2261 Hughes Avenue Suite 155, JBSA-Lackland AFB, Texas, 78236-9853, DSN 945-3237, Commercial (210) 925-3237, e-mail: **afcec.cztq.workflow@us.af.mil**, using AF Form 847; route AF Forms 847 from the field through the appropriate functional chain of command.

A3.3. Background. The EPA published NESHAP for boilers for both Area and Major Sources on March 21, 2011 and amendments to the Major Source Rule on February 1, 2013 and September 14, 2016.

A3.4. Exemptions.

A3.4.1. Both the Area Source and the Major Source Rules list specific types of units which are exempt from all requirements of the rule. Exemptions from the Area Source Rule are identified in 40 CFR § 63.11195 and exemptions from the Major Source Rule are identified in 40 CFR § 63.7491. Key exemptions include the following:

A3.4.1.1. Any boiler specifically listed as, or included in the definition of, an affected source in another standard(s) under 40 CFR Part 63.

A3.4.1.2. A unit that burns hazardous waste covered by 40 CFR Part 63, Subpart EEE, *National Emission Standards for Hazardous Air Pollutants from Hazardous Waste Combustors.*

A3.4.1.3. An electric utility steam generating unit covered by 40 CFR Part 63, Subpart UUUUU.

A3.4.1.4. Any boiler specifically listed as an affected source in any standard(s) established under Section 129 of the Clean Air Act (CAA) (Solid Waste Combustion).

A3.4.1.5. A boiler that is used specifically for research and development. This exemption does not include boilers that solely or primarily provide steam (or heat) to a process or for heating at a research and development facility.

A3.4.1.6. Any boiler that is used as a control device to comply with another subpart under 40 CFR Parts 60, 61, 63, or 65, provided that at least 50 percent of the average annual heat input is provided by regulated gas streams that are subject to another standard.

A3.4.1.7. Temporary boilers: See **Attachment 1** for definition.

A3.4.1.8. Hot water heaters: See **Attachment 1** for definition.

A3.4.1.9. Residential boilers: See **Attachment 1** for definition.

A3.4.2. The following additional units are also exempt specifically under the Major Source Rule:

A3.4.2.1. A recovery boiler or furnace covered by 40 CFR Part 63, Subpart MM, *National Emission Standards for Hazardous Air Pollutants for Chemical Recovery Combustion Sources at Kraft, Soda, Sulfite, and Stand-Alone Semi-chemical Pulp Mills.*

A3.4.2.2. A refining kettle covered by 40 CFR Part 63, Subpart X, *National Emission Standards for Hazardous Air Pollutants From Secondary Lead Smelting.*

A3.4.2.3. An ethylene cracking furnace covered by 40 CFR Part 63, Subpart YY, *National Emission Standards for Hazardous Air Pollutants for Source Categories: Generic Maximum Achievable Control Technology Standards*.

A3.4.2.4. Blast furnace stoves as described in EPA-453/R-01-005, *National Emission Standards for Hazardous Air Pollutants (NESHAP) for Integrated Iron and Steel Plants,* (the blast furnace converts iron oxide into molten iron for subsequent refining to produce steel).

A3.4.2.5. Blast furnace gas fuel-fired boilers and process heaters: See Attachment 1for definition.

A3.4.3. The following additional units are exempt specifically under the Area Source Rule only:

A3.4.3.1. Electric boilers: See **Attachment 1** for definition.

A3.4.3.2. Gas-fired boilers: See **Attachment 1** for definition.

A3.5. Requirements. 40 CFR Part 63 stipulates operational requirements for boiler (and process heater for a Major Source) tune-ups for Area Source and Major Source boilers. A boiler tune-up optimizes the air-fuel mixture for the operating range of the boiler which improves combustion and reduces emissions of HAPs. The first step is to determine the source type for the facility in regards to HAP emissions: Area Source or Major Source. Check with the base Environmental Management office to confirm the facility's source type. **Note:** The facility's source type designation (Area Source or Major Source) can be different for different pollutants; therefore, be sure to obtain the source type designation that specifically pertains to HAP emissions.

A3.5.1. **Area and Major Source Definitions Applicable to the Boiler NESHAP Rules.**

A3.5.1.1. Area Source: See **Attachment 1** for definition.

A3.5.1.2. Major Source: See **Attachment 1** for definition.

A3.5.2. **Tune-ups.** Boiler (and process heater for a Major Source) tune-ups are required for Area Source and Major Source boilers according to 40 CFR Part 63, Subparts JJJJJJ and DDDDD. All tune-ups shall be conducted following the procedures described in 40 CFR Part 63, Subpart JJJJJJ, Section 63.11223 for an Area Source and 40 CFR Part 63, Subpart DDDDD, Section 63.7540 for a Major Source. **(T-0).**

A3.5.2.1. **Tune-up Applicability and Frequency** . Perform tune-ups on boilers (and process heaters for a Major Source) at the frequency provided in **Table A3.1**. **(T-0). Note:** Gas-fired boilers are exempt from tune-up and all other requirements under the Area Source Rule, including dual-fuel boilers that burn liquid fuel only during periods of gas curtailment, gas supply interruption, startups, or periodic testing on liquid fuel. Periodic testing of liquid fuel shall not exceed a combined total of 48 hours during any calendar year. Reference Attachment 1 for a definition of "period of gas curtailment or supply interruption."

A3.5.2.2. **Tune-up Compliance Deadlines.** Tune-ups on boilers (and process heaters for a Major Source) shall be performed per the schedule and due dates as stated in 40 CFR Part 63, Subpart JJJJJ or Subpart DDDD, as applicable. **(T-0).** Reference **Table A3.2** for a summary of initial tune-up due dates and the schedule for subsequent tune-ups.

A3.5.2.2.1. **Initial Tune-Up Due Date** . Existing boilers (and process heater for a Major Source) (see definitions, Attachment 1, "Existing Boiler/Process Heater") shall have an initial tune-up on or before the compliance dates as stated in 40 CFR 63, Subpart JJJJJJ or Subpart DDDDD. New and reconstructed boilers (and process heater for a Major Source) (see definitions, Attachment 1, "New Boiler/Process Heater" and "Reconstructed Boiler/Process Heater") are not required to have an initial tune-up, but they shall comply with their first tune-up no later than 13 months (if subject to annual tune-ups), 25 months (if subject to biennial tune-ups), or 61 months (if subject to 5-year tune-ups) after start-up, whichever is applicable. (**T-0).**

A3.5.2.2.2. **Subsequent Tune-Up Schedule** . Tune-ups shall be conducted according to the schedule stated in 40 CFR 63, Subpart JJJJJJ and Subpart DDDDD. (**T-0).** The tune-up schedule is summarized in **Table A3.2**.

A3.5.2.2.3. **Early Tune-up** . A tune-up may be conducted early as long as the tune-up included all elements of the tune-up specified in 40 CFR Part 63, Subpart JJJJJJ or Subpart DDDDD. If the initial tune-up for an existing boiler was completed prior to the compliance date, the next tune-up shall be due no later than 13 months, 25 months, or 72 months from when the initial tune-up was conducted, as applicable. **(T-0).**

A3.5.2.2.4. **Boiler/Process Heater Not In Operation on Compliance Date.** If the boiler (or process heater for a Major Source) is not operating on the required date for a tune-up (because it is a seasonal boiler, or because it is down for maintenance, for example), the tune-up shall be conducted within 30 days of startup. (**T-0).**

A3.5.2.2.5. **Burner Inspection.** Burner inspections may be performed before the tune-up or delayed until the next scheduled shutdown (scheduled or unscheduled shutdown for Major Source boilers or process heaters subject to a 5-year tune-up). However, the inspection delay shall not exceed 36 months from the previous inspection

for boilers/process heaters subject to biennial tune-ups and 72 months from the previous inspection for boilers/process heaters subject to 5-year tune-ups. **(T-0).**

A3.5.2.2.6. **Boilers or Process Heaters Located at a Major Source Where Entry Into a Piece of Process Equipment or Into a Storage Vessel Is Required.** Tune-up inspections are required only during planned entries into the storage vessel or process equipment. Remaining tune-up requirements shall be met according to the applicable tune-up schedule for the unit. **(T-0).**

A3.5.2.3. **Tune-up Notification and Reporting Deadlines.** Notification and reporting of tune-up applicability and completion shall be conducted per the requirements in 40 CFR Part 63 Subpart JJJJJJ (Area Source) or Subpart DDDDD (Major Source) as applicable. (**T-0).** Tune-up notification and reporting due dates and deadlines are summarized in **Table A3.3** For boilers (and process heaters for a Major Source) subject to an initial tune-up, a signed statement indicating an initial tune-up was conducted shall be included in the Notification of Compliance Status (NOC). For Area Sources, first tune-ups for new boilers and subsequent tune-ups for all boilers are reported and certified as completed in the Compliance Certification Report which is prepared by March 1st on an annual, biennial, or 5-year basis, as applicable. For Major Sources, first tune-ups for new boilers and subsequent tune-ups for all boilers are reported and certified as completed in the semi-annual Compliance Report (postmarked or submitted no later than July 31 or January 31, as applicable) or the annual, biennial, or 5-year Compliance Report (postmarked or submitted no later than January 31, as applicable). If it is determined that a tune-up compliance deadline passed, immediately contact the AFCEC/CZTQ Air Quality Subject Matter Expert for a consult on developing a compliance strategy.

A3.5.2.4. **Overview of Tune-up Requirements.** Tune-up requirements are summarized in **Table A3.4** for Area Source and Major Source tune-ups. The tune-up shall be conducted while burning the type of fuel (or fuels in case of units that routinely burn a mixture) that provided the majority of the heat input to the boiler or process heater over the 12 months prior to the tune-up. See referenced sections of 40 CFR Part 63 Subpart JJJJJJ or Subpart DDDDD for complete requirements and details. **(T-0).**

Table A3.1. Tune-up Applicability and Frequency.

	APPLICABILITY	
	AREA SOURCE (Boilers Only)	**MAJOR SOURCE (Boilers and Process Heaters)**
Annual (Every Year)	None	Existing or New ≥ 10 MMBtu/hr, Coal/Oil/Biomass/Gaseous Fuel
Biennial (Every 2 Years)	Existing ≥ 10 MMBtu/hr, Oil/Biomass Existing or New >5 and <10 MMBtu/hr Oil Existing or New < 10 MMBtu/hr, Coal/Biomass	Existing or New < 10 MMBtu/hr, Coal/Oil (Heavy Liquid)/Biomass Existing or New >5 and <10 MMBtu/hr Gaseous Fuel, Oil (Light Liquid)
5-year (Every 5 Years)	Existing or New ≤ 5 MMBtu/hr Oil Existing or New Seasonal Existing or New Limited-Use	Existing or New ≤ 5 MMBtu/hr, Gaseous Fuel, Oil (Light Liquid) Existing or New Limited Use
	Boilers (and process heaters for a Major Source) with an oxygen trim system that maintains an optimum air-to-fuel ratio	

Table A3.2. Tune-up Compliance Deadlines.

	TUNE-UP COMPLIANCE DEADLINES	
	AREA SOURCE (Boilers Only)	**MAJOR SOURCE (Boilers and Process Heaters)**
INITIAL TUNE-UP DEADLINES		
Rule Reference	*§63.11196(a)(1), (b) or (c)*	*§63.7495(a) or (b)*
Existing Boilers/Process Heaters	Was required by 21 March 2014	Was required by 31 January 2016
	If the initial tune-up has not yet been performed (i.e., the above compliance date was missed), immediately contact the AFCEC/CZTQ Air Quality Subject Expert for a consult on developing a compliance strategy.	
New Boilers/Process Heaters	Initial tune-up by Air Force not required. New boilers/process heaters are assumed to be initially tuned up by installer/manufacturer.	
	However, the first tune-up shall be conducted no later than 13 months (if subject to annual tune-ups), 25 months (if subject to biennial tune-ups), or 61 months (if subject to 5-year tune-ups) after start-up.	
SUBSEQUENT TUNE-UP SCHEDULE		
Rule Reference	*§63.11223(b)*	Annual*: §63.7540(a)(10),* Biennial*: §63.7540(a)(11)* 5-year: *§63.7540(a)(12)* All: *§63.7515 (d)*
General	Conduct biennial tune-ups no more than 25 months after previous tune-up.	Conduct annual tune-ups no more than 13 months after previous tune-up.
		Conduct biennial tune-ups no more than 25 months after previous tune-up.
	Conduct 5-year tune-ups no more than 61 months after previous tune-up.	Conduct 5-year tune-ups no more than 61 months after previous tune-up.

Table A3.3. Tune-up Notification and Reporting Deadlines.

	TUNE-UP NOTIFICATION & REPORTING DEADLINES	
	AREA SOURCE (Boilers Only)	**MAJOR SOURCE (Boilers and Process Heaters)**
INITIAL NOTIFICATION (OF APPLICABILITY)		
Rule Reference	*§63.11225(a)(2)*	*§63.7545(b) and (c)*
Existing Boilers/ Process Heaters	Was required by 20 January 2014 or within 120 days after the boiler becomes subject to the standard.	Was required by 31 May 2014 if startup was before 31 January 2013.
New Boilers/ Process Heaters		If startup is on or after 31 January 2013, then within 15 days after startup.
INITIAL TUNE-UP NOTICE OF COMPLIANCE (NOC) STATUS*		
Rule Reference	*§63.11225(a)(4)*	*§63.7545(e)*
Existing Boilers/ Process Heaters	Was required by 19 July 2014 (or within 60 days of stack test, if required).	To be submitted within 60 days following the completion of all compliance demonstrations, including performance test results and fuel analyses, for all boiler or process heaters at the facility.
New Boilers/ Process Heaters	NOC not required for tune-ups.	
SUBSEQUENT TUNE-UP REPORTING & DUE DATE*		
Rule Reference	§63.11225(b)	§63.7545(e)
Existing Boilers/ Process Heaters	Tune-up reporting to be included in the Certificate of Compliance which shall be prepared by March 1st, on an annual, biennial, or 5-year basis, as applicable.	Tune-up reporting to be included in the Compliance Report which shall be prepared on a semi-annual, annual, biennial, or 5-year basis, as applicable.
New Boilers/ Process Heaters		
*If a notice or report was not submitted by the due date, immediately contact the AFCEC/CZTQ Air Quality Subject Expert for a consult on developing a compliance strategy.		

Table A3.4. Tune-up Requirements.

	TUNE-UP REQUIREMENTS	
	AREA SOURCE (Boilers Only)	**MAJOR SOURCE (Boilers and Process Heaters)**
Rule Reference	*§63.11223*	*§63.7540*
Tune-up Requirements	1. The tune-up shall be conducted while burning the type of fuel (or fuels in case of units that routinely burn a mixture) that provided the majority of the heat input to the boiler (or process heater for a Major Source) over the 12 months prior to the tune-up. 2. As applicable, inspect the burner and clean or replace any components of the burner as necessary (you may delay the burner inspection until the next scheduled unit shutdown, but you shall inspect each burner at least once every 36 months). 3. Inspect the flame pattern, as applicable, and adjust the burner as necessary to optimize the flame pattern. The adjustment should be consistent with the manufacturer's specifications, if available. 4. Inspect the system controlling the air-to-fuel ratio, as applicable, and ensure that it is correctly calibrated and functioning properly. 5. Optimize total emissions of carbon monoxide. This optimization should be consistent with the manufacturer's specifications, if available, and with any nitrogen oxide requirement to which the unit is subject. 6. Measure the concentrations in the effluent stream of carbon monoxide in parts per million, by volume, and oxygen in volume percent, before and after the adjustments are made. Measurements may be either on a dry or wet basis, as long as it is the same basis before and after the adjustments are made. Measurements may be taken using a portable CO analyzer.	
	7. Maintain records onsite and submit, if requested by the EPA administrator, a biennial report containing the information below: (i) The concentrations of carbon monoxide (CO) in the effluent stream in parts per million, by volume, and oxygen in volume percent, measured before and after the tune-up of the boiler. (ii) A description of any corrective actions taken as a part of the tune-up of the boiler. (iii) The type and amount of fuel used over the 12 months prior to the tune-up of the boiler.	7. Maintain records on-site and submit, if requested by the EPA administrator, an annual report containing the information below: (i) The concentrations of carbon monoxide (CO) in the effluent stream in parts per million by volume, and oxygen in volume percent, measured before and after the adjustments of the boiler. (ii) A description of any corrective actions taken as a part of the combustion adjustment. (iii) The type and amount of fuel used over the 12 months prior to the annual adjustment, but only if the unit was physically and legally capable of using more than one type of fuel during that period. Units sharing a fuel meter may estimate the fuel use by each unit.
	8. If the unit is not operating on the required date for a tune-up, the tune-up shall be conducted within 30 days of startup.	

A3.5.3. **Notification, Reporting, and Recordkeeping Requirements.** 40 CFR Part 63, Subpart JJJJJJ and Subpart DDDDD includes notification, reporting, and recordkeeping requirements for both Area Source and Major Source boilers. Notifications and reports also involve other requirements which require coordination and consultation with the Base Civil Engineer Environmental function's Air Quality Program Manager.

A3.5.3.1. **Area Source.** Area Source notification, reporting, and recordkeeping requirements are listed in 40 CFR Part 63, Subpart JJJJJJ, Section 63.11225. The notification and reporting due dates are summarized in **Table A3.3**. Notification, reporting, and recordkeeping requirements related to tune-ups are summarized below.

A3.5.3.1.1. Submit an "Initial Notification of Applicability" form (required under 40 CFR § 63.9(b) and 40 CFR § 63.11225(a)(2)) to the appropriate State agency if it has been delegated the authority for this regulation under section 112(l) of the CAA. If the state has not been delegated the authority for this rule, submit the notification to the appropriate EPA regional office. EPA regional office addresses are provided in 40 CFR § 63.13. The notice shall be signed by a responsible official (**paragraph 2.5**, "Installation Commander"). **(T-0).** Download a sample "Initial Notification of Applicability" form at: https://www3.epa.gov/ttn/atw/area/paints_example.pdf.

A3.5.3.1.2. Submit the following compliance reports to the EPA for boilers subject to a tune-up: **(T-0).**

A3.5.3.1.2.1. A NOC Status report is required under 40 CFR 63.9(h) and §63.11225(a)(4) for all existing boilers. **(T-0).** The report shall be signed by a responsible official (paragraph 2.5, "Installation Commander") and state "This facility complies with the requirements in §63.11214 to conduct an initial tune-up of the boiler." **(T-0).** In addition, for existing boilers with a heat input capacity of 10 MMBtu/hr or greater, the NOC Status report shall state, "This facility has had an energy assessment performed according to §63.11214(c)." **(T-0).** The NOC Status report shall be submitted electronically using the Compliance and Emissions Data Reporting Interface (CEDRI) that is accessed through EPA's Central Data Exchange (**www.epa.gov/cdx**). **(T-0). Note:** The electronic version of the NOC Status report for Area Sources became available in CEDRI on 1 January 2014. Prior to that date, the EPA allowed submission of a written NOC Status report for Area Sources and there is no requirement to resubmit the report electronically. **(T-0).**

A3.5.3.1.2.2. A Compliance Certification Report shall be prepared (Report shall be prepared and submitted to the EPA or delegated authority upon request, following the submission process provided by the EPA or submission authority at the time of the request) by March 1st of the year following the calendar year during which a biennial or 5-year tune-up is completed for boilers not subject to emission or operating limits. **(T-0).** To comply with 40 CFR § 63.11225(b), the Compliance Certification Report shall be signed by a responsible official (paragraph 2.5, "Installation Commander") and include a statement, "This facility complies with the requirements in §63.11223 to conduct a biennial or 5-year tune-up, as applicable, of each boiler." **(T-0).**

A3.5.3.1.3. Recordkeeping requirements associated with Area Source boilers are specified in 40 CFR 63.11225(c). Requirements related to tune-ups include the following:

A3.5.3.1.3.1. A copy shall be kept of each notification and report that was submitted to comply with Subpart JJJJJJ and all documentation supporting any Initial Notification or NOC Status that was submitted. Notification using the NOC status report shall be accomplished as described in paragraph A3.5.3.1.2. **(T-0).**

A3.5.3.1.3.2. Records shall be kept to document conformance with the work practices and management practices required by 40 CFR 63.11214 and 63.11223, including boiler tune-up requirements. **(T-0).**

A3.5.3.1.3.3. For boilers requiring tune-ups, records shall identify each boiler (include National Board Number and also operating permit number, if applicable), the date of tune-up, the procedures followed for tune-up, and the manufacturer's specifications to which the boiler was tuned. **(T-0).**

A3.5.3.1.3.4. For each boiler required to conduct an energy assessment, a copy shall be kept of the energy assessment report. **(T-0).** A copy of the report is not required to be submitted to the EPA. **(T-0).**

A3.5.3.1.3.5. All records shall be in a form suitable and readily available for expeditious review. Each record shall be kept for five (5) years following the date of each recorded action. **(T-0).** Each record shall be kept on-site or be accessible from a central location by computer or other means that instantly provides access at the site for at least two (2) years after the date of each recorded action. If desired, records may be kept off-site for the remaining three (3) years, in accordance with AFMAN 33-363. **(T-0).**

A3.5.3.1.4. All records/documents associated with Subpart JJJJJJ compliance shall also be uploaded into the Air Program Information Management System (APIMS) to comply with AFMAN 32-7002, which requires all air quality compliance and resource management data to be accurately maintained in APIMS by the installation environmental function. **(T-1).**

A3.5.3.2. **Major Source.** Major Source notification, reporting, and recordkeeping requirements are listed in 40 CFR Part 63, Subpart DDDDD, sections 63.7545 through 63.7560. The notification and reporting due dates are summarized in **Table A3.3**, and **Table A3.5** Requirements related to tune-ups a are summarized below.

A3.5.3.2.1. Submit an Initial Notification of Applicability form (required under 40 CFR §§ 63.9(b), 63.7545(b), and 63.7545(c)) to the appropriate State agency if it has been delegated the authority for this regulation under section 112(l) of the CAA. If the state has not been delegated the authority for this rule, submit the notification to the appropriate EPA Regional Office. EPA regional office addresses are provided in 40 CFR §§ 63.13. The notification shall be signed by a responsible official (paragraph 2.5, "Installation Commander"). **(T-0).**

A3.5.3.2.2. Submit the following compliance reports to the EPA for boilers and process heaters subject to tune-up requirements. **(T-0).**

A3.5.3.2.2.1. A NOC status report is required under 40 CFR 63.9(h) and 63.7545(e) for existing boilers with a submission to the EPA no later than before close of business on the 60th day following the completion of all performance tests and/or other initial compliance demonstrations required under 40 CFR § 63.7530. The report shall be signed by a responsible official (paragraph 2.5, "Installation Commander") and state, "This facility completed the required initial tune-up for all of the boilers and process heaters covered by 40 CFR Part 63 subpart DDDDD at this site according to the procedures in section 63.7540(a)(10)(i) through (vi) and has had an energy assessment performed according to §63.7530(e)." **(T-0).**

A3.5.3.2.2.2. A Compliance Report shall be prepared for boilers and process heaters that conducted an annual, biennial, or five-year tune-up the previous

calendar year and are not subject to emission or operating limits. **(T-0).** Boilers and process heaters subject to emission or operating limits are required to report semi-annually. **(T-0).** To comply with 40 CFR 63.11225(b), the Compliance Report shall be signed by a responsible official (paragraph 2.5, "Installation Commander") and include a statement, "This facility complies with the requirements in §63.11223 to conduct a biennial or 5-year tune-up, as applicable, of each boiler." **(T-0).**

Table A3.5. Summary of Due Dates for Compliance Reports.

Required Report Frequency	Report Due Date	Covering
Semi-annual	31 July of each year	1 January through 30 June of each year
	31 January of each year	1 July through 31 December of each year
Annual	31 January of each year	1 January to 31 December of each year
Biennial	31 January of every other year	The 2-year period from 1 January to 31 December
5-Year	31 January of every fifth year	The 5-year period from 1 January to 31 December

A3.5.3.2.3. Recordkeeping requirements associated with Major Source boilers are specified in 40 CFR § 63.7555 and 63.7560. Requirements related to tune-ups include the following:

A3.5.3.2.3.1. A copy shall be kept of each notification and report that was submitted to comply with Subpart DDDDD and all documentation supporting any Initial Notification or Notification of Compliance Status or Compliance Report that was submitted. **(T-0).**

A3.5.3.2.3.2. All records shall be in a form suitable and readily available for expeditious review. Each record shall be kept for five (5) years following the date of each report or record. Each record shall be kept on-site or be accessible from on-site (for example, through a computer network) for at least two (2) years after the date of each report or record. If desired, records may be kept off site for the remaining three years in accordance with AFMAN 33-363 . **(T-0).**

A3.5.3.2.4. All records/documents associated with Subpart DDDDD compliance shall also be uploaded into APIMS to comply with AFI 32-7002, which requires all air quality compliance and resource management data to be accurately maintained in APIMS by the installation Environmental function. **(T-1).**

Attachment 4

TUNING BOILERS FOR MAXIMUM EFFICIENCY

A4.1. General. The following combustion efficiency tables can be used to tune natural gas and oil-fired, condensing and non-condensing, steam and hot water boilers. **Note:** Area and Major Source boiler tune-up procedures are described in 40 CFR § 63.11223(b) and 40 CFR § 63.7540(a)(10), respectively.

A4.1.1. The tables are divided by fuel type,. These parameters vary between typical limits and should reasonably reflect actual field conditions at various times of the year. All tables are calibrated for standard sea level pressure (14.696 psia).

A4.1.2. These tables are for reference use only, as it is difficult to capture all variables affecting a boiler's operating combustion efficiency (e.g., fuel impurities, burner condition, firing rate). However, the tables do provide accurate trend information.

A4.2. Combustion Efficiency Parameters . . Extrapolating table data outside these ranges is not advised; using the tables at pressure altitudes exceeding 1500 feet above sea level is also not recommended.

A4.3. Measuring Combustion Efficiency Using Tables .

A4.3.1. First, determine the fuel that you are using.

A4.3.2. Next, using a calibrated portable combustion analyzer, measure and record the temperature and O_2 concentrations in the flue duct. Use the sampling procedures described in ASME Code PTC 19.10-1981, Section 3. Use a minimum of eight sampling points to ensure the velocity is uniform in each area of the duct.

A4.3.3. Finally, calculate and record the temperature difference between the flue gas and the ambient temperature (ΔT). Using the information previously gathered, find the appropriate combustion efficiency values from the table(s). Interpolation between values is permissible.

A4.4. Adjusting Combustion Air Trim. The combustion air should always be set within the range specified by the manufacturer. If the range is specified in terms of excess O_2, then use the flue gas readings from the combustion analyzer. If the range is specified in terms of excess air, then use the tables to cross-reference the excess air value based on the excess O_2 reading.

A4.4.1. **Outside Air Temperature.** Air temperature is inversely proportional to air density. As the outside air temperature decreases, the air density increases. For boiler systems using fixed combustion air intakes (such as venturi air intakes), increased air density causes the excess air rate to increase (decreasing combustion efficiency). A temperature swing of ±50 °F can cause a fluctuation of up to 35% in excess air. To mitigate this effect, the combustion air should be adjusted to the minimum excess air limit at the corresponding highest operational outside air temperatures. For example, consider a boiler with a fixed venturi air intake and a manufacturer's recommended excess air range of 20–60%. Assuming the boiler is expected to be firing at outside air temperatures from 0–50 °F, the venturi air intake should be set for minimum excess air (20%) while the outside air temperature is at or near a maximum (50 °F). This procedure assures that the boiler shall still fire inside the appropriate range when the outside air temperature is 0 °F. Boilers using automatic combustion air control regulators (i.e., excess O_2 flue gas sensors) are not affected by outside air temperature.

A4.4.2. **Flue Stack Temperature.** Flue gas (or stack) temperatures are driven by the temperature of the boiler supply water (or steam) and the efficiency of the heat transfer across the boiler's internal heat exchanger (i.e., tube bundle). Flue stack temperatures are always greater than the water/steam supply temperature due to heat losses. To increase boiler efficiency, the supply temperature should be set to the lowest temperature that shall satisfy the load. Flue stack temperatures that rise over time (while the supply set point remains constant) may indicate fouling of the internal heat exchanger or tube bundle. In this case, consider scheduling the boiler for shutdown and heat exchanger cleaning.

A4.5. List of Tables.

Table A4.1. Natural Gas. Ultimate Analysis: Carbon – 68.75%; Hydrogen – 22.3%; Sulfur – 0.06%; O_2 – 0.37%; N_2 – 3.3%; CO_2 – 5.2%; H_2O – 0.02%; H2S – 0.00076% [HHV = 1030 BTU/ft^3]; [$T_{(ambient)}$ = 20°F]; [$P_{(ambient)}$ = 14.696 psia]

Flue Gas Dew Pt (°F)	% Excess Air	% O_2 (dry)	% CO_2 (dry)	ΔT = 70°F		ΔT = 80°F		ΔT = 90°F		ΔT = 100°F		ΔT = 110°F		ΔT = 120°F	
				η (%) Non-Cond.	η (%) Condensing	η (%) Non-Cond.	η (%) Condensing	η (%) Non-Cond.	η (%) Condensing	η (%) Non-Cond.	η (%) Condensing	η (%) Non-Cond.	η (%) Condensing	η (%) Non-Cond.	η (%) Condensing
138.02	0.00	0.00	12.07	90.08	98.85	89.90	98.60	89.71	98.36	89.53	98.12	89.35	97.89	89.16	89.16
137.26	2.20	0.50	11.78	90.06	98.83	89.87	98.58	89.68	98.33	89.50	98.09	89.31	97.85	89.12	89.12
136.49	4.50	1.00	11.50	90.03	98.80	89.84	98.55	89.65	98.30	89.46	98.05	89.27	97.81	89.08	89.08
135.69	6.93	1.50	11.21	90.01	98.77	89.81	98.52	89.62	98.27	89.42	98.02	89.23	97.77	89.03	89.03
134.87	9.48	2.00	10.92	89.98	98.75	89.78	98.49	89.58	98.23	89.38	97.98	89.18	97.73	88.98	88.98
134.03	12.18	2.50	10.63	89.95	98.72	89.75	98.45	89.54	98.19	89.34	97.94	89.14	97.68	88.93	88.93
133.16	15.02	3.00	10.35	89.92	98.69	89.71	98.42	89.50	98.15	89.30	97.89	89.09	97.63	88.88	88.88
132.27	18.02	3.50	10.06	89.88	98.65	89.67	98.38	89.46	98.11	89.25	97.85	89.04	97.58	88.82	88.82
131.35	21.20	4.00	9.77	89.85	98.62	89.63	98.34	89.42	98.07	89.20	97.80	88.98	97.53	88.76	88.76
130.4	24.57	4.50	9.48	89.81	98.58	89.59	98.30	89.37	98.02	89.15	97.74	88.92	97.47	88.70	88.70
129.43	28.16	5.00	9.20	89.77	98.54	89.55	98.26	89.32	97.97	89.09	97.69	88.86	88.86	88.63	88.63
128.42	31.97	5.50	8.91	89.73	98.50	89.50	98.21	89.26	97.92	89.03	97.63	88.80	88.80	88.56	88.56
127.37	36.04	6.00	8.62	89.69	98.46	89.45	98.16	89.21	97.86	88.97	97.57	88.73	88.73	88.49	88.49
126.3	40.39	6.50	8.33	89.64	98.41	89.39	98.11	89.15	97.80	88.90	97.50	88.65	88.65	88.40	88.40
125.18	45.05	7.00	8.05	89.59	98.36	89.33	98.05	89.08	97.74	88.83	97.43	88.57	88.57	88.32	88.32
124.02	50.05	7.50	7.76	89.53	98.31	89.27	97.99	89.01	97.67	88.75	97.35	88.49	88.49	88.22	88.22
122.82	55.45	8.00	7.47	89.47	98.25	89.20	97.92	88.93	97.59	88.66	97.27	88.39	88.39	88.12	88.12
121.57	61.27	8.50	7.18	89.41	98.19	89.13	97.85	88.85	97.51	88.57	97.18	88.29	88.29	88.01	88.01
120.27	67.57	9.00	6.90	89.34	98.12	89.05	97.77	88.76	97.43	88.47	97.08	88.18	88.18	87.89	87.89
118.91	74.43	9.50	6.61	89.27	98.05	88.97	97.69	88.67	97.33	88.37	88.37	88.07	88.07	87.76	87.76
117.5	81.91	10.00	6.32	89.19	97.97	88.87	97.60	88.56	97.23	88.25	88.25	87.94	87.94	87.62	87.62
116.02	90.10	10.50	6.04	89.10	97.88	88.77	97.50	88.45	97.12	88.12	88.12	87.80	87.80	87.47	87.47
114.47	99.11	11.00	5.75	89.00	97.78	88.66	97.39	88.32	96.99	87.98	87.98	87.64	87.64	87.30	87.30
112.85	109.07	11.50	5.46	88.89	97.68	88.53	97.27	88.18	96.86	87.82	87.82	87.47	87.47	87.11	87.11
111.13	120.13	12.00	5.17	88.77	97.56	88.40	97.13	88.02	96.71	87.65	87.65	87.28	87.28	86.91	86.91
109.33	132.50	12.50	4.89	88.63	97.43	88.24	96.98	87.85	87.85	87.46	87.46	87.07	87.07	86.67	86.67
107.42	146.41	13.00	4.60	88.48	97.28	88.07	96.81	87.65	87.65	87.24	87.24	86.83	86.83	86.41	86.41
105.39	162.18	13.50	4.31	88.31	97.12	87.87	96.62	87.43	87.43	86.99	86.99	86.56	86.56	86.12	86.12
103.23	180.20	14.00	4.02	88.11	96.93	87.64	96.41	87.18	87.18	86.71	86.71	86.25	86.25	85.78	85.78
100.92	200.99	14.50	3.74	87.88	96.71	87.38	96.16	86.89	86.89	86.39	86.39	85.89	85.89	85.39	85.39
98.43	225.25	15.00	3.45	87.62	96.45	87.08	87.08	86.54	86.54	86.01	86.01	85.47	85.47	84.93	84.93

Table A4.1.1. Natural. Ultimate Analysis: Carbon – 68.75%; H_2 – 22.3%; O_2 – 0.37%; S_2 – 0.06%; N_2 – 3.3%; CO_2 – 5.2%; H_2O – 0.02% [HHV = 1030 BTU/ft^3]; [$T_{(ambient)}$ = 20°F]; [$P_{(ambient)}$ = 14.696 psia]

Flue Gas Dew Pt (°F)	% Excess Air	% O_2 (dry)	% CO_2 (dry)	ΔT = 125°F η (%) Non-Cond.	ΔT = 150°F η (%) Non-Cond.	ΔT = 175°F η (%) Non-Cond.	ΔT = 200°F η (%) Non-Cond.	ΔT = 225°F η (%) Non-Cond.	ΔT = 250°F η (%) Non-Cond.	ΔT = 300°F η (%) Non-Cond.	ΔT = 350°F η (%) Non-Cond.	ΔT = 400°F η (%) Non-Cond.	ΔT = 450°F η (%) Non-Cond.	ΔT = 500°F η (%) Non-Cond.	ΔT = 600°F η (%) Non-Cond.
138.02	0.00	0.00	12.07	89.07	88.61	88.15	87.68	87.21	86.75	85.81	84.86	83.91	82.95	81.98	80.02
137.26	2.20	0.50	11.78	89.03	88.56	88.09	87.61	87.14	86.66	85.70	84.74	83.77	82.79	81.80	79.81
136.49	4.50	1.00	11.50	88.98	88.50	88.02	87.54	87.06	86.57	85.59	84.61	83.62	82.62	81.62	79.59
135.69	6.93	1.50	11.21	88.93	88.45	87.96	87.46	86.97	86.47	85.48	84.48	83.47	82.45	81.43	79.36
134.87	9.48	2.00	10.92	88.88	88.39	87.89	87.38	86.88	86.37	85.36	84.34	83.31	82.27	81.22	79.11
134.03	12.18	2.50	10.63	88.83	88.32	87.81	87.30	86.78	86.27	85.23	84.19	83.14	82.08	81.01	78.85
133.16	15.02	3.00	10.35	88.78	88.26	87.73	87.21	86.68	86.16	85.10	84.03	82.96	81.87	80.78	78.58
132.27	18.02	3.50	10.06	88.72	88.19	87.65	87.12	86.58	86.04	84.96	83.86	82.77	81.66	80.55	78.29
131.35	21.20	4.00	9.77	88.66	88.11	87.56	87.02	86.47	85.91	84.81	83.69	82.57	81.43	80.29	77.99
130.4	24.57	4.50	9.48	88.59	88.03	87.47	86.91	86.35	85.78	84.65	83.50	82.35	81.19	80.03	77.66
129.43	28.16	5.00	9.20	88.52	87.95	87.37	86.80	86.22	85.64	84.48	83.31	82.13	80.94	79.74	77.32
128.42	31.97	5.50	8.91	88.44	87.86	87.27	86.68	86.09	85.49	84.30	83.09	81.88	80.67	79.44	76.96
127.37	36.04	6.00	8.62	88.37	87.76	87.16	86.55	85.94	85.33	84.10	82.87	81.63	80.38	79.11	76.57
126.3	40.39	6.50	8.33	88.28	87.66	87.04	86.41	85.79	85.16	83.90	82.63	81.35	80.06	78.77	76.15
125.18	45.05	7.00	8.05	88.19	87.55	86.91	86.27	85.62	84.98	83.68	82.37	81.06	79.73	78.40	75.70
124.02	50.05	7.50	7.76	88.09	87.43	86.77	86.11	85.45	84.78	83.44	82.10	80.74	79.38	78.00	75.22
122.82	55.45	8.00	7.47	87.99	87.31	86.62	85.94	85.26	84.57	83.19	81.80	80.40	78.99	77.57	74.71
121.57	61.27	8.50	7.18	87.87	87.17	86.47	85.76	85.05	84.34	82.91	81.48	80.03	78.58	77.11	74.15
120.27	67.57	9.00	6.90	87.75	87.02	86.29	85.56	84.83	84.09	82.62	81.13	79.63	78.13	76.61	73.54
118.91	74.43	9.50	6.61	87.61	86.86	86.10	85.35	84.59	83.82	82.29	80.75	79.20	77.64	76.06	72.89
117.5	81.91	10.00	6.32	87.47	86.68	85.90	85.11	84.32	83.53	81.94	80.34	78.73	77.10	75.47	72.17
116.02	90.10	10.50	6.04	87.31	86.49	85.67	84.85	84.03	83.21	81.55	79.89	78.21	76.52	74.82	71.38
114.47	99.11	11.00	5.75	87.13	86.28	85.43	84.57	83.71	82.85	81.13	79.39	77.64	75.88	74.10	70.52
112.85	109.07	11.50	5.46	86.94	86.05	85.15	84.26	83.36	82.46	80.66	78.84	77.01	75.17	73.31	69.57
111.13	120.13	12.00	5.17	86.72	85.79	84.85	83.91	82.97	82.03	80.13	78.23	76.31	74.38	72.43	68.51
109.33	132.50	12.50	4.89	86.48	85.50	84.51	83.52	82.54	81.54	79.55	77.54	75.53	73.50	71.45	67.32
107.42	146.41	13.00	4.60	86.21	85.17	84.13	83.09	82.04	81.00	78.89	76.78	74.65	72.50	70.35	65.99
105.39	162.18	13.50	4.31	85.90	84.80	83.70	82.59	81.49	80.38	78.15	75.91	73.65	71.38	69.09	64.48
103.23	180.20	14.00	4.02	85.54	84.38	83.20	82.03	80.85	79.67	77.30	74.91	72.51	70.09	67.66	62.75
100.92	200.99	14.50	3.74	85.14	83.89	82.63	81.38	80.12	78.85	76.32	73.76	71.20	68.61	66.01	60.76
98.43	225.25	15.00	3.45	84.66	83.32	81.97	80.62	79.26	77.90	75.17	72.42	69.66	66.88	64.08	58.43

Table A4.2. #2 Fuel Oil. Ultimate Analysis: Carbon – 87.2%; Hydrogen – 12.54%; Oxygen – 0.04%; Sulfur – 0.22% [HHV = 147,400 BTU/gal=18,400 BTU/lb]; [$T_{(ambient)}$ = 20°F]; [$P_{(ambient)}$ = 14.696 psia]

Flue Gas Dew Pt (°F)	% Excess Air	% O_2 (dry)	% CO_2 (dry)	ΔT = 70°F		ΔT = 80°F		ΔT = 90°F		ΔT = 100°F		ΔT = 110°F		ΔT = 120°F	
				η (%) Non-Cond.	η (%) Condensing	η (%) Non-Cond.	η (%) Condensing	η (%) Non-Cond.	η (%) Condensing	η (%) Non-Cond.	η (%) Condensing	η (%) Non-Cond.	η (%) Condensing	η (%) Non-Cond.	η (%) Condensing
121.129	0.000	0.000	13.790	91.969	98.371	91.759	98.127	91.548	97.883	91.337	97.638	91.126	91.126	90.915	90.915
120.260	2.593	0.500	13.462	91.935	98.338	91.720	98.089	91.505	97.840	91.289	97.590	91.073	91.073	90.857	90.857
119.372	5.316	1.000	13.133	91.899	98.303	91.679	98.049	91.459	97.795	91.238	91.238	91.017	91.017	90.796	90.796
118.464	8.179	1.500	12.805	91.862	98.266	91.636	98.007	91.411	97.747	91.185	91.185	90.958	90.958	90.732	90.732
117.537	11.192	2.000	12.477	91.823	98.227	91.591	97.963	91.360	97.698	91.128	91.128	90.896	90.896	90.664	90.664
116.588	14.369	2.500	12.148	91.781	98.186	91.544	97.916	91.307	97.645	91.069	91.069	90.831	90.831	90.593	90.593
115.617	17.721	3.000	11.820	91.737	98.143	91.494	97.867	91.250	97.590	91.006	91.006	90.762	90.762	90.518	90.518
114.623	21.266	3.500	11.492	91.691	98.098	91.441	97.815	91.191	97.531	90.940	90.940	90.689	90.689	90.438	90.438
113.604	25.018	4.000	11.163	91.642	98.050	91.385	97.760	91.128	97.469	90.870	90.870	90.612	90.612	90.354	90.354
112.558	28.999	4.500	10.835	91.590	97.999	91.326	97.701	91.061	97.404	90.796	90.796	90.530	90.530	90.265	90.265
111.486	33.228	5.000	10.507	91.535	97.945	91.262	97.639	90.990	97.334	90.717	90.717	90.444	90.444	90.170	90.170
110.383	37.729	5.500	10.178	91.476	97.887	91.195	97.574	90.914	97.260	90.633	90.633	90.351	90.351	90.069	90.069
109.250	42.531	6.000	9.850	91.413	97.826	91.123	97.503	90.833	90.833	90.543	90.543	90.252	90.252	89.962	89.962
108.084	47.664	6.500	9.522	91.346	97.760	91.047	97.428	90.747	90.747	90.447	90.447	90.147	90.147	89.846	89.846
106.883	53.164	7.000	9.193	91.274	97.690	90.965	97.348	90.655	90.655	90.345	90.345	90.034	90.034	89.723	89.723
105.643	59.071	7.500	8.865	91.197	97.615	90.876	97.262	90.556	90.556	90.234	90.234	89.913	89.913	89.591	89.591
104.364	65.433	8.000	8.537	91.114	97.534	90.781	97.170	90.449	90.449	90.115	90.115	89.782	89.782	89.448	89.448
103.042	72.303	8.500	8.208	91.024	97.446	90.679	97.070	90.333	90.333	89.987	89.987	89.641	89.641	89.294	89.294
101.673	79.746	9.000	7.880	90.927	97.352	90.568	96.962	90.208	90.208	89.848	89.848	89.488	89.488	89.127	89.127
100.253	87.836	9.500	7.552	90.821	97.249	90.447	96.845	90.072	90.072	89.697	89.697	89.322	89.322	88.946	88.946
98.780	96.662	10.000	7.223	90.706	97.138	90.315	90.315	89.924	89.924	89.532	89.532	89.140	89.140	88.748	88.748
97.247	106.328	10.500	6.895	90.580	97.016	90.171	90.171	89.761	89.761	89.352	89.352	88.942	88.942	88.531	88.531
95.650	116.961	11.000	6.567	90.441	96.882	90.012	90.012	89.583	89.583	89.153	89.153	88.723	88.723	88.293	88.293
93.982	128.713	11.500	6.238	90.287	96.734	89.836	89.836	89.385	89.385	88.934	88.934	88.482	88.482	88.030	88.030
92.236	141.771	12.000	5.910	90.116	96.571	89.641	89.641	89.166	89.166	88.690	88.690	88.214	88.214	87.737	87.737
90.403	156.365	12.500	5.582	89.926	96.388	89.423	89.423	88.921	88.921	88.418	88.418	87.914	87.914	87.410	87.410
88.475	172.784	13.000	5.253	89.711	89.711	89.178	89.178	88.645	88.645	88.111	88.111	87.577	87.577	87.042	87.042
86.439	191.391	13.500	4.925	89.468	89.468	88.900	88.900	88.332	88.332	87.764	87.764	87.194	87.194	86.625	86.625
84.282	212.657	14.000	4.597	89.190	89.190	88.583	88.583	87.975	87.975	87.366	87.366	86.758	86.758	86.148	86.148
81.985	237.194	14.500	4.268	88.870	88.870	88.216	88.216	87.563	87.563	86.908	86.908	86.253	86.253	85.598	85.598
79.530	265.821	15.000	3.940	88.496	88.496	87.789	87.789	87.082	87.082	86.374	86.374	85.665	85.665	84.956	84.956

Table A4.3. #2 Fuel Oil. Ultimate Analysis: Carbon – 87.2%; Hydrogen – 12.54%; Oxygen – 0.04%; Sulfur – 0.22% [HHV = 147,400 BTU/gal=18,400 BTU/lb]; [T(ambient) = 20°F]; [P(ambient) = 14.696 psia]

Flue Gas Dew Pt (°F)	**% Excess Air**	**% O_2** (dry)	**% CO_2** (dry)	**ΔT = 125°F** **η (%)** Non-Cond.	**ΔT = 150°F** **η (%)** Non-Cond.	**ΔT = 175°F** **η (%)** Non-Cond.	**ΔT = 200°F** **η (%)** Non-Cond.	**ΔT = 225°F** **η (%)** Non-Cond.	**ΔT = 250°F** **η (%)** Non-Cond.	**ΔT = 300°F** **η (%)** Non-Cond.	**ΔT = 350°F** **η (%)** Non-Cond.	**ΔT = 400°F** **η (%)** Non-Cond.	**ΔT = 450°F** **η (%)** Non-Cond.	**ΔT = 500°F** **η (%)** Non-Cond.	**ΔT = 600°F** **η (%)** Non-Cond.
121.129	0.000	0.000	13.790	90.809	90.279	89.747	89.213	88.677	88.139	87.057	85.967	84.868	83.761	82.644	80.385
120.260	2.593	0.500	13.462	90.749	90.206	89.662	89.116	88.568	88.018	86.911	85.796	84.672	83.540	82.398	80.089
119.372	5.316	1.000	13.133	90.685	90.130	89.573	89.014	88.453	87.890	86.758	85.617	84.467	83.308	82.140	79.777
118.464	8.179	1.500	12.805	90.618	90.050	89.479	88.907	88.333	87.756	86.596	85.428	84.251	83.064	81.869	79.450
117.537	11.192	2.000	12.477	90.548	89.965	89.381	88.794	88.206	87.615	86.427	85.230	84.023	82.808	81.583	79.105
116.588	14.369	2.500	12.148	90.474	89.876	89.277	88.675	88.072	87.466	86.248	85.020	83.784	82.537	81.282	78.742
115.617	17.721	3.000	11.820	90.395	89.782	89.167	88.550	87.930	87.309	86.059	84.799	83.531	82.252	80.964	78.358
114.623	21.266	3.500	11.492	90.312	89.683	89.051	88.417	87.781	87.143	85.859	84.566	83.263	81.950	80.628	77.953
113.604	25.018	4.000	11.163	90.225	89.578	88.928	88.277	87.623	86.967	85.647	84.319	82.980	81.631	80.272	77.523
112.558	28.999	4.500	10.835	90.132	89.466	88.798	88.128	87.455	86.780	85.423	84.056	82.679	81.292	79.895	77.068
111.486	33.228	5.000	10.507	90.033	89.347	88.659	87.969	87.277	86.582	85.185	83.778	82.360	80.932	79.494	76.584
110.383	37.729	5.500	10.178	89.928	89.221	88.512	87.801	87.087	86.371	84.931	83.481	82.020	80.549	79.067	76.069
109.250	42.531	6.000	9.850	89.816	89.087	88.355	87.621	86.885	86.146	84.660	83.165	81.658	80.140	78.611	75.520
108.084	47.664	6.500	9.522	89.696	88.943	88.187	87.429	86.668	85.905	84.371	82.826	81.270	79.703	78.125	74.933
106.883	53.164	7.000	9.193	89.568	88.788	88.007	87.223	86.436	85.647	84.061	82.464	80.855	79.235	77.603	74.304
105.643	59.071	7.500	8.865	89.430	88.623	87.814	87.002	86.187	85.370	83.728	82.075	80.410	78.732	77.043	73.628
104.364	65.433	8.000	8.537	89.281	88.444	87.605	86.764	85.919	85.072	83.370	81.656	79.929	78.191	76.440	72.900
103.042	72.303	8.500	8.208	89.121	88.252	87.380	86.506	85.630	84.750	82.983	81.203	79.411	77.606	75.788	72.114
101.673	79.746	9.000	7.880	88.947	88.043	87.137	86.228	85.316	84.401	82.563	80.712	78.849	76.973	75.083	71.263
100.253	87.836	9.500	7.552	88.758	87.816	86.872	85.925	84.975	84.022	82.107	80.179	78.238	76.284	74.316	70.337
98.780	96.662	10.000	7.223	88.552	87.569	86.583	85.595	84.603	83.608	81.610	79.598	77.572	75.533	73.479	69.328
97.247	106.328	10.500	6.895	88.326	87.298	86.267	85.233	84.196	83.155	81.065	78.961	76.843	74.710	72.562	68.222
95.650	116.961	11.000	6.567	88.078	87.000	85.919	84.835	83.747	82.657	80.466	78.260	76.040	73.805	71.554	67.006
93.982	128.713	11.500	6.238	87.803	86.670	85.534	84.395	83.252	82.106	79.803	77.486	75.153	72.804	70.440	65.661
92.236	141.771	12.000	5.910	87.498	86.304	85.107	83.906	82.702	81.494	79.067	76.625	74.167	71.693	69.202	64.168
90.403	156.365	12.500	5.582	87.158	85.895	84.629	83.360	82.087	80.810	78.245	75.664	73.066	70.451	67.818	62.498
88.475	172.784	13.000	5.253	86.774	85.435	84.091	82.745	81.395	80.040	77.320	74.582	71.827	69.053	66.261	60.620
86.439	191.391	13.500	4.925	86.340	84.913	83.482	82.048	80.610	79.168	76.271	73.356	70.422	67.469	64.497	58.492
84.282	212.657	14.000	4.597	85.843	84.317	82.786	81.252	79.714	78.171	75.072	71.955	68.817	65.659	62.480	56.059
81.985	237.194	14.500	4.268	85.270	83.629	81.983	80.334	78.680	77.021	73.690	70.338	66.965	63.571	60.154	53.252
79.530	265.821	15.000	3.940	84.602	82.826	81.046	79.262	77.473	75.679	72.076	68.452	64.804	61.134	57.439	49.978

Table A4.4. #6 Fuel Oil. Ultimate Analysis: Carbon – 87.0%; Hydrogen – 10.0%; Oxygen – 1.5%; Sulfur – 1.2%; Nitrogen – 0.3% [HHV = 18,690 BTU/lb]; [$T_{(ambient)}$ = 20°F]; [$P_{(ambient)}$ = 14.696 psia]

Flue Gas Dew Pt (°F)	% Excess Air	% O_2 (dry)	% CO_2 (dry)	ΔT = 100°F η (%) Non-Cond.	ΔT = 150°F η (%) Non-Cond.	ΔT = 200°F η (%) Non-Cond.	ΔT = 250°F η (%) Non-Cond.	ΔT = 300°F η (%) Non-Cond.	ΔT = 350°F η (%) Non-Cond.	ΔT = 400°F η (%) Non-Cond.	ΔT = 500°F η (%) Non-Cond.	ΔT = 600°F η (%) Non-Cond.	ΔT = 700°F η (%) Non-Cond.	ΔT = 800°F η (%) Non-Cond.	ΔT = 900°F η (%) Non-Cond.
115.678	0.000	0.000	14.814	92.928	91.960	90.984	90.001	89.010	88.011	87.004	84.966	82.896	80.793	78.658	76.491
114.826	2.574	0.500	14.461	92.884	91.893	90.895	89.89	88.876	87.855	86.825	84.741	82.624	80.474	78.292	76.077
113.957	5.276	1.000	14.108	92.838	91.824	90.802	89.773	88.736	87.691	86.637	84.505	82.340	80.140	77.908	75.643
113.069	8.116	1.500	13.755	92.789	91.750	90.704	89.65	88.589	87.518	86.440	84.257	82.040	79.789	77.504	75.186
112.162	11.107	2.000	13.403	92.737	91.673	90.601	89.521	88.433	87.337	86.232	83.996	81.725	79.419	77.079	74.705
111.233	14.259	2.500	13.050	92.683	91.592	90.492	89.385	88.270	87.146	86.013	83.721	81.393	79.029	76.631	74.198
110.282	17.586	3.000	12.697	92.626	91.506	90.378	89.241	88.097	86.944	85.781	83.430	81.042	78.618	76.158	73.663
109.309	21.103	3.500	12.345	92.565	91.415	90.256	89.09	87.914	86.730	85.537	83.123	80.671	78.183	75.658	73.098
108.311	24.827	4.000	11.992	92.501	91.319	90.128	88.929	87.721	86.504	85.278	82.797	80.279	77.723	75.129	72.499
107.288	28.777	4.500	11.639	92.433	91.217	89.992	88.758	87.516	86.264	85.003	82.452	79.863	77.234	74.568	71.863
106.237	32.973	5.000	11.287	92.361	91.108	89.847	88.577	87.298	86.009	84.711	82.085	79.420	76.715	73.971	71.189
105.158	37.440	5.500	10.934	92.284	90.993	89.693	88.384	87.066	85.738	84.400	81.695	78.949	76.163	73.336	70.470
104.048	42.206	6.000	10.581	92.202	90.870	89.528	88.178	86.818	85.449	84.069	81.279	78.447	75.574	72.659	69.704
102.906	47.299	6.500	10.228	92.115	90.738	89.353	87.958	86.554	85.139	83.715	80.834	77.910	74.944	71.935	68.885
101.730	52.757	7.000	9.876	92.021	90.597	89.164	87.722	86.270	84.808	83.335	80.357	77.335	74.269	71.159	68.007
100.516	58.619	7.500	9.523	91.920	90.446	88.962	87.469	85.966	84.452	82.928	79.845	76.717	73.544	70.326	67.064
99.263	64.932	8.000	9.170	91.811	90.282	88.744	87.197	85.638	84.069	82.489	79.293	76.052	72.763	69.429	66.049
97.968	71.749	8.500	8.818	91.694	90.106	88.509	86.902	85.284	83.655	82.014	78.698	75.333	71.920	68.460	64.953
96.627	79.135	9.000	8.465	91.567	89.916	88.255	86.583	84.901	83.207	81.501	78.052	74.555	71.007	67.410	63.765
95.236	87.164	9.500	8.112	91.429	89.708	87.978	86.236	84.484	82.719	80.942	77.351	73.708	70.014	66.269	62.474
93.792	95.922	10.000	7.760	91.278	89.482	87.676	85.858	84.029	82.187	80.333	76.586	72.785	68.931	65.024	61.065
92.291	105.514	10.500	7.407	91.113	89.234	87.345	85.444	83.531	81.605	79.666	75.748	71.774	67.745	63.661	59.523
90.725	116.065	11.000	7.054	90.932	88.961	86.981	84.988	82.983	80.964	78.932	74.826	70.662	66.440	62.161	57.826
89.091	127.727	11.500	6.701	90.731	88.660	86.578	84.484	82.377	80.256	78.121	73.807	69.433	64.998	60.504	55.950
87.379	140.685	12.000	6.349	90.508	88.325	86.131	83.925	81.704	79.470	77.220	72.675	68.067	63.396	58.662	53.866
85.584	155.168	12.500	5.996	90.259	87.951	85.632	83.299	80.952	78.590	76.213	71.410	66.541	61.605	56.604	51.537
83.693	171.460	13.000	5.643	89.978	87.530	85.07	82.596	80.106	77.601	75.080	69.986	64.823	59.591	54.288	48.917
81.697	189.925	13.500	5.291	89.661	87.053	84.433	81.798	79.147	76.480	73.796	68.373	62.877	57.307	51.664	45.948
79.582	211.028	14.000	4.938	89.298	86.508	83.705	80.887	78.051	75.199	72.328	66.529	60.653	54.698	48.664	42.554
77.330	235.377	14.500	4.585	88.879	85.879	82.865	79.835	76.787	73.720	70.634	64.402	58.086	51.687	45.204	38.638
74.922	263.785	15.000	4.232	88.390	85.145	81.885	78.608	75.312	71.996	68.659	61.920	55.092	48.174	41.166	34.070

Table A4.5. Alaskan Coal. Ultimate Analysis: Carbon – 45.2%; Hydrogen – 2.9%; Oxygen – 16.1%; Sulfur – 0.2%; Nitrogen – 0.6%; Water – 27%; Ash – 8% [$T_{(ambient)}$ = 0°F]; [HHV = 7,800 BTU/lb]; [$P_{(ambient)}$ = 14.696 psia]

Flue Gas Dew Pt (°F)	% Excess Air	% O_2 (dry)	% CO_2 (dry)	ΔT = 200°F	ΔT = 250°F	ΔT = 300°F	ΔT = 350°F	ΔT = 400°F	ΔT = 450°F	ΔT = 500°F	ΔT = 550°F	ΔT = 600°F	ΔT = 700°F	ΔT = 800°F	ΔT = 900°F
				η (%) Non-Cond.	η (%) Non-Cond.	η (%) Non-Cond.	η (%) Non-Cond.	η (%) Non-Cond.	η (%) Non-Cond.	η (%) Non-Cond.	η (%) Non-Cond.	η (%) Non-Cond.	η (%) Non-Cond.	η (%) Non-Cond.	η (%) Non-Cond.
103.625	0.000	0.000	18.549	92.032	91.049	90.058	89.059	88.051	87.034	86.008	84.974	83.931	81.819	79.674	77.497
102.814	2.600	0.500	18.108	91.944	90.939	89.926	88.904	87.873	86.833	85.785	84.728	83.662	81.503	79.311	77.086
101.985	5.330	1.000	17.666	91.851	90.823	89.786	88.741	87.687	86.623	85.551	84.469	83.379	81.172	78.931	76.655
101.139	8.200	1.500	17.225	91.754	90.701	89.640	88.570	87.490	86.402	85.304	84.198	83.082	80.824	78.530	76.202
100.274	11.221	2.000	16.783	91.651	90.573	89.486	88.390	87.284	86.169	85.045	83.912	82.769	80.457	78.109	75.726
99.389	14.405	2.500	16.341	91.543	90.438	89.324	88.200	87.067	85.924	84.772	83.611	82.440	80.070	77.664	75.223
98.482	17.766	3.000	15.900	91.429	90.295	89.152	87.999	86.837	85.665	84.484	83.293	82.092	79.662	77.195	74.692
97.554	21.319	3.500	15.458	91.309	90.145	88.971	87.787	86.594	85.392	84.179	82.956	81.724	79.231	76.700	74.131
96.603	25.082	4.000	15.016	91.181	89.985	88.779	87.563	86.337	85.102	83.856	82.601	81.335	78.774	76.175	73.537
95.627	29.072	4.500	14.575	91.046	89.816	88.575	87.325	86.065	84.794	83.514	82.223	80.922	78.290	75.618	72.908
94.625	33.311	5.000	14.133	90.902	89.636	88.359	87.072	85.775	84.468	83.150	81.822	80.483	77.775	75.026	72.238
93.595	37.825	5.500	13.691	90.749	89.444	88.129	86.803	85.467	84.120	82.763	81.395	80.016	77.227	74.397	71.526
92.537	42.639	6.000	13.250	90.586	89.240	87.883	86.516	85.138	83.749	82.350	80.939	79.518	76.643	73.725	70.766
91.447	47.785	6.500	12.808	90.412	89.021	87.621	86.209	84.787	83.353	81.908	80.453	78.986	76.018	73.007	69.954
90.324	53.298	7.000	12.366	90.225	88.787	87.339	85.880	84.410	82.928	81.435	79.931	78.415	75.349	72.238	69.083
89.166	59.220	7.500	11.925	90.024	88.536	87.037	85.527	84.006	82.472	80.927	79.371	77.802	74.630	71.412	68.148
87.970	65.598	8.000	11.483	89.808	88.266	86.712	85.147	83.570	81.981	80.380	78.767	77.142	73.856	70.522	67.141
86.733	72.486	8.500	11.041	89.575	87.973	86.361	84.736	83.099	81.451	79.789	78.116	76.429	73.020	69.561	66.054
85.452	79.947	9.000	10.600	89.322	87.657	85.980	84.291	82.590	80.876	79.149	77.410	75.657	72.114	68.520	64.876
84.125	88.058	9.500	10.158	89.047	87.312	85.566	83.807	82.036	80.251	78.453	76.642	74.818	71.129	67.388	63.596
82.746	96.906	10.000	9.716	88.747	86.937	85.115	83.280	81.431	79.570	77.694	75.805	73.902	70.055	66.154	62.199
81.311	106.596	10.500	9.275	88.418	86.526	84.620	82.702	80.770	78.823	76.863	74.888	72.899	68.879	64.802	60.669
79.815	117.256	11.000	8.833	88.057	86.073	84.077	82.066	80.041	78.002	75.948	73.880	71.796	67.585	63.314	58.987
78.253	129.038	11.500	8.391	87.657	85.573	83.476	81.363	79.237	77.095	74.938	72.765	70.577	66.154	61.671	57.127
76.617	142.129	12.000	7.950	87.214	85.018	82.808	80.583	78.342	76.086	73.815	71.526	69.222	64.565	59.844	55.060
74.900	156.759	12.500	7.508	86.718	84.397	82.061	79.710	77.343	74.960	72.559	70.142	67.708	62.789	57.803	52.751
73.093	173.219	13.000	7.066	86.160	83.698	81.222	78.729	76.219	73.692	71.147	68.585	66.005	60.791	55.506	50.152
71.184	191.874	13.500	6.625	85.527	82.907	80.270	77.616	74.945	72.255	69.547	66.820	64.074	58.526	52.904	47.207
69.159	213.193	14.000	6.183	84.805	82.002	79.182	76.345	73.488	70.613	67.718	64.803	61.868	55.938	49.929	43.842
67.005	237.792	14.500	5.742	83.971	80.958	77.927	74.878	71.808	68.718	65.607	62.476	59.322	52.952	46.497	39.959
64.699	266.491	15.000	5.300	82.998	79.740	76.463	73.166	69.848	66.508	63.145	59.760	56.352	49.468	42.493	35.428