DEP SPECIFICATION

# ONSHORE STEEL STRUCTURES

DEP 34.28.00.31-Gen.

September 2011

ECCN EAR99

**DESIGN AND ENGINEERING PRACTICE**

© 2011 Shell Group of companies
All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, published or transmitted, in any form or by any means, without the prior written permission of the copyright owner or Shell Global Solutions International BV.
This document contains information that is classified as EAR99 and, as a consequence, can neither be exported nor re-exported to any country which is under an embargo of the U.S. government pursuant to Part 746 of the Export Administration Regulations (15 C.F.R. Parts 746) nor can be made available to any national of such country. In addition, the information in this document cannot be exported nor re-exported to an end-user or for an end-use that is prohibited by Part 744 of the Export Administration Regulations (15 C.F.R. Parts 744).

Documents
Document Sharing Hub

Full document details: SHELL 34.28.00.31 2011

## PREFACE

DEP (Design and Engineering Practice) publications reflect the views, at the time of publication, of Shell Global Solutions International B.V. (Shell GSI) and, in some cases, of other Shell Companies.
These views are based on the experience acquired during involvement with the design, construction, operation and maintenance of processing units and facilities. Where deemed appropriate DEPs are based on, or reference international, regional, national and industry standards.
The objective is to set the recommended standard for good design and engineering practice to be applied by Shell companies in oil and gas production, oil refining, gas handling, gasification, chemical processing, or any other such facility, and thereby to help achieve maximum technical and economic benefit from standardization.
The information set forth in these publications is provided to Shell companies 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 Units 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 such use, including the quality of their work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will typically expect them to follow those design and engineering practices that will achieve at least 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.
The right to obtain and to use DEPs is restricted, and is granted by Shell GSI (and in some cases by other Companies) under a Service Agreement or a License Agreement. This right is granted primarily to Shell companies and other companies receiving technical advice and services from Shell GSI or another Shell Company. Consequently, three categories of users of DEPs can be distinguished:

1) Operating Units having a Service Agreement with Shell GSI or another Shell Company. The use of DEPs by these Operating Units is subject in all respects to the terms and conditions of the relevant Service Agreement.
2) Other parties who are authorised to use DEPs subject to appropriate contractual arrangements (whether as part of a Service Agreement or otherwise).
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, Shell GSI disclaims any liability of whatsoever nature for any damage (including injury or death) suffered by any company or person whomsoever as a result of or in connection with the use, application or implementation of any DEP, combination of DEPs or any part thereof, even if it is wholly or partly caused by negligence on the part of Shell GSI or other Shell Company. The benefit of this disclaimer shall inure in all respects to Shell GSI and/or any Shell Company, or companies affiliated to these companies, that may issue DEPs or advise 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 Shell GSI, 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 Shell GSI. The copyright of DEPs vests in Shell Group of companies. Users shall arrange for DEPs to be held in safe custody and Shell GSI 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 Shell GSI.

Documents
Document Sharing Hub

Full document details: SHELL 34.28.00.31 2011

## TABLE OF CONTENTS

1. **INTRODUCTION** ....4
1.1 SCOPE....4
1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS ....4
1.3 DEFINITIONS ....4
1.4 CROSS-REFERENCES ....5
1.5 SUMMARY OF MAIN CHANGES....5
1.6 COMMENTS ON THIS DEP ....5
1.7 DUAL UNITS....5

2. **DESIGN CRITERIA** ....6
2.1 GENERAL ....6

3. **DESIGN REQUIREMENTS** ....7
3.1 TEMPERATURE RANGE, HIGH AND LOW TEMPERATURES ....7

4. **MATERIALS** ....8
4.1 GENERAL ....8

5. **CONSTRUCTION DETAILS**....10
5.1 GENERAL ....10
5.2 STRUCTURAL MEMBERS....10
5.3 CONNECTIONS ....10

6. **FABRICATION** ....13
6.1 GENERAL ....13
6.2 MATERIAL ....13
6.3 WELDING AND WELD INSPECTION ....13
6.4 HANDLING, SHIPPING, AND DELIVERY....14

7. **PROTECTION AGAINST CORROSION**....15
7.1 GENERAL ....15
7.2 PAINTING ....15
7.3 HOT-DIP GALVANIZATION ....15
7.4 THERMAL SPRAYED SYSTEMS ....16

8. **ERECTION**....17
8.1 GENERAL ....17
8.2 RECEIVING, INSPECTION, AND STORAGE....18
8.3 BOLTED CONNECTIONS AND FIELD WELDING ....18
8.4 CORRECTION OF ERRORS ....18
8.5 COATING REPAIRS....18

9. **QUALITY CONTROL DURING FABRICATION AND ERECTION**....19
9.1 GENERAL ....19
9.2 QUALITY CONTROL ....19
9.3 PERFORMANCE REQUIREMENTS....19

10. **REFERENCES** ....22

## APPENDICES

APPENDIX A DERRICK STRUCTURES FOR FLARES ....25

APPENDIX B FATIGUE DUE TO VORTEX SHEDDING OR OTHER CYCLIC LOADS....26

APPENDIX C PROJECT DOCUMENTATION REQUIREMENTS....27

APPENDIX D. USA AND CANADA DEFINITIONS FOR FABRICATION AND ERECTION ....28

Documents
Document Sharing Hub

Full document details: SHELL 34.28.00.31 2011

# 1. INTRODUCTION

## 1.1 SCOPE

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

This is a revision of the DEP of the same number dated January 2009; see (1.5) regarding the changes.

## 1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to onshore oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could 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 with regards to the 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, the objective being to obtain agreement to follow this DEP as closely as possible.

## 1.3 DEFINITIONS

### 1.3.1 General Definitions

The **Contractor** is the party that 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 **Principal** is the party that initiates the project and ultimately pays for it. 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

For US and Canada specific definitions refer to (APPENDIX D).

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

Documents
Document Sharing Hub

Full document details: SHELL 34.28.00.31 2011

### 1.3.3 Abbreviations

| Term | Definition |
|---|---|
| **API** | American Petroleum Institute. |
| **ASME** | American Society of Mechanical Engineers. |
| **AWS** | American Welding Society. |
| **BS** | British Standard. |
| **CICIND** | International Committee on Industrial Chimneys |
| **DEP** | Design and Engineering Practice. |
| **DTI** | Direct Tension Indicator |
| **ISO** | International Standards Organization. |
| **WPS** | Welding Procedure Specification. |

## 1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the reference section number is shown in brackets ( ). Other documents referenced by this DEP are listed in (10).

## 1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated January 2009. There were major changes to the content of this DEP. All changes are the result of segregating the DEP in to Specification and Informative.

## 1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal http://sww.shell.com/standards and on the main page of the DEPs DVD-ROM.

## 1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

Documents
Document Sharing Hub

Full document details: SHELL 34.28.00.31 2011

## 2. DESIGN CRITERIA

### 2.1 GENERAL

The design of a steel structure shall take into account the following aspects to achieve both a safe and economical design:

a) local / national building regulations

b) properties of the materials of construction

c) corrosion protection

d) calculated stresses for the members

e) prevailing conditions of the local environment

f) details of construction

g) methods of erection and fabrication, including their effect on cost

The design shall take into account the minimum loads as defined in local building codes, specified project specifications, and operations / maintenance requirements, see Table 2.1 for reference.

For existing facilities, actual loads may be used with prior written approval by the Principal.

**Table 2.1 Regional Standards, Specifications, Codes, and Regulations(1)**

| EUROPE (EU) (2) | United States of America (US) | Canada (CA) | International |
|---|---|---|---|
| EN 1990<br>EN 1991<br>EN 1993<br>EN 1994<br>EN 1998 | ANSI / AISC 360<br>AISC Steel Construction Manual<br>CBC<br>IBC | CSA S16<br>CISC Handbook of Steel Construction<br>NBCC<br>ABC<br>OBC | ISO 10721-2<br>ISO 1461 |

NOTES 1. If local standards, specifications, codes and regulations exist for the materials, section properties, design, and test methods covered by this DEP that yield equivalent quality and performance, they shall be substituted only with prior written approval by the Principal.

2. All Eurocodes shall include National annexes, amendments, corrigendums and references to other codes.

Documents
Document Sharing Hub

Full document details: SHELL 34.28.00.31 2011

## 3. DESIGN REQUIREMENTS

### 3.1 TEMPERATURE RANGE, HIGH AND LOW TEMPERATURES

Additional consideration will be necessary for structures at locations where very high or low temperatures occur.

#### 3.1.1 High Temperatures:

The allowable design stresses of structural steel elements that are continuously exposed to a temperature above 260°C (500°F) shall be reduced in proportion to reductions in yield strength of the steel.

#### 3.1.2 Low Temperatures:

The steel to be selected for cold climate (e.g. arctic) applications shall satisfy the fracture toughness and shall be selected appropriate to the climate in which structure is erected. When the design lowest ambient mean temperature is below 0°C (32°F), specific requirements for Charpy V-test results shall be provided for steel over 25 mm (1 in) thick and those subject to fatigue loading.

Attention shall be paid to dimensioning in view of fatigue of structures and to stresses caused by combined effects of snow and wind loads as well as large temperature variations. High quality corrosion protection shall be of prime importance in most arctic environments.

Documents
Document Sharing Hub

Full document details: SHELL 34.28.00.31 2011

# 4. MATERIALS

## 4.1 GENERAL

Acceptable materials are listed in Tables 4.1.1 through 4.1.4.

The use of alternative materials not listed in the tables below shall be submitted to the Principal for review and comment. Alternative materials shall be selected in accordance with local codes and regulations, taking weldability and the required finished weldment mechanical properties into consideration. The utilization of the GB ( Guo Biao) 150 standard for selection of alternative materials may be considered.

**Table 4.1.1 Material Grades for Structural Shapes, Pipe and Tubing**

| Type | Material Grades Standards[1] |
|---|---|
| Structural Shapes/ Sections (e.g. W, WT, H, UC, UB, HE) | EU - EN 10025-2 / Euronorm 19, 53<br>US - ASTM A992 / A992M<br>CA - CSA G40.21-M, Grade 350W<br>CH - GB/T 11263 |
| Rolled Steel Joists (e.g. RSJ, IPN) / Miscellaneous Structural Shapes (e.g. S) | EU - BS 4-1, DIN 1025-1<br>US - ASTM A992 / A992M, ASTM A36 / A36M<br>CA - CSA G40.21-M, Grade 350W<br>CH - GB/T 706 |
| For elements such as channels shapes, angles, plates, bars and those shapes not available in grades listed in the rows above. | **General**<br>EU - EN 10025-2<br>US - ASTM A36 / A36M<br>CA - CSA G40.21-M, Grade, 300W<br>**Other materials permitted as indicated below for specific material types:**<br>**Angles**:<br>EU - EN 10056-1<br>CH - GB/T 706<br>**Plate** :<br>CH - GB/T 3274, GB/T 19879-2005 |
| Steel pipe as structural members (hollow round shapes with relatively thicker wall thickness than round tubing). | EU - EN 10210-2<br>US & CA - ASTM A53 / A53M Type E (welded) or S (seamless), Grade B or ASTM A106 / A106M Grade B<br>CH - GB/T 8162-2008 |
| Structural tubing (hollow sections in round, square, and rectangular shapes). | EU - EN 10210-2 / EN 10219-2<br>US - ASTM A501 or ASTM A500 Grade B<br>CA - CSA G40.21-M, Grade 350 Class C or H<br>CH - GB/T 6725-2008 |

NOTES 1. EU = Europe; US = United States of America; CA=Canada, CH=China.

Documents
Document Sharing Hub

Full document details: SHELL 34.28.00.31 2011

**Table 4.1.2 High-Strength Bolt Assemblies**

| Type | Material Standards[1] |
|---|---|
| Bolt | EU / International - ISO 4014, ISO 898-1 and ISO 898-2<br>US and CA - ASTM A325 Type 1 or ASTM A490 / A490M |
| Washer | US & CA - ASTM F436 / F436 M |
| Direct Tension Indicator (DTI) Washers[2] | US & CA - ASTM F959 |
| Heavy Hex Nut / Thread | EU / International - ISO 4032 / ISO 888<br>US and CA - ASTM A563 Grade DH |

NOTES
1. EU = Europe; US = United States of America; CA=Canada, CH=China.
2. Compressible-washer-type direct tension indicator shall be installed according to the DTI manufacturer's published specifications. DTI, if used, shall be galvanized by the DTI manufacturer requirements. Compressible-washer-type direct tension Indicator are preferred.

**Table 4.1.3 Standard Bolt Assemblies**

| Type | Materials Standards[1] |
|---|---|
| Bolt [3] | EU / International - ISO 4014, Grade 8.8 or equivalent in accordance with ISO 898-1 and ISO 898-2[2].<br>US and CA - ASTM A307 Grade A heavy hex |
| Washer | US and CA - ASTM F436 / F436M |
| Heavy Hex Nut / Thread | EU / International - ISO 4032 / ISO 888<br>US and CA - ASTM A563 Grade A |

NOTES
1. EU = Europe; US = United States of America; CA=Canada, CH=China.
2. High-strength friction-grip connections, grade 10.9 or equivalent, may be used for transport and / or lifting applications or other special applications if approved by the Principal.
3. High-strength friction-grip (pretension bolts) shall not be used for steel connections that are required for gravity or other sustained load conditions, because of their loss of pre-tension in a fire.

**Table 4.1.4 Welding Consumables**

| Type | Materials Standards[1] |
|---|---|
| Welding Electrode | EU and US - ANSI / AWS D1.1,[2].<br>CA - CSA W48.1-M, E48018 (E7018) |

NOTES
1. EU = Europe; US = United States of America; CA=Canada, CH=China.
2. Low hydrogen with an electrode strength of 400 MPa (58 ksi) minimum yield strength and 70 ksi 480 MPa (70 ksi) minimum tensile strength.

Documents
Document Sharing Hub

Full document details: SHELL 34.28.00.31 2011