

Changes shown by

SCOPE

- I 1.1 This practice covers instrumentation and protection systems for single, dual, and multi-fuel fired heaters. Specific heater arrangement, design, and operating conditions will require Owner's Engineer to select alternatives and provide further definition of requirements.
- I 1.2 **An asterisk (*)** indicates that either a decision by the Owner's Engineer or Purchaser is required, that additional information is to be furnished by the Owner's Engineer, or that information for the Owner's Engineer's approval is to be supplied by the vendor or Purchaser.

SUMMARY OF ADDITIONAL REQUIREMENTS

- I 2.1 **Table 1** lists the practices and standard which shall be used with this practice.
- I 2.2 **Table 2** lists the practice which shall be used with this practice **as specified** by the Purchaser.

TABLE 1

PRACTICES			
IP 1-1-1	Drawings, Diagrams and Line Lists	IP 15-2-1	Temperature Instruments
IP 3-4-1	Piping for Fired Equipment	IP 15-3-1	Pressure Instruments
IP 3-6-1	Piping for instruments	IP 15-4-1	Flow Instruments
IP 3-6-2	Piping at Control and Protective System	IP 15-7-2	Protective Systems
	Valve Stations	IP 15-7-3	Alarm Systems
IP 3-12-1	Valve Selection	IP 15-9-1	Control Valves
IP 7-1-1	Fired Heaters		
STANDARD			
API Standard			
RP551	Process Measurement		

TABLE 2

PRACTICE	
IP 16-2-1	Power System Design

DEFINITIONS

- I 3.1 **Reliable Pilot gas source:** A source that supplies pilot gas to the fired heater battery limit and meets all of the following conditions:
 - a. Separate from the main fuel gas supply such that both supplies will not be simultaneously interrupted by a single contingency such as power or instrument air failure or inadvertent valve closing.
 - b. Available during startup.
 - c. Liquefied petroleum gas vaporizers are not considered a reliable source.
- I 3.2 **Fail-Action (Fail-Safe) Design:** Failure or loss of energy or loss of circuit continuity to any protective system component causes the protective system to take a predetermined corrective action and move the process to its safe state. A circuit which is energized and uses closed contacts during normal operation is fail-action.
- I 3.3 **Control Damper:** A damper used to regulate flue gas or combustion air flow or firebox draft.

GENERAL REQUIREMENTS

- O * 4.1 **All natural draft fired heaters** shall, as a minimum, have the instrumentation and controls shown in **Figure 1**, unless specified otherwise.
- S,E * 4.2 **Control systems for the regulation of fuel, air, or both** shall maintain a safe air-fuel mixture under all conditions. Cross limiting air-fuel ratio control shall be provided for fired heaters with forced draft fans in accordance with the minimum requirements as shown in **Figure 2**. The design of airflow measurement devices shall be approved by the Owner's Engineer.



FLUE GAS INSTRUMENTATION

- O 5.1 A draft gauge or draft transmitter **shall be provided at the following locations.**
 - a. The bridgewall.
 - b. Downstream of stack or duct control dampers.
 - c. Upstream of stack or duct control dampers.
 - d. In the side wall at the floor.
- S 5.2 **Firebox high-pressure alarm** shall be provided on all fired heaters to detect and alarm on high pressure at the bridgewall. The pressure measurement shall be by a differential pressure transmitter with a calibrated span of -0.5 to 1 in. H₂O (-12 to +25 mm H₂O). The atmospheric pressure tap shall be shielded to prevent any errors caused by wind effects. **Pressure switches should not be used.**
- S,E ♦ * 5.3 **A combined oxygen/combustibles analyzer** shall be provided to permit continuous analysis of the flue gas in the stack. If a zirconia type oxygen analyzer is used, then it should be equipped **with flame arrestors** to prevent flame propagation in the event of ignition by the heated sensor. The sensor shall be located below the stack damper. For multiple cell fired heaters with individual firing controls, an oxygen/combustibles analyzer shall be provided near the top of each radiant cell **and** also in the heater stack(s).
- E ♦ * 5.4 **Connections for manual sampling of gaseous components in flue gas** shall be provided at the stack damper and bridgewall near the flue gas analyzer. If an air preheater is installed, flue gas sampling is required in the flue gas ducting upstream and downstream of the preheater. Connections shall not be located near possible sources of air leakage. Unless otherwise specified:
 - a. Stack connections shall be 4 in. (100 mm) flanged.
 - b. Air preheater connections shall be 2 in. (50 mm) NPT.
 - c. All other connections shall be 1 in. (25 mm) NPT.
 Additional connections required for particulate sampling and environmental compliance shall be specified by the Owner's Engineer.
- O 5.5 **Thermocouples and thermowells** shall be provided:
 - a. In the stack below the damper.
 - b. At the bridgewall. When possible, the thermocouples shall be placed in the arch out of view of the shield tubes.
- O 5.6 **Control damper and louver designs** shall include:
 - a. A **manual loading station mounted at grade or at the local panel**, capable of manually setting the damper position.
 - b. A remote/local control switch mounted at grade or at the local panel. This switch may be combined with the manual loading station in **Par. 5.6a**.
 - c. "Fail-Action" operation such that **upon loss of instrument air, loss of control signal or linkage failure**, the flow path shall be opened.
- O 5.7 **Each stack** shall be provided with a **multi-bladed control damper** capable of being operated by hand and mechanically locked into position. A position transmitter shall be provided for each remotely actuated stack control damper. This transmitter shall be directly connected to the damper or actuator linkage and position indication shall be transmitted to a local indication at grade and to the control house. These requirements also apply to **combustion air control dampers**.
- S,O 5.8 **Actuators** for pressure relief dampers shall:
 - a. Be capable of fully opening the damper within **ten seconds**.
 - b. Fail open on loss of instrument air or control signal.

PROCESS INSTRUMENTATION

- O * 6.1 **Total process feed flow meters** shall be provided for all fired heaters. Flow meters shall be in accordance with **IP 15-4-1**. The Owner's Engineer will specify flow distribution and measurement design for heaters with **two-phase flow** at the process feed inlet.

- O * 6.2 **All fired heaters in liquid process or vaporizing process service shall have control house flow indication** for each pass.
 - a. A **low flow alarm** shall be provided on each pass.
 - b. Coking services shall have an **automatic flow controller** for each pass.
 - c. Non-coking services shall have local manual flow control for each pass.

Unless otherwise specified the distribution of flow in all vapor services will be controlled by the manifold design.
- S * 6.3 All fired heaters in heavy coking service, such as delayed coking service, **and** equipped with an automatic flow controller on each pass, shall have a **low flow cut-out [FL(CO)] with pre-alarm** which shuts off the main fuel(s) on **low process feed flow in any one pass**. All other fired heaters shall have a **low flow cut-out [FL(CO)] with pre-alarm** which shuts off the main fuel(s) on **low total process feed flow**. The FL(CO) for low process feed flow shall be located on the fired heater inlet side only. In multi-cell fired heaters, any FL(CO) shall result in shutdown of all cells. Low flow trip shall take place after a time delay of 10-20 seconds.
- S * 6.4 If a pressure relief valve is specified on the fired heater feed line, the total feed flow meter used to sense low feed and actuate the fuel cut-out shall be located downstream of this pressure relief valve.
- O * 6.5 A **pressure gauge or pressure transmitter** shall be provided at the following locations:
 - a. Common coil inlet.
 - b. Each pass downstream of individual pass valves.
 - c. Common coil outlet.
 - d. In vaporizing service, at each pass crossover.
- O 6.6 **Temperature indication**, using measuring elements and thermowells, shall be provided in the control house for:
 - a. Common coil inlet.
 - b. Each pass crossover between convection and radiant sections.
 - c. Each coil or pass outlet.
 - d. Combined coil outlet.
- S * 6.7 All fired heaters shall be provided with a **Priority 1 high temperature alarm** in the combined coil outlet. The measuring element shall be installed in a separate thermowell less than 18 in. (450 mm) from the coil outlet temperature controller's thermowell. The measuring element shall also serve as a check sensor for the coil outlet temperature controller. The Owner's Engineer will specify if individual pass alarms are required.
- R,M 6.8 **Coil outlet thermowells in coking service** shall be designed to minimize coke buildup on thermowells.
- O 6.9 Fired heater **coil outlet temperature controllers** shall be capable of having both a suppressed range for normal control in accordance with [IP 15-2-1](#), and a range which covers all other operations such as startup, shutdown, and decoking.
- S,O * 6.10 If **valves** have been specified in each pass to provide for flow distribution in multi-pass heater, **protection against low process flow** and subsequent tube overheating shall be provided by:
 - a. The valve closure shall be limited to a specific minimum percent of the design flow rate to that pass. This shall be done by a **mechanical limit stop**.
 - b. Control valves shall fail open or remain stationary and drift to the open position on actuating medium or signal failure.
- O 6.11 **Valve installations** shall be able to control properly over their design range.

FUELS SYSTEM INSTRUMENTATION

- O * 7.1 **Fired heaters with continuous pilots** shall have the fuel instrumentation and controls shown in [Figure 3](#) for each specified fuel, unless specified otherwise.
- O 7.2 **Pressure and flow indication of each main fuel supply** to the fired heater, or each cell in multi-cell fired heaters, shall be provided in the control house.
- O 7.3 **All main fuel systems and pilot gas systems** shall have a **high pressure and low pressure alarm** installed downstream of the fuel control valves. A pressure gauge shall also be installed on each fuel header to the fired heater.

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- S * 7.4 **Pilot gas** which is **not supplied by a reliable gas source** shall have a protective system which shuts off all main fuels and pilot gas on low pilot gas manifold pressure.
- S 7.5 Each **knockout drum** provided in the **main fuel gas** supply shall have a priority 2 high level alarm.
- S,E * 7.6 Fired heater fuel systems using **atomizing steam**, and firing liquid fuels having a flash point of less than or equal to 100°F (38°C) shall have the following pressure instrumentation installed downstream of the atomizing steam control valve.
- A differential pressure low cutout or pressure low cutout which causes its associated main fuel block valve(s) to close.
 - An independent pressure or differential pressure low alarm.

PROTECTIVE SYSTEM

- S 8.1 A **hardwired emergency switch or pushbutton** shall be provided in the control house and at the fired heater local panel which closes all fuel and pilot gas protective system valves.
- S 8.2 All **air or hydraulically actuated main fuel and pilot gas valves in protective system service** shall **close** on loss of actuating medium.
- S,O 8.3 **Dampers associated with protective system action** shall be provided with manual reset action located at grade.
- S 8.4 The fired heater **protective system shall be standardized** at each Owner's location. Deviations from the most recent standard design shall be approved by the local Safe Operations Committee.
- S,O * 8.5 In **fired heaters with one burner**, continuous main flame verification using redundant detectors (such as UV, IR or flame ionization rods) shall be provided. UV or IR sensors shall be self-checking type.
- S 8.6 **For fired heaters with more than one burner and continuous pilots, each pilot shall be equipped with an ionization flame rod.** These flame rods shall be connected to a **permissive interlock system** which prevents **any fuel gas protective system valve** from opening during startup unless **more than 50%** of the pilots are sensed. For **two-burner fired heaters, only one pilot must be sensed** to satisfy the 50% criterion. In addition:
- The flame rods **shall initiate the closure of all main fuel gas protective system valves** during fired heater startup when the pilot voting is "on" and 50% or less of the pilots are sensed.
 - A **common alarm in the control house** shall be provided to indicate when one or more pilots are not sensed. This alarm shall have a "reflash" feature to alarm when subsequent pilots go out, after the first.
 - Individual indicators** for each pilot shall be provided **on the local panel**.
 - A **"Voting Off" pushbutton** shall be provided which allows the operator to deactivate the pilot voting system when the fired heater is in stable operation.
 - A **"Voting On" pushbutton** shall be provided that allows the voting to be manually activated.
 - On the closure of all main fuel gas valve(s), the pilot voting system shall **automatically be reactivated** such that the greater than 50% permissive is required before the main fuel gas valve(s) may be opened again.
 - The fired heater local panel shall be provided with a key-lock bypass facility for this pilot voting logic.
- S 8.7 **Fired heaters which are designed for a constant firing rate**, such as pyrolysis furnaces whose firing rate is **not** modulated with coil outlet temperature, **and have a large number of small burners** [less than 1.5MBtu/hr (0.44MW)], do not require pilots. These heaters shall be equipped with PL(CO) for shutoff of all fuel on loss of fuel pressure. A separate low pressure pre-alarm shall also be provided. These requirements are shown in [Figure 4](#).

ADDITIONAL REQUIREMENTS FOR FORCED DRAFT FIRED HEATERS, BALANCED DRAFT FIRED HEATERS, AND FIRED HEATERS WITH COMBUSTION AIR PREHEATERS

- S * 9.1 **Induced draft fired heaters** are considered special cases and protective instrumentation systems shall be approved by the Owner's Engineer.

- S,O ▶ **9.2** **Forced draft fired heaters** shall have additional cutouts with pre-alarms as shown in [Figure 5](#) and as given below:
- a. Low combustion airflow.
 - * b. Loss of forced draft fan. The preferred measurement method is low fan speed. Other methods must be approved by the Owner's Engineer. No pre-alarm is required.
 - c. Firebox high pressure. The firebox PH(CO) shall shut off all main fuels [and pilot, where the pilot flame would be unstable at pressures above the PH(CO) set point] if high firebox pressure persists for more than 10-15 seconds.
 - d. Loss of forced draft fan or low combustion air shall shut off all main fuels (and pilot, where the pilot air is from same supply as main combustion air) if no facilities (i.e., per **Subpar. 9.2e**) have been specified to permit fired heater to revert to a natural draft mode of operation.
 - * e. If the use of **automatic air dropout doors** with a forced draft fired heater with natural draft type burners has been approved by the Owner's Engineer, the dropout doors shall open on either loss of FD fan or low combustion airflow. Dropout doors shall have positive open position detection which shall trip all main fuels (and pilot gas, if pilot air supply is from within combustion air ducting) should the doors not open within 10 seconds of the open command.
 - f. The forced draft fan shall not shut down on actuation of the pilot gas PL(CO) or main fuel PL(CO) or any flame detector cutouts.
- O ▶ **9.3** **All fired heaters with preheaters and induced draft fans** shall have additional cutouts and alarms as shown in [Figure 6](#) and as given below:
- a. Low performance ratio alarm across the preheater (excluding circulating oil preheaters). This alarm monitors the ratio of the decrease in flue gas temperature to the increase in the air temperature across the air preheater as a means of fire detection.
- $$\text{Low Performance Ratio} = \frac{(\text{Temperature flue gas in}) - (\text{Temperature flue gas out})}{(\text{Temperature air out}) - (\text{Temperature air in})}$$
- b. High flue gas temperature alarm and cutout, measured in the ducting upstream of the preheater. High temperature cut-out shall bypass the air preheater by opening the pressure relief damper and shutting down the ID fan.
 - c. High flue gas temperature alarm and cutout, measured in the ducting at the inlet of the ID fan. High temperature cut-out shall shut down the ID fan and open the pressure relief damper.
 - d. Firebox PH(CO) shall first open the pressure relief damper. If the high firebox pressure persists for more than 10-15 seconds, the firebox PH(CO) shall shut off all fuels except as noted in [Table 4, note 5](#).
- S **9.4** In the event of an **induced draft fan failure**, as sensed by a speed sensor on the fan side of the coupling (preferred), the following actions should occur in sequential order:
- a. Fan failure alarm. (No pre-alarm is required.)
 - b. The pressure relief damper shall open.
- S * **9.5** **Induced draft fired heaters fitted with natural draft burners.** If natural draft backup is not inherent in the fired heater design, the heater shall be shut down on loss of the induced draft fan(s).

SUMMARY OF ALARMS AND SHUTDOWNS

- I 10.1 Summary of alarms and shutdowns for natural draft fired heaters is provided in [Table 3](#).
- I 10.2 Summary of alarms and shutdowns for forced draft fired heaters, balanced draft fired heaters and combustion air preheaters is provided in [Table 4](#).