Braemar Technical Services

Cargo Handling and Emergency Shutdown Systems in an LNG cargo vessel - What is the Connection?

By Ray Martyn

20th April 2017
Overview

- Introduction to the Cargo Handling System
- An overview of the Emergency Shutdown System
- How the two systems are interlinked
Introduction to Cargo Handling System

LNGC with Membrane Cargo Tanks
The Key Components of the Cargo Handling System

- Piping
- Valves
- Pumps
- Instrumentations
- Cargo Machinery
- Control System
Introduction to Cargo Handling System

LNGC with Moss Type
Introduction to Cargo Handling System

LNGC with Membrane Cargo Tanks
Introduction to Cargo Handling System

LNGC with Membrane Cargo Tanks

- Compressor Room
- Cargo Machinery
- Cargo Valves
- Instrumentations, Pipes
- Control System
  (in the Cargo Control Room)
- Cargo Tanks
- Cargo Pumps
Introduction to Cargo Handling System

General Arrangement

- Cargo Compressor Room
- Cargo Machinery
- Control System (in the Cargo Control Room)
- Cargo Tanks and Cargo Pumps
- Cargo Valves, Instrumentations, Pipes
Introduction to Cargo Handling System

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Introduction to Cargo Handling System

Cargo Handling System mimic
Introduction to Cargo Handling System

LNGC with Membrane Cargo Tanks

- Compressor Room
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Introduction to Cargo Handling System

Loading Point, Manifold Valves and Pipes

- Pipes
- Manifold Valves
- Loading Point
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Cargo Dome Area

- Pipes
- Instrumentations
- Valves
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Cargo Vapour Area and the Vent Stacks

Vapour Area

Vent

Cargo Compressor Room (Cargo Machinery)
Introduction to Cargo Handling System

Cargo Pump - Illustration
Cargo Pumps - In Situ

- Cargo Pumps
- Stripping/Spray Lines
- Emergency Cargo Pump is inside this pipe
- Loading Pipe
Radar Gauge, Pressure and Temperature Sensors
Introduction to Cargo Handling System

Radar Gauge and Pressure Sensors
Introduction to Cargo Handling System

Temperature Sensors
Introduction to Cargo Handling System

Outstation Mimic Showing the Cargo Tank, Cargo Pumps, Cargo Valves, Cargo Level, Pressure and Temperature.
Introduction to Cargo Handling System

Cargo Operation

- Post Dry Dock Operation
- Ballast Voyage
- Loading
- Loaded Voyage with Boil-Off Gas Burning
- Discharging
- Pre-Dry Dock Operations

The cargo operations can be summarised using a functional diagram.
Introduction to Cargo Handling System

Cargo Operation - Functional Diagram

- Post Dry Dock Operation/Ballast Voyage

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Dry Dock
  Barrier Tests
  Inerting Insulation Spaces
  Drying Cargo Tanks
  Inerting Cargo Tanks
  Gassing-up Cargo Tanks
  Cooling Down Cargo Tanks

Ballast Passage
  Cooling Down Before Arrival
  Spraying Before Arrival

Ready for Loading
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Introduction to Cargo Handling System

Cargo Operation - Functional Diagram

- Loading and Laden Voyage

- Ready for Loading
- Cool Down
- Loading
- Laden Voyage
- Natural/Forced Boil Off
- Preparation for Unloading
- Ready for Discharging
Introduction to Cargo Handling System

Cargo Operation - Functional Diagram

- Discharging (Unloading)

- Ready for Discharging
- Cooling Down
- Discharging
  - Ballast Passage
  - Stripping
    - Warm-up
    - Inerting
    - Aeration
    - Dry Dock
  - Warm-up
  - Inerting
  - Aeration
  - Dry Dock

"Dry Dock" is mentioned in the list but not connected to any other process in the diagram.
Introduction to Cargo Handling System

Cargo Control System (CCS)

- The Cargo Handling System can be Represented by a Simple Sketch:
Introduction to Cargo Handling System

Cargo Control System (CCS)

- Showing Local IOs, Communications Module and the CPUs
Introduction to Cargo Handling System

Outstation Mimic Showing the Cargo Handling System
Introduction to Cargo Handling System

Any Questions?
Overview of ESD System

What is ESDS?

The Emergency Shut Down (ESD) System is a safety system that is designed to stop the entire cargo handling system in an event of a fire or other emergency condition. This will result in the stoppage of cargo operations and the gas supply to the engine will be isolated.
What Causes an ESD Activation?

- Manual activation by personnel using the ESD pushbuttons
- Fire
- Cargo tank extremely high level
- Cargo vapour pressure low
- Hydraulic oil low pressure
- Control air pressure low
- Gas leak
- Electric power failure
- Shore activation of their ESD system (assuming a linked system)
Overview of ESD System

The Activation of ESD will Usually Lead to the Following

- All ESD manifold loading valves will close
- The cargo pumps will stop
- Cargo tank filling/discharging valves will close
- The vapour gas compressors will stop
- Fuel/Master gas valve will close
- All shore pumps will stop (while loading and assuming a linked system)
Overview of ESD System

Cause and Effect

- Manual Activation
- Fire
- ESD Signals to/from Shore
- Cargo Tank Extremely High Level
- Hydraulic Oil Low Pressure
- Cargo Vapour Pressure Low
- Control Air Pressure Low
- Electric Power Failure

Cargo Tank Pressure Low Low

Cargo Tank level Very High Alarm

Cargo Tank Pressure High High

Gas/Leak Detection

Tank Protection Function

STOP
- Cargo Pumps (affected Tanks only)
- Cargo Tank Valves (affected tanks only)
- Cargo Machinery

CLOSE
- Cargo Filling Valves

CLOSE
- Stripping/Spray Pumps
- Spray Nozzle Valve (port and starboard)

STOP
- Cargo Machinery

Cargo Operation STOP
- Cargo Pumps – Stop
- Vapour Compressors – Stop
- Manifold Valves – Close
- Cargo Filling/Discharge Valves – Close
- Cargo Machinery - Stop
ESDS Topology

- The ESDS can be represented as below:
The ESDS is a control system just like the CCS. It has components such as CPUs, communication modules and Input/Output (IO) modules.
Overview of ESD System

The ESDS RIO Components

Remote Input/Output (RIO) components showing communication modules and Input/Output (IO) modules.
Overview of ESD System

The ESDS Components - Fusible Plugs
Overview of ESD System

The ESDS Components - Manual Activation Pushbutton
CCS and ESDS

So, What is the Connection?

The connection between the two systems is in the way that they are integrated together.

The integration is in two levels:
- Hardware
- Software
CCS and ESDS

Recap:

- The ESDS and the CCS are two independent systems.
- The **CCS** is responsible for the **process** aspect of the cargo handling system.
- The **ESDS** is responsible for the **safety** aspect of the cargo handling system.
### Hardware Integration

- Lets consider the CCS and ESDS topology:
Integrated topology

- The CCS and ESDS “integrated” topology:

- **CCS**
  - Cargo Handling System via local IO and R IO
  - (Valves, Machinery, Instrumentations)

- **ESDS**
  - OUTSTATION
  - Ethernet
  - Triggers (causes) via local IO and R IO
    - (Fire, Fusible Plugs, Manual Pushbutton, Cargo Tank issues, Gas Leak, Power Failure)

- Comms Link
**CCS and ESDS**

**Software Integration**

For the CCS and the ESDS to perform their function (process and safety), they both run and execute programs. The programs are set of logical instructions that are strung together to perform or execute a task.

Opening a valve for example:

The CCS has a logic for opening a valve, and maybe written as follows:

- Check for the command to open signal (this should be present, in logic terms = 1)
- Check for alarm signals (no alarms present, in logic terms = 0)
- Check for inhibit signals (no alarms present, in logic terms = 0)

When all the above conditions are met, only then that the logic will allow the valve to open.
CCS and ESDS

The CCS and ESDS Logic Diagram

Valve Opening

- ESD Interlock (ESD active, signal from the ESDS)
- Open Valve Command (by the CCS)
- Alarm Condition (by the CCS)

Valve Closing

- ESD Interlock (ESD active, signal from the ESDS)
- Close Valve Command (by the CCS)
- Alarm Condition (by the CCS)
CCS and ESDS

The CCS and ESDS Flow Chart - Valve Opening

1. **Open Valve Command**
2. **Alarms present?**
   - Yes: **Clear the Alarm**
   - No: **ESDS Inhibit's present?**
     - Yes: **Clear the ESDS Inhibit Alarm/s**
     - No: **Open Valve Command Enabled**
For the LNG loading operation, the cargo handling components involved are the ESD valves (manifold valve), the loading valve, vapour return compressor and the vapour return valve.
Introduction to Cargo Handling System

Loading Arm and the Vessel
Introduction to Cargo Handling System

Loading Arms showing the Emergency Release Coupling
Introduction to Cargo Handling System

Loading Arms and the Vessel
CCS and ESDS

Rules and Regulations

The IGC Code


When the CCS and the ESDS complies with the IGC Code:

- Safe handling of the LNG cargo,
- Safe operation of the cargo handling system,
- The protection of the cargo handling system, the vessel, the terminal and most importantly,

- The personnel
CCS and ESDS

Any Questions?
Thank you for your time!

The End...

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