TECHNICAL SPECIFICATION

STEEL STRUCTURES

DEP 34.28.00.31-Gen.

July 1996

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:

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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.

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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.

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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design, fabrication and erection of onshore steel structures.

Design requirements for steel sub-structures for fixed offshore platforms are covered in DEP 37.19.00.30-Gen., and material requirements for fixed offshore structures are covered in DEP 37.19.10.30-Gen.

This DEP is a revision of the DEP with the same number dated July 1984.

This DEP shall be used in conjunction with DEP 34.00.01.30-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 managed by a Group company and to Contractors nominated by them (i.e. the distribution code is "C" as described in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, chemical plants, gas plants, exploration and 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, environment, 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

The **Contractor** is the party which carries out all or part of the design, 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 supplied 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 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.

1.4 CROSS-REFERENCES

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

2. DESIGN AND ENGINEERING

2.1 GENERAL

The design of a steel structure shall take into account not only the properties of the materials of construction and the calculated stresses for the members, but also the prevailing conditions of the local environment and the requirements at site, the details of construction, methods of erection and fabrication and their effect on cost, in order to achieve a safe and economic design.

2.2 DESIGN REQUIREMENTS

2.2.1 General

The design shall comply with DEP 34.00.01.30-Gen. and one of the following Codes:

ENV 1993-1-1, or

BS 5950 Parts 1 and 2, or

AISC Steel Construction Manual.

For the design and engineering of buildings see DEP 34.17.00.32-Gen.

2.2.2 Derrick structures for flares

The Shell standard design of flare structures with retractable flares is based upon a structure consisting of 4 legs and a rectangular cross section, built up from rolled steel sections.

A structural concept based on a 3-leg derrick with a triangular cross section is acceptable if the Contractor can clearly demonstrate (for the approval of the Principal) the structural integrity of both piping and structure. This demonstration shall include the following factors:

- impact of dynamic wind loading (vortex shedding);
- torsion effects due to asymmetrical wind loading;
- fatigue;
- allowance for spare flare positions in case of future extension. This shall also include maintenance during operation and flare lifting activities.

If load carrying steelwork will be subjected to a temperature greater than 315 °C, the appropriate coefficient, K_t, as defined in BS 4076, shall be applied to the allowable stresses.

The expected temperature of the steel components shall not exceed 480 °C.

If tubular members are used, they shall be designed to prevent ingress of rainwater and shall have adequate provisions for drainage of water condensate.

Tubular members shall be protected against internal and external corrosion.

2.2.3 Fatigue due to vortex shedding or other cyclic loads

For structures sensitive to the effects of vibration, calculations shall be made for vortex shedding and/or cyclic loads from other sources. The effects of fatigue shall be verified in compliance with ANSI/AWS D1.1.

The Palmgren-Miner's rule shall be applied to judge the combined effect of various types of cyclic loading; the DNV Rules refer. The design shall ensure adequate safety against damage within the planned life of the structure under the applicable loading.

The method of analysis shall be agreed with the Principal. A detailed fatigue analysis may not be necessary when the design is based on previous and satisfactory experience which is strictly comparable.

As most of the wind loads which contribute to fatigue are of a random nature, statistical consideration will normally be required for determining the long term distribution of fatigue loading effects. See also Appendix 1 (Section 6) of DEP 34.00.01.30-Gen.

2.2.4 Maximum allowable stresses

The maximum allowable stress on foundations for steel structures shall not exceed the following values:

	Maximum allowable stress (N/mm^2)	
on concrete:	sand cement grout	4.0
	non-shrink ready mixed grout	8.0
on masonry:		1.0

2.2.5 Deflection and displacement

Unless otherwise specified, the following criteria for deflection shall apply for the load combinations A and C of Section 3.14 of DEP 34.00.01.30-Gen.:

Wall stanchions: max. 1/300th of the height

Purlins: max. 1/250th of the span

Supporting beams: max. 1/400th of the span

Lifting applications:

Crane gantry girders: max. 1/600th of the span

Overhead runway beams: max. 1/500th of the span

Cantilevered runway beams: max. 1/250th of the overhang

Maximum total horizontal displacement of portal frames shall not exceed 1/150th of the height.

2.2.6 Slenderness

Unless otherwise specified, the ratio of effective length to the appropriate radius of gyration shall not exceed 180.

2.2.7 Temperature range

Additional consideration will be necessary for structures in special conditions and in locations where wide temperature ranges occur.

2.3 CONSTRUCTION MATERIALS

Materials shall be selected in accordance with EN 10025 taking weldability into consideration.

In locations where the lowest service temperature is 0 °C or lower, materials of construction shall also comply with the requirements of Table 3.2 and Annex C of ENV 1993-1-1.

2.4 CONSTRUCTION DETAILS

2.4.1 General

Structures shall be designed and constructed such that the joints/nodes are accessible for proper inspection, cleaning and painting.

Pockets or depressions which could hold water shall have drain holes or shall be otherwise protected.

2.4.2 Structural members

For open steel structures higher than 20 m, the thickness of any parts of structural

members shall not be less than 6 mm.

Gusset plates shall not be thinner than the members to be connected, and shall have a thickness of at least 6 mm.

For overhead runway beams with underhung cranes, joists with inside tapered flanges are preferred. If only broad flange beams are available, the bottom flange shall be checked separately for distortion, and reinforced if required (see BS 2853).

The flange width of purlins supporting light-weight concrete slabs shall be not less than 80 mm. For supporting roof sheeting and wall cladding, the flange width shall be not less than 50 mm.

Purlins shall be fixed to the roof beams or trusses by means of angle cleats.

2.4.3 Bolting

Bolts, nuts and threads shall comply with ISO 4014, ISO 4032 and ISO 888, respectively. The use of other threads requires prior approval of the Principal.

All bolts, unless otherwise stated, shall be grade 8.8 or equivalent in accordance with ISO 898-1 and ISO 898-2.

High-strength friction-grip bolts may be used for appropriate applications if approved by the Principal.

Washers shall be used in all bolted connections.

2.4.4 Walkways, platforms, staircases, ladders and handrailing

The minimum width of walkways, platforms and staircases shall be 750 mm.

The minimum headroom for platforms and walkways shall be 2100 mm.

The width of walkways over ground level pipe tracks shall be 600 mm and the walkways and steps shall be fitted with handrails on one side only.

For design criteria and details of staircases, see Standard Drawing S 28 001.

Stair treads shall be made of hot-dip galvanized grating (see 4.).

GRP or aluminium stair treads shall not be used unless approved by the Principal.

Ladders may be installed instead of staircases if the ladders are only required for occasional use and escape routes.

Ladders should be made with side steps.

For details of ladders, see Standard Drawing S 28.011.

Where handrailing is installed, floors, platforms and walkways shall be provided with toe plates 75 x 6 mm.

On platforms, the distance to a stair or ladder shall not exceed 25 m.

For standard details, reference is made to the following Standard Drawings:

S 28.001, S 28.002, S 28.003, S 28.004, S 28.005, S 28.006, S 28.007, S 28.008, S 28.009, S 28.010, S 28.012, S 28.013, S 28.014 and S 28.023.

2.4.5 Flooring and grating

Open flooring shall be used, using grating in accordance with S 28.022.

Solid flooring shall not be used unless approved by the Principal. If used it shall be made out of 6 or 8 mm checkered floor plate.

Grating and fixing material shall be hot-dip galvanized (see 4.).

GRP or aluminium grating shall not be applied unless approved by the Principal.

2.4.6 Anchor bolts

If anchor bolts are included in the supply of the steel structure they shall be fabricated and despatched to the construction site in advance for timely installation prior to concreting the foundations.

For standard details of anchor bolts, see S 28.020.

Anchor bolts shall be derusted and degreased. Thread and nuts shall be oil-dipped.

2.5 ACCESSORIES

2.5.1 Rain water down pipes and roof gutters

Rain water down pipes and roof gutters shall be made either of 1.5 mm thick steel sheet, hot dip galvanized after construction, or of rigid PVC or equivalent. The bottom 2 m of exposed down pipe shall be of galvanized steel.

2.5.2 Roof and wall sheets

If the supply of roof and wall sheets is included in the order for the steel structure, the type required shall be stated on the instruction drawing(s) or requisition. Only galvanized steel sheets shall be used, and they shall have a coating giving maximum protection against the local climate and other environmental factors. The type of coating shall be selected in consultation with the Principal.

The sheets shall be fixed in accordance with the sheet manufacturer's standards.

2.5.3 Translucent sheets

Translucent sheeting shall be of the same size and profile as the adjacent wall cladding and/or roof sheeting.

The translucent sheets shall be of glass fibre reinforced polyester resin of self extinguishing quality, with a resin rich external surface to prevent aging (see DEP 34.17.00.32 Gen.).

2.6 FIREPROOFING OF STEEL STRUCTURES

The method and extent of fireproofing of the steel structure and parts thereof shall be in accordance with DEP 34.19.20.11-Gen.

Cover plates for the protection of fireproofing for stanchions and beams shall be included in the supply of the steel structures.

3. FABRICATION

3.1 MATERIAL

Only new material shall be used, which shall be thoroughly straightened in the shop by methods that will not cause damage before it is laid aside or worked in any way.

All bolting material, including washers and nuts, required for erection shall be furnished by the supplier of the steel structure, who shall allow 5% for spares.

3.2 WELDING AND WELD INSPECTION

AWS D1.1 shall apply.

Records of all data, tests and examinations relating to all welding procedures used during construction and erection shall be made available to the Principal.

4. PROTECTION AGAINST CORROSION

Surface preparation and surface protection, i.e. painting, shall be in accordance with DEP 30.48.00.31-Gen., thermal sprayed coatings shall be in accordance with DEP 30.48.40.31-Gen. and hot-dip galvanizing shall be in accordance with ISO 1461.

Structural steelwork, platform flooring and handrailing located above stainless steel piping or equipment shall not be galvanized or coated with zinc-containing paint. The flooring shall be of stainless steel and the paint should be zinc-free. Alternatively a shield of steel, coated with zinc-free paint, may be fitted to protect the stainless steel equipment.

5. ERECTION

5.1 GENERAL

The method used to erect a steel structure depends upon the type of structure, the size of the structure, the risk involved, whether the structure is to be erected without interfering with other work or operations, the lifting gear available and the local conditions.

All tools, equipment and ropes used for erection shall comply with national and/or local regulations and shall be certified for the purpose intended.

5.2 BY SUPPLIER OF THE STRUCTURE

If specified on the requisition, e.g. for complicated structures, the Supplier shall submit to the Principal an erection plan complete with data on heavy lifts, shipping weights and the calculations involved.

5.3 BY OTHERS

If the erection of the steel structure is not to be carried out by the Supplier, it shall provide the Principal with all information essential for erection of the structure.

5.4 FIELD WELDING

Refer to Section 3.2.

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.
Index to standard drawings	DEP 00.00.06.06-Gen.
Metallic materials - Selected standards	DEP 30.10.02.11-Gen.
Metallic materials - Prevention of brittle fracture	DEP 30.10.02.31-Gen.
Welding of metals	DEP 30.10.60.18-Gen.
Painting and coating for new construction projects	DEP 30.48.00.31-Gen.
Thermal spraying of coatings of zinc, aluminium and their alloys (Endorsement of ISO 2063)	DEP 30.48.40.31-Gen.
Minimum requirements for structural design and engineering	DEP 34.00.01.30-Gen.
Minimum requirements for design and engineering of buildings	DEP 34.17.00.32-Gen.
Fire hazard and fireproofing/cold splash protection of steel structures	DEP 34.19.20.11-Gen.
Design of steel substructures for fixed offshore platforms (amendments/supplements to API RP 2A-LRFD)	DEP 37.19.00.30-Gen.
Weldable structural steels for fixed offshore structures (amendments/supplements to BS 7191)	DEP 37.19.10.30-Gen.

STANDARD DRAWINGS

NOTE The latest edition of Standard Drawings can be found in DEP 00.00.06.06-Gen.

Stairways: general arrangement	S 28.001
Stairways: base of stringers	S 28.002
Stairways: railing connections	S 28.003
Stairways: intermediate platform	S 28.004
Stairways: to connections of stringers	S 28.005
Handrailing: Type 'A'	S 28.006
Handrailing: Type 'B'	S 28.007
Handrailing: Type 'C'	S 28.008
Handrailing: connection to concrete Type 'A'	S 28.009
Handrailing: connection to concrete Type 'B' and 'C'	S 28.010
Ladder: general arrangement to columns	S 28.011

Ladder: sliding/fixed connections	S 28.012
Column platforms: cleats and brackets for design load 300 kg max	S 28.013
Column platforms: cleats and brackets for design load over 300 kg	S 28.014
Anchor bolts	S 28.020
Grating	S 28.022
Fastening of apparatus to fireproofed beam	S 28.023

AMERICAN STANDARDS

Structural Welding Code - Steel	AWS D1.1

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

Steel Construction Manual	AISC

Issued by
American Institute of Steel Construction, Inc.
400 North Michigan Avenue
Chicago, Illinois 60611, USA.

BRITISH STANDARDS

Structural use of steelwork in building, Part 1 and 2	BS 5950
The design and testing of steel overhead runway beams	BS 2853
Steel chimneys	BS 4076

Issued by
British Standards Institution
389 Chiswick High Road
London W4 4AL, United Kingdom.

EUROPEAN STANDARDS

Design of Steel structures, Part 1-1: General Rules and rules for buildings	ENV 1993-1-1
Hot rolled products of non-alloy structural steel	EN 10025

Issued by:
Comité Européen de Normalisation
Secrétariat Central
Rue de Stassart 36
B-1050 Bruxelles, Belgium

Copies can also be obtained from national standards organizations

INTERNATIONAL STANDARDS

Metallic coatings; hot-dip galvanized coatings on fabricated ferrous products; Requirements	ISO 1461
Hexagon head bolts; product grades A and B	ISO 4014
Hexagon nuts, style 1; product grades A and B	ISO 4032
Plain washers for high-strength structural bolting, hardened and tempered	ISO 7415
Bolts, screws and studs; nominal lengths, and thread lengths for general purpose bolts	ISO 888
Mechanical properties of fasteners;	
Part 1: bolts, screws and studs	ISO 898-1
Part 2: nuts with specified proof load values; coarse thread	ISO 898-2

Issued by:
International Organisation for Standardisation
1, Rue de Varembé
CH-1211 Geneva 20
Switzerland.
Copies can also be obtained from national standards organizations.

NORWEGIAN STANDARDS

Rules for the classification of fixed offshore installations	DNV Rules

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