

DEP SPECIFICATION

**PROCESS ENGINEERING AND SAFEGUARDING
PRACTICES (PRENSAP)**

DEP 01.00.02.13-Gen.

February 2017

ECCN EAR99

DESIGN AND ENGINEERING PRACTICE



© 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 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. Part 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. Part 744).

This document has been supplied under license by Shell to:
UOP Honeywell ted.fuger@honeywell.com 19/01/2018 05:47:31

AVA Documents
Document Sharing Hub

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

PART I	INTRODUCTION	5
1	GENERAL	5
1.1	SCOPE	5
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	5
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	INTENDED USE	7
PART II	ELEMENTS OF PROCESS ENGINEERING SAFEGUARDING	8
1	PROCESS SAFETY RISK MANAGEMENT	8
2	LAYERS OF PROTECTION ANALYSIS (LOPA) DATA TABLES	9
3	HEAT EXCHANGERS.....	9
4	PUMPS (INCLUDING CENTRIFUGAL, RECIPROCATING AND ROTARY PUMPS)	10
4.1	GENERAL	10
4.2	MINIMUM FLOW PROTECTION.....	10
4.3	NET POSITIVE SUCTION HEAD (NPSH)	10
4.4	SHAFT SEALING.....	11
4.5	DYNAMIC REVERSE PRESSURE CAPABILITY	11
5	COMPRESSORS (INCLUDING CENTRIFUGAL AND RECIPROCATING COMPRESSORS)	12
6	STORAGE TANKS.....	13
6.1	STORAGE TANKS GENERAL	13
6.2	REFRIGERATED LIQUIFIED GAS (RLG) STORAGE.....	14
7	FIRED EQUIPMENT.....	15
8	ISOLATION OF MECHANICAL EQUIPMENT AND PIPING	16
9	VALVES.....	16
10	SAMPLE CONNECTIONS FOR MANUAL SAMPLING SYSTEMS	17
11	PROTECTIVE HEATING OF PIPING SYSTEMS	18
12	FLAME ARRESTORS	19
13	BASIC CONCEPTS OF SAFEGUARDING	20
14	PRESSURE RELIEF DEVICES	20
15	CALCULATION PROCEDURES	21
16	DISPOSAL SYSTEMS - FLARE	21
17	DEPRESSURING SYSTEMS.....	22
18	REACTIVE HAZARDS ASSESSMENT	23
19	DUST EXPLOSIONS.....	24
20	FLOWLINES AND GATHERING SYSTEMS.....	25
21	INTERFACES WITH OTHER UNITS AND OTHER UNIT SECTIONS.....	25
22	PERSONNEL PROTECTION FROM BURNS OR EXPOSURE TO CHEMICALS.....	26

23	SAFE HANDLING OF “VERY TOXIC-ACUTE” AND “VERY TOXIC_CHRONIC” SUBSTANCES	26
24	BENZENE.....	27
PART III	REFERENCES	28
PART IV	BIBLIOGRAPHY	31
 ANNEXES		
ANNEX A	LAYERS OF PROTECTION ANALYSIS (LOPA) DATA TABLES	33

PART I INTRODUCTION

1 GENERAL

1.1 SCOPE

This DEP specifies requirements and gives recommendations for process engineering safeguarding across all Shell businesses. The objective of this DEP is to provide safeguarding practices that should be incorporated during project design work, in order to achieve a design that is safe to operate.

In most cases, safeguarding requirements and guidelines for design and construction of facilities and installations are provided in other DEPs that are referenced in this DEP. The intention is not to repeat these requirements in this DEP, but rather to reference the applicable DEP when it exists. Therefore, requirements that are stated in this DEP generally are requirements that are not included in other DEPs.

During project execution, the project is required to demonstrate that risks are controlled to ALARP with regard to people, assets, the environment, and the reputation of the Principal.

This DEP addresses a number of different process engineering safeguarding topics in (Part II). Requirements and recommendations are specified under each topic, as well as references to other DEPs that are applicable to each topic.

This DEP supersedes the Process Engineering & Safeguarding Practices Manual (PRENSAP), report GS.10.50067.

This DEP is a revision of the same number dated February 2016; 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 word **should** indicates a recommendation.

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

1.3.2 Abbreviations

Term	Definition
ALARP	As Low As Reasonably Practicable
EFD	Engineering Flow Diagram
HAZOP	Hazard and Operability (assessment)
HEMP	Hazards and Effects Management Process
IEF	Initiating Event Frequency
LOPA	Layers of Protection Analysis
MOC	Management of Change
P&ID	Piping and Instrumentation Diagram
PEFS	Process Engineering Flow Scheme
PFD	Process Flow Diagram
PFD	Probability of Failure on Demand
PHA	Process Hazard Analysis
PSA	Process Safety Assessment
PSBR	Process Safety Basic Requirements
QRA	Quantitative Risk Assessment
SIL	Safety Instrumented Level
SME	Subject Matter Expert

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 (Part III).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated February 2016. The only changes are to DEP cross-references to reflect changes in the DEP library in 2017.

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 INTENDED USE

This DEP is a primarily a guidance document that is intended to be used during the design development of a project. It provides supplemental information on certain requirements in other DEPs and is applicable to Process Engineers as well as other discipline engineers.

1. Where a referenced DEP is more stringent than this DEP, the referenced DEP requirements shall take precedence over this DEP.

PART II ELEMENTS OF PROCESS ENGINEERING SAFEGUARDING

1 PROCESS SAFETY RISK MANAGEMENT

1. The Hazard & Effect Management Process (HEMP) should be applied during the various phases of a Project to assess and manage the risks associated with process hazards. Refer to Project Standard 01 - HSSE & SP Management.
2. The actual hazard identification and risk analysis is a major part of this work process and can be done in a number of different ways. The following are a few examples of methodologies that may be applied:
 - a. HAZOP
 - b. PHA
 - c. PSA
 - d. Bowtie analysis
 - e. Quantitative Risk Assessment (QRA)
3. The risk assessment should identify and address the risk of process hazards for People, Assets, Environment and Reputation.
4. For Shell projects, the Group Risk Assessment & Management Guide should be used. Refer to the HSE Control Framework.
5. When HEMP is applied, the output of the structured work process shall be documented in the project design HSSE Case.
6. All process safety risks that are identified shall be managed prior to commissioning by either eliminating the hazard, or controlling the hazard (i.e., mitigating to ALARP).
7. For risks that are not eliminated, the remaining risk shall be verified to be As Low as Reasonably Practicable (ALARP) based on the risk acceptance criteria of the Principal, and if applicable, local regulations. For Shell projects, reference is made to the HSSE Control Framework for risk reduction and ALARP requirements and Project Standard 01 HSSE & SP Management.
8. Risk may be estimated qualitatively, semi-quantitatively, e.g., using a Layer of Protection Analysis (LOPA), or quantitatively using QRA methodology and compared with applicable Business risk tolerance and ALARP criteria. Reference is made to the Shell Group or individual business unit HSSE & SP Business standards and practices and/or to external regulations and literature.

Detailed guidance on risk tolerance and ALARP criteria is considered outside the scope of this DEP.

2 LAYERS OF PROTECTION ANALYSIS (LOPA) DATA TABLES

LOPA is an industry accepted tool for estimating residual risk where a supportable data set is available and maintained.

1. Refer to (Annex A) for Data Tables of initiating event frequencies (IEFs) and Probabilities of Failure on Demand (PFDs) and an abbreviated rule set for use with LOPA.
2. Management of Change (MOC) is required to change the data.
3. A LOPA SME shall be contacted in order to process the LOPA-specific MOC, since it is essential to maintain consistent application.
4. The Principal shall establish a set of acceptance criteria to enable the use of LOPA for purposes of establishing Tolerability and ALARP.
5. A LOPA study shall be facilitated by a qualified LOPA facilitator, approved by the Principal.

The suitable LOPA qualification route within Shell is for the facilitator to have satisfactorily completed the HEMP 101 and LOPA methodology courses, followed by guided practice. A complete rule set and application expectation is provided during these courses.

3 HEAT EXCHANGERS

1. Requirements for the design of exchangers are covered in the following DEPs:

Shell and tube heat exchangers	DEP 31.21.01.12-Gen. DEP 31.21.01.30-Gen.
Air cooled heat exchangers	DEP 31.21.70.10-Gen. DEP 31.21.70.31-Gen.

DEP 31.21.01.30-Gen. is based on ISO 16812 with amendments specific to Shell's requirements.

DEP 31.21.70.31-Gen. is based on ISO 13706 with amendments specific to Shell's requirements.

2. The Contractor shall provide the Project with a design supported by modelling using industry accepted software that supports both the thermal/process requirements and Asset Integrity (e.g., the modelling should indicate that vibration and velocity concerns have been resolved).
3. Fans in air-cooled heat exchangers could be a potential source of noise. Requirements for noise control are specified the DEP 31.10.00.31-Gen. Excessive equipment noise should preferably be eliminated by low noise design.
4. Where other noise control measures, such as acoustic insulation or acoustic enclosures, are required, they shall not in any case obstruct operational or routine maintenance activities.

4 PUMPS (INCLUDING CENTRIFUGAL, RECIPROCATING AND ROTARY PUMPS)

4.1 GENERAL

1. Pumps shall be selected by the rotating equipment engineer in consultation with the process engineer based on DEP 31.29.02.11-Gen. In all instances the type of pump should be fit for service considering a full range of operational conditions.
2. For pump piping arrangement requirements, reference is made to DEP 31.38.01.11-Gen. Section 4.2. All vent and drain connections, and hook-ups for example for flushing oil, seal oil, steam and cooling water should be shown on the PEFS.
3. For pump sparing requirements, reference is made to DEP 31.29.02.11-Gen. Generally, common spare pumps for different duties or for different process services are not recommended. However, when there is a strong incentive to apply common spare pumps, the effects of a possibly incorrect operational line-up should be carefully considered and taken into account for piping, equipment design, and safeguarding.

4.2 MINIMUM FLOW PROTECTION

1. Centrifugal pumps minimum flow protection requirement depends on their minimum continuous flow in comparison to the normal turndown of the process. If the turndown is below the minimum continuous stable flow, then a minimum flow protection should be provided.
Typically, high speed pumps and multistage pumps always have minimum flow protection.
2. When minimum flow protection is required, an instrumented minimum flow recycle may be installed with the following typical features:
 - a. Return back to the suction vessel rather than the direct suction to avoid overheating.
 - b. One recycle is installed per pump set.
 - c. An individual recycle for each pump is preferable for operability.
3. The recycle control valve should be air fail open.

A cheaper alternative of a permanent recycle flow above the minimum flow, usually set by a restriction orifice, is often applied when the flow varies considerably for operational reasons and the pump uses little power, i.e., the cost of the extra flow is quite low. However, this cheaper alternative is usually not an option for the high speed pumps, as the head falls off rapidly at flows not much higher than the design flow.

4.3 NET POSITIVE SUCTION HEAD (NPSH)

1. If at all possible, the centrifugal pump elevation should be below the lowest level of the liquid supply, so that the pump remains primed at all times and the NPSH requirements are met.
2. Where this criterion cannot be met, for example pumping from below grade pits, rotating equipment engineer advice should be sought regarding alternatives such as self-priming pumps and submerged pumps.

4.4 SHAFT SEALING

1. Seals shall be provided to prevent liquid leakage out of the pump (centrifugal and rotary), at the point where the rotating shaft passes out through the pump casing.
 - a. External to the seal, a throttle bushing should be fitted to limit the amount of liquid release to atmosphere upon mechanical seal failure.
 - b. A floating throttle bushing may be fitted to reduce further the gap to atmosphere in case of seal leak.
2. Seal type and selection is described in DEP 31.29.00.33-Gen. Three main seal types may be distinguished: single seal (Arrangement 1), double unpressurised seal (Arrangement 2), and double pressurised seal (Arrangement 3).

4.5 DYNAMIC REVERSE PRESSURE CAPABILITY

1. A pump with a double pressurised seal may or may not have 'dynamic reverse pressure capability'.

If the outer seal of a double mechanical seal fails, the differential pressure across the inner seal reverses. If the seal is 'reverse pressure capable', it is able to withstand this pressure reversal on the inner seal. If it is not 'reverse pressure capable', it can result in the inner seal failing and loss of process containment.

Seal Manufacturer/Supplier can only provide 'reverse pressure capable' pressurised double seals for duties up to about 15 bar (atmospheric) sealing pressure, and not all seals below this pressure have this capability. Non-pressurised double mechanical seals are not affected by the 'reverse pressure capability' issue.
2. For the population of pressurised double mechanical seal (high suction pressure) pumps that cannot meet the reverse pressure requirements, additional barriers shall be added to prevent a product release or mitigate release consequences including:
 - a. Application of effective cooling.
 - b. Application of throttle bushing (combined with risk assessment of foreseen leakage rate).
 - c. Installation of non-pressurised (Arrangement 2) double mechanical seals if it is Hazardous Category 2 Service (Principal approval is required) or Category 3 Hazardous Service.
 - d. Application of a second transmitter with trip function and timer which stops/trips the pump automatically when the allowable reverse pressure differential is reached. The trip setting of the second transmitter shall be determined based on the actual reverse pressure capability of the inner seal on a case-by-case basis.
 - e. Where a trip function is used, an appropriate time delay should be applied to avoid unnecessary trips caused by momentary pressure reversal (i.e., process upset, start-up).
3. The P&T Rotating Equipment SME shall be consulted for Arrangement 3 mechanical contact-type seals in hazardous services' to provide guidance on how to assess and address such double seals.

5 COMPRESSORS (INCLUDING CENTRIFUGAL AND RECIPROCATING COMPRESSORS)

1. The type of compressor selected shall be based on both the technical and economical application following the requirements of DEP 31.29.40.10-Gen.

Choosing which type of compressor to install depends on the required flow rate to be compressed, the properties of the gas and the compression ratio required.

2. For centrifugal compressors to be installed in new facilities, seal type selection is described in DEP 31.29.40.10-Gen., Section 4.

For flammable or toxic fluid, this selection usually results in Tandem Gas Seal (DGS) with Intermediate Labyrinth. In some cases, such as large shaft diameters in LNG plant applications, mechanical and/or thermal conditions in the compressor are beyond the proven capabilities of DGSs and liquid film (floating ring) seals are selected. Existing facilities however still have liquid seals for many applications.

In certain scenarios (e.g., limited vibrations), seal leaks from a Tandem Gas Seal (DGS) with Intermediate Labyrinth are unlikely to result in a flammable/toxic gas cloud outside the casing. However, in other scenarios (e.g., surge, turbine overspeed), a major release to atmosphere at the shaft location may be expected if unsuitable safeguarding is provided.

3. The required safeguarding for compressors is detailed in DEP 32.29.20.10-Gen.

Reciprocating compressors are usually more sensitive to failures than centrifugal compressors and consequences are typically more dramatic.

4. When specifying a compressor for breathing air applications, DEP 80.10.10.31-Gen., breathing air and supply systems shall be applied.

- a. The Project shall consider all design parameters required (e.g., intake, type of compressor, discharge knockout, connections) such that a product stream is provided that meets minimum breathing air requirements.

5. The control system specified shall decouple the capacity control from the anti-surge control to avoid possible instability.

During steady-state operation, the capacity control of the compressor (discharge pressure, suction pressure or flow control) can conflict with the anti-surge control, since each attempts to vary the flow through the compressor in contrary directions.

6. Liquid knock out drains should be as follows:

- a. routed to a closed system.
- b. It is preferable that level is controlled automatically; however, manual draining is permitted especially when little to no liquid is expected in the feed stream.
- c. If a manual drain system is elected, the drain line should include a spring loaded valve such that the drain valve cannot be inadvertently left open.

7. For skid package units, if the project elects to review the design package in a HAZOP separate from the rest of the unit, interfaces between the package and the rest of the unit shall be considered.

Frequently, compressors are purchased as a skid package including the control package and auxiliary equipment.

6 STORAGE TANKS

6.1 STORAGE TANKS GENERAL

Storage tanks have been involved in a number of incidents within industry resulting in large scale asset loss and loss of life. For this reason, Shell has established Process Safety Basic Requirements for the prevention of tank overfill. PSBR 7 is a part of the Design and Engineering Manual (DEM) 2 under Process Safety Manual of Control Framework. While PSBR 7 is directed to overfill of atmospheric storage tanks, the same principles may be applied for pressurised storage.

1. DEP 34.51.01.33-Gen. shall be applied when designing atmospheric storage tanks based on API 650. For tanks designed to EN 14015, apply DEP 34.51.01.31. When selecting the type of tank to be used, the storage temperature, flash point, and vapour pressure shall be considered.
 - a. DEP 34.51.01.31-Gen. is based on EN 14015
 - b. DEP 34.51.01.33-Gen. is based on API STD 650.
2. Overpressure scenarios and relief device application and installation shall be per API 2000 (see DEP 80.45.10.10-Gen.). A risk assessment shall be completed to determine the impact of overfill scenarios and the required mitigation.
3. Where multiple tanks are being specified or a tank is being located adjacent to an existing tank, spacing and bund arrangements shall be established to minimize the impact of environmental spills, fires, and explosions. The layout shall be optimised to reduce to an ALARP level the probability of coincidence of a flammable vapour-air mixture and known electrical or other sources (e.g., hot equipment, traffic, fired sources) of ignition.
4. For tanks in liquid sulphur service, refer to the Sulphur Recovery Unit Subject Matter Expert.

6.2 REFRIGERATED LIQUIFIED GAS (RLG) STORAGE

The RLG storage tank is vertical tank which is used for storage of light hydrocarbons (boiling point -4°C (24.8°F) to -160°C (-256°F)) at atmospheric pressure but at sub-zero temperature at or below their boiling point. These tanks are insulated to limit heat inleak into the tank thus keeping the light hydrocarbon in liquid phase. Insulation thickness depends on the boil-off rate limits, which may vary from 0.06 % (for LNG tank) to 0.12 % (for LPG tank) per day of the nominal tank capacity.

Four types of RLG tanks are generally applied in Shell.

- LPG tank (C3 and C4) Pre-stressed concrete, full containment type
- LPG tank (C3 and C4) steel full containment type
- LNG tank (C1 and C2) Pre-stressed concrete, full containment type
- LNG tank (C1 and C2) Pre-stressed concrete, membrane type

1. Requirements for RLG tanks include the following:

- a. There should be no piping or instrumentation penetrating the primary or secondary container walls.
- b. All piping and instrumentation connections shall be routed via the tank roof.
- c. All piping and connection in the dome space shall be insulated, whilst nozzles near the roof should be sealed to prevent external condensation.
- d. The location of the liquid inlets should not allow for splashing into the annular space and liquid entrainment in the vapour outlets.
- e. A cool-down line shall be installed under the suspended deck designed for the specified cool-down rate. Spray nozzles shall be used to ensure dispersion of liquid.
- f. Vent openings should be installed on the suspended deck to ensure equal pressure below and above the suspended deck. The vent openings shall be sized such that the differential pressure cannot exceed the weight of the deck. Special provisions shall be provided if condensations could occur in the dome space of butane tanks (when the inside roof temperature falls below the dew point of butane vapour) via, e.g., holes or diverting plates at roof edge, to drain the condensed liquid into the tank and prevent any overflow to the annular space.
- g. A purge/venting system shall be installed in the bottom insulation so that the space can be purged/vented when needed e.g., leakage at tank bottom. A purge line should also be installed in the annular space to purge the annular space from the top to bottom.
- h. For LNG tanks, additional vent shall be installed in the insulation layer underneath the bottom protection system (9 % Ni plate). This system shall have open connection with the dome roof vapour space so that the pressures under and above the 9 % Ni plate can equalize.
- i. Submerged type loading pumps are installed in the tank at the bottom of a vertical pump well.
- j. A PRV (Pressure Relief Valve) shall be installed to relieve the inner tank vapour space to avoid cold vapour entering the (warm) dome space under relieving conditions.
- k. The relief valve for each individual tank should be capable of discharging flow rates of any likely combination of the following:
 - i. Hot* rundown from the plant.
 - ii. Evaporation due to heat input

- iii. Displacement due to filling
 - iv. Flash at filling
 - v. Variations in atmospheric pressure
 - vi. The recirculation from a submerged pump (heat input)
 - vii. Control valves failures (e.g., inadvertent opening of the vacuum breaker control valve.
 - viii. Roll over in case no other device is envisaged.
 - ix. Fire (not relevant as a scenario for full containment - concrete roof and wall tanks. The fire scenario would be relevant for steel outer wall and roof tanks.
- * "Hot" is defined as liquid at the temperature trip setting or train end flash RV set pressure.

7 FIRED EQUIPMENT

In fired equipment, fuel is burned to generate heat. This can be used to heat up a hydrocarbon stream that enters a distillation column, or to boil water to produce steam. It can also be used to produce power, e.g., in a gas turbine, to run a compressor.

1. Fired equipment is more than just the combustion chamber or 'fire box' where fuel and air are reacting. The scope of fired equipment also includes the supply systems (piping, valves and instrumentation) of both fuel and air, consisting of the piping valves and instrumentation.
2. The exhaust of the combustion products is part of the fired equipment, as well as any form of heat recovery, e.g., air pre-heating and exhaust gas heat recovery.
3. The process stream that needs to be heated up by the combustion process shall also be considered.
4. Requirements for fired heaters are covered in ISO 13705 and DEP 31.24.00.30-Gen. Requirements for fuel systems are specified in DEP 20.05.60.10-Gen.
5. Open flames as well as hot surfaces on fired equipment pose a threat to the unit if unexpected releases occur. Therefore, at a minimum, layout considerations of DEP 80.00.10.11-Gen. shall be followed.
6. Additional separation distance may be required depending on the type and orientation of the adjacent equipment. Where risk assessment is used to demonstrate ALARP, fired equipment will limit or prohibit ignition source control consideration as a barrier unless it can be demonstrated that a release will disperse to the extent that no flammable gas mixture will form prior to reaching fired equipment.
7. Safety in fired equipment is characterized by implementation of barriers to prevent accumulation of dangerous flammable mixtures inside the equipment. This may be caused by:
 - a. Fuel pressures outside of the operating range
 - b. Air/fuel ratios in the firebox
 - c. Burner flame out
 - d. Process tube leaks
8. Instrumented protected functions (IPFs) are required to address fuel box operations and may be additionally required for process operations.
9. IPFs shall be identified through hazard identification and analysis. Typical IPFs for fired equipment are discussed in DEP 32.24.20.44-Gen.

8 ISOLATION OF MECHANICAL EQUIPMENT AND PIPING

1. Process isolation of mechanical equipment and piping is required for maintenance activities for both hydrocarbon and utility services. This is to allow safe access from hazards resulting from stored energy in pressurised systems, fire and explosion, asphyxiation and toxic fluids.
2. One of the goals of the design phase of a project is to provide the appropriate isolation hardware for the required maintenance tasks consistent with the facility design without over specification.

The isolation methodologies are of two forms:

- *prescriptive*
 - *risk-based assessment*
3. The Contractor shall follow the design requirements in DEP 31.38.01.11-Gen., Section 8.7 and the isolation methodologies noted in this (Section 8).
 4. The following reference documents are identified by HSSE Control Framework as resources in the design of projects when determining the level of isolation to be provided:
 - a. HSSE & SP Control Framework, Personal Safety Manual - Safe Isolation – Lock Out Tag Out Guide;
 - b. Oil Products procedure for Electrical and Mechanical Isolations and by reference OSHA 1910.147;
 - c. EP Work Instruction – Implement and Monitor Plant and Equipment Isolations, Document No. EP200909327736;
 - d. UK HSE – “The safe isolation of plant and equipment”, HSG 253.
 5. The reference documents in (8, Item 4), as well as information included in this DEP Specification, do not apply to the following:
 - a. Isolation for emergency shutdown or automatic process shutdown purposes.
 - b. Energised systems such as electric power or hot tap of a system.
 6. In a process plant design, one objective should be to keep the number of potential leak sources as low as possible without jeopardizing operability and the possibilities for maintenance, inspection and construction by minimizing the number of flanges. This objective is particularly valid for systems (high pressure and/or toxic) which contain fluids forming a potential safety/occupational health hazard and/or have a potential negative environmental impact (refer to DEP 31.38.01.11-Gen.).

9 VALVES

1. The selection of valves type shall follow the design requirement (e.g., stop, throttle) in DEP 31.38.01.11-Gen.
2. Valve materials and specifications are found in the piping classes:
 - a. DEP 31.38.01.12-Gen.
 - b. DEP 31.38.01.15-Gen.
3. The piping class shall be determined in accordance with DEP 31.38.01.10-Gen.
4. Control valves are not listed in the piping classes (although materials are similar). They should be as specified in DEP 32.36.01.17-Gen.
5. The specific component and design requirements for valves in Ethylene Oxide (EO) service are detailed in DEP 31.38.01.11-Gen. Section 8.

6. The piping class break between utility and process shall be located such that the check valve and upstream block valve satisfy the process piping class.
7. For shut-off valves, the actuators shall be capable of keeping the valve shut against the full upstream pressure.
 - a. See DEP 32.36.01.18-Gen. for specific requirements for actuator for on/off valves
 - b. Shut off stations shall be located at a minimum of 15 m (50 ft) away from the equipment to be isolated.
8. Shutoff valves specified for fire safety shall be fail-safe or fire safe, as per ISO 10497 (old BS 6755, part 2), or API SPEC 6FA, for minimum 15 minutes in a pool fire. Remote operation is the preferred design over provision of shut off stations.
9. For systems containing more than 4 m³ of LPGs or 10 m³ of liquids above their auto-ignition temperature upstream of a pump, an ROV is recommended to avoid sending the operator into harm's way. Refer to DEP 80.47.10.30-Gen.

10 SAMPLE CONNECTIONS FOR MANUAL SAMPLING SYSTEMS

1. Manual sampling is a routine task performed by operational personnel on a daily basis. To prevent and minimise personnel exposure to hazard during manual sampling, the activity should be safeguarded by engineering design, selection of sampling tools, sampling procedure and PPE.
2. For manual sampling procedures and ergonomic issues, refer to:
 - a. DEP 30.00.60.20-Gen.
 - b. ASTM D4057-12//API MPMS 8.1 (Developed jointly between API and ASTM)
 - c. ASTM D1265
 - d. API MPMS 8.4
 - e. ISO 3170
3. See DEP 31.38.01.11-Gen. for the following:
 - a. general requirements for the location of sample points,
 - b. precautions for phase and temperature control at sample points
 - c. required valving and connections.
4. Standard Drawings, which shall be used for sample purposes, are S 38.007, S 38.013, S 38.034, S 38.037 and S 38.038.

11 PROTECTIVE HEATING OF PIPING SYSTEMS

There are many examples in industry of loss of containment resulting in fire/explosion and/or fatalities related to freezing, condensation, or solidification of process fluids due to heat loss to the environment (e.g., during no flow conditions). In addition, the temperature of some fluids needs to be kept above a certain operating temperature to prevent the fluid from being too viscous causing flow restrictions.

1. When heat insulation alone is insufficient to maintain operating temperature, external heating should be added to the system. The following external heating systems are usually applied:
 - a. Steam tracing (DEP 31.38.30.11-Gen.)
 - i. Permanent heating
 - ii. Winterising*
 - b. Steam jacketing (DEP 31.38.30.11-Gen.)
 - i. Fully jacketed
 - ii. Not fully jacketed
 - c. Glycol tracing (DEP 31.38.30.11-Gen.)
 - i. Winterising*
 - d. Hot oil tracing (DEP 31.38.30.11-Gen.)
 - i. Permanent heating
 - e. Electrical tracing (DEP 33.68.30.32-Gen.)
 - i. Permanent heating
 - ii. Winterising*

** Winterising is to prevent freezing of the process fluid due to low ambient temperature having low or no flow operation.*

12 FLAME ARRESTORS

Flame arrestors are installed for personnel and equipment protection, where there is a potential for flashback/flame transmission into a process or storage system. Examples of flame arrestor applications include:

- *For atmospheric vents the most common source of ignition may be lightning, since disposal is usually to a safe location, commonly at a high point in the structure.*
 - *For disposal to furnaces there is permanent ignition at the entry point into the furnace, whilst for vapour recovery systems the ignition source may for example be sparks from a discharge of static electricity.*
 - *For all systems, a further source of ignition of a flammable mixture could be the presence of pyrophoric iron deposits in equipment and piping.*
1. The credibility of a flammable mixture being present in the system concerned should be established for every case. There is no need for flame arrestors if, for example, there is insufficient time or insufficient flammable material to develop a flammable mixture.
 2. Examples where flame arrestors are required as follows:
 - a. Flame arrestors in a continuous flow of waste gas shall be suitable for endurance burning if stabilised burning could exist at the flame arrestor and cannot be detected and stopped within a specified time.
 - b. Tanks that are connected to a vapour recovery unit (VRU) shall be equipped with flame or detonation arrestor.
 3. The choice to apply either a flame or detonation arrestor is determined by two factors:
 - a. The location of the ignition source and what needs to be protected.
 - b. Between these locations, the numbers of restrictions with respect to enhanced turbulence, which can eventually lead to detonation.
 4. In order to properly size an arrestor, its pressure drop for a given application shall be known.

Minimizing pressure drop can be achieved by increasing the overall tube bank diameter, to provide increased free area, and by decreasing the length of the element, which allows a larger hydraulic diameter of the element passage ways to be used. When an "end of line" flame arrestor is installed with a tail pipe, the maximum allowable L/D ratio is dependent on the composition of the gas
 5. Refer to Manufacturer/Supplier's capacity-pressure drop charts when determining the correct size of arresting device.