

PETRONAS TECHNICAL STANDARDS

MANUAL

ESD SYSTEMS FOR LOADING & DISCHARGING REFRIGERATED & PRESSURISED LNG & LPG CARRIERS

PTS 30.06.10.20

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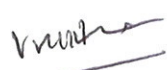
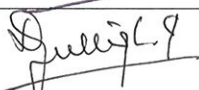
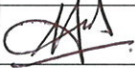
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This revision of PTS 30.06.10.20 - **ESD Systems for Loading and Discharging Refrigerated and Pressurised LNG and LPG Carriers** has been updated incorporating PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards..

The previous version of this PTS **October 1992** will be removed from PTS binder/ e-repository from herein onwards.

Document Approval

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1. INTRODUCTION

1.1 SCOPE

This PTS intended to give guidance on the design of Emergency Shutdown (ESD) systems for marine loading and discharge terminals for liquefied gas carriers. This PTS 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) the PETRONAS Marine Loading Arm Specification
- (ii) the OCMF (Oil Companies International Marine Forum) "Design and Construction Specification for Marine Loading Arms"
- (iii) relevant PTSs for structures, piping, instrumentation and equipment.

Whilst this PTS is aimed at the designer, it also provides the user with essential information on operational and maintenance aspects of marine terminal ESD systems.

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

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to companies forming part of PETRONAS or managed by a Group company, and to Contractors nominated by them.

This PTS is intended for marine LNG and LPG terminals.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this PTS the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this PTS 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 with the object of obtaining agreement to follow this PTS 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 work and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant, authorised to act for the Principal.

The word **shall** indicate a requirement.

The word **should** indicate a recommendation.

1.3.2 Specific definitions and abbreviations

CCR	Central Control Room
DBV	Double (interlocked) Block Valves associated with ERS
DV	Dump Valve (or Diverter valve)
DCS	Distributed Control System
ERC	Emergency Release Coupler, required to uncouple the loading arm after initiation of an ESD-2 action
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
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
HC	Hand controlled valve
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
MOV	Motor Operated Valve (as an MOV is not considered fail-safe, it shall not be used for valves with ESD functionality)
NRV	Non-return valve
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
PS	Process Safety requirements. Shall be mandatory.
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
RV	Relief Valve
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 PTS are made, the referenced section number is shown in brackets. Other documents referenced in this PTS are listed in (5).

2. EMERGENCY SHUTDOWN SYSTEMS

2.1 GENERAL

The Terminal Emergency Shutdown (ESD) system has been developed to minimise potential 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).

Because of the large volumes of flammable vapours formed on liquid spillage and the high liquid transfer rates at many refrigerated and pressurised gas terminals, the emergency scenarios envisaged at the ship/shore interface all require initial action to stop the transfer operation in a quick, safe and controlled manner (ESD-1). Certain specific cases, where the is potential damage to the loading arms of the ship, require in addition the rapid disconnection of the loading arms from the ship (ESD-2).

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. It is recommended that ship and shore ESD systems are linked so that initiation of either system simultaneously activates the other system.

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. Simultaneously, an ESD-1 action is initiated.

The linking of the ship's ESD system to the shore ESD-1 system by a 'delay free' link system (i.e. electronic, fibre optic or radio) is a requirement for LNG operations and a recommendation for LPG operations. The intrinsically safe electrical link as proposed by SIGTTO for adoption as an international standard ([see 3.7.2 and Appendix 7](#)) is strongly recommended.

The hydraulic control system operating the loading arm ERS should have a pressure retention capability of minimum 3 hours in the event of AC and/or DC power failure.

Accidental manual uncoupling of the ERC during manoeuvring of the loading arm should be inhibited by logic interlocks.

If the loading arms are equipped with quick connect/disconnect couplers (QCDC), the opening of the QCDC must be interlocked with other valves to prevent accidental spillage.

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 PTS requires an intrinsically safe design for the common product supply headers which will withstand the maximum pressure due to surge by closure of valves. By keeping the loading rate below a pre-determined maximum value in relation to a specific ship manifold closure time, excessive surge pressures above design pressures will be avoided. 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.

Sections 3, 4 and 5 are for export terminals only. Section 6 (import terminals) only states differences with export terminals to prevent duplications.

The structure of this PTS 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 SILs in this PTS together with the instrumentation implementation description shall be the minimum standard for the described ESD systems. Local circumstances or alternative process line-ups may result in higher SIL requirements. Therefore, every project or process line-up modification in an existing facility requires a review of the SIL results as presented in this PTS i.e. execution of IPF Studies.

3. MAIN SYSTEM COMPONENTS

3.1 MANIFOLD VALVES

3.1.1 Ship Manifold Valves

The International Maritime Organisation (IMO) code for the construction and equipment of ships carrying liquefied gases in bulk (IGC Code) requires ship manifold valves to close within 30 seconds of initiation of the shutdown. As the response/signal time is included in the quoted 30 seconds, a long response time can result in a short valve closure time.

Each terminal should have available graphs indicating the relationship between: flow rate, effective valve closure time and type of ship's valves to prevent excessive surge pressures exceeding the design pressures of the shore and/or the ship's piping systems.

For all vessels calling at the export terminal, the valve type and closure times should be compared with these graphs during the cargo handling discussions and the loading rate should be adjusted accordingly. The total valve closure time should be measured during the ESD-1 test before commencing loading.

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 be remote operated fire-safe tight shut-off valves (PS). The valves may be either pneumatically or hydraulically operated but in either case shall be 'fail-safe', i.e. close automatically on loss of actuating power (PS). (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 (which is the time taken for the valve to travel from the fully open to the fully closed position).

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 to ensure that the piping is not subjected to surge pressures higher than design. Typical closure time is 30 to 60 seconds (to be verified by surge pressure calculations using selected valve type).

If a jetty is equipped with multiple liquid LAs, one liquid LA should be designed as backup for the vapour transfer arm. In that case, this liquid LA run shall be spaded off from the manifold, the vapour return arm shall be spaded at base and a removable spool piece (RSP) shall be fitted to connect the liquid LA base to the vapour return run (refer to figures in Appendices 1 and 2). This switch shall not be made through the use of additional ROVs (PS).

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

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 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. This manual valve also makes it unnecessary to drain or purge large loading or vapour return line volumes for LA ROV maintenance.

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 remain in the common product supply header (PS).

The dedicated ESD-1 valves:

- (a) should be on the edge of the jetty platform to maximise the distance to the manifold, so that the manifold can be isolated from the loading lines in the event of damage due to maintenance activities or fire;
- (b) shall be protected against mechanical damage e.g. as a result of crane activity;
- (c) shall close within 15 seconds (verified by surge pressure calculations) (PS). If the LA ROV incorporates one of the two ESD-1 actuator functions, then the closure time of this ROV can be set at 30 to 60 seconds. The closure speed is not critical for tank overfill protection and the SIL for arm over-extension requires only one (fast closing) ESD-1 valve;
- (d) shall be remote operated fire-safe tight shut-off valves (PS). The valves may be either pneumatically or hydraulically operated but in either case shall be 'fail-safe', i.e. close automatically on loss of actuating power (PS);
- (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 not be provided with hand wheels or lever operators (PS);
- (g) shall be protected from fire by fireproof insulation of actuator, cabling and hydraulic lines (PS).

3.2.2 ESD-1 valves in vapour return line

The SIL for this function requires one ESD-1 valve, which can be incorporated in the vapour return LA ROV. 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. If vapour is lost to atmosphere due to a leak at the jetty, the vapour flow towards the jetty cannot be stopped without this isolation valve from shore (which is connected to the onshore tank vapour space).

3.3 EMERGENCY RELEASE SYSTEM (ERS)

The PERC in combination with the DBVs is known as the ERS. The ERS has been developed to uncouple the LAs quickly with minimal spillage in an emergency when the ship or LAs are at risk.

All LPG and LNG loading facilities shall have ERS units installed on all liquid loading and vapour return arms (PS).

The PERC and both DBVs shall be mechanically linked to guarantee that the DBVs are closed before the PERC is released (PS). 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). The use of single-ended rods in the cylinders actuating the PERC and DBVs ensures that no spurious ESD can occur as a result of inadvertently pressurising both sides of the cylinder at the same time.

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 should 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.

NOTE: Adoption of the OCIMF Design and Construction Specification for Marine Loading Arms, in which the DBVs are closed upon ESD-1, has been considered. Upon an ESD-2, a separate cylinder would again close the DBVs but also release the PERC (with mechanical link). However, the ERS in the OCIMF standard would be unnecessarily complex, given the requirement to have at least one ESD-1 valve in the loading line; moreover the LA ROV can easily serve as 2nd ESD-1 valve. It is also advantageous to maintain the ERS as a dedicated ESD-2 function only, hence providing a clear separation from the ESD-1 function.

3.4 LOADING ARMS

3.4.1 Loading arm control modes

The mode selection switch of the loading arm electro-hydraulic control system shall have two positions :

(i) MODE 1 (Freewheeling) - the 'connected' mode used when the loading arm is connected to the ship's manifold

(ii) MODE 2 (Parking/manoeuvring) - the 'drive' mode used when the arm is either parked or being manoeuvred to and from the ship.

3.4.2 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 2.5 metres before the design limit of the mechanical reach of the loading arm.

The proximity switches (GZA H and HH) shall be of 2 out of 3 design, each with its own separate alarm on the DCS.