

NFPA 8506

Standard on Heat Recovery Steam Generator Systems

1998 Edition



National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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NFPA 8506

Standard on

Heat Recovery Steam Generator Systems

1998 Edition

This edition of NFPA 8506, *Standard on Heat Recovery Steam Generator Systems*, was prepared by the Technical Committee on Heat Recovery Steam Generators, released by the Technical Correlating Committee on Boiler Combustion System Hazards, and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 18–21, 1998, in Cincinnati, OH. It was issued by the Standards Council on July 16, 1998, with an effective date of August 5, 1998, and supersedes all previous editions.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

This edition of NFPA 8506 was approved as an American National Standard on August 6, 1998.

Origin and Development of NFPA 8506

With the increased use of heat recovery steam generators (HRSGs) in industry, a technical committee was formed in 1993 to prepare a standard covering heat recovery steam generators. This document is the result of the work of this committee. This is the second edition of NFPA 8506 and is similar in organization to the other documents in the 8500 series boiler combustion system hazards standards.

The 1998 edition has incorporated several major changes. Most notable are the revision of purge requirements, the addition of mandatory language for combustion turbine exhaust bypass systems for unfired HRSGs, the elimination of nonmandatory language, and the addition of new definitions.

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Committee Scope: This Committee shall have primary responsibility for documents on the reduction of combustion system hazards in single- and multiple-burner boilers with a heat input rate of 12,500,000 Btu/hr and above. This includes all fuels. This Committee also is responsible for documents on the reduction of hazards in pulverized fuel systems, fluidized-bed boilers, heat recovery steam generators, and stoker-fired boilers, at any heat input rate.

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents covering the operation of heat recovery steam generators and the related reduction of combustion system hazards and prevention of boiler furnace explosions. This includes all fuels at any heat input rate.

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Appendix A.

Information on referenced publications can be found in Chapter 11 and Appendix D.

FOREWORD

This document is intended to be used in the design, installation, operation, and maintenance of heat recovery steam generator (HRSG) systems. It is not possible for this standard to encompass the specific hardware applications, nor should it be considered a “cookbook” for the design of a safe HRSG system.

The simplest combined cycle plant automatically has certain hazards that are common to all designs. Coupling various designs of heat recovery units with combustion turbines of varying characteristics in different configurations (such as varying damper arrangements) can produce very unique hazards.

The potential ineffective use of the combustion turbine as the source of the purge and potential sources of substantial fuel entering the HRSG from normal and false starts are major considerations that need to be addressed.

Other concerns include special provisions such as automatic transfer during transients, multiple stacks that can create reverse flows, internal maintenance of the HRSG with the combustion turbine in operation, multiplicity of cross connections between units to prevent shutdown, and/or fitting it into a small space using finned tubes which are more sensitive to temperature and subject to iron fires.

Insufficient failure analysis of arrangements, configurations, and equipment can increase the number of damaging incidents, lost production, and the possibility of personal injury or death.

It is vital that the designer of the combustion turbine and any burner safety system(s) be completely familiar with the features, characteristics, and limitations of the specific hardware and also possess a thorough understanding of this standard and its intent.

Chapter 1 Introduction**1-1 Scope.**

1-1.1 This standard shall apply to steam generators that recover heat from a combustion turbine. Purge requirements shall apply to all fired and unfired heat recovery steam generator (HRSG) systems regardless of the fuel(s) used.

1-1.1.1 The combustion turbine shall be permitted to fire the following fuels either alone or in combination:

- (a) Natural gas
- (b) No. 2 fuel oil
- (c) Kerosene
- (d) JP4 jet fuel
- (e) Diesel fuel

1-1.1.2 The HRSG shall be permitted to be unfired, or supplemental firing shall be permitted to be provided from natural gas or fuel oil, as defined in this standard.

1-1.2 The intent of this standard shall not be construed to dictate the methods or details of the combustion turbine manufacturer's product or control system. Specific functional considerations are identified for proper interfacing related to the safety aspects of the combined combustion turbine and the HRSG.

1-1.3 This standard shall not specifically address the firing of fuels other than those specified in 1-1.1.1 and 1-1.1.2. This standard shall apply to other fuels not covered by 1-1.1.1 and 1-1.1.2 (*see 1-2.2*). Other fuels have unique characteristics and shall require additional design and operation considerations for fuel handling and burning.

1-1.4 This standard shall not cover simultaneous firing of more than one fuel in the supplemental firing of the steam generator. Simultaneous firing shall involve requirements that are not addressed by this document.

1-1.5 This standard is not retroactive. This standard shall apply to new installations and to major alterations or extensions of existing equipment for the preparation and burning of fuel contracted for 6 months subsequent to the date of issue of this document.

1-1.6 Since the standard is based on the present state of the art, its application to existing installations shall not be required. Nevertheless, operating companies are encouraged to adopt those features of the standard that are considered applicable and reasonable for existing installations.

1-1.7 This standard shall not address multiple combustion turbines exhausting into a single HRSG, nor does it address single or multiple combustion turbines exhausting into multiple HRSGs through a header. Any system applying this concept shall require special design considerations that are not addressed in this standard.

1-1.8 The standard shall be applied with consideration of the document as a whole. Chapters 1 and 2 are introductory and provide general guidelines and focus. Where any real or perceived conflict exists, the guidelines outlined in subsequent chapters shall be followed.

1-2 Purpose.

1-2.1 The purpose of this standard shall be as follows:

- (a) To contribute to operating safety
- (b) To prevent explosions, implosions, and uncontrolled fires in HRSG sections and exhaust ductwork
- (c) To establish minimum standards for the design, installation, operation, and maintenance of heat recovery steam generators and their fuel-burning, air supply, and combustion products removal systems
- (d) To require the coordination of operating procedures and components, control systems, interlocks, and structural design
- (e) To require the establishment of training programs in equipment operation and maintenance, for both new and existing personnel, to ensure that minimum standards for operation and maintenance are understood and followed

1-2.2 No standard can guarantee the elimination of HRSG explosions and implosions. Technology in this area is under constant development and is reflected in revisions to this stan-

dard. The user of this standard shall recognize the complexity of firing with regard to the type of equipment used and the characteristics of the fuel. Therefore, the designer is cautioned that the standard is not a design handbook. The standard does not eliminate the need for the engineer or for competent engineering judgment. It is intended that a designer capable of applying more complete and rigorous analysis to special or unusual problems shall have latitude in the development of such designs. In such cases, the designer shall be responsible for demonstrating the validity of the approach.

1-2.3 Emphasis shall be placed on the importance of component coordination and on knowledge of expected operating conditions, along with adequate structure strength, proper operation and maintenance procedures, combustion and draft control equipment, safety interlocks, alarms, trips, and other related controls that are essential to proper operation.

1-2.4 The effect of gas cleanup systems located within or downstream of the HRSG shall be considered in the design and operation of the system.

Chapter 2 General

2-1 HRSG Fires and Explosions.

2-1.1 The basic cause of uncontrolled fires or explosions in an HRSG system is the ignition of an accumulated combustible mixture within the HRSG enclosure.

2-1.2 A dangerous combustible mixture within the HRSG sections and ductwork consists of the accumulation of combustibles mixed with air in proportions that result in uncontrolled combustion when an ignition source is supplied. An explosion might result from ignition of this accumulation if the quantity of combustible mixture and the proportion of air to fuel are such that an explosive force is created within the HRSG enclosure. The magnitude and intensity of the explosion depends on both the relative quantity of combustibles that has accumulated and the proportion of air that mixes with them at the moment of ignition. Explosions, including "puffs," are the result of improper procedures used by operating personnel, improper design of equipment or control systems, or equipment or control system malfunction.

2-1.3 Numerous situations that produce uncontrolled combustion conditions can arise in connection with the operation of an HRSG. These situations include the following:

- (a) An interruption of the fuel or combustion air supply or ignition energy to the burners, sufficient to result in a momentary loss of flame, followed by the delayed reignition of an accumulation of combustibles
- (b) Fuel leakage into the enclosure and the ignition of the accumulation by a spark or other source of ignition
- (c) Repeated unsuccessful attempts to light off the combustion turbine or supplementary fired burners without appropriate purging, resulting in the accumulation of an explosive mixture
- (d) The accumulation of an explosive mixture of fuel and combustion air as a result of loss of flame or incomplete combustion at one or more burners in the presence of other burners operating normally or during light-off of additional burners
- (e) The accumulation of an explosive mixture of fuel and combustion air as a result of a complete burner flameout

and the ignition of the accumulation by a spark or other ignition source, such as an attempt to light off burners without adequate purge

2-1.4 An examination of reports of steam generator explosions suggests that occurrences of small explosions, puffs, or near-misses are far more frequent than is usually recognized. Improved instrumentation, safety interlocks and protective devices, proper operating sequences, and a clearer understanding of the problem by designers, operators, and maintenance personnel can greatly reduce the risks and actual incidence of HRSG explosions.

2-1.5 In an HRSG with supplementary firing, upset conditions or control malfunctions can lead to an air/fuel mixture that could result in a flameout followed by reignition after a combustible mixture has been reestablished. Dead pockets might exist in HRSG sections and ductwork or other parts of the unit where combustible mixtures can accumulate under upset conditions. These accumulations can ignite with explosive force in the presence of an ignition source.

2-1.6 Statistics indicate that human error is a contributing factor in the majority of explosions. It is important to consider whether the error is the result of any of the following conditions:

- (a) Unfavorable operating characteristics of the equipment or its controls
- (b) Lack of functional coordination of the various components of the steam-generating system and its controls
- (c) Lack of understanding of, or failure to follow, proper operating procedures, safeguards, and equipment operation recommendations

2-1.7* HRSG Enclosure, Fin-Metal Tube Fires.

CAUTION

Due to misoperation, there have been occurrences of fin-metal tube fires in HRSGs, and there is a need to address this potential. See Appendix E for specific articles related to iron fires which in turn have references to previous literature.

2-1.7.1 Consideration shall be given to detecting and alarming fin-metal tube fires.

2-1.7.2 A procedure shall be provided to contain (i.e., confine or seal off) a fin-metal tube fire and to protect the buildings and adjacent equipment.

2-1.7.3 The initial response shall include the removal of all fuel from the combustion turbine and the HRSG.

2-2 HRSG Implosions. For HRSGs that use an induced draft fan where the potential exists for excessively low HRSG enclosure gas side pressures, the HRSG enclosure shall conform with the requirements of NFPA 8502, *Standard for the Prevention of Furnace Explosions/Implosions in Multiple Burner Boilers*, Chapter 5.

2-3 Manufacture, Design, and Engineering.

2-3.1 The owner or the owner's agent shall, in cooperation with the manufacturer, ensure that the unit is not deficient in apparatus that is necessary for proper operation with respect to pressure parts, fuel-burning equipment, combustion air and fuel, and safe light-off and maintenance of stable flame.

2-3.2 All fuel systems shall include provisions to prevent foreign substances from interfering with the fuel supply to the duct burner.

2-3.3 An evaluation shall be made to determine the optimum integration of manual and automatic safety features considering the advantages and disadvantages of each trip function.

CAUTION

The maximum number of automatic trip features does not necessarily provide for maximum overall safety. Some trip actions result in additional operations that increase exposure to hazards.

2-3.4 This standard shall require a minimum degree of automation. However, in the cases of more complex plants, plants with increased automation, and plants designed for remote operation, the following minimum provisions shall be required:

- (a) Information on significant operating events that allow the operator to make a rapid evaluation of the operating situation
- (b) Continuous and usable displays of variables in the normal control location that allow the operator to avoid unsafe operation
- (c) Additional automated control points that allow a remotely located operator to control the unit safely
- (d) In-service maintenance and checking of system functions without impairment of the reliability of the overall control system
- (e) Control areas environmentally designed to provide suitable conditions for personnel, control equipment, or both
- (f) Visual displays and alarms that are easily identifiable and readable

2-3.5 The duct burner piping and equipment shall be designed and constructed to prevent the formation of hazardous concentrations of combustible gases under any operating conditions.

2-4 Basic Operating Objectives.

2-4.1 Basic operating objectives shall include the requirements of this section.

2-4.1.1 Standard operating procedures shall be established that result in well-defined and controlled operations. All operating procedures shall be rigidly enforced at all times.

2-4.1.2 Interlocks shall be used to minimize improper operating sequences and to interrupt sequences when conditions are unsafe for continuation.

2-4.1.3 No interlocks shall be bypassed during start-up or operation of the unit unless the bypass is alarmed and is governed by operating procedures.

2-4.1.4 The mass flow of combustion air to the duct burner system shall be maintained at or above its purge rate and within the duct burner design operating range during all operations of the duct burner system.

2-4.2 Written operating procedures and detailed checklists for operator guidance shall be provided for achieving these basic operating objectives. All manual and automatic functions shall be included in these procedures and checklists.

Chapter 3 Definitions

3-1 Definitions. The following definitions shall apply to this standard.

Air, Combustion. The air used to fuel the combustion process. For duct burners, this generally is combustion turbine exhaust. (See *Air, Primary* and *Air, Vitiated*.)

Air, Excess. Air supplied for combustion in excess of theoretical air. This is not the same as *Air-Rich* as defined in this section.

Air, Furnace Purge. See Purge, Combustion Turbine; Purge, Duct Burner; and Purge Rate.

Air, Primary. The air that is contained in the combustion turbine exhaust.

Air, Seal. Air supplied to any device at pressure for the specified purpose of minimizing contamination.

Air, Secondary. The air for combustion supplied to the burners by the forced draft fan.

Air, Stoichiometric. See Air, Theoretical.

Air, Tertiary. The air supplied to certain types of burners to cool the burner metal or to improve the combustion process.

Air, Theoretical. The chemically correct quantity of air needed for complete combustion of a given quantity of a specific fuel.

Air, Vitiated. Air with an oxygen content below normal, for example, combustion turbine exhaust.

Air/Fuel Ratio. A ratio of air to fuel supplied to a combustion process.

Air-Rich. Indicates a ratio of air to fuel supplied to a combustion process that provides more than the minimum excess air needed for optimum combustion of the fuel.

Alarm. An audible or visible signal indicating an off-standard or abnormal condition.

Approved.* Acceptable to the authority having jurisdiction.

Atomizer. A device in a burner that emits liquid fuel in a finely divided state.

Atomizer, Mechanical. A device in an oil burner that emits liquid fuel in a finely divided state without using an atomizing medium.

Atomizing Medium. A supplementary fluid, such as steam or air, that assists in breaking down liquid fuel into a finely divided state.

Augmented Air Firing. Supplementary firing with the addition of air at the duct burners to support and stabilize combustion or to improve emissions.

Authority Having Jurisdiction.* The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

Auxiliary Firing. See Supplementary Firing.

Availability. The percent of time during a fixed period that a generating unit is capable of providing functional operating service.

Burner. A device or group of devices for the introduction of fuel and air at the velocities, turbulence, and concentration necessary to maintain ignition and combustion of the fuel.

Burner Management System. The control system dedicated to combustion safety, operator assistance in the starting and stopping of fuel-burning equipment, and prevention of misoperation and damage. The burner management system includes the following functions specified in this standard:

- (a) Interlock system
- (b) Fuel trip system

- (c) Master fuel trip system
- (d) Master fuel trip relay
- (e) Flame monitoring and tripping systems
- (f) Ignition subsystem
- (g) Duct burner subsystem

Combustion Control System. The control system that regulates the fuel input (and air, if applicable) to maintain continuous combustion and stable flame. This control system might include drum level, desuperheater spray, or draft control where applicable.

Combustion Turbine. A turbine in which the rotating element is actuated by the pressure of combustion gases on curved vanes.

Commercial Operation. The date that the full plant capacity is formally added to the power grid.

Commissioning. The time period of plant testing and operation between initial operation and commercial operation.

Damper. A mechanical device for controlling or blocking gas flow to a specific component.

Damper, Air Inlet.* A damper used to admit fresh air into the HRSG, either as an alternative method of purging or to supply combustion air when the combustion turbine is out of service.

Damper, Bypass.* A damper that allows combustion turbine exhaust gases to bypass the HRSG.

Damper, Diverter. A damper that is used to select alternate gas paths.

Damper, HRSG Isolation.* A damper used to block combustion turbine exhaust gases from entering the HRSG.

Damper, Stack.* A damper used to block gas flow through the stack.

Damper, Tight Shutoff. A close-fitting damper to inhibit leakage of air or flue gas into any system component.

Directional Blocking. An interlock that, upon detection of a significant error in HRSG process variables, acts to inhibit the movement of all appropriate final control elements in the direction that increases the error.

Drip Leg. A chamber of ample volume with suitable clean-out and drain connections over which fuel gas is passed so that liquids and solids are trapped.

Duct Burner. A burner located in a duct ahead of or within an HRSG section.

Explosive Mixture. A flammable or combustible mixture in a confined space.

False Start. A condition where the combustion turbine fails to complete its ignition sequence (failure to start) and can result in unburned fuels entering the HRSG enclosure.

Fan, Seal Air. A fan used to supply sealing air.

Fan Test Block Capability. The point on the head versus the flow characteristics curve at which the fan is selected. This is the calculated operating point associated with the maximum continuous rating of the steam generator furnace plus the head and flow margins.

Flame. The visible or other physical evidence of the chemical process of rapid conversion of fuel and air into products of combustion.

Flame Detector. A device that senses the presence or absence of flame and provides a usable signal.

Flame Detector, Self-Checking. A flame detector that automatically, and at regular intervals, tests the entire sensing and signal processing system of the flame detector. This ensures that the failure of any single component cannot result in a false indication of flame.

Flame Envelope. The confines (not necessarily visible) of an independent process that converts fuel and air into products of combustion.

Fresh Air Mode. The operation of an HRSG with atmospheric instead of combustion turbine exhaust.

Fuel Cutback. An action of the combustion control system to reduce fuel flow.

Fuel Gas. See LP-Gas and Natural Gas.

Fuel, JP4.* A light, volatile fuel with a boiling point between gasoline and light distillate.

Fuel, Kerosene.* A light, highly refined fuel. It is slightly more volatile than No. 2 fuel oil.

Fuel Oil.* Liquid fuels defined as Grades 2, 4, 5, and 6.

Fuel-Rich. Indicates a ratio of air to fuel supplied to a burner that provides less than the minimum excess air needed for optimum combustion of the fuel.

Fuel Trip. The automatic shutoff of a specific fuel as the result of an interlock or operator action.

Gas. See LP-Gas and Natural Gas.

Heat Recovery Steam Generator (HRSG). A heat exchanger that uses a series of heat transfer sections (e.g., superheater, evaporator, and economizer) positioned in the exhaust gas flow of a combustion turbine to recover heat and supply a rated steam flow at a required temperature and pressure.

HRSG. See Heat Recovery Steam Generator.

HRSG Control System. The group of control systems that regulates the HRSG process, including the combustion control but not the burner management.

HRSG Enclosure. All ductwork from the combustion turbine exhaust through the steam generator to the stack, including any bypass duct connection.

HRSG Purge. See Purge, Combustion Turbine; Purge, Duct Burner; and Purge Rate.

HRSG System. The unit assembly from the combustion turbine inlet to the flue gas outlet to the atmosphere.

Igniter. A permanently installed device, removable for maintenance only, that provides proven ignition energy for light-off of the main burner.

Igniter, Class 1. An igniter applied to ignite the fuel input through the burner and to support ignition under any burner light-off or operating conditions. Its location and capacity are such that it provides sufficient ignition energy (generally in excess of 10 percent of the full-load burner fuel input) at its associated burner to raise any credible combination of burner inputs of both fuel and air above the minimum ignition temperature.

Igniter, Class 2. An igniter applied to ignite the fuel input through the burner under prescribed light-off conditions. The

range of capacity of such igniters generally is 4 percent to 10 percent of the full-load burner fuel input.

Igniter, Class 3. A small igniter applied, in particular, to gas and oil burners to ignite the fuel input to the burner under prescribed light-off conditions. The capacity of such igniters generally does not exceed 4 percent of the full-load burner fuel input.

Igniter, Class 3 Special. A special Class 3 high-energy electrical igniter capable of directly igniting the main burner fuel.

Initial Operation. The first coordinated operation of the combustion turbine and HRSG.

Interlock. A device or group of devices arranged to sense a limit or off-limit condition or improper sequence of events and to shut down the related equipment or to prevent proceeding in an improper sequence in order to avoid a hazardous condition.

JP4. See Fuel, JP4.

Kerosene. See Fuel, Kerosene.

Listed.* Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets identified standards or has been tested and found suitable for a specified purpose.

Logic System. The decision-making and translation elements of the burner management system. A logic system provides outputs in a particular sequence in response to external inputs and internal logic.

- (a) *Hardwired Systems.* Individual devices and interconnecting wiring
- (b) *Microprocessor-Based Systems.*
 1. Computer hardware, power supplies, input/output devices, and the interconnections between these elements
 2. Operating system and logic software

Low Water Cutout. A device arranged to effect a master fuel trip when the water level in the steam drum(s) falls to a predetermined low level.

LP-Gas. A liquefied gas composed of any of the following hydrocarbons or their mixtures: propane, propylene, normal butane, isobutane, and butylenes.

Master Fuel Trip. An event resulting in the rapid shutoff of all fuel to the duct burners, including igniters.

Master Fuel Trip Relay. An electromechanical relay(s) utilized to trip all required equipment simultaneously.

Monitor. To sense and indicate a condition without initiating automatic corrective action.

Natural Gas. A gaseous fuel consisting mostly of a mixture of organic compounds (normally methane, ethane, propane, and butane). The Btu value of natural gases varies from 700 Btu/ft³ to 1500 Btu/ft³ (26.1 MJ/m³ to 55.9 MJ/m³) with the majority averaging 1000 Btu/ft³ (37.3 MJ/m³).

Oil. See Fuel Oil.

Open Flow Path. A continuous path for movement of an airstream through the exhaust to the stack.

Operating Range, Burner. The range between the maximum fuel input and the minimum fuel input within which the burner flame can be maintained in a continuous and stable manner.

Outlet Draft. The flue gas pressure at the outlet of the last convection pass of the steam generator.

Partial Loss of Flame. Loss of flame at any of the separate flame envelopes or burners while flame is maintained at any of the other flame envelopes or burners.

Positive Means of HRSG Isolation. A device in the gas path to the HRSG that will completely prevent turbine exhaust gas entrance to the HRSG and allow personnel entry into the HRSG enclosure (e.g., a blocking plate).

Prove. To establish by measurement or test the existence of a specified condition, such as flame, level, flow, pressure, or position.

Purge, Combustion Turbine. A flow of air at purge rate through the combustion turbine and the appropriate portion of the HRSG enclosure for a sufficient number of volume changes that effectively removes any gaseous or suspended combustibles and replaces them with the purging medium.

Purge, Duct Burner. A flow of combustion turbine exhaust gas or air at purge rate through the HRSG enclosure for a sufficient number of volume changes that effectively removes any gaseous or suspended combustibles and replaces them with the purging medium.

Purge Rate. A constant flow of purging medium at sufficient velocity to achieve a purge.

Reliability. The probability that a generating unit or system will perform for at least a given period of time where used under specified conditions.

Remote Operation. Control from a location that is removed from the combustion turbine and HRSG.

Repeatability. The ability of a device to maintain a constant set point characteristic.

Runback, Combustion Turbine. The controlled unloading of a combustion turbine to a level required by HRSG or other equipment control demands.

Scavenging. The procedure by which liquid fuel left in a burner or igniter after a shutdown is cleared by admitting steam or air through the burner passages, typically through a dedicated scavenging medium valve.

Selective Catalytic Reduction (SCR). A method of reducing NO_x in flue gas.

Separator, Filter, Scrubber. A device incorporated in the main fuel supply line that effectively separates foreign liquids or solids from the fuel.

Set Point. A predetermined value to which a device or system is adjusted and at which it shall be required to perform its intended function.

Shall. Indicates a mandatory requirement.

Should. Indicates a recommendation or that which is advised but not required.

Shutdown, Controlled. The normal unloading and shutdown sequence of plant components based on the manufacturer's criteria.

Shutdown, Emergency. An event resulting in the rapid shutoff of all fuel to the combustion turbine along with a master fuel trip.

Stable Flame. A flame envelope that retains its continuity throughout the maximum rate of change within the operating range of the HRSG.

Stack, Bypass. A stack applied in addition to and separate from the normal HRSG exhaust stack that allows combustion turbine exhaust gas to flow independently to the atmosphere.

Standard. A document, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

Start-Up Combustion Control System. A control system used to regulate and maintain proper air/fuel ratio during the start-up period where the customary indexes, such as pressure, temperature, load, or flow, that motivate the normal automatic combustion control system are not available or suitable.

Steam Generator. A closed vessel in which water is converted to steam or steam is superheated or in which any combination thereof takes place.

Steam Generator Enclosure. The physical boundary for all steam generator pressure parts and the combustion process.

Supervise. To sense a condition needing attention and automatically initiate corrective action.

Supplementary Firing. The provision of duct burners in an HRSG to increase the temperature of the combustion turbine exhaust gases.

Unit. The confined spaces of the combustion turbine, the HRSG, and the associated ducts that convey the air and combustion gases from the air intake to the stack outlet.

Valve, Charging. A small valve bypassing the main safety shutoff valve that is used for charging the fuel headers and piping and for testing for leaks.

Valve, Check. A valve used to prevent reverse flow.

Valve, Flow Control. A valve capable of regulating quantity of throughput to a controlled range.

Valve, Safety Shutoff. A fast-closing valve that automatically and completely shuts off the fuel supply to main burners or igniters in response to a fuel trip.

Valve, Supervisory Shutoff. A manually operated shutoff valve with a means to provide a “valve closed” position signal.

Valve, Vent. A valve used to allow venting of air or gas from the system to the atmosphere.

Watch-Dog Timer, External. A timer external to a microprocessor-based control that is used to compare the microprocessor cycle timing against itself and that fails safely if the microprocessor timing stops or exceeds the watch-dog time interval.

the owner or the owner’s designated representative from system inception through commercial operation to enhance equipment reliability and personnel safety.

CAUTION

An HRSG is a complex system, often involving numerous components; multiple steam pressure levels; emission control systems; and auxiliary, augmented air, or supplementary firing.

4-1.1.1 The ability of the combustion turbine to satisfy the flow requirements through the HRSG enclosure as required in Section 7-4 shall be considered in the basic design phase.

4-1.1.2 An HRSG system shall be designed to meet the user’s specified modes of operation.

4-1.1.3 System components and control loops shall be compatible and capable of stable operation and control during both steady-state and transient conditions.

4-1.1.4 Control and protective systems and operating sequences shall prohibit the operators from bypassing interlocks.

Exception: As permitted by 2-4.1.3.

4-1.1.5 Training shall ensure operator understanding of the relationships between components; the proper start-up, operation, and shutdown procedures; and the significance of alarms and proper action in response to those alarms.

4-1.2 Explosions and fires have occurred in fuel-fired steam-generating systems as a result of incomplete functional designs. Investigations have revealed human error but often have overlooked the chain of events contributing to the operating error. Therefore, the design, installation, and functional objectives of the overall system components and their controls shall be integrated. Ergonomics and an environment conducive to efficient operator actions and decisions shall be provided.

4-1.3 The planning and engineering phases of plant design and construction shall be coordinated with operating personnel to ensure that operations important to safety can be achieved by qualified operators. Where this is not possible, the needs of operating personnel shall be considered and anticipated.

4-1.4 The proper operator functions, maintenance activities, and training shall be the responsibility of the operating company.

4-2 Project Inception. In the project inception phase, the following shall be accomplished to ensure a plant design that meets expected operating modes and reliability needs:

- (a) Establishment of plant operating parameters
- (b) Identification of site-related constraints
- (c) Review of steam cycle, including generating a family of heat balance diagrams for the expected operating ranges and modes
- (d) Conceptualization of plant layout to provide for personnel safety, operability, and maintenance needs
- (e) Definition and verification of requirements of worst case operating transients, including start-ups
- (f) Definition of required test program
- (g) Definition of start-up criteria and goals
- (h) Identification of the authority having jurisdiction. If multiple authorities having jurisdiction are identified, the

Chapter 4 Project Coordination

4-1 General.

4-1.1 Project coordination, including proper integration of the various system components, shall be the responsibility of

scope of each authority having jurisdiction shall be defined.

4-3 Design.

4-3.1* The project approach shall include full evaluation of all systems and components to ensure compatibility, interface requirements, system dynamics, and the ability to meet all plant operating parameters.

CAUTION

Safety in any plant is the direct result of an extensive up-front effort in the engineering, design, and selection of equipment for each individual application.

4-3.2* This evaluation shall consider the use of dynamic simulation or prior operating experience, or both, before equipment is selected.

4-3.3 Electrical area classifications shall be established by the owner or the owner's designated representative in conjunction with the HRSG system designer prior to commencing detailed design. (*See 5-6.4.*)

4-4 Construction and Installation. The constructor and owner/operator responsible for the erection and installation of the equipment shall verify that all equipment is properly installed and connected.

4-5 Initial Training. The training program shall be specific to the equipment being installed, and all applicable design data shall be made available.

4-5.1 Operator Training. See also 8-2.1.

4-5.1.1 The owner or designated representative shall establish minimum levels of education and competence to be used in the selection and qualification of operators.

4-5.1.2 Prior to commissioning, a formal training program shall be established to prepare personnel to operate equipment safely and effectively.

4-5.1.3 Operator training shall include the following:

- (a) Start-up procedures
- (b) Normal operating procedures
- (c) Normal shutdown procedures
- (d) Emergency shutdown procedures
- (e) Control and safety system check-out and test procedures

4-5.1.4 Where different modes of operation are possible, the procedures identified in 4-5.1.3 shall be prepared for each operating mode. Procedures also shall be prepared for switching from one mode to another.

4-5.2 Maintenance Training. See also 8-2.2.

4-5.2.1 A formal maintenance training program shall prepare personnel to perform any required maintenance tasks safely and effectively. This program shall consist of study or review of maintenance manuals, videotapes, and programmed instruction and testing; field training; and training by equipment manufacturers, among others.

4-5.2.2 Maintenance procedures shall be established to cover routine and special techniques. Any potential safety factors, such as temperature, dust, contaminated or oxygen-deficient atmosphere, internal pressures, and limited-access or confined space conditions, shall be included.

4-5.2.3 Procedures shall be consistent with safety requirements and the manufacturer's recommendations.

4-6 Commissioning.

4-6.1 The HRSG system shall not be operated until safeguards have been tested and demonstrated to operate properly as a system. Any temporary procedures, interlocks, and instrumentation shall be reviewed by the owner or owner's agent, the engineering consultant, the equipment manufacturer, and the operating company, and agreement shall be reached on their suitability in advance of start-up. All temporary modifications shall be documented and permanent resolutions shall be accomplished prior to commercial operation.

4-6.2 The design and function of all safety interlock systems and protective devices shall be reviewed by the organization having HRSG system design responsibility together with those who are to operate and maintain the systems and devices. After installation, coordinated tests of all systems shall be accomplished before initial operation.

4-6.3 The HRSG system shall not be released for commercial operation before the installation and check of the required safeguards and instrumentation system have been confirmed by those responsible for the design and commercial operation.

4-6.4 Documentation of the plant equipment, the system, and maintenance activities shall be updated to reflect accurately changes in the status of equipment and operating procedures.

Chapter 5 Equipment

5-1 General. Equipment required by this standard for safe operation of the HRSG system shall be approved (*see definition of Approved in Section 3-1*) or shall have a demonstrated history of satisfactory and reliable operation for the intended service.

5-2 Combustion Turbine.

5-2.1 Fuel Supply.

5-2.1.1 For fuel oil, two stop valves or equivalent valves in series, with proof of closure, shall be provided in the oil line to the combustion turbine. Means shall be provided to prevent or relieve excess pressure between these valves.

5-2.1.2 For fuel gas, two stop valves or equivalent valves in series, with proof of closure, shall be provided in the gas line to the combustion turbine. An automatic vent valve shall be provided between the two valves.

5-2.2 Purge.

5-2.2.1 The combustion turbine shall have means for purging in accordance with Section 7-4.

Exception: In the event the combustion turbine cannot provide purge in accordance with Section 7-4, other means shall be provided.

5-2.2.2 During the purge sequence, means shall be provided to ensure that fuel does not enter the combustion turbine system downstream of the combustion turbine fuel stop valves.

5-2.2.3 The volume between the combustion turbine stop valves shall be minimized.

5-2.3 Interlocks.

5-2.3.1 Interlocks shall be provided to prevent starting the combustion turbine unless HRSG safety conditions are satisfied. Additional interlocks might be required for unusual intended plant operating scenarios. Typical permissives that shall be considered include the following: