

DEP SPECIFICATION

GASEOUS OXYGEN SYSTEMS

DEP 31.10.11.31-Gen.

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(DEP Circular 05/12 has been incorporated)

DESIGN AND ENGINEERING PRACTICE

DEM1



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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 -20 °C and +150 °C (-4 °F and 302 °F).

Operating temperatures outside that range are addressed in Best Practices, covering specific processes (such as gasification) 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 volume fraction 90% or higher). This DEP does not cover design and use of oxygen for welding, cutting and respiratory systems.

For gas mixtures with an oxygen volume fraction greater than 21% and for air at pressures above 50 bar (5000 kPa) (ga) (725 psi), the cleanliness and inspection requirements of (6) shall apply.

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 January 2010; 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.

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. Application in other facilities may also apply.

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 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 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.

1.3.2 Specific definitions

Term	Definition
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
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 percent or more of the total volume of the mixture
oxygen	any gas mixture with an oxygen volume fraction of 90 % or greater

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section 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 revision of the DEP of the same number dated January 2010. The following are the main, non-editorial changes.

Old section	New section	Change
General	General	Segregation of content done as per the DEP transformation process. DEP is separated into three parts: DEP Specification: Project related content DEP Informative: Background and guidance for Project use RM Practise: Asset life related information
4.4.4	4.4.4	Allow for non return valves that are in accordance with piping class for oxygen service. Combination of requirements in original text only allowed for Hoerbiger type check valve.
6.2	6.2	Added note on the use of desiccant bags
6.3	6.3	Added that air used for post erection cleaning should also be dry (besides oil free)
7.3	7.3	Replaced boiler feed water (for pressure testing) with (buffered) demin water as boiler feedwater is normally defined as treated pressurised deaerated demin water, which is too hot for pressure testing and often not available in construction stage.
6.3	6.3	Added remark that hydrochloric acid shall not be used for cleaning of stainless steel in line with EGGS 2 GS-23
6.5.2	6.4.2	Added minimum specification inspection tools (bright light/UV light) as per EGGS 2 GS-23 and ASTM G93

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://www.shell.com/standards> and on the main page of the DEPs DVD-ROM.

1.7 DUAL UNITS

Amended per

Circular 05/12

Dual units have been incorporated throughout this DEP.

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.

2. GENERAL SAFETY PRINCIPLES

Once ignited, many materials (including most metals) will burn violently in an oxygen atmosphere. Because of the risks associated with the ignition of oxygen handling systems, the goal of high system integrity shall not be compromised under any circumstances. In some cases, hazard analyses may be necessary.

Ignition may occur when energy in any form is supplied, but the likelihood of ignition will depend on many different aspects. Valves, fittings, heat exchangers and compressors, for instance, have higher ignition risks than long straight lines and the shells of vessels.

It is important for heat energy (e.g. as a result of friction) to be able to dissipate before the ignition temperature is reached, and therefore materials with a high thermal conductivity shall be used.

The risk of ignition of materials in oxygen shall be minimised by adhering to a number of basic rules:

1. Use materials which have
 - a sufficiently high ignition temperature
 - possibly a low heat of combustion
 - high thermal conductivity
 - proved to be suitable for oxygen serviceSee (3)
2. Provide smooth surfaces and round edges in piping and equipment design and construction;
3. Use thick walls and internals with low surface to volume ratio. Thin or small items like wire meshes and (throttling) valve internals require the most ignition-resistant materials.
4. Remove all contaminants which may react easily, such as oil, grease and organic materials, see (6) and (7);
5. Avoid all 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);
6. Avoid 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;
7. Safeguard personnel and equipment against leakages by fitting shields where necessary and/or remote operation of valves and machinery;
8. Use experienced personnel in the design, construction, pre-commissioning, operation and maintenance of oxygen systems.

3. MATERIALS

3.1 METALLIC MATERIALS

Dry gaseous oxygen in the temperature range -20 °C to +150 °C (-4 °F to 302 °F) is normally handled in carbon steel or austenitic stainless steel, subject to the velocity limitations given in (4.2). Higher velocities generally require the use of nickel-based (or copper-based) alloys. Specific metallic materials for oxygen system components shall be selected in accordance with the guidelines given in (4.2 to 4.7).

Carbon steels

Plain carbon steels are extensively used for dry gaseous oxygen service, in particular for transportation pipelines, but also for on-plot piping with maximum operating temperatures below 90 °C (194 °F). For minimum metal temperatures below 0 °C (32 °F), carbon steels shall be designed according relevant guidelines (DEP 30.10.02.31-Gen.) to avoid the risk of brittle fracture.

Stainless steels

Plain austenitic stainless steels, which nominally contain some 18%w of chromium and 8%w of nickel, generally have a higher ignition temperature than carbon steels and are more suitable for oxygen service. Oxygen cleanliness is more easily maintained. Suitable grades are S30403, S32100 and S31603. Grades with higher chromium concentrations should not be used. Likewise, duplex stainless steels that have higher chromium contents should not be used. Externally, protection is required against pitting corrosion and at temperatures above 50 °C (122 °F) against chloride stress corrosion cracking. In particular at interface piping (e.g. purge, steam and air supporting systems), risk of chloride stress corrosion cracking shall be carefully assessed.

Nickel-based alloys

Nickel-based alloys with low chromium content are practically non-ignitable in oxygen. They have a high ignition temperature and the heat of combustion is low. The most common alloys used for oxygen service are N06600 (e.g. Inconel 600) and N04400 (e.g. Monel 400). In steam service or in external corrosive environments, the N06600 alloy shall be specified with a carbon content below 0.025 %w. This will reduce the allowable design stresses. Inconel is the preferred Ni alloy in an acidic environment where condensation can occur on a cold surface.

The use of other nickel-based alloys that contain higher chromium, iron or molybdenum contents than those of the above alloys requires approval by the Principal, if the conditions are beyond the limits for stainless steel.

Aluminium

Aluminium and its alloys SHALL [PS] not be used within the scope of this DEP, which covers the temperature range from -20 °C to +150 °C (-4 °F to 302 °F).

3.2 NON-METALLIC MATERIALS

The selection of all non-metallic components SHALL [PS] be based on proof of oxygen compatibility in the required range of temperature and pressure. Such a proof can be derived from the list produced by the Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany).

Non-metallic materials that are not proven by BAM are subject to the approval by the Principal.

4. COMPONENT DESIGN

4.1 GENERAL

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

4.2 VELOCITY AND SIZING

Material selection shall be as shown in Figure 1, see (Appendix A).

Oxygen piping systems SHALL [PS] be designed so that the average velocity in the pipe or component at the design maximum flow of oxygen is kept, as far as reasonably practicable, in the carbon steel area on Figure 1.

NOTE: Average velocity is calculated using the design maximum flow rate and the internal cross-sectional area at the section under consideration.

4.3 PIPING AND FITTINGS

4.3.1 Materials

Materials for straight piping, and for bends with a radius larger than 1.5D, SHALL [PS] be selected in accordance with the velocity limits described in (4.2) and Figure 1 in (Appendix A). Nickel-based alloys in accordance with (3.1) are required for:

- Fittings where direct impingement of entrained particles may occur, such as short radius elbows and tees, see Figure 2, and valve internals;
- Piping downstream of control valves for a distance of at least 10 times the nominal diameter, see Figure 6.

Other common impingement locations where the flow pattern changes direction abruptly or where the presence of eddies leads to the impact of particles with the system wall such as:

- Orifice plates and thermo wells (see 4.4.5);
- Strainers/filters (see 4.5);
- Valves and valve internals (see 4.4);
- Welded connections such as weldolet (see 4.3.2);
- Multiple hole diffusers;
- Silencer internals (see 4.6).

Areas in Figure 1 (Appendix A) where carbon steel or stainless steel construction is permitted; fittings, valve internals and downstream piping of the same material may be used if the velocity limit is reduced by half. For example; a stainless steel piping system at 48 bar (4800 kPa) (ga) (696 psig) shall still use the same material for a 1.5D elbow provided the velocity is below 10 m/s (33 ft/s).

Pipe sizes smaller than DN 50 (NPS 2) shall not be used. The minimum wall thickness for carbon steel and stainless steel piping shall be 5.8 mm (0.23 lin) as per the relevant piping classes for oxygen service

Minimum pipe size and thickness shall not apply to instrument tubing.

4.3.2 Design

Oxygen piping systems shall be kept as simple as possible, with the smallest possible number of valves, fittings, branches and nozzles.

Oxygen piping should be located as far as possible from other piping. Pipes containing flammable fluid or gas or steam SHALL [PS] not be installed within 1 m (3.3 ft) distance of oxygen piping. At points where the above requirements cannot be fulfilled, the Principal shall be asked whether any additional preventive or corrective measures are required.