TECHNICAL SPECIFICATION

SHOP FABRICATION OF HEATER PIPING

DEP 31.24.49.31-Gen.

July 1993

DESIGN AND ENGINEERING PRACTICE

USED BY

COMPANIES OF THE ROYAL DUTCH/SHELL GROUP

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.

Subject to any particular terms and conditions as may be set forth in specific agreements with users, SIOP, SIEP and SIC disclaim 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 DEP, combination of DEPs or any part thereof. The benefit of this disclaimer shall inure in all respects to SIOP, SIEP, SIC and/or any company affiliated to these companies that may issue DEPs or require the use of DEPs.

Without prejudice to any specific terms in respect of confidentiality under relevant contractual arrangements, DEPs shall not, without the prior written consent of SIOP and SIEP, be disclosed by users to any company or person whomsoever and the DEPs shall be used exclusively for the purpose for which 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 SIOP and SIEP. The copyright of DEPs vests in SIOP and SIEP. Users shall arrange for DEPs to be held in safe custody and SIOP or SIEP may at any time require information satisfactory to them in order to ascertain how users implement this requirement.

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

APPENDICES

1. INTRODUCTION

This DEP is a revision of the earlier DEP of the same number and title dated April 1981.

This DEP gives minimum requirements for the fabrication, inspection and testing of carbon steel, alloy steel and stainless steel piping (coils) to be used in fired equipment and waste heat boilers. The requirements also apply to field work on these coils.

Where applicable, the words "piping" and "pipe(s)" used in this DEP shall also mean "tubing" and "tube(s)", respectively.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIPM, 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 described in DEP 00.00.05.05-Gen.).

This DEP is intended primarily for use in oil refineries, chemical plants, gas plants and, where applicable, in exploration and production 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 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

Design code is ANSI B 31.1 unless otherwise specified by the Principal.

1.4 CROSS-REFERENCES

Where cross references are made in this DEP, the number of the section or sub-section referred to is shown in brackets. All publications referred to are listed in (6).

2. DOCUMENTS

The Supplier shall be provided by the Principal with one or more drawings together with covering requisition(s) giving all information on the coils to be fabricated.

In addition to the data stated on these drawing(s), shop drawings provided by the Supplier shall state:

- Details of the welded joints with reference to the welding procedure specification, pre- and post-weld heat treatment procedures.

Before the start of manufacture, all shop drawings, weld procedure specifications including pre- and post-weld treatment procedures, welding procedure qualification records and welder performance qualifications shall have been approved by the Principal.

Manufacture shall be in conformity with these approved drawings.

The Manufacturer shall, upon completion, supply a manufacturing report containing all the relevant documentation. The format for this report should be in accordance with DEP 31.22.10.35-Gen., making use of all the applicable sections.

3. FABRICATION REQUIREMENTS

3.1 MATERIALS

3.1.1 General

The material shall comply with the specification as given on the drawing and/or requisition.

Unless otherwise specified, only seamless pipe and fittings shall be used.

Materials shall be in accordance with DEP 30.10.02.11-Gen.

3.1.2 Material certification

All materials used in pressure-containing parts and in load-bearing components shall be traceable to material test certificates ISO 10474 type 5.1.B or 5.1.C.

For low-alloy steels, high-alloy martensitic, ferritic and austenitic stainless steels, and carbon steels requiring notch toughness (as per DEP 30.10.02.31-Gen.) traceable material certificates according to type 5.1 C shall be provided (including welding consumables).

3.1.3 Traceability

The heat number(s) for certified materials (see 3.1.2) shall be recorded on an as-built drawing of the heater piping.

3.2 CUTTING AND BEVELLING

3.2.1 General

Cutting of pipes may be done either by mechanical or thermal (flame, arc or plasma) means. The following shall be taken into account for thermal cutting:

- For carbon steel, thermal cutting and bevelling may be used only if the cut is reasonably smooth and all oxides are removed from the surface. This shall be achieved by dressing back approximately 2 mm by grinding or machining to remove all the heat affected zone.
- For low- and intermediate-alloy steel, thermal cutting may be used only where machining or water cutting is not feasible. After thermal cutting, approximately 2 mm of material shall be removed from the surface of the bevel by grinding or machining. The dressed bevels then shall be examined by either magnetic particle or dye penetrant methods prior to welding, to confirm that the bevel is free from linear indications.
- Stainless steel piping shall not be flame or arc cut. Plasma cutting may be applied.

If preheat is specified for welding, the same preheat shall be applied for thermal cutting.

3.2.2 End preparation for butt-welding

End preparations for butt-welding shall be in accordance with ANSI B16.25.

Pipes having a wall thickness of less than 3 mm shall be cut square.

3.3 WELDED JOINT

The type of flanges, fittings and connections and the extent to which welded joints are applied shall be indicated on the Principal's drawings.

No intermediate welds shall be made in the pipes used for the coils, unless approved by the Principal.

All branch welds and structural attachment welds shall be dressed to a reasonably smooth finish, free from undercut and merging smoothly into the pipe surface, and without any sharp corners or other stress raisers.

Backing rings shall not be used.

3.3.1 Assembly

End profiles of pipes and fittings to be butt-welded shall be in accordance with (3.2.2).

For butt-welding of all piping components, a uniform root gap shall be used as specified below:

Nominal pipe size	Root opening
smaller than DN50	1.5 mm
DN50-DN250	1.5 - 2.5 mm
DN350 and larger	2.5 - 3.5 mm

Alignment of butt-welded piping components shall be in accordance with ANSI B31.1 with the exception that the internal trimming shall be 1 : 4 instead of 30°.

3.3.2 Branch connections

All cuts shall be carefully bevelled and accurately matched to form a suitable groove for welding and to permit complete penetration of the welds at all points.

3.4 FLANGED JOINTS

Unless otherwise stated on the Principal's drawing, the bolt holes of all flanges shall straddle the centre lines of the pipe ends.

Slip-on or socket weld flanges shall not be used.

3.5 SPACER STRIPS

The weld connecting the spacer strip and the pipe shall have full penetration as indicated on the Principal's drawing.

Material of these strips shall be the same as of the pipes concerned.

3.6 BENDS

Only welding elbows in accordance with ANSI B16.9 shall be used.

Bending of pipe may be done only with the approval of the Principal regarding the location(s), method(s) of bending, final heat treatment condition, tolerances and subsequent inspection methods.

3.7 FINAL CORRECTIONS

3.7.1 General

If final corrections cannot be avoided they shall be carried out as much as possible by rewelding. Where cold work is unavoidable, hardness testing on the strained area shall be carried out to confirm the maximum hardness requirements of (5.3) are met.

For cold deformation greater than 5% or where the maximum hardness requirements are exceeded, thermal stress relief shall be applied (with correctly fabricated pipework, it is not the intention that 5% cold deformation should ever be reached or undue stress be imposed on the system during installation). In all cases the Principal shall be informed beforehand. The following requirements shall also apply.

3.7.2 Carbon steel, 0.3 Mo and 0.5 Mo steel piping

After final heat treatment all corrections to the piping should be made in the cold condition.

3.7.3 Chromium-molybdenum steel piping

After final heat treatment all corrections to the piping should be made in the cold condition.

If this is not possible the piping may be heated, for which approval of the Principal is required. The heating shall be applied uniformly and carefully controlled in accordance with an approved procedure and the temperature shall not exceed the maximum temperature limit of post-weld heat treatment as indicated in Appendix 1. Re-heat treatment is not then required.

3.7.4 Austenitic chromium-nickel and chromium-nickel-molybdenum steel piping

After final heat treatment all corrections to the piping should be made in the cold condition.

If this is not possible the piping may be heated, for which approval of the Principal is required. The heating shall be applied uniformly and carefully controlled, the temperature shall not exceed 450 °C, and it shall be applied in accordance with an approved procedure.

3.8 TOLERANCES

The following dimensional tolerances shall apply.

3.8.1 Dimensions

For dimensions stated on the Principal's drawing(s), see (2.) for lengths of less than 1.5 m a tolerance of ± 1.5 mm shall apply; for lengths 1.5 m and over a maximum of ± 3 mm shall apply.

NOTE: For prefabricated bends the tolerances shall comply with those specified in ANSI B16.9 or ANSI B16.28 or BS 1640.

3.8.2 Flange face alignment

The maximum deviation measured in any direction shall not exceed 2.5 mm/m.

When branches are in the same plane and their flanges are also positioned in one plane, the flange facings shall not deviate more than 1 mm from the latter plane in the same direction.

3.8.3 Position of bolt holes for flanged piping

The maximum deviation allowed from the required position is 1.5 mm (measured around the bolt circle).

4. WELDING

4.1 GENERAL

All welding shall be carried out in accordance with DEP 30.10.60.18-Gen.

No production welding shall be carried out before welding procedures and welders are qualified according to the design code requirements.

4.1.1 Welding procedure specification

Welding procedure specifications shall be subject to approval by the Principal. Welding procedures shall be qualified before welder performance qualification and production welding.

4.1.2 Consumable Approval

Welding materials used shall be in accordance with the current list of approved welding consumables published by Lloyds Register of Shipping, Controlas, or other body approved by the Principal. Welding consumables not mentioned in these shall be subject to approval by the Principal.

4.2 PREHEATING

The preheating temperature limits for the types of steel used are given in Appendix 1.

Where a temperature range is given in Appendix 1, the upper temperature shall be used for tack welding.

4.3 POST-WELD HEAT TREATMENT

Post-weld heat treatment temperatures for various materials are given in Appendix 1 and shall be specified on the drawing or the requisition.

Post-weld heat treatment shall be carried out by one of the following methods:

- heating the fabricated piping in an enclosed furnace, whenever practicable,
- local heat treatment in a small furnace,
- heat treatment by electric induction or radiation,

Heating shall not be applied with hand torches.

In all cases the temperature shall be suitably controlled, e.g. by thermocouples attached to the parts to be treated. Temperature-indicating crayons shall not be used to control the temperature.

Oxy-acetylene shall not be used.

The heating shall be uniform and within the temperature range given in Appendix 1.

5. SHOP INSPECTION AND TESTING

All dimensions shall be checked to ensure that the fabrication meets the requirements of the coil drawings, within the specified tolerances.

5.1 INSPECTION OF WELDS

All inspection and testing is the responsibility of the Manufacturer. The Principal shall advise if he wishes to witness inspection.

Unless otherwise specified by the Principal, inspection of welds shall be carried out after final heat treatment in accordance with inspection classes shown in Appendix 2.

All inspection and testing shall be carried out before any paint, coating or lining is applied.

The method of radiography to be employed for inspection shall be in accordance with the design code.

Acceptance criteria of welds shall be in accordance with the design code.

The Principal may indicate the specific welds to be examined unless 100% inspection is required by code, purchase order, or Appendix 2.

NOTE: Coil service shall be indicated on the Principal's drawing(s) or requisition.

5.2 HYDROSTATIC PRESSURE TEST

All shop-fabricated heater piping shall be hydrostatically tested before shipment.

Test pressure shall be maintained for a period of time sufficiently long to enable the piping to be checked for leaks.

Water quality and post-test flushing/draining shall be in accordance with DEP 31.38.01.31-Gen.

5.3 HARDNESS REQUIREMENTS

Maximum hardness limits and hardness vertification shall be in accordance with requirements of DEP 31.38.01.31-Gen., based on the intended service.

5.4 POSITIVE MATERIAL IDENTIFICATION

For all materials (other than carbon steel) which require 5.1.C certificates (see 3.1.2) the alloying elements in materials and weld deposits shall be verified by chemical, spectroscopic or X-ray fluorescence methods approved by the Principal. The results shall be included in the manufacturing report.

5.5 TUBE FINNING

Finned tubes shall be inspected to ensure that the fins are perpendicular to the tube within 15 degrees. The maximum discontinuity of the resistance weld shall be 64 mm in any 2500 mm of weld.

6. REFERENCES

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.

SHELL STANDARDS:

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Metallic materials selected standards	DEP 30.10.02.11-Gen.
Metallic materials - Requirements for equipment for low-temperature service, and for equipment containing liquefied gas or lethal substances	DEP 30.10.02.31-Gen.
Welding of metals	DEP 30.10.60.18-Gen.
Manufacturing report for pressure vessels	DEP 31.22.10.35-Gen.
Shop and field fabrication of steel piping	DEP 31.38.01.31-Gen.

AMERICAN STANDARDS

Factory-made wrought steel buttwelding fittings	ANSI B16.9
Buttwelding ends	ANSI B16.25
Wrought steel buttwelding short radius elbows and returns	ANSI B16.28
Power piping	ANSI B31.1

Issued by:
American National Standards Institute
1430 Broadway
New York NY 10018
USA.

BRITISH STANDARDS

Steel butt-welding pipe fittings for the petroleum industry	BS 1640

Issued by:
British Standards Institution
2 Park Street
London W1A 2 BS
England.

INTERNATIONAL STANDARDS

Steel and steel products - Inspection documents	ISO 10474

Issued by:
International Organisation for Standardisation
1, Rue de Varembé
1211 Geneva 20
Switzerland.

7. APPENDICES

Appendix

1 Preheat and PWHT temperatures

2 Inspection classes for piping

APPENDIX 1 PREHEAT AND PWHT TEMPERATURES

Material	PREHEAT		POST-WELD HEAT TREATMENT		
	Wall thickness, mm	Minimum temperature, °C	Wall thickness, mm	Temperature range, °C, min-max (8)	Holding time, minutes per mm thickness (7)
Carbon and carbon-manganese steel	≤ 20	20	≤ 35	Optional	2.5
	> 20	20	> 35	580-620	
Fine-grained and low-nickel alloy steels	≤ 20	100 optional	≤ 35	Optional	2.5
	> 20	100-150	> 35	580-620 (1) 540-580	
0.3-0.5 Mo steel	≤ 20	20	≤ 20	Optional 580-620 (5)	2.5
	> 20	100-150	> 20	620-660	
1 Cr-0.5 Mo	All	100-150	All	640-680 (2)	2.5
1.25 Cr-0.5 Mo	All	100-150	All	680-720 (3)	2.5
2.25 Cr-1 Mo	All	200	All	630-680 (2) 680-720 (3) 710-750 (4)	5
5 Cr-0.5 Mo	All	250-300	All	680-720 (2)	5
9 Cr-1 Mo	All	250-300	All	720-760 (4)	5
3.5 Ni			≥ 50	570-590	2.5
9 Ni			≥ 50	570-590	2.5
12-17 Cr martensitic steels	All	200-300	All	700-790	2.5

NOTES:
1. Temperature for fine grained steels.
2. Temperature for optimum high-temperature properties.
3. Temperature range in the case of service for hydrogen or general refinery services.
4. Temperature range for maximum softening.
5. For hydrogen service PWHT is required irrespective of the wall thickness.
6. If ambient temperature is below 5 °C preheat to 50 °C is recommended.
7. Minimum holding time one hour.
8. The Principal shall specify the required PWHT temperature range where alternatives are included in this column.

The temperature of the item or weld shall not exceed 300 °C at the time of insertion in the furnace.

APPENDIX 2 INSPECTION CLASSES FOR PIPING

Material	Service	ANS Class	Percentage Radiography (2) (3) (4) (5)	Percentage MPI	Percentage Liquid Penetrant	Hardness
Carbon steel, 0.3 Mo and 0.5 Mo steel	Utility	150/600	10	10	-	See par. 5.3
		≥ 900	100	10	-	See par. 5.3
	Process: Liquefied gas, Hydrogen Services (1)	All ratings	100	10	-	See par. 5.3
	Process: Lethal Substances	All ratings	100	100	-	See par. 5.3
	Process: All other Services	150/600	10	10	-	See par. 5.3
		≥ 900	100	10	-	See par. 5.3
Ferritic Alloy steel excl. 0.3 Mo and 0.5 Mo steel	All services	All ratings	100	100	-	See par. 5.3
Austenitic Alloy	Process: Liquefied Gas Hydrogen Service (1) Lethal Substances	All ratings	100	-	100	N.A.
	All other Services	150/300	10	-	10	N.A.
		≥ 600	100	-	100	N.A.
Dissimilar Metal Weldments	All services:	All ratings	100	-	100	See par. 5.3.

NOTES:
1. Hydrogen partial pressure ≥ 7 bar.
2. Ultrasonic examination may be applied if the configuration precludes radiography.
3. The indicated percentage of welds to be radiographed shall apply to all welders involved.
4. Branch welds to be included.
5. The following film qualities shall be applied:
   - For X-ray, fine grain or ultrafine grain may be used, e.g. Class II or Class 1.
   - For gamma-ray, ultra-fine grain film shall be used, e.g. Class I.

   N.A. = Not Applicable.
   MPI = Magnetic Particle Inspection.