

DEP SPECIFICATION

ESD SYSTEMS FOR LOADING AND DISCHARGING LIQUEFIED GAS CARRIERS

DEP 30.06.10.20-Gen.

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(DEP Circular 12/12 has been incorporated)

DESIGN AND ENGINEERING PRACTICE

DEM1



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and give recommendations for the design of Emergency Shutdown (ESD) systems for marine loading and discharge terminals for liquefied gas carriers. This DEP seeks to clarify the design philosophy of the ESD system and describe the hardware required. It does not, however, attempt to cover engineering details, for which reference should be made to:

- (i) DEP 31.06.15.10-Gen.
- (ii) Relevant DEPs for structures, piping, instrumentation and equipment.

This DEP includes recommendations aimed at achieving a measure of standardisation in the design and implementation of ESD systems at Group marine LNG and LPG terminals.

The main focuss of this DEP is on shore based ESD systems, its associated hardware and on the ship/shore interface.

Sections 3, 4 and 5 of this DEP are for export terminals only. Section 6 (import terminals) only states differences with export terminals to prevent duplications. Although this DEP is written for on shore based ESD systems it shall be applied for off shore based systems as much as reasonably practical.

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 with the same number dated January 2010; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

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This DEP is intended for use in facilities related to marine LNG and LPG terminals. This DEP may also be applied in other similar facilities.

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

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **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
Accumulator system	System that provides sufficient hydraulic oil in case of electric power failure.
Apex angle	Angle between inboard and outboard arm. (The highest point of the Marine Loading Arm)
'Dry break' uncoupling	Uncoupling without significant release of product.
Effective Valve Closure Time	being the period within which a given ESD valve reduces the flow from 90 % of its steady state to zero
ESD valve	Emergency ShutDown valve
Instrumented Protective Function	A function comprising one or more sensors, a Logic Solver and one or more Final Elements whose purpose is to prevent or mitigate hazardous situations and that have SIL 1, SIL 2, SIL 3 or SIL 4.
Quick Connect/ Disconnect Couplers	The manual or hydraulic mechanical device used to clamp the loading arm to the presentation flange of the ship's manifold without the use of bolts.
Safety Integrity Level	Discrete level (one out of four) for specifying the safety integrity requirements of the safety instrumented functions (IPF in this DEP) to be allocated to the safety instrumented systems (trip systems). Safety integrity level 4 has the highest level of safety integrity; safety integrity level 1 has the lowest.
Ship manifold valve	The first valve downstream the manifold presentation flange
Ship/ shore link	Transmits ESD and communication signals from ship to shore or vice versa via compatible system.
SIGTTO link	A standardised ship/shore link developed by SIGTTO members.
Slew angle	Horizontal rotation angle of the arm assemblies.
Sway values	Values of drift motions is sideways direction.
Total Valve Closure Time	which is the time taken for the valve to travel from the fully open to the fully closed position

1.3.3 Abbreviations

Term	Definition
CCR	central control room
DBV	double (interlocked) block valves associated with ERS
DV	dump valve (or Diverter valve)
DCS	distributed control system
ERS	emergency release system; a system for quickly and safely disconnecting with minimal product spillage, consisting of a PERC and two isolation valves (DBVs), one upstream and one downstream of the coupler
ESD	emergency shutdown

Term	Definition
ESD-1	emergency shutdown of the transfer operation in a quick controlled manner by closing the shutdown valves and stopping the transfer pumps. On board ships this stage is commonly referred to as emergency shutdown (ESD).
ESD-2	emergency shutdown of the transfer operation (ESD-1) and simultaneous uncoupling of the LAs (operation of the PERC) after closure of both the DBVs.
FAR	field auxiliary room
GBS	position indicator
GBZ	position switch with trip action
GZA	apex or slewing angle over-extension alarm with emergency action
HBS	backlighted switch
HIC	hand indicating controller
HZ	push buttons for manual initiation of the ESD-1 and ESD-2 systems
IGC	international code for the construction and equipment of ships carrying liquefied gases in bulk
IMO	International Maritime Organisation
IPF	Instrument Protective Function
IPS	instrumented protection system
LA	loading arm (also used for unloading)
LZA	level alarm with emergency action
OCIMF	Oil Companies International Marine Forum
OOS	operational override switch; enables circulation through loading lines in the absence of a ship and testing of the ESD system of one jetty whilst a second jetty is in operation (indicated as HBS on Process Engineering Flow Schemes)
PERC	powered emergency release coupling
PLC	programmable logic controller
PZA	pressure alarm with emergency action
ROV	remote operated valve. Operable from the CCR, these valves can have ESD functionality if they are hydraulically or pneumatically driven.
RSP	removable spool piece
QCDC	quick connect/disconnect coupler
SIGTTO	Society of International Gas Tanker and Terminal Operators
SIL	safety integrity level
TOS	test override switch; required to allow testing of initiating devices when the actual ESD-2 and/or ESD-1 action may not occur.
XZA	general safeguarding function

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 (9).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated January 2010.

The only non-editorial change has been the extraction of the recommended practices for ESD systems into a companion Informative document.

The process safety requirements have been reviewed and revised where appropriate.

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 12/12**

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

The Terminal Emergency Shutdown (ESD) system has been developed to minimise risks during the transfer of liquefied gases between ship and shore loading and unloading installations. The ESD system includes fast closing valves, LAs equipped with emergency release couplers, and surge protection equipment (where required).

The first stage emergency shutdown system (known as the ESD-1 system) shuts down the product transfer operation in a controlled way by closing valves and stopping pumps in the shore facilities.

The second stage emergency shutdown system (ESD-2) activates the LA emergency release system (ERS) to disconnect the arm from the ship. 'Dry break' uncoupling is achieved by ensuring the closure of two isolation valves, one directly upstream and one directly downstream of the emergency release coupler (ERS) prior to the uncoupling action.

Valves are required for operation, maintenance and emergency shutdown. The closure of valves in the terminal or at the ship during loading or offloading will cause a pressure surge. This DEP requires an intrinsically safe design for the common product supply headers which will withstand the maximum pressure due to surge by closure of valves.

Closure of any valve available in the system requires detailed surge pressure verification and may necessitate a surge pressure relief system.

The lifting of the access gangway and disconnection of the ship/shore link in the event of a ship drifting away from the loading jetty should also be considered.

The structure of this DEP is as follows:

- main system components (valves, arms and ERSs, hydraulics, etc.)
- safeguarding system (logic functions and interlocks)
- differences for import terminals
- instrumentation

The available IPFs in the ESD system design covering LNG and LPG terminals have been classified generically. The derived SIL levels in this DEP together with the instrumentation implementation description shall be the minimum standard for the described ESD systems unless the project specific SIL Assessment leads to different SIL levels. Local circumstances or alternative process line-ups may result in higher SIL scores. Therefore, every project or process line-up modification in an existing facility requires a review of the SIL results as presented in this DEP.

3. MAIN SYSTEM COMPONENTS

3.1 MANIFOLD VALVES

3.1.1 Ship manifold valves

Ship manifold valves are not in the scope of this DEP.

3.1.2 Jetty manifold valves

Each LA (vapour and liquid) shall be provided with a remote operated valve as primary isolation for connection and disconnection of the LAs. This valve is called the LA ROV for both liquid and vapour transfer arms.

The Loading Arm ROVs:

- (i) SHALL [PS] be remote operated fire-safe tight shut-off valves. The valves may be either pneumatically or hydraulically operated but in either case SHALL [PS] be 'fail-safe', i.e. close automatically on loss of actuating power. Refer to (3.2.1) if the ROV does not have ESD functionality, then this requirement is not mandatory.
- (ii) shall be provided with a mechanically secured means of setting or adjusting Total Valve Closure Time.

These 'LA ROVs' shall be fitted with proximity switches to indicate when the valves are in the 'closed' and 'not closed' position, which are incorporated in the safeguarding logic of ESD-1.

The LA ROVs shall not close faster than the ESD-1 valves in the loading lines.

If a jetty is equipped with multiple liquid LAs, and in case one liquid LA is designed to be the backup for the vapour return arm, the switch SHALL [PS] not be made through the use of additional ROVs, but SHALL [PS] be carried out by means of appropriate spading and the use of a removable spoolpiece (RSP).

Furthermore, if LAs have been manifolded for multiple product transfer, these arms SHALL [PS] each be provided with a LA ROV at each manifold connection. The logic system SHALL [PS] inhibit the opening of a second Loading ROV when another is in the 'not closed' position.

Loading HICs

These are for operational purposes only and are not related to the ESD system. However, the total valve closure time for an HIC needs to be considered in a surge pressure verification.

Isolation valves

A manual isolation valve should be installed upstream of each LA ROV to allow maintenance of this valve while the other LAs remain operational.

3.2 ESD-1 VALVES

3.2.1 ESD-1 valves in loading lines

The implementation of the ESD-1 function depends on the requirement for a surge pressure relief system (refer to section 3.6 and figures in Appendices 1 & 2):

- (i) the SIL of the high level trip on a surge drum requires two dedicated ESD-1 valves in series upstream of the surge pressure relief valves and the dump valve.
- (ii) if there is no surge pressure relief system, then the SIL requires two ESD-1 valves for overfill protection of the ship's tanks (3.7.2), but the LA ROV can serve as one of these, if it is specified with full ESD functionality. The dedicated ESD-1 valve SHALL [PS] remain in the common product supply header.

The dedicated ESD-1 valves:

- (a) should be on the edge of the jetty platform;

- (b) shall be protected against mechanical damage e.g. as a result of crane activity;
- (c) SHALL [PS] close within 15 seconds (verified by surge pressure calculations). If the LA ROV incorporates one of the two ESD-1 actuator functions, then the closure time of this ROV shall be set at a higher value between 30 to 60 seconds;
- (d) SHALL [PS] be remote operated fire-safe tight shut-off valves. The valves may be either pneumatically or hydraulically operated but in either case SHALL [PS] be 'fail-safe', i.e. close automatically on loss of actuating power;
- (e) shall be provided with a mechanically secured means of setting or adjusting Total Valve Closure Time (which is the time taken for the valve to travel from the fully open to the fully closed position);
- (f) SHALL [PS] not be provided with hand wheels or lever operators;
- (g) SHALL [PS] be protected from fire by fireproof insulation of actuator, cabling and hydraulic lines.

3.2.2 ESD-1 valves in vapour return lines

The SIL for this function requires one ESD-1 valve. The closure time of this valve should match the closure time of the ESD-1 valves in the loading line.

A manually activated isolation valve shall be installed in the vapour return line at the jetty/shore interface to allow maintenance.

3.3 EMERGENCY RELEASE SYSTEM (ERS)

The PERC in combination with the DBVs is known as the ERS

All LPG and LNG loading facilities SHALL [PS] have ERS units installed on all liquid loading and vapour return arms.

The PERC and both DBVs SHALL [PS] be mechanically linked to guarantee that the DBVs are closed before the PERC is released. The ERS shall be driven by one "one stroke" hydraulic cylinder. The link shall provide a mechanical device to test stroke the cylinder with closure of the DBVs, but without actually releasing the PERC.

The cylinder should be of the 'pull-stroke cylinder' type (Appendix 5) with single-ended rods.

The closing time of the DBVs in the ERS shall be set to 5 seconds and the PERC shall open within 2 seconds after closure of the DBVs. The design of the LA (working envelope) shall allow for the anticipated ship drift speed.

A liquid LA may be equipped with a smaller diameter line mounted piggy-back for transfer of vapour or other products. This smaller line shall also be equipped with an ERS and the hydraulic system shall be designed to ensure that the smaller line is uncoupled before the main loading ERS is uncoupled.

3.4 LOADING ARMS

3.4.1 Excessive arm movement detection

To safeguard the LA when connected to a ship, the former has to be uncoupled before it reaches its mechanical limit or exceeds the design operating envelope.

The ESD actions are initiated by separate sets of proximity switches preset as follows:

- (i) initiate an ESD-2 at 2.0 metres before the design limit of the mechanical reach (ref. "d"- "c" Table 4 OCIMF). Ship motion calculations shall validate overall design surge and sway values, allowing for typical operational tolerances increased with the maximum displacement over the normal closure time of the DBVs and opening time of the PERC).
- (ii) initiate an ESD-1 at 0.5 metres within the design limits as calculated for ESD-2.

For both Apex and Slew angle, one proximity switch shall be provided at the ESD-1 position, and two additional proximity switches shall be provided at the ESD-2 position. Together, these switches form a 2oo3 voting system for ESD-2. Hence, a total number of 9 switches per loading arm is the base case. Failure of one ESD-1 or ESD-2 sensor shall initiate a failure alarm. Failure of any two sensors shall initiate an ESD-2

To avoid undesired ESD-2 trips or mechanical damage, the manoeuvring movement of the arm shall be kept within the limits of the ESD-1 envelope. If the LA reaches the operating envelope limit for ESD-1 while being manoeuvred, the hydraulic system shall restrict any further outward movement while allowing the operator to move it back into the normal envelope using the hydraulic system.

The LA manufacturers have developed continuous position monitoring systems. These can be programmed to initiate an ESD-1 and ESD-2 in response to the position, rate of drift and acceleration of the LA towards the design envelope, thus providing an additional degree of protection against overextension. Installation of these systems may be considered, but the hardwired proximity switch systems set as above SHALL [PS] be retained.

3.4.2 Movement of loading arm upon emergency release

LAs shall be counter balanced in such a way that immediately after an emergency disconnection the upper ERS flange shall rise and move towards the shore. Over the first 3 metres (10 ft) the average speed shall be more than 0.15 m/s (6 in/s). This movement shall continue until full retraction behind the berthing line is completed. At the end of the movement the speed shall slow down to zero. Thereafter the position of the LAs shall be hydraulically blocked.

The above shall be accomplished under the following concurrent conditions of the arm:

- (i) the ERS has been disconnected; and
- (ii) the entire arm assembly is either full of product or empty; and
- (iii) the arm is covered with ice to the extent specified; and
- (iv) the arm is exposed to a wind blowing towards the ship with a specified speed.

Any forces applied on the dummy manifold and / or ship's manifold upon an ESD-2 test shall not be hydraulically generated (see 4.2.5).

3.4.3 Dummy Manifold

Each LA shall be provided with a dummy manifold, to be used for testing and maintaining the ERS unit. When the arm is connected to the dummy manifold a working area (floor space) of at least 1 m (3 ft – 3 in) wide all around the ERS unit shall be available.

3.5 HYDRAULIC SYSTEM

3.5.1 ERS hydraulics

3.5.1.1 Solenoid arrangement

Appendix 5 shows the standard arrangement of the solenoid valves on an ERS system. The ERS solenoids require a common fuse to prevent a single fuse or power failure causing an ESD-2.

In the event of a fuse/power failure, the ERS will remain in a 'safe' condition but manual activation of the ERS via a push button on one of the solenoids shall still be possible. On the return of power a signal shall be provided to the logic indicating that the solenoid has been switched manually.

3-way valve puppet type solenoid valves are preferred. These valves should be 100 % leak proof and should be directly electrically operated (no pilot valves). All hydraulic solenoids shall be of the fully enclosed type (no bare metal pins exposed to ambient air).