

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

TECHNICAL SPECIFICATION

FIRED HEATERS, INCLUDING WASTE HEAT BOILERS (AMENDMENTS/SUPPLEMENTS TO ISO 13705:2006)

PTS 31.24.00.30

March 2010



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PTS Circular March 2010 - PTS 31.24.00.30		
PTS No:	31.24.00.30	
PTS Title:	Fired Heaters, Including Waste Heat Boilers (Amendments/Supplements To ISO 13705)	

This revision of PTS 31.24.00.30 – **Fired Heaters, Including Waste Heat Boilers (Amendments/Supplements TO ISO 13705) (March 2010)** has been updated to new ISO 13705:2006. All updates in the document are highlighted in *italic* font.

The previous version of this PTS 31.24.00.30 (**December 2004**) will be removed from PTS binder / e-repository from herein onwards.

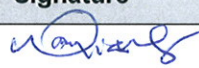
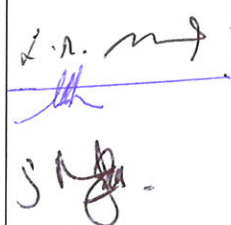
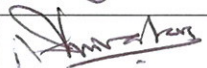
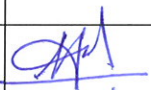
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Revision History

Rev No.	Reviewed by	Approved by	Date
2	Uthan Ak Chuat Bijay Nepak Kumar	M K Shrivastava	March 2010
1	Based on ISO 13705: 2001	-	December 2004
0	Based on API 560, 1 st Edition (1986)	-	October 1995

PREFACE

PETRONAS Technical Standards (PTS) publications reflect the views, at the time of publication, of PETRONAS OPU/Divisions.

They are based on the experience acquired during the involvement with the design, construction, operation and maintenance of processing units and facilities. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good technical practice to be applied by PETRONAS' OPU in oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where PTS may not cover every requirement or diversity of condition at each locality. The system of PTS is expected to be sufficiently flexible to allow individual operating units to adapt the information set forth in PTS to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use PTS they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, it is expected of them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the PTS. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the owner.

The right to use PTS rests with three categories of users:

- 1) PETRONAS and its affiliates.
- 2) Other parties who are authorized to use PTS subject to appropriate contractual arrangements.
- 3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) and 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

Subject to any particular terms and conditions as may be set forth in specific agreements with users, PETRONAS disclaims any liability of whatsoever nature for any damage (including injury or death) suffered by any company or person whomsoever as a result of or in connection with the use, application or implementation of any PTS, combination of PTS or any part thereof. The benefit of this disclaimer shall inure in all respects to PETRONAS and/or any company affiliated to PETRONAS that may issue PTS or require the use of PTS.

Without prejudice to any specific terms in respect of confidentiality under relevant contractual arrangements, PTS shall not, without the prior written consent of PETRONAS, be disclosed by users to any company or person whomsoever and the PTS shall be used exclusively for the purpose they have been provided to the user. They shall be returned after use, including any copies which shall only be made by users with the express prior written consent of PETRONAS.

The copyright of PTS vests in PETRONAS. Users shall arrange for PTS to be held in safe custody and PETRONAS may at any time require information satisfactory to PETRONAS in order to ascertain how users implement this requirement.

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PART I INTRODUCTION

1.1 SCOPE

This PTS specifies requirements and gives recommendations for the design, engineering, fabrication and inspection 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.

Excluded from the scope of this PTS are:

- materials selection for special heaters such as high-temperature conversion and steam heaters (tube wall temperature above 700 °C), and for heaters for catalytic chemical reactions; these aspects are covered by PTS 31.24.40.31
- waste heat boilers associated with gas turbine exhausts; this aspect is covered by PTS 30.75.10.31

This PTS is a revision of, the PTS of the same number dated *December 2004*; it is impractical to summarise the differences, see (1.5).

This PTS is based on ISO 13705:2006. Part II of this PTS amends, supplements and deletes various clauses of ISO 13705:2006. Clauses of ISO 13705:2006 that are not mentioned in this PTS shall apply as written.

NOTES: 1. ISO 13705:2006 is identical with ANSI/API Standard 560, 4th Edition, August 2007, as indicated in ANSI/API Standard 560, 4th Edition, August 2007.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to companies forming part of PETRONAS or managed by a Group company and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them.

This PTS is intended for use in oil refineries, chemical plants, gas plants, exploration and production facilities and, where applicable, supply/marketing installations. When PTS are applied, a Management of Change (MOC) process should 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 may be more stringent than in this PTS the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this PTS 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 with the object of obtaining agreement to follow this PTS as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

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

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

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. 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 word **should** indicates a recommendation.

1.3.2 Specific definitions

The words **tubes** or **tubing** shall also mean **pipe** or **piping** unless clearly distinguished otherwise.

1.4 CROSS-REFERENCES

Where cross-references are made, the number of the clause or sub-clause referred to is shown in brackets.

All publications referred to in this PTS are listed in (Part III).

1.5 SUMMARY OF MAIN CHANGES SINCE PREVIOUS EDITION

This PTS is a revision of the PTS of the same number dated *December 2004*, which was based on *ISO 13705:2001*. The current edition of the PTS is now based on *ISO 13705 2nd Edition 2006*. The following are the changes to the previous edition.

Old Section	New Section	Subject
1.1		Notes updated.
4.3	4.2	Renumbering to match ISO 13705 2 nd Edition 2006.
4.4	4.3	Renumbering to match ISO 13705 2 nd Edition 2006.
4.5	4.4	Renumbering to match ISO 13705 2 nd Edition 2006.
4.5.1	4.4.1	Renumbering to match ISO 13705 2 nd Edition 2006.
4.5.2	4.4.2	Renumbering to match ISO 13705 2 nd Edition 2006.
5.2		Renumbering.
5.4		Renumbering.
6.1.1		Change title to "Replace this clause". Rephased 1 st paragraph.
6.3.13		Renumbering table to match ISO 13705 2 nd Edition 2006.
7.1.3		Deleted.

8.1.3		Renumbering.
11.1.5	11.1.6	Renumbering to match ISO 13705 2 nd Edition 2006.
11.1.6	11.1.7	Renumbering to match ISO 13705 2 nd Edition 2006.
11.1.7	11.1.8	Renumbering to match ISO 13705 2 nd Edition 2006.
11.1.9	11.1.11	Renumbering to match ISO 13705 2 nd Edition 2006.
11.1.10	11.1.13	Renumbering to match ISO 13705 2 nd Edition 2006.
11.4		Replacing "Man-Made Vitreous Fibre Guidelines as issued by Shell Chemicals (HSE)" with "PTS 60.1502.05".
11.4.2		Deleted.
11.4.3		Deleted.
11.4.4		Deleted.
11.4.5		Deleted.
11.4.6		Deleted.
11.4.9		Deleted.
11.4.11		Deleted.
11.4.13		Deleted.
11.4.15		Deleted.
11.4.17		Deleted.
11.4.18		Deleted.
11.5.3		Deleted.
11.5.5		Deleted.
11.6.2		Deleted.
15.1.1	15.1.1.1	Renumbering to match ISO 13705 2 nd Edition 2006.
16.5.8		Paragraph rephrased and updated.
17.4.7		Change title from "Add new clause" to "Add to this clause".
17.5.2.2	17.5.2	Renumbering to match ISO 13705 2 nd Edition 2006.
PART III References		Deleted "Man-made Vitreous Fibres Guidelines, Shell Chemical HSE" in the list. Added "PTS 60.1502.05 Man-made Mineral Fibres (guideline)".

PART II AMENDMENTS AND SUPPLEMENTS TO ISO 13705

INTRODUCTION

Add the following:

A bullet (•) *at the beginning of a clause or subclause* in this PTS indicates that *a decision is required* or further decisions or information are to be provided by the Principal.

1. SCOPE

Add to this clause:

This PTS also covers unfired waste heat boiler convection sections. For waste heat boilers downstream of gas turbines, PTS 32.24.20.42 shall apply.

4. GENERAL

4.2 **Regulations**

Replace this clause by:

If national and/or local regulations exist in which some of the requirements may be more stringent than in this PTS, the Contractor shall determine, by careful scrutiny, which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects.

If these requirements result in deviations from this PTS, the Contractor shall inform the Principal accordingly.

4.3 **Heater nomenclature**

Add to this clause:

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 also be applied.

Convection sections may be either top- or side-mounted, provided an even flue gas distribution is obtained.

Add new clause:

4.4 **Conflicting requirements**

4.4.1 The descending order of precedence for requirements shall be:

1. The purchase order.
2. Pre-purchase correspondence including notes of pre-selection and pre-award meetings.
3. Data sheets and relevant Basic Design Package.
4. This PTS.

4.4.2 All exceptions to the above documents shall be specifically stated by the vendor and, if approved by Purchaser, shall be included in the purchase order.

5. PROPOSALS

5.1 **Purchaser's responsibilities**

5.1.2 Add to this clause:

Instead of the data requisition sheets given as examples in ISO 13705 Annex A, the data requisitions sheets PTS 31.24.00.93 should be used.

5.2 **Vendor's responsibilities**

Add to this clause:

- k) confirmation that the equipment meets all requirements of this PTS;
- l) confirmation that the equipment will render satisfactory performance under continuous operation at design conditions outlined on the data sheets. Satisfactory performance includes operation at the design throughput at the design heat absorption and specified process temperatures at or below the specified pressure drop;
- m) confirmation that the thermal efficiency will not be less than that stated on the data sheet;
- n) Confirmation that the noise level will not exceed that stated on the Noise Data Sheet;
- o) confirmation that all heater parts are suitable for operation at up to 110 % of design heat release with the excess air level as indicated in Clause 6.2.3 (no increase in design absorption is implied);
- p) confirmation that flue gas emissions (NO_x, CO, particulates, hydrocarbons, etc.) will not exceed the specified levels;
- q) confirmation of the maximum air leakage (to flue gas) for air preheaters.

Alternative designs may only be offered in addition to that requested by the Principal.

5.3 Documentation

5.3.1 Drawings for purchaser's review

Add to this clause:

The English language shall be used throughout. However, descriptions on drawings may be in other languages, provided English translations are given.

All information shall apply specifically to the installation being supplied.

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.

Approval of drawings for construction or release of equipment by an authorized inspector shall not relieve the vendor of his responsibilities for the heater.

5.4 Final records

Add to this clause:

- k) list of major sub-suppliers and country of manufacture;
- l) 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;
- m) list of all tools necessary for operation, maintenance, inspection and cleaning that are not normally found in a refinery workshop;
- n) the weight of each unit:
 - empty;
 - full (hydraulic test conditions);
 - full (working conditions).

6. DESIGN CONSIDERATIONS

6.1 Process design

6.1.1 Replace this clause:

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

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 10 % of the individual pass pressure drop.

6.1.2 Add to this clause:

Where in-tube decoking is not required, multiple passes in an upstream section (usually the convection section) can combine to a single pass.

6.1.3 Replace this clause with:

Average radiant absorption rate shall be calculated by dividing the total heat absorbed by the total radiant tube area. Convection shield tubes not directly in view of the flame zone shall not be used in determining the average absorption rate or bridgewall temperature. When shield tubes are exposed to the flame zone only the first row shall be considered in determining average radiant flux and bridgewall temperature.

6.1.4 Replace this clause with:

Unless specified otherwise, the average heat absorption rates in the radiant cell shall be limited as follows:

ARRANGEMENT	kW/m ²
Horizontal tube fired from one side	35
Vertical tube fired one side from bottom	31.5
Single tube row uniformly fired both sides	
a) From bottom	43
b) From both sides or ends	47.7

Deviation from the above may be allowed provided it can be proven by verifiable modelling that the maximum allowable film temperatures are not exceeded, this being subject to approval by the Principal.

Add new clause:

6.1.6 The maximum heat flux basis inside the tube surface to any convection or shield tube shall not exceed 70 kW/m². The maximum flux shall be calculated as the sum of (A + B + C) below. Temperature difference for calculations is based on the process inlet temperature and flue gas temperature entering the tube row being studied.

A) Calculated maximum 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.

Deviation from the above may be allowed provided it can be proven by verifiable modelling that the maximum allowable film temperatures are not exceeded, this being subject to approval by the Principal.

Add new clause:

- 6.1.7 Design in-tube velocities in vapour and vapour-liquid flow shall be limited to a maximum of 85 % of critical velocity. Where vapour and liquid phases coexist in the heater coil the following conditions shall be met:
1. Flow regimes shall assure fully liquid-wetted walls. Acceptable regimes are bubble, froth, plug, slug, and annular.
 2. Vertical tube heaters shall be designed to maintain stable flow conditions over the complete range of predicted operating flow rates and heat inputs.

Add new clause:

- 6.1.8 For the process engineering of transfer lines the following shall be taken into account:
- Transfer lines from a heater to a distilling column shall, immediately upon leaving the heater, be led to an elevation above the one at which the column is to be entered.
- The lines shall then slope towards the column.
- 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.

6.2 Combustion design

- 6.2.1 Replace this clause by:
- The combustion system (burners, fans, ducts, instrumentation, draught system) shall be sized for a maximum heat release of 110 % of normal heat release at design conditions, with design air excess levels as defined in Clause 6.2.3. Further over-sizing of burners shall be avoided.
- This margin is not intended to permit continuous operation of the heater at greater than the design process duty.
- 6.2.2 Add to this clause:
- Efficiency shall be based on stated average ambient air temperature at 60 % relative humidity.
- Notwithstanding the design excess air levels as indicated in this clause, heaters are to be designed and constructed for minimum air infiltration so that operation with 10 % excess air can be continuously sustained at 100 to x % duty, where x is the specified process turndown (but not lower than 50 %).
- 6.2.5 Replace this clause by:
- Volumetric heat release shall not exceed 83 kW/m³ for oil firing and 124 kW/m³ for gas firing at the design heat absorption and excess air.
- 6.2.6 Replace this clause by:
- Flue gas passages including convection sections, breeching, ducts, and stack shall be sized to maintain a minimum of 25 Pa (2.5 mm water) draft at the arch with design excess air as defined in Clause 6.2.2 and 110 % of design heat release, unless otherwise specified.
- If a draft at the arch of greater than 25 Pa (2.5 mm water) is required to obtain the design heat release, for example due to burner placement/elevation, such greater draft shall be substituted in the previous sentence.

6.3 Mechanical design

- 6.3.4 Add to this clause:
- The following shall be included in the convection section design, unless otherwise specified:
- The convection section tube layout shall provide open access lanes to permit inspection, water or steam lancing and installation of sootblowers or water wash systems. Minimum

vertical clear space in these lanes shall be 600 mm. Soot blower or water wash systems shall be provided if specified.

Inspection spaces shall be installed at the following locations:

- between bare shock tubes and finned tubes
- preferentially at locations where there is a change in process
- for clean gas firing between each 15th tube row
- for oil firing further inspection lanes correspond with sootblower lanes (see ISO 13705 Clause 14.2.4).

6.3.5 Replace this clause by:

Vertical tube cylindrical heaters shall have a maximum radiant chamber height of 2.8 times the tube circle diameter (typically for single burner heaters) and a minimum height of 1.75 times the tube circle diameter (typically for heaters with 8 to 12 burners) and 1.5 times the tube circle diameter for heaters with more than 12 burners.

The above radiant cell dimension requirements shall be read in conjunction with new Clauses 6.3.13 and 6.3.14.

6.3.6 Replace this clause by:

Box type heaters with floor firing shall have a chamber height between 2.2 and 3.5 times the center-to-center distance between tube rows or between tube row and enclosing parallel wall.

The above radiant cell dimension requirements shall be read in conjunction with (new) Clauses 6.3.13 and 6.3.14.

6.3.8 Replace this clause by:

The tubes of convection sections and waste heat boilers shall be placed with a square or rectangular pitch in such a way that standard short-radius welding return bends can be used. A triangular pitch may only be used if clean, solids-free fuel gas is fired. The clearance between the refractory and the tubes of the convection section/waste heat boiler shall be selected to allow for proper installation of the prefabricated coil in between the tube guides and to minimize bypassing of flue gas. For triangular pitch, corbels or baffles shall be used. Flue gas baffle plates shall be installed to prevent flue gas bypassing if a combination of (bare) welded bends and finned tubes are located in the same flue gas path (i.e. if no end tube sheets are applied).

Add new clause:

6.3.13 In addition to Clause 6.3.5 and Clause 6.3.6, the height, width and length of any radiant cell (cylindrical, square, or rectangular) shall be suitably sized in line with the number of burners. To this end, the box dimensions shall be chosen in line with ISO 13705 Clause 14.1 (Table 13 or Table 14).

In any case, for vertical firing the heater height shall be at least 1.5 times the flame length.

Add new clause:

6.3.14 In order to prevent too high radiant heat flux on tube ends in radiant sections, the following requirements shall be adhered to:

- In vertical heaters, the radiant cell tubes shall cover the full height of the radiant cell wall, apart from the space required for expansion of the tubes.
- In horizontal heaters with single side fired tubes in the radiant cell, tubes shall 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 shall be 1.5 times the nominal tube diameter, with a minimum clearance of 100 mm.

Add new clause:

6.4 Coils and coil layout

6.4.1 General

Heater coils shall be of seamless tube or of seamless pipe. The general requirements for tubes shall be as specified in ASTM A 450 and for pipes shall be as specified in ASTM A 530. For further details on material selection, see Clause 7.

Pipes or tubes may be used for all-welded coils. However, tubes shall be used if they have to be expanded into return bend fittings.

In a vertical heater, the inlet/outlet of coils of radiant cells shall always be located at the top of the heater.

In radiant sections of heaters only bare coils shall be used.

Centre-to-centre spacing of radiant tubes/pipes shall be at least twice the nominal diameter.

Cross-over piping shall be made of the same material grade and have the same nominal wall thickness as the upstream coil. Cross-over piping shall be located outside the radiant or convection section, unless otherwise agreed with the Principal.

6.4.2 Coils for crude, reboil, hot oil, vacuum, visbreaker and thermal cracking heaters

- These coils are normally fitted with welded return bends. The Principal shall specify whether mechanical cleaning shall be possible, in which case horseshoe-type return bend fittings (plug type fittings) shall be installed at the top only for vertical heaters or at one side for horizontal heaters). If hydraulic pigging is specified, no horseshoe type fittings shall be applied.

In heaters where coke is not expected to form inside the coils, or in heaters for which steam/air decoking or hydraulic pigging is specified, maximum use should be made of welded return bends.

If two-phase flow is envisaged in parts of the heater coils, the following shall apply:

- 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.
- Under no circumstances shall a process pass be split at any point between the flow controller and heater outlet. However, process passes may be combined downstream of their flow controllers.
- Connections for steam-out of radiant coils of both residue and distillate cracking heaters shall be provided as described in PTS 10.02.51.11
- If hydraulic pigging is specified, pig launch/receiving connections shall be installed at the inlet and outlet of each coil. The pigging connection shall have the same diameter as the relevant inlet or outlet tube. To prevent damage to pigs, there shall be no branch connections between the pig launch/receiving connections (other than small bore instrument connections).

6.4.3 Coils for platforming, hydrotreating and hydrodesulphurization heaters

These coils shall be of all-welded construction using tubes and welded return bends.

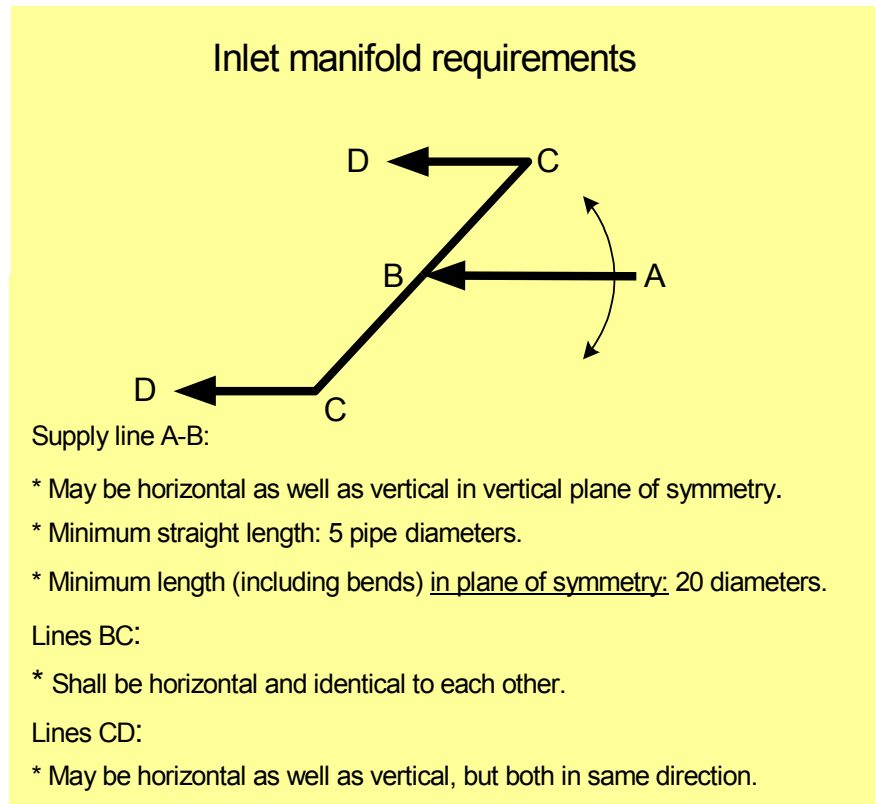
The nominal diameter of the pipes/tubes should not exceed 200 mm.

The number, size and arrangement of tubes and the size and arrangement of interconnecting piping pertaining to each parallel coil shall be such that an equal flow in each parallel coil is obtained at all required working loads.

This will only be achieved with symmetrical coil arrangements. Valves and flow measuring elements shall not be installed.

Two-phase flow division of a feed stream into a multiple parallel coil system shall be effected in several stages, each stage consisting of a split from one into two streams. Each

split shall also be fully symmetrical. The two outlets of each split shall be in the horizontal plane, and the inlet shall lie in the vertical plane of symmetry for a minimum of 20 diameters (see sketch below). As splitting is done via bifurcation, the number of passes is restricted to 1, 2, 4, 8 etc. The passes can be combined via one large header.



Add new clause:

6.5 Noise control

6.5.1 Limits

The Contractor shall comply with PTS 31.10.00.31., Noise Control, and thereby communicate to the Vendor the specified equipment noise limitations by using data sheet PTS 31.10.00.94., which forms part of the requisition. The Vendor is responsible for assuring that these equipment noise limitations have been specified.

6.5.2 Information to be submitted with the tender

The Vendor shall submit guaranteed sound power levels and sound pressure levels (including octave band spectrum) of the equipment, together with any other relevant information as requested in the data sheet, PTS 31.10.00.94. The Vendor shall indicate what special silencing measures, if any, are proposed in order to meet the specified levels.

Add new clause:

6.6 Electrical installations

Electrical installations shall comply with PTS 33.64.10.10. and be suitable for use in the applicable hazardous area classification.