

DEP SPECIFICATION

GASEOUS OXYGEN SYSTEMS

DEP 31.10.11.31-Gen.

February 2017

DESIGN AND ENGINEERING PRACTICE

DEM1



© 2017 Shell Group of companies

All rights reserved. No part of this document 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 has been supplied under license by Shell to:
UOP Honeywell ted.fuger@honeywell.com 19/01/2018 06:38:00

Full document details: SHELL 31.10.11.31 2017

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 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 typically granted by Shell GSI (and in some cases by other Shell 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.

TABLE OF CONTENTS

1.	INTRODUCTION	4
1.1	SCOPE	4
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	4
1.3	DEFINITIONS	5
1.4	CROSS-REFERENCES	6
1.5	SUMMARY OF MAIN CHANGES.....	6
1.6	COMMENTS ON THIS DEP	7
1.7	DUAL UNITS.....	7
1.8	NON NORMATIVE TEXT (COMMENTARY).....	7
2.	GENERAL PRINCIPLES.....	8
3.	MATERIALS	8
3.1	METALLIC MATERIALS	8
3.2	NON-METALLIC MATERIALS	9
4.	COMPONENT DESIGN.....	9
4.1	GENERAL	9
4.2	MATERIAL SELECTION	10
4.3	PIPING AND FITTINGS.....	11
4.4	VALVES AND INSTRUMENTS	14
4.5	FILTERS	17
4.6	SILENCERS.....	18
4.7	COMPRESSORS.....	18
4.8	OXYGEN CONTROL AND ISOLATION/MEASURING STATIONS	19
5.	ORDERING, MARKING, PACKAGINGS	19
6.	CLEANING	20
6.1	GENERAL REQUIREMENTS.....	20
6.2	PRECLEANING	20
6.3	POST ERECTION (IN-SITU) CLEANING.....	21
6.4	INSPECTION FOR CLEANLINESS	22
7.	CONSTRUCTION	23
7.1	CLEANLINESS PRECAUTIONS	23
7.2	WELDING	24
7.3	INSPECTION AND TESTS.....	24
8.	REFERENCES	26

APPENDICES

APPENDIX A	FIGURES.....	27
APPENDIX B	OILY CONTAMINATION DETECTABILITY	33

1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design, construction, commissioning and testing of gaseous oxygen systems with operating temperatures between -30 °C and +200 °C (-22 °F and 392 °F) and pressures up to 100 barg (1450 psig). Operating temperatures outside that range are addressed in best practices, covering specific processes (such as gasification for higher temperatures) or by the industrial gas vendors supplying the oxygen.

For the purposes of this DEP, oxygen systems comprise vessels, heat exchangers, compressors, pipe, fittings, valves and instruments that come into contact with and are used for the transport and utilisation of dry gaseous oxygen (oxygen content 35 vol % or higher, with the remainder of the components being inert).

The cleanliness and inspection requirements specified in this DEP apply to systems with Oxygen at concentrations greater than 21 % and to systems containing air at pressures above 50 barg (725 psig).

This DEP does not cover design and use of oxygen for calibration gases at analyzer houses, welding, cutting and respiratory systems and oxygen supplied from cylinder.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual (DEM) 1 - Application of Technical Standards.

This is a revision of the DEP of the same number dated February 2014; 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 authorisation to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to 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 shall 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 regard 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 **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by 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 capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

The word **may** indicates a permitted option.

1.3.2 Specific definitions

Term	Definition
BAM	Bundesanstalt für Materialforschung und -prüfung
Dry gaseous oxygen	Gaseous oxygen whose dew point at the maximum operating pressure is below the lowest ambient temperature and at least 10 °C (18 °F) below the minimum operating temperature
Exempt material	Exempt materials are engineering alloys that are exempt from any oxygen velocity limitations within defined limits of pressure, temperature, material thickness, and oxygen purity (see EIGA IGC Doc 13/12/E -APPENDIX D).
Flammable fluid	Fluid having a flash point below 37.8 °C (100 °F), except any mixture having components with flash points equal or higher than 37.8 °C (100 °F), the total of which make up 99 % or more of the total volume of the mixture
Oxygen	Any gas mixture with an oxygen content of 35 vol % or greater

1.3.3 Abbreviations

Term	Definition
AIT	Auto Ignition Temperature
BAM	Bundesanstalt für Materialforschung und -prüfung
CGA	Compressed Gas Association
CSU	Commissioning and start-up
DEM	Design Engineering Document
GTAW	Gas Tungsten Arc Welding
MOC	Management of Change
SI	International System
TIG	Tungsten Inert Gas
TOC	Total Organic Carbon
USC	United States Customary

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (8).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a minor revision of the DEP of the same number dated February 2014. The following are the main, non-editorial changes.

Section/Clause	Change
ALL	Restructured and clarified requirements, enforced shall/should.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://swwww.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

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.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

2. GENERAL PRINCIPLES

1. The risk of ignition of materials in an enriched oxygen environment (oxygen content 35 vol % or higher) shall be minimised by adhering to the following basic principles:
 - a. Use of materials which have:
 - i. sufficiently high ignition temperature;
 - ii. low heat of combustion;
 - iii. high thermal conductivity;
 - iv. proven to be suitable for oxygen service.
 - b. Avoiding the use of non-metallic components in the oxygen flow path. When non-metallic parts cannot be avoided, the requirements mentioned in (3.2) to be taken into account.
 - c. Ensuring smooth surfaces and round edges in design and construction of piping and equipment;
 - d. Use of thick walled construction and internals with low surface to volume ratio.
 - e. Thin or small items like wire meshes and (throttling) valve internals require materials that have the most ignition-resistance;
 - f. Ensuring removal of all contaminants which may react easily, such as oil, grease and organic materials, see (6) and (7);
 - g. Avoiding all potential sources of energy which could initiate a fire (e.g., high velocities, turbulence, uncontrolled elevation of temperature by adiabatic compression or gas vibration), see (4);
 - h. Avoiding the presence of dust or particulate matter which, due to friction and/or impact, may react with the oxygen to eventually cause the ignition of the material of construction;
 - i. Safeguarding of personnel and equipment against potential leakages by fitting shields where necessary and/or remote operation of valves and machinery;
 - j. Use of experienced personnel in the design, construction, (pre-) commissioning, operation and maintenance of oxygen systems.

The goal of high system integrity is not to be compromised where elevated risks associated with ignition in oxygen handling systems are present. In some cases, hazard analyses and risk mitigation might be necessary.
2. For all systems handling gas mixtures with an oxygen content greater than 21 %, and for air at pressures above 50 barg (725 psig), the cleanliness and inspection requirements of (6) shall apply.

3. MATERIALS

3.1 METALLIC MATERIALS

3.1.1 General

1. Metallic materials for oxygen system components shall be selected in accordance with the guidelines given in (4.2) to (4.7).

3.1.2 Carbon steels

1. For minimum metal temperatures below 0 °C (32 °F), carbon steels shall be designed to minimize the risk of brittle fracture; see DEP 30.10.02.31-Gen.

3.1.3 Stainless steels

1. Suitable grades of austenitic stainless steel include S30403, S32100 and S31603. Grades with higher chromium concentrations should not be used.
2. Duplex stainless steels should not be used.
3. Grades not listed in the EIGA IGC 13/12-E should not be used.
4. Where metal temperatures above 50 °C (122 °F) could occur, protection against external chloride stress corrosion cracking shall be provided and risk of chloride stress corrosion cracking to be assessed and mitigated by effective means.

A particular concern is interface piping (e.g., purge, steam and air supporting systems).

5. Where external pitting corrosion could occur, protection of external surfaces shall be provided. Refer DEP 30.46.00.31-Gen. and DEP 30.48.00.31-Gen.

3.1.4 Nickel-based alloys

The most common alloys specified for oxygen service are N06600 (e.g., Inconel 600) and N04400 (e.g., Monel 400).

1. In steam service or in external corrosive environments, alloy N06600 shall be specified with a carbon content below 0.025 %w.

This will reduce the allowable design stresses.

2. The selected Ni alloy should be Alloy N06600 (e.g., Inconel) in an acidic environment where condensation can occur on a cold surface.
3. The use of nickel-based alloys that contain higher chromium, iron or molybdenum contents than alloys listed above (alloy N06600 and alloy N04400) shall be subject to approval by the Principal if the conditions are beyond the limits for stainless steel.

3.1.5 Aluminium

1. Aluminium and its alloys SHALL [PS] not be used for gaseous oxygen systems in the temperature range from -30 °C – +200 °C (-22 °F – 392 °F).

3.2 NON-METALLIC MATERIALS

1. The use of non-metallic components in the oxygen flow path shall be avoided where possible.
2. When non metallic components cannot be avoided, selection SHALL [PS] be based on certification of oxygen compatibility of the product in its final form from the Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany) for the maximum operating temperature and pressure
3. This certificate from BAM shall be delivered together with the product.
4. A margin of at least 50 °C (90 °F) between the maximum operating temperature and the Auto Ignition Temperature (AIT) shall be applied to design.

4. COMPONENT DESIGN

4.1 GENERAL

1. In case of any changes to the design of the oxygen system, an oxygen subject matter expert shall be consulted before the changes are implemented.

The design recommendations given below relate to the general safety principles outlined in (2).

4.2 MATERIAL SELECTION

4.2.1 Impingement and non-impingement

1. Material selection shall start with an assessment to identify all locations where impingement will occur.

Impingement locations are locations where oxygen impinges directly on the material.

2. Impingement locations shall include, but are not limited to, the following:
 - a. fittings such as short radius elbows ($R < 1.5D$) and tees, see Figure 3E, and valve internals;
 - b. a length of 10 nominal pipe diameters upstream and downstream of valves where throttling can take place. See (4.4.1) for definition of throttling;
 - c. orifice plates and thermowells (see also (4.4.6));
 - d. strainers/filters (not the entire strainer/filter but rather specific components within - see also (4.5));
 - e. valves and valve internals (see also (4.4));
 - f. certain welded connections such as weldolet (see also (4.3.2));
 - g. multiple hole diffusers;
 - h. silencer internals (see (4.6));
 - i. tubes and baffles in heat exchangers;
 - j. heat exchanger heads and tubesheets;
 - k. cooler fins and turbulators.

Non-impingement sites are straight pipes and large radius bends ($R \geq 1.5D$).

4.2.2 P*v criterion

1. The velocity used in the criterion shall be calculated using the flow rates from the design cases and the internal cross-sectional area at the section under consideration.
2. The pressure used in the criterion shall be the pressure from the design cases.
3. The $p*v$ shall be calculated for all operational cases.
 - a. The highest value calculated shall be the determining case.
4. Once it is determined whether piping elements are impingement or non-impingement locations, the pressure (in bar-a) times velocity (in m/s) shall be determined.
5. For impingement sites, Figure 1 in (Appendix A) applies, which means that for:
 - a. $p*v < 450$ bar-a m/s, carbon steel and stainless steel may be selected;
 - b. $p*v > 450$ bar-a m/s, an exempt material, as defined in (1.3.2) SHALL [PS] be selected.
6. For non-impingement sites, Figure 2 in Appendix A applies, which means that for:
 - a. $p*v < 800$ bar-a m/s, carbon steel and stainless steel may be selected;
 - b. $p*v > 800$ bar-a m/s, an exempt material, as defined in (1.3.2) SHALL [PS] be selected.

4.3 PIPING AND FITTINGS

4.3.1 General

1. Pipe sizes smaller than DN 50 shall not be used.
2. The minimum wall thickness for both carbon steel and stainless steel shall be 5.5 mm as per the relevant piping classes for oxygen service.
3. By-pass piping (Refer Figure 7) shall be made from exempt material.

Instrument tubing consists of small bore pipes in a non-flowing application, which permits the use of stainless steel tubing without thickness limitation.

4.3.2 Design

1. Oxygen piping systems shall be kept as simple as possible, with the smallest possible number of valves, fittings, branches and nozzles.
2. Piping containing flammable fluid or gas or steam SHALL [PS] not be installed within 1m (3ft) distance of oxygen piping pressurized with oxygen.
 - a. At points where this requirement cannot be fulfilled (e.g., for brownfield projects), the Contractor shall work with the Principal to determine the extent to which additional preventive or corrective measures are required.

The free space may be utilised for lines carrying water, nitrogen or other non-flammable fluids at ambient temperature.

3. Oxygen piping should be located on the outermost position of pipe bridges.
4. Installation of oxygen piping through tunnels or (covered or uncovered) trenches should be avoided.
5. Where the installation of oxygen piping through trenches or (covered or uncovered) trenches cannot be avoided:
 - a. flanged connections or valves shall not be used (except for low point drain connections);
 - b. the tunnel or trench shall not contain lines carrying flammable fluids or gases.
6. Oxygen piping shall not support other pipes.
7. Underground oxygen piping should be installed outside process and other hazardous areas.
8. Underground oxygen piping shall be:
 - a. clearly identified above ground;
 - b. kept separate from electrical cables and other piping;
 - c. The underground piping shall have external corrosion protection.
9. Expansion bellows shall not be used.
10. The following components SHALL [PS] not be used (in instrumentation tubing these can be allowed):
 - a. slip-on flanges;
 - b. lap flanges;
 - c. threaded connections for valves and fittings;
 - d. socket welds.
11. Branches in carbon steel and stainless steel piping systems should be made with equal tees, reducing tees or swept outlets.