TECHNICAL SPECIFICATION

FIRED HEATERS, INCLUDING WASTE HEAT BOILERS
(AMENDMENTS/SUPPLEMENTS TO API 560)

DEP 31.24.00.30-Gen.

October 1995
(DEP Circular 33/96 has been incorporated)

DESIGN AND ENGINEERING PRACTICE

PREFACE

DEP (Design and Engineering Practice) publications reflect the views, at the time of publication, of:

Shell International Oil Products B.V. (SIOP)
and
Shell International Exploration and Production B.V. (SIEP)
and
Shell International Chemicals B.V. (SIC)

The Hague, The Netherlands,

and other Service Companies.

They are based on the experience acquired during their involvement with the design, construction, operation and maintenance of processing units and facilities, and they are supplemented with the experience of Group Operating companies. 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 design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, 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 DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use DEPs 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, the Principal will expect them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the DEPs. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal or its technical advisor.

The right to use DEPs is granted by SIOP, SIEP or SIC, in most cases under Service Agreements primarily with companies of the Royal Dutch/Shell Group and other companies receiving technical advice and services from SIOP, SIEP or SIC. Consequently, three categories of users of DEPs can be distinguished:

1) Operating companies having a Service Agreement with SIOP, SIEP, SIC or other Service Company. The use of DEPs by these Operating companies is subject in all respects to the terms and conditions of the relevant Service Agreement.

2) Other parties who are authorized to use DEPs subject to appropriate contractual arrangements.

3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) or 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

All administrative queries should be directed to the DEP Administrator in SIOP.

NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

TABLE OF CONTENTS

PART I	**INTRODUCTION**	4
1.1	SCOPE	4
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	4
1.3	DEFINITIONS	4
1.4	CROSS-REFERENCES	5
PART II	**AMENDMENTS AND SUPPLEMENTS TO API 560**	6
SECTION 1	GENERAL	6
SECTION 2	DESIGN CONSIDERATIONS	10
SECTION 3	TUBES	13
SECTION 4	HEADERS	21
SECTION 5	PIPING, TERMINALS AND MANIFOLDS	22
SECTION 6	TUBE SUPPORTS	23
SECTION 7	REFRACTORIES AND INSULATION	25
SECTION 8	STRUCTURES AND APPURTENANCES	26
SECTION 9	STACKS, DUCTS AND BREECHING	28
SECTION 10	BURNERS AND AUXILIARY EQUIPMENT	29
SECTION 11	INSTRUMENT AND AUXILIARY CONNECTIONS	34
SECTION 12	SHOP FABRICATION AND FIELD ERECTION	36
SECTION 13	INSPECTION AND TESTING	37
APPENDIX A	FIRED HEATER DATA SHEET	38
APPENDIX B	FIRED HEATER CHECKLIST	39
APPENDIX C	PROPOSED SHOP ASSEMBLY CONDITIONS	40
APPENDIX D	WASTE HEAT BOILERS	42
APPENDIX E	SPECIFICATION FOR CAST "HORSESHOE" TYPE RETURN FITTINGS	44
PART III	**REFERENCES**	46

PART I INTRODUCTION

1.1 SCOPE

This DEP specifies the minimum requirements for design, engineering, fabrication and inspection of fired heaters. It includes related equipment such as convection banks/waste heat boilers, air preheaters, burners, air and flue gas ducts, forced and induced draught fans. This DEP is a revision of, and replaces, the DEP of the same number dated December 1982. This DEP also replaces DEP 31.24.15.31-Gen. dated April 1992, which is hereby withdrawn.

This DEP is based on API 560, First edition, January 1986. Part II of this DEP amends, supplements and deletes various sections of API 560. Sections of API 560 that are not mentioned in this DEP shall apply as written.

Excluded from the scope of this DEP are the following:

- the subject of materials selection for special furnaces such as high-temperature conversion and steam heating furnaces (tube wall temperature above 700 °C), and for furnaces for catalytic chemical reactions - this is covered by DEP 31.24.40.31-Gen.
- the subject of waste heat boilers associated with gas turbine exhausts - this is covered by DEP 30.75.10.31-Gen.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP and SIEP, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors and Manufacturers/Suppliers nominated by them (i.e. the distribution code is "F", as defined in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, chemical plants, gas plants, oil and gas production facilities, and supply/marketing installations.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable 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 DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this DEP 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 word **requisition** means DEP 31.24.00.93-Gen., which comprises six data/requisition sheets on which the data are provided on which to base the design. The use of these sheets is described in (Part II, Section 1.7).

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

1.4 CROSS-REFERENCES

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

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

PART II AMENDMENTS AND SUPPLEMENTS TO API 560

SECTION 1 GENERAL

1.1 Scope

Add to this Section:

This standard also covers unfired waste heat boiler convection sections.

1.1.2 Change the text of the note as follows:

A bullet (•) at the beginning of a paragraph indicates that a decision by the Principal shall be made. These decisions are indicated in the data requisition sheets or in the enquiry or in the order.

1.2 Alternative Designs

Replace this Section by:

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

1.5 Nomenclature

Add to this Section:

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.

1.6 Referenced Publications

1.6.1 Add to this Section:

Additional referenced publications are given in Part III and form part of this standard. In case of conflict, the publications in Part III are overruling.

1.6.2 Replace this Section by:

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

1.7 Proposals

Replace this Section by:

1.7 Proposals and Relevant Documentation

1.7.1 GENERAL

The English language shall be used throughout. However, descriptions on drawings may be in other languages, provided English translations are given. Where the word **requisition** is used it means DEP 31.24.00.93-Gen., which comprises six data/requisition sheets on which the data are provided on which the design is based or is to be based.

The Manufacturer/Supplier shall provide all drawings, design details, operation and maintenance manuals, and other information necessary for the design assessment, erection, operation and maintenance of the installation.

All information shall apply specifically to the installation supplied.

1.7.2 REQUISITION SHEETS AND DOCUMENTATION REQUIRED AT TENDERING STAGE

When preparing an enquiry the Principal shall complete at least all those items identified by an asterisk on the requisition. The Manufacturer/Supplier shall complete the remaining portions of the sheets, as applicable, to define his proposal.

Where the sheets show alternatives, those items which are not applicable shall be crossed out.

Alternative data shall be provided for each type of fuel, as necessary.

1.7.2.1 Requisition sheets 1 and 2

These sheets describe, in conjunction with this DEP, the extent of the project and mostly contain data to be provided by the Principal.

Battery limit conditions for all items mentioned under the heading "Utilities Data" will normally be indicated on the flow scheme and on the proposed control schemes. Where necessary, additional information on existing equipment shall be given by the Principal.

1.7.2.2 Requisition sheets 2, 3, 4 and 5

Sheets 3 to 5, and the relevant parts of sheet 2, shall be completed by the prospective Manufacturer/Supplier at the tendering stage and are intended to provide the minimum information required by the Principal to enable pre-selection of the tenders.

The following drawings and information shall be submitted by the Manufacturer/Supplier, along with the completed requisition sheets:

(a) Drawings of:

- dimensioned general arrangement, front and side elevations, of the complete installation showing burners, galleries and ladders, ducting, fan, stack, refractory or ceramic type furnace linings;
- dimensioned front and side sectional elevations showing casing, furnace, burners, access and observation ports (and their fields of view), soot blowers and all tube coils. The furnace radiant cell(s) shall be fully dimensioned including burner centre lines.

(b) Description, where applicable, of:

- extent of shop fabrication;
- general (description of) installation;
- site fabrication required;
- casing;
- refractory, insulation, stack lining;
- burners, ignition burners and flame detectors;
- desuperheater;
- aspirating, sealing and cooling air system;
- fan(s) and drive;
- soot blowing system;
- mountings, valves and fittings, including safety valves;
- control schemes and description of all controls, especially combustion control scheme;
- expansion joints for both flue and air ducting.

1.7.3 DOCUMENTATION AND INFORMATION REQUIRED AFTER CONTRACT AWARD

The following shall be submitted after the contract has been awarded:

- a fully completed requisition;
- detailed calculations for tube dimensions and materials for heat transfer equipment and steam drum;
- detailed calculation and installation drawings of refractory lining system and instructions on refractory dry-out;
- all necessary information on mass, moments, location of foundation bolts, etc., for the design of the foundation. The Manufacturer/Supplier shall approve the foundation drawings, mounting and foundations of fans, pumps and drives;

- resistance characteristics on the air and the flue gas side over the whole installation;
- characteristic of the combustion air flow-metering Venturi;
- details of all pumps, fans (with characteristic curves), drives and instruments.
- list of major sub-suppliers;
- 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;
- list of all tools necessary for operation, maintenance, inspection and cleaning that are not normally found in a refinery workshop;
- the weight of each unit:
  - empty
  - full (hydraulic test conditions)
  - full (working conditions)
- details of ignition burner;
- details of flame detection system, if applicable;
- details of expansion joints in air and flue gas ducts;
- burner fuel oil atomizer details
- burner pressure drop characteristic for combustion air, fuel gas and fuel oil, including size of orifice installed inside gas burner inlet flange;
- copies of the operation and maintenance manuals, as specified in the order;
- welding procedure qualifications and detailed NDT procedures;
- inspection plan and hold points (if any);
- pre-commissioning and dry-out procedures for refractories.
- the furnace wall construction details, showing tubes, insulation, refractory lining and casing;
- dimensioned details of drums and internals;
- support and expansion details;
- tube coil support details;
- diagram showing coil materials and corresponding metal temperatures at design and maximum load cases;
- diagram showing superficial gas and liquid velocities inside the coils throughout the furnace;
- FD fan characteristics;
- list of drives, showing type, manufacturer, duty, delivered power, couplings and gear boxes;
- list of vents, stop and check valves, showing sizes, capacities and manufacturers;
- list of refractories and insulation materials, stating type, location, protection, fastening and surface temperature;
- erection plan (see also 1.7.4).

1.7.4 DOCUMENTATION REQUIRED AFTER APPROVAL OF CONSTRUCTION DRAWINGS

A specification for the field erection of the furnace and associated equipment shall be provided, including at least:

- installation of casing radiant cell(s);
- installation of coils in radiant cell(s);
- installation of convection bank/waste heat boiler;
- installation of air preheater (if applicable);
- installation of refractory lining/insulation;
- installation of burner equipment;
- installation of air and flue gas ducting;
- erection sequence.

1.8 Documentation

Delete this Section.

SECTION 2 DESIGN CONSIDERATIONS

2.1 Process

Add new Section 2.1.5:

2.1.5 For the process engineering of transfer lines the following shall be taken into account:

Transfer lines from a furnace to a distilling column shall, immediately upon leaving the furnace, 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 furnace as specified in the requisition.

2.3.4 Replace this Section by:

Vertical heaters, cylindrical, square, or rectangular, shall be designed with a height-to-diameter ratio of 2.5 to 2.8 for oil firing, 2.8 to 3.0 for gas firing and 2.5 to 2.8 for dual fuel firing. The height is the radiant section height (inside refractory face) and the diameter is the hydraulic tube circle diameter, Dh, which is determined by the following formula:

$$Dh = 4 * \left(\frac{\text{Cross-sectional area}}{\text{Cross-sectional circumference}} \right)$$

with both dimensions in the same units.

2.3.6 Replace this Section 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 be used if clean, solids-free fuel gas is fired. The clearance between the refractory and the coils 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. Special care with regard to flue gas bypassing shall be taken if a combination of bare, non-finned, welded bends and finned tubes are located in the same flue gas path.

Where finned tubes are applied, the type of extended surface and the material shall be approved by the Principal. Fins should be mechanically rigid and fully welded to the tubes. The Principal shall indicate in which cases extended surfaces (see also Section 3.2) are acceptable in combination with an effective on-line cleaning system, such as a soot blowing system.

Add new Section 2.4:

2.4 Coils and Coil Lay Out

2.4.1 GENERAL

Furnace 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 in ASTM A 530. For further details on material selection, see Section 3.3 (general) and Appendix E (for horseshoe type fittings).

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 furnace, the inlet/outlet of coils of radiant cells shall always be located at the top of the furnace.

In radiant sections of furnaces 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.

2.4.2 COILS FOR CRUDE , REBOIL, HOT OIL, VACUUM, VISBREAKER AND THERMAL CRACKING FURNACES

These coils are normally fitted with welded bends. If mechanical cleaning is specified by the Principal, horseshoe-type return bend fittings shall be installed at the top only (or at one side in case of horizontal furnaces). However, in furnaces where coke formation inside the coils is not expected, or where the coil material can withstand the conditions prevailing during steam-air decoking, maximum use should be made of welded return bends.

When designing for two-phase flow in parts of the furnace coils, the following shall apply:

An automatic flow controller shall be incorporated in the inlet of each process pass of the furnace, 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 furnace 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 furnaces shall be provided as described in DEP 10.02.51.11-Gen.

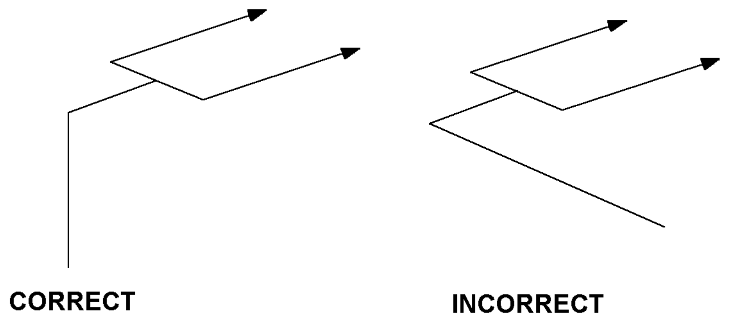
2.4.3 COILS FOR PLATFORMING, HYDROTREATING AND HYDRODESULPHURIZATION FURNACES

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

The nominal diameter of the pipes/tubes should not exceed 8 inches.

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. Moreover, 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.

Splits shall be made in one plane. The line immediately upstream of each split shall run in the same plane of symmetry as the lines downstream of the split. In the line immediately upstream of each split, any bends within 15 diameters of the split shall be in the plane of symmetry. Examples of correct and incorrect configurations are:



Add new Section 2.5:

2.5 Noise Limitations

2.5.1 GENERAL

EEMUA specification No. 140 shall be met with regard to definitions, notations, measuring, calculation and reporting.

The equipment shall be designed to minimize the generation of noise and shall not exceed the noise limit given below.

2.5.2 NOISE LIMITS

The sound pressure level shall not exceed 85 dB(A) in the work area (i.e. any position accessible to personnel, not less than 1 m from equipment surfaces) unless otherwise stated in the noise limitation data sheet, DEP 31.10.00.94-Gen.

The requirements apply in the absence of reverberation and background noise from other sources, and for all operating conditions between no-load and full-load.

If the equipment produces impulsive and/or narrow band noise, the noise limits shall be 5 dB(A) lower than the values stated above.

2.5.3 NOISE ABATEMENT

Excessive equipment noise should be eliminated by low noise design. Where other noise control measures, such as acoustic insulation or enclosures (including noise hoods) are required, they shall be designed to allow routine operational and maintenance activities. Use of such enclosures is subject to prior approval of the Principal regarding construction, materials and safety requirements.

2.5.4 INFORMATION TO BE SUBMITTED WITH THE TENDER

The Manufacturer/Supplier shall submit the guaranteed sound power levels and sound pressure levels of the equipment, together with any other relevant information as requested in the equipment noise limitation sheet, DEP 31.10.00.94-Gen.

The Manufacturer/Supplier shall indicate what special silencing measures, if any, are proposed in order to meet specified noise levels.

Add new Section 2.6:

2.6 Electrical Installations

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

SECTION 3 TUBES

3.1 General

3.1.1 Add to this Section:

A brief description of the procedure, including some clarification and amendments, follows below.

3.1.1.1 Design of tubes in the elastic range

If furnace tubes are designed to operate in the elastic range, the wall thickness shall be chosen such that the calculated stress does not exceed the elastic allowable stress (Se) as given in API RP 530 for the applicable material.

Stress calculations shall be based on the maximum pressure that the furnace coil will experience (even for a short period during a pressure excursion). This is normally related to relief valve set pressures or pump shut-off pressures. The allowable stress shall be based on the design metal temperature of the coil. This is the highest calculated metal skin temperature for clean tube conditions increased by a temperature allowance of 15 °C. The design metal temperature shall be based on that combination of peak heat flux on the coil and the local bulk process temperature which results in the highest tube metal temperature. The values of bulk temperature and peak heat flux shall be based on the same operating conditions. In addition to the above, the thermal stresses shall be checked in accordance with the procedure given in API RP 530.

3.1.1.2 Design of tubes in the creep-rupture range

If furnace tubes are designed to operate in the creep-rupture range, the wall thickness shall be chosen such that the calculated stress does not exceed the rupture allowable stress (Sr) for a life time of 100 000 hours, and shall be equal to or less than the elastic allowable stress (Se) at that temperature.
Stress calculation shall be based on the maximum sustained operating pressure during normal operation. The normal operating inlet pressure for the relevant coil section, convection bank or radiant cell shall be used. The allowable stress shall be based on the design metal temperature as described in 3.1.1.1.

Also, the elastic allowable stress at design temperature shall not be exceeded when applying the maximum possible pressure as explained in 3.1.1.1. Thermal stress calculations are not applicable for a creep-rupture design.

3.1.1.3 Tube selection

Tube wall thicknesses shall be selected using ANSI/ASME B36.10M.
The applicable tolerances for tubes shall be taken into account when selecting a wall thickness. Tube size shall be selected from the following table.

Nominal size (inches)	Outside diameter (inches)	Outside diameter (mm)
1.5	1.9	48.3
2	2.375	60.3
2.5	2.875	73.0
3	3.5	88.9
3.5	4.0	101.6
4	4.5	114.3
5	5.563	141.3
6	6.625	168.3
8	8.625	219.1
10	10.75	273.0

Other sizes shall only be used if warranted by special process considerations. Practical limits to minimum thickness, as specified in Table 1 of API RP 530, shall be adhered to.

A straight tube shall not have a circumferential weld, unless approved by the Principal. If a weld has to be made in the exposed straight length of tubes, it shall not be located within one metre of the elevation of maximum heat flux.

Shop fabrication of heater piping/tubing shall comply with DEP 31.24.49.31-Gen.

3.1.1.4 Operation under fouled conditions

If fouling of tubes under normal operation is to be expected, this condition shall be indicated by the Principal and accommodated in the tube design. This is, for example, applicable for a thermal cracker furnace where coke formation inside the tubes cannot be prevented.

In order to prevent premature failure of furnace tubes, the accumulated damage over the entire design tube life shall be estimated by calculation.

The calculation procedure as given in API RP 530 Appendix E, based on the Larson Miller correlations, shall be used. The calculated accumulated damage shall not exceed 1.0.

The estimated operational conditions during the entire tube life shall be specified by the Principal. The total tube life shall be taken as 100 000 hours. Tube life shall be divided into two cycles:

- One long cycle, typically 95 000 hours, during which the tube wall temperature (clean) linearly increases with time from the initial design value, as mentioned in 3.1.1.1, to the limiting design metal temperature (fouled), or to a lower temperature as specified by the Principal. During this long cycle all the corrosion allowance will be used up.
- followed by a short cycle of typically 5,000 hours during which the tube skin temperature will be constant at the limiting design metal temperature, or a temperature specified by the Principal.

Limiting design metal temperatures for the various tube materials are given in API RP 530 Table 4 (see Notes 1 and 2 below for deviations). The normal furnace inlet pressure as explained under 3.1.1.2 shall be used in the stress calculations. The minimum rupture strength Larson Miller parameter curves shall be used.

For the accumulated damage calculation, an equivalent metal temperature in accordance with API RP 530 shall be calculated for the first operational cycle (typically 95 000 hours). Since it is assumed that the corrosion allowance is consumed, an average tube wall thickness shall be used in the stress calculation. For calculating the accumulated damage over the second cycle (typically 5000 hours), the limiting design metal temperature from API RP 530 Table 4 shall be used in combination with normal furnace inlet pressure and the tube wall thickness minus the corrosion allowance. If the calculated accumulated damage for the total operational tube life of 100 000 hours exceeds 1, the tube wall thickness or the tube material strength shall be increased accordingly.

In addition to the life time calculations, the elastic allowable stress at the limiting design metal temperature (fouled conditions) shall not be exceeded when applying the maximum possible pressure as explained in 3.1.1.1.

NOTES:

1. 9Cr 1Mo tube as pipe material (T9, P9, T91, P91) shall not be used above a skin temperature of 650 °C except in special cases, and then only with the approval of the Principal.
2. 9Cr 1Mo (T91, P91) shall not be applied in units where coking can take place and steam-air decoking is applied, such as in Thermal Cracking Units.
3. The calculation method for thick wall tubes outside the applicable code limits shall be submitted to the Principal for approval.

3.1.2 Add to this Section:

The corrosion factor (f) as used in API RP 530 shall be taken as 1.0.

3.1.3 Delete this Section.

3.1.4 Add to this Section:

See also Section 3.1.1.

3.1.5 Add to this Section:

For rules for calculating the extent to which furnace tubes have to be expanded into plug type return bends, reference is made to DEP 61.10.08.11-Gen.; Appendix 1.

3.2 Extended Surface

Change Table 3 as follows:

The maximum fin density for oil firing is 2 fins per inch, and the maximum fin density for gas firing is 4 fins per inch.

3.3 Materials

Replace this Section by:

3.3.1 PREVENTION OF DEW-POINT CORROSION

Where sulphur-containing fuels are fired, the metal surface of heated coils in contact with flue gas shall be at least 10 °C above the acid dew-point of the flue gases. For sulphur-free fuels this temperature shall be at least 70 °C.

The temperature of all bare metal surfaces in contact with flue gas shall always be higher than the maximum calculated acid dew-point of the flue gas for the specified operating conditions and fuels.

Dew-point corrosion shall also be avoided, by design and/or by temperature control, on the flue gas side of air preheaters, waste heat boilers or any other facilities in contact with flue gases.

3.3.2 EXTERNAL OXIDATION

To avoid severe scaling by external oxidation, the metal skin temperatures should not exceed the following values:

Material	Skin Temperature
Carbon steel	565 °C
1 1/4 Cr 1/2 Mo	595 °C
2 1/4 Cr 1 Mo	625 °C
5 Cr 1/2 Mo	650 °C
9 Cr 1Mo	705 °C (Note 1)
Austenitic Steels: Types 316, 321, 347	870 °C

NOTE 1 Approval of the Principal is required for use above 650 °C (see also 3.1.1.4, NOTE 1).

3.3.3 COILS AND RETURN BENDS

The material used for furnace coils, welded return bends and horseshoe type return bend fittings shall be selected according to the service requirements and also taking into account resistance to internal corrosion and creep. Materials shall comply with the standards stated in the table below and DEP 30.10.02.11-Gen.

MATERIAL TYPE	PIPE/TUBE	RETURN BEND 3)	
		Butt welded	Horseshoe
Carbon Steel Pipe	A 106-B	A 234-WPB	N.A.
Carbon Steel Tube	A 192	A 234-WPB	A 216 WCB A 216 WCC
1.25Cr 5Mo Pipe	A 335-P11	A 234 WP-11	N.A.
1.25Cr 5Mo Tube	A 213-T11	A 234 WP-11	A 217 WC-6
2.25Cr 1Mo Pipe	A 335-P22	A 234-WP22	N.A.
2.25Cr 1Mo Tube	A 213-T22	A 234-WP22	A 217 WC-9
5Cr 0.5Mo Pipe	A 335-P5	A 234-WP5	N.A.
5Cr 0.5Mo Tube	A 213-T5	A234-WP5	A 217-C5
9Cr 1Mo Pipe	A 335-P9	A 234-WP9	N.A.
9Cr 1Mo Tube	A 213-T9	A 234-WP9	A 217-C12
9Cr 1Mo V Pipe	A 335-P91	A 234-WP91	N.A.
9Cr 1Mo V Tube	A 213-T91	A 234-WP91	A 217 WC-12
Stainless Steel Tube or Seamless Pipe	A 213-TP321 A 213-TP316 1) A 312-TP321H 2)	A 403-WP-321 A 403-WP-316 1) A 403-WP-321H	N.A.

1) Titanium or Niobium stabilized grades are acceptable subject to approval of the Principal. This is also applicable to centrifugally cast tubes.

2) Only if required for high design metal temperatures, seamless pipe only.

3) Seamless bends preferred; welded bends subject to approval of the Principal.

Alternative materials may be offered in addition to the materials in the above table (ref. Section 1.2).

Austenitic stainless steel tube and fittings shall be purchased in the solution annealed, water quenched, or solution annealed plus stabilized at 950 °C (+/- 15 °C) condition.

All other materials shall be purchased in the normalized or normalized and tempered condition. The Manufacturer/Supplier shall comply with DEP 30.10.60.18-Gen. for welded components.

Welding or repair welding of these materials, and requirements in terms of percentage of carbon and carbon equivalent, post weld heat treatment, selection of welding consumables, etc., shall also comply with DEP 30.10.60.18-Gen.

3.3.4 FURNACES FOR DISTILLATION AND THERMAL CRACKING UNITS AND HTF (HEAT TRANSFER FLUID) SYSTEMS

Selection criteria related to corrosion phenomena are based on the **tube inside film process temperature**, the sulphur and the organic acid content (total acid number (TAN) in mg KOH/g) of the related process stream and the external oxidation and creep resistance.

LOW SULPHUR FEED (% S ≤ 0.3%)

	TAN < 0.3		TAN 0.3-0.5		TAN > 0.5		
	Temp. (°C)	Material	Temp. (°C)	Material	Temp. (°C)	TAN	Material
Coils	≤ 350	CS	≤ 300	CS	≤ 300		CS
	> 350	5Cr 0.5Mo	> 300	5Cr 0.5Mo	> 300	≤ 1	5Cr 0.5Mo
						> 1	316Ti [2,3]
Outlet piping	≤ 350	CS [1]	≤ 300	CS[1]	≤ 300		CS[1]
	> 350	5Cr 0.5Mo	> 300	5Cr 0.5Mo	> 300	≤ .7	5Cr 0.5Mo
						> .7	316Ti [2,3]
Transfer lines	CS [1]		CS clad with 316		CS clad with 316		

HIGH SULPHUR FEED (% S > 0.3%)

	TAN < 0.5		TAN > 0.5		
	Temp. (°C)	Material	Temp. (°C)	TAN	Material
Coils	≤ 330	CS	≤ 300		CS
	> 330	5Cr 0.5Mo	> 300	≤ 2	5 Cr 0.5Mo
				> 2	316Ti [2,3]
Outlet piping	≤ 330	CS [1]	≤ 300		CS [1]
	> 330	5Cr 0.5Mo	> 300	≤ 1	5Cr 0.5Mo [1]
				> 1	316Ti [2,3]
Transfer lines	CS clad with 316		CS clad with 316		

1) With 3 mm corrosion allowance.

2) 316Nb for castings.

3) 316 clad for diameters above 8".

3.3.5 PLATFORMER FURNACES

The materials for this application are 2.25Cr 1Mo, 5Cr 0.5Mo or 9Cr 1Mo steels. These high strength steels allow for reduced wall thickness, which results in lower metal skin temperatures and thus less external corrosion. They are also resistant to hot hydrogen attack. The temperatures given below are tube skin temperatures.

Temperature	T ≤ 625 °C	T < 650 °C	T < 650 °C
Material	2.25Cr 1Mo	5Cr 0.5Mo	9Cr 1Mo (P 9/91)

NOTE: API RP 530 does not have allowable stress data available for P91 material. The allowable stress data given in the ASME I shall be used up to a temperature of 650 °C.

3.3.6 FURNACES FOR HYDRO-DESULPHURIZERS, HYDROTREATERS AND HYDROCRACKERS

The corrosion rates for the hydrogen sulphide and hydrogen environment found in these units dictate that only austenitic stainless steel, which is fully resistant to hot hydrogen attack, shall be used. Otherwise it is impossible to avoid rapid fouling of the reactors by sulphides and to design with sufficient corrosion allowance.

Materials resistant to naphthenic acids, i.e. molybdenum-containing austenitic stainless steels, should be selected whenever the total acid number (TAN) in the related process stream is above 0.3 mg KOH/g.

	TAN ≤ 0.3	TAN > 0.3
Material	AISI 321	AISI 316 Ti

3.3.7 HOT HYDROGEN RESISTANCE

Selection criteria shall be in accordance with API 941.

SECTION 4 HEADERS

4.1 General

4.1.2 Add to this Section:

Return bends shall comply with ANSI B16.9 or with BS 1640. They shall have the same schedule and nominal outside diameter as the connecting tubes.

4.1.3 Add to this Section:

Return bends shall be used if inside cleaning by mechanical means is not required.

4.2 Plug-type Headers

4.2.1 Add to this Section:

Return bend fittings shall be in accordance with Standard drawings S 24.201, S 24.202, S 24.203, S 24.204, S 24.205, S 24.206, S 24.207, S 24.208 and S 24.209.

Return bend fittings larger than 8 inch nominal size shall not be used; flanged return bend fittings shall be applied in such cases.

4.2.3 Delete this Section.

4.2.4 Delete this Section.

4.4 Materials

Add to this Section:

For materials selection see also Section 3.3.

SECTION 5 PIPING, TERMINALS AND MANIFOLDS

5.1 General

Delete this Section.

5.3 Materials

Delete this Section.

Add new Section 5.4:

5.4 Piping

Piping shall comply with DEP 31.38.01.11-Gen. and DEP 31.38.01.12-Gen.

For piping systems not covered in DEP 31.38.01.12-Gen., the Principal shall be consulted.

Coils having horseshoe-type return bend fittings shall be flanged at their terminal connections, e.g. cross-overs and furnace inlets and outlets.

An adequate number of flanged connections shall be installed for steaming out, water freeing after pressure testing, steam-air decoking and chemical cleaning.

Hydraulic bolt tensioning equipment shall be used for bolting larger than 38 mm ($1^{1}/_{2}$"). See DEP 70.08.10.11-Gen.

SECTION 6 TUBE SUPPORTS

Add new Section 6.1.7:

6.1.7 SUPPORTS FOR VERTICAL RADIANT COILS

Coils fitted with horseshoe-type return bend fittings shall be suspended from the roof by means of a ring welded around each tube which rests on a sleeve in the roof, see Standard Drawings S 24.236 and S 24.237.

All-welded coils shall be suspended from roof panels by means of suspension tubes and support pins, see S 24.233, S 24.234, S 24.235 and S 24.240.

The inlet and outlet tubes and tubes connected to cross-overs over the furnace roof shall be suspended from the roof panels by means of rings welded around these tubes, see S 24.238.

Individual supports shall be shimmed as necessary to ensure uniform support of the radiant coil, such that the coils hang vertically and do not touch each other or the furnace refractory wall. The lower end of coils with welded return bends at the bottom shall hang freely in the furnace, see S 24.217. Bottom tube guides to limit sideways displacement to not more then 50 mm may be used for fuel gas fired furnaces, in order to reduce the forces on the roof at the protruding point of the outlet tubes.

Add new Section 6.1.8:

6.1.8 SUPPORTS FOR CONVECTION COILS

Convection bundles may be supported by the cooled support system, or by steel beams or tube plates.

The cooled support system shall be used if:

- the local flue gas temperature exceeds 1000 °C under any operating conditions; or
- the local flue gas temperature exceeds 700 °C under normal operating conditions and vanadium corrosion is expected.

The following considerations apply for the choice of a cooled support system.

Cooled supports can be applied in combination with end tube plates and header boxes in the case of finned tubes. The latter prevents flue gas bypassing around the bends which have no fins.

In case of bare tubes, the bends can be located inside the flue gas path. In the latter case no tube plates are required.

Cooled supports shall consist of single tubes, dual-type or quadruple-type hairpins, see S 24.505. The legs of the hairpins shall be interconnected and stiffened by slotted plates, thus forming a supporting member, through which the medium to be heated flows as a cooling medium before entering the convection coil.

The material of the cooled supports shall be of the same type as the coil material.

Convection tubes shall not be interconnected, so that they can expand freely and independently of each other. They shall be kept apart and support each other by means of lateral and longitudinal spacer strips, see S 24.107. The spacer strips shall be bevelled for welding and shall be attached to the tubes by a full double weld to ensure good heat conduction. The strip material shall have at least the same heat resistance as the coil material; however, the furnace designer shall check whether the higher strip temperature requires a more heat-resistant material.

In order to prevent dislocation of the convection coil tubes, lateral movements shall be restricted. For this purpose tube guides shall be connected to the side walls of the convection section near the spacer strips over the full height of the tube bundle, see S 24.104 and S 24.503.

6.3 Materials

6.3.2 Modify this Section as follows:

Delete item 1 (since no coating is allowed).

SECTION 7 REFRACTORIES AND INSULATION

7.1 General

7.1.1 Replace this Section by:

The thickness and the type of inside lining shall be such that the outside casing temperature of the furnace components is between 60 and 80 °C for the ambient temperature specified on the requisition. A typical wind velocity of 2.5 m/s shall be assumed. In the final design this figure shall be confirmed by the Principal. The same applies for externally insulated hot air ducts and for internally or externally insulated flue gas ducts.

Add new Section 7.1.8:

7.1.8 If sulphur-containing fuels are used, the thermal insulation of radiant cells, convection sections and flue ducts shall be monolithic type refractory concrete linings as specified in DEP 64.24.32.30-Gen. or refractory bricks as specified in DEP 44.24.90.31-Gen. If low sulphur fuels are used, modular type ceramic fibre lining may be used if approved by the Principal. Measures shall be taken to prevent flue gas sulphuric acid dew-point corrosion of the metal furnace walls, e.g. via a vapour barrier system.

7.2 Brick and Tile Construction

Replace this Section by:

Brick and tile construction shall be in accordance with DEP 44.24.90.31-Gen.

7.3 Castable Construction

Replace this Section by:

Castable constructions shall be in accordance with DEP 64.24.32.30-Gen.

7.3 Materials

Delete this Section.

SECTION 8 STRUCTURES AND APPURTENANCES

8.1 General

Replace this Section by:

The steel structure shall comply with DEP 34.00.01.30-Gen., DEP 34.28.00.31-Gen. and the following requirements:

- The deflection of roof, floor and wall beams shall not exceed 1/500th of the span. They shall be designed to a pressure based on the most severe combination of the wind pressure/suction loads as described in DEP 34.00.01.30-Gen. and the minimum/maximum furnace box pressures as defined in (i), (ii) and (iii) below. The Manufacturer/Supplier shall state the minimum and maximum allowable pressures for which his furnace box is designed.
  - (i) If only an induced-draught fan is applied, the minimum furnace box pressure shall be taken to be equal to the culmination point of the head-capacity curve of the induced draught fan. The maximum pressure shall be taken to be 1 bar (abs).
  - (ii) If only a forced-draught fan is applied, the maximum pressure in the furnace box shall be taken to be equal to the culmination point of the head capacity curve of the forced draught fan. The minimum pressure shall be taken to be the draught from the stack.
  - (iii) If both an induced-draught fan and a forced-draught fan are applied, the minimum furnace box pressure shall be taken to be equal to the culmination point of the head-capacity curve of the induced draught fan, and the maximum pressure shall be taken to be equal to the culmination point of the head capacity curve of the forced draught fan.

The distance between two box-type structures (radiant cells or convection sections) shall be at least 2.5 m, to ensure accessibility for erection, maintenance and operation. This distance should also provide sufficient space for routing of piping (transfer lines/cross-overs) and air ducting.

8.2.7 Replace this Section by:

If fireproofing is specified it shall be in accordance with DEP 34.19.20.11-Gen.

8.3 Header Boxes, Doors and Ports

8.3.1.2 Replace this Section by:

Header boxes enclosing headers shall have bolted end panels.

8.3.2.1 Add to this Section:

As a minimum one unobstructed access door shall be provided in the wall of a vertical box type heater for access from the burner platform. Typical panel dimensions are 600 x 900 mm.

8.3.2.2 This Section is valid for cylindrical and box type vertical heaters.

8.3.2.5 Replace this Section by:

Observation windows shall be installed in the furnace walls to provide a clear view of the burner(s), flame(s) and the flame-exposed tube surfaces in the radiant sections. For typical designs, refer to Standard Drawings S 24.101, S 24.102, S 24.108 and S 24.109. Each radiant cell shall have at least one circular 4-inch peephole in the roof, providing a clear view to all burner throats. Particular attention shall be given to the arrangement and positioning of peepholes for burner viewing to ensure that there is an unobstructed view of each burner throat and flame zone up to 1 m outside the burner throat. Due account shall be taken of the radiant coil layout to prevent tubes from obstructing the view of the burners.

All observation windows in forced draught furnaces shall be provided with a glass cover, protection flapper and purge air connection. Horizontal observation windows shall be provided with rain protection.

Add new Section 8.3.2.6:

8.3.2.6 If the return bends of convection section tubes are located in the flue gas path, one end wall shall be removable to enable removal of the tube bundle for maintenance purposes. The opposite end wall may also contain removable panels to provide access for field welds.

In case of a side mounted, flue gas down flow, convection section, the bottom shall be provided with at least two nominal four inch drain connections to allow for wet cleaning during a shutdown. Explosion doors should normally not be applied.

8.4 Ladders, Platforms and Stairways

8.4.2 Replace this Section by:

All vertical cylindrical heaters shall have a full circular platform at the floor level.

8.4.3 Replace this Section by:

Platforms shall have a minimum **clear** width as follows:

	Minimum width
Operating platform at the burner control side	1.5 m
In case burner guns have to be manipulated from this platform (horizontal firing)	1.8 m
All other platforms	0.9 m
Walkways	0.8 m

8.4.4 Add to this Section:

Only open grating shall be applied as platform decking.

8.4.8 Add to this Section:

Stairways shall be provided for platforms where operators require access at least once per shift or under emergency conditions. Burner platforms and soot blower platforms shall always be accessible by stairways. Stairways giving access to various levels shall be combined in a flight of stairs.

8.4.7 Add to this Section:

Ladders shall be made such as to provide a side step at the top. The hand railing shall extend at least one metre above the top platform.

8.4.10 Add to this Section:

Railings shall be mounted on the top of the radiant section and the top of a side mounted convection section where access is necessary platforms are not required.

SECTION 9 STACKS, DUCTS AND BREECHING

9.1 General

9.1.11 Add to this Section:

Flue ducts to side mounted stacks shall be equipped with a hand or motor operated damper accessible from grade. A guillotine blind plate shall also be fitted in each individual flue gas duct if more than one furnace group is connected to a stack. The blind plate shall be downstream of the damper and as close as possible to the stack, see S 24.303. Inspection doors close to the damper shall be accessible by means of a ladder.

Add new Section 9.1.12:

9.1.12 Flue gas ducts between radiant sections and convection sections shall be designed for a maximum velocity of 14 m/s. Flue gas ducts between convection sections and stacks shall be designed for a maximum velocity of 12 m/sec.

Add new Section 9.1.13:

9.1.13 The design of a stack shall be based on a minimum exit velocity of 5 m/s for the minimum operating case of the unit. This requirement is to prevent downwash of flue gas at turn-down conditions. Stack outlet velocities should be between 10 m/s and 15 m/s for the maximum design operating case. In case local regulations are more severe, they shall be met.

9.2 Design Considerations

Replace this Section by:

The design of stacks shall be based upon DEP 34.24.26.31-Gen. or DEP 34.24.27.31-Gen.

SECTION 10 BURNERS AND AUXILIARY EQUIPMENT

10.1 Burners

10.1.4 Replace this Section by:

For residue type liquid fuel fired heaters, the oil burner design capacity of individual burners shall be greater than 4 MW to limit the number of burners installed.

10.1.5 Replace this Section by:

The Principal will indicate if pilot or ignition burners will be installed. See also Section 10.1.12.

10.1.7 Replace this Section by:

Burners shall have a turndown capability from 100% to at least 25% of the normal heat release (heat release required for design furnace process duty) without adjusting the air controls. The flame shall remain stable and in case a flame detector is applied, it shall produce a stable signal over the whole operating range of the burner.

10.1.8 Replace this Section by:

For all types of floor-mounted burners, the line-up shall be such that the presence of personnel under the furnace is not required at the moment of ignition. For manually operated systems, main burner ignition is controlled from the first platform around the furnace (burner platform). On the burner platform, the operator shall be able to view the flame of the igniter via a peephole and, whilst maintaining the burner in view, introduce the fuel to that burner. Therefore, valves for fuel admission, purge air and steaming-out shall be within reach of the operator when observing the burner via the designated observation window.

If an automatically controlled start-up system is applied, the line-up can be simplified because the operator will not be present on the platform during burner start-up. However, for automatic start-up systems on fuel oil, a manual steam-out valve shall be provided on the burner platform, such that the flame can be observed during steaming-out.

Burner piping shall be arranged to minimize obstruction to access. Below the furnace, the piping shall be arranged such that the operator has a clear unobstructed route of emergency escape from below the furnace.

Piping to burners shall be arranged such that burner assemblies can be removed without cutting/welding (e.g. flanged connections to be provided).

The guide MF 92-0410, provides information on the various control schemes for manual and automatic start-up systems for oil and gas fired furnaces. The Principal will indicate which control scheme is to be used and will provide the appropriate drawings and narrative description.

10.1.9 Replace this Section by:

Burner gas guns/tips and oil guns shall be removable while the heater is in operation.

10.1.11 Replace this Section by:

When liquid fuels are fired a safety interlock shall be provided on each burner. The interlock shall sequentially shut off the fuel and the atomizing steam before the gun can be removed. A separate steam purge valve shall be installed on the burner operating platform.

Add new Section 10.1.12:

10.1.12 Burner types shall be approved by the Principal.

Each burner shall be suitable for the fuels specified in the requisition. If the Principal has indicated that both gaseous and liquid fuels may be fired, this shall be understood as requiring the capability of firing in the dual fuel mode, i.e. firing of both fuels simultaneously on all burners.

For manual start-up, use shall be made of a portable ignition unit approved by the Principal (e.g. Smitsvonk ignition burner type 51 with a Smitsvonk ignition transformer).

For automatic start-up, the permanently installed ignition unit shall be approved by the Principal (e.g. Smitsvonk ignition burner type 54 with built-in flame rod and provided with a Smitsvonk ignition transformer).

Neither flexible hoses nor screwed connections shall be used for fuel oil or fuel gas supply to the burners.

10.2 Soot Blowers

10.2.1 Add to this Section:

Fixed position rotary type soot blowers shall not be applied at flue gas temperatures above 650 °C.

Soot blowers shall be provided with a purge air supply, either forced draught or natural draught.

Soot blowers shall be provided with an automatic sequence control system.

10.3 Fans and Drivers

10.3.1 Add to this Section:

DEP 31.29.47.30-Gen. shall apply. The turn-down on flow for a forced draught fan on a single furnace shall be at least from design capacity down to 25% of design without surging. For multi-furnace fan combinations, the Principal will specify the turn-down requirement and the type of control to be applied. Due consideration shall be given in establishing a design basis for capacity and head generation to the operation using cold or hot air, i.e. with or without the air preheater being bypassed.

10.3.5 Delete this Section.

10.3.6 Add to this Section:

The sizing of the fan driver for an FD fan should be such that the fan can be started with a fully opened control damper.

The sizing of the fan driver for an ID fan should be such that the fan can be started and operated under cold (furnace purging) conditions at the design mass flow rate.

10.4 Damper Control

10.4.2 Add to this Section:

For the control of combustion air from a common fan, a damper with a pneumatically driven operating mechanism shall be installed in the combustion air supply line to each furnace.

For the control of combustion air from a fan to a single furnace, pneumatically operated inlet guide vane control shall be applied. The operating mechanism, which should be integrated with the damper or inlet guide vanes, shall include an adjustable minimum stop device which can be adjusted between 0 and 50% damper opening, a position indicator and a locking device.

Only if an automatic burner start-up system is selected (in accordance with S 24.022 to S 24.026) shall each burner in a multi-burner installation be equipped with its own motor operated shut-off damper. The damper shall be provided with an adjustable maximum stop to allow trimming of the combustion air flow.

For an example of a damper construction, see S 24.405.

Add new Section 10.5:

10.5 Combustion Air Ducts

10.5.1 GENERAL

Combustion air ducting shall be designed to distribute air evenly to all burners. The design of hot air ducts shall allow for thermal expansion. Ducting shall have a design pressure based on a combination of the wind pressure, see DEP 34.00.01.30-Gen., and the maximum operating pressure in the ducting. The plate thickness of the air ducting and air boxes shall be 4.8 mm minimum. Hot air ducts shall be insulated on the outside. Air ducts shall be painted externally in accordance with DEP 30.48.00.31-Gen. to prevent corrosion under the insulation. To obtain an even distribution of air to the burners, the layout of air ducts shall be as symmetrical as possible to each burner and group of burners (see also 10.6.2). The air ducts shall have sufficient inside cross-sectional area to keep the air velocity below 20 m/s. The air ducts shall be provided with inspection panels near the dampers to allow for damper blade inspection and maintenance.

10.5.2 FD FAN INLET DUCT

The forced-draught fan shall be provided with a vertical suction pipe with its inlet at least 8 m above ground level. The requisition shall specify the height of the inlet. The inlet shall be adequately protected against ingress of rain and solid matter and shall be located in a non-hazardous area of the furnace plot, to be indicated by the Principal, but at least 3 m from the furnace wall, see S 24.407.

For combustion air measurement a Venturi tube shall be installed in the suction pipe of the forced-draught fan. If the fan supplies air to more than one furnace or to a furnace with more than one cell, venturi tubes shall be installed in each discharge duct (i.e. one for each independently controlled furnace, furnace cell or furnace group, see S 24.002 and S 24.005).

Add new Section 10.6:

10.6 Air Preheaters

10.6.1 GENERAL

The following types of air preheaters may be applied:

- Recuperative (static) air preheater; or
- Liquid-coupled air preheat system.

The regenerative (rotary) types of air preheater shall not be used.

The recuperative type shall be used in combination with a grade-mounted down flow convection section.

The liquid-coupled type of air preheater with circulating water shall be applied if a forced circulation type waste heat boiler is present at the site and the furnace is separated from it. In other cases, high pressure water or circulating heating oil may be used as the heat transfer medium. The Principal shall specify the system to be applied, based upon economic considerations.

Air preheaters shall comply with the following requirements:

It shall be possible to clean the flue gas side surfaces during operation by steam soot blowing. At the flue gas side, the wall temperature at any point shall be at least 10 °C above the flue gas dew-point. This applies to all specified operating conditions, including start-up, to prevent 'dew-point' corrosion by condensation of sulphuric acid and water from the flue gases. A flue gas (acid) dew-point calculation shall be provided by the supplier.

10.6.2 RECUPERATIVE AIR PREHEATERS

The air preheater shall be installed directly downstream of the convection section. Design and mounting of these air preheaters shall result in complete separation of air and flue gas.

An air bypass with damper shall be installed for the full combustion air flow rate during start-up and shutdown of the unit and for partial bypassing if low furnace load or cold climate conditions would otherwise result in too low skin metal temperatures causing dew-point corrosion. Bypass ducting around the air preheater shall be arranged such that uniform mixing of cold and hot air is ensured, in order to prevent uneven temperature distribution to the burners. A damper shall be included in the air supply to the air preheater to ensure that air can be fully bypassed during start-up and shut-down.

Where low grade heat is available, e.g. LP steam, consideration should be given to first preheating the combustion air to 60-80 °C before it enters the recuperative air preheater, to reduce the risk of dew-point corrosion and to allow for lower flue gas outlet temperatures.

Glass tubes shall not be used.

In the closed position the air bypass shall not pass more than 5% of the maximum air flow rate at maximum pressure differential.

Access doors for inspection/maintenance shall be installed in the flue gas and air ducts upstream and downstream of the air preheater. In order to prevent cold corner corrosion, there shall be a uniform distribution of the combustion air over the elements. For that purpose air inlet vanes or orifices may be used. In addition, elements with reduced finning on the air side may be required.

Skin thermocouples shall be installed to monitor "cold corner" metal temperatures at the flue gas side.

10.6.3 LIQUID COUPLED AIR PREHEAT SYSTEMS

10.6.3.1 General

Boiler (feed or evaporator) water shall normally be used as the heat transfer medium. The Principal shall indicate in which cases a heat transfer fluid or the process medium may be applied.

When firing sulphur-containing fuels, the design and control of fluid flow through the flue gas cooler shall guarantee a minimum metal wall temperature of at least 10 °C above the flue gas dew point under all specified operating conditions .

No vaporization shall occur in the flue gas cooler at the maximum operating temperature of the system.

Extended surface tubes are generally acceptable for the air preheater itself, but for a flue gas cooler they shall be subject to the same limitations as specified in Section 3.2 and 3.3.

10.6.3.2 Water as heat transfer medium

These air preheaters shall be fully drainable and equipped with adequate drain and vent facilities in order to prevent plugging due to freezing when the unit is standing idle.

If the air preheater does not form part of a waste heat boiler system, the maximum operating pressure shall be chosen as low as compatible (to prevent steaming) with the required combustion air preheat temperature.

The system should also have an expansion vessel (preferably with inert gas blanket), a safety valve and a supply of deaerated water to boiler feed water specifications.

10.6.3.3 Hydrocarbon as heat transfer medium

As a heat transfer medium, hydrocarbons have the advantage over water of having a lower vapour pressure. This means that both the operating pressure and the capital cost involved are lower.

However, a leak in a coil of such an air preheater presents the risk of a fire or explosion in the air duct. In order to reduce this risk to an acceptable level, the following features shall be incorporated in the design of the air preheater:

- The length of the air duct between air preheater and burner shall be as short as practically possible;

- Seamless tube of a small diameter (maximum 1.5 inch) shall be used in the preheater;
- Fins shall either be attached by continuous high frequency welding or be of the embedded type;
- Circumferential tube welds shall be located outside the air duct;
- The design pressure for the coil itself, not the connecting piping and flanges, shall be at least twice the highest pressure which can occur in the system (e.g. pump shut-off pressure or relief valve set pressure). The coil shall be hydrostatically tested at this design pressure;
- The coil shall be self-draining;
- The header boxes containing the welds shall be provided with a 10 mm weep hole to reveal any leakage.

Basically the system can be set up similar to a water air preheat system, with expansion vessel, circulation pumps, inlet temperature of flue gas cooler etc. Apart from the above, the general design rules for heat transfer fluid systems as described in DEP 20.05.50.10-Gen. shall apply.

SECTION 11 INSTRUMENT AND AUXILIARY CONNECTIONS

11.1 Flue Gas and Air

11.1.1 Replace this Section by:

One connection shall be provided in each flue gas radiant cell outlet. In horizontal furnaces a connection shall be provided for each 9 m of radiant cell length.

The corresponding thermowells shall protrude at least 60 cm into the flue gas path or to the centre of the flue gas duct, whichever is the shorter.

In case of side mounted convection sections, the connection(s) shall be provided in the cross-over ducts between radiant section and convection section, approximately to the centre of the duct and thus not facing the flames or the convection section tubes.

11.1.1.6 Add to this Section:

Thermowell connections shall be in accordance with drawing S 24.601.

11.1.2.1 Add to this Section:

For vertical box type (bottom fired, vertical tubes) or cylindrical furnaces at least one connection shall be provided.

11.1.2.3 Add to this Section:

Vertical heaters require only one connection in each radiant section outlet duct.

11.1.2.9 Add to this Section:

Pressure connections shall be in accordance with S 24.601.

11.1.3.4 Add to this Section:

The connections shall be in accordance with S 24.603. A connection shall be provided for a Westinghouse type insertion oxygen analyzer. If multiple radiant sections are applied in combination with one convection section, each radiant cell outlet shall be provided with a connection. In other cases one connection shall be provided at the outlet of the convection section, but upstream of the air preheater.

For gas testing purposes a $1^1/2$ inch connection shall be provided in the flue gas section downstream of the last hydrocarbon-containing coil.

Add new Section 11.2.4:

11.2.4 Thermowell connections shall be provided on return bends where specified in the requisition and shall be constructed in accordance with S 24.616.

11.3 Auxiliary Connections

11.3.1 SNUFFING STEAM CONNECTIONS

11.3.1.3 Replace this Section by:

Amended per Circular 33/96

The construction of the snuffing connections shall be in accordance with S 24.607.

Multiple connections to one compartment shall be combined to one common supply line. e.g. one supply line to the radiant cell and one supply line, e.g. to all header boxes. Each line from the smothering steam header shall have a block valve and shall be self-draining to a weep hole of 6 mm diameter at the lowest point downstream of the block valve. The header and block valves shall be located and shielded such that personnel can gain access even during a furnace fire. The weepholes shall be arranged such that the safety of operating personnel will not be jeopardized by steam blowing out of the weep hole.

11.3.2 PURGE CONNECTIONS

11.3.2.1 Add to this Section:

Air purge connections shall be installed on observation windows on forced draught furnaces. The purge air take-off shall be from the combustion air supply system upstream of the air preheater. The take-off connection shall comply with S 24.606.

11.4 Tube Skin Thermocouples

Add to this Section:

Installation and type of tube skin thermocouples shall be in accordance with drawings S 24.604, S 24.615, and S 35.405.

11.5.1 Add to this Section:

This requirement includes the nozzles for tube skin thermo-couples.

SECTION 12 SHOP FABRICATION AND FIELD ERECTION

12.3 Coil Fabrication

Replace this Section by:

Welding of tubing shall be in accordance with ASME I and DEP 31.24.49.31-Gen. All welding shall be done by qualified welders in accordance with qualified welding procedures. Qualification tests for welders and welding procedures shall comply with ASME IX.

No welding shall be performed after post weld heat treatment unless it is followed by an additional post weld heat treatment.

12.4 Painting and Galvanizing

12.4.1 Add to this Section:

Paint systems in accordance with DEP 30.48.00.31-Gen. shall be applied for the protection of steel surfaces.

Surfaces which will be in permanent contact with insulating refractory concrete lining shall not be painted.

If ceramic fibre lining is applied, the metal surface shall have a protective coating suitable for the calculated surface temperatures and temperature variations.

SECTION 13 INSPECTION AND TESTING

Add new Section 13.1.3:

13.1.3 Inspection procedures shall be in accordance with DEP 61.10.08.11-Gen.

13.2 Weld Inspection

13.2.1 Replace this Section by:

Tubing/piping welds shall be inspected in accordance with DEP 31.24.49.31-Gen.

13.3 Castings Inspection

13.3.3 Replace this Section by:

Horseshoe type return bend fittings shall be inspected and tested as indicated in Appendix E.

A "record of expansion" shall be compiled in order to check whether tubes have been correctly expanded in the return bends. The record shall contain readings of:

- ID of header
- OD of each tube
- ID of each tube
- original expansion.

13.5.2 Replace this Section by:

See Section 7 of this DEP.

APPENDIX A FIRED HEATER DATA SHEET

Replace this Appendix by:

The requisition shall be used to specify the necessary data.

APPENDIX B FIRED HEATER CHECKLIST

Delete this Appendix.

APPENDIX C PROPOSED SHOP ASSEMBLY CONDITIONS

Delete this Appendix.

Add new Appendix D:

APPENDIX D WASTE HEAT BOILERS

1.1 GENERAL

Waste heat boilers shall comply with DEP 30.75.10.31-Gen. The design shall be in accordance with ASME I or BS 1113 as specified by the Principal.

The choice of waste heat boiler type and design requires approval by the Principal, who will specify whether S 24.110 is also applicable, in which case the following sections are applicable:

1.2 WASTE HEAT BOILERS PER S 24.110

1.2.1 General

In addition to the applicable specifications in Section 1.1 above, a waste heat boiler shall be complete with a steam disengaging drum, two 100% capacity circulation pumps, cleaning facilities for the outside coil surface, supporting structure, platforms with stairs and all interconnecting piping. For water/steam circulation systems, see S 24.010.

The Principal will provide a requisition in which the thermal and hydraulic rating of the waste heat boiler is specified.

1.2.2 Coils and coils suspension

Coils should be constructed with welding return bends; 'pulled' bends may be used provided that the restrictions of DEP 31.38.01.31-Gen. are applied.

The tube sizes and thicknesses shall be as specified in Part II, Section 3.

Superheater coils shall be shielded by part of the evaporator coils so as to provide an even superheater steam temperature at varying loads.

Each coil tube shall be supported separately by U-shaped lugs welded onto the cooled vertical suspension tubes.

The suspension tubes hang from large horizontal boiler-water-cooled supports, mounted in the top section and embedded in both longitudinal side walls, see S 24.110.

Water circulation shall remain sufficient to protect the coils and coil suspension pipes against the residual heat accumulated in the furnace(s) during a complete power failure and (for forced circulation waste heat boilers) during the period between breakdown of one circulation pump and take-over by the spare pump.

Inlet headers of economizer and evaporator coils shall have hand-operated blowdown facilities for sludge removal.

Carbon or alloy steels selected to match the service requirements shall be used for the coils and welded return bends in accordance with this DEP.

The type and material specifications of the tubing shall be stated on the requisition.

1.2.3 Steam disengaging drum

The steam disengaging drum shall be of the vertical type with standard water/steam separating devices, see S 24.111.

Saturated steam and boiler water shall be as specified in the requisition.

A saturated steam sampling device and a sample cooler, both made from stainless steel AISI 316 material, shall be installed.

Between the normal water level and the bottom tangent line, the steam drum shall have a capacity corresponding to at least eight minutes of full steam production to allow for measures to be taken if the feed water supply fails. Between high-high and normal level, and between normal and low-low level, a capacity of at least one minute each is required for if the feed water supply fails.

The steam drum shall be equipped with continuous blowdown facilities at the location where drum water is expected to have the highest salt concentration. A water sampling connection in the drum outlet to the circulation pumps shall be included, complete with sample cooler.

The water sampling connection up to and including the globe valve shall be made of carbon steel, as the use of stainless steel may lead to chloride stress corrosion cracking. Stainless steel may be used downstream of the globe valve. Refer to S 38.007.

1.2.4 Chemical cleaning

Provisions shall be made for chemical/acid cleaning of the boiler in accordance with S 24.010 and as described in DEP 70.10.80.11-Gen.

Add new Appendix E:

APPENDIX E SPECIFICATION FOR CAST "HORSESHOE" TYPE RETURN FITTINGS

Fabrication, inspection and testing of cast steel "horseshoe" type return fittings shall be in accordance with the ASTM standard selected from the table in (Section 3.3.3).

In addition the following requirements shall be met:

1. MATERIAL CERTIFICATION

A certificate type 3.1.B in accordance with ISO 10474 shall be furnished by the manufacturer, containing at least the following information:

- chemical analysis of each heat of steel;
- mechanical values as specified in the relevant ASTM standard;
- heat treatment of the fittings;
- Brinell hardness of each fitting body.

The hardness requirements are as follows:

- ASTM A 216 WCB/WCC: Brinell hardness 180-200;
- ASTM A 217 C5: Brinell hardness 220-275.

2. VISUAL INSPECTION (VI)

VI shall be performed on each fitting in accordance with ASME V, Article 9. All surfaces shall be inspected. Acceptance criteria shall be in accordance with MSS SP-55.

3. MAGNETIC PARTICLE EXAMINATION (MT)

MT shall be performed on each fitting in accordance with ASME VIII, Division 1, Appendix 7. All surfaces shall be examined. Liquid Penetrant Examination (PT) shall only be substituted for areas where MT is not possible; in which case it shall also be done in accordance with ASME VIII, Division 1, Appendix 7.

4. RADIOGRAPHIC INSPECTION (RT).

10% of the total number of fittings on order shall be radiographed, with a minimum of one per heat. RT shall be performed in accordance with ASME VIII, Division 1, Appendix 7 and API 560. Critical sections of each casting shall be fully radiographed; where such sections cannot be radiographed and/or for wall thicknesses above 50 mm, ultrasonic testing (UT) shall be substituted (also in accordance with ASME VIII, Division 1, Appendix 7). The Manufacturer shall submit details of the critical sections proposed to receive RT/UT for the Principal's approval. In the event that a fitting is found to contain defects, the remaining fittings of that heat shall be radiographed (or UT). In the event that any of those fittings contain defects, the remaining fittings of the order shall be radiographed (or UT).

5. TIMING OF INSPECTION

- VI/MT/PT shall be performed after final heat treatment in the final machined condition.
- RT/UT shall be performed after final heat treatment but need not be in the final machined condition provided that the thickness is within 90% of the final thickness (i.e. no more than 10% further reduction in thickness allowed). In any case the radiographic sensitivity indicator (e.g. penetrameter) shall be selected based on the actual thickness being radiographed.

6. REPAIR

If a repair is necessary, the requirements as given in the selected ASTM material standard shall be adhered to as well as the following:

- Approval by the Principal shall be obtained before any major* weld repair is carried out;
- All repairs shall meet the inspection requirements and acceptance standards of the original material;
- Repair procedures for, and subsequent inspection methods of, major* weld repairs are subject to approval of the Principal before starting the repairs
  Welders and welding procedures shall be qualified in accordance with this DEP and as per the appropriate ASTM standard;
- The total quantity of weld metal deposited shall be less than 10% of the mass of the casting;
- Weld repairs shall be heat-treated in accordance with the particular ASTM material standard and this DEP;
- Details of all major weld repairs and the subsequent heat treatments shall be recorded on the relevant certificates and reported to the Principal.

* A major weld repair is defined as either the removal of more than 50% of the wall thickness, or a length of more than 150 mm in one or more directions, or a total surface area of all repairs exceeding 10% of the original surface area.

7. MARKING

Each fitting shall have a unique cast-in identity ensuring positive traceability to its material certificate.

8. HYDROSTATIC TEST

All fittings shall be hydrostatically water tested at a pressure and for a period as determined by the governing code and the applicable standard drawing (S 24.201-209).

PART III REFERENCES

Amended per Circular 33/96

In this DEP reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto. For standard drawings, the latest issue is identified in DEP 00.00.06.06-Gen.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Index to standard drawings	DEP 00.00.06.06-Gen.
Steam injection systems for safeguarding thermal cracking units	DEP 10.02.51.11-Gen.
Design guide for high temperature heat-transfer fluid systems	DEP 20.05.50.10-Gen.
Metallic materials - selected standards	DEP 30.10.02.11-Gen.
Welding of metals	DEP 30.10.60.18-Gen.
Painting and coating for new construction projects	DEP 30.48.00.31-Gen.
Gas turbine heat recovery steam generators	DEP 30.75.10.31-Gen.
Data/requisition sheet for equipment noise limitation	DEP 31.10.00.94-Gen.
Data/requisition sheets for furnaces and waste heat boilers	DEP 31.24.00.93-Gen.
Selected materials for furnace parts for high-temperature conversion processes	DEP 31.24.40.31-Gen.
Shop fabrication of heater piping	DEP 31.24.49.31-Gen.
Centrifugal fans	DEP 31.29.47.30-Gen.
Piping - general requirements	DEP 31.38.01.11-Gen.
MF Piping classes	DEP 31.38.01.12-Gen.
Shop and field fabrication of steel piping	DEP 31.38.01.31-Gen.
Electrical engineering guidelines	DEP 33.64.10.10-Gen.
Minimum requirements for structural design and engineering	DEP 34.00.01.30-Gen.
Fire hazards and fireproofing/cold splash protection of steel structures	DEP 34.19.20.11-Gen.
Steel stacks	DEP 34.24.26.31-Gen.
Reinforced concrete stacks	DEP 34.24.27.31-Gen.
Steel structures	DEP 34.28.00.31-Gen.
Refractory bricks and shapes	DEP 44.24.90.31-Gen.
Field inspection prior to commissioning of mechanical equipment	DEP 61.10.08.11-Gen.

Insulating and dense refractory concrete linings	DEP 64.24.32.30-Gen.
Mechanical maintenance - equipment, tools and bolt tensioning	DEP 70.08.10.11-Gen.
Cleaning of equipment	DEP 70.10.80.11-Gen.
Basic requirements for safe operation of fired heaters	MF 92-0410

STANDARD DRAWINGS

Typical arrangement for air flow measurement in suction of forced-draught fans	S 24.002
Typical arrangement for air flow measurement in discharge of forced-draught fans	S 24.005
Typical waste heat boiler water/steam circulation system	S 24.010
Fuel-oil and fuel-gas system for an automatically started forced draught furnace with two steam atomized burners	S 24.022
Control and safeguarding system for a forced draught furnace with one gas burner	S 24.026
Observation window for observing burner throats, coils and furnace cell	S 24.101
Detail of handles and weather protection for observation windows	S 24.102
Tube guides in walls of convection sections with refractory thickness of 100 mm or 125 mm	S 24.104
Spacer strips for convection section piping	S 24.107
4 in. air-cooled peep hole with flapper	S 24.108
Sight glass for 4 in. air-cooled peep hole with weather protection	S 24.109
Typical drawing suspension of waste heat boiler coils	S 24.110
Typical drawing of steam-disengaging drum	S 24.111
Two-hole return bend fitting, nominal 3 in.	S 24.201
Two-hole return bend fitting, nominal 4 in.	S 24.202
Two-hole return bend fitting, nominal 6 in.	S 24.203
Two-hole return bend fitting, nominal 8 in.	S 24.204
Two-hole return bend fitting, nominal 4/3 in	S 24.205
Two-hole return bend fitting, nominal 6/4 in	S 24.206
Two-hole return bend fitting, nominal 8/6 in.	S 24.207
Two-hole return bend fitting, nominal 3 1/2 in.	S 24.208
Two-hole return bend fitting, nominal 5 in.	S 24.209

Detail of furnace bottom (without header box)	S 24.217
Typical roof for large furnaces (single cell with welding return bends)	S 24.233
Typical roof for large furnaces (double cell with welding return bends)	S 24.234
Typical roof for small furnaces (single cell with welding return bends)	S 24.235
Typical roof for large furnaces (single cell with fittings at the top only)	S 24.236
Typical roof for small furnaces (single cell with fittings at the top only)	S 24.237
Roof detail 1 and 2 (Coil suspension/stuffing box)	S 24.238
Roof detail 3 (Coil suspension)	S 24.240
Sliding plate in flue duct	S 24.303
Damper for air duct	S 24.405
Vertical suction pipe with rain cap for forced-draught fan	S 24.407
Connection for tube guides	S 24.503
Detail of supporting cooled support	S 24.505
Connections for thermowell and pressure instrument	S 24.601
Sample connection for flue gas analyser	S 24.603
Connection for skin thermocouple	S 24.604
Connection on air duct for purge and cooling purposes	S 24.606
1 inch and 1-1/2 inch smothering steam connection for air ducts, furnaces and flue ducts	S 24.607
Installation of thermocouple on furnace tubes	S 24.615
Thermowell assembly for return bend fitting, type horse shoe class 600	S 24.616
Furnace tube skin thermocouple assembly	S 35.405
Steam sample device	S 38.007

AMERICAN STANDARDS

Factory - Made wrought steel buttwelding fittings	ANSI B16.9
Welded and seamless wrought steel pipe	ANSI/ASME B36.10M

Issued by:
American National Standards Institute
11 West 42nd street, 13th. floor
New York
NY 10036, USA

Calculation of heater tube thicknesses in petroleum refineries	API RP 530 Third Edition 1988
Fired heaters for general refinery services	API 560 First Edition 1986
Steels for hydrogen service at elevated temperatures and pressures in petroleum refineries and petrochemical plants	API RP 941

Issued by:
The American Petroleum Institute
1220 L Street, North west
Washington, D.C. 20005, USA.

ASME Boiler and Pressure Vessel Code:

Section I - Power Boilers	ASME I
Section V - Non destructive Testing	ASME V
Section VIII - Pressure Vessels	ASME VIII
Section IX - Welding Qualifications	ASME IX

Issued by:
American Society of Mechanical Engineers
345 East 47th Street
New York, NY 10017, USA.

Specification for steel castings, carbon suitable for fusion welding for high-temperature service	ASTM A 216
Specification for steel castings, martensitic stainless and alloy, for pressure-containing parts suitable for high-temperature	ASTM A 217
Standard specification for general requirements for Carbon, ferritic alloy and austenitic alloy steel tubes	ASTM A 450
Standard specification for general requirements for specialized carbon and alloy steel pipe	ASTM A 530

Issued by:
American Society for Testing and Materials
1916 Race Street
Philadelphia, Pa. 19103, USA.

Quality Standard for Steel Castings	MSS SP-55

Issued by:
The Manufacturing Standardization Society
of the Valve and Fitting Industry Inc.
126 Park Street
NE Vienna, Virginia 22180, USA.

BRITISH STANDARDS

Specification for design and manufacture of water-tube steam generating plant etc.	BS 1113
Steel butt-welding pipe fittings for the petroleum industry	BS 1640

Issued by:
British Standards Institution
389 Chiswick High Road

London W4 4AL, England

Noise Procedure Specification	EEMUA 140

Issued by:
The Engineering Equipment and Materials Users Association
14 Belgrave Square
London SW1X 8PS, England

INTERNATIONAL STANDARDS

Steel and steel products - Inspection documents	ISO 10474

Issued by:
International Organisation for Standardisation
1, Rue de Varembé
CH-1211 Geneva 20, Switzerland.
Copies may also be obtained through the national standards organisations.