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MANUAL

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

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DESIGN AND ENGINEERING PRACTICE

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1. INTRODUCTIONS

1.1 SCOPE

This DEP is intended to give guidance on 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) the SIPM Marine Loading Arm Specification
(ii) the OCIMF (Oil Companies International Marine Forum) "Design and Construction Specification for Marine Loading Arms"
(iii) relevant DEP's for structures, piping, instrumentation and equipment.

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

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.

This DEP supersedes Report No. MF 83-0025.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIPM, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors nominated by them (i.e. the distribution code is "C", as described in DEP 00.00.05.05-Gen.).

This manual is intended for use in 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 DEP 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 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 with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party which 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 which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project 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, and on behalf of, the Principal.

The word **Shall** indicates a requirement.

The word **Should** indicates a recommendation.

1.3.2 Specific definitions and abbreviations

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 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 loading arms after closure of both the ERS isolation valves.
ERS	emergency release system; consisting of an ERC and two isolation valves (DBV's), one upstream and one downstream of the coupler.
DBV	double block valves associated with ERS.
ERC	emergency release coupler; required to uncouple the loading arm after initiation of an ESD-2 action.
TOS	test override switch; required to allow testing of initiating devices when the actual ESD-2 and/or ESD-1 action may not occur.
OOS	operational override switch; enables circulation over 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).
MOV	motor operated valve (operated electrically, hydraulically or pneumatically).
HC	hand controlled valve.
DV	dump valve (or Diverter MOV).
PZA	pressure alarm with emergency action.
LZA	level alarm with emergency action.
GZA	apex or slewing angle over-extension alarm with emergency action.
GBS	position indicator.
HZ	push buttons for manual initiation of the ESD-1 and ESD-2 systems.
NRV	non-return valve.
RV	relief valve.
IMO	the International Maritime Organisation.
OCIMF	the Oil Companies International Marine Forum.
SIGTTO	the Society of International Gas Tanker and Terminal Operators.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this manual are made, the referenced

section/paragraph number is shown in brackets. Other standards referenced in this manual are listed in (10).

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, loading arms 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 there is potential for damage to the loading arms or 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 loading arm 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 10 and Appendix 13) 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 manoevring of the loading arm should be inhibited by logic interlocks.

Because of the requirement to stop the flow quickly, surge pressures have to be carefully evaluated and shore and shipboard piping systems designed accordingly.

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.

It should be noted that, in the event of a ship drifting away from the loading jetty, emergency retraction of the access gangway and disconnection of the ship/shore link should also be considered.

2.2 ESD-1, FIRST STAGE EMERGENCY SHUTDOWN SYSTEM

2.2.1 ESD-1 General

The ESD-1 (First Stage Emergency Shutdown System) shuts down the transfer operation in a quick, safe and controlled manner so as to minimise the potential release of liquefied gas or vapour in the event of an emergency.

The ESD-1 is initiated :

- MANUALLY by means of push buttons
- AUTOMATICALLY by means of (emergency) alarm signals received from the transfer facilities

and acts to close valves and stop pumps in the transfer system.

The ESD-1 system should be designed to allow transfer to be restarted with minimum delay after corrective action has been taken.

2.2.2 ESD-1 System components

The ESD-1 system comprises :

(i) ESD valves installed in each of the liquid and vapour lines at a safe location about 70 metres from the jetty head
(ii) push buttons installed at strategic locations in the shore facilities
(iii) a pendant box which will be put aboard a ship prior to commencement of transfer operations for those ships not equipped with a compatible ESD system
(iv) a ship/shore link to convey the shutdown signal to and from the ship for those ships equipped with a compatible ESD system
(v) the ESD-1 logic control system.

2.2.3 ESD-1 Initiation

At ALL terminals :

- From the shore manually by push buttons at various locations and automatically by ESD (emergency) alarm signals.
- From the ship manually from various locations and automatically by ESD (emergency) alarm signals for those ships equipped with a compatible ESD system by means of a ship/shore link.
- From the ship manually by a single push button on the pendant box put aboard the ship prior to loading for those ships not equipped with a compatible ESD system.
- Rupture of the ship/shore link.

2.2.4 ESD-1 Action

The initiation of an ESD-1 will :

(i) close the shore and/or ship ESD valves within such time as is permissible in accordance with the IMO codes and consistent with acceptable surge pressures at agreed maximum pumping rates ;
(ii) stop the shore or shipboard transfer pumps ;
(iii) open the shore pump spillback valves immediately.

2.2.5 ESD-1 Valves

ESD-1 valves installed as part of the ESD system shall be remote operated fail-safe fire-safe tight shut-off valves. ESD-1 valves may be either pneumatically or hydraulically operated but in either case must be 'fail-safe', i.e. close automatically on loss of actuating

power.

ESD-1 valves should be provided with a 'key locked' 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).

The generation of surge pressures on activation of an ESD system is a vital consideration in ship/shore transfer systems as transfer rates may have to be reduced to avoid excessive surge pressures generated by rapid valve closure.

For surge calculation purposes the Effective Valve Closure Time shall be established, being the period over which a given ESD valve reduces the flow from 90 % of its steady state to zero. Typically this occurs during the last 5 % for gate valves, about the last 15 % for butterfly valves and about the last 25 % for ball valves of the Total Valve Closure Time when the valves are installed at the end of a ship/shore transfer system.

Ball valves are recommended for ESD-1 service in view of their relatively smooth closure characteristic in comparison with other types of valve. With a primary soft (PTFE) seal and a secondary (back-up) metal seal, ball valves are also considered to be fire-safe to relevant BS and API codes.

ESD-1 valves shall not be provided with handwheels or lever operators. They shall be provided with hydraulic or pneumatic actuators of the fail-safe spring-to-close type, i.e. actuator with fluid on one side and a spring on the other.

The ESD-1 valves and actuators shall be protected from fire by a spray water system and in addition the actuator, cabling and hydraulic lines shall be protected by fireproof insulation.

2.2.6 Operational Override Switch (OOS)

At terminals handling refrigerated products an operational override switch (OOS) is required to open the ESD valves and allow circulation of cold product over the loading/discharge lines and loading manifold to avoid thermal cycling when the jetty is not occupied.

The OOS overrides the initiation of an ESD-1 action under the following conditions:

(i) absence of a healthy signal from the ship/shore link
(ii) PZA - low-low pressure of the hydraulic oil in the control system
(iii) PZA - low-low pressure of the hydraulic oil in the ERS control system.

All three conditions occur at the end of each loading operation when the ship/shore link is disconnected and the hydraulic oil pumps are stopped.

The OOS shall be interlocked with the 'closed' position signals from all the Loading MOV's to ensure that they are 'closed' before the override allows opening of the ESD valves.

In the case of a terminal with an ESD system serving two jetties an OOS would be required to override the initiation of an ESD-1 action under similar conditions. It would also be required to override the closure of the ESD valves when the handling of a ship at one jetty is terminated whilst a ship is loading or discharging the same product at another jetty.

2.2.7 Loading MOV's

Each loading arm should be provided with motor operated valves as primary isolation at the connection to each product loading/discharge manifold on the jetty head. These 'Loading MOV's should be fitted with proximity switches to indicate when the valves are in the 'closed' and 'not closed' position.

The position signals from the Loading MOV's are incorporated in the safeguarding logic of both ESD-1 and ESD-2.

2.2.8 Loading/discharge lines

Each liquid loading line shall be equipped with two emergency shutdown (ESD) valves mounted in series as close as possible (some 0.5 metres apart) to provide space for the actuators and, additionally, to avoid the requirement for thermal expansion relief). The two valves ensure a smoother shutdown, allow for one valve failing to close and will provide a double block and bleed facility for isolation of the downstream jetty head piping if required.

Liquid discharge lines shall be equipped with at least one ESD valve and a non-return valve.

The ESD valves should be located in a safe area near the jetty head.

This arrangement ensures that, in the event of an emergency at the jetty head, the pipeline contents between tanks and product pipeline ESD valves do not blow down into the area at risk.

During their design, the product transfer lines should be checked for the maximum surge pressure resulting from total closure of the loading arm ERS valves in 5 seconds to determine whether or not a surge drum with associated RV and dump valves are required.

2.2.9 Vapour return lines

It is recommended that each vapour return line is equipped with one ESD valve located in a safe area some 70 metres from the jetty head.

Consideration shall be given to installing a non-return valve as close as possible to the base of the vapour return arm or manifold. This NRV in an export terminal will reduce the risk of vapour release in an emergency when the ESD valve fails to close.

2.3 ESD-2, SECOND STAGE EMERGENCY SHUTDOWN SYSTEM

2.3.1 General

The ESD-2 (Second Stage Emergency Shutdown) system has been developed to uncouple the loading arm/s quickly with minimal spillage in an emergency when the ship or loading arm/s are at risk.

The ESD-2 shutdown is initiated :

- MANUALLY by means of push buttons
- AUTOMATICALLY when the ship moves beyond the design envelope of the loading arm/s and acts to initiate an ESD-1 and, simultaneously, to close the isolating valves in the loading arm/s emergency release system (ERS) and uncouple the loading arm/s.

The ERS is installed when there is potential for damage to the loading arms or the ship due to ship drift under adverse weather or current conditions. For LPG facilities in well protected harbours, where the ship or barge can be securely moored with minimal impact of wind, tide and current, and surge from other ship movements in the vicinity is not a problem, the installation of an ERS is not essential. Apex and slewing angle alarms should however be installed to initiate an ESD-1 action.

2.3.2 ESD-2 System components

The ESD-2 system comprises:

(i) the Emergency Release Coupling (ERC)
(ii) two isolation valves (i.e. the ERS valves), one upstream and one downstream of the ERC. As for the ESD-1 valves, the ERS valves should preferably be ball valves
(iii) the ESD-2 logic control system.

In combination these three items are known as the emergency release system (ERS).

2.3.3 ESD-2 Initiation

The ESD-2 action is initiated manually by push buttons located at manned strategic points in the shore facilities. Manual ESD-2 initiation will uncouple all the loading arms connected to the ship provided each arm is set in the 'Freewheeling' mode and one Loading MOV on the arm manifold is 'not closed'.

The ESD-2 action is initiated automatically by the over-extension signal of the loading arm apex or slewing angle. Automatic ESD-2 initiation will only uncouple the loading arm from which the over-extension signal has been triggered. However, an ESD-1 action for the whole system will be initiated simultaneously if not already initiated by the pre-alarm signal.

It is not necessary to initiate an ESD-2 action manually from the ship since the automatic system will disconnect individual arms as they reach their over-extension limits. The ship/shore link required would also introduce an additional source of spurious trips due to both mechanical failure and human error. LPG terminals should not be provided with manual ESD-2 initiation from on board the ship. However, at LNG terminals where dedicated ships and crews can be expected, provision of manual ESD-2 initiation from on board the ships could be conceived as a special case.

2.3.4 ESD-2 Action

The initiation of an ESD-2 will:

(i) initiate an ESD-1 action in the shore system and also in the ship's systems if a ship/shore link is provided to convey the ESD-1 shutdown signal from the shore to the ship's ESD system;
(ii) close both isolating valves of the ERS;

(iii) uncouple the loading arm after the ERS isolation valves have been closed (interlock);
(iv) activate the shore surge relief system if installed.

2.3.5 Safeguards to prevent accidental activation of ESD-2

Since the weight of the end section of the loading arm together with its ERS valve is substantial, additional safeguards are required to prevent accidental uncoupling (with associated safety hazards) occurring when the arm is parked or being manoeuvred (i.e. not connected to the ship's manifold).

The following provisions shall therefore be included:

(i) push buttons shall be provided for manual activation of ESD action, no switches shall be provided
(ii) all push buttons for manual ESD-2 initiation shall be provided with a protective cover
(iii) each loading arm shall be provided with:
  (a) a mechanical parking/storm lock with:
  - a proximity switch inhibiting manual ESD-2 initiation and to indicate when the arm is in the parked position and the parking/storm lock is secured
  - a hydraulic switch to prevent power to the ERS when the parking lock is properly secured (see Figure 6 - Appendix 11)

  (b) a warning light which shall flash if the parking lock is not properly secured and hence the hydraulic control system of the ERS is live. In consequence the light will also flash during manoeuvring of the arm. However, it shall be switched off automatically when the loading arm is placed in the 'Freewheeling' position (MODE 1) after connection to a ship

  (c) a key operated valve in the hydraulic supply lines to the ERS interlocked with the arm control unit. When the hydraulic supply to the ERS is isolated the key shall be trapped in the valve and the control unit shall be locked in the 'Parking/manoeuvring' position (MODE 2). On connection to the ship, the valve shall be opened allowing the key to be removed and inserted in the control unit enabling the arm to be switched to the 'Freewheeling' position (MODE 1). The key shall be trapped in the control unit when in the 'Freewheeling' position.

(iv) manual initiation of an ESD-2 action shall only be possible if a Loading MOV on the shore side of the loading arm is in the 'not closed' position. Where there is more than one loading arm on a manifold the following shall apply:

  (a) a manual initiation of an ESD-2 action is only possible if one or more of the Loading MOV's is in the 'not closed' position

  (b) no manual initiation of an ESD-2 action is possible when all Loading MOV's on the manifold are in the 'closed' position.

(v) where the loading arm is provided with a hand operated loading valve instead of a MOV, manual initiation of an ESD-2 action shall only be possible if the following two conditions have been satisfied:

  (a) the mode selection switch of the loading arm is in the 'Freewheeling' position (MODE 1)

  (b) the hand operated Loading valve on the loading arm is in the 'not closed' position.

NOTES:
1. Opening of the Loading MOV on a loading arm shall only be possible if the mode selection switch is in the 'Free-wheeling' position (MODE 1), i.e. when the arm is connected to a ship.

2. When the mode selection switch of the loading arm is put in the 'Parking/manoeuvring' position (MODE 2) the Loading MOV on the shore side of the loading arm shall close if it is not already closed.

3. Notes 1 and 2 shall also be valid in the case of a manifold with more than one Loading MOV on the same loading arm (i.e. the loading arm is connected to more than one supply/return line).

4. Installation of a Loading MOV on the shore side of each loading arm is strongly recommended. However in the case of a small terminal where a hand operated valve instead of a MOV is economically justified Item (iv) should be superseded by Item (v).

5. When a hand operated valve is installed on the shore side of the loading arm instead of a Loading MOV, two additional alarms are required to indicate:

(i) when the hand operated valve on the shore side of the loading arm is closed and the mode selection switch is in the 'Freewheeling' position (MODE 1) - an indicator light only

(ii) when the hand operated valve on the shore side of the loading arm is 'not closed' and the mode selection switch is in the 'Parking/manoeuvring' position (MODE 2).

6. The logic schemes (Figures 3, 4 and 5 - Appendices 4, 5 and 6) reflect the situation in a terminal where each loading arm has been equipped with one or more Loading MOV's.

2.3.6 Loading arm excess angle alarms

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

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

(i) Pre-alarm
A proximity switch is set to initiate a pre-alarm and ESD-1 at 2.5 metres before the design limit of the mechanical reach of the loading arm.

(ii) Trip Alarm
If the loading arm is further extended beyond the pre-alarm setting to a position 2.0 metres before the design limit of the mechanical reach, an ESD-2 action shall be initiated. The ESD-2 signal shall initiate an ESD-1 and simultaneously activate the ERS.

The isolation valves in the ERS are normally set to close in 5 seconds and the ERC (Emergency Release Coupling) will open within 2 seconds after closure of the ERS valves. This allows safe uncoupling at a ship drift speed of up to 25 cm/sec. To avoid spurious ESD-2 trips it is necessary to keep the movement of the arm within the limits of the pre-alarm envelope during manoeuvring (MODE 2), the excess angle pre-alarm signals inhibit the hydraulic circuits governing movement beyond the pre-alarm envelope.

Continuous position monitoring systems using microprocessors are being developed by the loading arm manufacturers. These can be programmed to initiate an ESD-1 and ESD-2 in response to the position, rate of drift and acceleration of the loading arm towards the design envelope thus providing an additional degree of protection against overextension. Installation of these systems may be considered but, since they are not fully proven in service, the hardwired proximity switch systems set as above shall be retained.

2.3.7 Multi-purpose arms and piggy-back transfer systems

During the loading/discharge of products, vapour return arms are usually connected to the ship in order to transfer displaced vapours. These arms shall also be equipped with a similar ERS as the liquid loading arms.

A liquid loading arm 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.

In multiple arm installations certain arms may be manifolded for both liquid transfer and vapour return duty, or multiple product transfer. In addition to the ERS system these arms shall each be provided with a Loading MOV at each manifold connection (liquid and vapour). The logic system shall inhibit the opening of a second Loading MOV when one is in the 'not closed' position.

2.3.8 Test Override Switch (TOS)

In order to test the over-extension trip settings of a loading arm and also when the loading arm has to be manoeuvred to a dummy manifold located beyond the pre-alarm and trip limits, the ERS action has to be overridden and a TOS is required.

The function of the TOS is to override:

(i) the restriction on manoeuvring the loading arm beyond the pre-alarm limit (the initiation of an ESD-1 action shall not be overridden)

(ii) the initiation of an ESD-2 action by the excess angle proximity switches (the ESD-2 alarm shall not be overridden).

Where the dummy manifold lies outside the normal operating envelope of the loading arm, the override signal to the ERS from the TOS shall not be cancelled until the arm has been manoeuvred back through the pre-alarm area to within the normal operating envelope.

3. EXPORT TERMINAL EMERGENCY SHUTDOWN SYSTEMS

3.1 ESD-1 AT EXPORT TERMINALS (Figures 1 and 3 - Appendices 1 and 4)

3.1.1 ESD-1 General requirements for Export Terminals

Flow stoppage is achieved by:

(i) fast closure (10-15 seconds) of the two ESD-1 valves
(ii) stoppage of the loading pumps, either instantaneously (preferred because of the lower surge pressure) or via a time delay to ensure line pack (sometimes necessary in hilly terrain).

In order to limit surge pressure effects at the loading pumps, the ESD-1 signal also opens the loading pump spillback valves to divert the liquid back into the tank. To ensure a line pack, a pump may be maintained in operation with a controlled spillback flow.

When a ship/shore link is connected to ships with an ESD system, the ship's manifold valves will be closed within 30 seconds (an IMO Code requirement, i.e. initiation + closure time).

3.1.2 Ship/shore shutdown at Export Terminals

At an export terminal it is important that the ship is able to stop the shore loading pumps and to shut the shore ESD-1 valves, thus achieving a safe emergency shutdown within the design parameters of the shore system. This facility can be achieved by presenting the ship with a pendant box containing a shutdown button connected to the shore ESD-1 system or, preferably, by means of a ship/shore link which interconnects the shipboard and shore ESD signal systems. The ESD-1 action can thus be initiated manually from both ship (via the pendant box or ship/shore link) and shore, automatically from the various shore signals and, if the ship/shore link is provided, automatically from various shipboard signals. Where a ship/shore link is provided, initiation of an ESD-1 signal either from shore or ship will also cause the ship's manifold valves to close.

Although there is no universally recognised standard ship/shore link, SIGTTO has proposed a standardised intrinsically safe electrical link system for international adoption (see 11.5 and Figure 8 - Appendix 13). It is recommended that shore ESD systems be designed to incorporate this proposed SIGTTO link for use with compatible ship's ESD systems. A pneumatic ship/shore link is shown in Figures 1,3,4 and 7 (Appendices 1, 2, 5 and 12), the disadvantage of a pneumatic link is the relatively long response time.

3.1.3 Manual initiation of ESD-1 at Export Terminals

ESD-1 will be initiated manually from the shore by push buttons located at:

(i) the approach to the jetty trestle
(ii) the jetty control room/cubicle and/or the jetty head
(iii) the main control room.

ESD-1 will be initiated manually from the ship by push buttons located as follows:

(i) for ships without a ship/shore link system - from the pendant box brought aboard the ship prior to loading and placed in a safe location e.g cargo control room
(ii) for ships equipped with a ship/shore linked ESD system - at various locations on board the ship.

The ship/shore link will normally carry the ESD-1 signal only (refer 3.3.3 and 4.2.2).

3.1.4 Automatic initiation of ESD-1 at Export Terminals

ESD-1 will be initiated automatically by ESD signals from the shore in case of :

(i) low-low pressure in the hydraulic circuit of the common loading arm manoeuvring system
(ii) low-low pressure in the hydraulic circuit of the ERS system of the individual loading arms
(iii) fuse blown in the logic system (after 1 second delay - see 7.2).
(iv) activation of ESD-2
(v) pre-alarm excess angle of loading arm i.e. apex and/or slewing angle
(vi) high liquid level alarm in the surge drum (where provided)
(vii) fire alarm in the terminal area (manual and automatic - 2oo2)
(viii) power failure at the installation (see 5.3).

ESD-1 will be initiated automatically by ESD signals from the ship for those ships equipped with an ESD system and having a ship/shore link connected.

IMO codes (see 10) require initiation of the ships ESD system in the event of:

(i) high level in a cargo tank
(ii) fire detection (fusible links)

Other initiators may be:

- high tank pressure
- power failure
- instrument air failure

NOTE: The PZA on low-low pressure of the nitrogen (N_2) back-up of the hydraulic systems will initiate an ESD-1 action in some terminals. However its function is meaningless as long as the hydraulic oil pumps are working. The latter will maintain the system pressure independently of N_2 pressure. The low-low N_2 pressure shall prevent the initial start-up of a hydraulic pump until an adequate N_2 pre-charge (to be specified for each project) has been established.

3.2 ESD-2 AT EXPORT TERMINALS

3.2.1 ESD-2 General requirements at Export Terminals

In order to achieve maximum protection for the loading arm systems should a ship drift or move away from the berth during loading, the loading arm should uncouple as fast as possible (typically within 8 seconds). It should therefore be designed for the maximum possible surge pressures at maximum loading rates and the fastest specified ERS Total Valve Closure Time (typically 5 seconds to achieve uncoupling within the subsequent 2 seconds).

3.2.2 Manual initiation of ESD-2 at Export Terminals

The shore personnel will be able to initiate ESD-2 action via protected push buttons located in the same positions as the ESD-1 manual stations (see 3.1.3). ESD-2 cannot normally be initiated from the ship.

3.2.3 Automatic initiation of ESD-2 at Export Terminals

Over-extension signals from the loading arm apex or slewing angles initiate the ESD-2 action automatically on each individual loading arm (see 2.3.3).

3.3 SUMMARY OF EXPORT TERMINAL ESD ACTIONS

3.3.1 ESD-1

- shore ESD (Emergency Shutdown) valves close in 10-15 seconds
- shore loading pumps stop immediately (unless line pack required)

- shore loading pump spill-back valves open immediately
- ship's manifold valves close within 30 seconds, but should be checked to ensure that they are slower acting than the shore valves (see 3.4.1).

3.3.2 ESD-2

- ESD-1 is initiated simultaneously by the ESD-2 signal
- loading arm ERS (Emergency Release System) valves close in 5 seconds
- loading arm uncouples within 2 seconds of ERS valve closure
- dump valve to surge drum opens in 5 seconds (where installed)
- dump valve to surge drum closes 10-15 seconds after ESD-1 initiation, i.e. after closure of ESD valves.

NOTE: If:

Signal response time = x (milli)seconds
ESD Total Valve Closure Time = a seconds
ERS Total Valve Closure Time = b seconds
Dump Valve Total Opening Time = b seconds

and:
ESD-2 is triggered at time t_0

ESD valves are closed at t_0 + (x + a seconds).
ERS valves are closed at t_0 + (x + b seconds).
Dump valve is open at t_0 + (x + b seconds).
Dump valve is closed at t_0 + (x + a + b seconds).

3.4 SURGE PRESSURES GENERATED BY ESD ACTIONS OR SHIP'S MANIFOLD VALVE CLOSURE AT EXPORT TERMINALS

The upper design pressure of the loading system including the liquid loading lines and the liquid loading arms shall at least exceed the maximum possible surge pressure generated at the maximum loading rate and the fastest specified Effective Valve Closure Time of the ESD-1 valves (see 3.2.5 and 3.3.6). SIGTTO have published guidelines on surge protection (see 11.5).

3.4.1 Ship's manifold valves

The International Maritime Organisation (IMO) 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.

At export terminals ship manifold valves should not close faster than the shore ESD-1 valves in order to ensure that the shore piping is not subjected to surge pressures higher than design should the ship's valves close for any reason.

For all vessels calling at the export terminal, the valve types and valve closure times of ship and terminal must be compared during the cargo handling discussions and the loading rate should be adjusted accordingly to prevent surge pressures exceeding the design pressures of the shore and/or the ship's piping systems.

Each terminal should have available graphs indicating the relationship between flow rates and effective closure time of ship's valves. These should also take into account different types of ship's valves in order to determine the maximum allowable loading rate for each particular ship.

3.4.2 Surge relief system

A surge relief system may be provided as an additional protection for the loading arms and manifold system (see Fig. 1 - Appendix 1).

Small terminals with low loading rates do not always require a surge relief system. However, whether a surge relief system is required should always be determined by the outcome of surge calculations executed in the design stage.

The surge relief system consists of a fast opening (5 seconds i.e corresponding to the fast closure time of the loading arm ERS valves) dump valve to a surge drum. The dump valve is opened by the ESD-2 signal and/or a high pressure detection system at the base of the loading arm. Liquid flow is diverted to the surge drum whilst the ERS and ESD-1 valves are closing thus minimising surge. Following closure of the ESD-1 valves the dump valve is closed (see 4.3.2 and 4.4.3).

The dump valve is backed up by a liquid relief valve which will operate if the dump valve fails to open. The relief valve over the dump valve has a double function:

(a) to act as a back-up in case the dump valve fails to open
(b) to protect the piping system against surge pressures created by unilateral closure of the ship's valves.

The relief valve must be designed to avoid the generation of secondary surge pressures exceeding the design pressure of the piping systems on closing and should preferably be located as close as possible to the loading arm ERS valves.

If liquid is diverted into the surge drum, either via the dump valve or the relief valve, a high liquid level sensor will initiate an ESD-1 action. The high level trip setting should be just above the normal liquid level at the bottom of the drum, to ensure that the drum has adequate spare capacity for the flow during ESD-1 valve closure.

Where a surge drum is provided, the vessel can also be used for drainage of the loading arm/s after loading. Hence, the volume of the surge drum should be sufficient to contain the surge volume in addition to the normal operating volume and the volume drained from the liquid arms on completion of loading.

The high level trip action should be of 'fail safe' or 'redundant' design.

3.4.3 Summary of Surge Relief Actions

- dump valve to surge drum opens in 5 seconds on ESD-2 signal
- dump valve to surge drum opens immediately by high pressure detection signal if the ship's manifold valves close unilaterally (the response of the dump valve shall be fast enough to cope with the actual closure time of the ship's manifold valves)
- if the dump valve fails to open, the parallel liquid relief valve opens either under ESD-2 conditions or upon unilateral ship's valve closure
- liquid level sensor in the surge drum acts to initiate an ESD-1
- following closure of the ESD-1 valves, the dump valve closes (i.e. 10-15 seconds after ESD-1 initiation).

4. IMPORT TERMINAL EMERGENCY SHUTDOWN SYSTEMS

4.1 ESD-1 AT IMPORT TERMINALS (Figures 2 and 4 - Appendices 3 and 5)

4.1.1 ESD-1 General requirements at Import Terminals

Flow stoppage is achieved by :

(i) closure of the ship's manifold valves within 30 seconds, either from a shipboard signal or from the shore via a ship/shore link
(ii) simultaneous stoppage of the ship's discharge pumps
(iii) closure of the shore ESD-1 valve/s. These valves should be slow closing (between 30 and 60 seconds) in order to minimise surge pressures in the loading arm.

In order to limit back flow during the shutdown period a non-return valve is installed in the shore line as close as possible to the loading arm. It is assumed that the design of the ship's piping system takes into account the surge pressures generated on activation of the ship's ESD system.

4.1.2 Ship/shore shutdown at Import Terminals

At an import terminal it is important that the shore should be able to stop the ship's pumps and shut the ship's manifold valves, thus achieving a safe emergency shutdown within the design parameters of the ship's system. This facility can best be achieved by means of a hard-wired ship/shore link which interconnects the shipboard and shore ESD signal systems. The SIGTTO intrinsically safe electrical link is described in Reference (see also Figure 8 - Appendix 13). A pneumatic link is shown in Figure 2 - Appendix 3 although the pneumatic link is not recommended in view of the slow response.

With a ship/shore link installed, the ESD-1 action can be initiated from both ship and shore.

4.1.3 Manual initiation of ESD-1 at Import Terminals

ESD-1 will be initiated manually from :

(i) various locations on the ship (or via the pendant box)
(ii) various locations on the shore via the ship/shore link e.g.
- the approach to the jetty trestle
- the jetty control room or cubicle
- the main shore control room
- the jetty head.

4.1.4 Automatic initiation of ESD-1 at Import Terminals

ESD-1 will be initiated automatically from the shore, where the ship has been equipped with an ESD system and a ship/shore link, by :

(i) high-high level in the receiving tank/s
(ii) high-high pressure in the receiving tank/s
(iii) low-low pressure in the hydraulic circuit of the common loading arm manoeuvring system
(iv) low-low pressure in the hydraulic circuit of the ERS system of individual loading arms
(v) fuse blown in the logic system
(vi) activation of ESD-2
(vii) pre-alarm loading arm excess angles (apex or slewing)
(viii) fire alarm at the jetty.

ESD-1 will be initiated automatically from a ship equipped with an ESD system. Some typical events which may initiate an automatic ESD-1 action from a ship are :

(i) power failure

(ii) instrument air failure
(iii) fire detection or alarm on board ship.

4.2 ESD-2 AT IMPORT TERMINALS

4.2.1 ESD-2 General requirements at Import Terminals

Loading arm uncoupling should occur as quickly as possible. In the case of import terminals the effect of fast closure of the ERS valves on the ship's systems must be evaluated. As the ship's piping systems are relatively short, loading arm ERS valve closure times of 5 seconds may not give rise to surge pressures exceeding the design pressure of the shipboard piping systems. However, each ship calling at a terminal must be investigated and appropriate action taken if necessary.

NOTE: If the pressure rating of the ship's piping is lower than the surge pressure created by 5 seconds ERS valve closure at maximum discharge rate, the discharge rate shall be reduced in order to lower the surge pressure to a level consistent with the pressure rating of the ship's piping (see 4.4).

4.2.2 Manual initiation of ESD-2 at Import Terminals

See 3.2.2.

4.2.3 Automatic initiation of ESD-2 at Import Terminals

See 3.2.3.

4.3 SUMMARY OF IMPORT TERMINAL ESD ACTIONS

4.3.1 ESD-1

- ship's manifold valves to close within 30 seconds after initiation.
- shore ESD-1 valves to close in between 30 and 60 seconds.
- ship's pumps to be stopped instantaneously.

4.3.2 ESD-2

- loading arm ERS valves to close in 5 seconds after initiation
- loading arm uncoupling occurs within 2 seconds of ERS valves closure
- ESD-1 is initiated simultaneously with the ESD-2 signal together with the ship's ESD via the ship/shore link (where compatible).

4.4 SURGE PRESSURES GENERATED BY SHORE VALVE CLOSURE

Surge pressures could be generated by closing the ESD-1 valves or another shore valve whilst the ship's pumps are still in operation and the ship's valves are open.

The minimum allowable effective closure time of the shore ESD-1 valves which does not result in surge pressures exceeding the design pressure of the shore and/or ship's piping systems shall be determined during the design phase.

It shall be assured that once this maximum allowable effective closure time has been set for the ESD-1 valves, it is impossible for any other shore valve to be closed faster.

4.5 SURGE PRESSURES GENERATED BY A TRIP OF SHIP'S PUMPS

During the design phase of the terminal it shall be investigated whether a trip of the ship's discharge pumps could generate surge pressures exceeding the design pressure of the shore and/or ship's piping systems in case of a difference in elevation of the piping systems. If so the design pressure shall be adapted.

The piping systems shall also be designed to cope with the transient forces generated as a result of surge pressures. Where these phenomena have not been investigated during the design phase and the possibility of generating surge pressures exceeding the design pressure of the shore and/or ship's piping systems exists, the discharge rate shall be reduced to a level such that the surge pressure does not exceed the design pressure during a trip of the ship's pumps.

Hence, as for export terminals, the valve types and valve closure times of ship and terminal shall be compared during the cargo handling discussions and discharge rates adjusted accordingly to prevent surge pressures exceeding the design pressures of the shore and/or ship's piping systems.

5. LOADING ARMS

5.1 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.

5.2 MOVEMENT OF LOADING ARM ON EMERGENCY RELEASE

In the event of an uncoupling of the emergency release coupler, the loading arm shall move free of the superstructure of the ship and back to a position behind the compressed jetty fender line.

5.3 MAINTAINED CAPABILITY OF HYDRAULIC CONTROL SYSTEM UNDER DEFINED FAULT CONDITIONS

Total Failure of:	ERS actions still possible:	Time available to execute actions:
AC power	1. Automatically by the over-extension signals of apex and slewing angle 2. Manually by the ESD-2 push buttons	Minimum 3 hours [1)]
DC power (vital power)	Only manually by button on selected solenoid valve	Unlimited [2)]
AC + DC power	Only manually by button on selected solenoid valve	Minimum 3 hours [3)]

NOTES :
1. The minimum required pressure retention time of the hydraulic circuit of the ERS system of 3 hours is considered to be sufficient to :
   - cure the power failure or,
   - to unbolt the mating flanges at the ship's manifold. This requirement is covered in the specification of the hydraulic system and N_2 backup facility.
2. Provided there is no simultaneous non-availability of the hydraulic system pumps, otherwise minimum 3 hours applies.
3. The requirement of a minimum retention time of 3 hours in the case of AC power failure and AC + DC power failure shall be included in the loading arm specification.
4. A dedicated alarm should be provided to indicate AC and/or DC power failure.

The following items could be considered in order to improve system reliability at some additional capital cost :

(a) the hydraulic power packs to be furnished with two pumps (one operational and one standby)
(b) each pump to have its own electrical power feeder
(c) a hand pump to be included and lined up to the manoeuvring circuit and the emergency release (ERS) circuit
(d) the hydraulic directional valves used in the ERS circuit to be leak proof.

5.4 QUICK CONNECT/DISCONNECT COUPLERS

Quick connect/disconnect couplers (QCDC) should not be used instead of bolted flanges. A loading arm concept with bolted flanges and mechanically interlocked ERS valves and coupling is preferred for system safety and operability reasons. The argument that time is saved during connection/disconnection of (a) loading arm(s) provided with QCDC is usually not valid as sufficient time is normally available for bolting/unbolting during preceding cargo handling/safety discussions and documentation activities prior to departure.

If local conditions dictate the use of QCDC's on loading arms, the following safeguards should be applied :

(a) QCDC on loading arm equipped with ERS

The QCDC fitted to the loading arm should be executed as a self contained unit with a local, manual, hydraulic operator and a mechanical interlock system to eliminate the risk of spill due to system error and also reduce the risk of human error.

The interlock system should be designed to ensure the following :

(i) the initiation of the QCDC disconnection should only be possible if all Loading MOV's on the arm are 'closed'.
(ii) to minimise spillage in the case of inadvertent opening, the disconnection of the QCDC should be linked to the closure of the shipside ERS isolation valve.

(b) QCDC on loading arm NOT equipped with ERS (for Export Terminals only)

The QCDC should be fitted with an integral ball valve mechanically interlocked to prevent disconnection with the valve in the open position. An interlock system to ensure that all Loading MOV's on the arm are 'closed' before initiation of the disconnection should also be considered.

Note: In both cases spillage from the ship's manifold is possible.

NOTES :
1. Refer 3.2.5 Note 1 - opening of the Loading MOV shall only be possible if the mode selection switch is in 'MODE 1' (Freewheeling).

2. Refer 3.2.5 Note 2 - when the mode selection switch is put in 'MODE 2' (Parking/manoeuvring) the Loading MOV on the shore side of the loading arm shall close if it is not already closed.

6. ESD LOGIC SYSTEMS

The most important components of the ESD logic systems are 'AND' ports to which all signals from the installations are connected. In normal operation all incoming signals to the 'AND' port are positive '1' and the output of the 'AND' port is '1'.

If one or more of the incoming signals is interrupted and becomes zero '0', the output from the 'AND' port becomes zero '0' initiating the safety trip actions connected to the 'AND' port output.

An 'AND' port may be equipped with a 'latch' that, once it has been activated, maintains the activated state by feeding back the 'AND' port's own output signal. This can be reset by inserting an 'OR' port in the feedback signal and feeding a reset signal to the 'OR' port from a reset push button.

An 'OR' port will output a positive '1' signal if any of the incoming signals are positive '1'. 'OR' ports are also utilised in the logic systems for operational and maintenance override switching.

6.1 ESD-1 LOGIC SYSTEMS

6.1.1 Main ESD-1 logic system at Export Terminals

Figure 3 - Appendix 4 shows a typical ESD-1 logic system at an export terminal.

All signals from the transfer system, the ESD-2 systems, the ship and push button stations are connected to the main 'AND' port (A). This port is activated if any one of the incoming signals becomes '0' instead of the normal '1'. On activation, the output becomes '0' initiating the safety trip actions of the individual components connected to the ESD-1 output (ESD-1 valves, ship/shore link, pumps and spillback valves).

The main 'AND' port is equipped with a latch (B), reset by a push button (C) located in the main control room.

The incoming signals to the main 'AND' port are provided with condition indicator lights to allow the operator to identify the source of a trip except where alternative indication is available on the control room panels (i.e. ESD-2 and fire alarm).

The incoming signals to the main 'AND' port (A) are :

(i) all shore ESD-1 push buttons - these are connected via a subsidiary 'AND' port (D) and provided with indicators (latched type) in the main control room;
(ii) the high level detection device in the drain/surge drum (when installed);
(iii) the jetty fire alarm;
(iv) the ESD-2 output;
(v) the hydraulic oil low pressure (manoeuvring circuit);
(vi) the ship/shore link;
(vii) the individual loading arms via subsidiary logic systems combining the signals from the apex and slewing angle pre-alarms, ERS hydraulic oil pressure, ERS solenoid power supply and the 'closed' position monitors on the Loading MOV's.

The output signal from the main 'AND' port is connected to :

(i) the ESD-1 valves;
(ii) the ship's ESD system via the ship/shore link;
(iii) the loading pump trip systems (via timers if required for line pack);
(iv) the loading pump spillback valves;
(v) the reset latch;
(vi) control room and jetty head audible and visual alarms.

An operational override switch (OOS) is provided in refrigerated loading systems to open

the ESD-1 valves and allow circulation of the loading lines and manifold between loadings to maintain them in the 'cold' condition. The OOS is interlocked with the individual Loading MOV position monitoring switches to ensure that all the loading arm inlet MOV's are 'closed' when the ESD-1 valves are opened in the absence of a healthy ship/shore signal.

6.1.2 Main ESD-1 logic system at Import Terminals

Figure 4 - Appendix 5 shows a typical ESD-1 logic system as applied to an import terminal.

The basic ESD-1 and loading arm logic are the same as for the export terminal. The differences lie in the process input and output signals.

At an import terminal, each receiving tank or vessel should be provided with high level and high pressure alarms and a MOV on the filling line. These input via 'AND' and 'OR' ports to the main ESD-1 'AND' port to initiate an ESD-1 thus protecting the receiving vessels.

The output from the ESD-1 logic system initiates closure of the shore ESD-1 valves (60 seconds), trips any shoreside booster pumps (if installed) and initiates the ship's ESD shutdown via the ship/shore link.

6.1.3 Loading arm subsidiary logic system

Each loading arm is provided with a subsidiary logic system within the main ESD-1 logic.

The input signals to each subsidiary logic system are :

(i) apex and slewing angle pre-alarms, and Loading MOV 'closed'
- if the apex and/or slewing angle move beyond the pre-alarm setting and the Loading MOV is 'not closed' an ESD-1 action will be initiated.

The apex and slewing angle pre-alarm signals input to an 'AND' port which outputs to an 'OR' port and to the ESD-2 logic system. The 'OR' port also receives a signal from the ESD-2 logic system indicating the position of the Loading MOV valve/s and outputs to 'AND' port (E) which in turn outputs to the main ESD-1 'AND' port (A). Thus if apex and/or slewing angle exceeds the pre-alarm limit and a Loading MOV is 'not closed' an ESD-1 will be initiated. If all Loading MOV's on the arm are 'closed', there is no ESD-1 action but there is a 'pre-alarm' and signal to the ESD-2 logic system.

Note: A loading arm may be connected to more than one supply and/or return line in which case each line shall be provided with a Loading MOV. An interlock system in the ESD-2 logic shall inhibit the opening of more than one valve at any one time.

(ii) common power failure to the 3 solenoids in the ERS hydraulic system of the loading arm inputs to 'AND' port (E).

A separate fuse is required in the supply to each loading arm ERS solenoid system. A 'blown' fuse will initiate an ESD-1 after a 1 second delay. In the event of a power failure the ERS will remain in a 'safe' condition (see Figure 6 - Appendix 11) and the ERS can only be activated by the manual push button on solenoid valve 5.

(iii) low-low pressure in the ERS hydraulic oil systems acts directly to initiate an ESD-1 via 'AND' port (E) except when the operational override switch (OOS) is activated.

6.2 ESD-2 LOGIC SYSTEM

Figure 5 - Appendix 6 shows a typical ESD-2 logic system at a terminal. Within the ESD-2 logic system each loading arm has its own subsidiary logic system controlling the individual arm ERS action and hydraulics. Each arm logic system has input from the 'common' manual ESD-2 push button system on shore and outputs via a 'common' 'AND' port to the ESD-1 logic system (and the dump valve to the drain/surge drum when installed).

6.2.1 ERS solenoid valve system

Figure 6 - Appendix 11 shows the standard arrangement of the solenoid valves on an ERS system.

Closure of the ERS valves and subsequent release of the coupling are controlled by solenoid valves 3 and 1 respectively.

Solenoid 5, 3 and 1 maintain the ERS valves and coupling in the 'normal' position in the event of power failure. Solenoid 5 provides for manual push button activation of the ERS in the event that all solenoids are de-energised. Solenoid 5 does not therefore appear in the ESD-2 logic system as it only plays a role in the event of power failure.

There is an interlock on the hydraulic system which prevents the release of the coupling before the ERS valves have fully closed.

In the event that the ERS unit is fitted with one hydraulic cylinder only, Solenoid 1 and the ERC interlock are not required.

The hydraulic interlock switch for the ERS valves (Note 1) is not required when the valves can only be opened manually.

6.2.2 Loading arm ESD-2 logic system

The primary function of the loading arm ESD-2 logic system is the control of the ERS valves and uncoupling action via solenoids 3 and 1. Various secondary functions are incorporated in the logic system to allow testing, maintenance and safeguarding against accidental uncoupling during operation.

These secondary functions and the signals generated in the logic system are detailed in the following logic diagrams :

(i) Figure 5A - Functioning of Test Override Switch
(ii) Figure 5B - Functioning of Stormlock
(iii) Figure 5C - Functioning of Loading Arm MOV
(iv) Figure 5D - Functioning of Two Position Switch

7. PROCESS CONTROL AND INSTRUMENTATION

7.1 DOCUMENTATION

Amended per Circular 17/99

For the preparation of process engineering flow schemes refer to DEP 32.10.03.10-Gen.
For the design and engineering of instrumentation systems refer to DEP 32.31.09.31-Gen.
Though not considered an integral part of this DEP, further information on instrumented safeguarding systems can be found in Report MF 91-880.

7.2 SEGREGATION OF FUNCTIONS

Each loading arm shall have its own dedicated logic system, which in itself shall be split into ESD-1 and ESD-2 safeguarding sections.

The 2-position (MODE) switch, though integrated in the control system, shall be considered as part of the safeguarding system because it is connected to, and controls, the safeguarding function.

On each loading arm a 'common' fuse shall be installed for solenoid 1, 3 and 5 (see Figure 6 - Appendix 11), to prevent a single fuse or power failure causing an ESD-2.

7.3 AVAILABILITY ASPECTS

The safeguarding functions (ESD-1, ESD-2) shall be designed as fail-safe.
For critical loading arms, e.g. single loading arm arrangements, the redundancy concept (e.g. 2 out of 2) should be applied.
Where feasible, line monitoring techniques shall be considered. The ESD-1, ESD-2 system design shall be approved by the Principal.

8. TESTING OF ESD AND HYDRAULIC SYSTEMS

8.1 GENERAL

Facilities and procedures are defined below for the testing of:

(i) the initiating devices, the final elements and the logic of the ESD-1 system;
(ii) the hydraulic systems;
(iii) the initiating devices, the inhibiting devices, the final elements and the logic of the ESD-2 system.

NOTES:

1. ERS Re-assembly
   The re-assembly/re- installation of ERC and cylinder requires close supervision by skilled personnel.

2. Solenoids
   For Solenoids 1, 3 and 5, a separate fuse is required. Normally no testing is required as the fuse is fail-safe. The system should be checked by removing the fuse which will initiate an ESD-1 action after a 1 second delay.

3. Apex and Slewing angles
   During normal manoeuvring of a loading arm all movement of the arm is stopped at the pre-alarm limit to avoid spurious ESD trips.

   (a) Testing of GZA pre-alarm (apex and slewing angles) can be carried out during manoeuvring as the hydraulic system stops the movement of the arm as soon as the alarm setting is reached.
   (b) Testing of GZA over- extension and trip alarm (apex and slewing angles) can be executed by covering the proximity switches with a metal plate.

4. Drain/surge drum
   The liquid level in the surge drum should be raised to simulate emergency condition and initiate an ESD-1 action. Note that the trip setting should be just above the normal liquid level at the bottom of the drum.

   The volume of the drain/surge drum shall be sufficient to cater for:

   (a) the normal operating volume, plus
   (b) the drainage volume, plus
   (c) the surge volume.

8.2 TEST FREQUENCY

The following test frequencies should be observed:

(i) if the berth is not located in a sheltered area testing to be carried out before each loading;
(ii) if the berth is located in a sheltered area testing to be done once a month;
(iii) the actual 'dry break' of the coupling to be tested twice a year under strict engineering supervision.

Note: A sheltered area is one in which under normal conditions there is no significant movement of the moored ship during loading/discharging.

8.3 OVERRIDE SWITCHES

It is strongly recommended that ESD functions are not overridden for testing whilst a ship is being loaded. This means that:

(i) the ESD functions of one product should not be tested whilst another product is being loaded at a multi-product jetty;
(ii) the ESD functions of a product at one jetty should not be tested whilst a ship is loading the same product at a second jetty.

In the unlikely case of a multi-product jetty being continuously occupied, the period between unmooring of one ship and the mooring of the next ship will provide ample time for testing without the need to override ESD functions.

8.3.1 Test Override Switch (TOS) - see Figures 5 and 5A - Appendices 6 and 7

8.3.1.1 Features of TOS

(a) the TOS is a key-locked switch;
(b) the key can only be removed from or inserted into the switch in position '0' of the switch;
(c) it shall be installed on the panel in the jetty cubicle;
(d) two yellow lights shall flash alternately if the TOS is put in the override position;
(e) as an additional safeguard it shall not be possible to open the Loading MOV's if the key of the TOS is in the 'override' position;
(f) indication that the TOS is activated shall also be provided at the main control room panel.

The maintenance department shall require a permit, issued by the operations supervisor, before the TOS may be used.

8.3.1.2 Need and Use of a TOS

To test the ERS of a loading arm, the loading arm has to be manoeuvred to a dummy manifold. When the dummy manifold is located beyond the pre-alarm limit or beyond pre-alarm and trip limits a TOS is required.

The function of the TOS is to override:

(a) the restriction on manoeuvring the loading arm beyond the pre-alarm limit (the initiation of an ESD-1 action shall not be overridden);
(b) the initiation of an ESD-2 when the loading arm has to be manoeuvred beyond the trip limit to reach the dummy manifold (the ESD-2 trip alarm shall not be overridden) or when a metal plate is inserted to test the proximity switches.

To execute the ERS test, the loading arm will be manoeuvred to its dummy manifold. It will then be connected to the manifold. The 'dry break' of the loading arm coupler is then tested by using the
- 'Test ERS' key.

The override signal to the ERS from the TOS shall not be cancelled in the event that the TOS switch is switched back to the neutral '0' position as long as the loading arm has not been manoeuvred back through its pre-alarm area to within the normal operating envelope.

8.3.2 Operational Override Switch (OOS)

8.3.2.1 Features of OOS

The OOS is a two position switch with a yellow back-light which will light up when the switch is in the override position. It shall be installed on the panel in the main control room.

On Process Engineering Flow Schemes the OOS is indicated as HBS.

8.3.2.2 Need and use of an OOS

In terminals handling refrigerated products the OOS is required to open the ESD-1 valves and allow circulation of cold product over the loading/discharge lines and manifold to avoid thermal cycling. The OOS overrides the initiation of an ESD-1 action under the following conditions:

(a) absence of a healthy signal from the ship/shore link;

(b) PZA - low-low pressure of the hydraulic oil in the control system;
(c) PZA - low-low pressure of the hydraulic oil in the ERS systems.

All three conditions will occur after each loading operation when the ship/shore link is disconnected and the hydraulic oil pumps are stopped.

In the case of a terminal with two jetties an operational override switch (OOS) is required at each jetty to override the initiation of an ESD-1 action under similar conditions. The OOS also is required to override the closure of the ESD-1 shutdown valves when the handling of a ship at one jetty is terminated whilst a ship is still loading or discharging the same product at another jetty.

The OOS is interlocked with the 'closed' position signals from all the Loading MOV's to ensure that they are closed before the override allows opening of the ESD-1 valves.

8.4 TEST PROCEDURES

The test procedure shall provide evidence of the correct functioning of:

(a) the various push buttons, proximity switches and initiating devices such as HZ, PZA, GZA, etc.;
(b) the alarm lights which indicate the initiation of an ESD and/or ERS action;
(c) the shutdown (ESD-1) valves at the start of each loading;
(d) the 'dry break' of the emergency release coupler (ERC);
(e) the DBV isolation valves installed each side of the ERC;
(f) each Loading MOV.

8.4.1 Testing of ESD-1 system

Testing of initiating devices, final elements and logic of the ESD-1 system.

8.4.1.1 Testing of ESD-1 initiating devices

The following devices which will initiate an ESD-1 shutdown action when activated shall be tested:

(a) PZA's on low-low pressure of hydraulic oil - these will be tested each time the hydraulic oil pumps are started and shutdown (before and after each loading);
(b) the ship/shore link - this will be tested each time the link is connected and disconnected (before and after each loading);
(c) GZA's pre-alarms on slewing and apex angles - these may be tested by manoeuvring the arm to its pre-alarm limits;
(d) LZA on high liquid level in the surge drum - this should be simulated to initiate an ESD-1 action;
(e) all fire alarms at jetty (HZ's and PZA's) - these should be simulated to initiate an ESD-1 action;
(f) HZ emergency push buttons at various locations - these will be tested by pushing a button to initiate an ESD-1 action;
(g) EZA on fuse failure to solenoids 1, 3 and 5 - although the fuse is fail-safe, it should be tested by removing it to initiate an ESD-1 action after 1 second delay;
(h) the push button on the pendant box - this should be tested by pushing the button.

8.4.1.2 Testing of ESD-1 final elements

The emergency shutdown (ESD-1) valves will be tested at the start of each loading.

The tightness of the valves should be tested during a normal maintenance shutdown.

8.4.2 Testing of ESD-2 system

Testing of initiating devices, inhibition devices, final elements and logic of ESD-2 systems.

Due to the expertise required and time involved in boxing up the coupling after an actual 'dry break', it is strongly suggested that an actual 'dry break' test of the coupling should be performed not more than twice a year per loading arm.

8.4.2.1 Testing of ESD-2 initiating and inhibiting devices

The following devices which will initiate or inhibit an ESD-2 action when activated shall be tested:

(a) GZA's on over-extension of apex or slewing angle - the proximity switches should be tested by inserting a metal plate to simulate an ESD-2 initiation. The ERS action should be overridden by the position of the test override switch (TOS - Excess Angles).
(b) HZ push buttons for manual initiation of ESD-2 - these will be tested by pushing a button whilst the arms are 'Parked' and observing the indicator lights and alarms.
(c) GBS proximity switches on the Loading MOV's - these will be tested live at the end of each loading. If more than one MOV is involved, testing of the proximity switches may be done with a metal plate.
(d) HS two position switch on the loading arm - this will be tested live during each loading.
(e) GBS proximity switch on loading arm stormlock - this will be tested live during each loading.
(f) Solenoid 3 - will be tested during the ERS valve (DBV) closure test.
(g) Solenoids 1 and 3 - will be tested during the actual 'dry break' of the coupling.
(h) Solenoids 1, 3 and 5 - will be tested by switching off the individual DC power supply. No ERS will occur as the flow of the oil will be reversed twice, i.e. once in solenoid 5 and once in solenoids 1 and 3 on the coupling and ERS isolation valves.

8.4.2.2 Testing of ESD-2 final elements

(a) ERS equipped with two hydraulic actuators, one for the isolation valves and one for the coupler.

    (i) Test of actual 'dry break' - connect the loading arm to a dummy manifold and initiate an ESD-2 by turning the key-locked 'Test - ERS' switch.
    (ii) Test closure of isolation valves and stroke of hydraulic actuators - disconnect the ERC hydraulic actuator from the coupler and simulate an ESD-2 (ERS) test.

(b) ERS equipped with one hydraulic actuator only.

Testing of the closure of the isolation valves and of the stroking of the ERS actuator can only occur during an actual 'dry break' of the coupler which should be restricted to twice a year.

In this case only two directional valves are required (solenoids 3 and 5) and the test switch for solenoid 1 shall be deleted.

8.4.3 Testing of hydraulic system

The hydraulic circuit of the common loading arm manoeuvring system will be tested each time a loading arm has to be manoeuvred to and from a ship.

The hydraulic circuit of the ERS systems of the individual loading arms will be tested during the testing of the initiating devices and final elements.

Tests of the hydraulic valves controlling the movement of the arm following ESD-2 action and the relief valves on the hydraulic systems should be carried out regularly.

8.4.4 Testing of nitrogen accumulator pre-charge

The low pressure alarms will be tested by opening a vent to atmosphere. After the test, the precharge should be re-established.

9. ADDITIONAL ALARMS

The alarm functions which initiate an ESD action at HH or LL should also be equipped with a pre-alarm at H or L. These include:

(a) high liquid level in the surge/drain drum;
(b) low pressure in the hydraulic circuit of the common loading arm manoeuvring system;
(c) low pressure in the hydraulic circuit of the ERS system of the individual loading arms;
(d) high tank level in the shore tank at import terminals;
(e) high tank pressure in the shore tank at import terminals.

Low level in the hydraulic oil tanks should trigger an alarm only (no ESD action involved).

Low pressure of the N2 pre-charge of the hydraulic system shall inhibit the start-up of the hydraulic oil pump(s).

In the case of a small terminal where a hand operated valve is installed instead of a Loading MOV on the loading arm, two additional alarms are required to indicate that:

(i) the hand operated valve is 'closed' when the two-position switch is set in MODE 1 (Freewheeling);
(ii) the hand operated valve is 'not closed' when the two-position switch is set in MODE 2 (Parking/manoeuvring).

9.1 LOCATION OF ALARM LIGHTS

All control, indicator and alarm lights shown in the logic systems (Figures 3, 4 and 5 - Appendices 4, 5 and 6) should be duplicated in the main control room and in the jetty control room.

In the absence of a jetty control room, the lights should be duplicated in the jetty cubicle.

10. REFERENCES

In this DEP, reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

Amended per Circular 17/99

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Instrumentation symbols and identification on Process Engineering Flow Schemes	DEP 32.10.03.10-Gen.
System Cabinets	DEP 32.30.10.30-Gen.
Instrumentation for equipment packages	DEP 32.31.09.31-Gen.
System Cabling	DEP 32.37.20.31-Gen.
The reliability of the loading arm uncoupling via an automatic ESD-2 action	SIPM-MFE Memo No. 232/82
SIPM's Marine Loading Arm Specification. Available from SIPM, MFSH/43.	

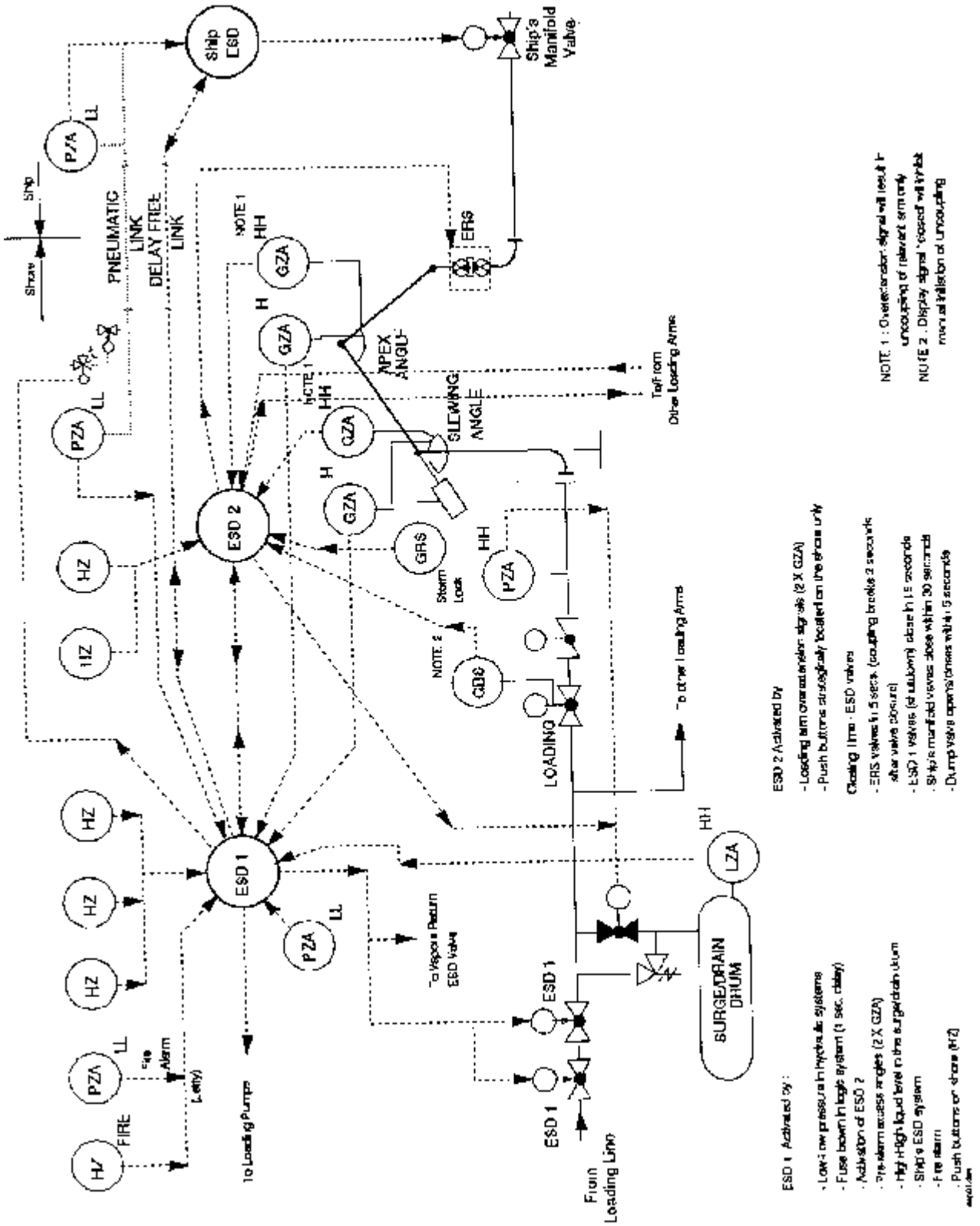
EXTERNAL STANDARDS

Design and Construction Specification for Marine Loading Arms	(OCIMF)
Recommendations and Guidelines for Linked Ship/Shore Emergency Shutdown of Liquefied Gas Cargo Transfer	SIGTTO (1987).
Guidelines for the Alleviation of Excessive Surge Pressures on ESD	SIGTTO (1987).
Code for the construction and equipment of ships carrying liquified gased in bulk (1983 edition including amendments 1 to 4).	IMO

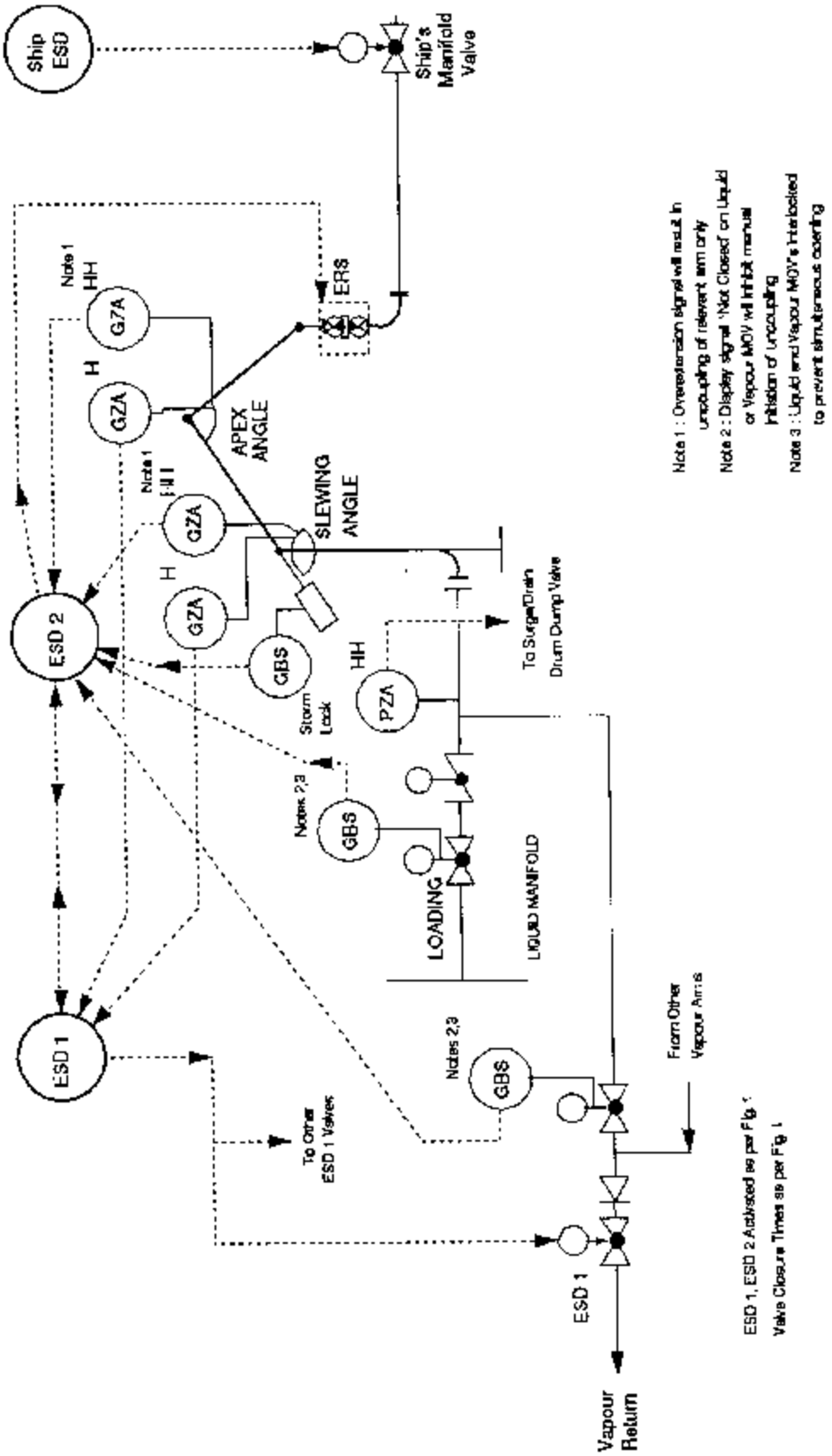
11. APPENDICES

Appendix

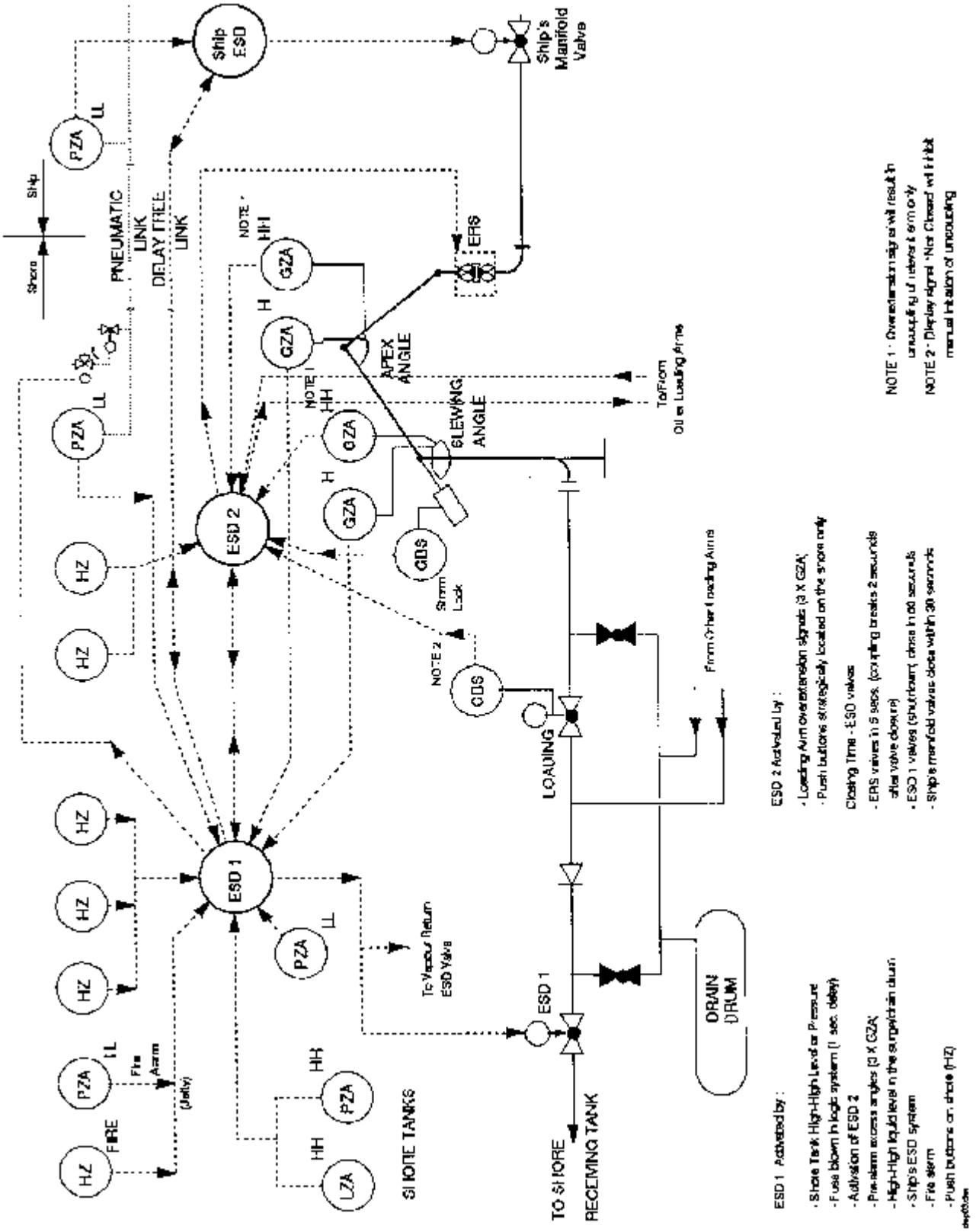
APPENDIX 1 EXPORT TERMINAL - LIQUID ARM



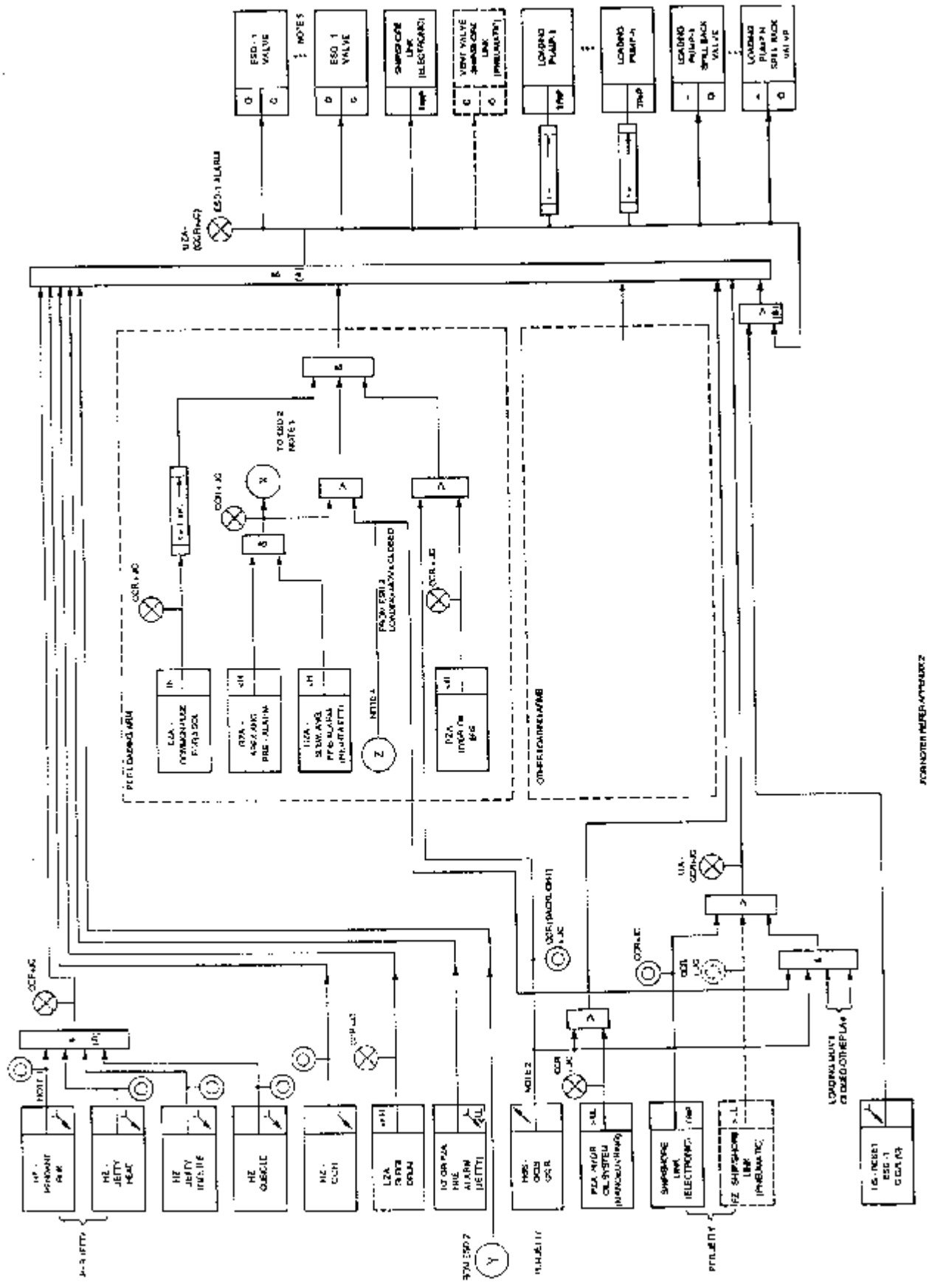
APPENDIX 2 EXPORT TERMINAL - VAPOUR/LIQUID ARM


Ship ESD
Ship's Manifold Valve
ERS
Note 1
HH
GZA
H
GZA
APEX ANGLE
Note 1
HH
GZA
SLEWING ANGLE
H
GZA
ESD 2
GBS
Storm Lock
HH
PZA
To Surge/Drain Drum Dump Valve
Notes 2,3
GBS
LOADING
LIQUID MANIFOLD
ESD 1
Notes 2,3
GBS
From Other Vapour Arms
To Other ESD 1 Valves
ESD 1
Vapour Return
Note 1 : Overextension signal will result in uncoupling of relevant arm only
Note 2 : Display signal 'Not Closed' on Liquid or Vapour MOV will inhibit manual initiation of uncoupling
Note 3 : Liquid and Vapour MOV's interlocked to prevent simultaneous opening
ESD 1, ESD 2 Activated as per Fig. 1
Valve Closure Times as per Fig. 1

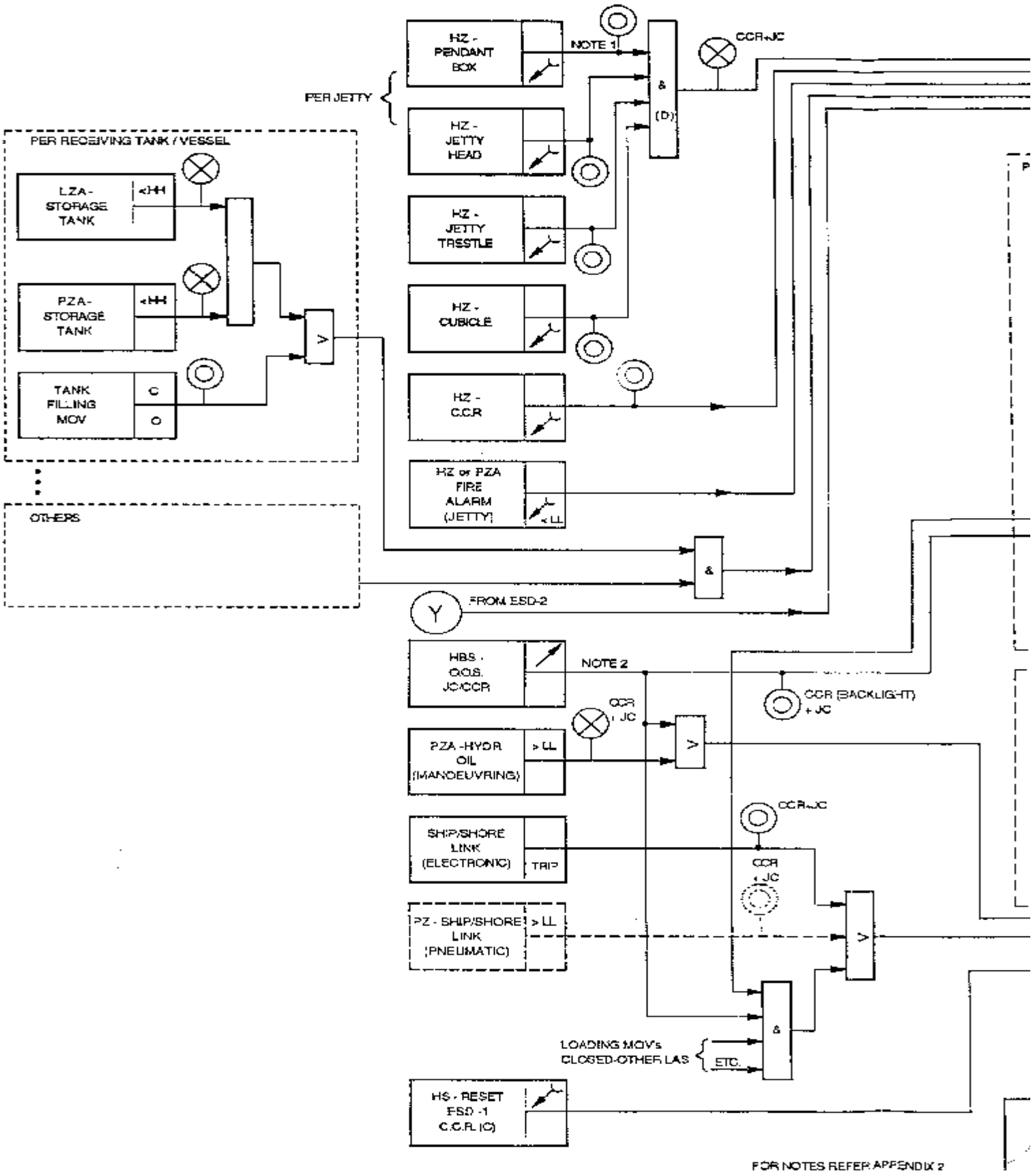
APPENDIX 3 IMPORT TERMINAL - LIQUID ARM

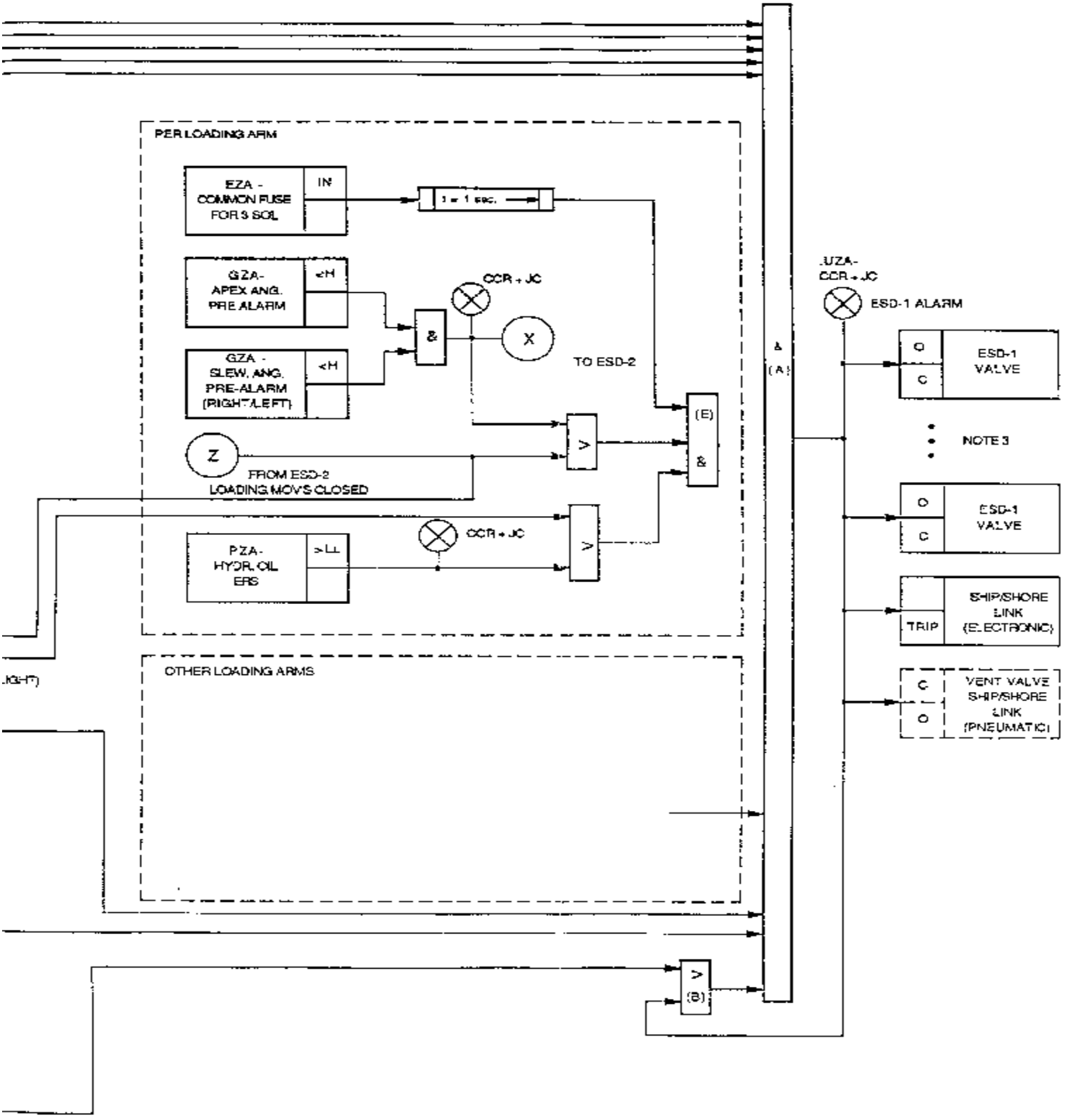


APPENDIX 4 LOGIC DIAGRAM ESD-1 SYSTEM - EXPORT TERMINAL

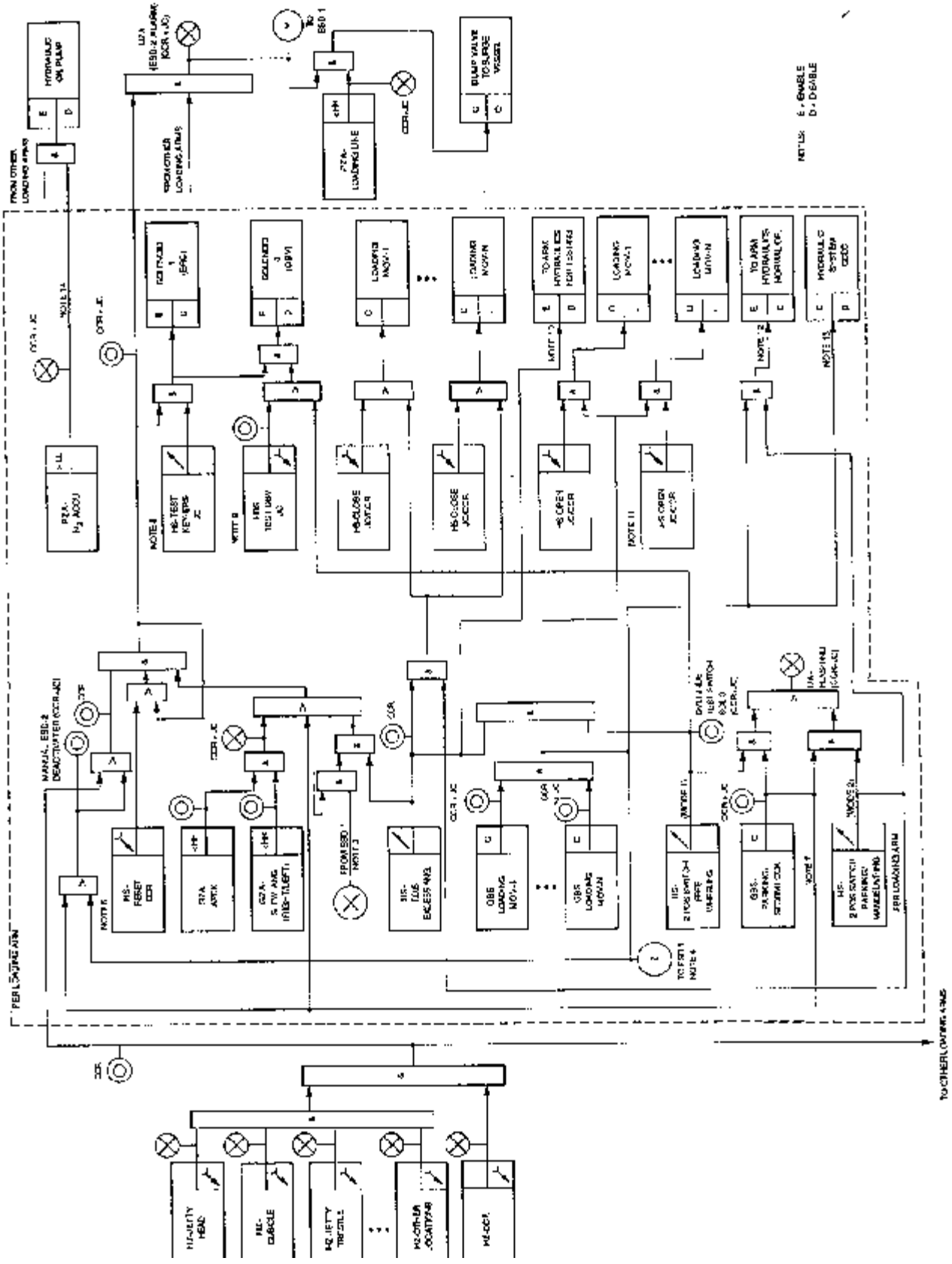


APPENDIX 5 LOGIC DIAGRAM ESD-1 SYSTEM - IMPORT TERMINAL

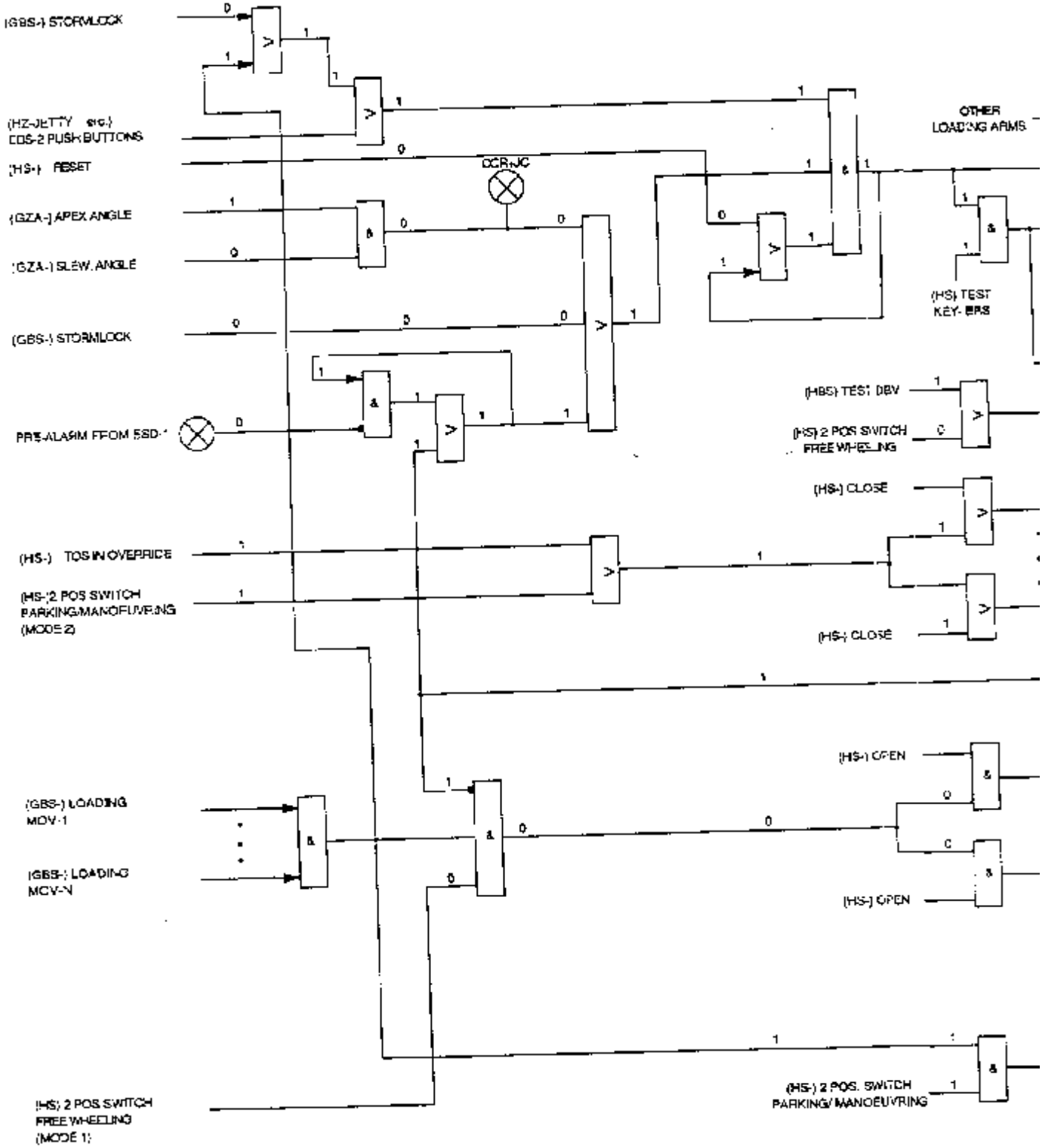

PER JETTY
HZ - PENDANT BOX
NOTE 1
HZ - JETTY HEAD
HZ - JETTY TRESTLE
HZ - CUBICLE
HZ - CCR
HZ or PZA FIRE ALARM (JETTY)
< LL
&
(D)
CCR+JC
PER RECEIVING TANK / VESSEL
LZA - STORAGE TANK
<HH
PZA - STORAGE TANK
TANK FILLING MOV
C
O
OTHERS
FROM ESD-2
HBS - O.O.S. JC/CCR
NOTE 2
CCR (BACKLIGHT) + JC
CCR + JC
PZA -HYDR OIL (MANOEUVRING)
> LL
SHIP/SHORE LINK (ELECTRONIC)
TRIP
PZ - SHIP/SHORE LINK (PNEUMATIC)
LOADING MOVs CLOSED-OTHER LAS
ETC.
HS - RESET ESD -1 C.C.R. (C)
FOR NOTES REFER APPENDIX 2

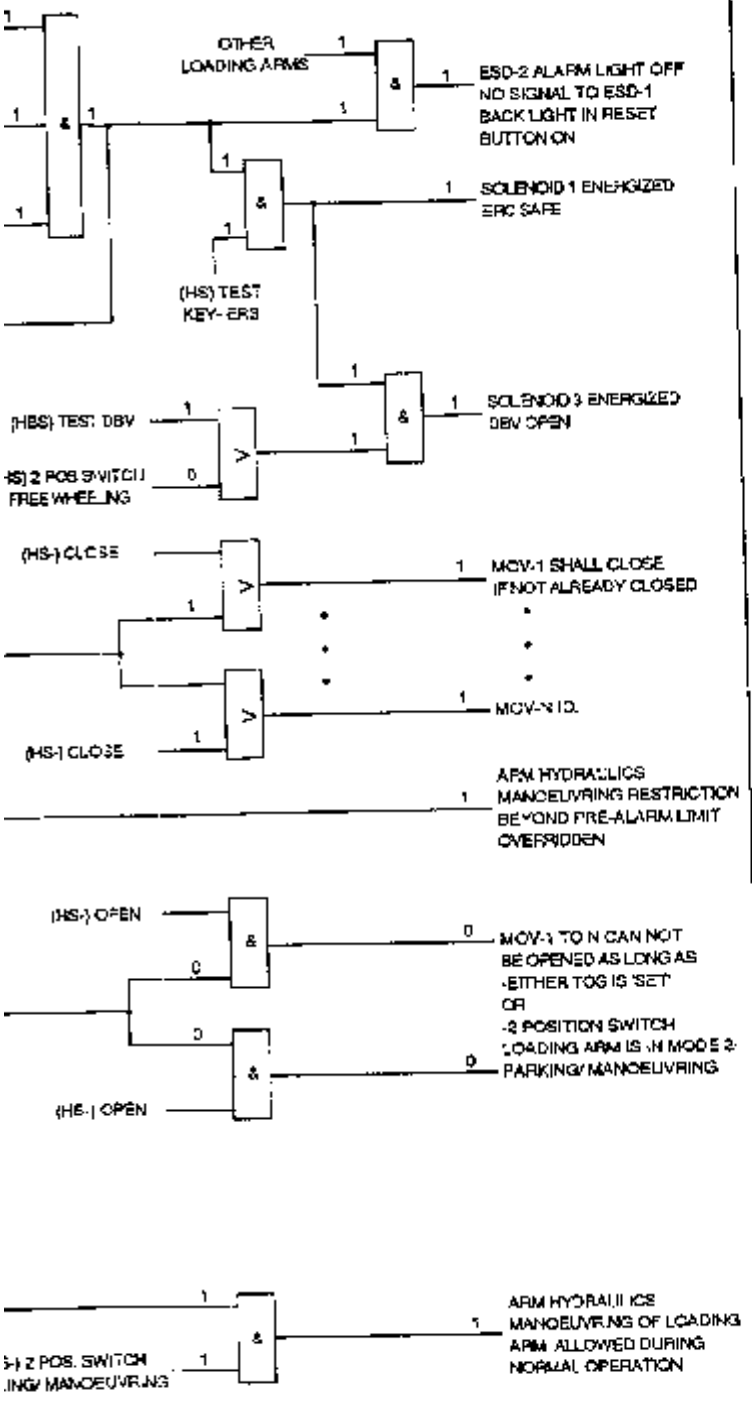

PER LOADING ARM
EZA - COMMON FUSE FOR 3 SOL
IN
t = 1 sec.
GZA - APEX ANG. PRE ALARM
<H
GZA - SLEW. ANG. PRE-ALARM (RIGHT/LEFT)
<H
&
CCR + JC
X
TO ESD-2
Z
FROM ESD-2 LOADING MOVS CLOSED
>
(E)
&
PZA - HYDR. OIL ERS
>LL
CCR + JC
>
OTHER LOADING ARMS
>
(B)
&
(A)
UZA - CCR + JC
ESD-1 ALARM
O
C
ESD-1 VALVE
NOTE 3
O
C
ESD-1 VALVE
TRIP
SHIP/SHORE LINK (ELECTRONIC)
C
O
VENT VALVE SHIP/SHORE LINK (PNEUMATIC)

APPENDIX 6 LOGIC DIAGRAM ESD-2 SYSTEM



APPENDIX 7 FUNCTIONING OF TEST OVERRIDE SWITCH TOS


(GBS-) STORMLOCK
(HZ-JETTY etc.) EDS-2 PUSH BUTTONS
(HS-) RESET
(GZA-) APEX ANGLE
(GZA-) SLEW. ANGLE
(GBS-) STORMLOCK
PRE-ALARM FROM ESD-1
(HS-) TOS IN OVERRIDE
(HS-) 2 POS SWITCH PARKING/MANOEUVRING (MODE 2)
(GBS-) LOADING MOV-1
(GBS-) LOADING MOV-N
(HS) 2 POS SWITCH FREE WHEELING (MODE 1)
OCR-JC
OTHER LOADING ARMS
(HS) TEST KEY- ESS
(HBS) TEST DBV
(HS) 2 POS SWITCH FREE WHEELING
(HS-) CLOSE
(HS-) CLOSE
(HS-) OPEN
(HS-) OPEN
(HS-) 2 POS. SWITCH PARKING/ MANOEUVRING



TESTING OF EMERGENCY RELEASE SYSTEM (ERS)

TO TEST THE ERS THE LOADING ARM HAS TO BE MANOEUVRED TO ITS DUMMY MANIFOLD.
IN CASE THE DUMMY MANIFOLD IS LOCATED BEYOND THE PRE-ALARM LIMIT OR BEYOND PRE-ALARM AND TRIP LIMIT OF THE LOADING ARM EXCESS ANGLES A TEST OVERRIDE SWITCH (TOS) IS REQUIRED TO ENABLE THE MANOEUVRING OF THE LOADING ARM TO ITS DUMMY MANIFOLD.

a) WHEN THE TOS IS PUT IN OVERRIDE POSITION THE FOLLOWING CONDITIONS SHALL BE ESTABLISHED:

(I) MOV OF LOADING ARM SHALL CLOSE WHEN OPEN;
(II) MANUAL ACTIVATION OF ERS NOT POSSIBLE DUE TO CLOSED POSITION OF MOV;
(III) MANOEUVRING RESTRICTIONS AT PRE-ALARM LIMIT CANCELLED BY OVERRIDE SIGNAL OF TOS (ESD-1 ALARM AND ESD-1 ACTION NOT OVERRIDDEN BY TOS)

b) TO EXECUTE THE DRY -BREAK OF THE LOADING ARM COUPLER THE KEY OPERATED TEST SWITCH HAS TO BE PUT IN THE TEST POSITION WHICH SHALL ESTABLISH THE FOLLOWING CONDITION:

ERS ACTIVATED:
- DBV SHALL CLOSE
- ERC SHALL UNCOUPLE

NOTE

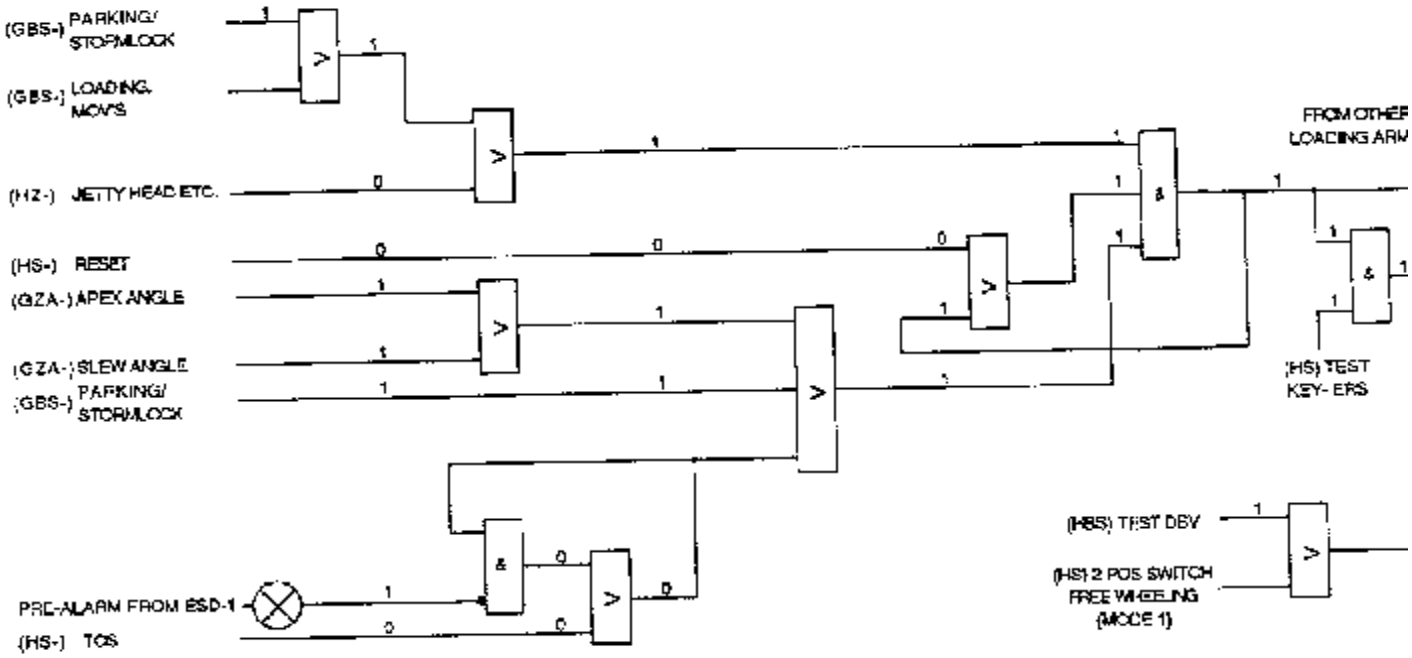
IF TOS IS SWITCHED BACK TO ITS NEUTRAL POSITION WHILST:

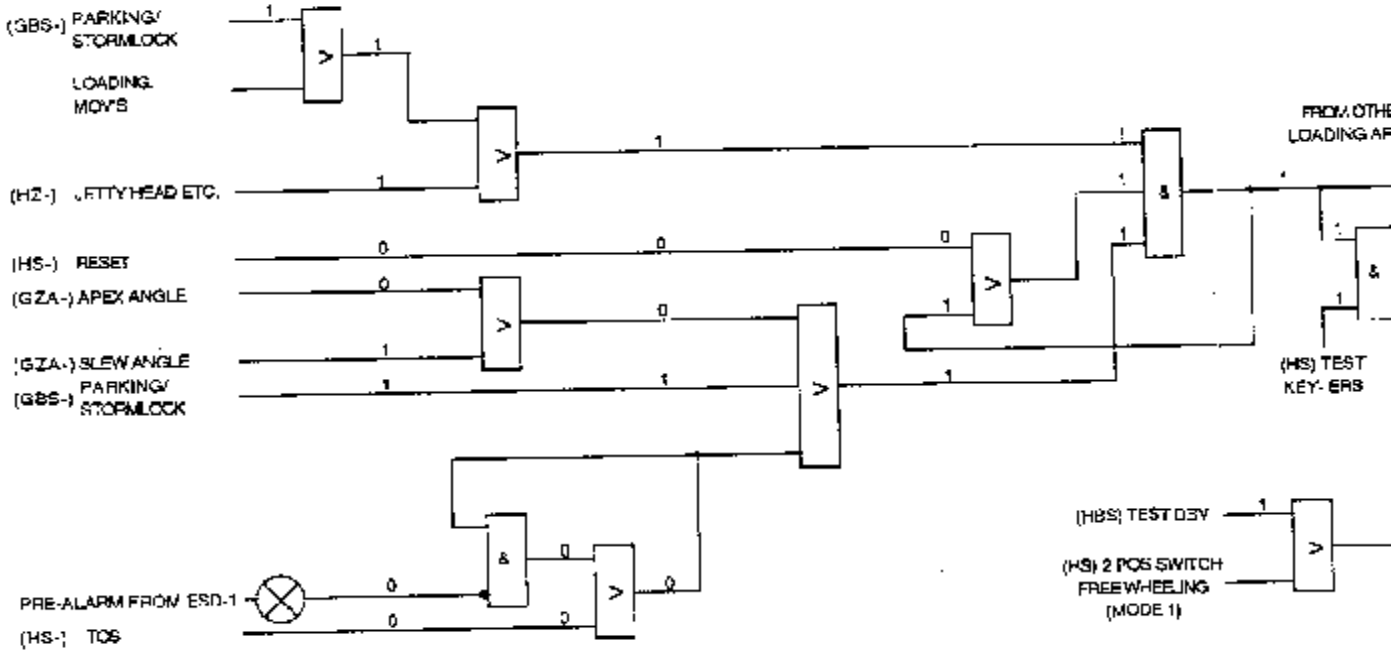
(I) THE LOADING ARM IS CONNECTED TO ITS DUMMY MANIFOLD;AND,
(II) THE DUMMY MANIFOLD IS LOCATED OUTSIDE THE PRE-ALARM LIMIT AND OUTSIDE THE TRIP ALARM LIMIT OF THE LOADING ARM EXCESS ANGLES.

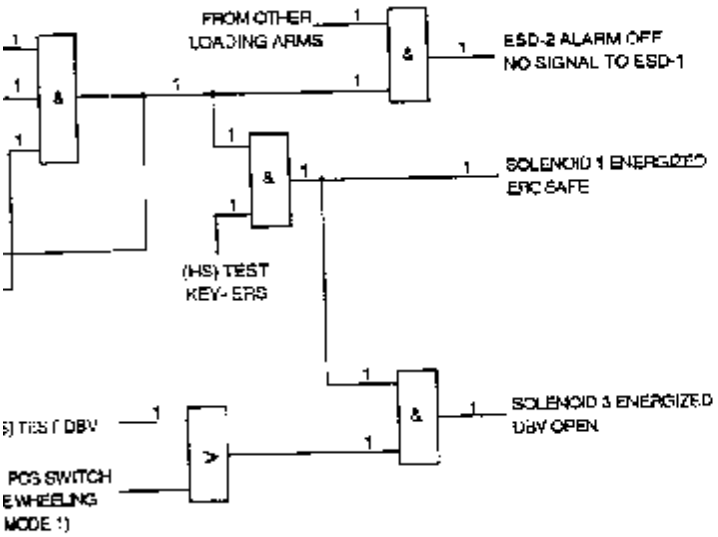
THEN ACTIVATION OF THE ERS SHALL NOT POSSIBLE AS LONG AS THE LOADING ARM HAS NOT BEEN MANOEUVRED BACK THROUGH ITS PRE-ALARM AREA TO WITHIN ITS NORMAL OPERATING ENVELOPE.

THIS FEATURE IS ESTABLISHED BY THE ESD-1 PRE-ALARM SIGNAL (X) ENTERING THE ESD-2 LOGIC.

APPENDIX 8 FUNCTIONING OF STORMLOCK


(GBS-) PARKING/ STORMLOCK
(GBS-) LOADING MOVS
(HZ-) JETTY HEAD ETC.
(HS-) RESET
(GZA-) APEX ANGLE
(GZA-) SLEW ANGLE
(GBS-) PARKING/ STORMLOCK
PRE-ALARM FROM ESD-1
(HS-) TOS
FROM OTHER LOADING ARM
(HS) TEST KEY- ERS
(HBS) TEST DBV
(HS) 2 POS SWITCH FREE WHEELING (MODE 1)


(GBS-) PARKING/ STORMLOCK
LOADING MOVS
(HZ-) JETTY HEAD ETC.
(HS-) RESET
(GZA-) APEX ANGLE
(GZA-) SLEW ANGLE
(GBS-) PARKING/ STORMLOCK
PRE-ALARM FROM ESD-1
(HS-) TOS
FROM OTHE LOADING AR
(HS) TEST KEY- ERS
(HBS) TEST DBV
(HS) 2 POS SWITCH FREE WHEELING (MODE 1)

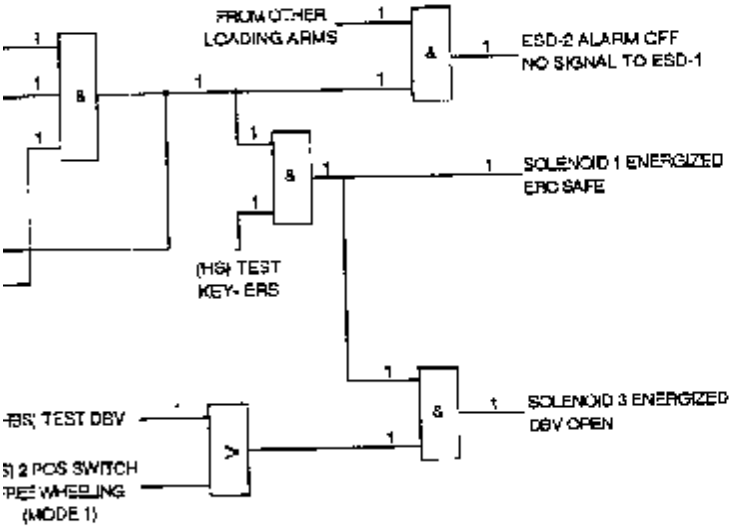


STORMLOCK LOADING ARM CLOSED :

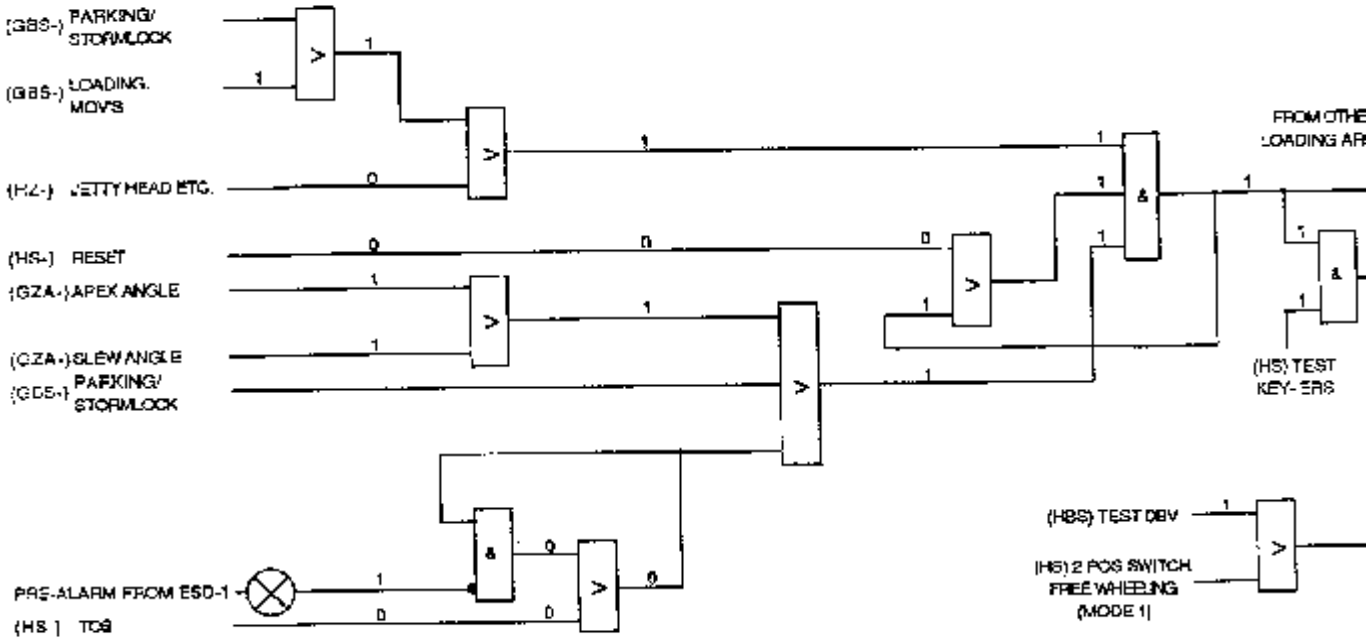
a) MANUAL ACTIVATION OF ERS NOT POSSIBLE

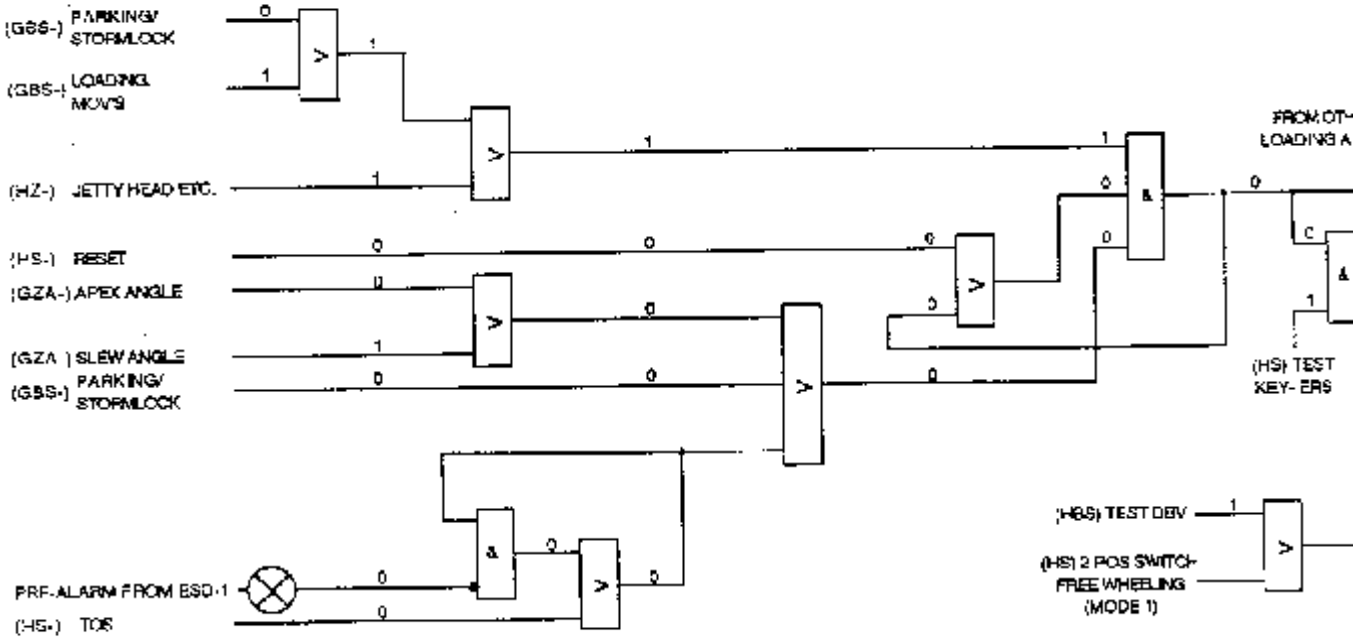
b) AUTOMATIC ACTIVATION OF ERS BY OVEREXTENSION OF SLEWING AND/OR APEX ANGLE NOT POSSIBLE

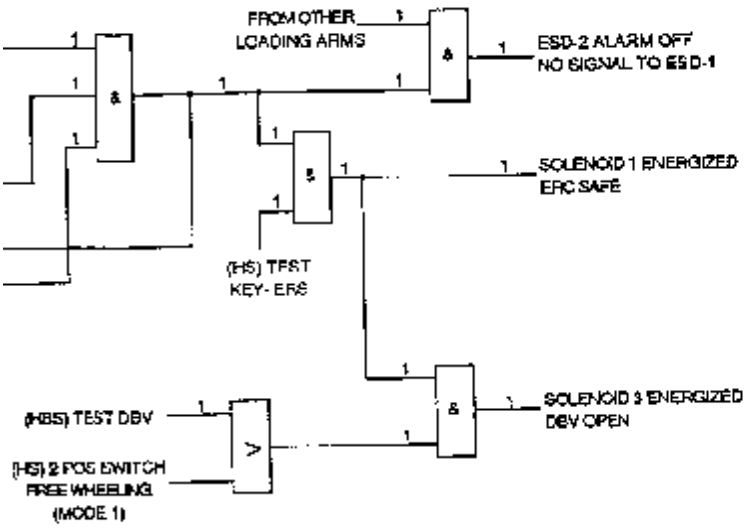
THE STORMLOCK OF THE LOADING ARM SHALL NEVER BE CLOSED WHEN THE LOADING ARM HAS BEEN MANOEUVRED OUT OF THE PARKED POSITION OTHERWISE THE WHOLE ERS SYSTEM IS DEFEATED.



APPENDIX 9 FUNCTIONING OF LOADING MOV


(GBS-) PARKING/ STORMLOCK
(GBS-) LOADING. MOVS
(HZ-) JETTY HEAD ETC.
(HS-) RESET
(GZA-) APEX ANGLE
(GZA-) SLEW ANGLE
(GBS-) PARKING/ STORMLOCK
PRE-ALARM FROM ESD-1
(HS) TOS
FROM OTHE LOADING AR
(HS) TEST KEY- ERS
(HBS) TEST DEV
(HS) 2 POS SWITCH FREE WHEELING (MODE 1)

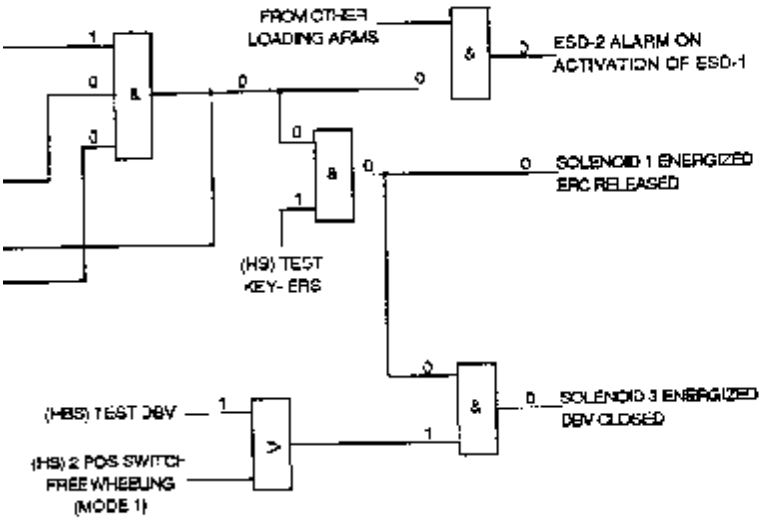

(GBS-) PARKING/ STORMLOCK
(GBS-) LOADING MOVS
(HZ-) JETTY HEAD ETC.
(HS-) RESET
(GZA-) APEX ANGLE
(GZA) SLEW ANGLE
(GBS-) PARKING/ STORMLOCK
PRE-ALARM FROM ESD-1
(HS-) TOS
FROM OT- LOADING A
(HS) TEST KEY- ERS
(HBS) TEST DEV
(HS) 2 POS SWITCH FREE WHEELING (MODE 1)



ALL LOADING ARM MOVS CLOSED

a) MANUAL ACTIVATION OF ERS NOT POSSIBLE

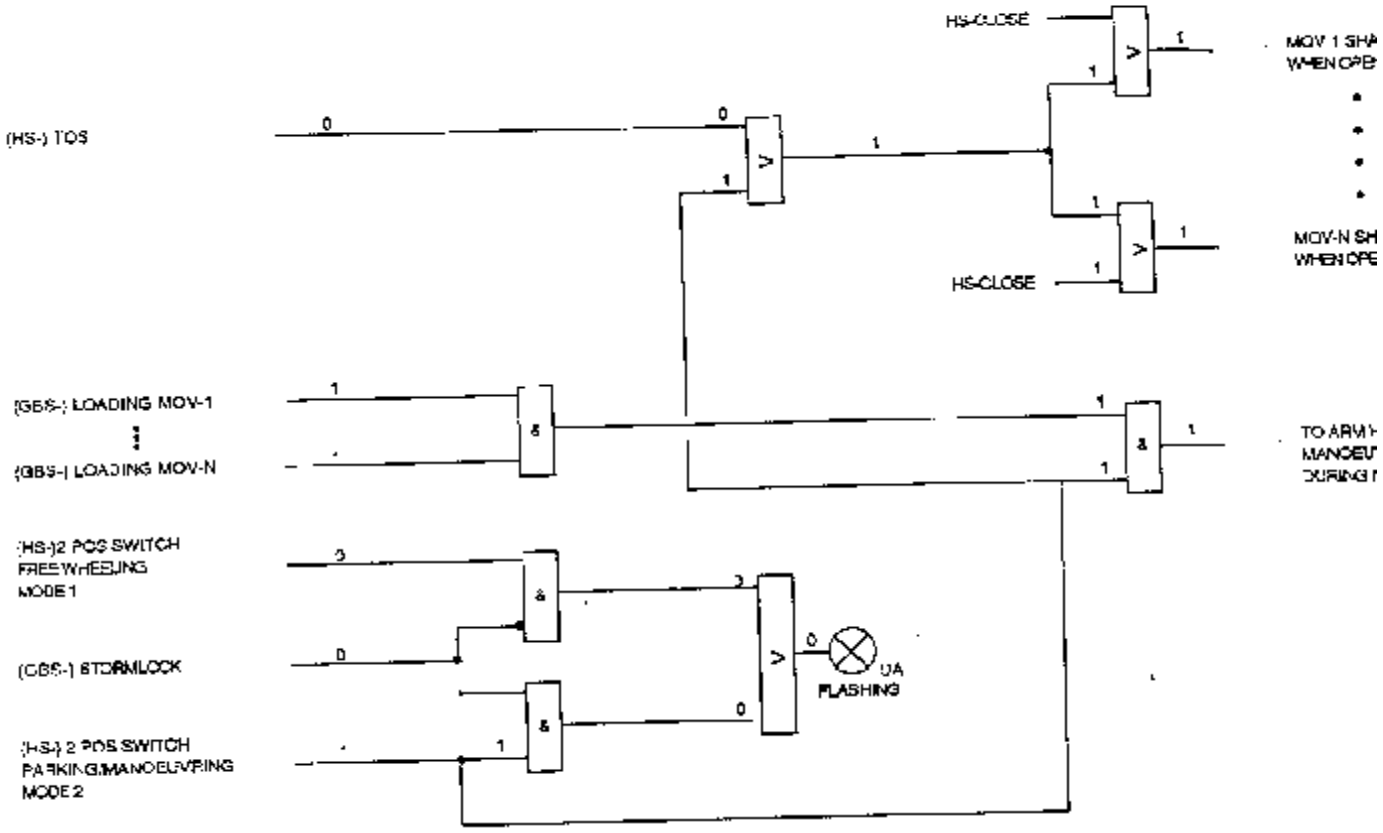
THIS MEANS THAT NO MANUAL ACTIVATION OF AN ERS IS POSSIBLE WHEN THE LOADING ARM IS CONNECTED TO A SHIP IN CASE THE LOADING ARM MOV IS CLOSED
THE POSITION OF THE STORMLOCK IS NOT RELEVANT FOR THIS CASE

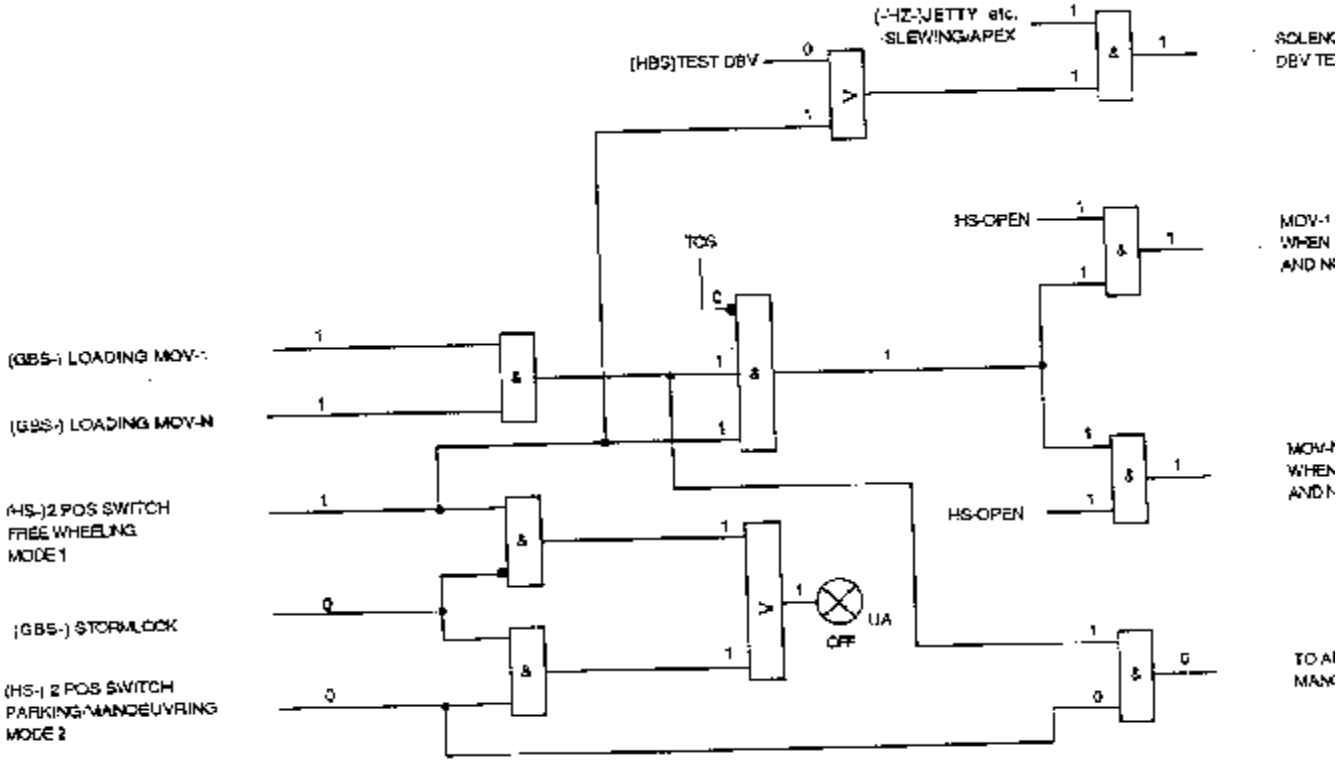


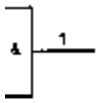
b) AUTOMATIC ACTIVATION OF ERS BY OVEREXTENSION OF SLEWING AND/OR APEX ANGLE STILL POSSIBLE

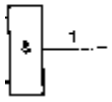
THIS MEANS THAT ACTIVATION OF AN ERS IS POSSIBLE WHEN THE LOADING ARM IS CONNECTED TO A SHIP
AND SLEWING AND/OR APEX ANGLE HAS REACHED ITS OVEREXTENSION LIMIT
THE STORMLOCK MUST BE OPEN.

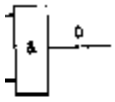
APPENDIX 10 FUNCTIONING OF TWO POSITION SWITCH


HS-CLOSE
(HS-) TOS
HS-CLOSE
(GBS-) LOADING MOV-1
(GBS-) LOADING MOV-N
(HS-)2 POS SWITCH
FREE WHEELING
MODE 1
(GBS-) STORMLOCK
(HS-) 2 POS SWITCH
PARKING/MANOEUVRING
MODE 2
UA
FLASHING


(-HZ-)JETTY etc.
-SLEWING/APEX
(HBS)TEST DBV
HS-OPEN
TOS
(GBS-) LOADING MOV-
(GBS-) LOADING MOV-N
(HS-)2 POS SWITCH
FREE WHEELING
MODE 1
(GBS-) STORMLOCK
(HS-) 2 POS SWITCH
PARKING/MANOEUVRING
MODE 2
HS-OPEN
UA
OFF







a) TWO POSITION SWITCH LOADING ARM IN MODE 2

MODE 2 (MANOEUVRING) SHALL:

(I) ACTIVATE THE FLASHING OF THE ALARM LIGHT WHEN THE STORMLOCK OF THE LOADING ARM IS IN THE 'NOT CLOSED' POSITION;
(II) CLOSE THE LOADING ARM MOV WHEN OPEN;
(III) ENABLE MANOEUVRING OF THE LOADING ARM DURING NORMAL OPERATION.

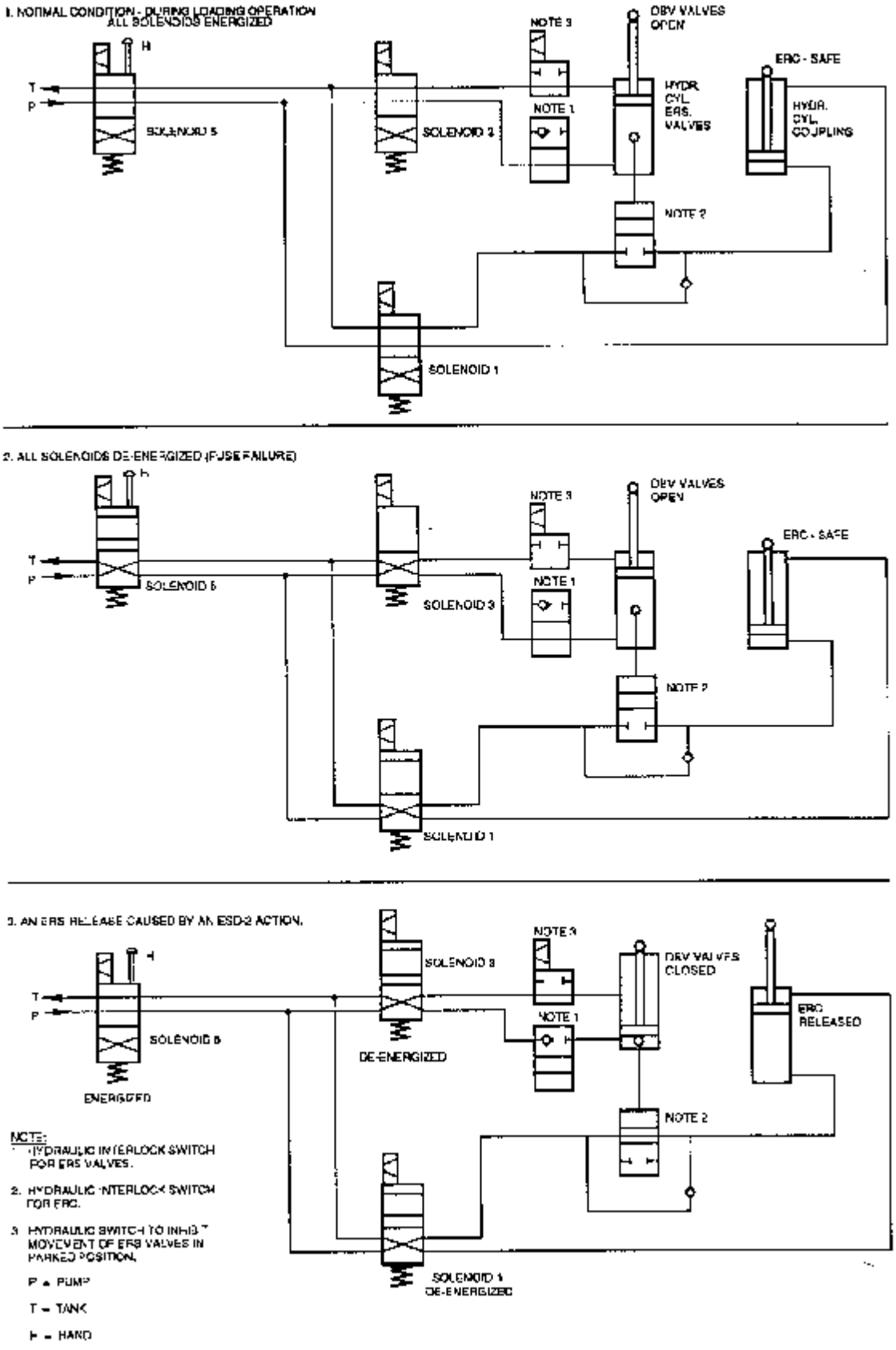
NOTE: THE MANOEUVRING SHALL BE STOPPED AT THE PRE-ALARM LIMIT.

b) TWO POSITION SWITCH LOADING ARM IN MODE 1

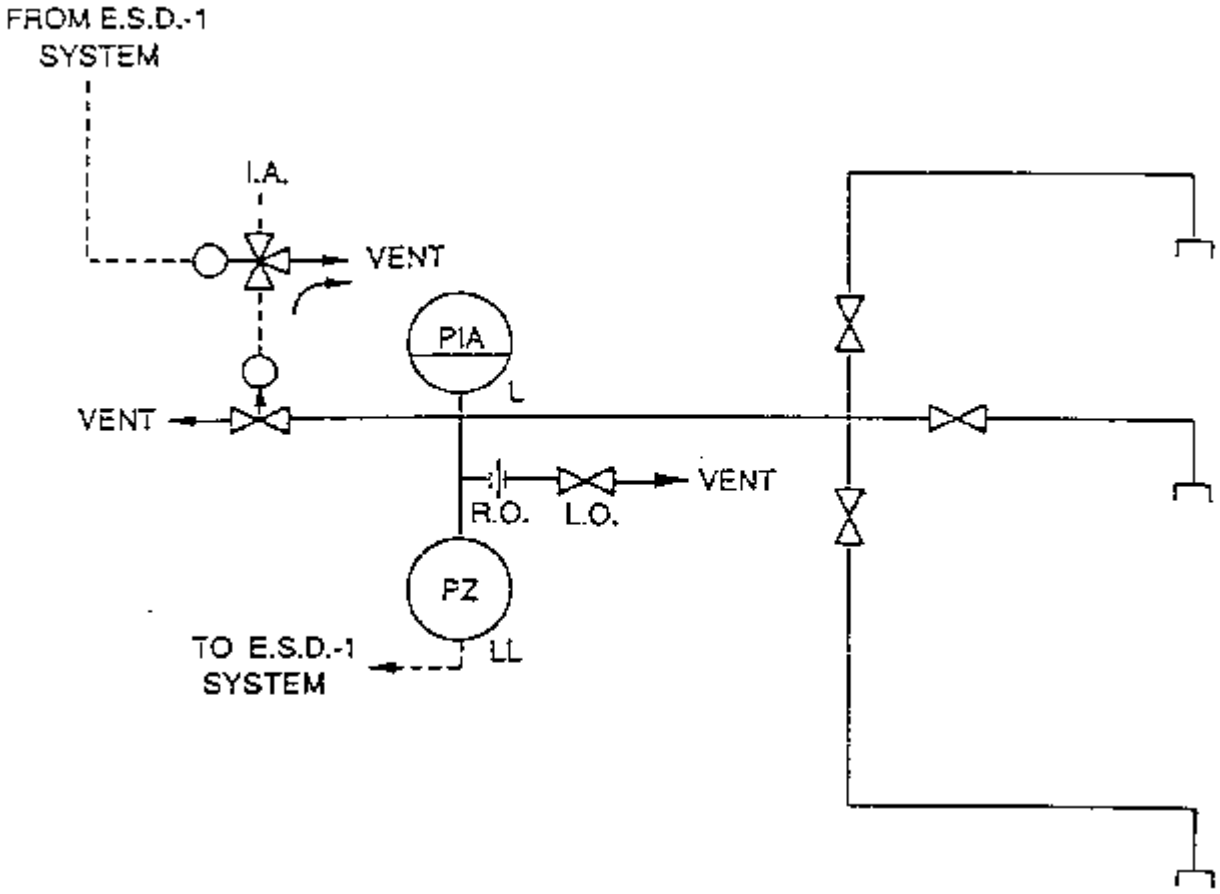
MODE 1 (FREE WHEELING) SHALL:

(I) SWITCH OFF THE FLASHING LIGHT;
(II) OVERRIDE THE ACTION OF THE DBV TEST SWITCH
(III) MAKE IT POSSIBLE TO OPEN ONE LOADING MOV.

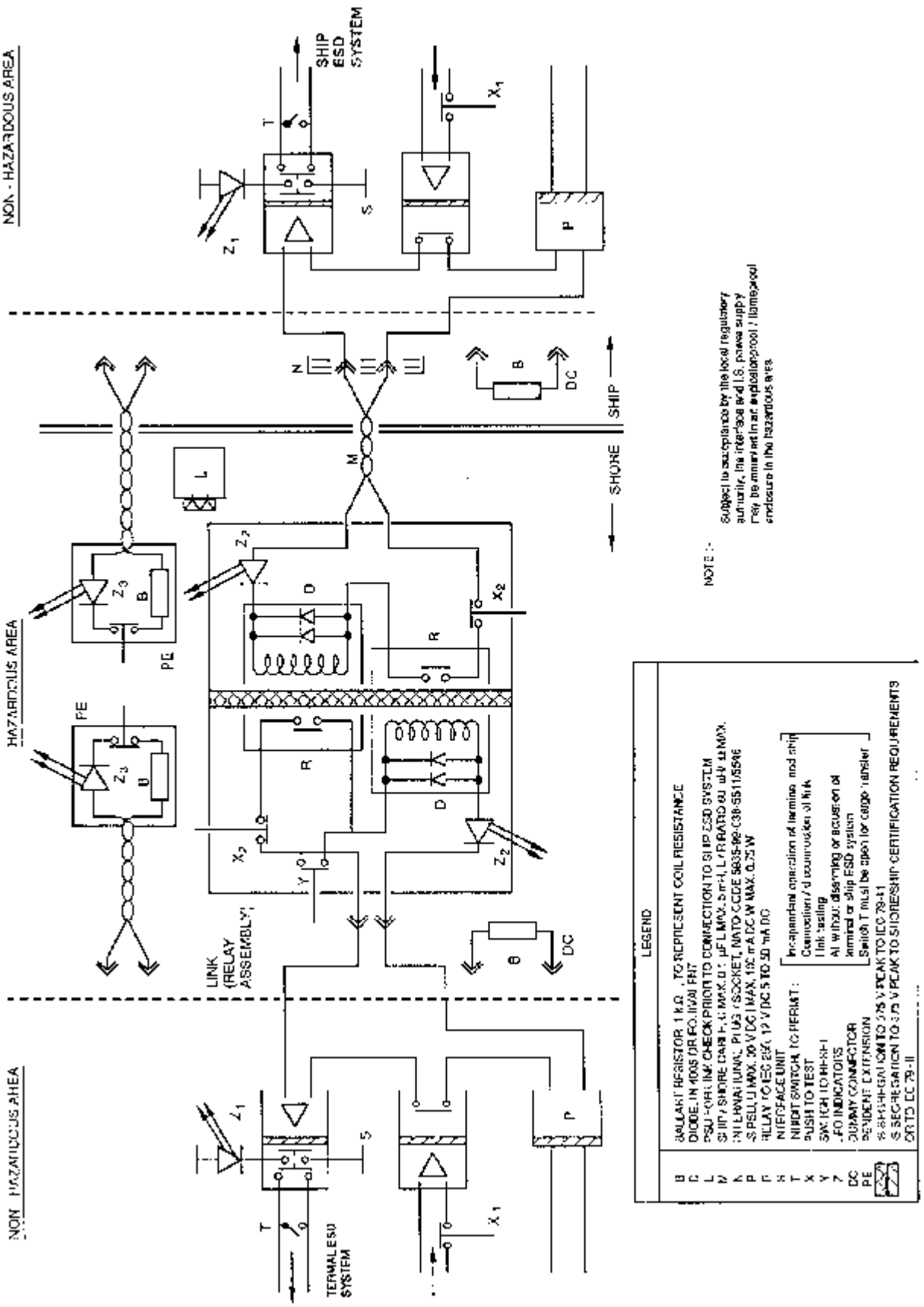
APPENDIX 11 ARRANGEMENT OF SOLENOIDS FOR ERS VALVES AND EMERGENCY RELEASE COUPLER (ERC)


1. NORMAL CONDITION - DURING LOADING OPERATION
ALL SOLENOIDS ENERGIZED
H
T
P
SOLENOID 5
SOLENOID 3
NOTE 3
NOTE 1
DBV VALVES
OPEN
HYDR.
CYL.
ERS.
VALVES
ERC - SAFE
HYDR.
CYL.
COUPLING
NOTE 2
SOLENOID 1
2. ALL SOLENOIDS DE-ENERGIZED (FUSE FAILURE)
H
T
P
SOLENOID 5
SOLENOID 3
NOTE 3
NOTE 1
DBV VALVES
OPEN
ERC - SAFE
NOTE 2
SOLENOID 1
3. AN ERS RELEASE CAUSED BY AN ESD-2 ACTION.
H
T
P
SOLENOID 5
ENERGIZED
SOLENOID 3
DE-ENERGIZED
NOTE 3
NOTE 1
DBV VALVES
CLOSED
ERC
RELEASED
NOTE 2
SOLENOID 1
DE-ENERGIZED
NOTE:
1. HYDRAULIC INTERLOCK SWITCH FOR ERS VALVES.
2. HYDRAULIC INTERLOCK SWITCH FOR ERC.
3. HYDRAULIC SWITCH TO INHIBIT MOVEMENT OF ERS VALVES IN PARKED POSITION.
P = PUMP
T = TANK
H = HAND

APPENDIX 12 PNEUMATIC SHIP/SHORELINK



APPENDIX 13 SIGTTO INTRINSICALLY SAFE ELECTRONIC SHIP/SHORE LINK


NON - HAZARDOUS AREA
HAZARDOUS AREA
NON HAZARDOUS AREA
SHIP ESD SYSTEM
TERMINAL ESD SYSTEM
LINK (RELAY ASSEMBLY)
SHORE
SHIP
LEGEND
NOTE :-

APPENDIX 14 NOTES ON ESD LOGIC SYSTEMS (FIGURES 3, 4 AND 5)

1. Pendant Box (Figures 3 and 4) - only required if the ship does not have a compatible ship/shore link. This may be the case in LPG terminals with non-dedicated shipping.

2. Operational Override Switch (Figures 3 and 4) - overrides the low-low pressure switch in the hydraulic oil system of the loading arm/s, the low-low pressure switch/es in the hydraulic oil supply to the individual ERS units and, if all Loading MOV's are closed, the ship/shore link.

3. Apex and/or Slewing Angle Pre-alarm (Figures 3, 4 and 5) - a signal from the ESD-1 logic of each individual loading arm shall inhibit manoeuvring of the loading arm beyond the pre-alarm limits except when overridden by the TOS in the ESD-2 logic system. The TOS override on ESD-2 action shall remain active until the loading arm is manoeuvred back inside the normal operating envelope.

4. Loading MOV's 'closed' (Figures 3, 4 and 5) - when all Loading MOV's are 'closed' on an arm, the ESD-1 trip on the apex and/or slewing angle pre-alarm of that particular loading arm is overridden. When all Loading MOV's on all arms are 'closed' the ship/shore link may be overridden by the OOS.

5. ESD-1 Valves (Figures 3 and 4) - two valves in series are required in each liquid loading line and one valve in each vapour return line at export terminals. At least one valve is required in each liquid discharge line and vapour return line at import terminals.

6. HS-Reset (Figure 5) - the reset switch is used to reset the ESD-2 condition. This shall only be possible if the loading arm is within the normal operating envelope. The reset switch is located adjacent to the MODE selection switch of the loading arm.

7. Parking/storm lock (Figure 5) - the stormlock of the loading arm shall never be closed when the loading arm has been manoeuvred out of the parked position. The closed position prevents any ERS action.

8. HS - Test-ERS Key - a key operated test switch shall be installed. The test key switch is used to override the TOS and initiate an ERS uncoupling when the loading arm has been connected to the dummy manifold. When the test key is put in the 'test' position, it shall de-energise solenoids 1 and 3, the ERS valves shall close and the loading arm coupler shall disconnect.

9. HBS - Test DBV - this test switch is required to test the closure of the ERS valves upstream and downstream the coupler. If switched to the 'test' position, it shall de-activate Solenoid 3 which shall result in the closure of the ERS valves. The action of this switch shall be overridden when the selector switch of the loading arm is in the MODE 1 (Freewheeling) position.

10. Signal to Arm Hydraulics from TOS - a signal which enables manoeuvring of the loading arm through the pre-alarm area. The MOS is used to override the pre-alarm and trip limits when the dummy manifold (used for testing the ERS) is located beyond the pre-alarm and trip limits of the apex and slewing angles. The ESD-1 and ESD-2 alarms shall not be overridden.

11. Only one Loading MOV on an arm shall be open at any one time. All other Loading MOV's on the arm shall be 'closed'.

12. Signal to Arm Hydraulics from Two-position Switch - a signal which enables manoeuvring of the loading arm (MODE 2). Manoeuvring shall stop at apex and/or slewing angle pre-alarm limits. The enabling signal to the hydraulic system is interlocked to ensure that all Loading MOV's on the arm have been closed.

13. Signal to Hydraulic System of QCDC - a signal which enables coupling or uncoupling

of the QCDC. The enabling signal to the QCDC hydraulic system ensures that all Loading MOV's on the arm have been closed.

14. N2 back-up pressure in the hydraulic systems - the low-low pressure from the N2 back-up in the hydraulic system shall be used to prevent the start-up of the hydraulic pump. The pump shall not start until an adequate N2 pre-charge (to be specified for each project) has been established.

Activation of ERS:

A. Manual activation of ERS is only possible if all the following conditions have been satisfied:
   (a) the Parking/storm lock of the arm is 'not closed'
   (b) a Loading MOV on the arm is 'not closed'
   (c) the two-position switch of the arm is 'not' in MODE 2 (Parking/manoeuvring)
   (d) the TOS is 'not' in the override position
   (e) the key-locked valve in the hydraulic supply to the ERS is 'open'.

B. Automatic activation of ERS is only possible if all the following conditions have been satisfied:
   (a) the Parking/storm lock of the arm is 'not closed'
   (b) the TOS is 'not' in the override position
   (c) the key-locked valve in the hydraulic supply to the ERS is 'open'.