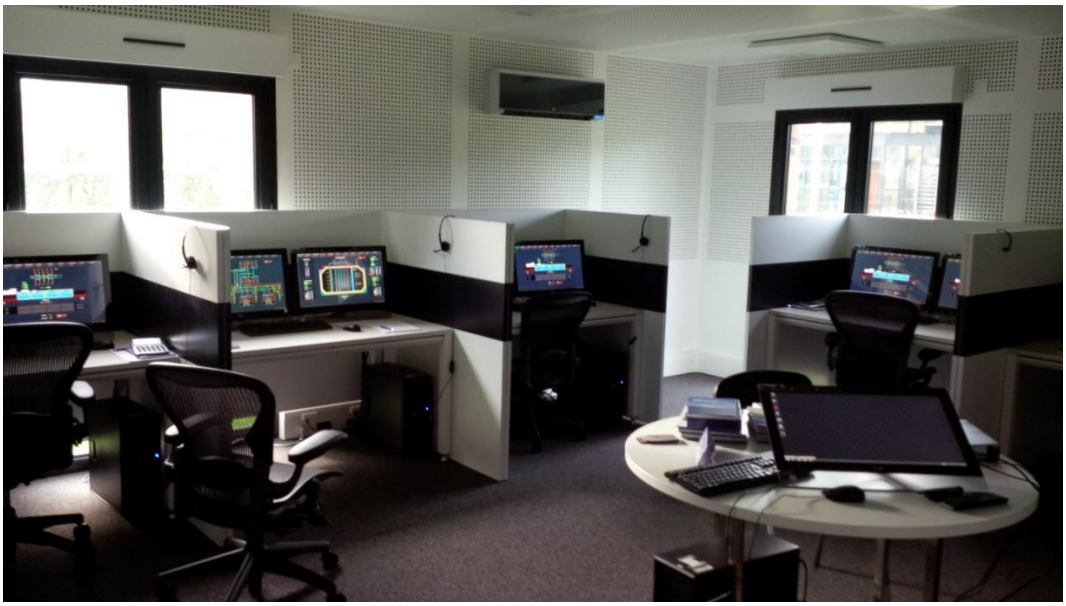
Technical Description

G-Sim
Liquid Gas Handling Simulator (LGHS)



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Introduction

Overview

The following provides a description of the equipment to be supplied together with the various options available.

G-Sim, Liquid Gas Handling Simulator developed by GTT Training Ltd., is a highly detailed simulation platform that allows operators to be trained in all aspects of handling Liquid Gas Cargoes on board ship and ashore, in a safe environment. The accuracy and realism of the simulator also allows it to be used for research and operation pre planning purposes.

Using high fidelity mathematical models, the system provides very realistic simulation of all the flow and control processes together with the appropriate equipment for the respective liquid gas system(s). These include the selection of vessel size, cargo, cargo containment, propulsion system and additional systems such as regas or reliquefaction. Each model includes all the components of a vessel or system that need to be considered in the management of a vessel or shore installation and allow any operation that may be undertaken on the real system to be replicated. Consequently, the models allow the full scope of training to be conducted from basic system familiarisation through to detailed problem solving and implementing emergency procedures.

The simulator has been designed for use on standard PC's and hence can be installed and used on hardware equipped with MS Windows operating systems (including tablets). The user interface has been designed to replicate real control systems used on board, whilst allowing simple operation by operators not familiar with the system. G-Sim provides maximum flexibility in tailoring the system configuration to suit the requirements of an organization, instructor or individual, both initially at the initial purchase stage, and at the time of running individual courses or exercises.

The control software for the simulators provides the instructor with all the tools that are required to set up the required configuration, monitor all aspects of the student's behaviour and provide material for use in evaluation and feedback. The software incorporated into the various models enables all cargo related activities to be conducted with a very high fidelity.

Full descriptions of the various components, tools and modelling can be found later in this document.

International Compliance

In the context of providing training for marine personnel, G-Sim allows the simulation of a realistic environment for the handling of liquid cargoes as per the requirements of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW). Specifically:

- G-Sim allows training to be conducted in accordance with STCW section A-II/1, A-II/2, A-II/3, A-III/2, A-V/1 and B-1/12.
- Is approved as meeting the 'Class A' requirements as specified by the DNV – Standard for Certification of Maritime Simulators, Section 6.
- Meets the requirements for the training and assessment of seafarers in accordance with:
    - SIGTTO - LNG Shipping Suggested Competency Standards
    - SGMF - Bunkering of ships with Liquefied Natural Gas (LNG) competency guidelines

DNV Certification

G-Sim is certified in accordance with the DNV Standard for Certification of Maritime Simulators as follows:

- G Sim platform – Class A
- LNG Carrier Module (all configurations) – Class A
- LNG Bunkering & Fuel Gas Handling Module – Class S

Validity of Simulation Models

The mathematical models for our simulators are derived from our extensive experience in the behaviour of LNG and other gases within closed and open systems, combined with a rigorous analysis of the physical characteristics of the simulated plant, and are in accordance with design data provided by relevant machinery manufacturers. Such characteristics include all the appropriate mechanical, thermodynamic, electrical and chemical properties and reactions with liquid and gas compositions, pressures, temperatures, flows, and levels being accurately modelled according to operational conditions present at the time, resulting in very accurate simulations.

During the development phase the results of the models are checked carefully against the design parameters of the individual items of equipment involved. Once initial development is completed the results are then checked again against real data obtained from the ship or plant that has been modelled to ensure the parameters are adjusted to take into account real life operations. Due to the validity of the modelling the models have been used in undertaking research into the effects of changing working procedures, maximize operational efficiency of actual vessels and may be used to assist in the design phase of new terminals and facilities to determine the requirement for new equipment.

In summary, every system is fully modelled using the appropriate mathematical method – thermodynamic, electrical, chemical, mechanical etc. Individual components such as sensors, controllers, actuators, valves etc are also modelled in sufficient detail to ensure that the simulator behaves naturally and realistically in response to any input – whether correct or incorrect.

During commissioning it is possible to 'fine tune' the simulator and malfunction operations to meet particular teaching requirements & operational needs.

Scope of Training Uses

G-sim can be used to provide very effective training across the full range of possible training requirements. The purpose of the system is to allow the effective transfer of knowledge and skills, no matter the initial skill set of the trainee.

When in run mode, G-Sim and the appropriate model provide the similar capabilities to a real vessel and hence the types of training that it can be used for equate to that which could be delivered using the real systems, if only there was no risk to personnel, equipment or the environment. G-Sim not only provides that capability in a totally risk-free environment, it allows training to be repeated as many times a required.

The following are some examples for the different ways in which G-Sim can be used to deliver training to persons who have differing training needs:

- Introduction to concepts

By taking advantage of the ability to group stations together or allow individuals to follow the actions of the instructor but also allow them to work out solutions for themselves under guidance means the system can be used very effectively for introducing trainees to new concepts and practices. Consequently, it can be used very well for the training of cadets or introducing practices to those unfamiliar with the requirements.

- Cargo Operation Practise
  By providing a very realistic environment G-Sim allows those trainees who already have some understanding of the operational practices to demonstrate their capability to undertake the operations effectively whilst always being in a safe and controlled environment. Consequently, it is ideally suited to the training of personnel prior to them receiving promotion to ensure they have the necessary understanding and skills that are going to be required in the new role.
- Problem solving and fault diagnosis
  Once trainees have the general understanding, their skills can be elevated by placing them into situations where they need to be able to identify a situation where a problem may be developing and allow them to work out and apply an effective solution. G-Sim, through the ability of the instructor to apply malfunctions on almost any item at any time during the running of a simulation exercise allows the instructor to create situations which will allow each individual trainee to develop the skills required, without having to compromise the training platform at any time.
- Handling Emergency Situations
  Developing on the problem solving capabilities, because it provides a totally safe environment, G-Sim allows the full simulation of situations which may lead to critical activities and emergency situations developing, but allow them to be handled in the correct way without any risks either to the trainee or those around them.

Typical training applications

The models allow any operation relating to the cargo and ballast systems that is able to be conducted on board the real vessel to be conducted within the simulated environment, without any restrictions being applied. Consequently, examples of typical training scenarios that may be conducted may include:

- Familiarisation with a type of vessel and its cargo system
- Preparation of the cargo tanks and cargo system for the loading of the cargo including:
  - The lining up and operation of the equipment during Inerting operations
  - The lining up and operation of the equipment during Gassing up operations
  - Cooling of the cargo system
  - Operation of the equipment and associated systems
- Detailed operation of compressors and heaters
- Planning for loading and discharge and associated ballast operations
- Various stages of loading and the procedures that should be applied
- Tank conditioning on passage
- Boil off gas management
- Supply of gas for use as fuel via the various systems related to the differing propulsion systems
- Various stages of discharging and the different methods that may be used to empty the tanks and how to effectively control cargo pumps to maximise efficiency
- Preparing of the vessel for drydock including:

    - Warming up of the cargo systems
    - Removal of the cargo vapour
- Stress and stability planning and monitoring
- Inter-ship and ship to shore communications
- Verification of operational procedures

Legislation, Rules & Regulations

G-Sim and the models available for use on the platform, are designed and constructed taking into account and incorporating the requirements where specified of the following rules and regulations as appropriate:

- Current Legislation
- Rules and Regulations of Government Departments
- Rules and Regulations of Classification Societies.
- SOLAS (Safety of Life at Sea)
- STCW (Standards of Training and Certification of Watch keepers) (All editions)
- MARPOL 73/78
- International Gas Carrier Code (IGC Code)
- International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code)

Equipment

G-Sim has been designed to take advantage of the latest hardware that is available in the market to ensure that it is flexible to the needs of our clients. No specific hardware specifications are required which provides for:

- The simulator to be always easy to support and upgrade
- Clients to purchase hardware from their own suppliers or use their own existing hardware (as long as the basic minimum requirements are met), should they wish to do so, either to minimise installation costs or integrate the simulator into their existing IT support arrangements.

The basic equipment required comprises of the following items.

PC

Each of the stations (student or instructor) comprises a standard PC running any of the MS Windows operating systems (see below). Any PC currently available will have sufficient resources to enable the efficient running of the G-Sim software. The software is also designed to be used on any Windows based tablets (e.g. MS Surface products or similar) which are equipped with suitable resolution displays.

The G-Sim software imposes minimal changes on the operating system and requires only a few resources, enabling the hardware to be used for other applications, in addition to being used for G-Sim, if so required.

Whilst the G-Sim software can be used effectively using a single monitor, the use of two monitors per workstation is recommended, hence ideally the hardware used should be capable of supporting multiple monitor arrangements.

G-Sim Online

G-Sim can also be installed and used on cloud based virtual machines hosted by GTT Training. The functionality of G-Sim when hosted online is the same as when installed on standard PC's/network as described in this document

Operating system

The G-Sim software can be installed on equipment using the following operating systems: Windows 7, Windows 8 & 8.1, Windows 10 and all associated variants.

Displays

The G-Sim software can support multiple display arrangements on each workstation. Except when being used in a portable or test environment, it is recommended that each student workstation should be equipped with a minimum of two high resolution displays, whilst the instructor station is equipped with two, three or four displays depending upon the space available and additional tools installed. The displays used should support the widescreen format with a minimum recommended resolution of 1920 x 1080, and a minimum size of 19" or higher (21"+ preferred). The only requirement is that the resolutions of the displays used on all the stations should be the same.

The software has been designed to be used effectively using 'touch' enabled devices such as touch displays, or on tablets.

Network

Each PC is linked using a network comprising the cabling and a network hub suitable for the total number of stations to be installed. If a new installation, the use of 100Mbs or 1000Mbs cabling and equipment is generally recommended, and is a requirement if the optional communications software is included within the installation.

Software Description

Operating Modes

The G-Sim software supports the running of the simulator in either a single PC or multi station environment.

For the training of groups the use of multiple stations, comprising of a number of student workstations connected to an instructor workstation, is recommended. Whilst there is not a limit imposed on the number of student workstations that can be installed or supported by the software, the recommended configuration comprises up to six students per instructor.

System Description

The design is based on the distributed processing model using networked PC's. The same software is installed on each PC, hence any of the PC's can all be run in either 'Instructor' or 'Student' mode.

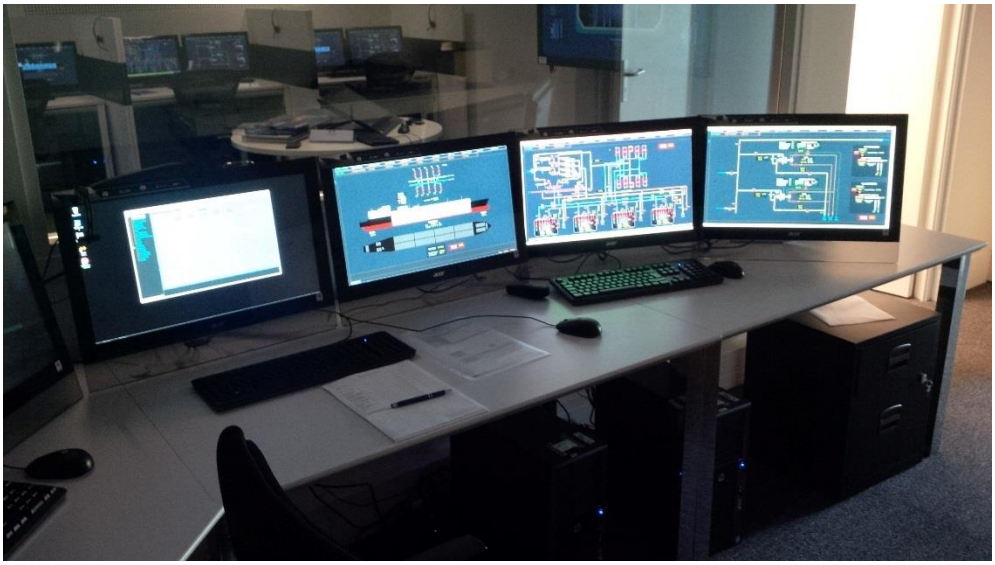
The advantages of this type of processing model are:

- It is easy to reconfigure the overall simulator to an arrangement suitable for the training to be delivered from within the software (ie no changes to the hardware are required). Each station can be configured to run exercises independently, linked together to form a ship to ship, or ship to shore combination, or combined to allow all the linked stations to be used to control a single model hence allowing group exercises to be undertaken.
- Each station performs its own modelling, display, and input processing. This allows the number of stations to be increased or decreased at any time after the initial installation with minimal effort.
- Any station can be configured as either an instructor or student station. Within the overall group of stations multiple subgroups of instructor and student stations can be configured if required.
- In the unlikely event of a hardware failure on the normal instructor PC, any of the students PC's can immediately be used in instructor mode minimizing any disruption that may result.
- The system enables all models to run in all possible combinations, either independently or concurrently.
- The need to back up the software is not required as a copy is maintained on each of the stations within the network.

As indicated the software can be operated in two modes:

Instructor Mode

When in instructor station mode the functionality is provided to allow the instructor to start /stop and set up the simulator for the training exercises, selection of the stations to be monitored and the facilities to record student actions and display them in various formats for later analysis. The instructor station is usually equipped with between 2 and 5 monitors depending on the arrangement selected.



The Instructor Station provides all the facilities to enable an instructor to:

- Select the configuration of the models to be used in the simulation
- Define simulator configuration, to suit a variety of training needs.
    - Independent - allowing individual tuition
    - Pairs of stations linked together - for direct ship/ship or ship/terminal operations
    - One model spread over a number of stations - to allow team training in a control room atmosphere
- Create and run exercise scenarios
- Enable recording / logging of all student actions
- Interact with individual students by adjusting model condition such as flow rates
- Monitor individual student activities
- Trend defined variables for each student
- Inject malfunctions in real time
- Interactive exercise replay
- Remotely monitor individual student performance, both visually and by using the optional Competence Assessment System
- Produce hardcopy de-brief / assessment material
- Communicate with each student individually both for instructive and role play purposes

The displays on the instructor station can also be linked directly to a projector or ‘SMART’ board to allow for demonstrations and feedback to be provided directly to the students.

The above functions are described in more detail in the following sections.

Student Mode

In student mode, each station performs the necessary math modelling to support the simulation exercises, and display the results.

Each student station is equipped with one or multiple monitors and is designed to allow the simulator to be operated by a single mouse, or by touch, with only minimal keyboard input required, minimizing the learning time required for a student to become familiar with its operation.

To the student, the ship or plant model is visible as a set of mimic diagram 'pages' displayed on the monitors. All monitoring and control of the system by the student is undertaken via these 'pages' replicating the control method used on modern ships and terminals, enhancing the transfer of knowledge to the real life environment. The provision of multiple displays provides the ability for the student to monitor different areas of a system at the same time, again enhancing the learning experience.

As well as being able to control every aspect of the vessel or plant, the student also has access to the following facilities:

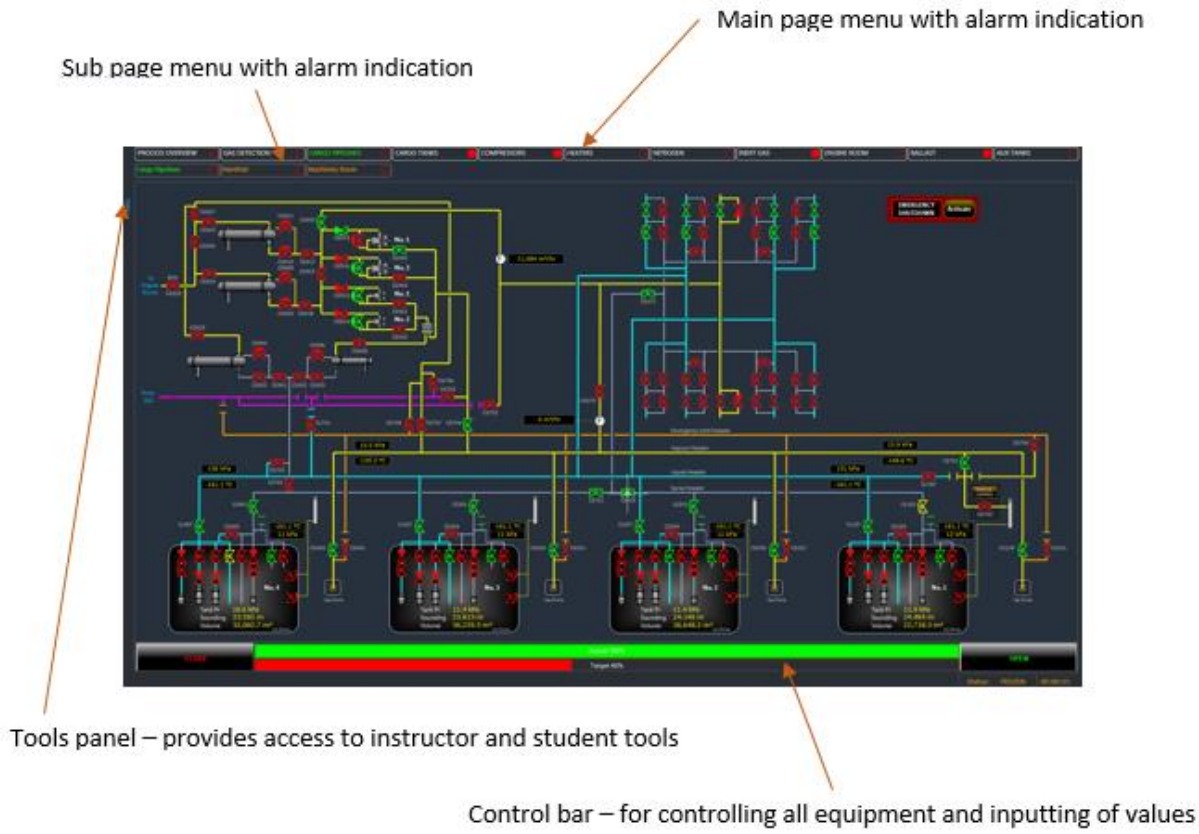
- Alarm logging and summary display
- Online/offline 'Cargomax stress and stability module
- Trending of specific variables

User Interface

Main display

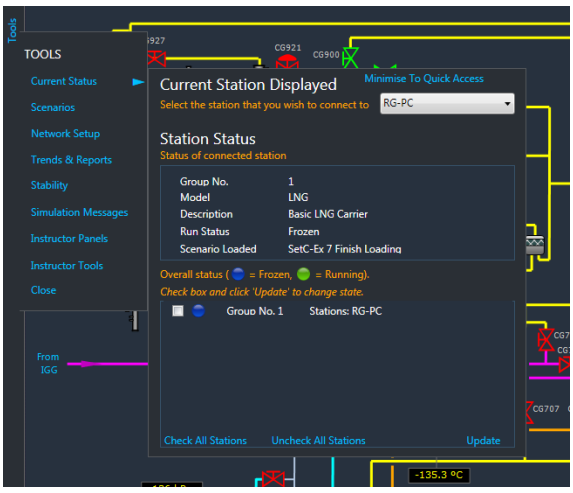
The user interface has been designed taking into account best practice within the control system industry, whilst maintaining ease of operation for both student and instructor.

The basic design of the system mimic pages incorporate the following:



The user can access all the controls required directly via the mimic display. Floating windows have been avoided due to the hiding of the main display. Instead, to operate or change any item, the operator selects the item and the appropriate settings are displayed in the control bar, which can them be changed accordingly. The same process is used for all items, making learning of the system easy to achieve.

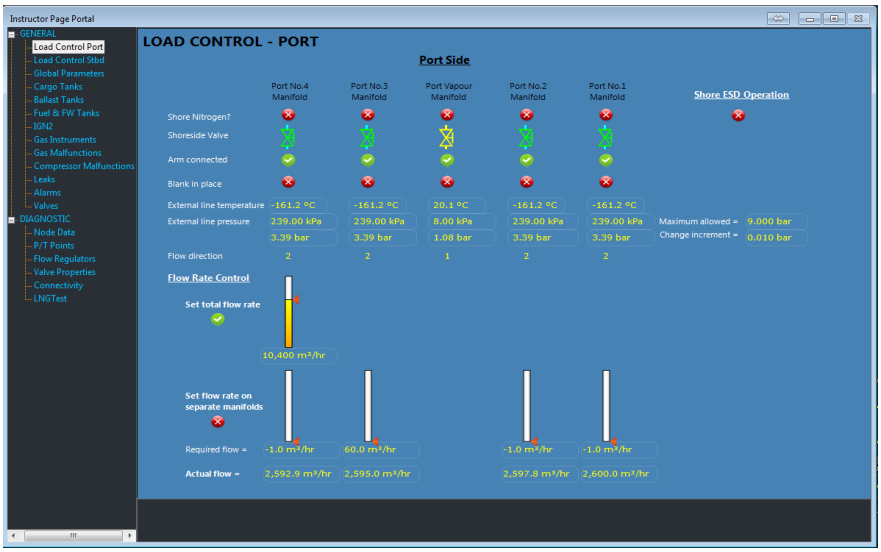
Initially the display that appears when either in Instructor or Student mode appears to be the same with the standard mimic display options as above. However, the options provided when the 'Tools' option is selected are different depending on the mode the workstation is operating in. The following is an example of the options displayed when in Instructor mode.



Example of tools menu selected

Instructor displays

In addition to the main displays the instructor has access to a number of 'instructor displays' which provide him/her with detailed information about each of the models running and the ability to interact and control the student models (ie changing flow rates, tank filling levels) as requested by the student.



Operating Tools

G-Sim includes a number of tools to allow the instructor to:

- Configure and set up the simulator so that it is suitable for a particular group or exercise
- Load and record exercises along with student performance
- Monitor individual student activities
- Interact with individual students by adjusting the conditions within the model (such as flow rates, equipment status etc)
- Inject malfunctions
- Communicate with the students in appropriate roles

Simulator configuration

The instructor is provided with the capability to change the setup of the student workstations within the simulator so that they are provided with full flexibility in the way the simulator may be used to deliver the training program concerned. The options available include:

- A separate model for each student.
  This allows each student to operate the ship or terminal model as an individual and their actions will not affect any of the other students.
- One model across all stations.
  Actions on one monitor will affect all stations. This type of configuration allows the "simulator" to be used to create a control room atmosphere with the potential for control room "team training".
- One model across a number of stations (eg 2, 3 or 4 stations etc).
  This allows students to be grouped in twos or threes to make maximum benefit of their experience and problem solving abilities when undertaking complicated exercises.

- Linking two or more models and stations directly.
  This enables ship/ship or ship/terminal exercises to be conducted directly between students.

When stations / models are not linked directly (final option above), the instructor plays the role of the terminal and loading or discharging is conducted to a "dummy" source or sink of cargo whose compositions are fixed, but pressures and flow rates and be adjusted by the instructor for each student. When the stations are linked directly, the values of the various parameters are transferred from one model to the other directly.

Scenarios

A 'Scenario' is a record of all the parameter values within the model on that station at a specific point in time which are then used to provide a start condition for an exercise and review. Facilities are provided so that the instructor has full control over the creation, storage and use of exercise scenarios within the simulator. The facilities include:

- Scenario selection
  On each station the instructor can select the scenario to be loaded and used from the scenario library. When delivered, the library will include a number of pre-defined scenarios which can be added to as required. Once loaded, the scenario can be adapted if required to create a particular condition by redefining some or all of the following: liquid levels, temperatures, pressures, liquid or gas compositions, oxygen concentrations, valve positions and equipment status.
- Scenario library
  The library of scenarios is unlimited so it is easy to produce and save scenarios for each of the exercises and courses that mat be run. Facilities are included to maintain the library by saving, deleting and changing the order in which the scenarios are displayed and for copying either individual scenarios or the complete library between stations. New scenarios can be saved at any time without affecting the running of the model.
- Automatic Scenario Recording
  In addition to the scenarios recorded into the library above, at time periods defined by the instructor, scenarios are recorded automatically. This means that a complete copy of the models database is stored to disk. If a student makes an error, or there is another issue, which affects the running of the exercise, the instructor is then able to return to an appropriate scenario taken just before the error occurred, for discussion, debriefing, or to allow another attempt. Consequently, an operator can continue with an exercise, without the need to return to the beginning, providing a considerable timesaving and reducing the possible frustration that can consequently result.

Trending and Reports

The ability to record the process variable values for any item within the model such as pressures, temperatures, flow rates and oxygen or liquid levels etc and display the results in a graphical format over time is provided. The instructor is able to record and few any item whilst for students trending is limited to a few key process variables such as tank pressures. In both cases the resulting trend graphs can be saved for later review or printed to provide a hardcopy.

In addition, the capability is provided to produce reports. The format of the report and the information to be included can be pre-defined and then during the running of an exercise the various defined values will be written to the report at the specified intervals. Upon completion of the operation the report can be exported into an Excel file for review and printing.

Both of these facilities can be used to produce hardcopy evidence to support the performance assessment of students during a training program.

Logging and Replay

All the events that happen within all the models throughout an exercise is recorded (i.e the time and identity of any student's or instructor's action, opening/closing valves or starting/stopping a pump and the automatic actions of any model, including alarm operation etc). The resulting file can be filtered to so that a particular station or time period may be viewed for examination or record keeping.

Associated with the logging of the model values is the replay capability. Using the produced log file, it is possible to replay any part of an exercise, from any station. This facility can therefore be used for demonstrating errors by simply replaying the exercise, and also for providing instant feedback to the students, as it is possible to interact with the replay as it is still in progress, and hence allow the correction of mistakes made previously, as they are replayed.

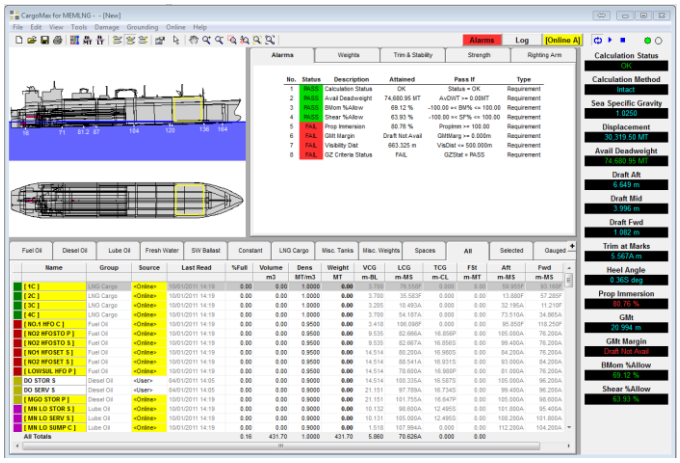
Malfunctions

The instructor can also apply malfunctions to many items within the model. The malfunctions can be activated either via the instructor displays or by selecting the item to be malfunctioned directly on the mimic display at any point in time. Some of the malfunctions available include:

- Valves
  - Sticking of valves
  - False indication
  - Movement of valves when not controlled
  - Freezing of valves
- Alarms
  - False indication
  - Incorrect set points
- Leaks
  - Leaks at manifolds
  - Leak from cargo tanks into barrier spaces
  - Ballast leaks
- Inert gas / Nitrogen
  - Temperatures increasing over time
  - O2 , CO2 or dewpoints changing over time
- Equipment failures

Stress and Stability Program (Cargomax)

Facilities are provided for each model (where appropriate) to enable the student to undertake a full assessment of the vessels stress and stability at any time both during planning and real time monitoring. These facilities are provided using the latest version of ‘Cargomax’



'CargoMax' is a commercial, fully class approved, stress and stability program for vessels supplied by Herbert –ABS. CargoMax displays all the information likely to be required regarding the draughts, trim, list, shear forces, bending moments and damage stability for a particular vessel. The information is displayed using a 'Windows' format using both analogue tables and graphical indicators.

A version of **'CargoMax'** has been developed for each of the ship models within the simulator library. The program is fully integrated into the simulator allowing it to be used as a 'standalone' planning tool or to provide 'on line' information as exercises are conducted on the simulated model. Once the Cargomax program has been started the interface appears as a normal simulator graphics display and is accessed via the simulator 'page menu'.

The basic functions included within CargoMax are:

Intact Stability calculation according to international requirements, including

- Calculation of GZ curve and comparison with IMO criteria
- Comparison of GMt / KGvirtual with Required GMt / Max. KG curves
- Warning and check of various loading restrictions such as draft limits, visibility requirements, and custom tank filling restrictions
- Longitudinal Strength (Bending Moment and Shear Force) if required by approved Loading Manual
- Comparison to class allowable at the required frames
- Comparison for both in Harbour & At Sea allowable
- User input of tank data by sounding, ullage, volume, weight or percent full and density (or specific gravity). Automatic conversion of the other input types.
- Damage Stability
- Online interface to the simulated model to automatically read in tank levels and cargo characteristics (such as density, temperature). CargoMax can be set to continuously monitor the gauging system at a user defined interval.

Simulation Models

Modelling Techniques

To allow the very complex operations to be conducted as required, all the models incorporate:

- Fluid dynamics
    - Incorporating all aspects relating to the control of flows within a system including specific features such as pump cavitation and heating by adiabatic compression
- Thermodynamics
    - Address both equilibrium and non-equilibrium aspects
    - Based on vapour/liquid equilibrium for a multi-component, multi-phase system
    - Heat exchange through tank walls and heat exchangers

G-Sim is designed as a Liquid Gas Operations Simulator. Currently the components / cargoes that may be modelled include:

- LNG - composition adjustable to suit
- Ethane
- Propane
- Butane
- Nitrogen
- Inert Gas
- CO2
- O2

Verification of models

The mathematical models within G-Sim are derived from a rigorous analysis of the physical characteristics of the simulated plant and the behaviour of liquids and vapours within closed systems. As well using the design data provided by relevant machinery manufacturers the models incorporate the extensive knowledge and expertise of the behaviour of LNG in its various phases that GTT have acquired during its 50 year history. Such characteristics include the mechanical, thermodynamic, electrical and chemical properties and reactions and the modelling of Pressures, Flows, Levels and Temperatures according to operational conditions. Each of the models a carefully checked against the design parameters of the individual items of equipment involved.

Once initial development is completed the results are then checked again against real data obtained from the ship that has been modelled to ensure the parameters are adjusted to take into account real life operations. Due to the validity of the modelling they are capable of been used in undertaking research into the effects of changing working procedures, maximizing operational efficiency of actual vessels and use in the design phase of new facilities to determine the requirement for new equipment.

In summary, every system is fully modelled using the appropriate mathematical method – thermodynamic, electrical, chemical, mechanical etc. Individual components such as sensors, controllers, actuators, valves etc are also modelled in sufficient detail to ensure that the simulator behaves naturally and realistically in response to any input – whether correct or incorrect.

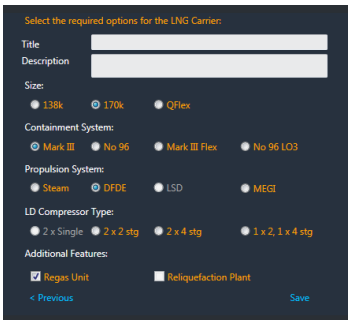
Model Libraries

LNG Carrier

Available immediately

Available for use in sixteen (16) different configurations, the LNG Carrier model is based on a modern membrane type vessel. The operator can currently select the configuration to be used from the following items:

- Ship size (138k or 170k m^3)
- Type of containment system (GTT MkIII or GTT NO96 and variations)
- Type of propulsion system (Steam or DFDE with 2 stage LD compressors, or MEGI)



The configuration of the model can be made by the operator in advance, allowing suitable scenarios to be generated, or immediately after the simulator is started with the configuration change being applied immediately the stations are loaded.

The basic configuration of the 138k and 170k vessels comprise of four cargo tanks each containing two cargo pumps, a single spray pump, emergency cargo pump, load lines and spray rails. The modelling of the inter-barrier insulation spaces around the tanks has been carefully considered to allow both the accurate monitoring of the various temperature gradients within the system but also the effects of a leakage of cargo into the respective spaces. In addition, each model includes:

- Complete cargo piping system
- LNG and forcing vaporizers
- High duty compressors
- Low duty compressors appropriate to the propulsion system selected
- Cargo heaters appropriate to the propulsion system selected
- Fuel gas supply system
- Inert gas/dry air supply and distribution system
- Nitrogen supply, distribution and inter-barrier space pressurization system

- Cofferdam heating system
- Steam & Lub oil systems
- Segregated ballast system
- Fixed gas detection systems
- Portable gas detection for Oxygen, %LEL, %Vol H/c, Carbon Dioxide and Dewpoint
- Emergency shutdown system
- Automatic control systems
- Temperature monitoring system

All of the models incorporate the equipment control logic, interlocks and alarms as installed on the real vessels. For more detail regarding the contents of each model see the full description in the 'Models' section below.

Available upon request

For the LNG Carrier the choices available for selection by the operator will be expanded to include:

- 4 stage DFDE
- Regas unit
- Reliquefaction
- MOSS Containment System

These will be introduced as they become available or upon request.

LNG as a Fuel and Bunkering Model

To enable training in the full range of operations that may be conducted on either the bunker supply or receiving vessel the LNG as a Fuel and Bunkering model comprises of two main configurations:

- LNG Supply Vessel
- LNG Fuelled Vessel Fuel Gas Handling Systems

LNG Supply Vessel

The LNG Supply vessel is based on the 2200m^3 capacity LNG Barge that is currently in service in the USA. The configuration has been designed so that it may be used to facilitate all the various types of transfer operation in which the supply vessel may be engaged including:

a) Refrigerated storage to/from pressurised storage
b) Pressurised storage to/from pressurised storage
c) Refrigerated storage to/from refrigerated storage

The configuration incorporates the following:

- LNG tank and associated systems – a pressurised or atmospheric tank may be selected
- Cargo piping system on board the supply barge
- Manifold connection arrangements (including selection of hose size)
- Transfer arm manifold and connection arrangements (including selection of hose size and arm elevation)
- Pressure management systems
- Vaporizer
- Reliquefaction system (Cryocoolers)
- Pressure Reduction Station
- Nitrogen supply and distribution system

- Segregated barge trim system
- Fixed and portable gas detection systems
- Emergency shutdown system
- Shore / receiving vessel storage facilities including atmospheric and pressurised storage
- Shore equipment including compressors, N2 & Dry Air production, shore heater, vapour disposal facilities
- Shore / receiving pipeline arrangement that allows either tank to be connected to either of the barge connection manifolds
- Pressurised tank includes ability to regulate gas flow to consumers

LNG Fuelled Vessel Fuel Gas Handling Systems

The Fuel Gas Handling configurations include various designs of LNG fuel systems being implemented on board real vessels to enable training to be provided in all the most common implementations. The design of the systems and equipment they therefore comprise being primarily dependent upon the type of fuel storage tanks and the type of consumers that are fitted on the vessels concerned.

The library will be expanded to include the different configurations as they become available but can already be supplied with the following:

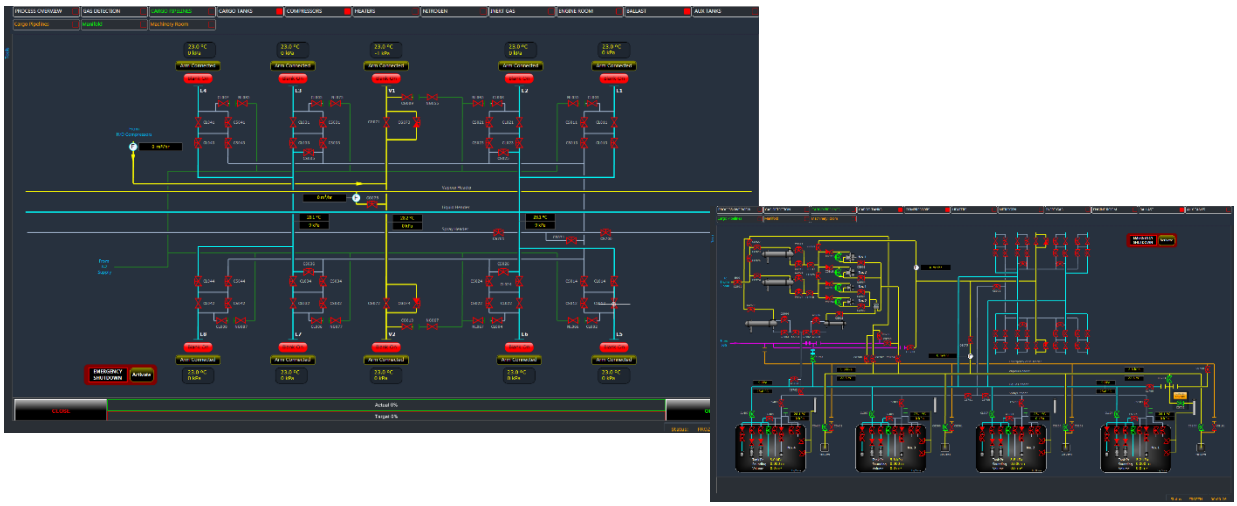
- Atmospheric Tanks to XDF primary and medium speed secondary consumers
- Pressurised tanks to medium speed consumers

Full details of the configurations available can be found in the following sections.

LNG Carriers – Detailed Description

Cargo System

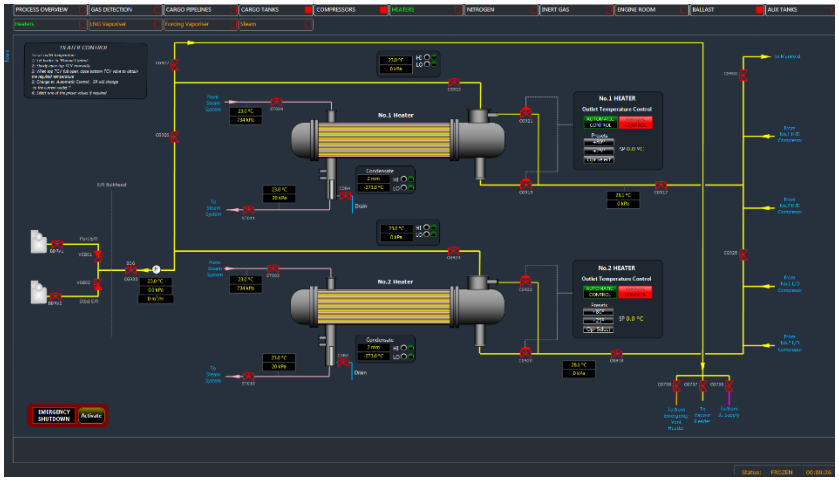
The cargo system includes all the relevant pipelines for the movement of liquid and vapour around the vessel, together with connections into supplementary systems allowing all required operations to be conducted. The operator is provided with complete control over the line-up used. Restrictions on the movement of spool pieces or valves are applied as would be in real life. The cargo manifold arrangement allows the operator to decide which manifolds should be used and connected to shore or atmosphere to allow full loading / discharge operations or line purging operations to be conducted.



Vaporisers & Heaters

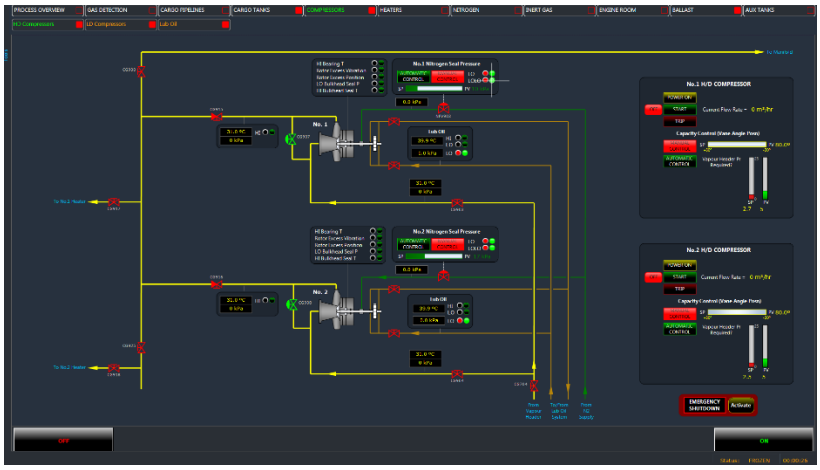
Two vaporisers are incorporated, one for the supply of LNG vapour for 'gassing up' and discharging purposes and the other for the supply of gas to the vessels propulsion system. Heaters are provided, which can be used for circulating LNG vapour and for supply to the propulsion system, in accordance with the propulsion system selected. Manual and automatic controls are provided to allow the system to be set up to deliver the correct temperature and pressure of boil off gas to the vessels engine room in combination with the low duty compressors.

The operator is provided with all the necessary controls including automatic systems for the operation of the vaporisers and heaters. All interlocks and alarms are provided as per the real vessel.



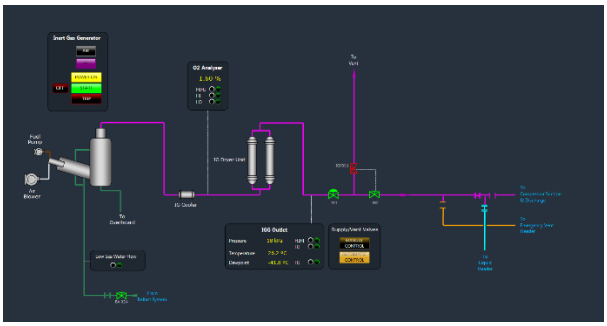
Compressors

Two high duty compressors are provided for the removal and circulation of LNG Vapour, along with two low duty compressors for the supply of boil off gas to the engine room. The type of compressors displayed is dependent upon the propulsion system selected. Full control mechanisms for the compressors are provided including automatic capacity control by adjustment of the inlet vane angle. Monitoring information includes the inlet and outlet pressures and temperatures together with flow.



Inert Gas / Nitrogen Systems

The vessels are equipped with an Inert Gas generator together with a drying system. The quality of the inert gas can be decided by the operator, with connections provided into the cargo lines or directly into the hold spaces surrounding the cargo tanks. Two Nitrogen generators of the membrane type are also included for the supply of Nitrogen to the compressors, Engine Room and purging of the inter-barrier space around the cargo tanks. The purging system incorporates all the flow and pressure controls as per the real vessel. In a similar way to the IG the quality of the Nitrogen can be adjusted by the operator.



Facilities allow all procedures to be conducted in preparing for the supply of gas to the engine room and to provide the correct quantity and temperature of gas to the boiler in the different service modes.

In the event of a gas leakage into the barrier spaces the models allow all the procedures to be conducted to remove or control the gas leakage as appropriate to the system modelled.

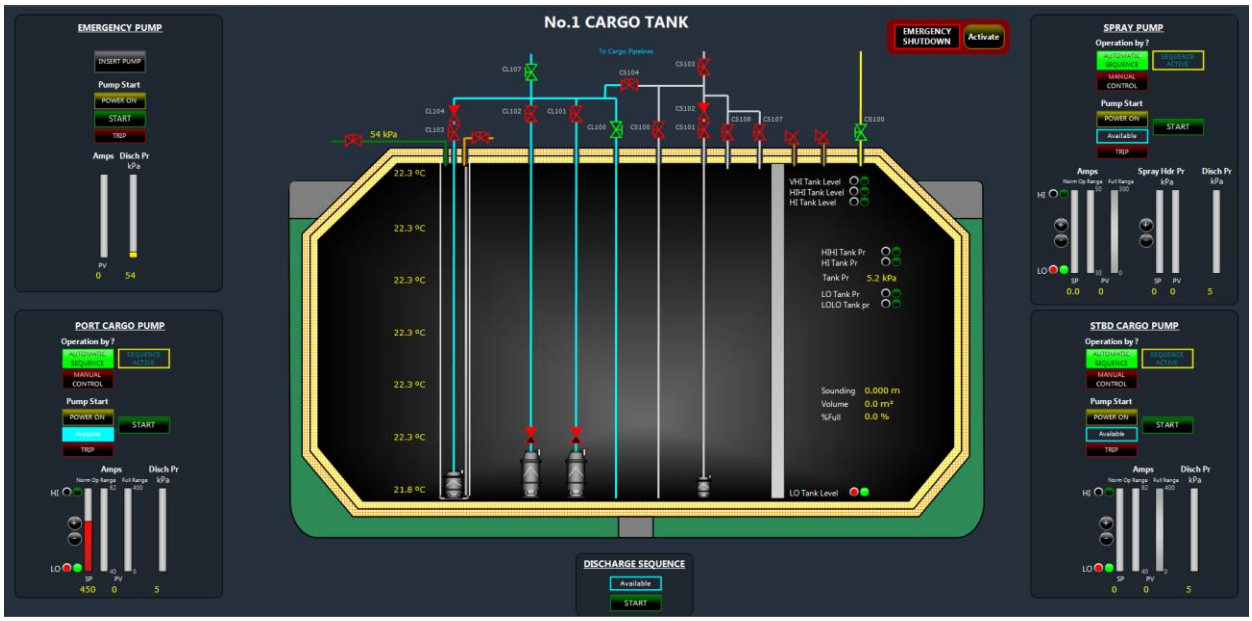
Gas Detection Systems

Both fixed, sequential and portable gas detection systems are provided. The two sequential systems continuously monitor the spaces around the cargo areas for leakages with appropriate alarms and shutdowns implemented if gas is detected. The portable system allows the operator to select the type of instrument to be used for the detection of oxygen, %LEL or %Vol. The sample location points, located

in the same location as per the actual vessel, can then be selected including cargo equipment and manifold connections, allowing the operator to check if operations are progressing correctly and safely.

Cargo Pumps & Controls

Automatic pump controls are provided which mimic the behaviour of the systems used on board the real vessels. Full pump start, and appropriate valve opening sequencing is included. Spray pump controls are provided with an additional controller to allow the required pressure to be maintained within the spray header to be set, and maintained for use when tank cooling or providing a supply to the Forcing vaporiser. An Emergency Pump is also provided in each tank together with the appropriate equipment to allow the full installation procedures to be conducted.

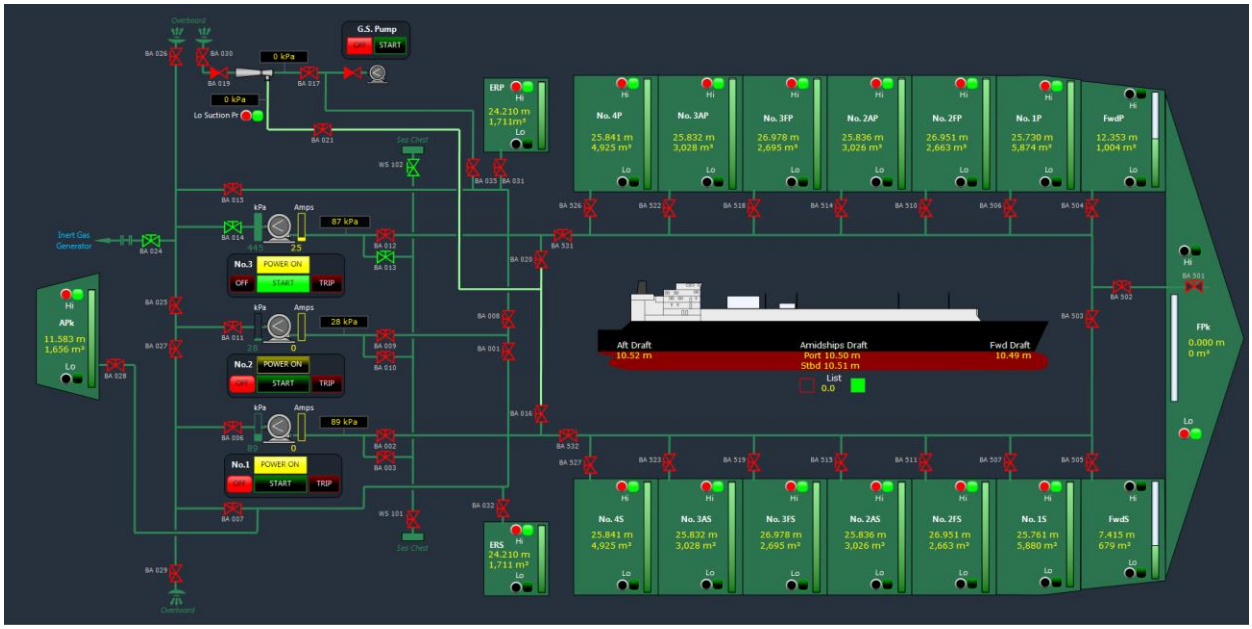


Glycol & Temperature Monitoring Systems

The full glycol circulation system is included to allow the operator to monitor and take appropriate steps to maintain the bulkhead temperatures fore and aft of the cargo tanks

Ballast & Auxiliary Systems

The ballast system comprises of two or three electric pumps for the supply and discharge of sea water ballast. A separate pump provides the supply to the stripping eductor. Appropriate connections are provided, for example to provide a supply to the Inert Gas Generator and to allow the emptying of interbarrier spaces. The operator is also provided with displays indicating the status of the lubricating oil supply for the compressors and the steam supply to the cargo heaters and vaporisers. Status of all fuel and water tanks is also shown to enable the correct assessment of trim and stability conditions.



The Emergency Shutdown System provides different links into shore based systems and provides indication of the cause of operation.

LNG Bunkering Vessel – Detailed Description

The LNG as a Fuel and Bunkering model comprises a LNG Supply vessel together with the various shore supply and LNG receiving facilities, and the storage and fuel gas handling systems representing those installed on vessels that are using LNG as a fuel. The model enables all the operations that may be conducted on an LNG supply vessel or onboard a vessel that uses LNG as a fuel to be conducted.

The full model comprises of two main configurations:

- LNG Supply Vessel
- Storage & Fuel Gas Handling Systems

LNG Supply Vessel

Unlike the LNG Carrier where only the vessel arrangement is detailed, the LNG Bunker Barge model includes the facilities and equipment on the barge and those that may be found on shore or on board the receiving vessel. In addition, the storage arrangement on the barge can be changed between an atmospheric tank and a pressurised tank, so that the operator can simulate any of the likely transfer operation scenarios that a bunker vessel may encounter.

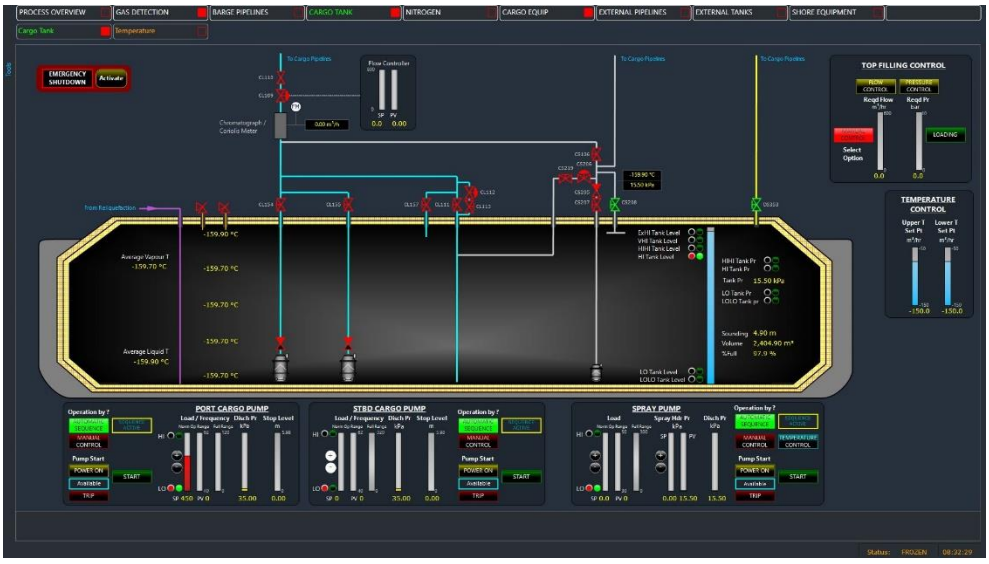
Barge Cargo System

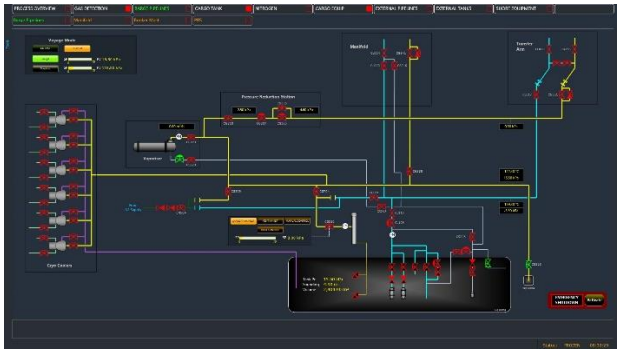
The cargo system includes all the relevant pipelines for the movement of liquid and vapour around the barge, together with connections into supplementary systems allowing all required operations to be conducted. As with the LNG Carrier, the operator is provided with complete control over the line-up used.

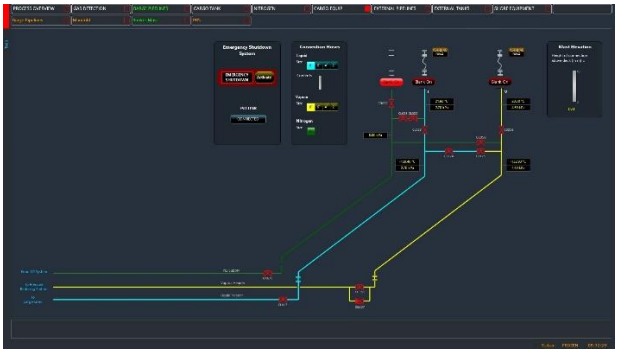
The main cargo tank can be either of the atmospheric or pressurised type allowing the full range of possible transfer scenarios to be simulated.

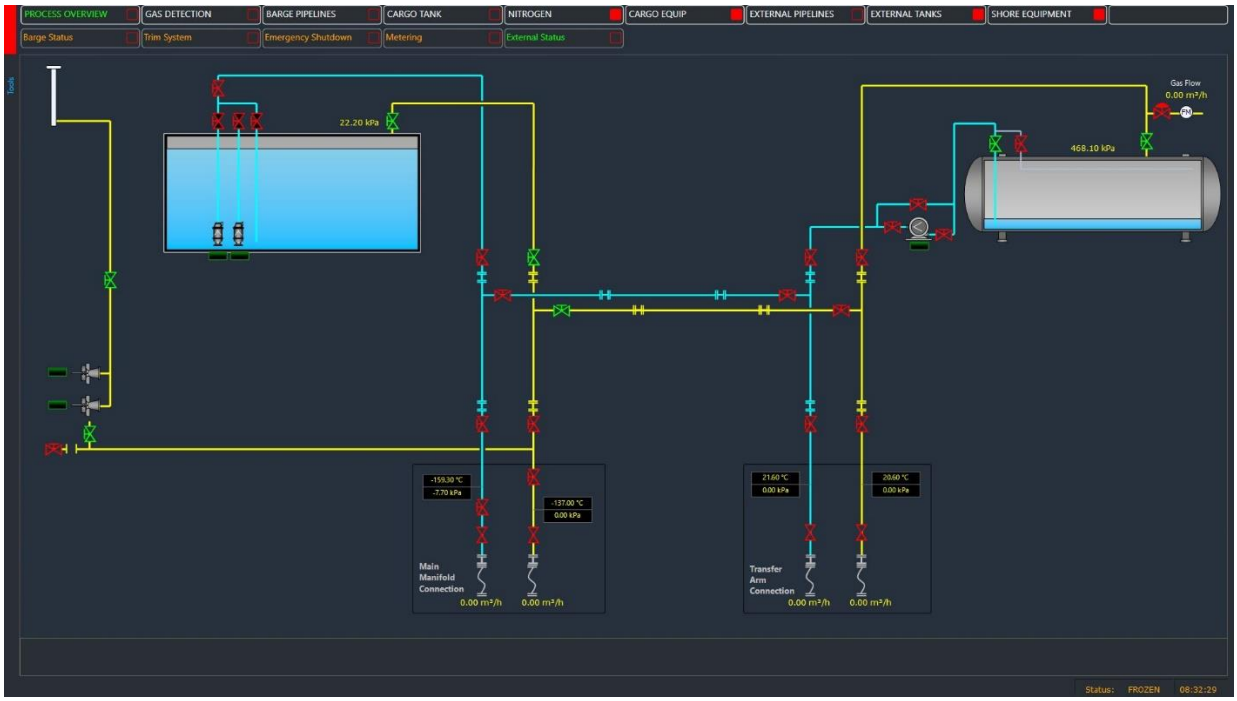
The equipment provided includes a reliquefaction system and vaporiser with the other equipment that may be required

The barge is equipped with two manifolds, a main manifold located on the main deck and also a transfer arm to facilitate the bunkering of the vessels. For both the operator is able to select the size of hose to be used, purge the connections prior to use and facilitate the ESD connection between the barge and the shore/vessel.



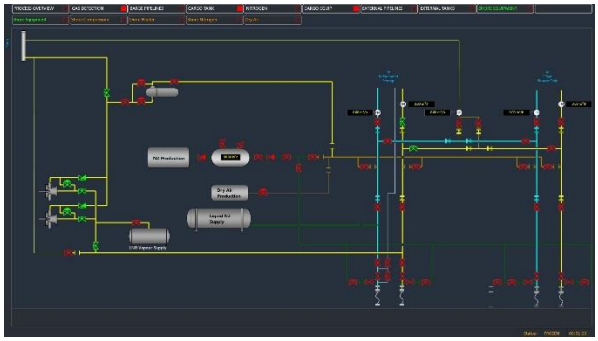


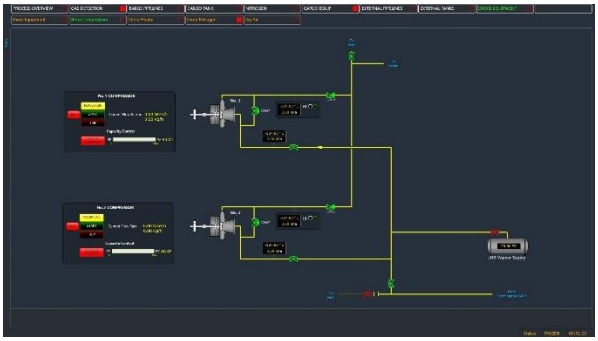




Receiving Vessel / Shore Storage Cargo System

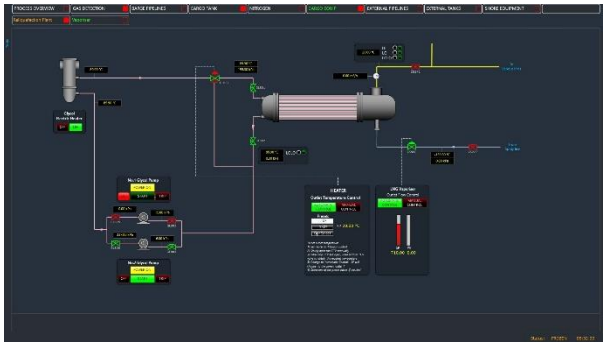
The shore system comprises of an atmospheric tank and a pressurised tanks together with a pipeline arrangement that allows either of the tanks to be connected to either of the manifolds on the barge. In addition a full set of shore based equipment is provided including compressors, heaters N2 & Dry Air production and a small LNG supply





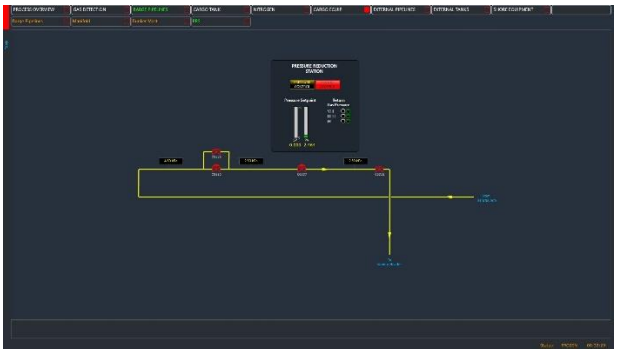
Vaporisers & Heaters

On the barge, one glycol based vaporiser is incorporated into the main configuration but a heater can also be added when the complete configuration is selected. Compressors and heaters are also available on the shore network allowing the operator to again simulator any of the likely scenarios that may be encountered



Reliquefaction & Pressure Reduction Station

The barge is equipped with six 'Cryocooler' units that provide the reliquefication capability. The Cryocoolers are standalone units that operate using the 'Stirling Cycle' and can be operated manually or in fully automatic mode where the units will start / stop dependent on the tank pressure and trend. A pressure reduction station is included that allows a high pressure vapour return to be handled within an atmospheric tank



Nitrogen Systems

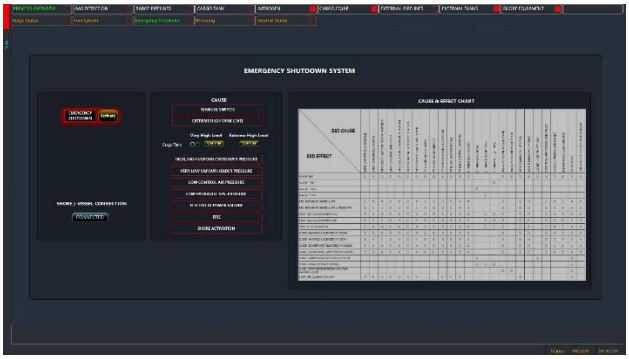
The barge is equipped with two Nitrogen generators of the membrane type are also included for the supply of Nitrogen to the compressors, and purging of the inter-barrier space around the cargo tanks. The purging system incorporates all the flow and pressure controls as per the real vessel. In a similar way to the IG the quality of the Nitrogen can be adjusted by the operator. As previously mentioned a shore based N2 production facility is also included.

Gas Detection Systems

Both fixed, sequential and portable gas detection systems are provided. The two sequential systems continuously monitor the spaces around the cargo areas for leakages with appropriate alarms and shutdowns implemented if gas is detected. The portable system allows the operator to select the type of instrument to be used for the detection of oxygen, %LEL or %Vol. The sample location points, located in the same location as per the actual vessel, can then be selected including cargo equipment and manifold connections, allowing the operator to check if operations are progressing correctly and safely.

Cargo Pumps & Controls

Automatic pump controls are provided which mimic the behaviour of the actual systems used on board the real barge. Full pump start, and appropriate valve opening sequencing is included. Spray pump controls are provided with an additional controller to allow the required pressure to be maintained within the spray header to be set, and maintained for use when tank / line cooling or providing a supply to the vaporiser.



Trim System

The barge trimming system comprises of four tanks is incorporated. The use of these tanks allows the trim of the barge to be maintained as required.

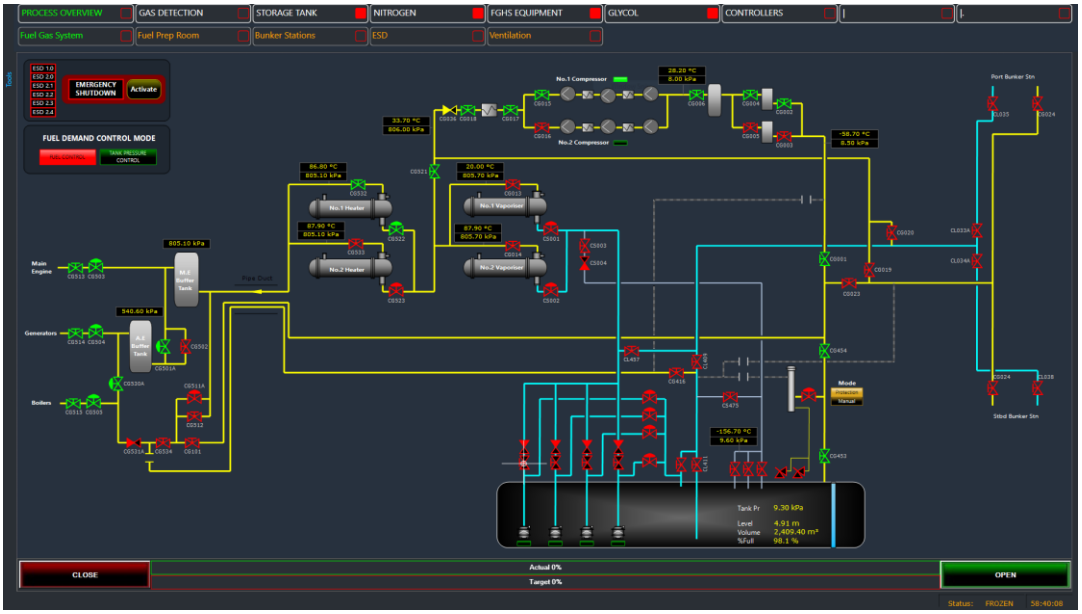
LNG Storage and Fuel Gas Handling Systems Library – Detailed Description

The model library incorporates a number of different configurations of storage and fuel gas handling systems (fghs) that may be found on vessels using LNG as a fuel and the different stypes of storage tank and the types of consumers that are fitted on the vessels concerned. The following describes the main features of each of the types of system currently available.

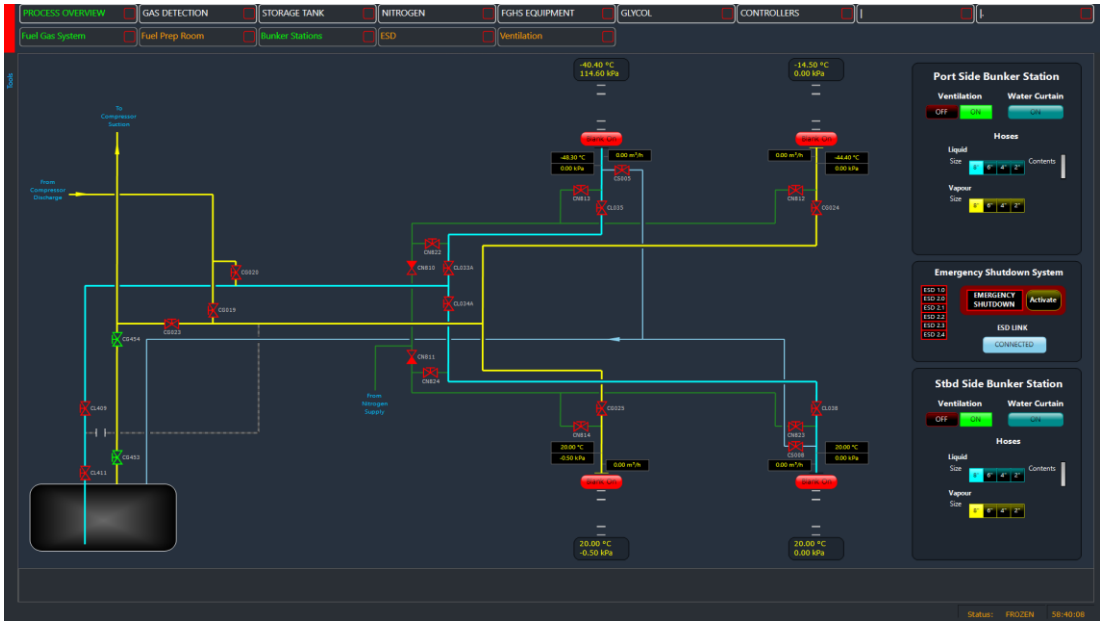
XDF - Atmospheric Tanks to XDF main engine and medium speed consumers

Fuel Gas Handling System

The fuel gas handling system includes all the relevant equipment and pipeline arrangements to retain the LNG within the storage tanks and then provide the gas to the various consumers in the appropriate quantities. The operator is provided with complete control over the line-up used. Restrictions on the movement of spool pieces or valves are applied as would be in real life. The bunker station



arrangements allow the operator to decide which manifolds should be used and connected to LNG bunker supplier to allow the operations to be undertaken as part of the full transfer to be conducted including setting the size of the hose to be used for the transfer and monitoring of the liquid content within the transfer hose.



Fuel Storage Tank

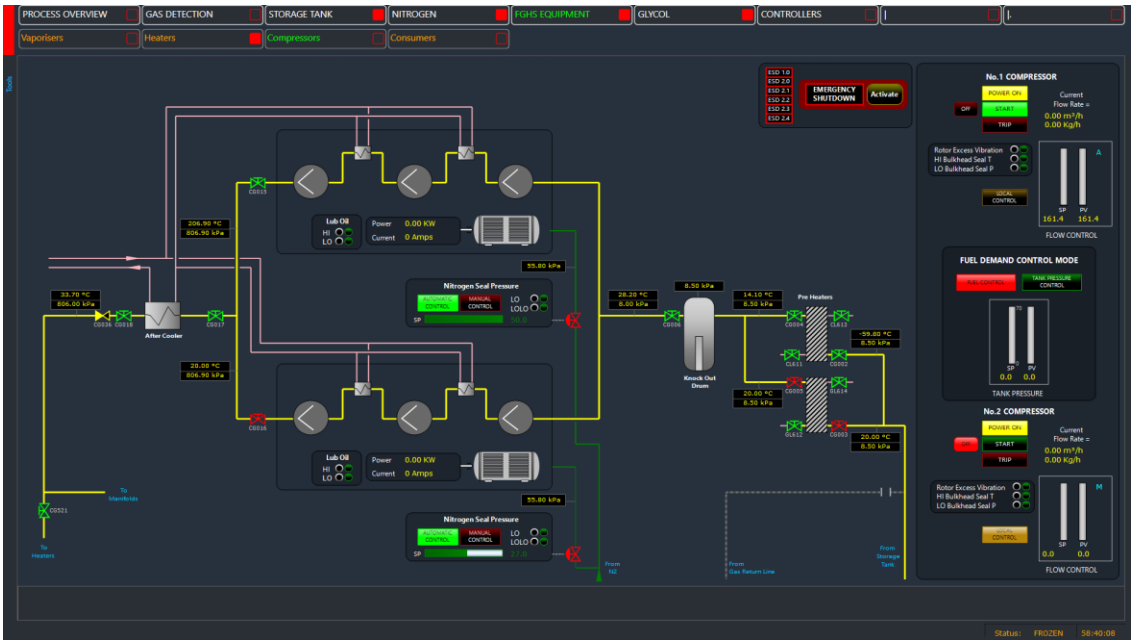
The system comprises of a single atmospheric storage tank (based on Membrane type but can be changed to Type C) which is fitted with four independent fuel supply pumps. The fuel supply pumps can also be used to maintain the condition in the tank. Full pump start and appropriate valve opening sequencing is included together with the automated control of the pump capacity to enable to appropriate amount of gas to be supplied to the consumers.

The maximum tank pressure can be adjusted by the instructor to allow both atmospheric and pressurised tank operations to be conducted

Compressors

The system includes two, 3-stage compressors which are used to provide gas directly from the storage tank to the consumers via the heaters. The cooling glycol circuit is also included together with the Nitrogen sealing arrangements. As with the other items of equipment all the start permissives and start

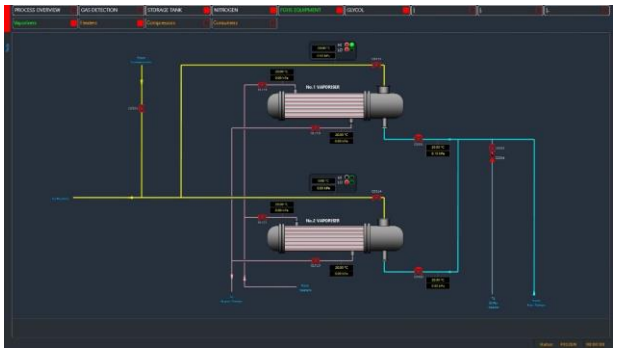
/ stop sequences are implemented as per the actual vessel together with the manual and automatic control functionality of the capacity of the compressor.

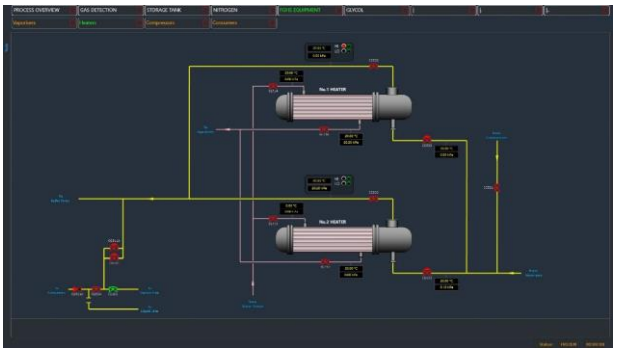


Vaporisers & Heaters

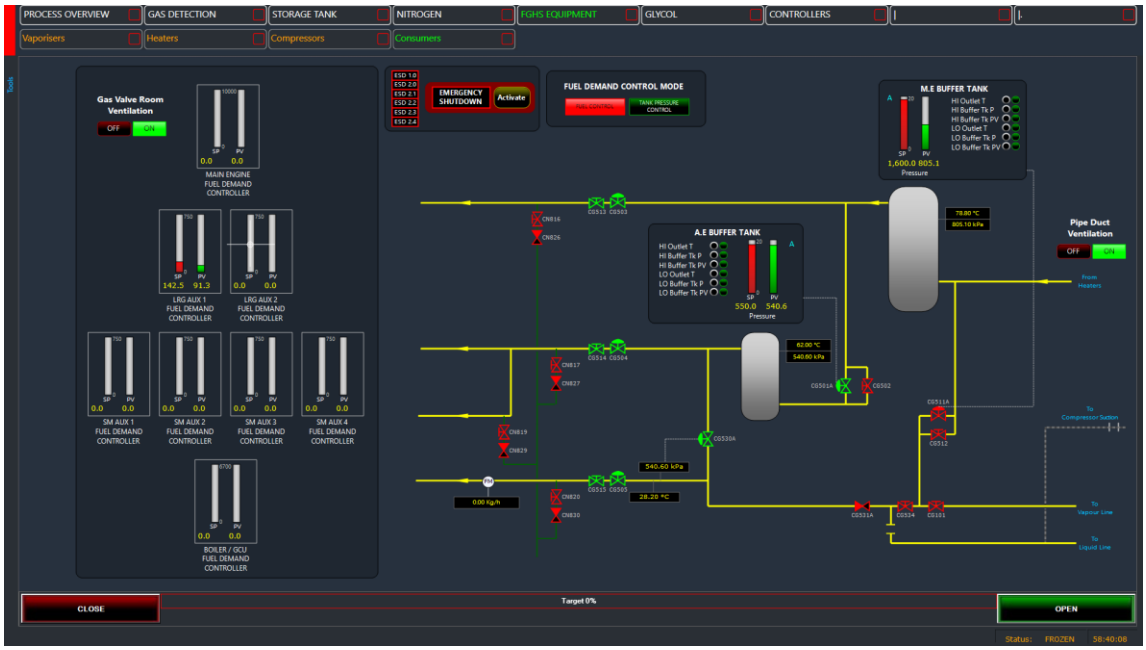
Two vaporisers and two heaters are included, to enable the gas to be supplied to the consumers at the appropriate temperature. one of each in use, whilst the others are standby units. The heating medium for both the vaporisers and heaters is a warm glycol system. Manual and automatic controls are provided to allow the system to be set up to deliver the correct temperature and pressure of boil off gas to the vessels engine room in combination with either one of the compressors or one of the fuel pumps.

The operator is provided with all the necessary controls including automatic systems for the operation of the vaporisers, heaters and the associated glycol system. All interlocks and alarms are provided as per the real vessel.





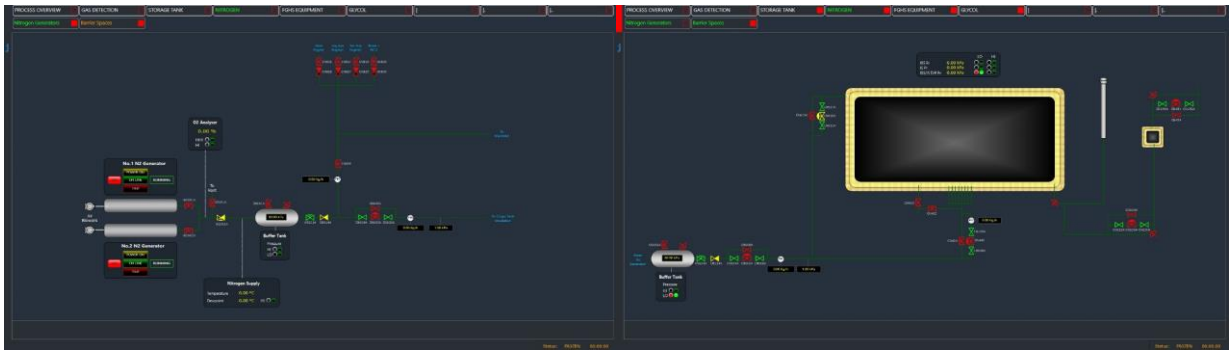
Consumers



The model allows the operator to control all the functions required from the storage tank through to the main gas valve unit of each consumer. The operator is able to set the required fuel demand on each consumer, which then adjusts to total fuel demand set point used by the automatic control system to adjust the capacity of the compressors or pump. The full control system is implemented and can be adjusted / controlled by the operator.

Nitrogen Systems

Aa Nitrogen Generator together with a drying system is incorporated. The Nitrogen is used for purging of the tank barrier spaces, compressor sealing arrangements and for inerting various parts of the pipeline system when required. The quality of the N2 can be decided by the operator, with connections provided into the barrier spaces around the storage tank. The purging system incorporates all the flow and pressure controls as per the real vessel.



In the event of a gas leakage into the barrier spaces the models allow all the procedures to be conducted to remove or control the gas leakage as appropriate to the system modelled.

Gas Detection Systems

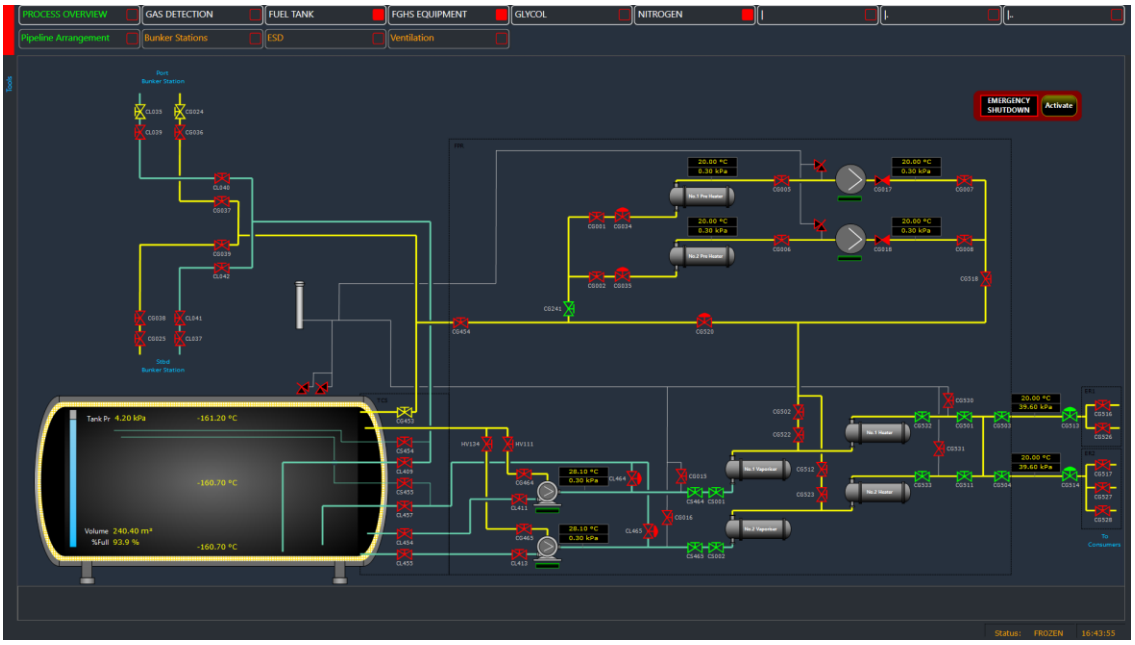
Both fixed and portable gas detection systems are provided. The portable system allows the operator to select the type of instrument to be used for the detection of oxygen, %LEL or %Vol. The sample location points, located in the same location as per the actual vessel, can then be selected including

cargo equipment and manifold connections, allowing the operator to check if operations are progressing correctly and safely.

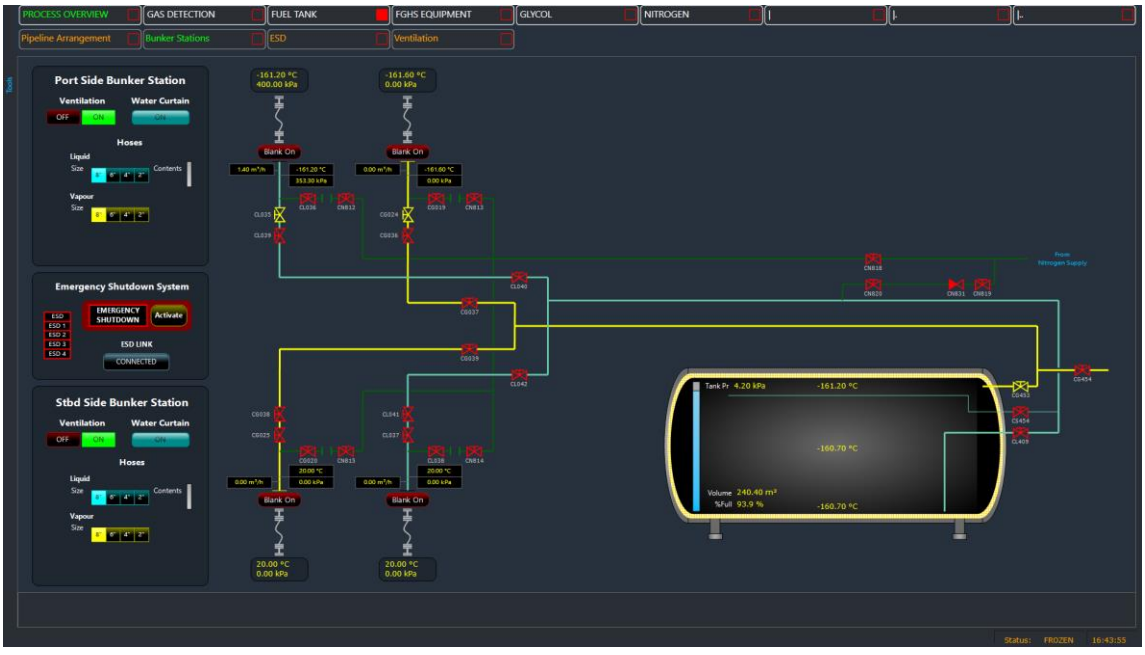
1PMS - Single Pressurised Tank (Type C) to medium speed consumers

Fuel Gas Handling System

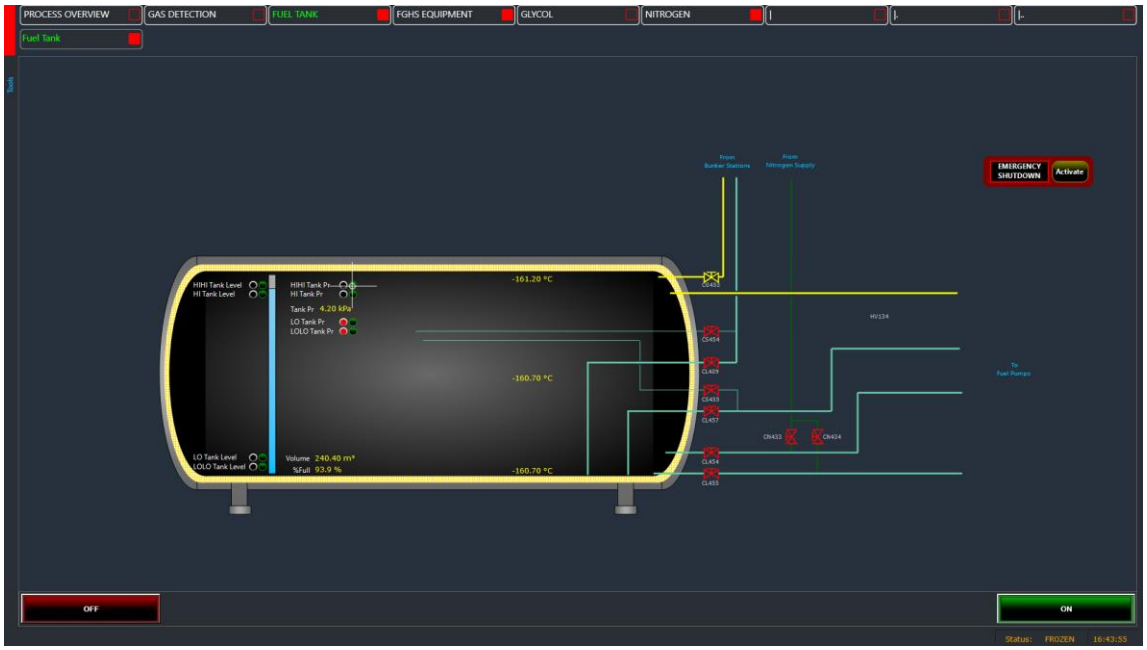
For this configuration the fuel gas handling system comprises a single Type C storage tank, and the vaporisers (evaporators), heaters to provide the fuel to the medium speed consumers. The system is also equipped with compressors to enable active management of the storage tank pressure.

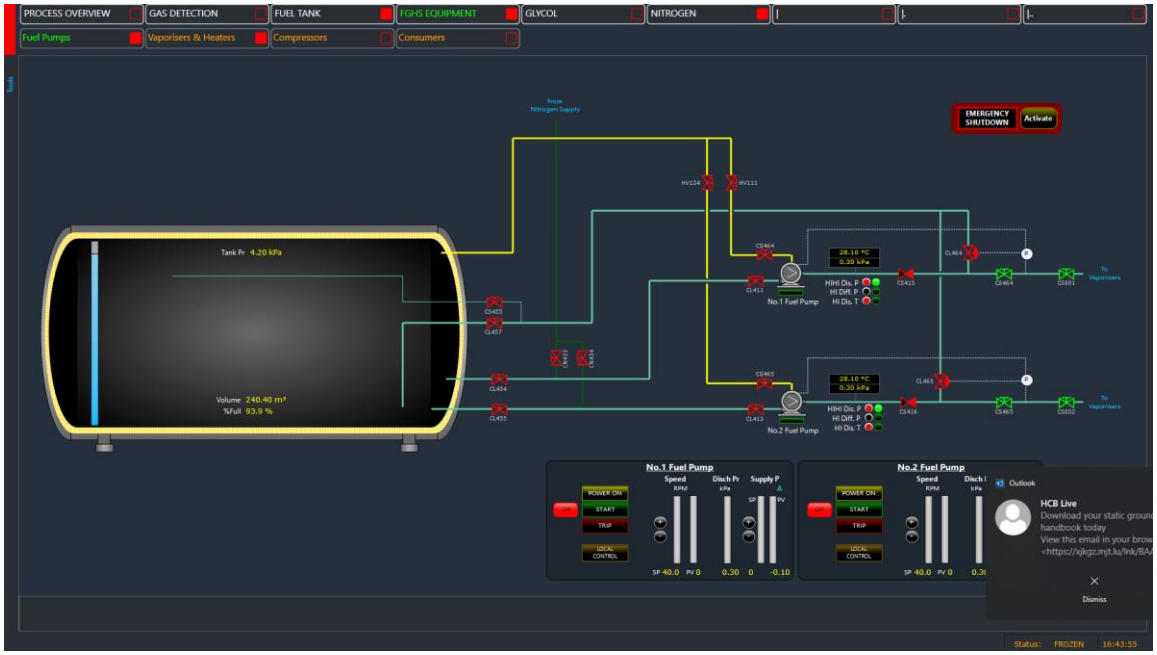


The bunker station arrangements comprise of a single liquid and vapour manifold on each side and as with the other models allow the operator to decide which manifolds should be used and connected to LNG bunker supplier to allow the operations to be undertaken as part of the full transfer to be conducted including setting the size of the hose to be used for the transfer and monitoring of the liquid content within the transfer hose.



Fuel Storage Tank



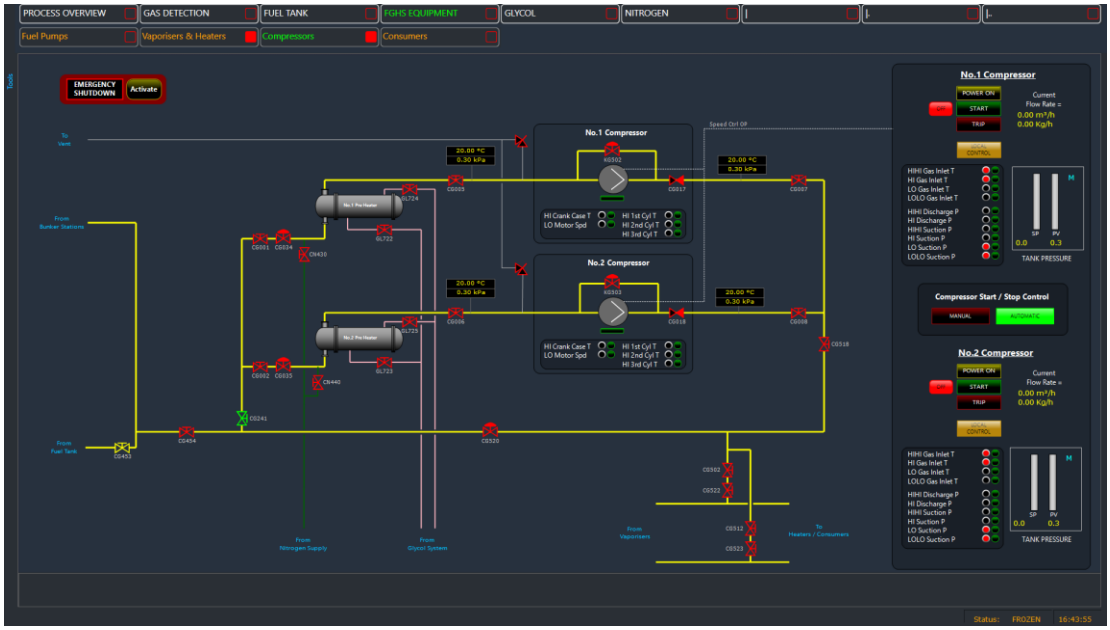


The system comprises of a single pressurised storage tank (Type C) and two fuel supply pumps. The fuel supply pumps can also be used to maintain the condition in the tank. Full pump start and appropriate valve opening sequencing is included together with the automated control of the pump capacity to enable to appropriate amount of gas to be supplied to the consumers.

The tank pressure and maximum relief valve settings can be adjusted by the instructor enabling the simulation of various fghs configurations that are in common use. The instructor also has the capability to change the LNG composition

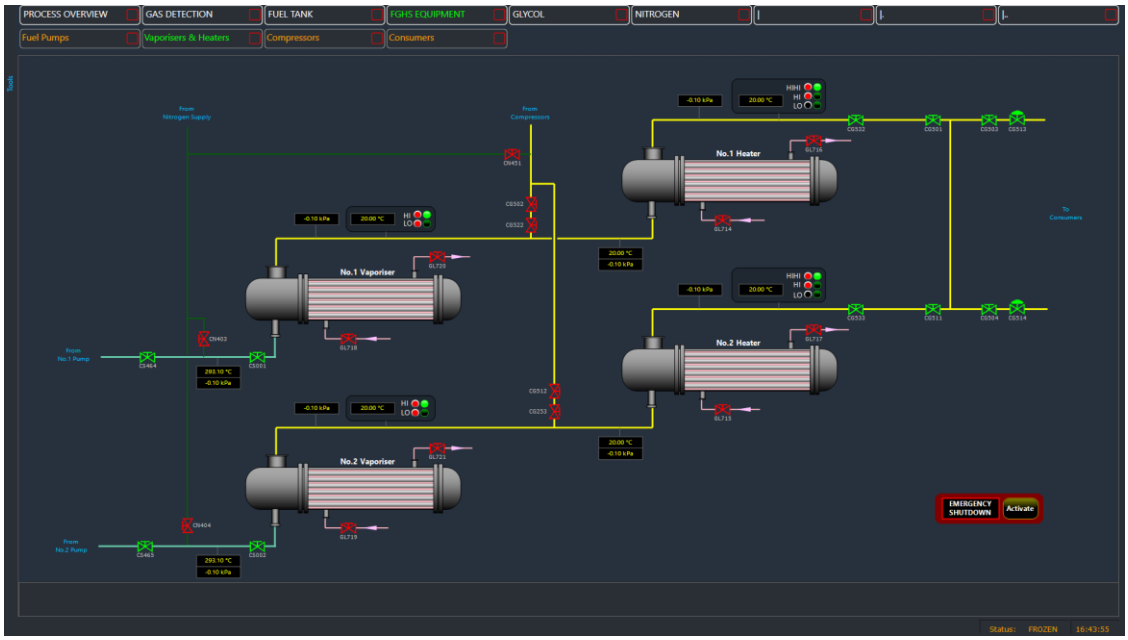
Compressors

The system includes two compressors which are used to provide gas directly from the storage tank to the consumers via the heaters. The glycol circuit is also included together with the Nitrogen sealing arrangements. As with the other items of equipment all the start permissives and start / stop sequences are implemented as per the actual vessel together with the manual and automatic control functionality of the capacity of the compressor.

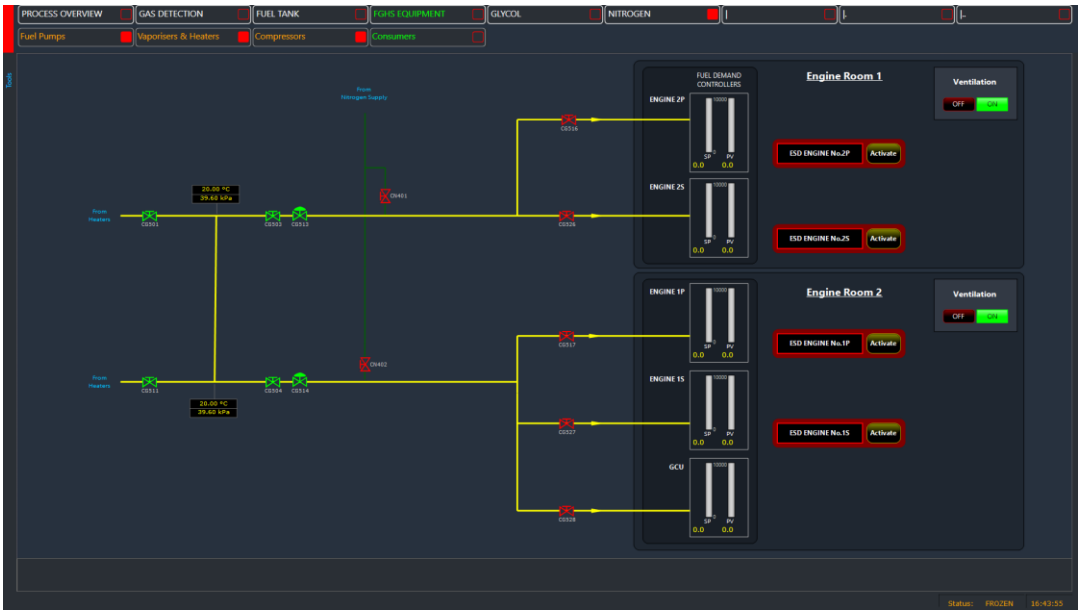


Vaporisers & Heaters

Two vaporisers and two heaters are included, to enable the gas to be supplied to the consumers at the appropriate temperature. one of each in use, whilst the others are standby units. The heating medium for both the vaporisers and heaters is the glycol system. Manual and automatic controls are provided to allow the system to be set up to deliver the correct temperature and pressure of boil off gas to the vessels engine room in combination with either one of the compressors or one of the fuel pumps.



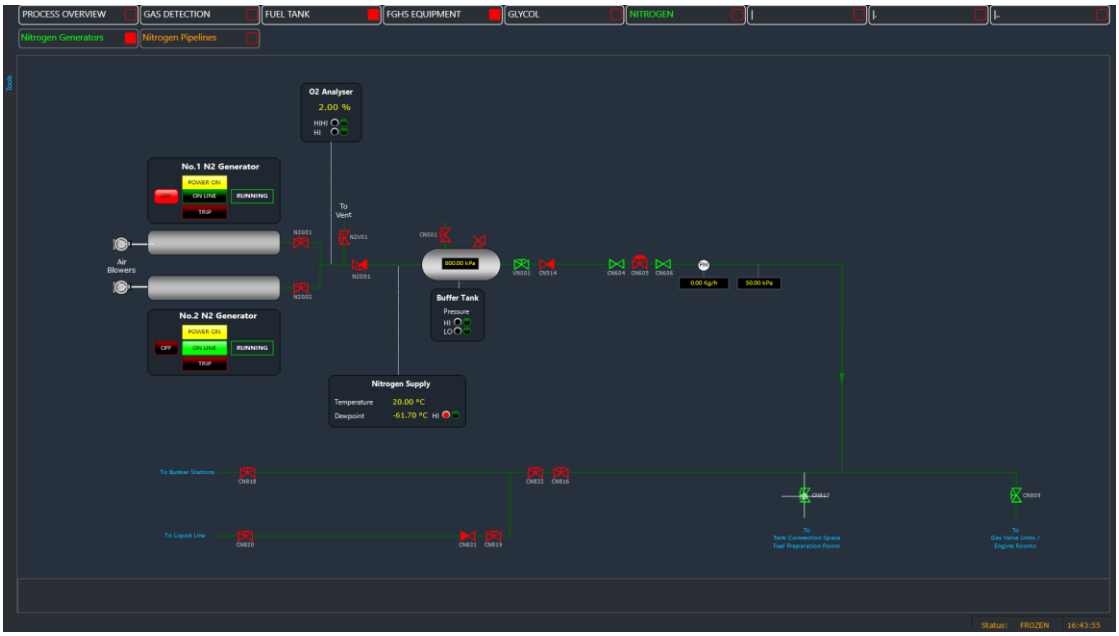
Consumers



The model allows the operator to control all the functions required from the storage tank through to the main gas valve unit of each consumer. The operator is able to set the required fuel demand on each consumer, which then adjusts to total fuel demand set point used by the automatic control system to adjust the capacity of the compressors or pump.

Nitrogen Systems

Aa Nitrogen Generator together with a drying system is incorporated. The Nitrogen is used for purging of the compressor sealing arrangements and for inerting various parts of the pipeline system when required. The quality of the N2 can be decided by the operator. The purging system incorporates all the flow and pressure controls as per the real vessel.



Gas Detection Systems

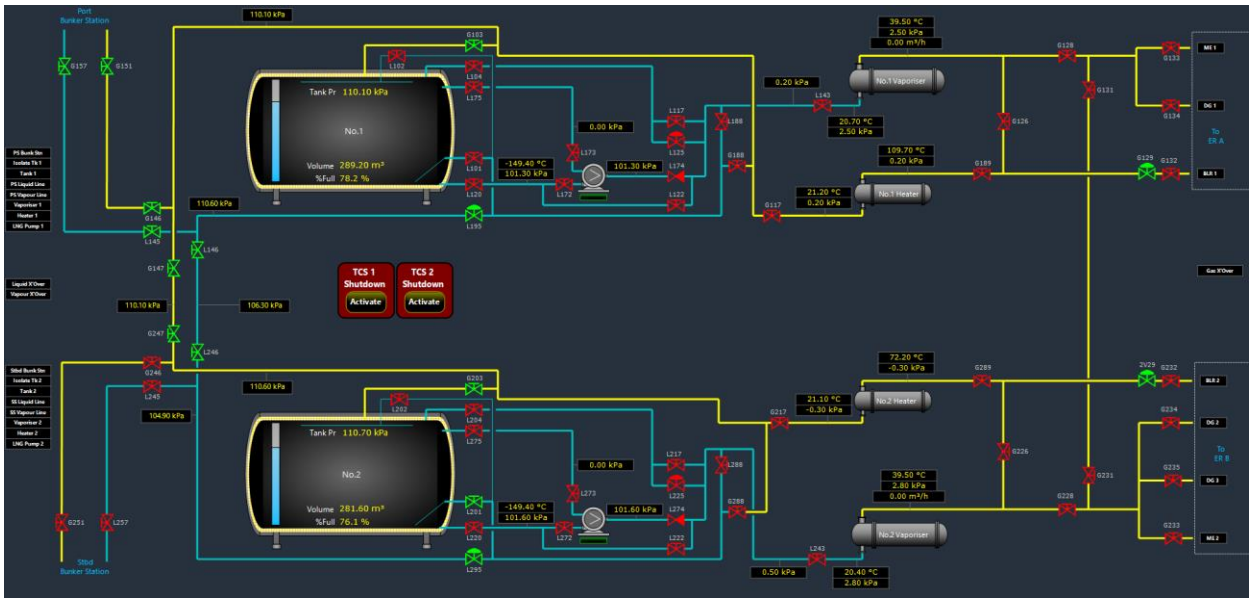
Both fixed and portable gas detection systems are provided. The portable system allows the operator to select the type of instrument to be used for the detection of oxygen, %LEL or %Vol. The sample

location points, located in the same location as per the actual vessel, can then be selected including cargo equipment and manifold connections, allowing the operator to check if operations are progressing correctly and safely.

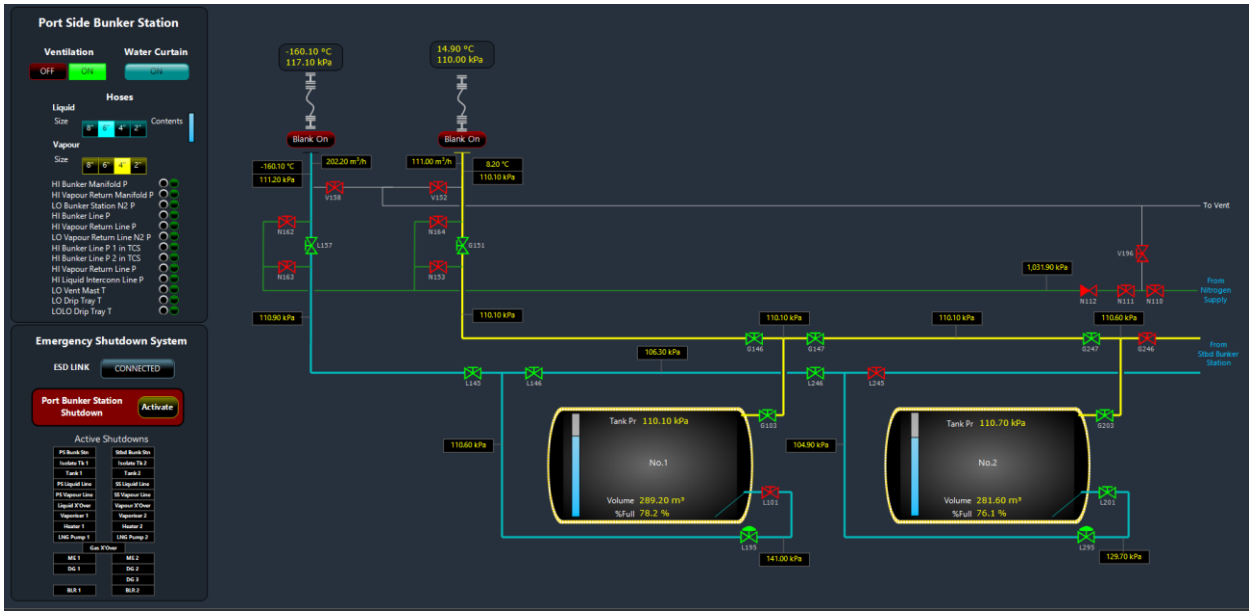
2PMS - Two Pressurised Tanks (Type C) to medium speed consumers

Fuel Gas Handling System

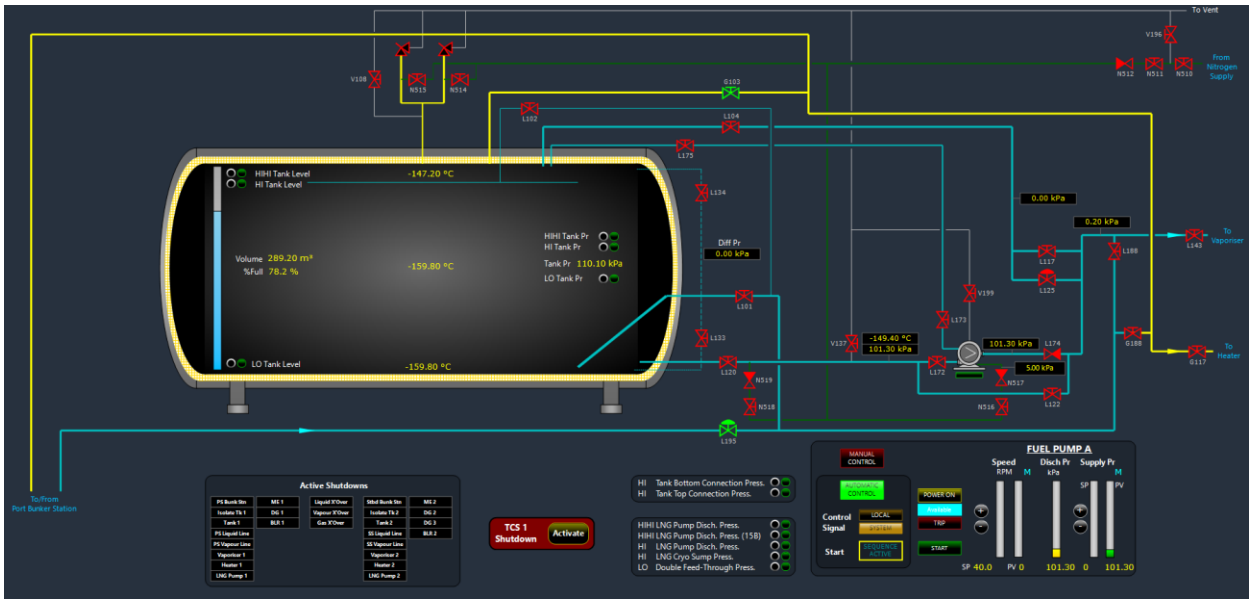
For this configuration the fuel gas handling system comprises two Type C storage tanks, and the vaporisers (evaporators), heaters to provide the fuel to the medium speed consumers.



The bunker station arrangements comprise of a single liquid and vapour manifold on each side and as with the other models allow the operator to decide which manifolds should be used and connected to LNG bunker supplier to allow the operations to be undertaken as part of the full transfer to be conducted including setting the size of the hose to be used for the transfer and monitoring of the liquid content within the transfer hose.



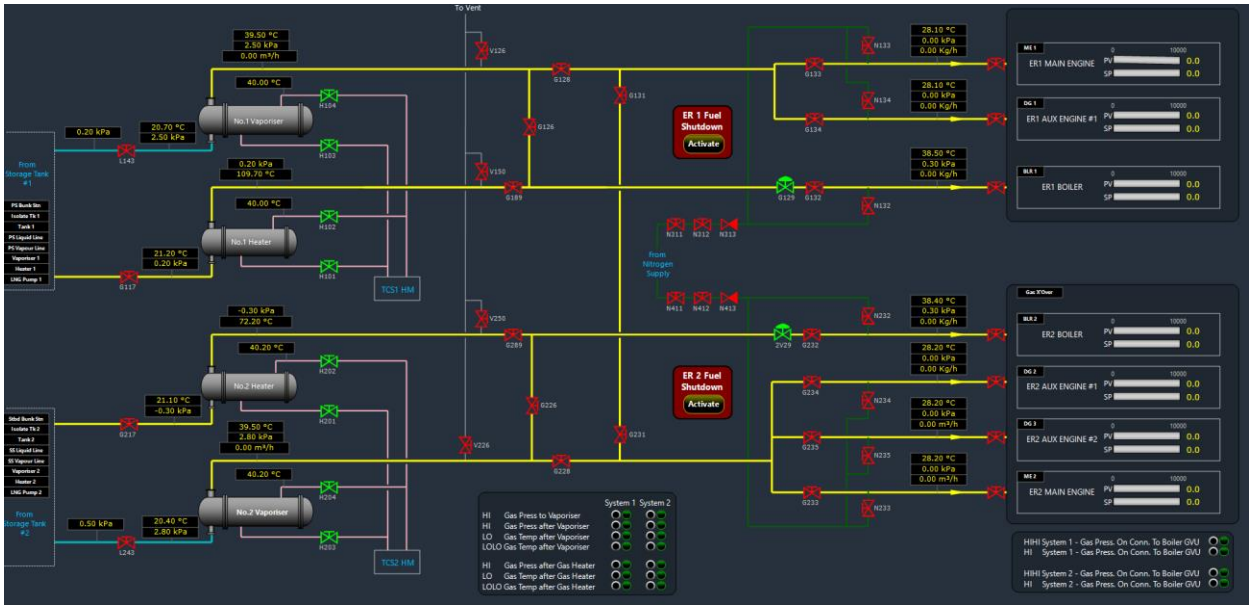
Fuel Storage Tanks



The FGHS comprises of two pressurised storage tank (Type C) each equipped with their own fuel supply pump, vaporiser and heater. The fuel supply pumps can also be used to maintain the condition in the tank. Full pump start and appropriate valve opening sequencing is included together with the automated control of the pump capacity to enable to appropriate amount of gas to be supplied to the consumers.

The tank pressure and maximum relief valve settings can be adjusted by the instructor enabling the simulation of various FGHS configurations that are in common use. The instructor also has the capability to change the LNG composition

Vaporisers & Heaters



Each system is equipped with a vaporiser, heater and glycol heating medium supply, to enable the gas to be supplied to the consumers at the appropriate temperature. Manual and automatic controls are provided to allow the system to be set up to deliver the correct temperature and pressure of boil off gas

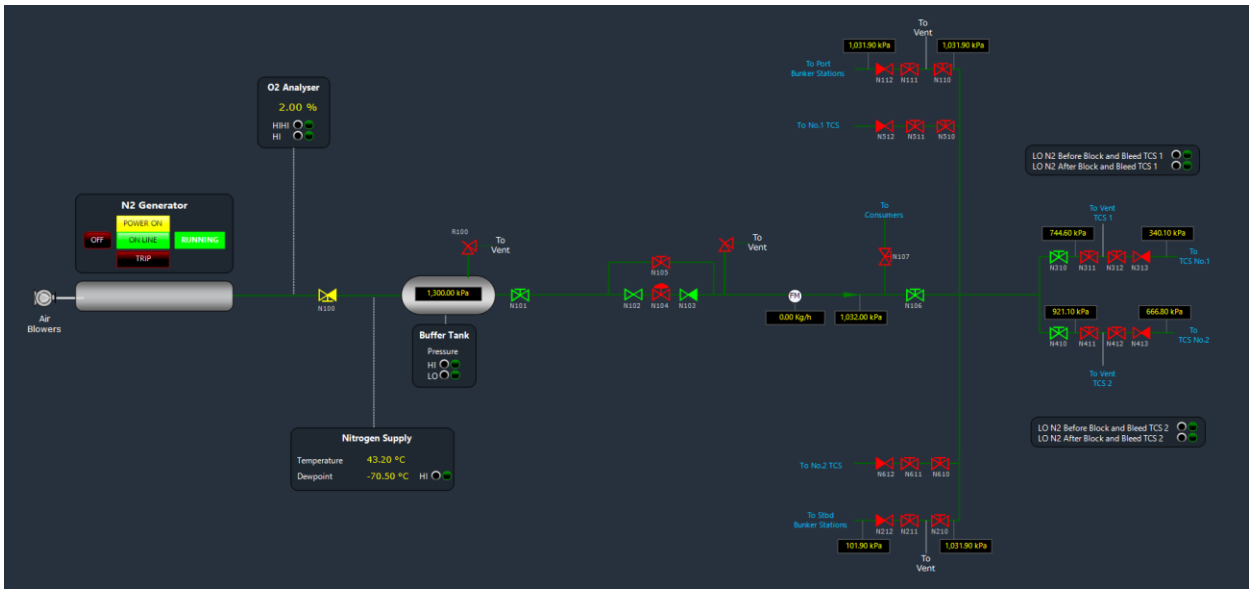
to the vessels engine room(s) in combination with either one of the fuel pumps or by free flow from the tanks.

Consumers

The model allows the operator to control all the functions required from the storage tank through to the main gas valve unit of each consumer. The operator is able to set the required fuel demand on each consumer, which then adjusts to total fuel demand set point used by the automatic control system to adjust the capacity of the compressors or pump.

Nitrogen Systems

Aa Nitrogen Generator together with a drying system is incorporated. The Nitrogen is used for purging of the compressor sealing arrangements and for inerting various parts of the pipeline system when required. The quality of the N2 can be decided by the operator. The purging system incorporates all the flow and pressure controls as per the real vessel.

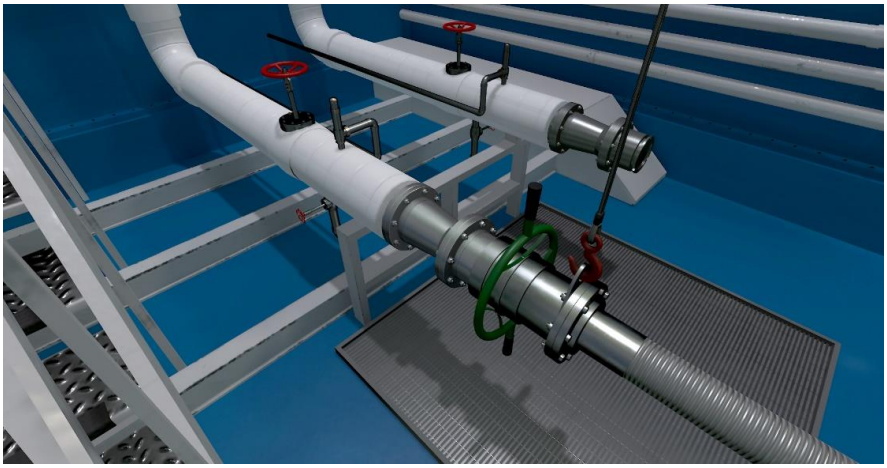


Gas Detection Systems

Both fixed and portable gas detection systems are provided. The portable system allows the operator to select the type of instrument to be used for the detection of oxygen, %LEL or %Vol. The sample location points, located in the same location as per the actual vessel, can then be selected including cargo equipment and manifold connections, allowing the operator to check if operations are progressing correctly and safely.

Bunker Station CCTV

A dynamic ‘CCTV’ visualisation of the bunker station is also available for fuel gas handling system (FGHS) models if required. The visualisation provides a ‘CCTV’ view of the bunker station that is linked to the actions conducted by the operator and provides a visual representation of the actions conducted at the bunker station including connection/disconnection of the hoses, cooling down and purging etc., and leaking of the couplings



Training

Introduction to G-Sim

GTT Training offer a comprehensive training program for the intended Operators and Instructors of the G-Sim Liquid Gas Handling Simulator. The program is delivered over a number of days, the actual duration being dependent upon:

- The models installed
- The previous experience of those being instructed
- The client's requirements

The training program normally comprises

- 1 day Setting up of the simulator and system operation
- 3-4 days Operation of the simulated models and instructor controls

Full details of the contents of the course can be provided on request.

G-Sim Advanced Training

If required GTT Training are able to provide advanced training programs in how to use G-Sim in the most efficient manner and the techniques that instructor should employ to ensure effective training.

The following is an example of a 'G-Sim Train the Trainer' program:

- Week 1 – A highly experienced trainer from GTT Training will undertake a LNG Cargo Handling Course based on a specific ship type for students supplied by the client, with the future instructors watching and assisting.
- Week 2 – A further week where the future instructors deliver the same LNG Cargo Handlin course for new students, but with the representative from GTT Training assisting as required.

This method has been found to be an extremely effective way of enabling instructors to quickly become familiar with using the G-Sim equipment and delivering courses in the appropriate way.

The above principle can be adapted to suit any client circumstances and if required GTT Training will work directly with the client to identify their specific requirements and will design and deliver courses accordingly.

Course Curriculums

GTT Training are able to supply 'off the shelf' course curriculums based on the use of G-Sim, for the running of courses in:

- LNG Cargo Operations
- LNG Cargo Operations in accordance with the SIGTTO Competency Guidelines
- LNG Bunkering Operations including the SGMF Competency Guidelines
- Basic & Advanced STCW Courses for personnel serving on board LNG fuelled vessels

Each of the curriculums include:

1) Guidelines for the setting up of the course including staff and student numbers, materials etc
2) Detailed timetable
3) Teaching Syllabus - including the aims and objectives for each of the exercises to be conducted during the course
4) Instructor manual – includes full instructions for the instructor regarding the content of exercise briefing/debriefing sessions, how to set up and use the simulator for each exercise including guidance on how to monitor and interact with the students when the exercises are in progress
5) Student exercise notes
6) PowerPoint slides to complement each exercise briefing
7) Exercise instructor checklists
8) Student course manual.

Each of the course materials are based on the same materials used by GTT Training in the delivery of their own courses and have been approved by the appropriate bodies accordingly.

DNV Training Centre Product Certificate

Traditionally, a training centre has had to apply to DNV-GL or another class society to obtain a Product Certificate certifying the use of the simulator within a specific establishment so that it can show the simulator meets the requirements of the bodies concerned.

DNV-GL have introduced a new scheme whereby certain simulator providers are able to obtain a 'Product Certificate' on behalf of the training centre for a DNV-GL approved simulator, once the installation and appropriate paperwork has been completed.

Consequently, should the client require, GTT Training are part of this scheme and hence are able to provide clients with a training centre 'Product Certificate' for G-Sim once the installation is completed. The main benefit of this scheme is that is avoids the training centre incurring the costs of having a separate audit by DNV-GL to obtain the Product Certificate.

Contact Details

To discuss further any of the contents within this document, or how GTT Training may be able to assist you, contact us at:

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