GUIDE FOR BUILDING AND CLASSING

LIQUEFIED GAS TANK BARGES WITH REMOTE CONTROL AND MONITORING OF ESSENTIAL SYSTEMS

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Foreword

This Guide has been developed to provide guidance for the design and construction of liquefied gas tank barges with remote control and monitoring of essential systems built in accordance with the ABS *Rules for Building and Classing Steel Barges* and the ABS *Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways*.

This Guide applies to Control, Alarm, and Monitoring Systems (CAMS) of periodically unattended barges from an attended Remote Control and Monitoring Station (RCMS) on their associated towing vessels. The ABS *Rules for Building and Classing Steel Barges (Barge Rules)*, ABS *Rules for Building and Classing Marine Vessels (Marine Vessel Rules)*, and the ABS *Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways (River Rules)* are to be used in association with this Guide, as applicable.

The effective date of this Guide is the first day of the month of publication.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version of this Guide is the most current.

We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org.

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SECTION 1 General

1 Application and Scope

This Guide has been developed to provide requirements for the design and construction of liquefied gas tank barges with remote control and monitoring of essential systems built in accordance with the ABS *Rules for Building and Classing Steel Barges (Barge Rules)* and the ABS *Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways (River Rules)*. Manning is established by the flag Administration.

This Guide is applicable to non-self-propelled barges equipped with various degrees of automation and remote control and monitoring of essential systems supporting cargo management that are periodically unattended and controlled primarily from the associated towing vessel navigation bridge.

For a periodically unattended barge assigned the **Liquefied Gas Tank Barge** notation, the provisions of this Guide are required to be complied with. The same may be applied to a barge assigned **Liquefied Gas Tank Barge, River Service** notation in accordance with the *River Rules*.

In addition to the above notation, the following comment will be maintained in the ABS *Record* in compliance with this Guide:

> "Classed to operate with barge remote control and monitoring with the associated towing vessel(s) (Vessel Name(s) and IMO Number(s))".
>
> Alternative identification number will be considered where an IMO number is not assigned.

This Guide is not intended for automation, remote control and monitoring for thrusters and dynamic positioning systems. For information on automation, remote control and monitoring for thrusters and dynamic positioning systems, see the ABS *Guide for Dynamic Positioning Systems*, as per 5C-8-1/2 of the *Marine Vessel Rules*.

2 Definitions

Active Component/Active Systems: Generators, refrigeration equipment, switchboards, cargo pressure/ temperature control computers, sensors, remote controlled valves, compensators, etc.

Alarm: An audible and visual indication of a hazardous or potentially hazardous condition that requires attention.

Automatic Control: Self-regulating in attaining or carrying out an operator-specified equipment response or sequence.

Availability Concept: In case of a single failure of a mechanical non-static component or a component of the control systems, the cargo tanks' pressure and temperature can be maintained within their design range without affecting other essential services.

Barge: A non-self-propelled vessel that is towed or pushed by another vessel.

Blackout: Loss of the main source of electrical power resulting in the main and auxiliary machinery being out of operation.

Cargo Machinery Spaces: Spaces where cargo compressors or pumps cargo processing units, are located, including those supplying gas fuel to the engine-room.

Cargo Pressure/Temperature Control (CPTC): The means to monitor and maintain a cargo tank's pressure and temperature.

Centralized Control and Monitoring Station (CCMS): A control station on the barge fitted with instrumentation and control systems enabling machinery to be controlled and monitored without requiring regular local attendance.

Closed Bus: Also called joined bus, tied bus or closed-ring. Describes an operational configuration where all or most sections and all or most switchboards are connected together, that is, the bus-tie breakers between switchboards are closed. The alternative to closed bus is open bus, sometimes called split bus or split ring.

Common Cause Failure: A failure that occurs when a single specific event or cause, because of dependencies, leads to failure of two or more systems.

Computer System: A system of one or more programmable electronic devices, associated software, peripherals and interfaces. Microprocessors, Programmable Logic Controllers (PLC), Distributed Control Systems (DCS), PC- or server-based computation systems are examples of computer-based systems.

Control: The application of restraint or direction over a desired function, thus commanding its actions.

Control, Alarm, and Monitoring Systems (CAMS): A grouping or arrangement of observation instrumentation, audible and visual indication, with devices interconnected or otherwise coordinated to convey commands or orders to indicate the state of cargo or equipment and assist with determining if a hazardous or potentially hazardous condition may exist and attention that may be required from either a Centralized Control and Monitoring Station (CCMS) or Remote Control and Monitoring Station (RCMS).

Control System: An assembly of devices interconnected or otherwise coordinated to convey commands or orders.

Essential System or Equipment: Equipment necessary for the safety of the vessel supporting cargo management. This typically includes, but is not limited to (See 4-8-1/7.3.3 of the *Marine Vessel Rules*):

- Services considered necessary to maintain dangerous spaces in a safe condition (inert gas systems, ventilation for air-locks, etc.)
- Voice communication equipment
- Fire detection and alarm systems
- Lighting systems
- Electric generators and associated power sources supplying essential equipment
- Control, monitoring and safety systems for cargo containment systems
- Control, monitoring and safety devices/systems of equipment for essential services
- Ambient temperature control equipment

Fail-safe: The ability of a system or a machine, upon the failure of a component or subsystem or its functions, to automatically revert to a designed state of least critical consequence. In the context of this Guide, failure states of least critical consequence are generally those that will not result in undesirable consequences such as a loss of control of cargo pressure and temperature or other hazardous conditions.

Failure Mode and Effect Analysis (FMEA): A failure analysis methodology used during design to postulate every failure mode and the corresponding effect or consequence. Generally, the analysis begins by selecting the lowest level of interest (part, circuit, or module level). The various failure modes that can occur for each item at this level are identified and enumerated. The effect for each failure mode, taken singularly and in turn, is to be interpreted as a failure mode for the next higher functional level. Successive interpretations will result in the identification of the effect at the highest function level, or the final consequence.

Gas Combustion Unit (GCU): A means of utilizing excess cargo vapor via thermal oxidation.

Hazard and Operability Analysis (HAZOP): A structured and systematic examination of a complex planned or existing process or operation, used to identify and evaluate problems that may represent risks to personnel or equipment.

Hidden Failure: A failure that is not immediately evident, such as protective functions upon which redundancy depends.

Human Machine Interface (HMI): A component of some devices that enables human-machine interactions. The interface consists of hardware and software that allows user inputs to be translated as signals for machines that, in turn, provide the required result to the user.

Independence: A system that can operate without the assistance of central control or other systems or subsystems. In this Guide it is mainly in reference to main machinery such as generators and thrusters. Auxiliary and control functions are to be provided in a manner that makes the machinery as independent as practical to minimize the number of failures that can lead to the loss of more than one main piece of machinery.

Instrumentation: A system designed to measure and to display the state of a monitored parameter and which may include one or more sensors, read-outs, displays, alarms and means of signal transmission.

Interface: A transfer point at which information is exchanged.

Liquid Cargo Cooling: The refrigeration of bulk cargo by coolant circulated through coils fitted either inside the cargo tank or onto the external surface of the cargo tank.

Liquefied Gas Tank Barge: Barges built in accordance with the ABS *Rules for Building and Classing Steel Barges*, and intended to carry those liquid gases addressed by the International Code for the Construction and Equipment of Ships Carrying Liquid Gases in Bulk.

Local Control: A device or array of devices located on or adjacent to a machine enabling operation within sight of the operator.

Machinery Space: In the context of this Guide, a space fitted with essential internal combustion engines required to be operating while the barge is periodically unattended.

Monitor: The use of direct observation, instrumentation, alarms, or a combination of these to determine the state of cargo or equipment.

Periodically Unattended Barge: A barge with no accommodation spaces or service spaces (as defined by 5C-8-1/2 of the *Marine Vessel Rules*), and where the barge is considered for ‘unmanned’ operation by the flag administration.

Peripheral: A device performing an auxiliary function in the system, such as a printer or data storage device.

Power System: All components and systems necessary to supply the CAMS system with power, including:

- Prime movers with necessary auxiliary systems including piping
- Generators
- Switchboards
- Electrical distribution system (cabling and cable routing)
- Power management

Redundancy: Ability of a component or system to maintain or restore its function, when a single fault has occurred. Redundancy can be achieved for instance by installation of multiple components, systems or alternative means of performing a function.

Refrigeration Unit: The machinery comprising the compressor, the compressor’s driving motor and a condenser, if fitted, independent of any other refrigeration machinery for provision stores or the air conditioning plant.

Refrigeration System: One or more cooling systems for chilling the cargo and maintaining it at the required temperature.

Reliquefaction System: A system that may be arranged in one of the following ways:

- A direct system, where evaporated cargo is compressed, condensed and returned to the cargo tanks
- An indirect system, where cargo or evaporated cargo is cooled or condensed by refrigerant without being compressed
- A combined system, where evaporated cargo is compressed and condensed in a cargo/refrigerant heat exchanger and returned to the cargo tanks

Remote Control: A device or array of devices connected to a machine by mechanical, electrical, pneumatic, hydraulic, or other means (e.g., wireless communications) and by which the machine may be operated remotely from, and not necessarily within sight of, the operator.

Remote Control and Monitoring Station (RCMS): A designated, normally attended, and permanent control station fitted with means of remote control and monitoring of cargo and machinery related to essential barge systems. In the context of this Guide, RCMSs are not located on the subject barges but rather the associated towing vessels.

Safety System: An automatic control system designed to automatically lead machinery being controlled to a predetermined less critical condition in response to a fault which may endanger machinery or the safety of personnel and which may develop too fast to allow for manual intervention.

To protect an operating machine in the event of a detected fault, the automatic control system may be designed to automatically perform one or more of the following:

- Slow down the machine or reduce its demand
- Start a standby support service so that the machine may resume normal operation
- Shut down the machine

For the purposes of this Guide, automatic shutdown, automatic slowdown and automatic start of standby pump are all considered safety system functions. Where “safety system” is stated hereinafter, it means any, some, or all three automatic control systems.

Separation: (Redundant systems) The reduction of the number of connections between systems to reduce the risk that failure effects may propagate from one redundant system to another.

Single Fault: The termination of the ability to perform a required function of a component or a subsystem.

Static Component: Non-moving components such as cables and pipes.

Summary Alarm: A common alarm activated by any abnormal condition of the monitored machinery or system.

Thermal Oxidation Method: A system where the boil-off vapors are utilized as fuel for shipboard use or as a waste heat system subject to the provisions of Section 5C-8-16 of the *Marine Vessel Rules* or a system not using the gas as fuel complying with the IGC Code.

Towing Vessel: An attending vessel engaged in pulling, pushing, or hauling alongside another vessel.

3 Certification

In lieu of Section 4-1-1 of the *Barge Rules*, mechanical and electrical machinery components of essential systems in support of cargo management are to be certified in accordance with the 4-1-1/3 of the *Marine Vessel Rules*. Survey at the manufacture is to be conducted as applicable.

4 Alternatives

Equipment, components, and systems for which there are specific requirements in this Guide, or its associated references, may incorporate alternative arrangements or comply with the requirements of alternative recognized standards, in lieu of the requirements in this Guide. This however is subject to such alternative arrangements or standards being determined by ABS as being not less effective than the overall safety requirements of this Guide or associated references. ABS will also for this purpose consider the

applications of risk evaluations for alternative arrangements in accordance with the ABS *Guide for Risk Evaluation for the Classification of Marine-Related Facilities*. Where applicable, requirements may be imposed by ABS in addition to those contained in the alternative arrangements or standards so that the intent of this Guide is met. In all cases, the alternative equipment, component or system is subject to design review, survey during construction, tests, and trials, as applicable by ABS for purposes of verification of its compliance with the alternative arrangements or standards. The verification process is to be to the extent as intended by this Guide.

Where alternatives are intended to be used in lieu of the requirements of the *International Convention on Load Lines, 1966*, such application is subject to approval by the flag Administration.

5 Plans to be Submitted

The following plans are to be submitted in addition to the plans reviewed by the *Barge Rules* and *Marine Vessel Rules*, as applicable:

5.1 Risk Assessment

Risk assessments (HAZOP and FMEA) are to be carried out to review the design of the CAMS. Further details can be found in Section 5.

5.2 Arrangements of Electrical Equipment

Arrangement plans showing the locations of the following equipment and systems:

- Generators, main switchboard, motor control centers, transformers/converters
- Batteries and battery charging and discharging boards
- Lighting systems
- Emergency Shutdown System
- Cables between barge and towing vessel

5.3 Machinery Safety System

Safety systems descriptions may include a list of all monitored parameters with settings for implemented protective actions (e.g., automatic shutdown and automatic slowdown), schematic diagrams showing the connections between the safety devices, control and display units, alarm devices, Human Machine Interface (HMI) and power supply arrangement, as appropriate, and operational descriptions for the following:

- Initiation of automatic shutdown
- Initiation of automatic slowdown
- Initiation of automatic starting of standby units
- Override of automatic shutdown
- Override of automatic slowdown

5.4 Machinery Monitoring System

Schematic diagrams showing the connections between the sensing devices, control and display units, alarm devices, human machine interfaces (HMI) and power supply arrangement, and description of monitoring systems including a list of alarms and displays including preset parameters for the machinery and all essential auxiliary machinery and systems at the following stations:

- Centralized control station alarm and instrumentation
- Remote control station alarm and instrumentation

5.5 Fire Safety Arrangements

Schematic diagrams and descriptions of the fire detection and alarm systems, fire precautions, fire-extinguishing equipment.

5.6 Communication Systems

Schematic diagrams and arrangements of the internal communication systems.

5.7 Wireless Data Communication Equipment

The following documentation is to be submitted for wireless data communication equipment.

- Documentation which demonstrates that the wireless data communication equipment provides an improvement in the safety of the vessel, compared to wired data communication
- General details of the wireless system and equipment
- Included in the scope of FMEA
- Evidence of type testing
- On-board test schedule
- Details of manufacturer's recommended installation and maintenance practices; network plan with arrangement and type of antennas and identification of location, and details of the wireless data communication network
- Specification of wireless communication system protocols and management functions
- Details of radio-frequency and power levels
- For functions that are provided with an alternative means of control, a description of the functions and a description of the alternative means of control

5.8 Test Program and Operations Manual

5.8.1 Factory Acceptance Tests

Factory Acceptance Tests (FAT) are test programs conducted at the manufacturer to include the description of test configuration and test simulation methods, initial test condition, steps to perform the test, observations during the test and acceptance criteria for each test.

5.8.2 Test Program for Sea or Dock Trials

Test program for sea trial or dockside trials is to include initial test condition, steps to perform the test, observations during the test and acceptance criteria for each test.

5.8.3 Operations Manual

For each vessel, an operations manual is to be prepared and submitted solely for verification that the information in the manual, relative to the remote control system, is consistent with the design and information considered in the review of the system. One copy of the operations manual is to be kept onboard the barge and associated towing vessel.

The operations manual is intended to provide guidance for the operator about the specific CAMS installations and arrangements of the specific vessels. The operations manual is to include but is not limited to the following information.

- A description of all the systems associated with the remote control of the vessel, including backup systems and communication systems
- The block diagram showing how the components are functionally related
- A description of the different operational modes and the transition between modes

- Operating instructions for the normal operational mode (and the operational modes after a failure) of the electrical or computer control systems, manual control system, manual local control to each equipment
- Operating instructions for the systems and equipment, indicated in the above paragraph, during failure conditions
- Maintenance and periodical testing procedure, acceptance criteria, fault identification and repair, list of the suppliers' service net, and maintenance log

6 Tests and Surveys

6.1 Installation Tests

Automatic or remote control and monitoring systems are to be subjected to tests witnessed by the Surveyor during and after installation onboard, as outlined in this Guide.

6.2 Periodical Surveys

Periodic survey of the automatic or remote control and monitoring systems installation are to be conducted as outlined in Section 5 of this Guide.

SECTION 2 Control, Alarm, and Monitoring Systems

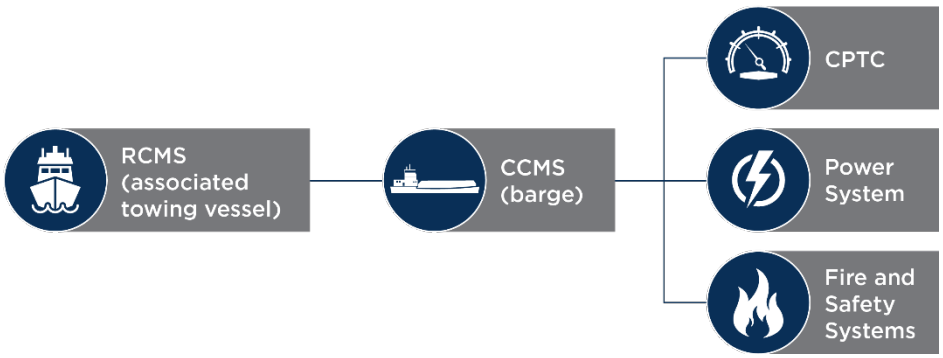
1 General

This Section addresses the Control, Alarm, and Monitoring Systems (CAMS) to be fitted on the barge and the associated towing vessel.

The design of the CAMS between the barge and associated towing vessel must be suitable for the intended service and route of the vessel.

For Liquefied Gas (LG) tank barges, the CAMS are considered ‘essential systems’ as a means to maintain the cargo containment system pressure and temperature.

FIGURE 1
Control Alarm Monitoring System (CAMS)



2 Control System Conceptual Requirements

The following are conceptual requirements for control system design in general and are to be complied with. An FMEA is to be conducted to demonstrate that control, monitoring and safety systems are so designed that any single failure will not result in undesirable consequences such as a loss of Cargo Pressure/Temperature Control (CPTC) or other hazardous conditions.

2.1 Fail-Safe

A Fail-Safe concept is to be applied to all the control systems for essential systems or equipment (including systems associated with local, centralized and remote stations).

Because systems and related subsystems may have different fail-safe criteria, each system or subsystem is to have a determination of the desired fail-safe condition, such fail As Is or Fail Stop, of the equipment controlled.

2.2 System Independence

Systems performing different functions (e.g.,. monitoring systems, control systems, and safety systems) are to be, as much as practical, independent of each other such that a single failure in one will not render the others inoperable.

2.3 Local Controls

In general, local manual controls are to be fitted as close as practicable to the subject equipment so as to enable safe operation during commissioning and maintenance, and to allow for effective control in the event of an emergency or failure of remote control. The fitting of remote controls is not to compromise the level of safety and operability of the local controls.

2.4 Centralized Control and Monitoring Station (CCMS)

The control station is to display information from the Cargo Pressure/Temperature Control (CPTC), power, fire and safety systems so that correct functioning of these systems can be maintained and monitored.

The operator is to have easy access to information on displays. The effect of any action is to be immediately displayed, preferably with graphics. In addition to the CPTC system command signals, the feedback signals are to be displayed where applicable.

Indication of the system in charge is to be clearly provided to the cargo operator.

Controls and indicators placed in the control stations are to be lighted properly to permit use under all lighting conditions. Lights for such purposes are to be easily adjustable.

2.5 Operator Interface

Where a computer is used as the operator interface, the CCMS and RCMS is to be provided with at least two independent computers, including keyboards and monitors, unless other means of human machine interface are provided with equivalent monitoring and control functionality in the CCMS and RCMS.

Failure of common facilities, such as self-checking routines, data transfer arrangements, and plant interfaces, is not to cause the failure of both computers.

The CPTC system is to perform self-monitoring and automatically transfer cargo control after a detected failure in one control computer.

2.6 Remote Control and Monitoring Station (RCMS)

Remote controls for essential systems and equipment are to be arranged to provide the same degree of safety and operability as is provided at the CCMS. The effects of a control input are to be continuously receivable at the RCMS in command. Alarms, displays, and controls are to be provided at the RCMS as per Section 3, Tables 1 through 3.

Additional CAMS that may be needed at the RCMS beyond those prescriptively required by Section 3, Tables 1 through 3 are to be evaluated by a Hazard and Operability Analysis (HAZOP)[1], described in Section 5, and alternative equivalent risk analysis may be specially considered on a case-by-case basis.

Where the towing vessel possesses a computer based control and monitoring system, such as for **ACCU** or **ABCU** class notations, and the towing vessel system is proposed to integrate the barge CAMS functions to act as the RCMS, such arrangements will be specially considered provided that integrated towing vessel and barge CAMS is not less effective than the barge CAMS with a separate RCMS. In this instance, the FMEA scope will include the towing vessel systems.

2.7 Safety System

An automatic control system is designed to automatically lead machinery being controlled to a predetermined less critical condition in response to a fault which may endanger the machinery or the safety of personnel and which may develop too fast to allow manual intervention.

To protect an operating machine in the event of a detected fault, the automatic control system may be designed to automatically:

- Slow down the machine or to reduce its demand
- Start a standby support service so that the machine may resume normal operation

[1] ABS *Guide for Risk Evaluations for the Classification of Marine-Related Facilities*

- Shut down the machine

For the purposes of this Guide, automatic shutdown, automatic slowdown and automatic start of standby pumps are all safety system functions. Where "safety system" is stated hereinafter, it means any or all three automatic control systems.

2.8 Automatic Control System

The automatic control system is to be designed to achieve safe and effective operation, where one is provided.

The fail-safe state for essential systems and actions required to reach the same, as identified by the HAZOP risk analysis of Section 5, "Automatic Control Systems", are to be provided with appropriate indicators and alarms (see Section 3, Table 1) at the CCMS and RCMS in association with actions taken.

2.9 Control Station Hierarchy

A decreasing authority is to be assigned according the following orders for arrangements with more than one control station.

i) Local controls at the controlled equipment on the barge

ii) CCMS on the barge

iii) RCMS on the associated towing vessel

Except for manual emergency shut down activation points, control stations of higher authority are to include a supervisory means for transferring control from a station of lower authority at all times, and to block any unauthorized request from any station of lower authority.

3 Alarms, Monitoring and Instrumentation

The main purpose of the alarm and monitoring system is to give the barge operators the abnormal condition and status information they require to maintain safe and efficient operation of the barge.

The displays and alarms as specified in Section 3, Tables 1 through 3 are to be provided at CCMS and RCMS, as applicable.

Section 3, Tables 1 through 3 provide a summary of minimum basic instrumentation at the CCMS and RCMS. Additional instrumentation may be necessary, as identified by the HAZOP risk analysis of Section 5.

3.1 Control Console Instrumentation

Control console instrumentation is to be sufficiently and clearly arranged as to provide for adequate control and status indication of the instrumented and controlled systems. Alarm indicators are to be audibly and visually different from other instrumentation.

3.2 Visual and Audible Alarms

Alarms are to be both audible and visual, and are to be provided at the control stations. Alarms are to clearly identify the system and service of the faulted system or components. Visual alarms are to be displayed in a distinguishable manner such that alarms for similar components or systems are grouped together, and the colors representing a particular function or condition remain uniform. Visual alarms are to flash when first activated. Audible alarms associated with cargo status and essential systems are to be of a tone distinctive from other alarms such as fire alarms and gas detection alarms, and they are to be sufficiently loud to attract the attention of personnel on duty. For spaces with unusually high noise levels, a beacon light or similar device installed in one or more conspicuous places are to supplement the audible alarms in such spaces. Red light beacons are only to be used for fire alarms.

A fault in the visual alarm circuits is not to affect the operation of the audible alarm circuits.

3.3 Acknowledgement of Alarms

Acknowledged alarms are to be represented by manually changing the flashing display of the incoming alarm to a steady display and by silencing the audible signal; the steady state light display is to remain activated until the fault condition is rectified. Alarming of other faults that may occur during the acknowledgement process is not to be suppressed by such action, and is to be alarmed and displayed accordingly. The silencing of the audible alarm from the RCMS is not to lead automatically to the silencing of the original alarm at the CCMS on the barge. Alternatively, arrangements may be made to silence the CCMS audible alarm from the RCMS based on operational considerations as evaluated by HAZOP, provided the associated visual alarm is not extinguished (see "Control Station Hierarchy", above).

Where alarms are not acknowledged at the CCMS or RCMS in a pre-set period of time, the system is to activate an audible and visual alarm on the barge that may be seen and heard from all readily accessible locations on the barge and associated towing vessel RCMS.

3.4 Temporarily Disconnecting Alarms

Alarm circuits may be temporarily disabled (for example, for maintenance purposes), provided that such action is clearly indicated at the associated station in control and at the CCMS and RCMS.

3.5 Built-in Alarm Testing

Audible alarms and visual alarm indicating lamps are to be provided with means of testing that can be operated without disrupting the normal operation of the monitoring systems. Such means are to be fitted at the CCMS and RCMS.

3.6 Self-Monitoring

The monitoring system is to include a self-monitoring mechanism such that a fault (e.g., power failure, sensor failure, etc.) may be detected and alarmed. Additionally, the alarm systems are not to react to normal transient conditions or spurious signals.

4 Voice Communications

Primary and secondary means of voice communication is to be provided.

The primary means of voice communication is to be provided between the RCMS, CCMS, each machinery space, and cargo machinery spaces fitted with essential systems.

The voice communication system is to be powered by a battery or an uninterruptible power supply system sufficient to operate the system for at least 30 minutes in the event of failure of the main source of electrical power.

Secondary voice communication may be by portable devices. The communication systems are to be located within the immediate reach of the cargo operator at the CCMS and RCMS.

5 Computer Based Systems

Computer based systems where used for control, monitoring, safety or communication systems are to comply with the provisions of Sections 4-9-3 and 4-9-4 of the *Marine Vessel Rules*, and are subject to the classification requirements.

Cyber security as associated with the use of wireless data communication is to be evaluated by a HAZOP. Wireless data communication between the CCMS and RCMS will be considered in the scope of the FMEA, and the loss of a data link between the CCMS and RCMS shall be specifically addressed. Further details can be found in Section 5.

The data link shall be self-checking, detecting failures on the link itself and data communication failures on nodes connected to the link. Detected failures or abnormal conditions are to be alarmed at the CCMS and RCMS.

6 Equipment

6.1 Environmental Test Conditions

Control, monitoring, safety or communication equipment are to comply with the provisions of 4-9-9/3 and 4-9-9/13 of the *Marine Vessel Rules*.

6.2 Environmentally Controlled Space

Where equipment is designed to operate only in a temperature-regulated environment, the temperature regulating system (e.g., air conditioner) is to be backed up by a standby unit to comply with the provisions of 4-8-3/1.17 of the *Marine Vessel Rules*. Failure of such a temperature regulating system is to trigger an alarm in the CCMS and RCMS. See Section 3, Table 1.

6.3 Electric and Electronic Equipment

Electric and electronic equipment that are components of control, safety and monitoring systems are to be designed and constructed in accordance with the provisions of Sections 4-8-3 and 4-8-4 of the *Marine Vessel Rules*.

7 Cables between Barge and Towing Vessel

7.1 Connection

Details of the hard-wired connections made for the supply of electrical power, communications, control and monitoring between the barge and associated towing vessel are to be submitted.

7.1.1 Power Connection Box and Cable

Where power is to be provided from the towing vessel to the barge or from the barge to the towing vessel, the requirements of 4-8-2/11 of the *Marine Vessel Rules* are applicable.

Connection boxes are to meet the requirements of 4-1-3/9.9 of the *Barge Rules*.

7.1.2 Control Connection Box and Cables

Connection boxes are to meet the requirements of 4-1-3/9.9 of the *Barge Rules*.

Control cables, including network cables, are to be at least 0.5 mm^2 (986.8 circ. mils).

Fiber Optic cables may be accepted provided they are manufactured and tested in accordance with recognized standards accepted by ABS.

7.1.3 Installation

Cables are to be installed and supported so as to avoid chafing and undue stress in the cable. Cable supports and associated accessories are to be robust and are to be of materials that are corrosion-resistant or suitably treated to resist corrosion and arranged that flexure of the cable from the axis of movement between the towing vessel and the barge is kept to a minimum. Where cables are run through the area between the towing vessel and the barge, the 400 mm (16 in.) distance between supports and retention may be relaxed provided details of the installation is submitted for consideration.

SECTION 3 Barges

1 General

This Section addresses the systems and equipment fitted on the barge. The construction and arrangement of the barge must be suitable for the service and route of the vessel.

The CAMS associated with an LG barge are considered essential systems for maintaining CPTC.

Systems and equipment associated with the maneuvering of the barge are not within the scope of this Guide.

2 Electric Power Systems

2.1 Power Generation

Electrical generation and distribution systems and associated control systems shall be designed such that a single fault failure will not result in the loss of ability to maintain cargo tank pressure and temperature control, within normal operating limits.

The power system is to be divisible into two or more systems such that in the event of failure of one system at least one other system will remain in operation. The power system may be run as one system during operation, but is to be arranged by bus-tie breakers to separate automatically upon failures which could be transferred from one system to another, including overloading and short-circuits.

Essential services for generators and their prime movers, such as cooling water and fuel oil systems, are to be arranged such that with any single fault sufficient power remains available to supply the essential loads.

Each power supply is to be monitored and its failure is to be alarmed. Electric power generating plant alarms displays, and controls in Table 1 are to be provided at the CCMS and RCMS.

2.2 Starting of Generators

In the event of the loss of any generators in service, the electrical supply to essential systems and equipment will be maintained or restored in accordance with 3/2.2.1 or 3/2.2.2 below. Arrangements are to be provided to enable manually starting, stopping, synchronizing, paralleling and placing in service any generator from the CCMS and RCMS.

Load shedding of nonessential services and, where necessary, essential services or other arrangements, as may be necessary, are to be provided to protect the generators against sustained overload.

2.2.1 Single Generator Operation

Where the electrical power is normally supplied by a single generator, provision is to be made upon loss of power for automatic starting and connecting to the main switchboard of a standby generator(s) of sufficient capacity for the automatic restarting of the essential systems and equipment in sequential operation, if necessary, to maintain the safety of the vessel. Starting and connecting to the main switchboard of the standby generator is to occur preferably within 30 seconds after loss of the electrical power supply but in no case in more than 45 seconds.

2.2.2 Multiple Generators Operation

Where the electrical power is normally supplied by more than one generator set simultaneously in parallel operation, the system is to be so arranged that in the event of the loss of any one of the generators in service, the electrical supply to essential systems and equipment will be maintained by the remaining generator(s) in service.

2.3 Power Distribution

The switchboard is to be arranged for manual and automatic remote controls and be provided with all necessary alarms, controls and indications to allow local manual control of the power plant.

The distribution system at the main power generation level is to be arranged to reflect the split in the availability concept.

Every UPS and battery system is to have a main power supply from an auxiliary system switchboard appropriate to the split in the availability concept.

The status of automatically-controlled circuit breakers is to be monitored as described in Section 3, Table 1.

The bus bar current and power levels are to be monitored as described in Section 3, Table 1. An alarm is to be initiated upon failure of any of the required power supplies.

A main bus bar system consisting of at least two sections, with at least one bus-tie breaker between any two bus sections, is to be arranged. Bus-ties are to be designed to prevent a fault from propagating from one bus section to another.

2.3.1 Closed Bus

When the CPTC system is designed, including the configuration of closed bus-tie breaker, this breaker is to be:

i) Capable of breaking the maximum short circuit current in the connected system

ii) Coordinated in relation to generator breakers

Consideration is to be given to effective intelligent detection and execution methods featuring ultra-fast actions by the devices, including rapid communication to other protective systems under the coordination scheme, to prevent and/or mitigate the detected fault spreading to other parts of the switchboard.

Bus bar control and protection systems are to be designed to operate with both open and closed bus-tie breakers.

2.4 Load Shedding Arrangements

Where the possibility exists for generators to be overloaded, load-shedding arrangements are to be provided to safeguard continuity of supply to essential services.

2.4.1 Provision for Load Shedding Arrangements

In order to safeguard electrical power supply continuity, automatic load-shedding arrangements or other equivalent arrangements are to be provided:

i) Where only one generating set is normally used to supply power, and a possibility exists that due to the switching on of additional loads, whether manually or automatically initiated, the total load exceeds the rated capacity of the running generator, or

ii) Where electrical power is normally supplied by more than one generator set simultaneously in parallel operation, upon the failure of one of the parallel running generators, the total connected load exceeds the total capacity of the remaining generator(s).

2.4.2 Services not allowed for Shedding

Automatic load-shedding arrangements or other equivalent arrangements are not to automatically disconnect the following services:

i) CAMS related to cargo pressure and temperature control systems

ii) Fire/Gas detection and alarm system

iii) Fire extinguishing systems

iv) Lighting systems

v) Internal communication systems

vi) Emergency Shutdown System

2.5 Uninterruptable Power System (UPS)

Equipment for essential services and transitional sources of power is to comply with 4-8-3/5.9 of the *Marine Vessel Rules*.

2.5.1 Uninterruptable Power System (UPS)

An uninterruptible power supply systems (UPS) is to be provided for the CAMS system.

The uninterruptible power supply system is to be capable of supplying power for a minimum of 30 minutes after failure of the main power supply. A fault in any UPS is to initiate an alarm in the CCMS and RCMS. See Section 3, Table 1.

2.6 Lighting

Machinery and Cargo Machinery Spaces are to be provided with lighting and provided with backup power supply for a period of at least 90 minutes.

2.7 Alternative Power Supply

Power supply from off the barge (e.g., towing vessel) may be specially considered on a case-by-case basis.

3 Essential Auxiliary Systems

The auxiliary systems that are part of the CPTC system are to be arranged in accordance with the availability concept.

Power for auxiliary systems associated with CPTC systems is to be taken from within the redundancy group. Auxiliary systems such as cooling water pumps and fans are to be powered from the same redundancy group as that providing the drives.

A static component is not considered to fail.

A single point failure for auxiliary systems is to be included in the CPTC system FMEA, such as the following where applicable:

i) Fuel oil system

ii) Lubricating oil system

iii) Cooling water system

iv) Compressed air system

v) Hydraulic system

vi) Pneumatic system, etc.

vii) Ventilation/HVAC system

viii) Piping system equipment (e.g., purifier, compressor, transfer pump, etc.)

4 Centralized Control and Monitoring Station Arrangement

The CCMS is to be located above the weather deck and outside the machinery space(s). Where fitted, glass windows forming parts of the boundaries are to be of the shatter resistant type (e.g., laminated glass or wire meshed embedded glass).

The CCMS may be located adjacent to a machinery space, provided a fire boundary common with the machinery space(s), including glass windows and doors, are A-60 rated. The doors opening into machinery space(s) are to be self-closing. The ventilation system to the CCMS is to be separate from other systems serving the machinery space(s).

The CCMS may be located in the Cargo Control Room.

5 Machinery Space

5.1 Machinery Equipment and Systems

Alarms, displays and safety shutdowns for machinery equipment and systems are to be provided as listed in Section 3, Table 1, as applicable.

5.2 Fuel Oil System Arrangements

Alarms, displays and safety shutdowns for the fuel oil system are to be provided as listed in Section 3, Table 1, as applicable.

5.2.1 Fuel Oil Settling and Service Tanks

Low level conditions of fuel oil settling and daily service tanks are to be alarmed. Where automatic filling is provided, the arrangements are to include automatic pump shutdown and start-up at predetermined high and low levels, respectively. In such cases, a fuel oil high level alarm is also to be provided.

5.3 Bilge Level Monitoring

Bilge Level and Monitoring Alarms and displays in Section 3, Table 1 are applicable for protection against flooding in machinery space.

5.3.1 Bilge Level

Where a machinery space is located below main deck, means to detect excessive rise of bilge water in the bilges or bilge wells is to be provided and alarmed. The arrangements including the number of sensors and locations are to be such that accumulation of bilge water may be detected at the various angles of barge's heel and trim.

5.4 Nitrogen Generator Inert Gas System

Alarms, displays and controls denoted in Section 3, Table 2 are to be provided and displayed at the CCMS, as applicable.

5.5 Liquefied Gas Cargo Machinery/Systems

Alarms, displays, and controls in Section, Table 3 are to be provided, as applicable.

5.5.1 Reliquefaction System

See Appendix 5C-8-A5 of the *Marine Vessel Rules*.

5.5.2 Gas Combustion Units/Thermal Oxidizers

See Appendix 5C-8-A6 of the *Marine Vessel Rules*.

5.5.3 Dual Fuel Diesel and Single Gas Fuel Engines

See Appendix 5C-8-A7 of the *Marine Vessel Rules*.

Additional Control, Alarm, and Monitoring Systems (CAMS) that may be needed at the RCMS are to be evaluated by a HAZOP as detailed in Section 5. The extent of additional CAMS will depend on the proposed design and operation of the CPTC system.

6 Emergency Shutdown (ESD)

As a minimum, the ESD system is to be capable of manual operation by a single control at the RCMS and CCMS, and no less than two locations in the cargo area. The ESD for the diesel engines and auxiliary systems in the power generation machinery space is to be independent of the ESD for cargo systems.

The CPTC system is not to be affected by failures of the emergency shutdown systems.

The ESD system shall be activated by the manual and automatic initiations listed in 5C-8-18/Table 1 of the *Marine Vessel Rules*. Automatic activation of the ESD in event of fire in the weather deck cargo area or cargo pump rooms is not to activate ESD for power generators and systems required to power fire suppression systems.

Any additional initiations are only to be included in the ESD system if it can be shown that their inclusion does not reduce the integrity and reliability of the system overall.

Emergency stops are to be hardwired and independent of any computer-based system. Alternatives to hardwired emergency stops are to be specially considered on a case-by-case basis where addressed by a risk analysis to demonstrate an equivalent level of safety. See Section 5 for more information.

A functional flow chart of the ESD system and related systems shall be provided at the CCMS and RCMS.

The ESD system is not to allow valves closed upon activation of ESD to automatically open upon ESD reset.

Where an ESD system utilizes a relay control system where stops are connected to relay contacts and the ESD energizes or de-energizes the relay to open or close the contacts, a theory of operation, along with the desired fail-safe state of the equipment controlled (e.g., fail AS IS or Fail Stop) for failure of the relay system is to be provided or included in the FMEA. Where the FMEA shows that feeder circuit power failure to relay panel results in an undesired fail-safe state, automatic changeover to an alternate power source is to be provided. A UPS with a maintenance bypass switch, dedicated to the ESD properly sized to maintain the ESD system until normal power failure can be restored would be acceptable. UPS failure and UPS on Battery alarm and indication is to be provide at the CCMS and RCMS.

7 Fire Safety

7.1 Fire Detection and Alarm Systems

In addition to fire detection systems required by 5C-8-18/10.3.2 of the *Marine Vessel Rules* for cargo area on the weather decks, a fire detection system is to be provided in the machinery spaces in accordance with 4-7-3/11 of the *Marine Vessel Rules.*

7.1.1 General

Machinery spaces with machinery running while the barge is periodically unattended are to be provided with a fixed fire detection and alarm system. This fixed fire detection and alarm system may be combined with other fire detection and alarm systems required on board the barge. The detection system alarm panel is to be located in the CCMS and be integrated into the CAMS for alarming at the CCMS and RCMS.

7.1.2 Temporarily Disconnecting Alarms

A fire detector loop or detector(s) covering the unattended machinery space may be temporarily disabled (for example for maintenance purposes), provided that such action is clearly indicated at the fire control panel and at the CCMS and RCMS. Disabled loops or detectors are to be reactivated automatically after a preset time period.

7.1.3 Fire Alarm Call Points

Manually operated fire alarm call points are to be provided at the CCMS and entrances to machinery spaces

7.2 Gas Detection and Alarm Systems

Gas detection equipment is to be installed to monitor the integrity of the cargo containment, cargo handling and ancillary systems per 5-2-5/41 of the *Rules for Building and Classing Steel Barges.*

Gas detection panels are to be located in the CCMS and integrated to the CAMS for display at the CCMS and RCMS.

7.3 Fixed Fire Extinguishing Systems

7.3.1 Machinery Spaces

Machinery Spaces are to be fitted with a fixed fire extinguishing system.

Fixed firefighting systems may include CO_2 or other fire suppressant agents such as water mist. These systems are to be arranged in a manner that supports the overall divisions in the CPTC availability.

7.3.2 Cargo Machinery Space

See 5-2-5/37 of the *Barge Rules*.

8 Guard Rails

Bulwarks and/or guardrails are to comply with Section 3-2-10 of the *Barge Rules.*

9 Anchoring Equipment

Barges for which the symbol Ⓔ is not requested in the classification designation are to have equipment in accordance with 3-3-1/Table 2 of the *Barge Rules*. Wire rope of equal breaking strength to the required tabular normal strength steel (Grade 1) stud-link bower chain will be approved in lieu of the required anchor chain, but the length of the wire rope is to be not less than 1.5 times the tabular chain length.

The windlass or winch is to comply with 3-3-1/19.1 of the *Barge Rules.*

10 Load Line and Stability

Where load line assignment is required, the barge is to receive and maintain a manned service load line in accordance with the International Convention on Load Lines, 1966, taking into account all current intact and damage (where applicable) stability requirements.

Special consideration may be given to flag Administration alternative requirements.

11 Installation, Tests and Trials

11.1 Tests and Trials

During sea trial or dockside trials, as applicable, the following tests as appropriate are to be carried out to the satisfaction of the Surveyor.

11.1.1 Centralized Control and Monitoring Station Tests

The machinery is to be operated over its full range of power to demonstrate the ability to control the machinery functions correctly for all loads without any manual intervention in the machinery space. The following tests are to be included, as applicable:

i) All alarm points and displays

ii) Operations of automatic controlled machinery

iii) Transfer of standby auxiliary

iv) Remote control of auxiliary machinery

v) Fire & Gas detection system

vi) Bilge alarm

11.1.2 Remote Control and Monitoring Station Tests

In conjunction with the testing required for the centralized control and monitoring station, repeatability of the alarms and control of machinery is to be verified.

Additionally, during trials, tests are to be conducted to demonstrate that radio-frequency transmission from wireless data communication equipment does not cause failure of any equipment and does not cause the wireless data communication equipment itself to fail as a result of electromagnetic interference during expected operating conditions.

Where electromagnetic interference caused by wireless data communication equipment causes failure of equipment or systems, the layout and/or equipment is to be changed to prevent further failures.

11.1.3 Loss of Generator Tests

The loss of electric power (see 2/5.3) is to be simulated to test:

i) Automatic restoration of electric power by standby generator(s)

ii) Automatic starting of vital auxiliaries

TABLE 1
Machinery Space Instrumentation and Controls at CCMS and RCMS

System	*Monitored/Controlled Parameter*		*A*	*D*	*C*	*Notes* *[A= Alarm; D= Display; C= Controller/Actuator]* *[x= applies]*
System Monitoring	A1	System power supply main and secondary feeders: failure, status and transfer	x	x		Applicable to main and secondary power sources
	A2	Individual power supply to control, monitoring and safety systems – fails	x	x		Alarm may be common
	A3	Alarm system – disconnected		x		
	A4	Integrated computer-based system: data highway abnormal conditions	x			Alarm is to be activated before critical data overload
	A5	Integrated computer-based system: duplicated data link – failure of one link	x			
	A6	Automatic Control Systems	x	x		2/2.10
Others	B1	Control station transfer		x	x	Display: to indicate the station in control. Control: to provide 1) transfer switch & 2) acknowledgment switch
	B2	Air conditioning system – fails	x			If necessary for equipment environment control 3/3.4
	B3	Fire detected	x	x		3/7.1
	B4	Machinery space – bilge level high	x			3/5.3
	B5	Cooling water pump failure	x	x	x	3/3.2
	B6	Air compressor failure	x	x	x	3/3.3
Electric Power Generating Plant	C1	Starting, paralleling & putting generator on line			x	
	C2	Generator running		x		
	C3	Voltage – high and low	x	x		
	C4	Current – high	x	x		
	C5	Frequency – high and low	x	x		
	C6	Failure of on-line generator	x			
	C7	Generator engine auxiliaries start/stop		x	x	Automatic start/stop, if fitted, is to be alarmed
	C8	Bearing lube oil inlet pressure – low	x	x		Automatic shutdown prime mover
	C9	Generator cooling inlet pump or fan motor – fails	x			
	C10	Generator cooling medium temp. – high	x	x		
Power Distribution System	D1	Status of automatically controlled circuit breakers		x		
	D2	Bus bar current and power levels		x		
	D3	UPS Fault	x			
Fuel Oil System	E1	Service tank level – low	x			
	E2	Pump Failure	x	x	x	3/3.1

TABLE 1 (continued)
Machinery Space Instrumentation and Controls at CCMS and RCMS

System		*Monitored/Controlled Parameter*		*A*	*D*	*C*	*Notes* *[A= Alarm; D= Display; C= Controller/Actuator]* *[x= applies]*
Diesel Engine	Lubricating oil	F1	Bearing oil inlet pressure – low	x	x		Automatic shutdown with alarm at low-low
		F2	Bearing inlet oil temperature – high	x	x		
		F3	Common rail servo oil pressure – low	x			
	Cooling medium	F4	Pressure or flow – low	x	x		
		F5	Temperature at outlet – high	x	x		
		F6	Expansion tank level – low	x			
	Fuel oil	F7	Fuel oil leakage from injection pipe	x			
		EF8	Common rail fuel oil pressure – low	x			
	Starting medium	F9	Energy level – low	x	x		For application requiring automatic generator paralleling
	Speed	F10	Overspeed	x			Auto shutdown

Display: Display of the analog or digital signal for the monitored parameter.

The display of the signal is to provide indication of the monitored parameter in engineering units (such as degrees, PSI, RPM, etc.) or status indication. The engineering unit is to effectively display the relevant information concerning the monitored parameter. An alternative engineering unit which provides equivalent effectiveness, may be considered.

TABLE 2
Nitrogen Generator Inert Gas System Instrumentation and Control at CCMS and RCMS

System		*A*	*D*	*Notes* *[A= Alarm; D= Display]* *[x= applies]*
Low air pressure or flow from compressor	A1	x	x	Automatic shutdown
High air temperature	B1	x	x	Automatic shutdown
High condensate level at automatic drain of water separator	C1	x	x	Automatic shutdown
Failure of electrical heater, if fitted	D1	x	x	Automatic shutdown
High oxygen content (5% by volume)	E1	x	x	Automatic shutdown
Power supply failure to instrumentation	F1	x	x	Automatic shutdown

TABLE 3
Cargo Machinery/Systems Instrumentation and Control at CCMS and RCMS

System		*A*	*D*	*C*	*Notes* *[A= Alarm; D= Display; C= Controller/Actuator]* *[x= applies]*
Air Lock	A1	x	x		MVR 5C-8-3/6.3
Liquid level gauge	A2		x		MVR 5C-8-13/2
Liquid Level Alarm	A3	x	x	x	MVR 5C-8-13/3
Tank Pressure/Vacuum	A4	x	x		MVR 5C-8-13/4
Tank Temperature	A5	x	x		MVR 5C-8-13/5
Gas Detection	A6	x	x		MVR 5C-8-13/6
Ventilation failure	A8	x	x		For spaces dependent on ventilation for hazardous area classification
Cargo pump discharge pressure					MVR 5C-8-13/4.4
Hold Space pressure indication					MVR 5C-8-13/4.6
Temperature Indication devices					MVR 5C-8-13/7.2
Emergency Shutdown	A11	x	x	x	MVR 5C-8-18/10
CPTC	A12	x	x	x	See 3/5.5 (HAZOP)
Hull Heating System	A13	x	x		MVR 5C-8-4/19.1.6
ESD	A14	x	x	x	See Subsection 3/6

SECTION 4 Towing Vessels

1 General

This Section provides guidance for systems and equipment to be fitted on the towing vessel that is provided with RCMS associated with the barge.

Regardless of the towing vessel length, tonnage and class notation, RCMS equipment is not considered essential or as emergency systems to the service of the towing vessel as an independent vessel. However, the RCMS is considered essential as a means to provide control of the barge.

For towing vessels provided with multiple pilot houses, such as a lower and upper pilot houses either of which may be used to control the tow during vessel transit, each pilot house should be provided with an RCMS.

Control and monitoring of the propulsion and navigating equipment on the towing vessel is not within the scope of this Guide.

1.1 Arrangement

Safe and readily accessible access between the towing vessel and barge is to be provided.

2 Power Supply on Towing Vessel

Each towing vessel is to have sufficient electrical power to provide for the applicable power needs for control of the barge. In the event of a main power source failure, the second source of independent power is to automatically start and be arranged so that the following RCMS-related loads can be energized such as essential alarms, lighting, radios, and any other essential systems identified.

The secondary source of independent power is to be capable of supplying the loads for at least 3 hours. A UPS on the towing vessel dedicated to RCMS loads can be considered as the secondary source of power.

3 Station in Navigation Bridge

Each towing vessel must have a reliable means to provide notification when an emergency condition exists or an essential system develops problems that require attention.

3.1 Barge Remote Control and Monitoring Station

The RCMS equipment as fitted on the towing vessel is to comply with Section 2 of this Guide. Also:

- All alarms, displays, and controls are to be provided at the RCMS as included by Section 3, Tables 1 through 3, and recommendations from the risk analysis as specified in Section 5.
- A means of communication is be provided between the RCMS and any crewmember(s) required to respond to alarms.

4 Electrical Equipment in Hazardous Areas

The towing vessel is to recognize the established hazardous areas on the barge, as applicable. Electrical equipment fitted on the towing vessel is not to be installed in hazardous areas unless it is essential for safety or for operational purposes. Where the installation of electrical equipment in such locations is necessary, it is to be selected based on its suitability for the hazardous area so classified.

This equipment is to be listed in the booklet of certified safe equipment as required by 4-1-3/11.3 of the *Barge Rules*. Permanent notices are to be posted in the vicinity of hazardous areas in which such electrical equipment is installed to advise crew of the availability of the booklet so that it can be reference during repair or maintenance.

SECTION 5 Risk Assessment

1 General

Control, Alarm, and Monitoring Systems (CAMS) that may be needed at the RCMS beyond those prescriptively required by Section 3, Tables 1 through 3 are to be evaluated by a Hazard and Operability Analysis (HAZOP). The extent of additional CAMS will depend on the proposed design and operation of the Cargo Pressure and Temperature Control (CPTC) system.

A Failure Mode and Effect Analysis (FMEA) is to be conducted to demonstrate that control, monitoring and safety systems are so designed that any single failure will not result in undesirable consequences such as a loss of CPTC or other hazardous conditions.

2 HAZOP

A HAZOP is to be conducted first to systematically identify the potential hazards or operability concerns related to the cargo containment system caused by potential deviations from the design intent with respect to pressure and temperature. The design intent is to maintain the cargo tank's pressure and temperature at all times within its design range.

The scope of the HAZOP is to include the CPTC, power system, fire, and safety systems. The objective is to at least include the following:

- The fail-safe state for essential systems and actions required to reach the same (See 2/2.8)
- Address acknowledgement of alarms between the RCMS and CCMS (See 2/3.3)
- Identify whether additional CAMS may be needed at the RCMS for the proposed design and operation of the CPTC system. (See Subsection 2/3 and 3/5.5)
- Cyber security as associated with the use of wireless data communication (See Subsection 2/5)

A risk assessment plan is to be developed and submitted to ABS prior to conducting the HAZOP study. ABS will review the risk assessment plan and confirm if the proposed study is satisfactory. Further guidance on the development of risk assessment plan can be found in the ABS *Guide for Risk Evaluations for the Classification of Marine-Related Facilities*.

Based on the results of the HAZOP when a CAMS design is developed, a Failure Modes and Effects Analysis (FMEA) is to be performed.

3 Failure Mode and Effect Analysis (FMEA)

FMEAs are to be conducted as required by Sections 4-9-3, 4-9-4, 5C-8-7, 5C-8-10 and 5C-8-13 of the *Marine Vessel Rules*.

In addition, an FMEA is to be conducted to demonstrate that CAMS are so designed that in the case of a single failure in the control systems, the cargo tanks' pressure and temperature can be maintained within their design range without affecting other essential services or safety functions as applicable. The FMEA is to demonstrate that the integrated system will "fail-safe", and that essential services in operation will not be lost or degraded.

The objective of the FMEA is to, at least, include the following:

i) Identify and provide recommendations to eliminate or mitigate the effects of all single faults and common cause failures in the CAMS equipment which, if any occurs, would cause loss of CPTC capability

ii) Identify potential hidden failures and determine the effects of a second failure

Single fault includes, but is not limited to following:

i) All redundant components, systems or subsystems

ii) A single inadvertent act of operation (ventilation, fire suppression, ESD) where applicable and if such an act is reasonably probable

iii) Hidden failures (such as protective functions on which availability depends) where applicable

iv) Governor and Automatic Voltage Regulator (AVR) failure modes where applicable

v) Main switchboard control power failure modes

vi) Bus-tie protection where applicable

vii) Power management system

viii) CPTC system input and output arrangement

ix) Networks

x) Communication failure, including wireless data communication

xi) Automatic interventions caused by external events, when found relevant (e.g., automatic action upon detection of fire)

xii) ESD relay system

xiii) Essential auxiliary systems as mentioned in Subsection 3/3.

Where parts of the system are identified as non-redundant and where redundancy is not possible, these parts are to be further studied with consideration given to their reliability and mechanical protection.

Results of the FMEA are to be verified during FMEA proving trials. The FMEA test program is to be developed based on the analysis results, analysis method and assumptions.

FMEA and FMEA test programs are to be kept onboard the associated vessels and they are to be updated to cover subsequent alterations to the CAMS system hardware or software.

3.1 FMEA Report

3.1.1 FMEA Report

The FMEA report is to be sufficiently detailed to address all the systems associated with the CAMS of the barge.

The cargo FMEA analysis report is to be a self-contained document including, but not limited to the following:

i) A brief description of the vessel

ii) Definitions of the terms, symbols and abbreviations

iii) Analysis method and assumptions

iv) A description of all the systems associated with the CAMS of the barge and a functional block diagram showing their interaction with each other. Such systems would include the cargo control systems, electrical power distribution system, power generation, fuel systems, lubricating oil systems, cooling systems, and backup control systems.

v) System block diagrams, where appropriate

vi) Analysis findings and recommendations

vii) Conclusions and recommended changes

viii) Recommended FMEA tests

The FMEA report is to be updated after major modifications and is to be kept onboard the associated vessels.

An FMEA worksheet is to be compiled for each equipment failure assessment. Some pertinent aspects to be included in the worksheets are:

i) System name (including main system, system, and subsystem)

ii) Reference drawings

iii) Equipment name or number

iv) Function description

v) Operational mode

vi) Failure modes

vii) Failure causes

viii) Failure effects (including local effect and end effect)

ix) Failure detection

x) Corrective action

xi) Severity of failure effect (providing definitions of categories of severity)

xii) Remarks

3.1.2 FMEA Proving Trial Report

An FMEA proving trial procedure is to be developed as part of the FMEA study. The objective of the FMEA proving trial is to confirm the FMEA analysis findings and also to confirm that essential functions and features upon which the fault tolerance of the CAMS system depends are functional in so far as it is practical to do so (e.g., protections, power management, etc.). The proving trial report is to establish the FMEA test list and the corresponding test procedures including but not limited to the following:

i) Purpose of test or failure mode

ii) Vessel and equipment setup

iii) Test method

iv) Expected results

v) Observed results

vi) Failure detection

vii) Failure effects

viii) Outstanding or resolved action items

ix) Comments

x) Witness name, signature and date for each test

SECTION 6 Surveys After Construction

1 General

Surveys after construction for liquefied gas tank barges with remote control and monitoring of essential systems are to be in accordance with the applicable requirements as contained in the ABS *Rules for Survey After Construction (Part 7)*.

1.1 Tests after relocation of the Remote Control and Monitoring Station

When a remote control and monitoring station is relocated to another vessel, or the remote control and monitoring station is replaced, the system is to be retested based on the review of the revised vessel application.

The ABS *Record* is to be updated reflecting the change in compliance with this Guide.

2 Annual Surveys

At each Annual Survey, the automatic and remote control systems are to be generally examined so far as can be seen and placed in satisfactory condition.

The barge and associated towing vessel(s) is to be operated to demonstrate that the automatic and remote control systems have been maintained properly and are in good working order. The operational testing is to be carried out to the Surveyor's satisfaction, and the tests are to demonstrate the level of redundancy established by the FMEA. See Section 5 for more information.

In addition, the following items in 6/2.2 through 6/2.5 are to be generally examined and tested so far as can be seen and placed in satisfactory condition:

2.1 Documentation

The following accepted documents are to be confirmed onboard the vessel as applicable:

- FMEA
- Trial Test Procedures/Results of Trials
- Operations Manual

2.2 Controls and Alarms

Control systems, including independent emergency shutdown(s) for each control station, redundancy, and alarms and instrumentation are to be generally examined and confirmed to be functioning satisfactorily.

2.2.1 Control Station

The operation of the automatic control system and a manual position control system, including manual transfer of control between the two systems is to be confirmed to be functioning satisfactorily.

- Verification that any hardware changes that may affect the CAMS have been submitted, approved, and tested as required.
- Confirmation that any software revisions since the time of last Survey have been tracked and tested as appropriate by Owner and suitably documented.

- Any hardware or software changes that have not been tested since the last performance test are to have their functionality proven and recorded by a supplementary trials program to verify the effect of the modifications with regard to the approved redundancy arrangements for the unit.

2.2.2 Additional Testing

The below Standby and Power Redundancy is to be confirmed/tested. The tests are to exercise the changeover functions as well as the redundant supplies.

- Test generator feeder automatic transfer switches
- Changeover to standby auxiliary services, such as seawater or freshwater cooling pumps and hydraulic pumps, is to be tested where these auxiliaries provide essential redundancy as identified in the FMEA
- Test the switchover and isolation of redundant DC power supplies, such as in control power circuits; where one DC power supply is failed or removed, voltage or current from the redundant DC power supply or any other source should not be present at the failed power supply

2.2.3 Alarms and Instrumentation

The examination is to be made with a barge's service generator in operation and the control system energized to permit random checking of the following function indicators, alarms, shutdowns and such control actuators as may be operational to the satisfaction of the attending Surveyor:

- Lamp test of alarm indicators
- Power supply arrangements and automatic controls
- Automatic controls for the cargo pressure/temperature control systems
- Automatic controls for the auxiliary essential systems
- Automatic changeover of selected pumps
- Automatic starting of and controls for the secondary power supply
- Associated towing vessel bridge function and alarm indicators
- Fuel oil system arrangements and alarms
- Machinery space bilge level alarms
- Engine low lubricating oil pressure
- Engine coolant high temperature
- Motor overload

2.3 Uninterruptible Power Systems (UPS)

The uninterruptible power systems (UPS) are to be operated and confirmed to be functioning satisfactorily. The uninterruptible power systems (UPS) are to be operated without the normal main power input to confirm that the batteries are capable of supplying the output power and are in satisfactory condition. The schedule of batteries is to be examined to show that the batteries have been maintained.

2.4 Communication

Means of voice communication between the towing vessel navigation bridge remote control station, centralized control station and local control stations as fitted on the barge are to be tested and found satisfactory.

2.5 Fire Safety Systems

Fire safety systems are to be operated and confirmed to be functioning satisfactorily, including operational tests of the fire detecting system. Fire Fighting Station controls and equipment are to be operated and confirmed to be functioning satisfactorily, if fitted.

The arrangements made to provide immediate availability of a supply of water from the fire main at the required pressure either by permanent pressurization or by remote starting arrangements for the fire pumps are to be verified, if fitted.

3 Special Periodic Surveys

At each Special Periodical Survey, in addition to the requirements of the Annual Survey, complete performance tests are to be carried out to the Surveyor's satisfaction. The schedule of these tests is to be designed to demonstrate the level of redundancy established in the FMEA (Failure Modes and Effects Analysis, see Subsection 5/3 of this Guide).