

DEP SPECIFICATION

**NITROGEN/OXYGEN SUPPLY AND DISTRIBUTION
SYSTEMS**

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DESIGN AND ENGINEERING PRACTICE

DEM1



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design and engineering of nitrogen supply and distribution systems to provide a reliable supply of nitrogen of the required quality. Oxygen supply is also in the scope of this DEP; however, distribution of gaseous oxygen is subject to DEP 31.10.11.31-Gen. due to its specific hazards.

This DEP does not cover design and use of oxygen for welding, cutting or respiratory systems.

This DEP defines minimum requirements for nitrogen and oxygen production, storage and evaporation systems as amendments to specific engineering guidelines of selected Suppliers and international codes.

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 2012; 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 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 **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
Design Class	Design Class is a categorization defining fit-for-purpose facilities developed through Value Improvement Processes (VIPs) during a project Front End Development (FED) phase.
Process Safety	Process Safety is the management of hazards that can give rise to major accidents involving the release of potentially dangerous materials, release of energy (such as fire or explosion) or both.

1.3.3 Abbreviations

Term	Definition
ABC	Air Borne Contaminants
Cryogenic ASU	Cryogenic Air Separation Unit
BAM	Bundesanstalt fuer Materialforschung
DEP	Design and Engineering Practices
DCS	Distributed Control Systems
EO	Ethylene Oxide
GOX	Gaseous Oxygen
GTL	Gas-To-Liquids
H₂	Hydrogen
IGC	Industrial Gases Council
IPF	Instrument Protective Function
LIN	Liquid Nitrogen
LNG	Liquefied Natural Gas
LOX	Liquid Oxygen
MAC	Main Air Compressor
MOC	Management of Change
N₂	Nitrogen
NPSH	Net Positive Suction Head
NRV	Non Return Valve
O₂	Oxygen
PEFS	Process Engineering Flow Schemes
PLC	Programmable Logic Controller
ppm	Parts per Million
PS	Process Safety
PSA	Pressure Swing Absorber
QMI	Quality Measurement Instruments
SGP	Shell Gasification Process

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 full revision of the DEP of the same number dated February 2012. The following are the main, non-editorial changes.

Section/Clause	Change
5.5.2	Added various requirements for manual block valves in oxygen systems based on LFI GRP-AW-201301
7.5	Changed statement on service testing
Appendix D	Updated figures according to PRENSAP
Appendix E	Corrected high selector into low selector for protective pressure controller.

1.6 COMMENTS ON THIS DEP

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

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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. NITROGEN GENERAL

2.1 GENERAL USERS

1. The systems that are subject of this DEP are typically designed to supply the site with gaseous nitrogen for the following purposes:
 - a. Purging systems of explosive and/or combustible gases before shutdown or maintenance activities will take place.
 - b. Blanketing of tanks and expansion vessels to ensure product quality.
 - c. Blanketing to avoid air and moisture ingress that may result in corrosion.
 - d. Blanketing to prevent formation of explosive mixtures when air can be drawn into a tank.
 - e. Inerting of piping systems before introduction of combustible gases to avoid creating an explosive atmosphere during start-up when systems have been exposed to air/oxygen.
 - f. Purging of small bore piping/nozzles to prevent accumulation of debris that causes restrictions or even blockages. This should only be considered in case there is no other, more economical, medium possible.
 - g. Compressors and pump sealing applications (dry gas seal).
 - h. Flare purging to prevent oxygen ingress.
2. A number of other special usages of nitrogen also include:
 - a. Continuous purge of cryogenic insulation spaces to prevent ice formation.
 - b. Make-up of mixed refrigerants for Liquefied Natural Gas (LNG) plant applications.
 - c. Purge drying of lines and equipment preservation.
3. Nitrogen SHALL [PS] not be used as back-up for site-wide instrument air systems.
4. The use of nitrogen supply to drive individual valve(s) shall be subject to approval by the Principal.

2.2 NITROGEN QUALITY

1. The required nitrogen quality and properties are dependent on the usage as per (2.1) and directly influences the generation options. Higher quality requirements tend to be capital intensive and should be challenged early in design.

2. Typically, the following nitrogen quality shall be used:

Purging of hydrocarbons	>95 vol%	Optimisation is required to balance purity with quantity required when membrane technology is applied.
Refrigerant make-up	99.5-99.9 vol%	Quality is typically achieved using cryogenic ASU (even up to a maximum of 3-10 ppm O ₂) or PSA technology as the limit, but in exceptional cases may also be possible with membranes.
Blanketing for corrosion prevention or product quality	99.9 vol%	Specification for amine, MEG/TEG is 99.9 vol% to prevent formation of degradation products and/or corrosion in the system that is treated (upstream applications).
Blanketing of heat transfer oil expansion vessel:	99.5 vol%	
Blanketing most cargo and storage tanks	>95 vol%	This quality can be achieved using membrane technology.
Oxygen control in injected chemicals	Application dependent	Oxygen content of injection chemicals can result in fouling/corrosion due to the formation of elemental sulphur. This is possible when the treated stream contains H ₂ S. Seek advice from a production chemistry specialist to confirm the minimum nitrogen quality when the treated stream contains H ₂ S.

3. For specific applications, such as purging of cryogenic storage tanks or refrigerant make-up, the water dewpoint temperature is critical. In case the specified dewpoint cannot be reached (e.g., using membrane technology), additional drying facilities shall be provided.

The atmospheric dewpoint (temperature at which water condenses from the vapour) of the nitrogen ranges from -50°C (-58 °F) to -76°C (-105 °F) and is usually determined by the nitrogen generation process.

4. The nitrogen quality requirements shall be challenged for the specific users at an early stage in the Project. A reduced quality may make it possible to consider alternative nitrogen generation options, such as membrane technology. If only cryogenic technology is being considered, then a reduced quality may enable reductions in capital and operating costs.
5. The normal operating pressure for nitrogen distribution systems shall be determined by the user(s) with the highest required pressure. Typical pressure range that is selected is around 6-12 barg (90-175 psig).
6. The normal operating temperature of a nitrogen distribution system should be ambient air or slightly above ambient temperature. However, due to the nature of an ambient air vaporizer the temperature a temperature slightly below ambient is acceptable. For applications that require multiple consumers of nitrogen above ambient temperature, a subheader for such nitrogen should be used.

2.3 NITROGEN QUANTITY

1. The quantity of nitrogen shall be determined, considering the following:
 - a. For purging to remove hydrocarbons for cold work maintenance or confined space entry without respiratory protection, a concentration of <10 vol% of the lower flammability limit of the hydrocarbon SHALL [PS] be achieved.
 - b. Purging to remove hydrocarbon from cargo systems: threshold value of 8 vol% O₂. Purging to remove hydrocarbons is usually achieved by cyclic pressurisation with a minimum of four pressurisation cycles.
 - c. Purging before introduction of hydrocarbons: achieve a final oxygen concentration of 1% before flammable hydrocarbons are introduced to the system. This is usually achieved by cyclic pressurisation with a minimum of three to four pressurisation cycles.
 - d. For blanketing of tanks and vessels, the maximum amount of nitrogen required to maintain the inert atmosphere is based on the inbreathing of the tank considering the maximum draw-off rate from the tank as well as thermal breathing.
 - e. Purging to prevent debris is based on achieving a velocity over the internal cross section of 1 m/s (3 ft/s).
 - f. If purges are used instead of conventional flame arresters, purge velocities of at least 1.5 m/s (4.5 ft/s) SHALL [PS] be applied. This corresponds to roughly 2-3 times the laminar burning velocity of hydrocarbon vapours and which is considered necessary to prevent flame flash back. Reference is made to GS.10.50067 (8).
 - g. For commissioning and pre-commissioning purposes.
2. Provisions shall be made in the design of the nitrogen distribution system to restrict the amount of nitrogen that can be taken off for each (group of) consumer(s). Refer to (6.3) for implementation details.
3. The total consumption shall consider continuous and intermittent usage to determine the minimum nitrogen generation capacity and the optimum liquid nitrogen back-up quantity. The consumption thus obtained should be multiplied by a factor to account for;
 - a. Uncertainties in the data and future losses; the capacity margin to be used is as per design class.
 - b. Uncertainties in the nitrogen consumption data estimate in the early phase of project; an additional allowance can be included to manage the data inaccuracies. At more detailed stages of a Project, this factor can be reduced or even removed.
4. The highest combination of normal and peak demand is referred to as the 'Peak Quantity of Nitrogen'.

2.4 BACK-UP SUPPLY

1. A dedicated back-up nitrogen storage vessel system SHALL [PS] be included in the design for consumers that require a minimum amount of nitrogen to safely shutdown during an emergency, when the normal nitrogen supply (e.g., from pipeline) may not be available.
2. The nitrogen back-up system SHALL [PS] be provided with secure instrument air and electricity.
 - a. For critical consumers that require relatively small back-up volumes, back-up nitrogen cylinder supply should be considered. More information is available in (4.3) and (4.4).

3. Prioritisation of critical and non-critical users (e.g., tank purge for product quality) is recommended in the supply from the back-up system to prevent excessive equipment sizing.
4. A back-up system may also be required to supplement peak demand or for improved availability during maintenance of a cryogenic ASU.

3. OXYGEN GENERAL

3.1 GENERAL USERS

1. Oxygen systems that are subject to this DEP are generally used for applications such as the following:
 - a. Partial oxidation in the Shell Gasification Process (SGP).
 - b. Partial oxidation in the Shell Coal Gasification Process (SCGP).
 - c. Reactant in the Ethylene Oxide (EO) process.
 - d. Debottlenecking projects replacing air (i.e. use of O₂-enriched air or pure oxygen for the Claus reaction or in biotreaters).

3.2 OXYGEN QUALITY

1. The oxygen quality required is dependent on its purpose. Typical values are as follows:
 - a. For SGP applications, the quality is at least 99.5 vol% to prevent high inert levels in the downstream catalytic processes (e.g., GTL or H₂ production).
 - b. For SCGP applications, the quality is at least 99.5 vol% for applications where high inert levels in the downstream processes are undesired and at least 95 vol% for applications with no such downstream limitations.
 - c. For EO applications, the quality is at least 99.8 vol%.
 - d. For oxygen enriched air applications, the quality is at least 23.5 vol%.
2. The required oxygen purity shall be challenged at an early stage of the Project, as a lower purity will reduce capex and/or operational costs of the air separation unit.
3. The operating pressure is typically in excess of 60 barg (870 psig) for SGP applications, above 30 barg (435 psig) for SCGP and above 25 barg (360 psig) for EO plants. For oxygen enriched air, the delivery pressure typically is much lower around 2-5 barg (30-70 psig) and is usually let-down from a higher pressure distribution grid.

3.3 BACK-UP SUPPLY

1. The design of the backup oxygen supply should take into consideration the scenario when the shutdown interval of the unit consuming the oxygen is not in parallel with that of the air separation plant.
2. Cryogenic oxygen generation shall include a liquid storage/vaporising system to ensure continuous supply of oxygen in case of short duration trips and/or maintenance on the air separation unit.

4. NITROGEN SUPPLY

4.1 GENERAL

1. The nitrogen supply strategy is dependent on the consumption profile, the required quality of nitrogen and the local market situation. Source options include:
 - a. Gaseous nitrogen import
 - b. Liquid nitrogen import
 - c. Cylinder supply
 - d. On site generation
 - i. Cryogenic ASU
 - ii. Membrane units
 - iii. Pressure Swing Adsorption (PSA)

4.2 GASEOUS NITROGEN IMPORT

1. Preferred supply mode for gaseous nitrogen is via pipeline connection from a third party Manufacturer/Supplier. Gaseous nitrogen can be imported to the site via one or more intake stations, where the nitrogen is measured and brought to the required pressure level. The typical line-up of a nitrogen intake station is included in (Appendix A).
2. A nitrogen intake station shall include the following (subject to local regulations and requirements):
 - a. Flow measurement for accounting purposes with high flow alarm to indicate unusually high nitrogen consumption.
 - b. Pressure reduction and relief valve to safeguard both the distribution network and the downstream users against high pressure (where the upstream pressure can exceed the downstream equipment design).
 - c. A low pressure alarm to warn the operator that there is a problem with the nitrogen supply.
 - d. Backflow protection to protect the main supply header from possible backflow from the site during periods of no supply or strongly reduced supply.
 - e. Quality measurement, which is usually done at the N₂ generation facilities; however, if the quality is critical, then this measurement can be included at the site premises.
 - f. Main automatic isolation valve to close the source supply. This valve shall be operable in case of major emergency (e.g., emergency instrument air/electrical supply).
3. In locations where liquids or solids contamination is an issue, the following additional equipment shall be installed:
 - a. Liquid knock-out facility to remove any excess water from the nitrogen; this facility shall be installed downstream of the pressure reduction. A knock out drum is not needed for cryogenic generated nitrogen.
 - b. Filtration facilities with differential pressure measurement to remove any solids that may be present in the nitrogen.

4.3 LIQUID NITROGEN IMPORT/STORAGE

1. If only small volumes [$<100 \text{ Nm}^3/\text{h}$ (~62 SCFM)] of nitrogen are required, then importing liquid nitrogen can be an alternative to importing gaseous nitrogen.