



NATIONAL PETROCHEMICAL COMPANY
STANDARDS

MATERIAL STANDARD
FOR
FIRED HEATERS

NPCS-MS-HM-09

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1 SCOPE

1.1 This standard covers the minimum requirements for design, fabrication, assembly, inspection, testing and supplying horizontal and vertical direct fired heaters (called "furnaces" for brevity). In the event of a conflict among the various documents, the order of precedence shall be as follows. It shall be the responsibility of the vendor to call attention to the conflict.

- a) Purchase order.
- b) Data sheet and inquiry or purchase order requisition.
- c) This standard.
- d) Other standards referred to.

No variations from the requisition, data sheet and this standard are permitted unless approved in writing by purchaser.

2 CODES AND STANDARDS

2.1 ABBREVIATIONS

API American Petroleum Institute.
ANSI American National Standards Institute.
ASME American Society of Mechanical Engineers.
ASTM American Society for Testing Materials.
AISC American Institute of Steel Construction.
AWS American Welding Society.

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2.2 REFERENCE CODES AND STANDARDS

ASME	"Boiler and Pressure Vessel Code", sections I, II, VIII, division 1 and division 2, and section IX.
AISC	"Standard Specification for the Design Fabrication and Erection of Structural Steel for Buildings". "Uniform Building Code" International Conference of Building Officials.
ANSI	Steel Pipe Flanges and Flanged Fittings ANSI B16.5.
API 630	Tube and Header Dimensions for Fired Heaters for Refinery Services.
ASTM	Relevant standards.
ANSI B31.3	Refinery Piping Code.
API 530	Radiant Coil Calculation Code.
AWS	Standards.

2.3 NPC REFERENCE STANDARDS

- NPCS-ES-PI-01	E.S. for Piping System Design.
- NPCS-ES-PI-02	E.S. for Piping Material Specification.
- NPCS-CS-PI-01	C.S. for Welding and Heat Treatment.
- NPCS-CS-PI-02	C.S. for Piping Fabrication and Erection.
- NPCS-CS-PI-04	C.S. for Testing, Flushing & Reinstatement of Piping.
- NPCS-CS-TP-06	C.S. for Painting.
- NPCS-CS-TP-07	C.S. for External Insulation.
- NPCS-ES-ST-02	E.S. for Steel Structure.
- NPCS-CS-ST-02	C.S. for Steel Structure.
- NPCS-ES-ST-03	E.S. for Fireproofing.

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- NPCS-ES-RE-01 E.S. for Noise Control.
- NPCS-ES-IN-01 E.S. for Instrumentation.
- NPCS-ES-EL-04 E.S. for Lighting System Design.
- NPCS-MS-EL-16 M.S. for Air Craft Warning Lights.

3 EXTENT OF THIS STANDARD

3.1 This standard covers the requirements for:

- Casing.
- All structural steel.
- Refractories.
- Burners.
- Tubes, fittings and hangers.
- Stacks and breeching.
- Dampers.
- Stairways, ladders and platforms.
- Roofs.
- Tube rollers and other special tools.

3.2 All components, including structural steelwork, ladders, stairs and platforms shall be shop fabricated, assembled and supplied by the heater seller, to the maximum possible extent in accordance with the available shipping and handling facilities. All structural steel subassemblies shall be clearly marked for field identification.

3.3 Approval of vendor's drawings shall not relieve him from his responsibility to provide equipment suitable for the intended services and designed and fabricated according to good workmanship practices.

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- 3.4 Where specification and data sheet refer to imperial units, they should be converted to the SI units of measurement, except for pipe diameter and nozzle sizes for which inch nominal size shall be used; see NPCS-ES-GN-03.
- 3.5 Texts on drawings and documents shall be in English. Descriptions may be in other languages, provided English translation is added.

4 THERMAL DESIGN

4.1 GENERAL

- 4.1.1 Calculated and guaranteed efficiencies shall be as what will be shown on the data sheets and shall be based on design duty, fuel lower heating value and 15% excess air for fuel gas or 30% excess air for fuel oil. If properties of the fuel gas are not given, the efficiency guarantee shall be based on the assumption that the fuel contains 20 wt% of hydrogen.
- 4.1.2 The average radiant heat flux which will be 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.
- 4.1.3 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 an operating average flux density for any given length of tube surface.
- 4.2 Process design conditions will be shown on the individual fired heater data sheets.
- 4.3 Thermal designer shall specify the amount of excess air and stack temperature when operating at the guaranteed efficiency.

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4.4 TUBE LENGTH

4.4.1. Circular, Updraft, Bottom Fired Heaters

The length of the radiant tubes * (exclusive of return bends) divided by the diameter of the tube circle, L/D, shall be as follows:

Design Absorption MW	mm BTU/h	Maximum L/D	Minimum L/D
Up to 2.930	10.0	2.00	1.50
2.930 to 5.860	10.0 to 20.0	2.50	1.50
Over 5.860	20.0	2.75	1.50

* The maximum tube length allowed is 18300 mm.

4.4.2 Horizontal Tube Heaters

4.4.2.1 The convection tubes shall be of the same length as those in the radiant section.

4.4.2.2 For bottom fired heaters **, the following shall apply:

An equivalent L/D factor shall be determined by dividing the height of the wall bank (or the straight tube length if tubes are vertically disposed) by the width of the tube bank and applying the limitations noted in paragraph 4.4.1 under circular updraft heater.

** This category also includes the box type heater with vertical radiant tubes. The maximum vertical tube length allowed is 18300 mm.

4.4.2.3 "T" shaped flue gas distributing baffles shall be provided to cover approximately 50% of the area just below the breaching and shall be so spaced as to equalize the draft along the length of the heater. They shall be supported independently of the tubes or the refractory. Crawl space of at least 760 mm in height shall be provided for access to the baffles. If the convection tubes have extended surface, baffles may be eliminated.

4.4.2.4 End Fired Heaters

Maximum tube length allowed is 15250 mm, unless otherwise noted.



4.5 DETERMINATION OF MINIMUM FIRING DISTANCES

4.5.1 Vertical Firing

4.5.1.1 The combustion chamber size shall be adequate to prevent flame impingement on the tubes. Minimum clearance between burner centerline and tube centerline shall not be less than the following for natural draft burners:

Max. Heat Release per Burner MW (mm BTU/h)	Distance, mm (inches)	
	Gas Firing	Liquid Fuel
0.733 (2 1/2) or less	838 (33)	991 (39)
0.733 (2 1/2) but less than 1.758 (6)	991 (39)	1219 (48)
1.758 (6) but less than 3.517 (12)	1143 (45)	1448 (57)
Greater than 3.517 (12)	To be approved	

4.5.1.2 For forced draft burners, user shall be consulted.

4.5.1.3 The minimum distance from the discharge of the burner to the tubes, refractory or stack entrance in-line of the burner throw, shall be 610 mm per 290 KW (1 mm BTU/h) plus 1800 mm for firing any fuel or combination of any fuels.

4.5.2 Horizontal Firing

4.5.2. For horizontal tube, side fired heaters, the following shall apply:

- The bottom radiant tube shall be shielded by a corbel ledge that extends 300 mm beyond the centerline of the tube. The clearance between the upper part of the burner block and the lowest tube shall be 610 mm.
- There shall be an unobstructed distance of 2130 mm minimum from the face of the burner block to the center wall or target wall. Opposing burners in this style of heater without the wall is unacceptable.

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4.5.2.2 For horizontal tube, end fired heaters, the following shall apply:

- a) A minimum of 2440 mm shall be provided between the uppermost horizontally disposed burner and the centerline of the top tube in the vertical wall tube bank.
- b) Opposing burners shall follow the criteria as outlined in paragraph 4.5.1.3.
- c) At least 1830 mm shall be provided between the centerline of any burner and the centerline of any tube.
- d) The centerline of the bottom radiant tubes shall be no less than 910 mm above the floor.

4.5.2.3 For bottom fired, horizontal tube heaters, the following shall apply:

- a) The centerline of the bottom radiant tubes shall not be less than 610 mm above the floor.
- b) One sight port per burner shall be provided in the floor.
- c) The burner clearances as stated under circular heaters shall apply.

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5 MECHANICAL DESIGN

5.1 All furnaces of the same type shall be designed as far as practical to use the maximum of interchangeable parts (heater tubes, tube headers, supports, etc.). Thus, an inventory of spare parts will be kept to a minimum.

5.2 Mechanical parts shall be designed, fabricated and tested in accordance with the applicable codes and standards, latest edition.

5.3 MATERIALS

Materials shall be according to the following specifications or approved equivalent. Unless otherwise specified on individual data sheets, the following material specifications shall be used:

5.3.1 Tubes

Carbon steel ASTM A106, grade A or B.

C-1/2 Mo A335, grade P1.

1 1/4" Cr-9 Cr Moly A335, applicable grade.

Cr/Ni A376, applicable grade.

- Tubes in a Hydrogen free environment subject to H₂S corrosion should have materials selected according to "High Temperature Sulfidic Corrosion in Hydrogen Free Environment" by Henry F. McComomy.

Fins or studs (where permitted):

a) Tip temperature up to 468°C (875°F), Carbon Steel.

b) Tip temperature up to 620°C (1150°F), 11-13 Cr Steel (minimum).

c) Tip temperature over 620°C (1150°F), 18-8 Stainless Steel.

5.3.2 Steel Piping Materials

ASTM, latest edition

5.3.3 Steam Coils

Per ASME Power Boiler Code, Section 1, latest edition.

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5.3.4 Columns, Beams, Structural Shapes and Refractory Protected end Tube Sheets

Carbon Steel ASTM A36, or equivalent.

5.3.5 Steel Plate Enclosure

Carbon Steel ASTM A283, grade C or equivalent.

5.3.6 Fittings

Material	Product			
	CASTINGS		FORGINGS	
	ASTM	Grade	ASTM	Grade
Carbon Steel	A-216	WCA or WCR	A-181	I or II
Carbon 1/2 Mo	A-217	WC-1	A-182	F1
1 1/4 Cr 1/2 Mo	A-217	WC-6	A-182	F11
2 1/4 Cr 1 Ma	A-217	WC-9	A-182	F22
5 Cr 1/2 Mo	A-217	c-5	A-182	F5
9 Cr 1 Mo	A-217	c-12	A-182	F9
18 Cr 8 Ni Cb	A-351	Applic. grade	A-182	Applic. grade
18 Cr 8 Ni Ti	A-351	Applic. grade	A-182	Applic. grade
25 Cr 20 Ni	A-351	Applic. grade	A-182	Applic. grade

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5.3.7 Flanges

Carbon Steel : ASTM A-181.
ASTM A-105 Gr.I or Gr.II.

Alloy Steel : ASTM A-182 applicable grade.

5.3.8 Bolts (for high temperature service)

Alloy Steel ASTM A193 or equivalent.

5.3.9 Tube Support Casting Bolting

ASTM A320 B8 or equivalent.

5.3.10 Nuts

Alloy Steel ASTM A194, type II or equivalent.

5.3.11 Stacks and Breeching

Carbon Steel ASTM A283, grade C or equivalent.

5.3.12 Dampers

For an all-radiant heater damper material shall be 25-20 Cr/Ni alloy. For a radiant-convection heater damper material shall be Stainless Steel type 321. If in both cases the fuel used exceeds 50 wt ppm Vanadium and the gas temperature exceeds 593°C (1100°F), the damper material shall be 50-50 Cr/Ni Niobium alloy.

5.3.13 Tube Hangers, Supports and Plates Other than Refractory Lined

All tube supports, tube guides, retainers, baffles and baffle supports shall be of cast 25-12 Cr/Ni alloy (ASTM A447, type II). Below 648°C (1200°F) Meehanite, type HR-1 (or equal) may be used for baffle and baffle supports. Where the fuel burned in the heater(s) contains more than 50 wt ppm Vanadium, 50-50 Cr/Ni niobium alloy castings (including baffles, dampers and bolts for fastening tube support castings) shall be used where the gases to which they are exposed exceeds 593°C (1100°F). End tube sheets, where required, shall be as what will be called for in the heater data sheets.

5.3.14 Setting and Refractories

Burner blocks shall be of prefired refractory shapes (no castable refractory).

Breechings and connecting duct work shall have a minimum of 76 mm (3") of insulating concrete or equal.

- Self-supporting grade mounted stacks (if applicable):

A steel plate having a minimum thickness of 10 gage shall be welded to the inside circumference of the stack just below the duct inlet connection(s). This plate shall be sloped and provided with a 2" pipe connection for draining any condensate that collects on the plate. This plate shall be surfaced with a minimum thickness of 75 mm of heat resisting concrete.

Overhead flues shall be constructed of mild steel plate 5 mm minimum thickness and shall be lined with 75 mm insulating concrete.

- End of Side Walls:

All refractory shapes shall be of high heat duty type and shall conform to ASTM specification C27.

- End walls:

a) Setting shall consist of minimum 150 mm of field applied refractory securely anchored to steel plate work. Materials and method of application shall be specified in the requisition.

b) The insulating concrete shall be protected (to a height just above the burner blocks or access doors) with 115 mm of high duty firebrick or 75 mm of high temperature castable.

- Miscellaneous joints:

All joints shall be packed moderately tight with slightly moistened insulating cement.

- Center wall (where required):

Unless otherwise noted, bricks shall be laid up in a high temperature, air setting cement. They shall be dipped into a mortar of a consistency as recommended by manufacturer and laid by the rub and tap method to ensure close fitting joints.

All joints are to be as thin as possible.

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