



RP 22-1

FIRED HEATERS

May 1992

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BP GROUP RECOMMENDED PRACTICES AND SPECIFICATIONS FOR ENGINEERING											
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FIRED HEATERS (Replaces BP CP 7)											
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SCOPE AND PURPOSE This Recommended Practice provides BP General requirements and additional information for fired heater and associated stacks to that specified in BP Group GS 122-1 Fired Heaters to API 560. The additional information is concerned with heater placement in a plant (concept and position) and the ancillary requirements which are either specified or provided by BP or main Contractor. It is intended that this Recommended Practice be used together with BP Group GS 122-1 when either individual heaters or units containing fired heaters are purchased											
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CONTENTS

Section	Page
FOREWORD	iii
1. SCOPE.....	1
2. CONCEPTUAL DESIGN.....	1
2.1 General	1
2.2 Layout and Sources of Hazard	3
2.3 Noise Control	5
2.4 Pollution	5
2.5 Fireproofing of Structural Steelwork.....	5
2.6 Platforms	5
2.7 Tube Cleaning.....	6
2.8 Stacks.....	6
3. PROCESS REQUIREMENTS	8
4. FUEL SYSTEMS	11
4.1 General	11
4.2 Shut-off Systems.....	15
4.3 Atomising Steam and Tracing.....	16
5. INSTRUMENTS	17
5.1 General	17
5.2 Heater Conditions	18
5.3 Process Conditions.....	21
5.4 Alarms	23
5.5 Flame Failure	24
6. SERVICES	26
6.1 Steam.....	26
6.2 Electrical Equipment.....	27
6.3 Routing of Instrument and Electrical Cables	27
7. TESTING	27
8. DATA AND DRAWINGS.....	28
FIGURE 1	29
ARRANGEMENT OF PIPEWORK FOR.....	29
SYMMETRICAL TWO-PHASE FLOW	29
FIGURE 2	30
TYPICAL ARRANGEMENT OF FUEL SYSTEMS.....	30
ON PROCESS HEATERS - MULTIPLE FUELS	30
FIGURE 3	32
TYPICAL ARRANGEMENT OF FUEL SYSTEMS.....	32
ON PROCESS HEATERS - SINGLE FUEL (GAS).....	32
FIGURE 4 (Sheet 1- method 'a')	34
TUBE SKIN THERMOCOUPLES INSTALLATION DETAILS.....	34



(HOCKEY STICK & SLIDING GLAND).....	34
FIGURE 4 (Method 'b')	35
FIGURE 5 (Method 'c')	38
TUBE SKIN THERMOCOUPLES INSTALLATION DETAILS FOR AXIAL, EXIT	38
FIGURE 5	39
TUBE SKIN THERMOCOUPLES INSTALLATION DETAILS FOR AXIAL, EXIT	39
APPENDIX A	40
DEFINITIONS AND ABBREVIATIONS.....	40
APPENDIX B	41
LIST OF REFERENCED DOCUMENTS	41
APPENDIX C	43
TUBE STEAM-AIR DECOKING	43
APPENDIX D	49
REGIONAL REQUIREMENTS.....	49
APPENDIX E	50
SUPPLEMENTARY COMMENTARY	50
E1 Scope.....	50
E2 Conceptual Design.....	50
E3 Stacks.....	51
E4 Instruments	52



FOREWORD

Introduction to BP Group Recommended Practices and Specifications for Engineering

The Introductory volume contains a series of documents that provide an introduction to the BP Group Recommended Practices and Specifications for Engineering (RPSEs). In particular, the 'General Foreword' sets out the philosophy of the RPSEs. Other documents in the Introductory volume provide general guidance on using the RPSEs and background information to Engineering Standards in BP. There are also recommendations for specific definitions and requirements.

Value of this Recommended Practice

This Recommended Practice has been prepared in order to collate and disseminate BP requirements for Fired Heater purchase and installation. It is required because:-

- (a) The recognised International Standard on Fired Heaters [API 560](#) is only concerned with heater fabrication. It does not cover the heater in relation to the rest of plant/unit/site.
- (b) [API 560](#) is not concerned with heater instrumentation, control or safety.
- (c) A fired heater contains combustion equipment and often processes hydrocarbons which are combustible. Thus there is always the risk of an explosion or serious fires. This Recommended Practice outlines good engineering practices that, if followed, minimise the risks.

Application

Text in *italics* is Commentary. Commentary provides background information which supports the requirements of the Recommended Practice, and may discuss alternative options. It also gives guidance on the implementation of any 'Specification' or 'Approval' actions; specific actions are indicated by an asterisk (*) preceding a paragraph number.

This document may refer to certain local, national or international regulations but the responsibility to ensure compliance with legislation and any other statutory requirements lies with the user. The user should adapt or supplement this document to ensure compliance for the specific application.

Feedback and Further Information

Users are invited to feed back any comments and to detail experiences in the application of BP RPSEs, to assist in the process of their continuous improvement.

For feedback and further information, please contact Standards Group, BP Engineering or the Custodian. See Quarterly Status List for contacts.



1. SCOPE

This Recommended Practice provides BP General Requirements and additional information for fired heaters and associated stacks to that specified in BP Group [GS 122-1](#) Fired Heaters to [API 560](#)

2. CONCEPTUAL DESIGN

2.1 General

2.1.1 Heaters shall be suitable for outdoor operation in a refinery or a petrochemical process plant environment and for the climatic conditions specified.

See Appendix E2

2.1.2 Fired heaters may be of the all-radiant, all-convective or radiant/convective type, depending on the duty. A group of heaters may share a common convection section where acceptable from the operational and maintenance points of view.

* 2.1.3 Where a heater forms part of a heat exchange train, the thermal efficiency of the heater shall be the optimum in relation to the overall efficiency of the associated systems, after taking into consideration the capital, operating and maintenance costs of the whole process unit and its operational flexibility and reliability. In arriving at the optimum efficiency, secondary heat recovery from the flue gases may be incorporated where applicable.

If not specified by BP, the efficiencies chosen shall be quoted at the design load, with the design percentage of excess air at the heater outlet, and the reasons for the selection shall be supported by an economic analysis. The thermal efficiency shall be guaranteed and based on the total useful heat transferred as a fraction of the net heating value of the fuel. The minimum flue gas temperature entering the stack will be agreed with BP.

For economic evaluation the heater efficiency should be based on the normal heater load. However,

- (a) *most heaters operate at their design load*
- (b) *when comparing vendors' quotations for fired heaters the load on which the efficiency is based is not usually relevant provided all the vendors have used the same heat absorbed load for their efficiency calculations.*



Where the design load is appreciably different from the normal operating load then the heater vendor should be given both loads and advised on which one he has to base his guaranteed efficiency.

- 2.1.4 If flue gas waste heat recovery equipment such as steam generators, air pre-heaters, etc. are provided with, or added to, a heater, precautions shall be taken to ensure that such equipment does not prejudice the satisfactory operation and maintenance of the process plant on the whole. In particular, the maximum running time between overhauls of the process plant shall not be prejudiced by statutory inspection requirements on such boiler plant. Where steam is generated by waste heat recovery account shall be taken of the loss of the steam during the fired heater shutdown. When required provision shall be made for an alternative source, either by auxiliary firing, or from supplementary boilers.

When selecting the waste heat recovery equipment account shall be taken of the possible need to make provision for alternative steam generation.

When steam is raised in a waste heat boiler with auxiliary firing, the boiler shall be located at grade and separated from the heater so that it can be bypassed to allow independent operation of the process heater.

The operating pressure and temperature of any steam produced shall be agreed with BP.

Obviously the operating temperature and pressure of the steam have to be compatible with the plant requirements which BP may have to specify.

The feed water quality is specified by BP Group [RP 56-2](#).

- 2.1.5 A group of heaters may share a common flue and stack, where advantageous either economically or from the environmental standpoint, provided that it is operationally acceptable. Where a common stack is operationally unacceptable, the cost and pollution advantages of a single stack may be obtained by using multiple bores in a common shell.

- 2.1.6 The excess air in the flue gas anywhere in the heater or stack shall not exceed 40% at any heater operating conditions other than startup and shutdown.



2.2 Layout and Sources of Hazard

2.2.1 A heater, or a group of heaters, shall be located on the periphery of a unit or a complex and immediately adjacent to an unrestricted road. There shall be adequate access for fire fighting from all sides of a heater and, in the case of a group of heaters, they shall be separated from the remainder of the unit(s) by restricted access roads on the other three sides.

- * 2.2.2 The layout and design of heaters shall normally be such that tube removal can be effected by mobile lifting equipment, for which there shall be proper access. When it is agreed with BP that this is not practicable, alternative means of handling shall be proposed for the approval of BP.

For vertical cylindrical heaters with integral stack, a rail on the stack, similar to a painter's trolley rail, may be used for removal of radiant tubes.

In other cases, special beams and trestles may have to be used.

2.2.3 A process heater shall be considered as a permanent source of ignition, therefore:-

- (a) Any electrical equipment, other than the exception noted below, installed on, or immediately adjacent to, a heater may be of a type suitable for installation in a non-classified area.

An exception shall be made for electrical equipment associated with fuel systems that have only one seal between the fuel and the electrical components, e.g. motorised valves and pressure switches. Such electrical items shall be at least to Zone 2 Standard.

- (b) The following equipment which handle flammable fluids shall be considered to be a source of hazard and shall be located 15 m (50 ft) or more from any part of a heater, and its associated electrical equipment housed in industrial type enclosures. Such sources shall also be located not less than 15 m (50 ft) from any transfer line to or from the heater, which may operate at 650°C (1200°) or more.

- (i) Pumps
- (ii) Compressors
- (iii) Air-cooled exchangers
- (iv) Hydrocarbon sample points



- (v) Hydrocarbon vents and drains and instrument vents (e.g. DP cells) that are opened to atmosphere during normal operation
 - (vi) All fuel gas and low-flash fuel control valves and meters
 - (vii) Filters on low-flash fuel supply lines
 - (viii) Fuel gas line filters
 - (ix) Pilot gas line filters
- (c) Surface drains shall not be located directly under a heater.
- (d) All connections in pipework within 15 m (50 ft) of the heater that contains hydrocarbons shall be welded or flanged.

The outlets from vents and drains that are opened only during plant shutdown or infrequent maintenance may be less than 15 m (50 ft) from a heater, provided they are closed and plugged during normal operation.

A fired heater is a source of ignition and, hence, the requirement that all sources of hazard (flammable fluids) be located at least 15 m (50 ft) away from the heater. In certain instances, this may not be adequate.

Because we believe it is not possible to prevent a heater from being a source of ignition where it is thought that 15m (50 ft) is not a safe distance, we suggest that hydrocarbon detectors with alarms are positioned around the heater.

All fuel lines around the heater should have welded connections where possible. The number of flanged connections should be kept to a minimum and be easily accessible for testing, etc.

Where a substantial volume of flammable liquid could escape under the heater on tube failure, or on fuel line fracture, it should either be directed to a safe area or be contained locally so that it would cause minimal damage to surrounding plant and equipment. Consideration should therefore be given to the contour of the floor area beneath the heater and to the surrounding area to prevent the spread of fire or to a containment arrangement provided with an adequate and safe drainage system.

2.2.4

The area under a heater shall be paved and free from tripping hazards. Similarly, an area around the heater extending 1800 mm (6 ft) from the periphery shall be free from obstruction by pipework, etc. so that rapid escape from under such heaters can be made in any direction.



2.3 Noise Control

2.3.1 General requirements for noise control are defined in BP Group [RP 14-1](#).

- * 2.3.2 Overall and local plant noise specifications shall be specified or approved by BP. Any noise emissions specified shall take into account normal operation and short term duration events such as relief valve lifting steam and process venting, heater steam air decoking, etc.

Allowable noise and stack emissions depend upon where the unit is situated. The pollution limits need to be established by BP or the contractor in conjunction with the local authorities. Noise levels should not exceed 85 dB (A) in the area of the header for personnel protection purposes.

2.4 Pollution

The emissions from the heater stack under specified operating conditions shall meet BP and any local authority requirements.

Additionally, where steam-air decoking is specified (see 2.7.1) full consideration shall be given to the quality requirements for the atmospheric emission and liquid effluent originating from the decoking drum.

2.5 Fireproofing of Structural Steelwork

This shall be in accordance with BP Group [RP 24-1](#). Particular note shall be taken of the requirement to fireproof the structural members of the flooring.

2.6 Platforms

When two or more heaters are grouped together the platforms at a high level shall be interconnected whenever practicable. Large or interconnected platforms shall have alternative escape routes to grade.

2.7 Tube Cleaning

- * 2.7.1 When specified, provision shall be made for cleaning each coil by the steam-air method. Details shall be agreed with BP in accordance with the recommendations of Appendix C. Sufficient space shall be provided to give proper access to swing bends and reversing valves, and to permit the elbows to be swung in situ.

Steam air decoking systems should be provided on all heaters where tube coking is expected. Typical heaters include crude, vacuum thermal crackers and furfural heaters.



2.7.2 Effluent knock-out pots shall be provided for the steam- air decoking operation. The decoking system shall incorporate water quench of effluent steam and the pots shall have facilities for removing coke. On furnaces where heavy coke laydown is expected, these facilities shall provide for continuous coke removal and subsequent coke disposal.

2.8 Stacks

2.8.1 Stacks shall meet the requirements of [API 560](#) as modified by BP Group [GS 122-1](#). Stacks may be either free standing or mounted on the heater.

2.8.2 Stacks may be either constructed from steel plate or be of a reinforced concrete construction.

2.8.3 Steel stacks shall meet the requirements of [API 560](#) as modified by BP Group [GS 122-1](#).

* 2.8.4 Unless National Codes govern, concrete stacks shall be designed in accordance with the [American Concrete Institute Standard 307](#) except that wind loading shall be in accordance with the appropriate National Codes. The stack design shall be approved by BP.

For the design of large multiple flue concrete stacks, expert advice is recommended, such as may be provided by BP Engineering.

2.8.5 The concrete chimney shall be lined for the full height to:

- (a) bring the stresses due to temperature in the concrete or reinforcement within acceptable limits;
- (b) protect the concrete from the abrasive action of impingement of the chimney gases;
- (c) protect the concrete from the chemical action of corrosive or destructive gases.

Linings shall be constructed of materials suitable to withstand the conditions stated in BP Group [GS 122-1](#) and can be classified as :

- (d) Independent brick or concrete.
- (e) Corbel supported brick.



(f) Steel liner.

2.8.6 Stacks may require facilities for flue gas sampling and smoke and temperature measurement if suitable locations in the flue ducts cannot be provided.

2.8.7 Aircraft warning lights shall be fitted if required by national or local regulations.

2.8.8 The minimum height above grade level and the exit gas velocity shall conform to the requirements of both national and local authorities. In any case :

(a) The height shall be dictated by draught requirements or shall be 6 m (20 ft) above the top platform of the unit or other nearby units, which ever gives the tallest stack.

(b) A three-minute mean ground level concentration of 460×10^{-6} gm/cu.m (20×10^{-3} grains/100 cu.ft) of SO₂ shall not be exceeded, taking account of the local topography.

(c) The exit area of the stack shall be such as to give a minimum flue gas exit velocity of 9 m/s (30 ft/s) when all units that are connected to the stack are at their design loads.

2.8.9 The inside temperature of the concrete shell shall be controlled by means of a complete air gap between the lining and shell.

If the contractor proposes to control the temperature by means of insulation in addition to the air gap, the insulation material shall not be able to slump or pack down into the lower end of the cavity nor shall it be used in such a manner as to restrain the movement of the lining in any way. There shall be no physical hindrance whatsoever to prevent or restrain expansion of the lining in radial and longitudinal directions, other than an elastic sealing at the lining overlaps adjacent to the corbels. The hot face of the lining material shall always be kept at a temperature above the acid dew - point of the flue gas.

See Appendix E3



3. PROCESS REQUIREMENTS

3.1 Where the process flow through a heater is divided into two or more parallel streams, the method of ensuring that the flow is equally divided between the passes shall depend on the conditions and shall comply with 3.2 to 3.6 inclusive.

3.2 Heaters on non-vaporising liquid heating duties shall have individual pass flow indication with hand control valves, preferably globe, on each pass, operable from grade. Flow indicators shall be in sight of the control valves.

A shared low flow alarm shall be provided in the control room.

3.3 Heaters on liquid vaporising duty where coking is not anticipated, e.g. distillate reboilers, shall have pass flow indicators and valves as specified in 3.2, but the flows shall be indicated at the heater near to the valve operating position and in the control room with a shared low flow alarm. The flow measuring elements shall be positioned where the flow through the element is wholly liquid.

* 3.4 Heaters on liquid vaporising duty where coking is likely, e.g. crude, vacuum, visbreaker, deasphalting and furfural heaters, shall have individual passes flow-controlled. Preference should be given to a master flow controller located in a common line cascading by individual bias and ratio relays to individual pass flow controllers.

The use of a master flow controller allows for the total flow to be adjusted in a simple manner, while the biasing allows compensation flow changes to be made.

The reliability of flow measuring elements should be carefully examined. In the case of visbreakers where the low flow automatically initiates a heater shutdown, each pass should be provided with two independent flow measuring elements, one for control and the other for alarm and shutdown. For vacuum and crude heaters consideration should be given to taking double tappings from the same orifice: one set for flow control and the other for alarm/shutdown. Consideration should also be given to the fitting of minimum stops on control valves where this is not detrimental to the operation of the unit.

The flow measuring elements shall be positioned where the flow through the element is wholly liquid and preferably downstream of any exchangers. In such cases, the system pressure shall be increased if necessary to suppress any vaporisation at or through the flow element. The flows shall be indicated both at the unit and in the control room with a shared low flow alarm.

Alternatively, and subject to the approval of BP, the measuring elements may be placed upstream of the exchanger bank in which vaporisation starts, but this arrangement is not normally acceptable due to the need to split exchanger banks, loss of heat transfer through vapour separation, and possible damage to tubes from uneven heating.

3.5 Heaters on non-coking duty where two-phase flow at the heater inlet cannot be avoided, e.g. hydrofiner, hydrocracker and ferrofiner heaters shall be arranged as follows:-

- (a) Where a fully-dispersed flow regime (as judged by the O. Baker parameters published in [Oil and Gas Journal, July 26th, 1954](#)) can be assured or arranged at the point of a split over the specified operating flow range, then uncontrolled symmetrical passes are acceptable. The preferred layouts of piping at the split point are shown in Fig. 1.

The splitting of passes within a vacuum heater shall also be governed by the above requirement. The injection arrangements of steam into the split headers of vacuum heaters shall also ensure even distribution between the passes.

- (b) Where a fully-dispersed flow regime cannot be achieved by any practical means, either a single pass shall be provided or the individual phases shall be flow-controlled to each pass before mixing.

It is recognised that the O. BAKER parameters and charts may not represent the actual operating conditions: however, for conventional refinery heater duties they appear to be satisfactory. Where special heater duties are required, if the vendors do not have proved operating experience, expert advice such as may be obtained from BP Engineering, should be sought.

3.6 Uncontrolled split flow is acceptable for gas heating duties, subject to symmetry in design and to the pressure drop across each coil being sufficiently high relative to the variation in the static head along the manifold to maintain equal pass flows, particularly at turn-down.

* 3.7 The heater vendor shall approve the arrangement and details of the inlet and outlet process piping which shall be supplied to him by the contractor or BP as appropriate.

* 3.8 Except in the case of hydrogen service, as defined in BP Group [GS 122-1](#), a blow-through connection shall be provided at the inlet to each hydrocarbon coil (individual pass). The connection shall be immediately downstream of the relevant inlet valve and shall be



permanently piped. This connection shall be at least 50 mm (2 inches) unless otherwise agreed with BP. Where individual pass process flow control valves are not fitted, then the blow-through connection can be installed in the common inlet manifold.

Normally the blowthrough connection should be to each individual hydrocarbon heating coil and, in most cases, the blowthrough medium is steam. However, in certain circumstances, steam should not be used, e.g. in alkylation reboilers.

- * 3.9 Arrangements shall be made for hydrostatic testing of coils. These arrangements shall be agreed with BP.

BP will need to carry out hydrostatic tests if any on-site repairs are required. Then it is essential that provision is made for the hydrostatic testing of the coils in situ. This usually means flanged inlet and outlet pipework on the heater and the means provided for filling and emptying the coils. (Vertical tubed coils have to be blown through in order to remove water).

4. FUEL SYSTEMS

4.1 General

- 4.1.1 The fuels shall include one or more from the following: gas, low flash liquid, heavy fuel oil, heavy residues waste fuels or off gas. The fuels and conditions of supply will be specified for each heater.

Where more than one fuel is specified, each individual fuel should be supplied to all the burners in order to avoid the possibility of poor distribution of the heat input. Where it is proposed to do something different, expert advice such as may be obtained from BP Engineering, is recommended.

Take care with the design of the heat-off system to ensure that, when waste or off gas is being fired in a burner, there is also a support flame from fuel oil and/or fuel gas and on heat-off the flow waste or off gas should also be stopped.

It is preferred that sour or waste gas is burned in a separate incinerator. Where waste gas is disposed of through a fired heater, consideration should be given to the need for an automatic alternative disposal system on the actuation of the heat-off or emergency shutdown systems.

- 4.1.2 The fuel system shall generally be in accordance with Figs. 2 and 3.

- * 4.1.3 The pilot gas, where practicable, shall be taken from a sweet gas supply, independent of the main burner gas, or from a separate off-take on the fuel gas main, with its own block valve and spade-off position. Unless otherwise approved by BP the pilot gas pressure shall be controlled at 0.35 bar (5 psig).



BP depend upon the pilots for the safety in their heaters. The 0.35 bar gas pressure is set to ensure that the pilots remain alight for a reasonable period after failure of the main fuel gas supply, which operates at approximately 2 bar. The assumption here is that both gas supplies come from the same source. Expert advice, such as may be obtained from BP Engineering, is recommended if vendors wish to use pilot gas pressures appreciably greater than 0.35 bar.

4.1.4 Fuel manifolds around heaters shall be sized such that the maximum pressure difference between individual burner off-takes shall not exceed 2% of the manifold pressure at any time. In addition, account shall be taken of the effect of individual burner pipework sizes and arrangements on the distribution of fuel flow to each burner.

4.1.5 Individual burner isolation valves for the main fuels and steam shall not be located under the heater. The burner isolating valves, excluding pilots, shall be located within an arm's length of the peep-holes giving a view of the flames from those burners. Where possible, a standard disposition of valves for each burner shall be used; namely, from left to right: gas, oil, steam.

All burner isolation valves shall, preferably, be of the ball valve type to [BS 5351](#) or equivalent, subject to the operating temperature and pressure, including any purge steam, being within the rating of the valve seat. All burner isolation valves shall have some readily recognisable indication of the valve position.

4.1.6 Each burner isolation valve for pilot gas shall be positioned safely away from the burner and so that an electrical portable ignitor, when inserted in the lighting port, can be remotely operated from the burner valve position. In the case of floor-fired heaters, the pilot burner valves shall not be located under the heater and shall be operable from grade (usually on the side of heater).

Pilot burner isolation valves shall be ball valves to [BS 5351](#) or equivalent.

4.1.7 The valves for controlling the flow of foul or waste gases to the individual nozzles shall not be located underneath floor-fired heaters but shall be positioned near the pilot gas valves.

A flame trap of an approved type shall be fitted in the main foul or waste gas lines leading to a furnace, with a high temperature alarm actuator installed immediately downstream of the trap. Cleaning of the traps shall be provided for.

4.1.8 Irrespective of any purging arrangements within the burners, steam purging of the oil lines between the burner valves and the burners shall be fitted.

The steam and purge valves shall be located adjacent to the burner isolation valves.

* 4.1.9 Each fuel supply to a heater, excluding waste or foul gases, shall be fitted with two filters in parallel or with dual filters. Where the latter incorporate two filter elements in one housing, individual elements shall be removable whilst in service without interruption of fuel flow. There shall be no leakage from the operating compartment to the open compartment when one element is removed.

The filter sizes shall be as specified by the burner supplier and approved by BP. The mesh material on main gas and pilot gas shall be Monel. For the pilot gas filter the mesh size should be approximately 0.5 mm (0.020 inches).

Fuel filters are required to catch the particles carried by the fuel in order to:-

- (a) *Reduce the risk of the shut-off valves being kept open by particles depositing in their seats*
- (b) *Stop blockages of the burner orifices.*

As a guide, we suggest that the main fuel filters be so sized that they will not pass a 1 mm gauge, or a pin gauge of 2/3 of the diameter of the smallest fuel orifice in the burners, whichever is the smaller.

In the case of the pilot gas supply, the pipework between the filters and the pilots shall unless otherwise approved by BP be in 18/8 stainless steel.

Stainless steel is specified for the pilot pipework to try to ensure that the pilots do not become blocked by any tube - corrosion products.

* 4.1.10 Pipework shall be in accordance with BP Group [RP 42-1](#), except that where fuel atomisers or gas nozzles require positional adjustment within the burner for optimum combustion, flexible piping for all fuels and steam connections to individual burners shall be provided. This flexible pipework shall be of the fire-proof continuously-formed stainless steel bellows type, protected by metal braiding. The flexible pipework and pipework arrangement shall be approved by BP.

Flexible hoses shall be suitable for high risk plant areas. They shall be fire safe and have suitable connections and terminations. When flexible hoses are proposed expert advice, such as may be obtained from BP Engineering, is recommended.



- 4.1.11 The fuel oil, atomising steam and gas piping to the burners shall be arranged so that the oil, main gas or pilot nozzles can be removed without isolating the other fuel supply to that burner.

In special circumstances, this requirement for furnaces with, say, 4 or more burners could be relaxed with regard to the gas nozzles.

Care must be taken in the design of the gas system to ensure that the main fuel gas pressure control (temperature reset) is compatible with the self operated pressure reducing valve which operates in parallel with it when the furnace is operating at turndown conditions.

Where there are large variations in molecular weights of the fuel gas the self operating pressure reducing valve limits the turndown capability of the fuel gas system. This needs to be taken into account in the design and operation of the header. Possible solutions to the problem are:-

- (a) *Operation with oil firing only when there is a large turndown requirement and the molecular weight of the fuel gas is high.*
- (b) *Reducing the number of burners that are in operation at the turndown condition.*
- (c) *Operation with gas and oil being fired separate burners and selecting the number of gas burners to suit the minimum allowable gas pressure. (Operation with gas and oil in separate burners may be required when the fuel gas supply is limited)*

- 4.1.12 Individual gas and oil burner off-takes shall be from the top of headers. The ends of oil and fuel gas headers shall be flanged to allow access for cleaning.

- 4.1.13 Each main fuel control valve shall be provided with a self-operated pressure reducing valve in parallel with it. This pressure reducing valve shall:

- (a) prevent the fuel pressure at the burner falling below the stable limit of the burner
- (b) where possible be used for burner light off.

N.B. The minimum allowable fuel pressure at the burner may have to be increased above its stable limit in order to cater for burner ignition.

Each control valve set shall be provided with isolation and hand operated bypass valves.

4.1.14 Pilot gas pressure reducing valves shall be of the self- operated type. They shall be provided with isolation and hand operated bypass valves.

4.1.15 All fuel control valves and meters shall be conveniently located at grade but separate from the furnace, see 2.2.3.

4.2 Shut-off Systems

4.2.1 The shut-down system shall comply with BP Group RP 30-5 and BP Group [RP 30-6](#).

All systems shall fail safe, i.e. in normal operating conditions sensor contacts shall be closed, relays and solenoid valves shall be energised, and in the trip conditions, air-operated valves shall vent.

4.2.2 To guard against the possibility of leakage of the safety shut-off valves, two of these shall be used in series on all fuels, waste and pilot gas. These valves shall be fitted with closed position monitoring.

* 4.2.3 Unless otherwise agreed with BP where only one main fuel is provided, the two safety shut-off valves on the fuel shall be completely duplicated to allow for testing and maintenance without furnace shut-down. No bypasses shall be fitted around these valves. Where two or more main fuels are provided on a heater, neither duplication nor bypassing of the safety main fuel shut-off valves is required, see Figs. 2 and 3.

If the heater is to be shut down at frequent intervals (once every 6 months or less) then the duplication of the two safety shut off valves is not required.

4.2.4 To monitor the leakage of the shut-off valves with a single main fuel, a pressure measuring connection shall be provided between the two safety shut-off valves. With multiple main fuels, a second measuring connection shall be provided downstream of the second safety shut-off valve. the pressure measuring connection, suitable for use with a sensitive test gauge to detect small leaks, shall be valved and blanked off in accordance with the line specification.

4.2.5 In addition to the automatically-operated safety shut-off valves, manually operated valves shall be provided on each fuel, waste and pilot gas line to the heater. These manual valves shall be grouped together with the heater snuffing steam valves, and the process blow-down valves. All these valves shall be readily accessible and operable from grade and placed 15 m to 20 m (50 ft to 70 ft) from the heater.



4.2.6 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 BP Group [GS 122-1](#). These arrangements shall be independent of any fan low-flow alarms provided.

4.2.7 Where induced-draught fans and/or forced-draught fans are installed, high radiant section pressure shall initiate the heat-off action.

4.2.8 The heat-off action on a furnace shall

- (a) open the ID fan bypass damper if fitted
- (b) stop the ID fan if fitted
- (c) keep the FD fan in service.

4.2.9 For regional requirements see Appendix D.

4.3 Atomising Steam and Tracing

* 4.3.1 The atomising steam supply shall be run from the main separately from the steam tracing supply, and shall not be used as steam tracing. Additionally, where light distillate fuel (LDF) firing is specified, the atomising steam lines shall be lagged separately from the fuel lines to prevent vapour locking.

Atomising steam off-takes to the burners shall be from the top of the header and adequate trapping arrangements shall be provided to prevent the admission of condensate to the burners, including steam traps at the end of manifolds.

* 4.3.2 Unless otherwise specified by the burner vendor, the atomising steam pressure shall be controlled by a steam/oil differential pressure controller capable of operating over the specified firing range, or by a steam pressure controller.

Most burners can operate with constant atomising steam pressure or constant differential oil/steam pressure but there can be stability problems with both. Normally we would accept the burner vendors recommendations but before we can give a reliable recommendation we need to know all the possible operating conditions at the burner.

- 4.3.3 Tracing of the fuel lines shall be separated from other tracing systems. The heavy fuel oil (HFO) system including instrument legs is to be traced right through to the burner, but that section of the fuel line common to both low flash and heavy fuel oils shall be traced separately from the rest of the HFO system. Tracing may be by steam or electricity. Where steam tracing is installed a steam trap shall be fitted for each burner.

Arrangements shall be made to ensure that traced lines and associated instrumentation are not over-pressured due to overheating if the fuel oil becomes stationary in the lines for extended periods.

- * 4.3.4 Unless otherwise approved by BP, fuel gas and pilot gas lines upstream of the burner isolating valves shall be traced.

Whenever there is a risk that the gas may contain high boiling point components, the lines in question shall be heat traced to avoid the possibility of liquid slugs extinguishing the flame on a cold day or of coking the gas nozzles. It is our experience that, even with a very small amount of high boiling point components in the fuel lines, coking of the gas nozzles takes place. This applies also to pilot and waste gas lines.

5. INSTRUMENTS

5.1 General

- 5.1.1 As a minimum requirement the sensing elements and instruments listed shall be provided unless otherwise specified. See also Figs. 2 and 3.

Additional information on instrumentation and control requirements are detailed in sections 3, 4, and 7. Other items may be specified by BP. Further guidance may be found in the Recommended Practices for Instrumentation, BP Group RP 30-1 to 30-5.

- 5.1.2 The location of instruments shall be as specified below:

- (a) For field mounted instruments, a simply-constructed panel shall be provided, located near the furnace, on which combustion control and indicating instruments are mounted.
- (b) For local draught measurements, sensing points within a suitable range of draught values shall be manifolded together and the gauge located at ground level.

See Appendix E4



5.2 Heater Conditions

- * 5.2.1 Draught - Local indication at ground level, except where noted.
- (a) In the plenum chamber(s), where fitted to natural draught burners. With forced draught burners, the common wind box pressure(s) shall be indicated locally and in the control room. In addition, provision shall be made to measure the individual burner air inlet pressures, either in the ducts downstream of individual burner dampers or in the burner wind box fitting shall be provided.
 - (b) At burner level of the furnace.
 - (c) At the inlet to the convection section, with draught gauge located, or repeated, near the damper controls at grade.
 - (d) At the outlet from the convection section.
 - (e) Before the outlet damper or at the induced draught fan inlet, where installed, if the draught is significantly different from that at the convection section outlet.
 - (f) Downstream of the outlet damper.
 - (g) Plugged draught connection for test purposes shall be provided in the furnace arch at positions to be approved by BP.

See Appendix E4.5

- * 5.2.2 Temperature in the control room (except where noted).
- (a) Liquid fuel in the burner manifold as near to the burners as possible (local indication only).
 - (b) Heavy fuel oil in the individual heater return main downstream of the return flow indicator (local indication only).
 - (c) Flue gas at the inlet to the convection section.
 - (d) Flue gas at the outlet from the convection section.
 - (e) If a combustion-air preheater is fitted, the flue gas temperature at the exit from the preheater and the combustion air temperatures at the exit from the preheater and in the common burner wind box.



- (f) Flue gas in the stack above the highest duct entry.

The number and positioning of sensing points required for 5.2.1 and 5.2.2 shall be such as to provide an adequate indication of the average flue gas temperature and pressure shall be approved by BP.

- (g) Radiant coil tube skin metal. Thermocouples for this duty shall be fabricated, attached and tested, according to Figs. 4 and 5. Fired reboilers and all heaters on duties where coking may be expected shall have at least two skin thermocouples per pass. Other heaters shall have skin thermocouples on selected passes. The thermocouples shall be positioned where maximum metal temperatures are anticipated and shall be approved by BP.

Where reverse steam-air decoking is intended, additional skin thermocouples shall be installed in each pass, on one of the shock tubes, see Appendix C.

Tube metal temperatures on cracking and reforming furnaces with cast tubes are measured by portable pyrometers; skin thermocouples shall not normally be fitted.

Positioning of tube skin thermocouples depends on type of duty, type of burners and fuel, these are no hard and fast rules. On visbreaker heaters to Shell licence, the positioning is recommended by the licensor.

On high temperature cracking and reforming furnaces, adequate number of peepdoors must be provided, with platforms on which tripods could be used, to allow for viewing the tubes steadily with pyrometers.

A compromise is required between two conflicting requirements: large numbers for good viewing and the least number to reduce air inleakage.

See Appendix E4.5

5.2.3 Pressure - Local indication, except where noted.

- (a) Fuel gas and liquid fuel:-
 - (i) Main supply line (with repeat in control room).
 - (ii) Individual furnace supply upstream of the control valve.
 - (iii) At each end of the burner manifold.
 - (iv) Pressure difference across filters.
- (b) Pilot gas:-

- (i) Main supply line, unless identical with (a) (i) above (with repeat in control room).
 - (ii) On the pilot burners manifold.
 - (iii) Pressure difference across filters.
- (c) Atomising steam downstream of the pressure control valve.

In addition to these pressure sensing elements and instruments, pressure measuring connections are required in order to monitor the leakage of the shut-off valves, as specified in 5.2 of this Recommended Practice.

See Appendix E4.5

5.2.4 Flow - Local indication, unless otherwise specified.

- (a) Combustion air flow where forced draught burners are fitted (with a repeat in the control room).
- (b) Liquid fuel to each heater supply, both supply and return, where applicable.
- (c) Fuel gas to each heater.
- (d) An additional flow element for pilot gas where this is piped independently of the main gas supply.

An accurate measurement of the combustion air flow usually present a problem. It either requires a long or high inlet duct to the fan or the use of ANUBAR or similar devices, which are seldom accurate over the full range of operating conditions.

* 5.2.5 Flue Gas Characteristics

- (a) A smoke density measuring device shall be fitted in the flue at the outlet of each heater with the indication on the local firing panel and an alarm in the control room.
- (b) A sample point, of a size to be specified by BP, shall be provided near the smoke measuring device for the insertion of solid and other emission sampling probes.

The size of sample points for measuring solid and other emissions depends on local regulations and should be established from the local authorities. It is important that the sample point measures representative samples, and care must be taken in selecting correct positions.

- (c) An analyser, or analysers, of a type to be specified by BP, shall be provided for taking samples of the flue gas at points to be approved by BP. The measurements will, as far as is practicable, relate to flame conditions and, where a convection bank is installed, a probe/sampler position shall be as near the fire box as is practical as well as in the heater outlet.

Both oxygen and combustibles shall be measured and indicated on the local firing panel and in the control room.

The oxygen and combustible analysers at present favoured by BP are in-situ analysers.

It should be realised that if different burners are firing at different excess air, the sample taken at one spot in the arch may be representative of one burner only. This is true when the flue gases do not mix well but are stratified, which is often the case. Several analysers may be required on one heater.

- (d) Sample points shall be provided to enable a fuel gas analysis to be carried out at the burner level and at the inlet and outlet of the convection section in each cell. The size of the sample points shall be specified by BP and shall be provided with screwed closures.
- (e) Where the furnace discharges into a common duct system, a provision similar to (b) shall be made in the combined flue gas duct or stack. Where statutory regulations require, an oxygen analyser as in (c) shall also be installed at the same position.

5.3 Process Conditions

5.3.1 Temperature - Transmitted to control room, unless otherwise indicated.

- (a) Process fluid in the common inlet manifold.
- (b) Process fluid at the crossover between the radiant and convection sections with local indication only, and at the outlet of each pass. When steam-air decoking is specified, to avoid damage from spalling, the last named thermowells shall be located downstream of the swing bends. To measure the decoking effluent temperature, additional thermowells with installed thermocouples shall be located in the decoking outlet lines. See Appendix C.
- (c) Process fluid in the common outlet manifold.



- (d) Where provision is made for future reverse steam- air decoking, a thermowell with installed thermocouple shall be provided at the normal inlet end of each individual pass which will become an outlet during decoking. This thermowell shall be located in the decoking piping, not the process piping, on the side of the swing bend away from the heater. Compensating cable shall be run from these thermocouple heads and terminated at a locally mounted junction box at grade to allow a temporarily-installed recorder to be connected.
- (e) On multiple-pass furnaces, e.g. reforming furnaces, the measurement of individual tube process outlet temperatures may be by the installation of in-tube thermocouples and/or thermocouples strapped, or fixed, to the outlet connectors (pigtailed).

5.3.2 Pressure - Local indication only.

- (a) Process fluid at the common inlet manifold.
- (b) Process fluid at the inlet to each pass, if it is fitted with a separate inlet regulating valve, to be measured after the regulating valve.
- (c) Process fluid in the common outlet manifold.
- (d) Pressure tapings only shall be provided in each crossover on all vaporising duty furnaces.

5.3.3 Flow

The requirements for flow measurement and individual pass flow control are detailed in Section 3.

5.4 Alarms

5.4.1 Alarms shall be provided in the control room, to be actuated by the following:-

- (a) The tube skin thermocouple sensing the highest temperature.
- (b) Low pilot gas pressure at the pilot burners.
- (c) Low pressures in the fuel mains, gas and liquid.
- (d) Low pressure in their fuel lines downstream of control valves.

- (e) Low flow in passes on non-coking or non-vaporising duty heaters and also where flow is automatically controlled (coking duties). A common alarm for all passes shall be used.
- (f) The pass outlet temperature sensing the highest temperature.
- (g) High smoke density.
- (h) Low atomising steam pressure for fixed atomising steam pressure burners and low differential pressure for burners using differential steam pressure.
- (i) Low percentage oxygen in the flue gas.
- (j) High percentage combustibles in the flue gas.
- (k) High percentage oxygen in shared flue ducts where specified.

High oxygen percentage in a shared flue duct may lead to an explosion if unburned combustibles find their way into the common duct and the temperature is high enough for ignition.

- (l) Low combustion air flow on forced draught burners.
- (m) High pressure at top of radiant section.
- (n) High wind box pressure if forced draught burners are fitted.

High wind box pressures can make burners unstable under turndown conditions.

- (o) Low wind box pressure if forced draught burners are fitted.

One of the alarms specified in (l) or (o) on normal operation should be redundant. However, there may be occasions during heater commissioning when a small number of burners is being fired. In these circumstances, operation of the low air flow alarm could be misleading.

- (p) Fan speed.

5.5

Flame Failure

*

Where main burner flame failure equipment is required, the type and manufacturers shall be approved by BP. The system required is as follows:-

- (a) The pilot burners shall have its own flame failure detector. In the event of pilot flame failure, the pilot only shall be shut down.



The interlocks shall be such that it is possible to relight the pilot without shutting down the main flame.

- (b) The main flame shall have its own flame failure detector. This device shall be capable of differentiating between the pilot and the main flame. In the event of main flame failure on a single burner heater, both the fuel supply to the main flame and the pilot flame shall be shut off. Where heaters are fitted with more than one burner failure or the main flame shall result in the isolation of the fuel supply to that burner. All the pilots shall remain a light.
- (c) The main flame failure detectors shall be self-checking.
- (d) If a burner fails to ignite within the prescribed period then the main burner shut off valves should close and a period sufficient to disperse any accumulation of unburnt gas shall elapse before a further ignition attempt is made (on any burner in the heater). If the failure to ignite is the result of the loss of combustion in air then a furnace prepurge should be carried out in order to obtain 5 volume changes in the furnace.
- (e) Duplicate automatic safety shut-off valves shall be provided in each fuel, pilot gas and where necessary waste gas line for each burner activated by the flame failure signal as appropriate. The valves shall be of a fail-close design with local electrical reset and shall have a closed position proving switch. Failure of valve to close shall operate an alarm only.
- (f) Provision shall be made to leak-test the individual shut-off valves. When combination burners are fitted it shall be possible to carry out the leak test with the burner firing on other fuel or fuels.
- (g) On forced draught furnaces with between 2 and 4 burners only, automatic shut-off for the combustion air isolating dampers shall be provided at each burner. This damper shall close when the main flame is not alight. See BP Group [GS 122-3](#). Provision shall be made to open these dampers during furnace purging, burner light-off, etc.
- (h) A local panel shall be provided to house the flame failure control.
- (i) Unless otherwise agreed with BP the pilot ignition shall be initiated at a position close to the burner but not directly under

the heater. A pilot flame on lamp shall be provided and an interlock to allow the main flame to be lit.

- (j) The main fuels and waste gas automatic shut-off valves shall be reset at a local push button station positioned close to the valves, within arm's reach of the peep-hole giving a view of the flame. See also para. 4. This station shall have a separate push button for each fuel and waste gas system.
- (k) Individual burner and pilot flame failures shall be indicated on the local panel. A common flame failure alarm shall be taken to the control room panel. The re-start of the pilot and main flame shall be initiated locally by the operator. Automatic restart is not permitted.
- (l) Care shall be taken to position the local panel and push button stations so they are not affected by the hot furnace steelwork.

At the present time, the experience of BP with the use of flame failure equipment on fired heaters is very limited. Manufacturers' experience on mixed fuel firing is also limited. BP tests indicate the flicker flame failure has given the best results to date and where flame failure devices are used they should be a self-checking flicker unit. Any flame failure unit should differentiate between the main and pilot flame.

6. SERVICES

6.1 Steam

- 6.1.1 Steam nozzles shall be provided in the side walls of the combustion chamber of all heaters and located so as to provide efficient snuffing and purging of the whole volume. The steam shall not impinge upon the coils. Low points in the lines of these nozzles shall have 6 mm (1/4 inch) drain holes to eliminate condensate. the preferred method of connecting the steam lines to the snuffing nozzles is through threaded Tees with branches pointing downwards. The plugged end allows for rodding the nozzle to clear it from blockage.
- 6.1.2 Where clean out headers are used, steam snuffing points shall be provided for each header box compartment arranged to avoid steam impingement or condensate dripping on to headers or tubes.
- 6.1.3 Valves for the combustion chamber purging and header box snuffing steam shall be independent of each other, manually-operated and situated with main fuel stop valves (see para. 4.2.5) at grade not less than 15 m (50 ft) from the heater.



- 6.1.4 Valves for steam blow-through of coils see para. 3.8 shall be located with valves as in para. 6.1.3 and shall be arranged with double-block and bleed on each steam inlet line.

In addition a non-return valve and an isolating valve (lockable open) shall be installed in each steam line positioned as close as possible to the blow-through connection on the individual process passes.

- 6.1.5 The quantities and qualities of feed water or steam supplied to any steam raising or superheater coils shall be specified to the heater designer.

The quality of steam should be specified, depending on its use.

The temperature of the superheated steam can vary considerably, depending on how the heater is operated, on heater load, on excess air, on type of fuel, etc.

- 6.1.6 Process steam superheater vents shall be fitted with silencers.

- * 6.1.7 Unless otherwise agreed with BP specific provisions shall be made for the control of the steam superheat.

If the maintaining of a certain temperature is important, the superheater should be oversized in design and a good quality interstage or outlet desuperheater installed. If there is only a maximum allowable temperature limitation then a desuperheater only will suffice.

A desuperheater with a very large turndown should always be provided.

6.2 Electrical Equipment

- 6.2.1 For electrical equipment attached to or closely associated with, the heater, see section 2.2.3.

- 6.2.2 Sufficient 110 V a.c. socket outlets shall be provided for portable igniters to ensure that no burner is more than 10 m (30 ft) from a socket. the socket outlets and cabling shall have a 5 minute rating of 3.3 kVA.

- 6.2.3 Lighting shall be provided on control platforms, at all ladders and walkways, and at burner firing positions, noting particularly the requirements of under-fired heaters.

Guidance on lighting levels is given in BP Group [RP 12-14](#).



6.3 Routing of Instrument and Electrical Cables

6.3.1 Specific attention shall be given to routing these cables to avoid high risk areas. See also BP Group [RP 24-1](#).

7. TESTING

7.1 Shutdown Systems

On-line testing of the furnace shut-down systems shall follow the procedure established in BP Group [RP 30-5](#) and BP Group [RP 44-1](#). Overriding of any primary or final shut-down element shall be signalled in the control room as a common alarm which will continue to flash irrespective of the override situation.

Thermal efficiencies are very difficult to prove. Whilst guarantees should be requested, a check of the vendor's proposals should be made. Computational techniques, for example BP Engineering computer program HE 36, can be used on conventional heaters to check the vendor's claims for the heater efficiencies.

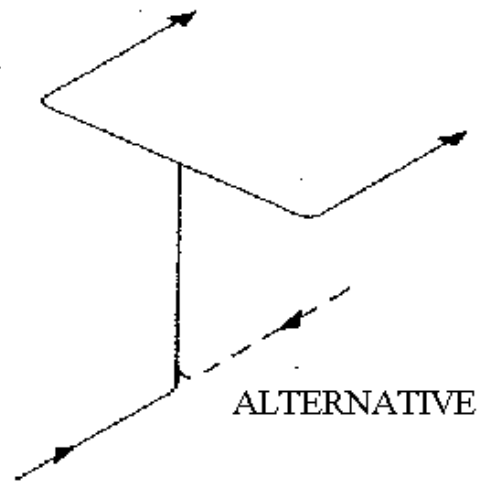
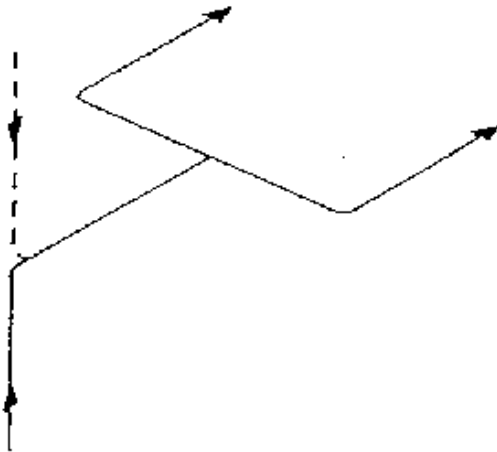
8. DATA AND DRAWINGS

8.1 Proposals for instrumentation systems, control systems and shutdown systems shall be supplied with any quotation for fired heaters.

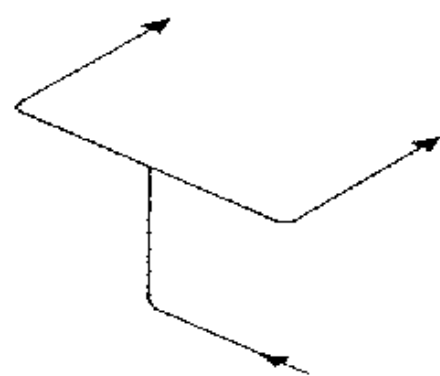
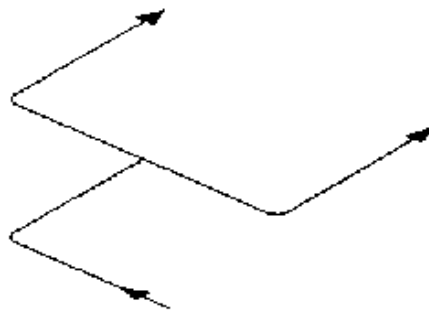
8.2 Details of utility requirements shall be supplied with any quotation for fired heaters.

FIRED HEATERS.

ALTERNATIVE



RECOMMENDED ARRANGEMENTS



ARRANGEMENTS NOT ALLOWED

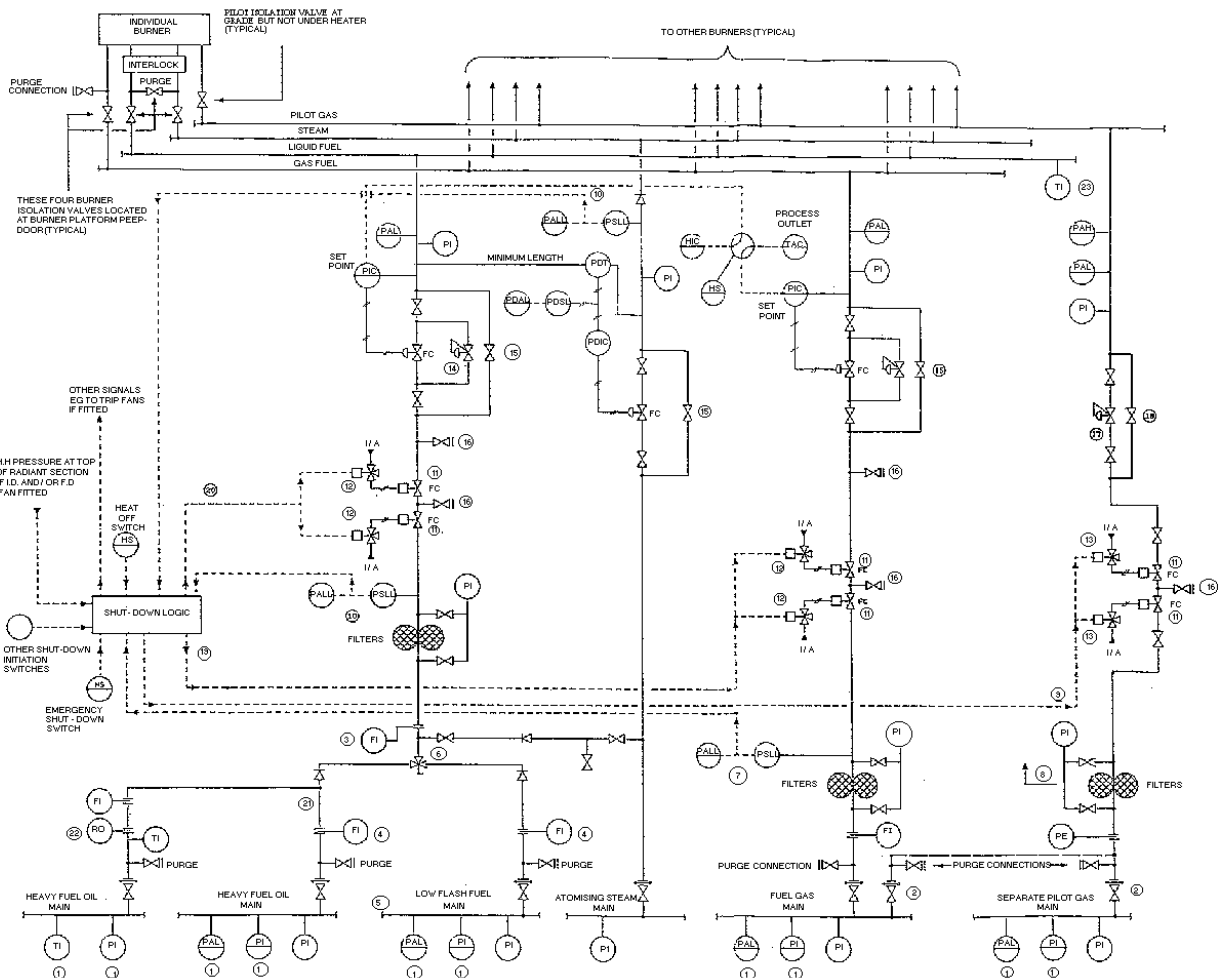
FIGURE 1

ARRANGEMENT OF PIPEWORK FOR SYMMETRICAL TWO-PHASE FLOW



TYPICAL ARRANGEMENT OF FUEL SYSTEMS ON PROCESS HEATERS - MULTIPLE FUELS

FIGURE 2



NOTES for Figure 2:

1. REQUIRED ONLY IF NOT PROVIDED ELSEWHERE IE. DO NOT DUPLICATE.
2. FROM EITHER SUPPLY ONLY, NOT FROM BOTH.
3. FLOW ELEMENT PREFERABLE IN COMMON LINE.
4. THESE ONLY REQUIRED IF (3) IS IMPRACTICABLE.
5. LOW FLASH FUEL SYSTEM TO BE PROVIDED ONLY WHEN SPECIFIED.
6. STEAM PURGE CONNECTION TO BE AS CLOSE TO 3-WAY VALVE AS POSSIBLE.
7. CLOSES FUEL GAS SAFETY SHUT-OFF VALVES ONLY.
8. ALL PILOT GAS PIPEWORK AND VALVING DOWNSTREAM OF FILTERS SHALL BE IN STAINLESS STEEL UNLESS OTHERWISE AGREED WITH BP.
9. OPERATED ON EMERGENCY SHUT-DOWN ONLY. NOT ON HEAT-OFF.
10. CLOSES LIQUID FUEL SAFETY SHUT-OFF VALVES ONLY.
11. SAFETY SHUT-OFF VALVES-BUBBLE TIGHT.
12. FUEL SOLENOID VALVES MANUALLY RESET. SAFETY SHUT-OFF ASSEMBLY (11) , (12) OF EACH FUEL SHALL BE TESTED WHEN FIRING SIMULTANEOUSLY LIQUID & GAS FUELS. THE SYSTEM TO BE TESTED SHALL BE PLACED ON MANUAL CONTROL.
13. PILOT GAS SOLENOID VALVES MANUALLY RESET. DURING NORMAL OPERATION ONE PAIR OF ONE LOOP ENERGISED, THE OTHER PAIR ON THE OTHER LOOP DE-ENERGISED, DETERMINED BY SELECTOR SWITCH ON SHUT-DOWN ENCLOSURE. DURING TEST BOTH PAIRS ENERGISED UNTIL TRIP SIMULATED ON ONE PAIR.
14. SELF OPERATED PRESSURE REDUCING VALVE ADJUSTED FOR MINIMUM SAFE PRESSURE TO MAINTAIN STABLE FLAME IN BURNERS.
15. HAND REGULATING VALVE, FOR LOCAL CONTROL WHEN CONTROL VALVE INOPERATIVE, DOWNSTREAM P.I. TO BE VISIBLE FROM THIS VALVE.
16. PRESSURE MEASURING CONNECTION (FOR TESTING OF SAFETY SHUT-OFF VALVES).
17. SELF-OPERATED PRESSURE REDUCING VALVE.
18. HAND REGULATING VALVE FOR CONTROL WHEN (17) INOPERATIVE. DOWNSTREAM P.I. TO BE VISIBLE FROM THIS VALVE.
19. NOT OPERATED ON LIQUID FUEL FAULT ONLY.
20. NOT OPERATED ON FUEL GAS FAULT ONLY.
21. THIS POINT TO BE AS NEAR TO THE HEATER AS PERMITTED. TO REDUCE THE LENGTH OF NON-CIRCULATING FUEL PIPEWORK.
22. ONLY REQUIRED WHEN NEEDED BY OIL MAIN SYSTEM.
23. LOCATION TO BE AGREED WITH BP.
24. SEE 4.3.2 FOR ALTERNATIVE ATOMISING STEAM PRESSURE.

GENERAL NOTES:

INSTRUMENT SYMBOLS ARE IN ACCORDANCE WITH ISA-S 5.1 LOOPS ARE ABBREVIATED.

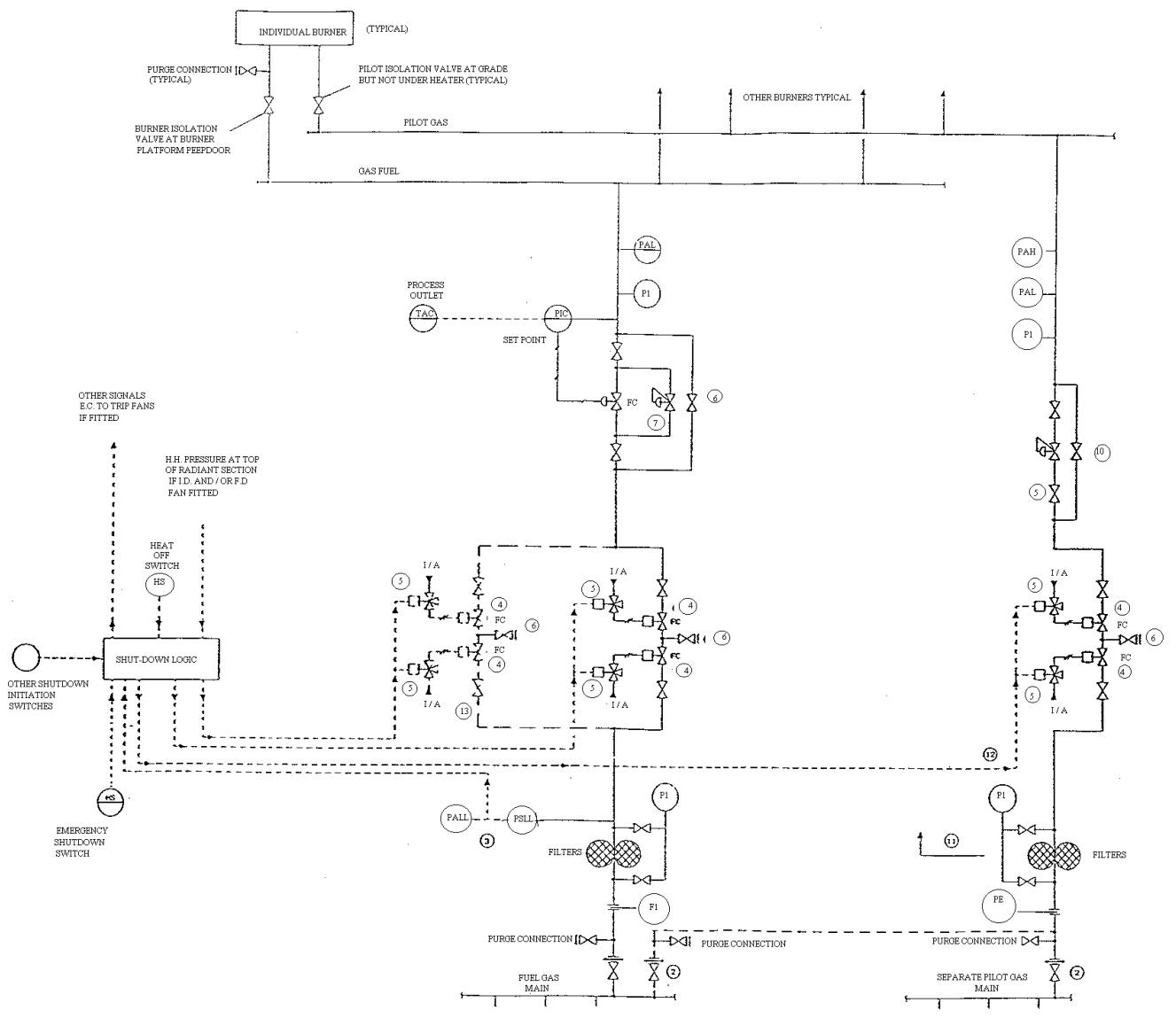
FOR HEAT TRACING SEE PARA. 8.3.3, 8.3.4





TYPICAL ARRANGEMENT OF FUEL SYSTEMS
ON PROCESS HEATERS - SINGLE FUEL (GAS)

FIGURE 3



NOTES for Figure 3:

1. REQUESTED ONLY IF NOT PROVIDED ELSEWHERE. IE. DO NOT DUPLICATE
2. FROM EITHER SUPPLY ONLY. NOT FROM BOTH.
3. CLOSE GAS VALVES ONLY. NOT PILOTS.
4. SAFETY SHUT-OFF VALVES-BUBBLE TIGHT.
5. SOLENOID VALVES MANUALLY RESET: ONE PAIR ON ONE LOOP ENERGISED. THE OTHER PAIR ON THE OTHER LOOP DE-ENERGISED DURING NORMAL OPERATION. DETERMINED BY SELECTOR SWITCH ON SHUT-DOWN ENCLOSURE. DURING TEST BOTH PAIRS ENERGISED UNTIL TRIP CONDITION IS SIMULATED ON ONE PAIR.
6. PRESSURE MEASURING CONNECTION FOR TESTING SAFETY SHUT-OFF VALVES.
7. SELF-OPERATED PRESSURE REDUCING VALVE, ADJUSTED FOR MINIMUM SAFE PRESSURE TO MAINTAIN STABLE MAIN FLAME IN BURNERS.
8. HAND REGULATING VALVE, FOR LOCAL CONTROL WHEN CONTROL VALVE INOPERATIVE, DOWNSTREAM P.I. TO BE VISIBLE FROM THIS VALVE.
9. SELF-OPERATED PRESSURE REDUCING VALVE.
10. HAND REGULATING VALVE, FOR CONTROL WHEN (9) INOPERATIVE. DOWNSTREAM P.I. TO BE VISIBLE FROM THIS VALVE.
11. ALL PILOT GAS PIPEWORK AND VALVING DOWNSTREAM OF FILTERS SHALL BE IN STAINLESS STEEL.
12. OPERATED ON EMERGENCY SHUT-DOWN ONLY, NOT ON HEAT OFF.
13. ADDITIONAL SHUT-OFF VALVES ONLY REQUIRED IF THE FIRED HEATER HAS TO OPERATE FOR CONTINUOUS PERIODS LONGER THAN 6 MONTHS.

GENERAL NOTES:

INSTRUMENT SYMBOLS ARE IN ACCORDANCE WITH ISA-S 5.1 LOOPS ARE ABBREVIATED.

GAS FUEL IS SHOWN - FOR LIQUID FUEL FOLLOW GENERAL REQUIREMENTS FOR LIQUID FUEL SHOWN ON FIGURE 2. BUT WITH SAFETY SHUT-OFF VALVES DUPLICATED.

FOR HEAT TRACING SEE PARA 8.3.3 AND 8.3.4



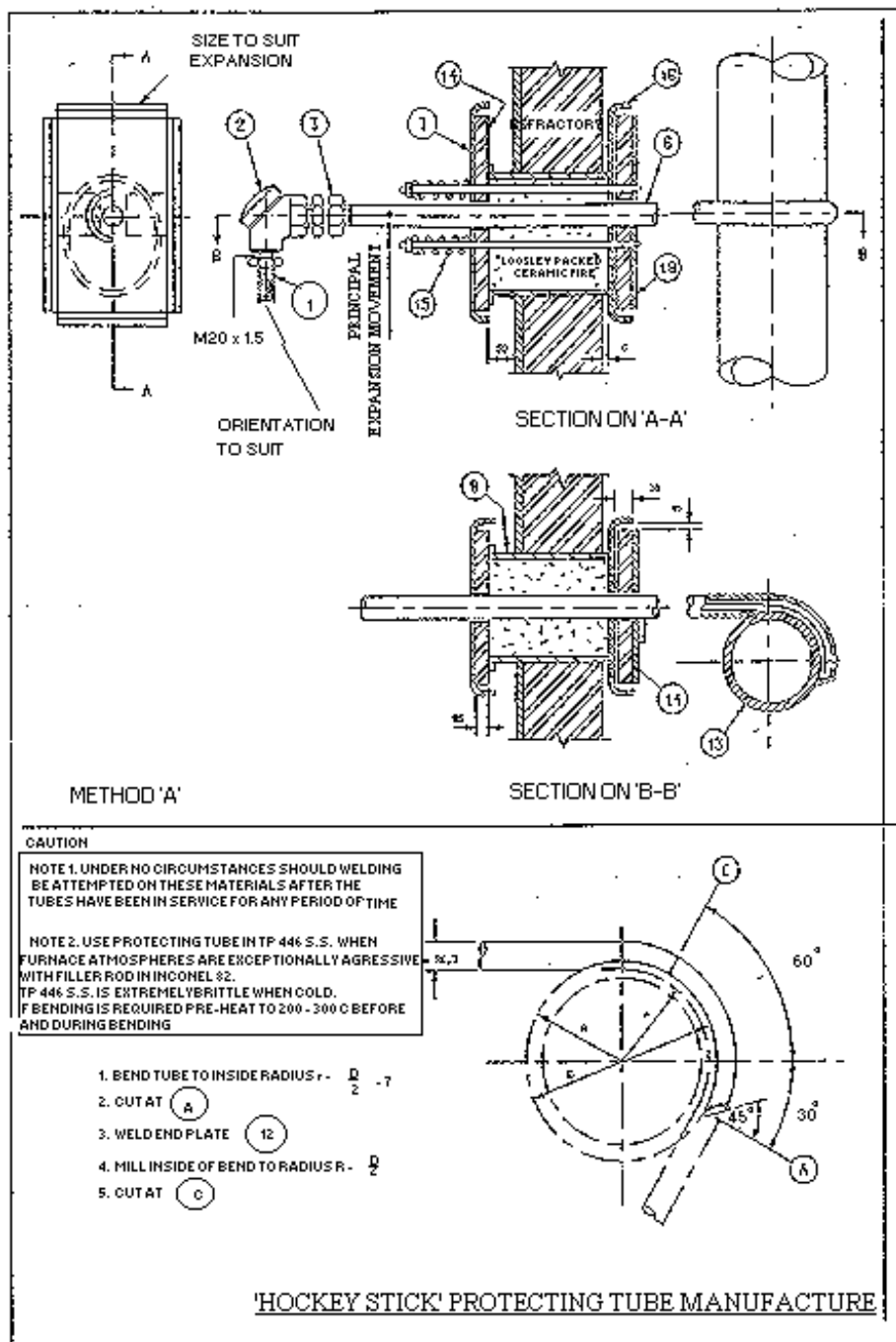
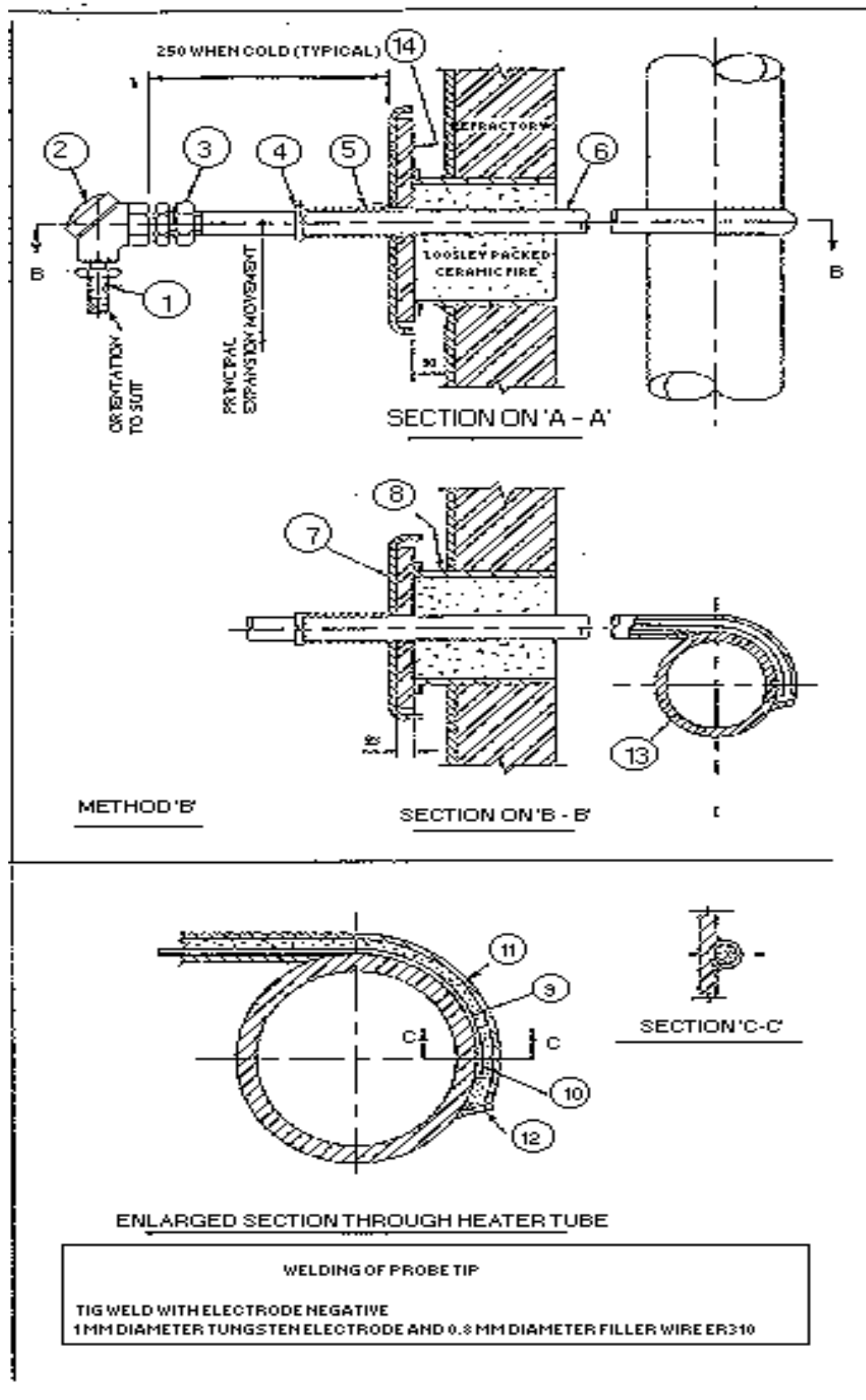


FIGURE 4 (SHEET 1- METHOD 'A')

TUBE SKIN THERMOCOUPLES INSTALLATION DETAILS
(HOCKEY STICK & SLIDING GLAND)



FIGURE

4

(Method

'b')

NOTES for Figure 4

ITEM:	DESCRIPTION	MATERIAL
1	FLEXIBLE CONDUIT	
2	SCREW COVER CONNECTION HEAD	
3	COMPRESSION FITTING	S.S. TP 304 OR 316
4	SPRING TOP WITH RETAINING SCREW	S.S. TP 304 OR 316
5	SPRING	S.S. TP 304 OR 316
6	PROTECTING TUBE 20 N.B. X SCH 80	SEE TABLE BELOW
7	SLIDING PLATE 5 THICK FLANGED ALL ROUND. HOLE DIAMETER = 28	S.S TP 316
8	SLEEVE 5 THICK, FLANGED ONE END. SHAPED AND SIZED TO SUIT EXPANSION	S.S TP 310
9	THERMOCOUPLE PROBE, MINERAL INSULATED (FOR SIZE AND RECOMMENDED TYPE SEE TABLE BELOW)	S.S. TP 310
10	SOLID TIP OF THERMOCOUPLE PROBE	S.S. TP 310
11	TOE OF PROTECTING TUBE	AS ITEM 6
12	END PLATE OF TOE	AS ITEM 6
13	HEATER TUBE	SEE TABLE BELOW
14	CERAMIC FIBRE BOARD (RELIEVED TO SUIT WHEN IN ITEM 16)	FIBREFRAX 6H BOARD OR EQUIVALENT
15	RETAINING ROD 6 DIAMETER, COMPLETE WITH SPRINGS, NUTS AND WASHERS	ROD - S.S. TP 310 SPRINGS NUTS & WASHERS - S.S. TP 304 OR 316
16	SIDING PLATE 5 THICK, FLANGED ALL ROUND HOLE DIAMETER = 28	S.S. TP 310
17	RETAINING CLIP FROM 12 X 4 PLATE	AS ITEM 6
18	RETAINING PLATE 3 THICK	S.S. TP 310
19	SLEEVE	S.S. TP 310
20	COVER PLATE. HOLE DIAMETER 28	S.S. TP 310

INSTALLATION INSTRUCTIONS

1. POLISH WELDING AREA OF HEAT EXCHANGER TO REMOVE OXIDE SCALE.
2. WELD PROTECTING TUBE TO HEATER TUBE.
3. INSERT THERMOCOUPLE PROBE FROM INSIDE WITH THE HELP OF PULL-THROUGH WIRE ENDING IN BRAIDED SELF-GRIPPING SLEEVE.
4. PURCHASE THE THERMOCOUPLE PROBE WITH THE SOLID TIP PRE-BENT TO THE DIMENSION OF THE OUTSIDE RADIUS OF THE HEATER TUBE.
5. SHAPE THE REMAINDER OF THE PROBE AT SITE TO THE CONTOUR OF THE HEATER TUBE, USING A RUBBER HAMMER.
6. WELD THE SOLID TIP OF THE PROBE TO THE HEATER TUBE FOR A DISTANCE OF 15MM. CARE SHALL BE TAKEN THAT MAXIMUM METAL TO METAL CONTACT IS ENSURED DURING WELDING BETWEEN THE SOLID TIP AND THE TUBE, AND THAT THE THERMOCOUPLE IS NOT DESTROYED BY THE HIGH WELDING TEMPERATURES. DURING TIP WELDING, A PORTABLE INSTRUMENT SHOULD BE CONNECTED TO THE THERMOCOUPLE AND WELDING INTERRUPTED FOR FIVE MINUTES IF THE TEMPERATURE EXCEEDS 500°C. MAKE FINAL ELECTRICAL TEST.
7. FILL THE PROTECTING TUBE WITH CERAMIC FIBRE.
8. FILL THE PROTECTING TUBE TOE WITH CERAMIC FIBRE, PLACE TOE OVER PROBE TIP AND WELD ALL ROUND.
9. TEST AIR TIGHTNESS WITH SOAPY WATER AND 100 PSI AIR.
10. COMPLETE INSULATION.



Figure 4 Notes continued

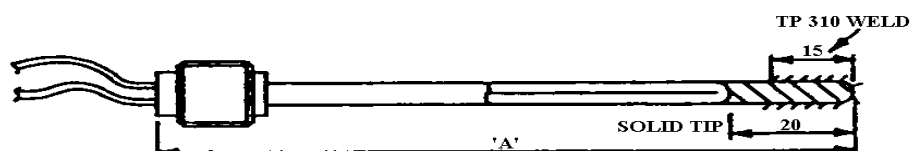
HEATER TUBE MATERIAL	PROTECTING TUBE	FILLER ROD	PRE-HEAT TEMPERATURE	STRESS RELIEF TEMPERATURE
CS P 1 C½Mo	TP 310	310	150° - 200°	NONE
P 11 1¼Cr ½Mo P 22 2¼ Cr1Mo P 5 5Cr½Mo P 7 7Cr½Mo P9 9Cr1Mo	TP 310	310	250° - 300°	NONE
TP 321 SS TP 347 SS TP 310 SS HK 40 - SEE NOTE 1	TP 310 SEE NOTE 2	310 SEE NOTE 2	NONE	NONE
INCOLOY 800 HT 30 - SEE NOTE 1	INCOLOY 800	INCONEL 82	NONE	NONE

RECOMMENDED THERMOCOUPLE PROBE: INSULATED NOT JUNCTION WITH SOLID TIP

2 CORE D 3 MM - TYPE: KWK 2830 WITH 20MM LONG SOLID TIP) BY BICC-PYROTENAX

4 CORE D 3MM - TYPE: KWK4830 WITH 20MM LONG SOLID TIP)

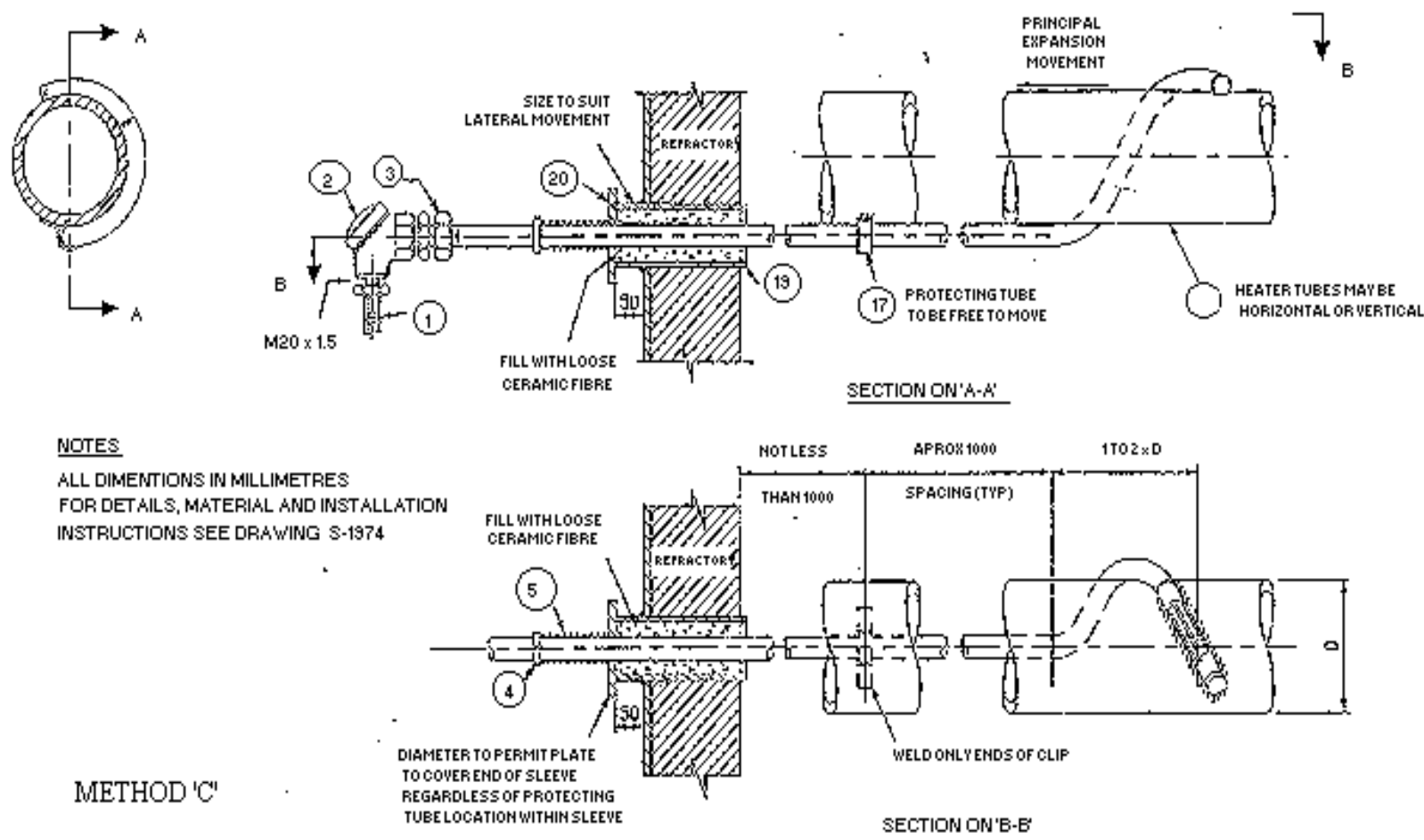
NOTE: WHEN ORDERING, QUOTE THE PRESENT RADIUS OF THE SOLID TOP = HALF O.D. OF HEATER TUBE, LENGTH 'A' OVER SEAL AND LENGTH OF TAILS.



8MM ISO EXTERNAL THREADED SEAL TO BE CLOSED TO ITEM 2, LEFT LOOSE INSIDE PROTECTING TUBE AND PACKED LIGHTLY WITH CERAMIC FIBRE.

NOTE: FOR OTHER METHODS AND APPLICATION NOTES, SEE DRAWING S-1975

FIGURE 5 (METHOD 'C')
TUBE SKIN THERMOCOUPLES INSTALLATION DETAILS FOR AXIAL, EXIT

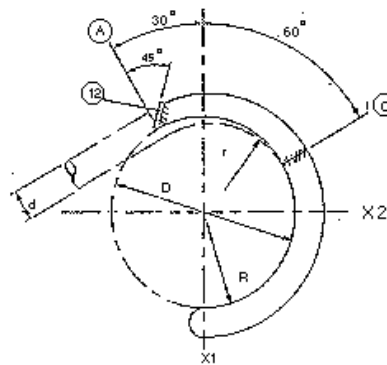


'HOCKEY STICK PROTECTING TUBE MANUFACTURE

2. CITE AT (A)

3. WELD END PLATE (12)

5. CUT AT



NOTES ON APPLICATION OF DIVERSE METHODS.

METHOD 'A': FOR CASES WHERE PRINCIPAL EXPANSION MOVEMENT IS LATERAL TO THERMOCOUPLE PROTECTING TUBE AND ACCESS FOR INSTALLING INTERNAL SLIDING PLATE IS AVAILABLE

METHOD 'B' AS METHOD 'A' ABOVE, BUT WHERE ACCESS IS NOT AVAILABLE, E.G. IN THE CONNECTION SECTION.

METHOD 'C': FOR CASES WHERE PRINCIPAL EXPANSION MOVEMENT IS AXIAL WITH THE PROTECTING TUBE AND HEAT ACTION ON SLEEVE (ITEM) 19) LIMITED, OTHERWISE USE METHOD 'A'

METHOD 'D' : (NOT SHOWN) FOR ANY OF THE ABOVE FOR CLOSURE OF THE OPENING, USE INSTEAD OF A SLIDING PLATE (ITEM7) OR COVER PLATE (ITEM 20 A FIBRE CLOTH GAITER OR BELLOWS ATTACHED AT ONE END TO THE SLEEVE AND AT THE OTHER TO THE THERMOCOUPLE PROTECTMG TUBE, USING STAINLESS STEEL 'JUBILEE' TYPE CLIPS.

FIGURE 5

TUBE SKIN THERMOCOUPLES INSTALLATION DETAILS FOR AXIAL, EXIT

DEFINITIONS AND ABBREVIATIONS

Standardised definitions may be found in the BP Group RPSEs Introductory volume

Definitions

supplier: the manufacturer, or authorised agent of the manufacturer, of equipment covered by this Recommended Practice.

Abbreviations

ACI	American Concrete Institute
API	American Petroleum Institute
FD	Forced Draught
ID	Induced Draught
IP	Institute of Petroleum
HFO	Hot Fuel Oil
LFD	Light Distillate Fuel
UK	United Kingdom
USA	United States of America

LIST OF REFERENCED DOCUMENTS

A reference invoke the latest published issue or amendment unless stated otherwise.

Referenced standards may be replaced by equivalent standards that are internationally or otherwise recognised provided that it can be shown to the satisfaction of the purchaser's professional engineer that they meet or exceed the requirements of the referenced standards.

National and Industry Documents

API 560	Fired Heaters for General Services
BS 5351	Steel ball valves for the petroleum, petrochemical and allied industries
ACI 307	Standard Practice for design and construction of cast-in-place reinforced concrete chimneys and commentary
Oil and Gas Journal	July 26th 1954

BP Documents

BP Group GS 122-1	Fired Heaters to API 560 (Replaces BP Std 162)
BP Group RP 12-14	<i>Electrical Systems: Lighting and Lighting Installations</i> (Replaces BP CP 17 Part 14)
BP Group RP 14-1	Noise Control (Replaces BP CP 2)
BP Group RP 24-1	Fire Protection - Onshore (Replaces BP CPs 15 & 16 for onshore application)
BP Group RP 30-1	<i>Instrumentation Part 1: Introduction</i> (Replaces BP CP 18 Part 1)
BP Group RP 30-5	Instrumentation Part 5: Protective Systems (Replaces BP CP 18 Part 5)
BP Group RP 30-6	Protective Instrumentation Systems (Replaces BP CP 48 and Report BPE.91.ER.103 Appendix 1)
BP Group RP 42-1	Piping Systems to ANSI B31.3 (Replaces BP CP 12)



BP Group [RP 44-1](#) Over Pressure Protection Systems
(Replaces BP CP 14)

BP Group [RP 56-2](#) Water Treatment for Boiler Installations
(Replaces BP CP 26)

BP 'Safe Furnace Operation Handbook'



TUBE STEAM-AIR DECOKING

C.1 DESCRIPTION OF PROCESS

Steam-air decoking refers to the removing of coke from the inside of furnace tubes by the action of steam and air.

The decoking operation comprises two parts, known as spalling and burning respectively.

During spalling, steam only is admitted to the furnace coil(s) at fairly high rates while the furnace is fired. Coke is removed: by the cooling action of the steam on the hot tubes causing the coke to contract and break away, by the scouring action of the high velocity steam and coke particles, and by chemical reaction between the steam and carbon. With proper operation, some heaters can be completely decoked by spalling and the burning operation can be omitted.

During the burning period, steam and air together flow through the coils to remove the remaining coke by combustion. The burning can be done: either one pass at a time whilst steam alone is admitted through the remaining passes to prevent overheating of the tubes, or simultaneously in all or in some passes in parallel, cooling the rest by steam alone.

The simultaneous method is used by some operators but requires good experience.

This appendix puts forward the design requirements for a steam-air decoking system in detail and gives only a short description of the process and its application. Further details may be obtained from experts such as those in BP Engineering.

C.2 APPLICATION OF STEAM-AIR DECOKING

(1) Common Refinery Fired Heaters

In refinery heaters where coking is expected, such as thermal crackers, atmospheric and vacuum distillation units, etc., steam-air decoking facilities are required when specified (see 2.7.1) and their design requirements are listed below.

* (2) Specialised Fired Heaters

In specialised fired heaters where high alloy tubes are used, such as steam cracking heaters, higher temperatures and special techniques may be used. The design requirements for these heaters shall be approved by BP.

The efficiency of both spalling and burning is increased as the temperature of the steam or steam-air mixture is raised through the

pass. Thus, in a heater where the majority of coke formation is at the normal outlet end of the passes, the decoking flow should be in the normal direction. Where coke forms largely towards the inlet or convection end, the decoking flow should be in the reverse direction to the process flow. In exceptional circumstances, some heaters may require decoking in both directions, but to minimise capital cost and simplify the procedure, single-direction decoking should be the aim. For completeness, this Appendix deals with the general case of decoking in both directions, but it will be clear from the text and figures which parts apply to single-direction decoking only.

C.3 DESIGN REQUIREMENTS FOR STEAM-AIR DECOKING

C.3.1 Fired Heater

(a) Pass Arrangement

Particular consideration shall be given to the arrangements for steam-air decoking of furnaces which have split passes or increases in tube diameter part way through the coil. The mass velocities of steam and air, that are defined later, shall be maintained through all parts of the coil. In order to achieve this, additional steam injection points, with flow measurement and control, may be required.

(b) Observation Doors

For safe decoking it is essential to have a complete view of all radiant and shield tubes to observe the colour of tubes during the burning period.

(c) Expansion Clearances

Where there is any possibility that furnace tubes, on any heater, will need to be decoked, adequate expansion clearances shall be provided to cater for the high tube metal decoking temperatures. for the purpose of expansion clearances only, assume that the maximum tube metal temperatures are :

carbon steel and 2% Cr to 9% Cr steels	705°C (1300°F)
18% Cr 8% Ni	900°C (1650°F)
25% Cr 20% Ni	1120°C (2050°F)

(d) Convection Section Cooling

If a heater has a separate convection section on an independent duty, provision shall be made to cool the convection section tubes during the furnace decoking periods.

(e) 18/8 Stainless Steel Coils

Where 18/8 stainless steel coils are used, consideration shall be given to the prevention of formation of polythenic acid. At least, nitrogen purge connections shall be provided.

C.3.2 Decoking Facilities

C.3.2.1 Pipework Arrangement

The attached Figs. 4 and 5 show typical connections to be made to furnace coils to permit the mixing of steam and air in desired proportions for forward and/or reverse directions of flow as required. The 40 mm (1 1/2 in.) sample connection shown is provided for observation of the characteristics of the heater effluent during decoking whilst the bulk is discharged to the heater stack or coke knock-out drum.

The change from process to decoking condition is usually accomplished by the use of swing bends, sometimes by blinds or valves. Arrangements shall be such that flow meters, control valves and process thermowells are not subjected to the damaging flow of the coke-laden effluent and the design shall ensure that 'blind' ends where coke can build up are avoided.

C.3.2.2 Design Steam Requirements

Steam mass velocity for spalling is 88 to 140 kg/s. sq.m (18 to 29 lb/s. sq.ft) and for burning or cooling some 30 to 60 kg/s. sq.m (6 to 12 lb/s. sq.ft). Steam pressures shall be sufficient to pass 140 kg/s. sq.m (29 lb/s. sq.ft) of steam through the pass. Normally steam is taken off the bar (145 psig) steam supply.

C.3.2.3 Design Air Requirements

The recommended design rate is 6 kg/s. sq.m (1.2 lb/s. sq.ft). If this rate cannot be achieved for burning all passes simultaneously, burning will have to be performed sequentially.

Air pressure shall be assumed to be 6 to 8 bar (87 to 116 psig).

C.3.2.4 Design Water Requirements

Normally sufficient quench water shall be provided to cool the effluent down from 650°C to 260°C (1200°F to 500°F). However, at times, total quench may be required. For total quench, the latent and the superheat shall be assumed to be removed from the steam.

Note: For the purpose of sizing the steam, air and quench lines, the contractor shall assume that all the passes are being decoked in parallel at the same time. The spalling steam per pass shall be assumed to be 88 kg/s. sq.m (8 lb/s. sq.ft), the air 6 kg/s. sq.m (1/2 lb/s. sq.ft), and the quench water sufficient to cool the effluent from all the passes down from 650°C to 150°C (1200°F to 30°F), or to remove the superheat and the latent heat from the steam when one pass is being steam air decoked and the clear passes steam cooled, whichever is the greater.

C.3.2.5 Instrumentation

Steam lines and air lines shall be fitted with flow elements for connecting to portable flow meters, followed by hand regulating valves and pressure gauges.

Temperature indication is required of the outlet temperatures from each pass, and during reverse flow decoking, at the crossover from the radiant to the convection section, and at the inlet to the heater. For this purpose some process and skin thermocouples may be used, providing their range is suitable. To avoid damage to the outlet process thermowells during spalling, they shall be placed in the piping on the side of the swing bends away from the heater. Special decoking thermowells shall be located in the decoking outlet lines and inserted for decoking only. As local indication is required during decoking, all thermocouples except the process outlet ones shall be wired to junction boxes at grade, for connection to a portable multi-point temperature indicator/recorder. Where there are no suitable process thermocouples special ones shall be provided, similarly wired.

* C.3.2.6 Decoking Effluent Disposal

Effluent may be discharged directly to a ground supported stack or, in other cases, through a coke knock-out drum. the method of discharge shall be discussed and agreed with BP. The effluent piping has its end open to atmosphere and as such is subjected to very low pressure only. Normally the piping material should be carbon steel, even the section upstream of water quench. To prevent erosion, the effluent piping shall



be sized for a maximum velocity of 300 m/s (1000 ft/s), assuming a temperature of 650°C (1200°F) upstream of the quench and 260°C (500°F) downstream, where flow volume is to include the vaporised quench.

The decoking lines from the furnace shall enter the main decoking header along the top quadrant at an angle not steeper than 45° to the horizontal as shown in Figure 2.

Where the effluent is discharged directly to the stack, a target plate shall be provided to protect the stack from erosion by the coke in the effluent. Where the effluent passes through a coke knock-out drum before entering the heater ducting or a stack, the effluent line shall enter the stack or heater ducting at an angle of not more than 45 degrees to the axis of the ducting or the stack. Where necessary, a target plate shall be provided to protect the stack or ducting from erosion.

C.3.2.7 Quench Nozzles

To control metal temperatures on the decoking system, the quench water shall be added to :-

- (a) the decoking effluent downstream of the sampling points, as close as possible to the heater,
- (b) the knock-out drum, where provided.

The quench nozzle(s) in the effluent pipework shall be so located that good contact with the effluent stream is maintained and so that there is a minimum of 4 m (13 ft) straight run of pipework downstream of the quench nozzle(s).

C.3.2.8 Coke Knock-out Drum

The coke knock-out drum shall be designed for a maximum temperature of 400°C (750°F) and a pressure equal to the pressure drop between the drum and the stack, plus 0.07 bar (1 psi). The size and layout of the pipework between the drum and the stack shall ensure that the drum design pressure does not exceed 1.0 bar (14.5 psig). A 3 mm (1/8 in.) corrosion allowance shall be used when the shell thickness is established.

On a stack mounted above a convection section, the knock-out drum shall be so designed that any particles not removed by the drum are small enough to be carried up the stack. To help achieve good separation of the coke particles and to prevent them from dropping into

the convection section with a furnace-mounted stack, the effluent velocity should be below 37 m/s (120 ft/s) for a distance of 20 pipe diameters upstream and 5 downstream of the drum. The knock-out drum should be designed as a cyclone with a tangential inlet and the top central outlet extending internally to Ω diameter below the bottom of the inlet. A rough guide to the size of the drum is that its diameter should be approximately 5 to 6 times the diameter of the inlet nozzle, and the height should equal the diameter plus the height required to hold all the coke from a 6 mm (1/4 in) thick layer of coke in all the radiant tubes. The top of the drum may be flat or conical, designed as a low pressure tank. Where the knock-out drum is placed inside the base of the stack under the false floor, or in such a way that the pressure drop downstream is very low, the drum may be bolted directly to the concrete base without having a bottom plate. All knock-out drums shall have a large bolted access and clean out door.

Note

- (1) For heaters with separate stacks, the knock-out drum design shall be approved by BP.
- (2) To estimate the bulk volume of coke, assume a solid density of 2.1 tonne/cu.m (131 lb/cu.ft) and bulk density of 0.78 tonne/cu.m (49 lb/cu.ft).



REGIONAL REQUIREMENTS**1. GENERAL****1.1 Shut-Off Systems**

We believe it is a statutory requirement in Holland and in Germany that shut-off valves should not be bypassed.

Whilst this is not a statutory requirement in the UK and the USA, the various standards and codes of practice for fuel oil and gas firing state, or indicate, that safety shut-off valves should not be bypassed with manually operated valves.

SUPPLEMENTARY COMMENTARY

E1

Scope

This Commentary relates to clause 1

BP Group RP 22-1 and BP Group [GS 122-1](#) should be applied to most refinery and petrochemical fired heaters. However, exceptions quoted in the main documents are made for the following reasons :

- (a) *Some heaters operate with relatively low flue gas temperature, with or without radiation sections, hence individual pass control equipment may not be necessary.*
- (b) *Some of the specialised heaters are prepackaged in the vendor's works and delivered to site complete with instrumentation, etc. They are designed as standard units and, as such, can be produced at competitive prices. Any alterations to make them suit BP Specifications would make them non-standard.*

Such packaged heaters are acceptable, even when not fulfilling all the requirements of BP Specifications provided that :

- (i) *The equipment supplied is suitable and safe for use in the plant for which it is intended, with specific reference to its design, materials, equipment classification, etc.*
- (ii) *The proposed heater is from the vendor's standard range and has been proved on similar duties.*
- (iii) *The heater is acceptable to the operator and the local authorities.*

Note We would not expect standard packaged heaters that do not conform to the requirements of BP Group [GS 122-1](#) and BP Group RP 22-1 to be used for most conventional duties.

It is essential that the proposed packaged heaters are the vendor's standard units, not just 'one-off' units designed as a package to avoid meeting the requirements of BP Group RP 22-1.

- (c) *Some heaters have to perform specialised duties and it may not be possible to insist that all of the requirement of BP Group RP 22-1 are complied with.*

Where such packaged or specialised heaters are proposed, BP and the Contractor should agree at the proposal stage which parts of BP Standards are not applicable. The rest should be complied with.

E2

Conceptual Design

This commentary relates to clause 2.1.1

Multiple Stacks and Excess Air Operation



Where a heater is on hydrocarbon heating duty and there is a tube leak there is with high excess operation a risk of explosion or a serious fire in the heater. Operation with low excess will reduce this risk.

Where it is expected to operate a heater or an incinerator with a high excess air for long periods or when a heater is on standby and, as the result of this, the mixture of flue gases from all heaters in the common duct would be expected to exceed 6% of oxygen, (approx. 40% excess air) consideration should be given to using multiple flues in a common stack. Multiple flues also help maintain stack efflux velocities as the heater loads vary.

Where it is expected that unburned combustibles occur in the flue gases during upset conditions, e.g. Cat Cracker flue gases, a separate flue should be considered for that system.

It is the requirement of BP Group RP 22-1 that the heater, the flue gas ducts and the stack are refractory lined to try to cater for fires caused by tube failures, etc. Other units, such as boilers, do not have this requirement for the ducts and stack. In addition, whilst conventional heater flues should be under negative pressure at all times, this is not the case for the other units, e.g. boilers. Hence, separate flues for heaters and boilers may be a more economical proposition.

E3

Stacks

This Commentary relates to clause 2.8

Refractory Lining

Where there is a possibility of tubes containing flammable liquids leading to and thus causing a fire in the heater and stack, BP require the flues and the stack to be lined internally with refractory. On special heaters with very short stacks, which can easily be replaced, and where the flue gas temperature does not exceed 450°C (850°F), this requirement could be waived, as it could be for gas fired water heaters. However, we warn of the problem of low temperature corrosion in stacks, caused by the stack metal temperature being below the dewpoint temperature of the flue gases in unlined stacks or by the intermittent operation of heaters with unlined or externally lined stacks.

The specification of the stack exit being 6 m (20 ft) above the top platform on the unit or nearby units is in order to avoid a hazard to personnel on that platform. Nearby units are defined as those that can be affected by the stack effluent. We are unable to give any data on this, and suggest that, if there is thought to be a problem, an attempt be made to establish the maximum gas temperature and the maximum possible concentration of dangerous contaminants that can occur at the platform. If the temperatures and concentrations are above those allowed for, either the stack height will have to be increased, or means will have to be provided to prevent access to the platform when flue gas is being discharged from the stack.

The 9 m/s (30 ft/s) is a BP requirement; it is possible that the local authorities will require at least 15 m/s (50 ft/s), but what needs to be established is what the 15m/s related to: stack design load or heater design load. To date BP have used stack design load which is greater than heater design load flue gas quantity.

Reinforced Concrete Stacks: Allowable Stresses



British Standards and Codes of Practice for reinforced concrete, or equivalent local national standards or codes, state general allowable stresses to be used in design for various grades of concrete and reinforcing steel. However, concrete windshields or shells of chimneys are subject to loading from self-weight, the effect of temperature, both vertical and circumferentially, and the effect of either wind or earthquake, whichever is the greater. Also, holes have to be provided through the windshield for the flue ducts to enter. To allow for the combined stresses that can occur due to various combinations of the aforementioned loadings, and for stress concentrations that can occur at change of section, e.g. openings, allowable stresses for both concrete and steel reinforcement, using classical elastic theory, shall be in accordance with those stated in Clause 4.9 of [ACI 307](#). Permissible stresses recommended for concrete in ACI 307 are in terms of 28-day cylinder strengths (f_c') and these may be related in terms of 28-day strengths of 150 mm (6 in) cubes (f_{cu}) by assuming $f_c' = 0.8 f_{cu}$.

Spacing of Corbels

In determining the spacing of corbels, used either to support directly sectional brick linings or, alternatively, used to support freely internal platforms with the sectional brick linings supported off the platforms, a number of items have to be taken into consideration. The main items are :-

- (a) The compressive strength of the bricks and the mortar.
- (b) The vertical thermal expansion.
- (c) Deflection of the outer concrete windshield under external wind load.

In practice, it has been found that a spacing of 10 m (35 ft) between the corbels provides the best solution to meet the requirements of the above-mentioned items. It should be noted that, at the expansion joint formed in the sectional liners, an adequate flexible gas tight seal should always be provided, the seal being amply capable of accommodating the maximum vertical thermal expansion of the height of the section of liner.

E4 Instruments

This Commentary relates to clause 5

E4.1 The section on instrumentation does not contain any references to automatic combustion control. This is intentional because to date we have not been able to find a proved reliable 'low maintenance' system. However, on single fuel systems with air or fixed MW gas, automatic combustion control should be possible. If vendors offer automatic combustion control equipment for a typical refinery duty, e.g. variable MW gas plus oil firing on the same unit with 10% or less excess air, check that they have similar systems operating under similar refinery conditions, and that these systems have been operating satisfactorily on several units for sufficiently long period.

E4.2 It is not mandatory to use all the instrumentation specified under this Section. The instrumentation is specified as a basic scheme. Each heater has to be considered separately and the instrumentation system selected to suit the heater duty. However, we feel that the instrumentation specified is the minimum generally required to enable the heater to be operated safely. In most instances, additional

process instrumentation will be required. See also BP Group [RP 30-1](#) to [RP 30-5](#), and BP Group [RP 30-6](#).

E4.3 *No attempt has been made to specify equipment for purge timing, flame establishment timing, etc. On conventional refinery heaters start-up is supervised by operators. Advice for commissioning the heaters and starting up during normal operation is given in the BP 'Safe Furnace Operation Handbook'. On special heaters, any proposals for automatic start-up should be checked carefully to ensure that the system is safe.*

The problem is that quite often the vendor does not fully understand the requirements and the processes of the equipment user.

Normal flame establishment period is 5 seconds for fuel gas and 10 seconds for fuel oil.

E4.4 *We have only specified the type of instrumentation required, not the number. Often on large heaters, several measuring points are required to do the same duty, e.g. oxygen analysis, flue gas pressures, etc., as outlined in 5.2.1, 5.2.2 and 5.2.5.*

E4.5 *This Commentary relates to clauses 5.2.1, 5.2.2 & 5.2.3*

The temperature and pressure of the flue gases may vary considerably along the length of a box heater if the firing of the burners is uneven, regarding either the amount of fuel burnt or the excess of air. Also, the flue gases may be stratified across the cross-section of the flow. It may be necessary to carry out tests using probes that can be inserted to check the temperature and pressure distributions before selecting a permanent position for the sensing points which would give a representative indication.