

DEP SPECIFICATION

FIRE HEATERS
(AMENDMENTS/SUPPLEMENTS TO API STD 560)

DEP 31.24.00.30-Gen.

February 2017

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DESIGN AND ENGINEERING PRACTICE

DEM1



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PART I INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for design, materials, fabrication, inspection, testing, preparation for shipment, and erection of fired heaters. It includes related equipment such as convection banks, air preheaters, burners, air and flue gas ducts, and forced and induced draught fans.

This DEP also specifies requirements and gives recommendations for unfired waste heat recovery steam generation and steam superheating convection sections for fired heaters.

Excluded from the scope of this DEP are the following:

- Materials selection for special heaters such as high-temperature conversion and steam heaters (tube wall temperature above 700 °C (1292 °F)) and for heaters for catalytic chemical reactions.
- Waste heat steam generators associated with gas turbine exhausts. This subject is covered by DEP 30.75.10.31-Gen.

This DEP is based on API STD 560, Fifth edition:2016. Part III of this DEP amends, supplements and deletes various clauses of API STD, Fifth edition:2016. Part III follows the clause numbering of API STD 560.

All clauses of API Standard 560, Fifth edition:2016 not modified by this DEP remain valid as written.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual (DEM) 1 – Application of Technical Standards.

This is a revision of the DEP of the same number dated February 2011; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorisation to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing and gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

In API STD 560, the term **Purchaser** is used. In this DEP, the term Purchaser shall be understood to mean the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

In API STD 560, the term **Vendor** is used. In this DEP, the term Vendor shall be understood to mean the Manufacturer/Supplier.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

The word **may** indicates a permitted option.

1.3.2 Specific definitions

Term	Definition
Delegated Technical Authority	A person who has received delegated authority from the applicable decision executive to approve technical decisions (including authorisation of deviations to the specification)
Design Class	A categorization defining fit-for-purpose facilities developed through Value Improvement Processes (VIPs) during a project Front End Development (FED) phase.
Fabricator	Provides the facilities and services to physically construct, all or part of the fired heater under contract to the Manufacturer/Supplier. The Fabricator is responsible for the quality control of their own works and quality assurance of any directly purchased or sub-contracted work by them.
Pipe	Equivalent to piping, tube, tubing
Process Safety	A general term for the management of hazards that can give rise to major accidents involving the release of potentially dangerous process materials, release of energy (such as fire or explosion) or both.
Proven	Proven means the system has accumulated 100,000 hours of successful operation at a minimum of three different installations.
Tube	Equivalent to tubing, pipe, or piping.

1.3.3 Abbreviations

Term	Definition
AES	Alkaline-Earth-Silicate
AMCA	Air Movement and Control Association
BDEP	Basic Design Engineering Package
HTF	Heat Transfer Fluid

Term	Definition
RCF	Refractory Ceramic Fibre
TAN	total acid number
VIV	variable inlet vane
WHMIS	Workplace Hazardous Materials Information System

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (Part IV).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated February 2011. The following are the main, non-editorial changes.

Section/Clause	Change
All	DEP fully based on API STD 560, ISO 13705 is no longer applied.
11	Substituted with refractory DEP 44.24.32.30-Gen.
6.4.2	Horse shoe fitting no longer specified in detail in view of their limited application for new furnaces.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://www.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

PART II GENERAL

1.1 GENERAL

Part III of this DEP is written as amendments and supplements to API Standard 560, Fifth Edition. Wherever reference is made to API Standard 560, Fifth Edition, it shall be understood to mean API Standard 560, Fifth Edition:2016 as amended/supplemented by this DEP.

For ease of reference, the clause numbering of API Standard 560 has been used throughout Part III of this DEP.

Clauses in API Standard 560 which are not mentioned in this DEP shall remain valid as written.

1.2 DESIGN CLASS CONSIDERATIONS

Decisions related to the Design Class performance categories for fired heaters are beyond the scope of this DEP. Such decisions are intended to be made by the Principal in the project DEFINE phase and detailed in project scope defining documentation, e.g., equipment BDEP (Basic Design Engineering Package), fired heater data sheet, fired heater checklist, and project specific specifications.

1.3 DECISIONS

A bullet (•) is shown in the margin of this DEP where further decisions or information are to be provided by the Principal or Contractor. Refer to Standard Form DEP 31.24.00.82-Gen. for recording decisions on the bulleted items of API STD 560 and additional ones added to this DEP.

Where the intent in this DEP is an action or decision primarily by the owner, the term Principal is used. Where the intent in this DEP is for an action or decision primarily by the engineering Contractor working on behalf of the Principal, the term Contractor is used.

PART III AMENDMENTS/SUPPLEMENTS TO API STD 560**1 Scope**

Delete this section and replace with (Part I, 1.1) of this DEP.

3 Terms, Definitions, Symbols, and Abbreviations**3.1 Terms and Definitions**

Add the following new terms:

3.1.116 Design Heat Release

Heat release including a defined capacity margin as a percentage of the calculated normal heat release for the burner(s).

3.1.117 WHMIS

Workplace Hazardous Materials Information System

4 General**4.1 Pressure Design Code**

Add the following to this clause:

- 1. Unless otherwise specified, the pressure design code shall be:
 - a. ASME VIII and ASME B31.3 for process piping/tubing and auxiliary piping;
 - b. ASME I and ASME B31.1 for steam piping/tubing and auxiliary piping.
- 2. Design, fabrication and testing requirements shall be in accordance with the pressure design code as amended by the following standards for process piping/tubing including any inlet, cross-over, outlet piping and auxiliary piping references:
 - a. API 530 for internal piping /tubing;
 - b. DEP 31.38.01.11-Gen. for external piping;
 - c. DEP 31.38.01.31-Gen. for fabrication and testing.

4.2 Regulations

Add the following to this clause:

- 1. Refer to (PART I, 1.2).

4.3 Heater Nomenclature

Add the following to this clause:

- 1. Vertical box-type heaters with radiant cells of rectangular or square horizontal cross section and separating walls consisting of single or double tube rows may be applied.
- 2. Convection sections may be either top or side-mounted, provided an even flue gas distribution is obtained.

Add the following new clause:

4.4 Conflicting Requirements

1. The descending order of precedence for requirements shall be as follows (i.e., the uppermost items takes precedence over the lower items):
 - a. regulatory requirements;
 - b. purchase order, including pre-purchase correspondence, clarifications, and notes of pre-selection and pre-award meetings;
 - c. data sheets, relevant Basic Design Package, related technical notes, and drawings;
 - d. Design and Engineering Practice (i.e., this DEP).
2. Exceptions or deviations to the documents in (4.4, item 1) shall not be permitted unless they meet all of the following:
 - a. specified by the Manufacturer/Supplier;
 - b. approved by the Principal;
 - c. included in the purchase order by the Contractor.

5 Proposals

5.1 Purchaser's Responsibilities

5.1.2

Replace the 2nd sentence of this clause with the following:

1. The purchaser shall complete, as a minimum, those items on the datasheet that are designated by an asterisk (*).
2. The Contractor and the Manufacturer/Supplier shall use API STD 560.
See 5.2, item a) in API STD 560.

5.1.3

Add the following to this clause:

- 1. The Contractor shall provide fired heater data sheets and project specifications that specify the following:
 - a. refractory lining system requirements;
 - b. requirements for the extent of shop and field installation of refractory linings;
 - c. requirements for Shop versus field refractory dryout;
 - d. degree of assembly for delivery to site including shipping requirements and constraints;
 - e. handling of field joints including the need for supply of refractory materials;
 - f. period of time before commissioning or heating for refractory preservation considerations;
 - g. any alternatives that may be requested and quoted in addition to the base requirements.

5.2 Vendor's Responsibilities

Replace items a), e), i) and j) with the following:

- a. completed data sheets for each fired heater and the associated equipment (including burners, air preheaters, fans and motors) with all missing data including the following:
 - i. Process conditions with a note for Total Acid Number and feed S wt% and properties at the convection and shield section outlets, including mixture enthalpy and in-tube vapour or superficial liquid and vapour velocities;
 - ii. Combustion design conditions along with flue gas emissions for each identified operating case;
 - iii. Refractory hot face temperatures to be used for heat flow calculations.
- e. a completed noise data sheet;
- i. a list of electrical power requirements for motors, other utilities and quantities required;
- j. a list of sub-suppliers and country of origin proposed for the supply, manufacture and fabrication of all components, including the following:
 - i. heater coils;
 - ii. fittings;
 - iii. extended surfaces;
 - iv. castings;
 - v. burners;
 - vi. fans;
 - vii. air preheaters;
 - viii. setting steel;
 - ix. refractory supply;
 - x. assembly/sub-assembly facilities;
 - xi. refractory installation;
 - xii. other auxiliary equipment (e.g., SCR).

Add the following new items:

- k. Vendor shall demonstrate that all heater parts are suitable for operation at up to 115 % of burner normal heat release with the excess air level as indicated in (6.2.1) (no increase in design absorption is implied);
- l. overall quality control/quality assurance plan applicable to all phases of the project.

Add the following new clauses:

- 1. Alternative designs may only be offered in addition to that requested by the Principal.
- 2. The proposal shall identify first-time use of any design or component, including materials, capacity, emissions, or any aspect of performance.

First-time use is considered to be fewer than two years of successful operation at two separate facilities.

- a. First-time use designs shall be subject to the approval of the Principal's Delegated Technical Authority.

- b. Supporting data and references shall be provided to the Principal upon request.

5.3 Documentation

5.3.1 Drawings for Purchaser's Review

Replace items f) and g) with the following:

- f. refractory and insulation types, product brand names, product continuous use temperature, layer thicknesses, extent of coverage and method of application;
- g. types, and materials, spacing and layout of anchors and supports for refractory and insulation;

Add the following new items to this clause:

- k. convection and shield section arrangement drawing, including all inside lining dimensions, tube layout, corbels, clearances between tubes/fins, and refractory, tubesheet details and any intermediate tube supports, including attachments as applicable;
- l. detailed drawing of all ancillary nozzles, instrument and sample connections;
- m. visibility diagram related to placement of observation ports together with details of their design;
- n. detailed drawings of the heater auxiliary equipment, including all louvers, dampers expansion joints, fans, motors, air heaters, burners, soot blowers, as applicable.

Add the following to this clause:

- 1. The Manufacturer/Supplier shall provide all drawings, design details, stress calculations, operation and maintenance manuals, and other information necessary for the design assessment, erection, operation and maintenance of the installation.
- 2. All information specific to the installation being supplied shall be in the English language.
 - a. Descriptions on drawings may be in languages other than English, provided English translations are given.

5.3.3 Documents for Purchaser's Review

Replace items c), e), f) and k) with the following:

- c. tube support details and design calculations, clearly stating basis, assumptions, and design margins;
- e. quality inspection and test plan (ITP) detailing welding examination and test procedures for all pressure and structural components as well as refractory anchors, studs, and pins;
- f. installation procedures, including surface preparation, curing, dry-out, and start-up and test procedures for refractories and insulation;
- k. noise data sheets.

Add the following items to this clause:

- l. refractory quality documentation as specified in (17.5.2);
- m. complete and current material safety data sheets (MSDSs) for each product;
- n. pressure profile curves or information demonstrating draught and draught loss profile throughout the heater and air preheater from air suction to stack outlet based on the conditions as defined in (6.2);

- o. percent of full travel versus pressure loss curves for combustion air and flue gas control dampers for design flows. See (6.2.1);
- p. burner capacity curves for all fuels specified and combustion air for forced draught burners at 15 °C (60 °F) and design temperature;
- q. burner test procedures;
- r. calculations and drawings for all lifting attachments;
- s. Manufacturer's/Supplier's documentation of tube by tube temperature, pressure and % vaporisation profile along the coil with intube vapour or superficial liquid and vapour velocities.

5.4 Final Reports

Replace items a), f) and g) with the following:

- a. certified as built drawings, calculations and inspection reports of lifting attachments (submitted 4 weeks prior to release of equipment to the Contractor);
- f. noise data sheets;
- g. refractory dry-out temperature recording charts including details of ambient conditions of lined equipment storage and time lapse between installation and first refractory dryout, when dry-out is included in the Manufacturer's/Supplier's scope of supply.

Add the following new clauses:

- k. environmental performance data, if requested by Contractor;
- l. burner test reports;
- m. list of all spare parts, including list of initial spare parts necessary for start-up and first year of operation, with detailed prices and time of delivery;
For requirements and recommendations for the identification, selection, purchase and setting of stock levels for spare parts see DEP 70.10.90.11-Gen. This DEP refers to www.e-spir.com, which is an application to support the Spare Parts identification process and workflow.
- n. list of all tools necessary for operation, maintenance, inspection and cleaning that are not normally found in a refinery workshop;
- o. weight of each unit for the following conditions:
 - i. empty;
 - ii. full (hydraulic test conditions);
 - iii. full (working conditions).

6 Design Considerations

6.1 Process Design

6.1.1

Replace the second sentence with the following:

1. Multi-pass heaters shall be designed for hydraulic symmetry of all passes and for equal heat pick-up per pass.

Add the following to the end of this clause:

2. Collection and distribution manifolds on multi-pass heaters shall be sized so that the frictional head loss over the total manifold length, based on a constant

velocity equal to the maximum (inlet) velocity, does not exceed 5 % of the individual pass pressure drop.

6.1.2

Add the following to this clause:

- 1. For non-vaporising service where in-tube decoking is not required, multiple passes in an upstream section (usually the convection section) may be combined to a single pass.

6.1.3

Replace this clause with the following:

1. Average radiant absorption rate shall be calculated by dividing the total heat absorbed in the radiant section by the total radiant tube area.
2. Convection shield tubes not directly exposed to the flame zone shall not be used in determining the average absorption rate or bridgewall temperature.
3. If shield tubes are directly exposed to the flame zone, only the first row shall be evaluated in determining average radiant flux and bridgewall temperature.

6.1.4

Replace this clause with the following:

- 1. Unless specified otherwise, the average heat absorption rates in the radiant cell shall be limited as in Table 6.1:

Table 6.1 Limits of average heat absorption rates in the radiant cell

Arrangement	kW/m ²	Btu/h-ft ²
Horizontal tube fired from one side	35.0	11 000
Vertical tube fired one side from bottom	31.5	10 000
Single tube row uniformly fired both sides		
From bottom	43.0	14 000
From both sides or ends	47.7	15 000

- 2. To allow deviation from Table 6.1 it shall be demonstrated to the satisfaction of the Principal's Delegated Technical Authority that, by verifiable modelling, the maximum allowable film temperatures are not exceeded.

Add the following new clauses:

6.1.6

1. The maximum heat flux, on the basis of bare tube surface, to any convection or shield tube shall not exceed twice the average radiant heat flux for single fired tubes, in accordance with the more stringent of the following:
 - a. data sheets;
 - b. 70 kW/m² (22 000 Btu/h-ft²).
2. The maximum flux shall be calculated as the sum of the following values for the specified heater design conditions:

Temperature difference for calculations is based on the process inlet temperature and flue gas temperature entering the tube row being studied.

- a. calculated average convection flux multiplied by 1.15;

- b. direct radiant heat flux from combustion chamber and reflected from reradiating walls to front 60° of tube and its extended surface;
 - c. average rate of radiant heat gain from flue gas to tube, including extended surface.
- 3. To allow deviation from (6.1.6, item 2) it shall be demonstrated to the satisfaction of the Principal's Delegated Technical Authority that by verifiable modelling, the maximum allowable film temperatures are not exceeded.
- 4. The maximum heat flux to the first row of finned tubes shall be lower than that to the shield tubes.
 - a. alternatively, an inspection lane shall be provided between bare and finned section. Reference (6.3.4).

6.1.7

- 1. Design in-tube velocities in vapour and vapour-liquid flow shall be limited to a maximum of 85 % of critical velocity (V_{crit}), which is calculated according to Equation 6.1 assuming homogeneous mixture, unless otherwise specified.

$$V_{crit} = (P_{crit}/\rho_{mix})^{0.5} \quad \text{Eqn. 6.1}$$

Where:

P_{crit} = Critical pressure; N/m^2 (lbf/ft²)

ρ_{mix} = homogeneous mixed phase density; kg/m^3 (lb/ft³)

• 6.1.8

- 1. All heaters in vapourising or two-phase flow service, including the outlet piping and transfer line, shall be subject to detailed review of flow regimes and potential for flow instability or erosion-corrosion over the full operating range, with evaluations subject to approval by the Principal's Delegated Technical Authority.
- 2. Where vapour and liquid phases can coexist in the heater coil, the following conditions SHALL [PS] be met:
 - a. heater tube coils are designed to maintain stable flow conditions over the complete range of specified operating flow rates and heat inputs;
 - b. flow regimes ensure fully liquid-wetted walls as follows:
 - i. two-phase flow regimes for both horizontal and vertical coils is either bubble, froth, plug, and/or annular;
 - ii. no cases where flow regime in horizontal coils is stratified, wave, or wave/mist;
 - iii. superficial velocity is greater than 1 m/s (3.3 ft/s) or the superficial vapour velocity is greater than 8 m/s (26.2 ft/s) for vertical flow and 10 m/s (32.8 ft/s) for horizontal flow;
 - iv. in hydroprocessing heaters, superficial velocity is greater than 1 m/s (3.3 ft/s) or the superficial vapour velocity is greater than 3 m/s (9.8 ft/s) for vertical flow.
- 3. Heater coil designs shall have an erosional velocity lower than the maximum allowable erosional velocity resulting for an erosional velocity coefficient of $C > 220$ in SI units (180 in US Customary units), unless otherwise approved by the Principal's Delegated Technical Authority. See Equation 6.2

$$C = V_m \times \text{SQRT } \rho_m \quad \text{Eqn. 6.2}$$

Where:

V_m = homogeneous mixed phase velocity; m/s (ft/s)

ρ_m = homogeneous mixed phase density; kg/m³ (lb/ft³)

- 4. The critical limits shall be established by the Contractor during design and incorporated into operating controls and procedures.

6.1.9

1. Transfer lines from a heater to a distilling column shall be routed so that, immediately upon leaving the heater, they rise to an elevation above the entry point to the column and slope continuously down towards the column, with no areas to accumulate liquid.
2. Vertical parts of lines transporting gas/liquid mixtures shall have stable flow conditions in the complete operating range of the heater as specified in the requisition.

6.1.10

1. For the design of convection sections, the minimum flue gas mass flux (between bare tubes) at design process duty should be 2.5 kg/m²s (0.52 lb/ft²-s).
 - a. for natural draught heaters with top mounted convection sections and stacks, if this results in either insufficient draught at the heater or impractical stack heights, the flue gas mass flux may be reduced to a minimum of 1.8 kg/m²s (0.37 lb/ft²-s).

6.2 Combustion Design

6.2.1

Replace this clause with the following:

1. The combustion system (fuel gas train and controls) shall be sized for a maximum heat release of 115 % of normal burner heat release for the heater operating at the specified process design conditions, with design air excess levels as (6.2.3).

This margin is not intended to permit continuous operation of the heater at greater than the design process duty.

Refer to Table 6.2 for further definition of burner heat release in reference to API STD 560, API RP 535, and guidance for sizing of fuel gas trains and alarm and trip settings.

2. The burner shall be capable of operating at minimum and maximum stable heat release conditions as per Table 6.2.
 - a. This should be verified during a burner test.
3. Refer to (14.1) for information on burner sizing and testing.

Table 6.2 Fuel gas train design, alarm, and trip settings

API STD 560		Fuel Gas Train Design		API RP 535	
Burner Heat Release	Definition	Fuel Flow	Definition	Burner Heat Release	Definition
		125 %	HIGH-HIGH burner pressure TRIP to minimum firing TRIP Pressure = pressure @ 125% of <u>normal heat release</u>	Maximum Stable Heat Release	The maximum heat release for the burner at the point of CO breakthrough with the air register at the same setting as “design” heat release <u>or</u> 100 % open
			HIGH fuel pressure critical alarm and cutback to 90% of last temperature control setting - midpoint between design and HIGH-HIGH pressure TRIP pressures	Maximum	The heat release for the burner with design excess air and design draft loss with air register 100% open
Design ¹ <u>Low ΔP burners</u> #. Burners ≤5 =120% 6-7=115% ≥8=110% <u>High ΔP burners</u> 115 %	The heat release per burner including a defined capacity margin as a percent of the calculated normal heat release	110 - 120 %	Design fuel flow for fuel gas train and controls with all burners operating at 110 % - 120 % of the calculated normal heat release with leanest design fuel ^{2,3} - Burner tip pressure design ~ 165 kPag ⁴ - Active high burner pressure control set point - HIGH Fired Duty standard alarm set point	Design	The specified design heat release for the burner with the air register set for the design excess air with design draft loss

API STD 560		Fuel Gas Train Design		API RP 535	
Normal	The heat release per burner required for the design total absorbed duty for the heater divided by the calculated fuel efficiency.	100 % 4:1 of Design	The fuel flow for control valve sizing with all burners operating at 100 % of the calculated normal heat release with leanest design fuel. Upper range of fuel flow and pressure for the "active minimum burner pressure control". Pressure = 1/16 th of Design	Normal	The specified normal heat release for the burner with the air register set for the design excess air with design draft loss
Minimum	The heat release per burner for the specified turndown of the heater or burner	5:1 of Design	Lower range of fuel flow and pressure for the active minimum burner pressure control. Pressure = 1/25 th of Design - LOW burner fuel pressure "critical" alarm = pressure @ midpoint of min. pressure control and LOW-LOW TRIP	Minimum	The specified “minimum” heat release for the burner with the air register set at the same setting as the “normal” heat release <u>or</u> with the air register set for the design excess air
		6:1 of Design	Expected minimum burner pressure for stable operation below which the fuel should be tripped. Pressure = 1/36 th of Design LOW-LOW burner pressure total fuel TRIP	Minimum Stable Heat Release	The minimum heat release for the burner at the point of CO breakthrough with the air register at the same setting as “normal” heat release
NOTE: 1 Refer to (14.1.7) 2 Leanest design fuel does not include natural gas when natural gas is identified for start-up considerations only. 3 Refer to (6.2.1) 4 Recommended design burner tip fuel pressure provides measurable fuel pressure at T/D and trip, and avoiding sonic flow conditions at maximum heat release					

6.2.2

Add the following to this clause:

1. Efficiency shall be based on the specified ambient air temperature at the stated relative humidity.
2. Heaters shall be designed and constructed for air infiltration low enough that operation with 10 % excess air can be continuously sustained at 100 to x % duty, where x is the specified process turndown and x is ≥ 50 %.

6.2.3

Replace this clause with the following:

1. Unless otherwise specified, calculated efficiencies for heaters without lead/lag closed loop combustion control (e.g., natural-draught operation) shall be based upon the following:
 - a. 15 % excess air if gas is the primary fuel;
 - b. 20 % excess air if oil is the primary fuel.
2. For heaters with lead/lag closed loop combustion control (e.g., forced-draught burners or balanced-draught operation), calculated efficiencies shall be based upon the following:
 - a. 10 % excess air for fuel gas;
 - b. 15 % excess air for fuel oil.

6.2.5

Replace this clause with the following:

1. Volumetric heat release in the radiant section shall not exceed 83 kW/m^3 (8000 Btu/h-ft^3) for oil firing and 124 kW/m^3 (12000 Btu/h-ft^3) for gas firing at the design heat absorption and excess air.

6.2.6

Add the following to this clause:

1. For heaters with induced draught fans, the stack and flue systems downstream of the fan shall be sized for 120 % of normal burner heat release.
2. The induced-draught fans shall be sized in accordance with the combustion system design specified in (6.2.1) and a 1.15 test-block flow factor as specified in (F.7.4.2).

Add the following new clause:

6.2.7

1. Stack sizing/draught calculations shall be based on the maximum specified ambient temperature.

6.3 Mechanical Design**6.3.4**

Add the following to this clause:

1. The convection section tube layout shall provide open access lanes to permit inspection, with a minimum vertical clear space of 600 mm (24 in) at the following locations:
 - a. between bare shock tubes and finned tubes where the heat flux to the first finned tube row is greater than that to the shield tubes (6.1.6);
 - b. at locations where there is a change in process;

- c. between each 15th tube row when firing clean gas;
- d. for oil firing, to align with soot blower lanes, see (14.2.4).

6.3.5

Replace this clause with the following:

1. Vertical tube cylindrical heaters shall have the following radiant chamber heights:
 - a. maximum of 2.8 times the tube circle diameter for heaters with 1 burner
maximum of 2.6 times the tube circle diameter for heaters with 2 to 8 burners;
 - b. minimum of 1.75 times the tube circle diameter for heaters with 8 to 12 burners;
 - c. minimum of 1.5 times the tube circle diameter for heaters with more than 12 burners.
2. See (6.3.14) and (14.1.4, Item 1).

6.3.6

Replace this clause with the following:

1. Box type heaters with floor firing should have a chamber height between 2.2 and 3.5 times the centre-to-centre distance between tube rows or between tube row and enclosing parallel wall.
2. See (6.3.14) and (14.1.4, Item 1)

6.3.8

Replace this clause with the following:

- 1. Tubes of convection sections shall be designed with short radius welding return bends (twice the nominal diameter).
- 2. Tubes of convection sections shall be designed with end tubesheets and tubes positioned as follows:
 - a. staggered pitch for gas firing that is clean and free of solids;
 - b. in-line pitch for all other services.
- 3. Corbels having a width of one half of the transverse tube pitch shall be used with the following exceptions:
 - a. coil sections with in-line tube arrangements;
 - b. the first two shield rows of convection sections with staggered pitch.

Add the following new clauses:

6.3.14

1. In order to prevent too high radiant heat flux on tube ends in radiant sections, the following shall be adhered to:
 - a. in vertical heaters, the radiant cell tubes to cover the full height of the radiant cell wall, apart from the space required for expansion of the tubes;
 - b. in horizontal heaters with single side fired tubes in the radiant cell, tubes to cover the full height and length of the long wall of the radiant cell, apart from the space required for expansion of tubes.

This implies that, for the top and bottom tubes, the vertical spacing between the centreline of the tubes and the refractory is 1.5 times the nominal tube diameter, with a minimum clearance of 100 mm (4 in).

6.3.15

1. Vertical cylindrical heaters with cruciform-style coil sections shall be designed according to the following:
 - a. all tubes are double fired and form a cross pattern in the centre of the radiant section with four burners (no tubes against the wall);
 - b. burners centered within the cold plane of tubes;
 - c. burner circle diameter such that burner clearances meet Table 15 or Table 16 as applicable;
 - d. use long radius fittings at the centre of the heater for one and two pass heaters;
 - e. use a radial clearance of half of the flange diameter plus 50 mm (2 in) for four pass heaters with centre outlets.

Additional long radius return bends may be required for burner clearance, centring burners within the cold plane and optimum radiant chamber height to diameter.

6.4 Coils and Coil Layout**6.4.1 General**

- 1. Heater coils shall be seamless tubes according to ASTM A450 or seamless pipes per ASTM A530.
- 2. For further details on material selection, see (7).
- 3. Pipe shall be used for all-welded coils.
 - a. Tubes may be used if they have to be expanded into return bend fittings.
- 4. In vertical heaters, the inlet and outlet of coils of radiant cells shall be located at the top of the heater.
- 5. Bare coils shall be used in radiant sections of heaters.
- 6. Centre-to-centre spacing of radiant tubes and pipes shall be at least twice the nominal diameter.
- 7. Cross-over piping shall be made of the same material grade as the upstream coil.
- 8. Cross-over piping shall be located outside the radiant and convection section.

6.4.2 Coils for Crude, Reboil, Hot Oil, Vacuum, Visbreaker, and Thermal Cracking Heaters

1. Coils for crude, reboil, hot oil, vacuum, visbreaker, and thermal cracking heaters shall be of all-welded construction using tubes and welded return bends.
- 2. The Contractor shall confirm with the Principal if mechanical cleaning is required and include in the specification.

Horse-shoe fittings for mechanical cleaning or steam-air decoking facilities are no longer applied for the heaters under consideration. Mechanical cleaning means installation of hydraulic pigging facilities.

3. If two-phase flow is envisaged in parts of the heater coils, an automatic flow controller shall be incorporated in the inlet of each process pass of the heater where the flow condition is still in the liquid phase:
 - a. process passes shall not be split at any point between the flow controller and heater outlet;
 - b. process passes may be combined downstream of their flow controllers;
 - c. connections for steam-out of radiant coils of both residue and distillate cracking heaters shall be provided in the inlet piping.