ENGINEERING AND MATERIAL STANDARD

FOR

FIRED HEATERS

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0. INTRODUCTION

This Standard specification gives the amendments and supplements to API Standard 560, First Edition, January 1986.

"Fired Heaters, for General Refinery Services"

It is intended that API Standard together with this Standard shall be used for fired heater equipment for use in oil refineries, chemical plants, gas plants and where applicable, in exploration and production and new ventures.

For ease of reference, the clause or section numbering of API standard 560 has been used throughout this Standard.

Clauses in API Standard 560 not mentioned remain unaltered.

For the purpose of this Standard, the following definitions shall hold.

Sub. (Substitution) : The API Standard clause is deleted and replaced by a new clause.

Del. (Deletion) : The API Standard clause is deleted without any replacement.

Add. (Addition) : A new clause with a new number is added.

Mod. (Modification) : Part of the API Standard clause is modified, and/or a new description and/or condition is added to that.

SECTION 1
GENERAL

1.1 Scope

1.1.3 The requirements outlined herein are supplementary to the data listed on the fired heater data sheet. (Add.)

1.6 References (Puplications)

Throughout this Standard the following standards and codes are referred to. The editions of these Standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor: (Sub.)

ANSI (AMERICAN NATIONAL STANDARDS INSTITUTES)

A 12.1 "Safety Requirements for Floor and Wall Openings, Railings and Toeboards"
A 14.3 "Safety Requirements for Fixed Ladders"

API (AMERICAN PETROLEUM INSTITUTE)

Std. 630 "Tube and Header Dimensions for Fired Heaters for Refinery Services"

ASME (AMERICAN SOCIETY OF MECANICAL ENGINEERS)

"Boiler and Pressure Vessel Code, Section I"

1.6.3 Units

This Standard is based on International System of Units (SI), except where otherwise specified.(Add.)

SECTION 2
DESIGN CONSIDERATIONS

2.1 Process

2.1.1 Heaters shall be designed for uniform heat distribution. Multipass heaters shall be designed for hydraulic and thermal symmetry, and uniform pressure drop per pass. (Mod.)

2.1.3 The average radiant heat flux specified on the data sheets is defined as the quotient of total heat absorbed by the radiant tubes divided by the total outside circumferential tube area inside the firebox, including any fitting inside the firebox. The rows of convection tubes exposed to direct radiation shall be considered as being in the radiant section and the maximum radiant heat absorption rate shall apply to these tubes, irrespective of whether extended surface elements are used or not. (Sub.)

2.1.5 The maximum radiant heat flux density is defined as the maximum heat rate to any portion of any radiant tube. The rate shall be calculated for the front 60 of the tube surface. This density is not to be considered as an operating average flux density for any given length of tube surface. (Add.)

2.1.6 Process design conditions are shown on the individual Fired Heater Data Sheet. (Add.)

2.2 Combustion

2.2.2 Calculated and guaranteed efficiencies shall be based on design duty, fuel lower heating value (LHV), calculated heat losses, and the following percentages of excess air. (Mod.)

TYPE OF FUEL		
TYPE OF OPERATION	GAS	OIL OR GAS/OIL COMB.
Natural draft	20%	30%
Forced draft	15%	20%

2.2.3 Volumetric heat release of the radiant section with natural draft burner shall not exceed 120,000 Kcal/hr/m³ for oil firing and 150,000 Kcal/hr/m³ for gas firing, at maximum heat release of furnace. (Mod.)

2.2.5 Under all operating conditions, the outside surface temperature of the metal wall of the heated coils shall be at least 150°C, to prevent "dew point" corrosion by sulphuric acid condensing form the flue gases, if sulphur-containing fuels are fired. (Add.)

2.2.6 Vendor shall specify the amount of excess air and stack temperature when operating at the guaranteed efficiency. (Add.)

2.3 Mechanical

2.3.5 If extended surface tubes are used for the convection, the bottom two tube rows (shield section) shall be bare tubes. (Sub.)

2.3.6 Corbels or baffles shall be utilized in the convection section to minimize flue gas bypassing. (Mod.)

Note:

Corbelling need not be used on the bottom two rows of shield tubes.

2.3.10 Heater arrangement shall allow for replacement of individual tubes, without disturbing adjacent tubes or fittings. (Mod.)

2.3.11 Radiant heating section tubes shall be single row and minimum center to center distance of adjacent tubes shall be two nominal pipe diameters. (Add.)

2.3.12 Convection tube length shall not be less than the radiant tube length on horizontal tube heater. (Add.)

2.3.13 Steam purge connections shall be provided on all heaters. (Add.)

2.3.14 Tubes shall be so located as to prevent flame impingment. (Add.)

2.3.15 More than one roof exit or stack shall be provided for effective convection tube lengths exceeding 12 meters. (Add.)

2.3.16 When specified on data sheet, drain connections shall be provided at the lowest point of each heating Coil. Normally these drains are located outside the furnace. (Add.)

2.3.17 Clearance between the assembled return bend and refractory wall shall be a minimum of 100 mm after 100% linear expansion of the tube under normal operating (or decoking operation) conditions. (Add.)

2.3.18 Clearance between the assembled return bend and insulation of header box cover shall be 50 mm minimum after 100% linear expansion of the tube under normal operation (or decoking operating) conditions. (Add.)

2.3.19 Coils shall not be installed on the floor of a heater. (Add.)

2.3.20 For horizontal tubes, the maximum span between supports shall be thirty-five (35) outside tube diameters, or 6 m, whichever is the lesser. In addition, the maximum distance from the butt weld between the tube and return bend, and the nearest support shall be ten (10) outside tube diameters, or 3 m, whichever is less. (Add.)

2.3.21 Intermediate guides on vertical tubes supported at the bottom shall be spaced such that the maximum distance between guides, or guide and bottom supports, shall not exceed fifty (50) tube outside diameters, or 7.6 m), whichever is the lesser. (Add.)

SECTION 3
TUBES

3.1.3 Design temperature for calculating the tube wall thickness required shall be 27°C above the maximum calculated tube wall temperature. The maximum calculated tubewall temperature shall be based on the maximum local heat flux.

The design metal temperature (Td or Te of API RP 530) shall not exceed the values shown in Table 1 below. (Sub.)

TABLE 1 - MAXIMUM DESIGN METAL TEMPERATURE FOR TUBE MATERIALS

TUBE MATERIAL	MAXIMUM TEMPERATURE
Carbon steel	450°C
Carbon ½ % Mo Alloy steel	500°C
1¼ % Cr 1 % Mo Alloy steel	600°C
2¼ % Cr 1 % Mo Alloy steel	600°C
5 % Cr ½ % Mo Alloy steel	650°C
7 % Cr ½ % Mo Alloy steel	650°C
9 % Cr 1 % Mo Alloy steel	650°C
18 % Cr 8 % Ni Stainless steel	815°C
18 % Cr 10 % Ni Stainless steel	815°C

3.1.8 Design pressure for calculating tube wall thickness shall be equal to the value stated on the individual data sheet. (Add.)

3.1.9 Corrosion allowance shown on the individual data sheet shall be added to the calculated tube wall thickness. Minimum tube wall thicknesses excluding corrosion allowances shall be as shown on the specification data sheets. (Add.)

3.1.10 For decoking purposes, heater tubes shall have a box or plug fitting at one end of each coil loop. If required, long tubes shall have a plug fitting at both ends of each coil loop. (Add.)

3.1.11 Tubes, tube supports, and extended surfaces shall be designed to withstand the metal temperatures and thermal stresses resulting from steam and air decoking. (Add.)

3.1.12 All attachments, clips, lugs, etc., (except extended surface fins or studs, and tube skin thermocouples) shall be of the same material as the tubes which they are attached. (Add.)

3.1.13 Coils in hydrogen service shall have butt welded return bends. (Add.)

3.2 Extended Surface

3.2.1 Convection section extended surface tubes shall be governed by the following:

a) Stud attachment shall provide full surface contact between the tube and the stud by the arc or resistance welding process.

b) Attachment of extended surface fins to the tube shall be by means of continuous welding. (Sub.)

3.2.2 The material of studs and fins based on the design temperature, shall be as shown in Table 2. (Sub.)

TABLE 2 - MATERIALS FOR EXTENDED TUBE

MATERIAL	DESIGN TEMPERATURE	
	STUDS	FINS
Carbon steel	510°C	450°C
1 Cr Alloy steel	600°C	600°C
5 Cr Alloy steel	650°C	650°C
13 Cr Alloy steel	700°C	700°C
18 Cr-8 Ni Stainless steel	815°C	815°C

3.3 Materials

3.3.1 To avoid stress corrosion cracking, all austenitic steels shall be supplied in the solution heat-treated (fully-softened) condition.

Where austenitic steels in Grades Type 321 or 347 are to be exposed to H_2/H_2S/hydrocarbon conditions above a metal temperature of 400°C, the solution heat treated pipe shall be given a final thermal stabilizing treatment at 870°C for 4 hours. This is to minimize intergranular attack from polythionic acids.

Stainless steel welded components shall be given a stress relief heat treatment after welding as specified in applicable code. (Add.)

SECTION 4
HEADERS

4.1 General

4.1.4 The minimum thickness of all headers and fittings inside the heater shall be at least equal to the minimum thicknesses of tubes to which they are attached. (Sub.)

4.1.5 Header type shall be as indicated on the individual data sheets. Headers shall be in accordance with the dimensional standard given in API-630. (Add.)

4.2 Plug-Type Headers

4.2.9 All plug headers shall be housed within air tight header boxes. (Add.)

4.2.10 After hydrostatic test, vendor shall lubricate plug and seating surface with high temperature rust preventative lubricant (Moly-kote or equal). (Add.)

4.3 Return Bends

4.3.5 All butt welded return bends shall be arranged as follows:

a) Radiant section return bends shall be located inside the heater.
b) Convection section return bends shall be located in header boxes.
c) Arrangement shall be provided for coil removal and replacement.

Convection section tube spacing shall provide sufficient clearance for field welding during initial installation and to facilitate repairs. This may be accomplished by staggering alternate rows of return bends at either end of the heater. (Add.)

4.3.6 All return bends shall be attached by butt welded construction. (Add.)

4.3.7 All butt welded fittings shall be seamless and of the same or greater wall thickness as the tube to which they are attached.

If fittings are of greater wall thickness than the tube to which they are attached, they shall be taper bored at an angle of 30° to match the inside diameter of the tube. (Add.)

SECTIONS 5
PIPING, TERMINALS, AND MANIFOLDS

5.1 General

5.1.2 Flanges shall be of the welding neck type, in accordance with ANSI B 16.5. The flange rating shall be at least ANSI class 300. The material of the flanges shall be compatible with that of the furnace coils to which they are welded: (Mod.)

FURNACE COIL MATERIAL FLANGE MATERIAL (ASTM)

Carbon steel	A 105 - Normalized (C - Content max. 0.25%)
0.5 Mo	A 182 - F1 (C - Content max. 0.25%)
1 Cr-0.5 Mo	A 182 - F12 or A 182 - F11
2.25 Cr-1 Mo	A 182 - F22
5 Cr-0.5 Mo	A 182 - F5
9 Cr-1 Mo	A 182 - F9
18/8 Cr-Ni*	A 182 - F321H
18/10/2 Cr-Ni - Mo*	A 182 - F316L or forged AISI 316 Nb

*** For the application of 18/8 Cr. Ni types 304 H and 321 H above 650°C and of 18/10/2 Cr- Ni-Mo type 316 above 500°C special tests with a view to sensitivity to sigma-phase formation shall be specified after consultation with the Company.**

5.1.7 Crossover piping from the convection section to the radiant section shall be external, welded and insulated. (Add.)

5.1.8 Manifold shall be designed to provide uniform flow distribution to all passes. The maximum differential flow between any two passes shall be limited to 5 percent. (Add.)

5.1.9 Manifolds shall have either extruded nozzles or welded fittings at all branch connections. (Add.)

SECTION 6
TUBE SUPPORTS AND GUIDES (Mod.)

6.1 General

6.1.1 The design temperature for the tube supports and guides shall be at least equal to the maximum flue gas temperature in contact with the supports at the maximum heater firing rate. (Mod.)

6.1.7 Maximum unguided length of vertical tubes fired on only one side shall be 10.7 m (35 ft). (Add.)

6.1.8 For bottom guided tubes, the guide pipes shall extent at least 13 mm (½ in) through the furnace floor. (Add.)

6.1.9 Intermediate tube sheets shall be designed as described below: (Add.)

a) If sootblowers are used, or space for addition of sootblowers is provided, any intermediate tube sheets required between adjacent sootblowers (or spaces provided therefore) shall be located equidistant between them.

b) The minimum thickness of the tube sheet flanges and web shall be 16 mm.

c) If tube sheets are to be refractory coated, sleeves shall be attached to the tube holes to prevent the refractory from being damaged by the tubes.

6.1.10 Tube bearing surfaces shall not have sharp points or ridges which could cause damage to heater tubes. (Add.)

6.2 Loads and Allowable Stress

6.2.2 Tube support maximum allowable stresses shall be as follows: (Sub.)

a) The maximum allowable dead load stresses shall not be greater than ½ the stress required to produce one-percent creep in 10.000 hours, or ½ the stress to produce rupture in 10,000 hours whichever is less.

b) The maximum allowable dead load plus frictional stresses shall not be greater than the full stress required to produce one percent creep in 10,000 hours or produce rupture in 10,000 hours whichever is less.

c) Tube support design shall be based on elastic design principles.

d) For the maximum allowable stresses see Appendix "D".

6.3 Material

6.3.3 The materials for bolts and nuts to be embedded in insulation shall be as given in Table 3 below: (Add.)

TABLE 3 - MATERIALS OF BOLTS & NUTS

PARTS	DESIGN TEMPERATURE °C	MATERIALS
Bolts & nuts (Fastening tube supports or guides to casing or lug)	500 and lower	Bolt ASTM A 193 B7 or equal Nut ASTM A 194 2H or equal
	815 and lower	Bolt ASTM A 193 B8 or equal Nut ASTM A 194 8N or equal
	1090 and lower	Bolt 25 Cr - 20 Ni Nut 25 Cr - 20 Ni

SECTION 7
REFRACTORIES AND INSULATION

7.1 General

7.1.8 Radiant and convection wall and arch designs may utilize brick, castable, block insulation and/or ceramic fiber refractory; except when the fuel fired contains greater than 0.5 percent (by weight) sulfur, or greater than 400 ppm (mg/kg) vanadium. For the latter cases, only castable shall be utilized. Walls subject to flame impingement or severe gas erosion shall have a "hot face" layer of first quality firebreak or dense castable refractory. (Add.)

7.1.9 When castable refractory is installed on heater panels prior to connection of the panels by welding in the field, a 150 mm (6 in.) gap shall be left unlined at the junction of the panels to allow room for assembly of panels. (Add.)

7.1.10 Convection section end tube sheets shall be protected by a minimum of 100 mm (4 in.) of castable refractory. Refractory tiebacks for end tube sheets shall be placed in a random orientation between the "ferrules" or "sleeves" attached to the end tube sheets. Wire mesh or wire wrap around the "ferrules" is not acceptable. In order to minimize flue gas flow into convection header boxes, the annular space between tubes and the end tube sheet "ferrules" shall be with ceramic fiber blanket or rope. The space between fins or studs shall be filled with castable refractory. In all cases, the packing shall extend through the thickness of the end sheets, including refractory. (Add.)

7.1.11 Portions of stacks and ducting which are adjacent to instrumentation or equipment which requires frequent attention shall be insulated so that the temperature of outer plate surface does not exceed 93°C. (Add.)

7.2 Brick and Tile Construction

7.2.3 Insulating firebrick shall have flat, uniform surfaces on all faces which have been ground or cut to size within a tolerance of plus or minus 1.6 mm for all dimensions. (Add.)

7.2.4 Each brick in a brick arch, or a brick lining on a sloped flat casing must be individually tied back to the furnace casing. Brick hangers shall be TP 304. (Note: Castable refractory type hangers are not acceptable for this service.) Except for the floor "hot face" layer of brick, all brick joints shall be set with fireclay or high temperature air setting mortar. The floor "hot face" layer of brick shall be field installed, with the brick laid dry.

Mortar joints should be dipped on two edges, except at expansion joints. Brick should be placed against mating surface and tapped gently to ensure uniform joints. (Add.)

7.3 Castable Construction

7.3.7 Additional refractory tie-backs shall be provided such that the entire refractory anchoring system extends to within 50 mm of the edge of all panels and door opening within the panel. (Add.)

7.3.8 When the fuel fired contains sulfur and/or vanadium compounds within the limits described below, the following material restriction shall govern. (Add.)

FUEL FIRED CONTAINS	ACCEPTABLE MATERIAL
Case I ≥ 0.5% (Wt) sulfur	1. Total concentration of free alkali, Mgo and iron in the aggregate shall be less than 1 percent. 2. "Hot face" to be medium weight castable or eavier. 3. Binder shall be calcium aluminate cement.
Case II ≥ 400 ppm (mg/kg) vanadium	1. "Hot face" to be only dense type castable. 2. Overall Al_2O_3 content 40 percent minimum with not less than 40 percent Al_20_3 in aggregate. 3. Si_2O_3 content 35 percent maximum.

7.4 Block Insulation Construction

7.4.1 Block insulation shall be used only as a "back-up" material for refractories exposed to products of combustion, and shall have a maximum thickness of 76 mm. (Mod.)

7.4.2 Block insulation shall be waterproof when used with castable construction to minimize water migration from the castable. Treatment shall consist of two coats of a resin base membrane curing compound or two coats of sodium silicate. (Mod.)

7.5 Ceramic Fiber Construction

7.5.2 Selection of tie-back material shall be based on temperature as follows: (Sub.)

REFRACTORY HOT FACE TEMPERTURE (1)	ACCEPTABLE MATERIAL
760°C	18 Cr-8 Ni (Type 304)
980°C	25 Cr-20 Ni (Type 310)
1040°C	50 Cr-50 Ni
1090°C	Inconel 601
1260°C	Inconel 601 with ceramic cuplocks

Note:

No credit may be taken for covering of the tie-back tip.

7.5.10 Exposed tie-backs shall be covered with ceramic fiber insulation or moldable ceramic. (Add.)

7.5.11 To inhibit gas flow behind fiber blanket linings, all overlaps between blanket sections perpendicular to the flow of combustion gases shall have the upstream blanket overlapping the downstream blanket. (Add.)

SECTION 8
STRUCTURES AND APPURTENANCES

8.1 General

8.1.2 Earthquake load shall be specified in the job specification with K=1.0 for horizontal (box type) heaters, and K=1.33 for vertical heaters per uniform building officials latest edition. (Mod.)

8.2 Structures

8.2.1 The structure shall be able to withstand the loads of coils, ducting, etc., live loads and any loads due to expansion and weights of transfer lines and other piping. (Mod.)

8.2.3 Heater casing shall be 5 mm (3/16 in.) minimum plate thickness, reinforced against warping, such that the maximum unreinforced panel size does not exceed 1.5 m^2 and no panel dimension is greater than 1.5 m. If casing is used as part of main heater structure, minimum plate thickness shall be 6 mm (¼ in.). Floor plates shall be 6.4 mm minimum thickness. (Mod.)

8.2.9 The minimum distance between two box-type structures (furnaces or convection sections) shall be 2.5 m, to ensure accessibility for erection, maintenance and operation.

This distance should also provide sufficient space for routing of piping (transfer lines/cross-overs) and air ducting. (Add.)

8.2.10 Floor plates shall be supported by structural beams which are a part of the heater structure, as follows:

a) Attachment to the beams shall be either by 12 mm diameter bolting with gasketing or by 100% welding.

b) A minimum of two bolts per side shall be installed for each plate, with 600 mm maximum center-to center spacing. (Add.)

8.3 Header Boxes, Doors, and Ports

8.3.1 Header boxes shall conform to the requirements of 8.3.1.1 through 8.3.1.6. (Mod.)

8.3.1.4 All convection return fittings and, if so specified on the data sheets, radiant return fittings shall be housed in airtight header boxes. (Add.)

8.3.1.5 Header boxes shall have doors allowing access to all return bends for inspection and maintenance. Where header boxes enclose plug type return bends, doors shall be hinged and shall be bolted on all sides to prevent leakage. Other header boxes shall have bolted doors with permanent lifting handles. (Add.)

8.3.1.6 Header housing (including such items as doors) shall be of steel plate. 6 mm minimum, reinforced against warping and internally insulated. The box shall be furnished with a drain connection. (Add.)

8.3.2 Door and ports shall be provided as described in 8.3.2.1 through 8.3.2.9. (Mod.)

8.3.2.5 Observation doors and ports shall be provided as required to permit visual observation of entire length of all radiant tubes, radiant tube supports, the bottom row of shield tubes, and all burner tips and flames. Observation doors shall be of cast construction, shall be equipped with a positive latching device and shall be located 1.37 m above platforms. (Mod.)

8.3.2.6 When sootblowers are provided, the inspection doors shall be provided on the walls in order to confirm the cleaning of convection tubes. (Add.)

8.3.2.7 Explosion doors shall be provided on all furnaces, with safety retaining device to support door weight in case of hinge failure.

Location and arrangement of explosion doors shall be such as to prevent direction of flame or explosive force onto any area or equipment accessible by operators or likely to cause other damage or fire. Flame deflectors may be used to direct flames from such areas. (Add.)

8.3.2.8 Access doors weighting more than 68 kg shall be provided with hinges or davits. (Add.)

8.3.2.9 Air leakage through the doors, when closed, shall be kept to a minimum. (Add.)

8.4 Ladders, Platforms and Stairways

8.4.1 Platforms shall be provided as follows:

6) At inlet and outlet terminals. (Add.)

8.4.9 Headroom over platforms, walkways, and stairways shall be minimum of 2 m as measured to the lowest point of overhead structural framing (including fireproofing) or equipment. (Mod.)

8.4.11 Platforms for servicing access doors shall preferably be located not more than 150 mm below the bottom of door. (Add.)

8.4.12 A means of escape, in addition to the usual access, shall be provided from platforms, where the travel distance to an access exceeds 15 m. (Add.)

8.4.13 Minimum live load on platforms and walkways shall be as shown in the following table:

Platform only for access operation or inspection	150 kg/m^2
Walkways	
Platforms for maintenance	300 kg/m^2

SECTION 9
STACKS, DUCTS, AND BREECHING

9.1 General

9.1.7 The top of stack linings shall be protected with a metal cap designed to effectively prevent water penetration between the stack shell plate and the lining. (Mod.)

9.1.12 An access opening for internal inspection at the base of each stack shall be provided. (Add.)

9.1.13 Top of stack shall be a minimum of 7 meters above any platform or walkway which is located within 15 meters horizontally, of the stack unless otherwise specified. (Add.)

9.1.14 Each duct shall have an access opening 600 mm × 600 mm minimum size. (Add.)

9.2 Design Considerations

9.2.16 Design shall be based on operation at 125% of furnace design capacity with 50% excess air. (Add.)

9.2.17 Maintenance access for heater stacks shall be provided. This should enable two men, with paint spray or gunite machine to work inside or outside each stack.

Inside access will be via 3 point stack tip mounted stainless trolley bars and stainless pilot cables, and outside access via a trolley rail around stack tip with pilot cable. In both cases loading should be designed for a trolley capacity of a minimum of one ton. (Add.)

9.5 Wind Induced Vibration Design

9.5.6 The entire vibrating structure including the stack, its lining, its supports and foundation must have sufficient damping capability to absorb the cycling energy input at the critical wind velocity(ies) within an amplitude which results in acceptable stresses. This requirement is waived where the critical wind velocity exceeds 97 km/hr due to the nonuniform nature of such winds.

The critical wind velocity must be calculated for all different axes, for both the corroded and uncorroded conditions, and must properly allow for support flexibility. (Add.)

9.5.7 When ladders, platforms, or piping are attached to stack, the wind loading shall be increased by multiplying the stack diameter by the following factors: (Add.)

Stack OD (mm)	Factor
610- 890	1.50
891-1350	1.37
1351-1960	1.28
1961-2570	1.20
2571-UP	1.18

SECTION 10
BURNERS AND AUXILIARY EQUIPMENT

10.1 Burners

10.1.3 All burners shall be capable of operation through a range of capacities from 33% to 120% (oil firing) or 25% to 120% (gas firing) of the maximum heat release without requiring any change in burner parts. The maximum heat release of all burners shall be suitable for 120% furnace design duty. (Sub.)

10.1.5 Each burner shall be provided with a fixed gas pilot burner arranged to light all the fuels.

The pilot burners shall be suitable for a gas pressure of between 0.2 to 0.5 kg/cm^2 g, be easily visible in normal operation and sized to remain alight under maximum furnace draft conditions. (Mod.)

10.1.6 Burner block or tile shall be prefired, have a minimum service temperature of 1650°C and shall be laid in high bonding cement. They shall be designed to be independent of the floor or wall refractory, with expansion space provided and filled with ceramic fiber insulation, so that the burner will be free to expand and contract as a unit. In addition, on bottom fired heaters only, the burner tile shall be designed such that it extends a minimum of 25 mm above the furnace floor refractory. (Mod.)

10.1.12 The Vendor shall provid burner outline drawings showing size and orientation of burner fuel connections; burner capacity data at maximum, normal and minimum heat release, density and heating value of fuel(s); gas tip drillings; atmospheric pressure and temperature at jobsite; and the draft loss across the burner and plenum.

In addition, the Vendor shall provide burner performance curves showing fuel pressure versus heat release for all fuels specified on the data sheets over the full operating range of the burner. The minimum fuel pressure for stable flame shall be labeled on all burner performance curves. (Add.)

10.1.13 Multiple burners are preferred on all heaters. (Add.)

10.1.14 Where foul gases or waste gases are disposed of by burning in a process furnace, such gases shall be piped separately to some or all of the main burner registers and injected into the main flame through separate gas nozzles. The distribution to the main burners shall be selected according to the quantities of such gases being burnt relative to the main fuel flows. (Add.)

10.2 Sootblowers

10.2.7 A local sootblowing panel shall be provided with the following facilities:

a) A master switch for the sootblowing sequence operation, also switches for individual operation or for the bypassing in sequence of the sootblowers;

b) indicating lamps showing the operation of each sootblower;

c) automatic control of the sootblower steam master valve;

d) an interlock to prevent sootblower operation until the piping has reached preset temperature, with a lamp to show "drainage complete";

e) an alarm if the sootblower has not retracted within a stipulated time;

f) retraction of the sootblower on low steam pressure or overload condition. (Add.)

10.2.8 Tube and fin erosion shall be avoided by locating the nozzles at sufficient distance from the tubes to avoid high velocity impingement. Unless otherwise specified by the sootblower vendor, blowing lance shall be 460 mm clear between the extended surfaces or tubes, as applicable. The build-up of condensate in the supply lines shall be avoided by the provision of adequate automatic drains and warming through connections. (Add.)

10.2.9 Sootblowers shall be Clyde Mark PM, Diamond power 1k or Vulcan (T) series or approved equivalent. (Add.)

10.3 Fans and Drivers

10.3.7 Induced and forced-draught fans and their drivers shall be freely accessible for maintenance, and mounted on foundation blocks separate from the heater at or near ground level. (Add.)

10.3.8 Where forced-draught is to be used, and unless otherwise the company approved by, each heater shall be provided with one forced-draught fan with a shut-off damper downstream of the fan. The fan shall be capable of supplying 120% of the air requirements when firing at 110% of the heater design duty with design excess air at the burners. (Add.)

10.3.9 On forced-draught fans driven by fixed speed drivers, control of the total air flow shall be provided by adjustable vanes in the air inlet to the fan. They shall fail open. (Add.)

10.3.10 Induced-draught fans shall meet the following requirements:-

a) The fan sizing shall be based on 125% of the flue gas quantities produced when the heater is firing at 110% of the design duty with design excess air.

The flue gas temperature in the fans shall be assumed to be at least 15°C above the calculated temperature with the furnace on design load.

b) A flue-gas bypass around the induced-draught fans shall be provided so that it is possible to operate the heater at, at least, 70% of heater duty with the induced-draught fan inoperative. The bypass shall be equipped with a quick-acting damper, the operation of which shall be initiated by fan failure. (Add.)

10.3.11 All fans shall be provided with a control room panel alarm, sensed on the shaft on the fan side of the driver coupling to indicate operational failure. In the case of forced-draught fans, this alarm signal shall initiate the "Heat-Off" action and, for induced- draught fans, the opening of the fan bypass, [see 10.3.11 (c)]. These arrangements shall be independent of any fan low-flow alarms provided. (Add.)

10.3.12 The casing shall be of such a design to facilitate removal of the rotor without dismounting the connecting ducting. The casing shall be center-line supported and guided to allow for thermal expansion without affecting the alignment of the equipment. (Add.)

10.3.13 In order to limit the effects of vibration and thermal expansion, the bearing should be mounted on rigid independent pedestals. (Add.)

10.3.14 The fan shall be statically and dynamically balanced without the coupling half. The coupling (and spacer) shall be separately balanced. (Add.)

10.3.15 The supplier shall guarantee that the installation is free of torsional critical frequencies during steady running, transient operation, during start-up, unloading or when tripped out. (Add.)

10.3.16 The direction of the fan shall be clearly and permanently marked. (Add.)

10.3.17 The baseplate for the fan shall be rigid, welded construction provided with machined and protected reference pads and shall be integral with the driver baseplate. (Add.)

10.4 Damper Controls

10.4.5 Materials for blades, shafts, and all damper components exposed to the flue gas shall be limited to a maximum service temperature as follows:

Carbon Steel	**343°C**
1-¼ Cr -½ Mo	**454°C**
Type 321 Stainless Steel	**760°C**
Type 310 Stainless Steel	**927°C (Add.)**

10.4.6 Dampers for stacks under 1.22 m inside diameter shall be of single blade construction. Larger diameter stacks shall have multiblade dampers with each blade of approximately equal surface area. Minimum blade thickness shall be 5 mm. (Add.)

10.4.7 Controllers for pneumatically operated dampers shall be located on the platform adjacent to the damper. (Add.)

SECTION 11
INSTRUMENT AND AUXILIARY CONNECTIONS

11.1.2 Flue gas and combustion air pressure

11.1.2.10 A high pressure alarm connection shall be installed immediately below the convection section of forced draft heaters. (Add.)

11.1.3 Flue gas sampling

11.1.3.5 Oxygen analyzer connections shall be provided below the damper, and at bridgewalls. (Add.)

11.1.3.6 Connections for manual flue gas sampling shall be provided at bridgewall and stack damper. (Add.)

11.3.2 Purge connections

11.3.2.3 Utility purging steam connections to provide three firebox volume changes per 15 minutes shall be distributed throughout the radiant section. (Add.)

SECTION 12
SHOP FABRICATION AND FIELD ERECTION

12.1 General

12.1.6 Where provided, feedwater preheat, steam generation, and steam superheat coils and manifolds, plus steam drums, drum trim, and all interconnecting piping shall be fabricated and stamped in accordance with section I of the ASME Boiler and Pressure Vessel Code. (Add.)

12.2 Steel Fabrication

12.2.13 Attachment of refractory anchors of tieback to heater casing shall be by manual or stud-gun welding. When manual welding is employed, welds shall be "all around". When stainless steel anchor to tieback material is used, a type 25 Cr-12 Ni electrode shall be used.

All refractory anchors shall be shop installed. Refractory anchors shall be welded on the corner of the convection opening "bullnose" for light and medium weight castable refractory. (Mod.)

12.2.18 All stacks shall be of full penetration butt-welded construction. Longitudinal seams shall be staggered and shall clear all stack openings and reinforcements. Field splices shall be welded joints with bolting for positioning only. (Add.)

12.3 Coil Fabrication

12.3.8 General requirements of welding described in 12.3.8.1 through 12.3.8.2. (Add.)

12.3.8.1 All attachments, clips,lugs and guides welded to coils shall be of the same or compatible material as the coil and shall be welded to the coil with a full penetration weld using an electrode of composition compatible with the coil and attachment. Post Weld Heat Treatment shall be the same as required for the coils, fins, and studs; tubeskin thermocouples are the only exceptions. (Add.)

12.3.8.2 Tack welds shall be made with the same type of electrode or filler wire that is used for the root pass. (Add.)

12.3.10 Filler material (Add.)

12.3.10.1 The use of carbon ½ moly filler metal for welding (P-1) carbon steel is not permitted without Purchaser's approval. (Add.)

12.3.10.2 Electrodes of the following classification are not acceptable for pressure containing welds:

E-6012, E-6013, E-7014, E-7020 and E-7024. (Add.)

12.4.3 All platforming, stair treads, railings, ladders and fasteners shall be galvanized.

Glavanized ladders, platforms and stairways defined to include galvanizing of all steel associated with the ladders, platforms, and stairways indluding knee bracing, handrails, kickplates, tread plates, and supporting longitudinal and cross framing steel. Only that steel which would be required structurally for the heater (even if platforming were excluded) shall be excluded from the galvanizing requirement. Galvanized to galvanized joints shall be bolted. (Mod.)

12.5 Refractories and Insulation

12.5.6.6 Immediately prior to resuming lining application, the exposed surfaces of the refractory, to which a bond will be made, shall be thoroughly wetted. (Add.)

12.5.7 Curing of castable refractories

12.5.7.1 The lining shall be properly cured by being kept moist during its period of hardening. The curing shall consist of light applications of clean, cool water, and shall be started as soon as the exposed surface is hard enough to permit spraying without washing out the cement which is approximately the period of initial set. Care must be exercised in avoiding a stream of water that is too harsh. The sprinkling shall consist of merely a fine mist or spray. (Add.)

12.5.7.2 During hot dry weather it may be found necessary to start spraying three or four hours after the lining has been applied. Therefore, arrangements shall be made for spraying the concrete already placed in the bottom portion of the stack while the succeeding rings are being applied. (Add.)

12.5.7.3 At no time during the curing period shall the intervals between spraying be greater than 2 hours. Once started the curing shall be continued without interruption for at least 24 hours after the last portion of the lining has been applied. (Add.)

12.5.8 Drying-out of castable refractories

12.5.8.1 After the water curing, the lining shall be allowed to dry under ordinary atmospheric conditions for as long as possible but not less than 72 hours. (Add.)

12.5.8.2 When first placed in service, the temperature of the equipment shall be raised slowly to gradually expel excess moisture. (Add.)

SECTION 13
INSPECTION AND TESTING

13.2 Weld Inspection

13.2.4 Weld repair (Add.)

13.2.4.1 Unacceptable discontinuities shall be completely removed by chipping, gouging, grinding or other methods (for the type of material being repaired) to clean, sound metal, and the excavated area shall be examined by magnetic particle or liquid penetrant methods to assure complete removal of defects. (Add.)

13.2.4.2 Repairs to correct weld defects shall be made using the same procedure used for the original weld, or other previously authorized weld procedure. (Add.)

13.2.4.3 The repaired areas shall be re-examined using the same inspection procedures by which the deffect was originally detected. (Add.)

13.2.4.4 Two repair attempts will be allowed on any one defective area. No further attempts to repair shall be carried out without the authorization of the company. (Add.)

13.5 Testing

13.5.1 Pressure testing

13.5.1.2 Pneumatic tests may be applied to heater coil assemblies under certain circumstances, upon approval of the company. The medium for such tests shall be air or inert gas. Pneumatic tests shall be at 1.1 times the design pressure. Test pressure shall be maintained for at least one hour. (Sub.)

13.5.1.5 The test pressure shall be applied as to vent all possible air from the tubes. It shall be held for sufficient time to permit examination of the entire heater for defects, but not less than one hour. No drop in pressure or leaks shall be permitted except pressure drop due to incidental temperature change. (Add.)

13.5.1.6 The pressure test shall be successfully repeated after any repairs for leaks. (Add.)

13.5.2 Refractory testing

13.5.2.1 One test sample shall be made at the beginning of each work shift and one test sample made at the end of each work shift. If two or more different materials or methods of application occur during a work shift, then test samples are required at the beginning and end of applying each material and/or method of application. (Add.)

13.5.2.2 These test samples shall be made in a carbon steel box 300 mm × 300 mm × 100 mm for castable insulation and 300 mm × 300 mm × 38 mm for medium weight (one shot) or dense castable refractories. (Add.)

13.5.2.3 Each sample shall be marked to indicate the material used, how applied (cast or gunned), and location being applied. These samples shall be weighed immediately to determine the acceptability of water to mixture ratio. Each sample shall be air dried for 12 hours and sample broken for inspection as to soundness. (Add.)

13.5.2.4 On dual layer linings test the insulating refractory lining prior to installation of stud washers and hex mesh refractory lining prior to installation of stud panels. (Add.)

13.5.2.5 Pre-Application tests

a) Sample mixtures shall be made of the refractory to be tested in strict accordance with the applicable refractory specification before proceeding to mix and apply for field installation. Three samples shall be prepared. (Add.)

b) The sample mix shall be water cured or membrane cured with applicable specification for 114 mm × 114 mm × 65 mm sample. (Add.)

c) Mixing and application for field installation shall not proceed until samples are satisfactory. (Add.)

d) Any change in materials or materials supplied from different manufacturer and change in water source shall require new sample mixture testing. (Add.)

SECTION 14
PREPARATION FOR SHIPMENT (Add.)

14.1 General

Preparation for shipment and material storage prior to shipment shall be in accordance with vendor's standards and as noted herein. The Vendor shall be solely responsible for the adequacy of the Preparation for shipment provisions employed with respect to materials and application to provide materials to their destination in ex-works condition when handled by a commercial carrier system. (Add.)

14.2 Pressure Parts

14.2.1 All liquids used for cleaning and/or hydrostatic testing shall be completely removed from all coils before shipment. (Add.)

14.2.2 Flange faces shall be clean, coated with a waterproof corrosion preventive and protected by securely fastened 6 mm thick full face metal covers, four full diameter bolts and composition or plastic gaskets.

Alternately, loose flanges may be bolted face-to-face, using four full diameter bolts and composition or plastic gaskets. (Add.)

14.2.3 Butt-weld beveled connections shall be blanked with plastic caps or plugs securely attached to the heater coil to prevent entry of any moisture. Threaded or socketweld connections shall be cleaned and plugged, or capped with metal or plastic protectors. (Add.)

14.2.4 Suitable bracing and supports shall be provided on all coils to prevent damage during shipment. Any damage during shipment that occurs because of insufficient or loose bracing shall be the responsibility of the Vendor.

This bracing and support shall be painted yellow to denote required removal before operation. (Add.)

14.2.5 Coils shall not be stored outdoors in direct contact with the soil. In addition, all openings shall be blanked at all times to prevent entry of moisture.

14.2.6 Extended surfaces on all coils with carbon steel fines shall be completely coated with suitable preservatives as recommended by the manufacturer.

Extended surfaces shall be cleaned with solvent prior to applying the preservative. (Add.)

14.2.7 Austenitic stainless steel coils (ferrous alloy coils containing more than 16 percent chromium and more than 6 percent nickel that have an austenitic structure) shall not be exposed to wetting by seawater or seawater spray, and shall be protected from rain or dew when subjected to industrial atmosphere. (Add.)

14.3 Structural

14.3.1 All external carbon steel surfaces (except those which require galvanizing) including stack shall be primed in accordance with IPS-E-TP-100 "Paints". (Add.)

14.3.2 All loose bolts and nuts shall be coated with a metallic base waterproof lubricant or shipped in watertight barrels. All threads of bolts of prefabricated items (i.e., bolts and flange covers) shall be coated with a metallic base waterproof lubricant and covered with metallic protectors. (Add.)

14.3.3 Suitable bracing and supports shall be provided to prevent damage during shipment. Any damages during shipment that occurs because of insufficient or loose bracing shall be the responsibility of the Vendor. This bracing and support shall be painted yellow to denote required removal before operation. (Add.)

14.3.4 Each heater and stack section shall be equipped with lifting lugs and structural bracing designed and positioned by Vendor to permit handling during shipment and lifting for erection without damage to the heater. (Add.)

14.4 Refractory and Internal Insulation

14.4.1 The Vendor shall be solely responsible for providing adequate preparation and protection of refractory for shipment. Preparation for shipment will be subject to inspection and rejection by the purchaser's inspectors. (Add.)

14.4.2 Adequate protection shall be provided against mechanical damage and degradation due to adverse weather conditions. (Add.)

14.4.3 For shop installed refractory, the lining shall be prepared for shipment using the following guidelines as a minimum. (Add.)

a) Castable shall be protected from rainfall and freezing.
b) Ceramic fiber shall be protected from moisture and wind.

14.4.4 Refractory which is shipped loose for field installation shall be prepared for shipment in the following manner. (Add.)

a) Castable shall be palletized shrunk wrapped in plastic and incased in waterproofed cardboard.
b) Brick and block shall be palletized.
c) Ceramic fiber shall be palletized and shrunk wrapped in plastic.

SECTION 15
GUARANTEES (Add.)

Heater manufacturer shall guarantee the following :

15.1 Heaters will process the quantities and types of material specified on the design data sheets from the inlet temperatures to the outlet temperatures specified under the pressure conditions and to be in accordance with all requirements as set forth in this specification and individual heater specification sheet. (Add.)

15.2 Heaters will provide the specified performance without exceeding suppliers specified maximum tubewall or refractory temperatures when temperature is measured with tube skin thermocouples.

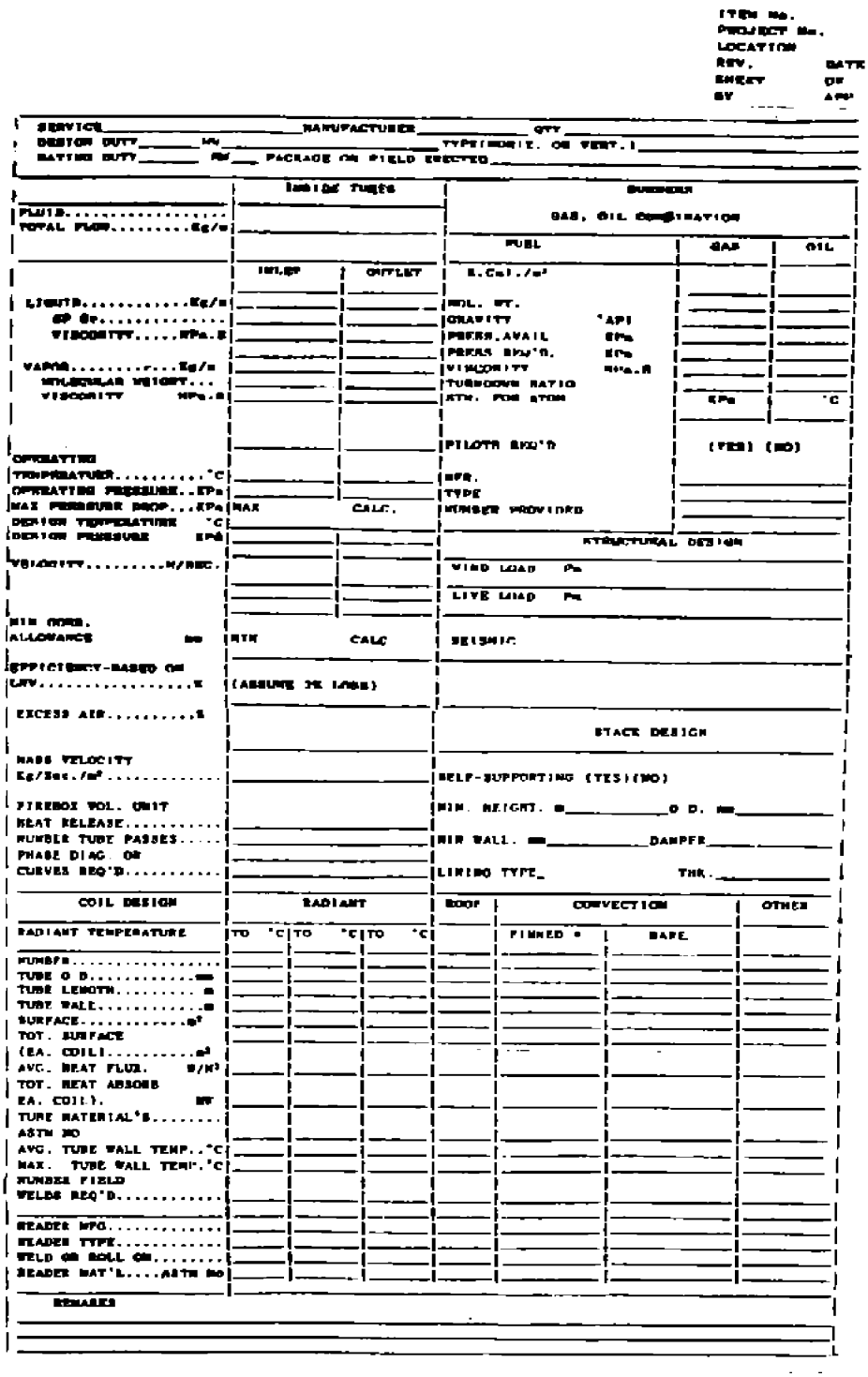
Location of peepholes to be used for guarantee test shall be marked on vendors drawing. The use of pyrometers or thermocouples for this check shall be at the option of the Company. (Add.)

15.3 Heater tubes will be completely free of all flame impingement. (Add.)

15.4 All parts which prove defective under operating use within one year from start of operation because of design, workmanship or materials used will be repaired or replaced with all charges of Freight, Site Labor, and supervision to be paid for by supplier. (Add.)

APPENDICES

APPENDIX A
FIRED HEATER DATA SHEET



(to be continued)

APPENDIX A (continued)

ITEM No._____
PROJECT No._____
LOCATION_____
REV_____DATE_____
SHEET_____OF_____
BY_____APP_____

SERVICE_____MANUFACTURER_____QTY_____
DESIGN DUTY_____MW_____TYPE (HORIZ. OR VERT.)_____
RATING DUTY_____MW__ PACKAGE OR FIELD ERECTED_____

TERMINALS (IN AND OUT) DESCRIBE	
CROSSOVERS (DESCRIBE)	
REFRACTORIES (DESCRIBE)	
TYPE-TUBE GUIDES &SUPPORTS	
NUMBER PROVIDED	
MATERIALS	
LADDERS AND PLATFORMS	
PAINT	
CONVECTIONS FINS *	HT. mm THK, mm No. PER m

DESIGN SPEC.

REMARKS

SKETCH

APPENDIX D
THE MAXIMUM ALLOWABLE STRESSES FOR THE MATERIALS GIVEN BELOW

TEMPERATURE(1) °F	°C	DEAD LOAD STRESS,(2) psi(3)	DEAD LOAD STRESS PLUS(2) FRICTIONAL STRESS, psi(3)
5Cr - 1/2Mo (A217/A 217M, Gr C5)			
800 and below	427	8750	17500
900	482	7350	14700
1000	538	4250	8500
1100	593	2500	5000
1150	621	1850	3700
18Cr 8Ni (A351/A 351M, Gr CF8)			
800 and below		6750	13500
900		6600	13200
1000		6350	12700
1100		5600	11200
1200	650	4000	8000
1300	704	2350	4700
1400	760	1500	3000
20Cr 30Ni + Nb (IN 657)			
1100		11700	23400
1200		6850	13700
1300		5175	10350
1400		3750	7500
1500	816	2525	5050
1600	871	1550	3100
25Cr 20Ni (HK-40)			
1200 and below		8750	17500
1300		6650	13300
1400		4600	9200
1500		3050	6100
1600		2000	4000
1700	927	1300	2600
1800	982	790	1580
1900	1038	410	820
2000	1093	130	260
50Cr 50Ni			
1200 and below		2000	4000
1300		1600	3200
1400		1200	2400
1500		750	1500
1600		400	800
1700		150	300
1800		75	150
60Cr 40Ni			
1200 and below		2800	5600
1300		2400	4800
1400		1800	3600
1500		1200	2400
1600		650	1300
1700		400	800
1800		250	500
1900		125	250

Notes:

1) For intermediate temperatures, allowable stresses may be obtained from a smooth curve through the data.

2) Casting factor has not been applied to these stress values.

3) 1 Psi = 6.9 kPa.