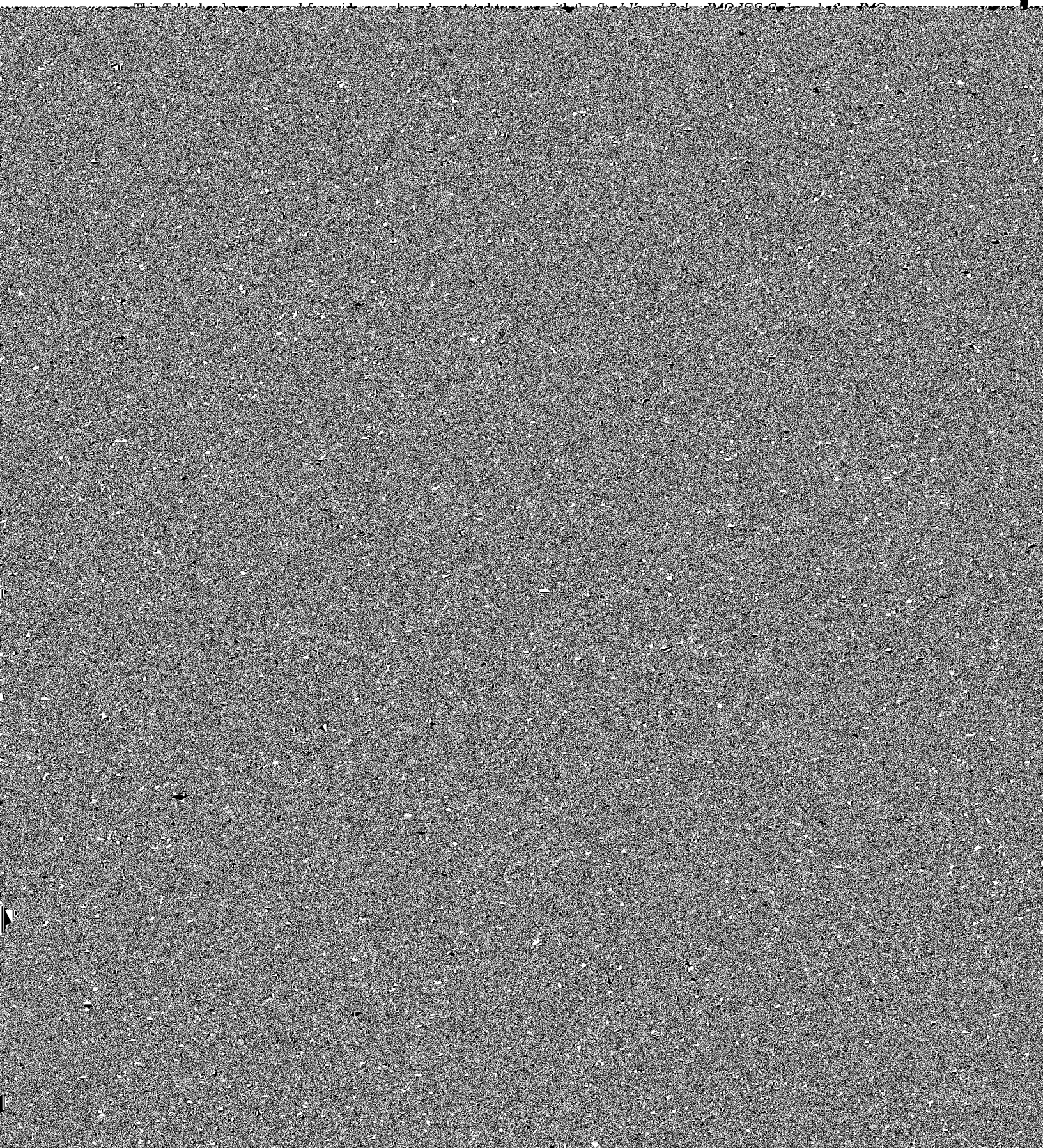
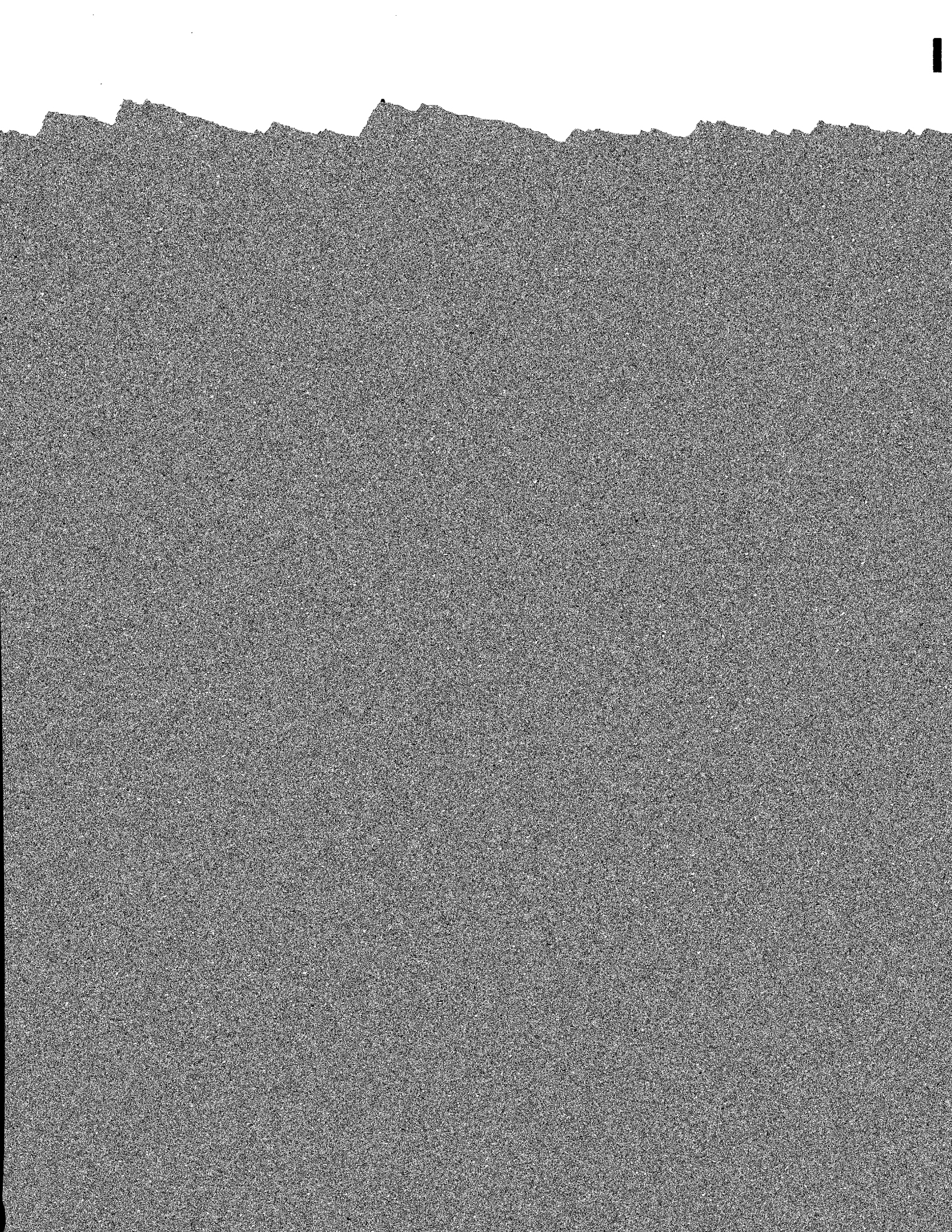


TABLE 3
Certification of Fuel Gas Supply Systems





Section 6 Re-liquefaction Unit

- iii) Where a cascade system is used requiring onboard storage of refrigerant, the refrigeration system is to be fitted with a receiver capable of holding the complete charge of the refrigerating units. Where each refrigeration unit is fitted with an individual receiver, the capacity is to be sufficient to hold the charge of that unit.
- iv) In the case of nitrogen, part of the charge may be discharged/vented to the atmosphere.

3.3 Compressors/Expanders

- i) Air-cooled compressors are to be designed for an air temperature of at least 45°C (113°F). Water-cooled compressors are to be designed for a water temperature of at least 32°C (90°F).
- ii) Compressor vibration resulting from gas pressure pulses and inertia forces is to be taken into account in the compressor design and mounting arrangement. Acceptable mounting arrangements include resilient rubber mounts or springs.
- iii) Material for housings, rotors and rotor casings is to be in accordance with the applicable requirements of 6-2-6/7 of the *Steel Vessel Rules*. The compressor casing design is to be suitable for the maximum design pressure of the high pressure side of the system.
- iv) For instrumentation, monitoring and control system for the compressors, see Section 6, Table 1 of this Guide.

3.4 Cryogenic Heat Exchangers and Cold Box

- i) The heat exchangers are to be designed, constructed and certified in accordance with Section 4-4-1

4.2 Control and Monitoring System

i) Automatic control, alarm and safety functions are to be provided to prevent operations exceeding

7 Gas Detection System

The machinery spaces containing the refrigeration equipment are to be fitted with a low oxygen level

Section 6 Re-liquefaction Unit

- v) To witness, as far as deemed necessary, weld nondestructive examination tests and to review records of nondestructive examinations.
- vi) To witness pressure and/or proof-load testing of equipment components and as a unit, as applicable and as called for in the fabrication procedures.

TABLE 1
Instrumentation and Alarms in Centralized Control Stations
for the Re-liquefaction Unit

<i>Item</i>		<i>Display</i>	<i>Alarm Activated</i>	<i>Automatic Shut Down</i>	
BOG Compressor	Flow rate	X	Low	X (Low-Low)	
	Driving motors	Running	Stop		
	LO temperature		High		
	LO Pressure		Low		
	Separator level, if fitted	X	High		
	Suction line	Pressure	X	High/Low	X (High-High)
		Temperature	X	High	X (High-High)
	Discharge line	Pressure	X	Low	X (Low-Low)
		Temperature	X	High/Low	X (High-High)
	Gas Detection in cold box		X (30% LEL)	X (60% LEL)	
Cryogenic heat exchanger inlet temperature	X	High	X (High-High)		
Refrigerating Compressor	Lubricating oil temperature	X	High	X (High-High)	
	Driving motors	Running	Stop		
	Inlet	Pressure	X	Low	X (Low-Low)
		Temperature	X	High/Low	X (High-High)
	Discharge line	Pressure	X	High	X (High-High)
		Temperature	X	High/Low	

TABLE 2
Certification of Re-Liquefaction Units

This Table has been prepared for guidance only and annotated to agree with the *Steel Vessel Rules*, IMO IGC Code and other IMO requirements. The list is not to be considered exhaustive; should additional equipment not listed be fitted onboard, same will be subject to special consideration for compliance with the *Steel Vessel Rules*, the IGC Code and other IMO requirements. This list is not to be considered as substitutive or integrative of the content of the *Steel Vessel Rules* and/or other applicable Regulations. In case of conflict between the content of this list and the applicable *Steel Vessel Rules* and regulations, the latter are to be considered applicable.

<i>Code</i>	<i>Explanation</i>
MD	<i>Manufacturer's Documentation</i> – Manufacturer should supply documentation as evidence that the material or the equipment complies with an acceptable standard (e.g., standard tests reports, ex certification, etc.).
DR	<i>Design Review</i> – Design review required.
MT	<i>Material Testing</i> – Material testing is to be witnessed by the Surveyor.
MS	<i>Manufacture Survey</i> – Product is to be surveyed during fabrication stages by the Surveyor.
FS	<i>Final Survey</i> – Finished product is to be subject to final hydrostatic, nondestructive, operational testing, or any other required tests, and witnessed by the Surveyor at manufacturer's facility.

<i>Equipment</i>	<i>MD</i>	<i>DR</i>	<i>MT</i>	<i>MS</i>	<i>FS</i>
BOG compressors		X	X		X
LNG pumps		X	X		X
Pump and compressor motors (rated at 100 kW and over)		X			X
LNG separators (where fitted)		X	X		X
Refrigerant compressors/expanders		X			X
Cryogenic heat exchanger/cold box ⁽¹⁾		X	X	X	X
Refrigerant/Sea water coolers ⁽¹⁾		X		X	X
Refrigerant accumulator ⁽¹⁾		X		Y	Y

- Gas compressors
- Gas heaters
- Gas storage pressure vessels
- Descriptions and schematic diagrams for control and monitoring system including set points for abnormal conditions
- Details of all electrical equipment in the GCU compartment
- Electric bonding (earthing) arrangement
- Emergency shutdown arrangements (see Subsection 7/10 of this Guide)
- Forced boil-off gas supply system from the tanks to the consumers
- Testing procedures during sea/gas trials.

2 Vapor (BOG) Circuit

2.1 Compressors

Compressors intended to be used for sending the boil-off gas to the GCU may be also used for other duties.

The compressors are to be designed in accordance with 5C-8-16/4.2 of the *Steel Vessel Rules*, except that the compressors are to be capable of being stopped locally and remotely from the control room and from the bridge.

For pressure and temperature measurement and control, see Section 7, Table 1 of this Guide.

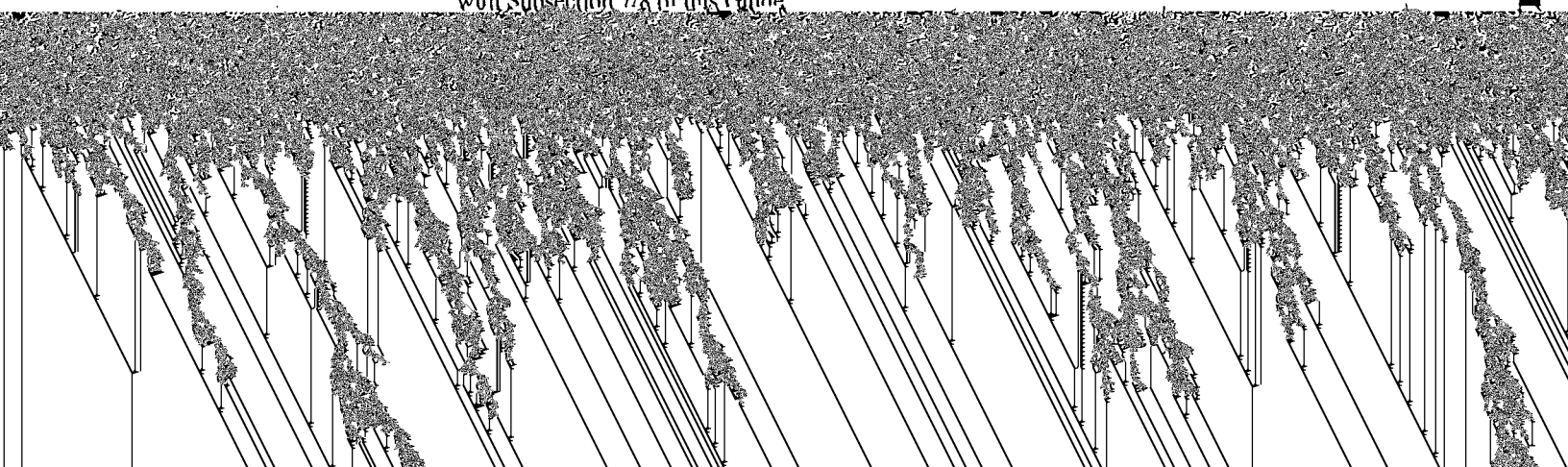
2.2 Heaters

The heaters are to be designed, constructed and certified in accordance with Section 4-4-1 of the *Steel Vessel Rules*.

2.3 Gas Fuel Supply to GCU

Gas fuel piping is not to pass through accommodation spaces, service spaces or control stations. Gas fuel piping may pass through or extend into other spaces, provided the arrangements fulfill one of the following:

- i) Gas fuel supply piping is to be installed to comply with 5C-8-16/3 of the *Steel Vessel Rules*.
- ii) Alternatively, where the fuel gas supply piping system is a single wall design and the associated valves including the burner gas fuel connection at the GCU are located inside a gas tight compartment inside an engine room or other non-hazardous spaces, the arrangements are to be as follows:
 - a) The pressure in the fuel gas supply line is not to exceed 10 bar (10.2 kgf/cm², 145 psi).
 - b) The pipes are to be of all-welded construction with flange connections only at connections to equipment.
 - c) This compartment is to have access to the open deck. Where this is not possible, entrance and exits to this compartment from a non-hazardous space are to be through a self-closing gas-tight door.
 - d) The compartment is to be fitted with a mechanical exhaust ventilation system complying with Subsection 7/8 of this Guide.



3 Gas Burner Unit and Burner Management System

- i) The gas burner management control philosophy for all modes of operation is to be submitted. This should be accompanied by a safety analysis identifying the modes of failures and shutdown and startup sequences of the system.
- ii) Where free flow of BOG to the GCU is intended, the GCU control system is to be designed to safely manage such mode of operation.
- iii) Gas nozzles should be fitted in such a way that gas fuel is ignited by the flame of the oil pilot burner described in Subsection 7/4 of this Guide or by an electrical ignition system.
- iv) The gas burner is to be fitted with a flame scanner. The flame scanner is to be dual scanners or a scanner of the self-checking type. The flame scanner control should provide for a trial-by-ignition period of not more than ten (10) seconds, during which time gas fuel may be supplied to establish a flame. If the flame is not established within ten (10) seconds, the gas fuel supply to the burner is to be immediately shut off automatically. In the case of flame failure, shut-off is to be achieved within four (4) seconds following flame extinguishment. In the case of failure of the flame scanner, the gas fuel is to be shut off automatically.
- v) After flame extinguishment, the gas burner supply piping and combustion chamber is to undergo the purge sequences required by 5C-8-16/5.4 and 5C-8-16/5.6 of the *Steel Vessel Rules*.
- vi) The burner management system is to be arranged such that the gas burner cannot be ignited until forced draft and dilution air fan flow is established.
- vii) The gas burner unit is to have the capability of automatic operation with manual local controls.

A manually operated shut-off valve is to be fitted on the pipe of each gas burner.

4 Oil Pilot Burner/Electrical Ignition System

Each gas fuel burner unit is to be fitted with an oil pilot burner and/or electrical igniter. The arrangements of the piping system, storage and heating of the fuel for the oil pilot burner are to be in accordance with the applicable requirements of 4-6-4/13 and 4-6-6/7 of the *Steel Vessel Rules*.

The oil pilot burner is to be fitted with a flame scanner designed to automatically shut off the fuel supply to the burner in the event of flame failure. The shut-off is to be achieved within six (6) seconds following flame extinguishment. In the case of failure of the flame scanner, the fuel to the oil pilot burner is to be shut off automatically.

5 Forced Draft Fans and Dilution Fans

There is to be a minimum of two forced draft fans for each gas combustion unit. Each fan is to be sized such that the total capacity is not less than 100% of the total capacity required to support the full rated capacity of the GCU with one fan kept in reserve. Forced draft fan motors are to be located in a non-hazardous space. Where operational or structural requirements are such as to make it impossible to install the motors in the non-hazardous space, the following certified safe type motors are to be provided:

- Increased safety type with flameproof enclosure; or
- Pressurized type

There is to be a minimum of two dilution fans provided. Each dilution fan is to be sized such that the total capacity is not less than 100% of the total capacity required to support the full rated capacity of the GCU with one dilution fan kept in reserve. Means are to be provided for measuring and monitoring of air flow in the forced draft and the dilution air flow streams on the discharge side.

6 Combustion Chamber and Associated Refractory

- i) The combustion chamber walls are to be protected with insulated fire bricks/refractory and/or a cooling system. Hot surfaces likely to come in contact with the crew during operation are to be suitably guarded or insulated.
- ii) The combustion chamber and the refractory are to be designed so that in the event of failure of the dilution fans, the temperature of the casing, or the outer casing where double casing is fitted, does not exceed 230°C (446°F).
- iii) Where the casing of the combustion chambers is required to be cooled due to temperature limitation of the material used, this may be achieved by dilution fans, as per Subsection 7/5 of this Guide. Alternative means of cooling will be considered subject to approval of the details.
- iv) The design is to take into consideration the expected frequency of operation of the GCU and possible vibrations.
- v) The design of the combustion chamber is to be such that the flame length always remains within the extent of the gas combustion unit under all modes of operation.
- vi) The combustion chamber is to be of suitable form such as not to present pockets where gas may accumulate.

7 Exhaust Gas Piping

- i) Exhaust gas temperature at the discharge from the GCU is not to exceed 535°C (995°F) during any operating mode.
- ii) The requirements of 4-6-5/11 of the *Steel Vessel Rules* for exhaust gas piping of internal combustion engines apply.

8 Ventilation

Ventilation arrangements are to comply with 5C-8-16/3 of the *Steel Vessel Rules*, except that where the gas fuel supply pipe is a single wall design, as described in 7/2.3ii) of this Guide, the ventilation of the spaces containing the gas combustion unit is to be in accordance with the following requirements:

- i) The gas combustion unit compartment is to be fitted with a mechanical ventilation system having a capacity of at least thirty (30) air changes per hour based on the gross volume of the compartment. The ventilation system is to be provided with at least two fans. Each fan is to be sized such that the total capacity is not less than 100% of the total capacity required with one fan kept in reserve.
- ii) Ventilation ducting is to be situated in the gas combustion unit compartment in such a manner as to provide immediate evacuation of the leaked gas from the entire compartment without the possibility of pockets of gas remaining in isolated corners. Either a gas dispersion analysis or a physical smoke test under all possible operating modes is to be conducted in order to prove that the inlets in the ducting are strategically positioned for the effective removal of the leaked gas from the compartment.
- iii) The ventilation system in the gas combustion unit compartment is to be separate from those intended for other spaces. The ventilation inlet and discharge are to be respectively from and to a non-hazardous area.
- iv) The ventilation fans are to be of non-sparking construction (see 5C-8-12/1.9 of the *Steel Vessel Rules*) and electric motors for these fans are to be located outside of the airflow stream.

9 Gas Detection

Gas detection arrangements are to comply with 5C-8-16/3 of the *Steel Vessel Rules*, except that where the gas fuel supply pipe is a single wall design as described in 7/2.3ii) of this Guide, the gas detection arrangements are to be in accordance with the following requirements:

- i) There are to be at least two independent fixed gas detection systems in the gas combustion unit compartment for continuous monitoring of the presence of leaked gas.
- ii) Each gas detection system is to be of the self-monitoring type.
- iii) In the case that a detection system fault is detected by the self-monitoring functions, the output of the detection system is to be automatically disconnected such that the detector fault will not cause false emergency shutdown.
- iv) Each gas detection system is to be so arranged that it provides functional redundancy when either one of the systems fails.
- v) Gas detection equipment is to be so designed that it may be readily tested.

Placement of the detectors is critical to the effectiveness of the gas detection. The exact location of the gas detectors is to be determined taking into consideration the sensitivity of gas detectors under the prevailing airflow. Arrangements will be subject to approval for each application based upon the gas dispersion analysis or the physical smoke test.

When the GCU is fitted with a double casing, care is to be exercised to preclude the possibility of gases leaking into and being trapped in pockets of the outer casing. Gas detection probes within the casing and explosion-relief doors on the outer casing are to be provided.

10 Automatic Shutdown System

The monitoring and safety system functions for the GCU gas fuel supply systems are to be provided in accordance with Section 7, Table 1 of this Guide. The alarms are to be provided at the GCU control station. In addition, a summary alarm is to be provided at the navigation bridge. Shutdown arrangements are to comply with 5C-8-16/3 of the *Steel Vessel Rules*, except that where the gas fuel supply pipe is a single wall design as described in 7/2.3ii) of this Guide, the shutdown arrangements are to be as follows:

- i) In the event of leakage of gas in the compartment, an alarm is to be given when the gas concentration within the compartment reaches 30% of LEL by volume.
- ii) If the gas concentration in the compartment continues to rise to 60% of LEL by volume, the master gas valve is to close automatically, the block and bleed valves are to operate and all non-certified electrical equipment within the compartment is to be isolated from their electrical supply. The ventilation fans are to continue operating until the gas concentration in the compartment has reached a safe level for entry.
- iii) In the event of ventilation system failure in the compartment (see Subsection 7/8 of this Guide), an alarm is to be given in the control center and on the bridge, the entire gas combustion unit is to shut down and the gas shut-off valve is to close automatically.

11 Fire Extinguishing System

The compartment described in 7/2.3ii) of this Guide is to be provided with a fixed fire extinguishing system complying with 4-7-2/1.1.1 of the *Steel Vessel Rules*.

12 Surveys During Construction

12.1 General

This Subsection pertains to surveys during fabrication at the manufacturer's facility and installation and testing of gas combustion units onboard. For surveys at the manufacturer's facility, the scope of the survey will be confined to only those items that are supplied by the manufacturer.

12.2 Surveys at Manufacturer's Facility

See Section 7, Table 2 of this Guide for the ABS certification requirements for gas combustion units. Survey requirements for equipment components and packaged units at the manufacturer's facility are summarized in relevant sections of the applicable Rules/Guides.

Certification of the complete gas combustion unit cannot be accepted based only on the ABS Type Approval Program, and therefore ABS Surveyor's attendance is required during fabrication for unit certification. However, component parts of the unit can be certified in accordance with ABS Product Quality Assurance (PQA) Certification system outlined in Appendix 1-1-A3 of the *ABS Rules for Conditions of Classification (Part 1)*.

When Surveyor's attendance at the shop of the manufacturer and at the assembly site is required by the applicable Rules or this Guide, the manufactured/assembled system components will be verified to be satisfactorily in compliance with a recognized standard. Surveyor's attendance is required typically for the following purposes:

- i) To confirm that the facility to manufacture, fabricate or repair gas combustion units or its components do have and maintain a quality-control program effectively covering design, procurement, manufacturing and testing, as applicable, and meeting the requirements of a recognized standard applicable to their product.
- ii) To qualify or verify welder's qualifications, welding procedure specifications and corresponding weld procedure qualification records to the extent deemed necessary by the attending Surveyor.
- iii) To verify material certificates/documentations, particularly for materials of piping, main pressure retaining parts of valves, including safety valves that have flanged or screwed ends or other specialty fittings. Witness of material testing where required by the *Steel Vessel Rules*.
- iv) To survey final weldments.
- v) To witness, as far as deemed necessary, weld nondestructive examination tests and to review records of nondestructive examinations.
- vi) To witness pressure and/or proof-load testing of equipment components and as a unit, as applicable and as called for in the fabrication procedures.
- vii) To witness testing of subassemblies and completed units as called for in the fabrication procedures.
- viii) To verify all certified safe systems, motor controllers, consoles and instrumentation and control panels are in compliance with approved drawings.
- ix) To carry out other inspections and to witness the final Factory Acceptance Test (FAT) as agreed upon during prefabrication meeting.

12.3 Surveys During Installation

The following surveys are to be carried out to the satisfaction of the attending Surveyor on the gas combustion unit and associated systems during installation and testing:

- i) Piping systems are to be visually examined and pressure-tested, as required by the *Steel Vessel Rules*. Pressure tests conducted on Class I piping (see 4-6-1/Table 1 of the *Steel Vessel Rules*) systems should preferably be recorded on test charts for the duration of their tests.
- ii) Electrical wiring and connections are to be in accordance with Part 4, Chapter 8 of the *Steel Vessel Rules* and checked for continuity and proper workmanship.
- iii) Instrumentation is to be tested to confirm proper operation as per its predetermined set points.
- iv) Pressure relief and safety valves installed on the unit are to be tested.
- v) Control system and shutdowns are to be tested for proper operation.
- vi) The gas combustion unit is to be checked for proper operation in accordance with the ABS approved installation test procedure.

12.4 Surveys During Trials

During the initial gas trials, the gas combustion unit is to be confirmed for its satisfactory operation, including associated controls, alarms and shutdowns. The tests are to be conducted in accordance with the ABS approved testing procedure during gas trials.

**TABLE 1
Instrumentation and Alarms in Centralized Control Stations for the GCU**

<i>Item</i>		<i>Display</i>	<i>Alarm</i>	<i>Automatic Shutdown</i>
Gas valves enclosure	Gas detection		30% LEL	60% LEL
	BOG flow rate	X	Low	X (Low-Low)
	BOG temperature	X	Low	
	Ventilation fan	Running	Stopped	X (failure)
Gas valve train	LD Compressor pressure	X	High	X (High-High)
	Discharge line temperature	X	High/Low	X (High-High)
Oxidizing Unit and burner casing	Combustion Fan	Running	Stopped/standby auto start	
	Dilution fan	Running	Stopped/standby auto start	
	Flame scanner		X	Failed
	Burner flame		X	Failed
	Furnace temperature	X	High	
	Fire or high temperature in flue gas section	X	High	X (High-High)
	Gas fuel pressure		Low	X (Low-Low)
	Gas fuel temperature		High/Low	X (HH/LL)
Burner Management and Control System	Control power supply		Failed	
	Emergency Shutdown		X	

TABLE 2
Certification of Gas Combustion Units

This Table has been prepared for guidance only and annotated to agree with the *Steel Vessel Rules*, IMO IGC Code and other IMO requirements. The list is not to be considered exhaustive; should additional equipment not listed be fitted onboard, same will be subject to special consideration for compliance with the *Steel Vessel Rules*, the IGC Code and other IMO requirements. This list is not to be considered as substitutive or integrative of the content of the *Steel Vessel Rules* and/or other applicable Regulations. In case of conflict between the content of this list and the applicable *Steel Vessel Rules* and regulations, the latter are to be considered applicable.

<i>Code</i>	<i>Explanation</i>
MD	<i>Manufacturer's Documentation</i> – Manufacturer should supply documentation as evidence that the material or the equipment complies with an acceptable standard (e.g., standard tests reports, ex certification, etc.).
DR	<i>Design Review</i> – Design review required.
MT	<i>Material Testing</i> – Material testing is to be witnessed by the Surveyor.
MS	<i>Manufacture Survey</i> – Product is to be surveyed during fabrication stages by the Surveyor.
FS	<i>Final Survey</i> – Finished product is to be subject to final hydrostatic, nondestructive, operational testing, or any other

- Arrangement and details of crankcase protection (see 8/3.3 of this Guide)
- Failure Modes and Effects Analysis (FMEA) to determine possible failures and their effects in the safe operation of the dual fuel diesel or single gas fuel engines (see 8/3.4 of this Guide) for each engine type
- Arrangement of explosion protection for air inlet manifolds and for exhaust manifolds including design basis and size calculations (see 8/3.2.4 and 8/3.5.1 of this Guide)
- Emergency shutdown arrangements
- Operating and maintenance instruction manuals
- Forced boil-off or LNG vaporization gas supply system from the tanks to the consumers
- Testing procedures during sea/gas trials

2 Arrangement of Engine Compartments with Single Wall Fuel Gas Piping

2.1 General

The propulsion and auxiliary arrangements for single wall fuel gas piping engine compartments are to comply with Subsection 2/5 of this Guide. Fuel gas supply arrangements are to comply with Section 5 of this Guide.

2.2 Ventilation

2.2.1 Capacity

Each single wall fuel gas piping engine compartment is to be fitted with at least two mechanical ventilation fans with a total capacity of at least 30 air changes per hour based on the gross volume of the compartment, without taking into consideration the combustion air required for the engine(s) in the compartment.

If one fan is out of service, the capacity of the remaining ventilation fan(s) is to be not less than 100% of the total required.

2.2.2 Ducting

Ventilation ducting is to be situated in the single wall fuel gas piping engine compartment in such a manner that immediate evacuation of the leaked gas from the entire compartment occurs without the possibility of pockets of gas remaining in isolated corners.

Either a gas dispersion analysis or a physical smoke test under the possible operating modes is to be conducted in order to prove that the inlets in the ducting are strategically positioned for the effective removal of the leaked gas from the compartment.

2.2.3 System Requirements

The ventilation system in each single wall fuel gas piping engine compartment is to be separated from those intended for other spaces including other single wall fuel gas piping engine compartments.

The ventilation inlet and discharge are to be respectively from and to a non-hazardous area.

The ventilation fans are to be of non-sparking construction (see 5C-8-12/1.9 of the *Steel Vessel Rules*) and electric motors for these fans are to be located outside of the airflow stream.

The ventilation system is to be always in operation when there is gas fuel in the piping while in normal operation, as well as in purging operation prior to maintenance works.

2.3 Gas Detection

2.3.1 System Requirements

There are to be at least two independent fixed gas detection systems in each single wall fuel gas piping engine compartment for continuous monitoring of the presence of leaked gas.

Each gas detection system is to comply with the following requirements:

2.7 Explosion Protection

Arrangements are to be such that effects of an explosion in a single wall fuel gas piping engine compartment can be contained or vented and will not cause damage to any space other than that in which the incident occurs nor render machinery or equipment in other spaces inoperable.

3 Dual Fuel Diesel and Single Gas Fuel Engines

3.1 General

- i)* The requirements of this Subsection are applicable to all gas fueled engines. The requirements may be applied to dual fuel diesel and single gas fuel engines operating according to the lean burn Otto cycle with pilot injection or spark ignition, dual fuel diesel and single gas fuel engines where the gas is mixed with air before the turbocharger (so called 'Pre-mixed engines') and dual fuel engines operating high pressure direct injection gas systems. Additional requirements specific to dual fuel diesel, single gas fuel and 'Pre-mixed' gas engines are given under 8/3.8 through 8/3.10 of this Guide.
- ii)* Gas fueled engines are to be capable of operating with possible variations of the Methane Number and Heat Value and the extent of those permitted variations are to be declared by the manufacturer and detailed in the operation and maintenance manuals required by Subsection 1/6 of this Guide.
- iii)* Gas engine components or systems containing or likely to contain gas are to be designed to the following general principles:
 - a)* It should be demonstrated that there is no risk of explosion; or
 - b)* The consequences of a possible explosion are acceptable and can be contained without any detrimental effect by either the inherent strength of the component or by safety pressure

3.2.4 Air Inlet Manifolds

An explosion relief valve or other appropriate protection against explosion is to be provided on the air inlet manifolds.

Protective devices that require dismantling or replacement prior to continued engine operation are not to be installed on single engine main propulsion installations.

The arrangement and location of the protection devices is to be such as to minimize the dangers to personnel and equipment from operation of the protective device.

Alternatively, documentation may be submitted for consideration showing that the system has sufficient strength to withstand a worst-case explosion, or that the assumed possible gas explosion in the air inlet manifold is not a plausible scenario due to the inherent design characteristics.

3.3 Protection of Crankcase

3.3.1 Explosion Relief Valves

The explosion relief valves are to be in accordance with 4-2-1/7.1 of the *Steel Vessel Rules*. High pressure dual fuel engines are to be fitted with explosion relief valves in way of each crank throw.

3.3.2 Ventilation

To avoid interconnection between crankcases and the possible spread of fire following an explosion, crankcase ventilation pipes and oil drain pipes for each engine are to be independent of any other engine.

The crankcase is to be continuously vented and arrangements are to be made so that any blow-by gas may readily reach the vent. However fresh air ventilation of the crankcase, and any arrangement which could produce a flow of external air within the crankcase, is not permitted.

Crankcase ventilation pipes are to be as small as practicable, in accordance with manufacturers recommendations, to minimise the inrush of air after a crankcase explosion. If a forced extraction of the oil mist atmosphere from the crankcase is provided (for mist detection purposes for instance), the vacuum in the crankcase is not to exceed 2.5×10^{-4} N/mm² (2.5 mbar).

The outlet of the vent line is to be led to a non-hazardous area in the open air, or to an alternative acceptable location to safely dispose of the gas, through a flame arrester.

3.3.3 Inerting

A means is to be provided for inerting and aerating the crankcase before opening the crankcase doors for maintenance.

The crankcase is to be fitted with a gas sampling connection in order to allow the measurement of the gas concentration by portable gas detection equipment.

3.3.4 Instrumentation

Instrumentation installed inside the crankcase is to be of the certified safe type.

The crankcase is to be protected by an oil mist detector.

3.3.5 Warning Notice

The warning notice required by 4-2-1/7.13.1 of the *Steel Vessel Rules* is to include a caution that the crankcase is not to be opened until adequate precautions have been taken to determine that no gas remains trapped in the crankcase.

3.4 Protection against Explosion

In addition to the requirements in 4-2-1/7 of the *Steel Vessel Rules*, a Failure Modes and Effects Analysis (FMEA) is to be carried out by the engine manufacturer in order to determine necessary additional means of safeguards to address the hazard associated with the use of gas as a fuel.

The analysis is to identify all plausible scenarios of gas leakage and the resulting possible explosion. Then the analysis is to identify necessary means to control the identified explosion hazards.

The FMEA is to be submitted to ABS for approval.

3.5 Engine Exhaust System

3.5.1 Explosion Protection

Explosion relief valves or other appropriate protection against explosion, such as burst discs of an approved type, are to be provided on the exhaust manifolds.

Protective devices that require dismantling or replacement prior to continued engine operation are not to be installed on single engine main propulsion installations.

The arrangement and location of the protective devices is to minimize the dangers to personnel and equipment from operation of the protective device.

Alternatively, documentation showing that the system has sufficient strength to withstand a worst-case explosion may be submitted for consideration.

3.5.2 Installation

The exhaust gas pipes from dual fuel diesel or single gas fuel engines are not to be connected to the exhaust pipes of other engines or systems.

Installation arrangements are to have the exhaust pipes sloped upwards after the turbocharger in order to avoid formation of gas pockets.

3.5.3 Purging

A manual purging connection is to be provided.

In the event that a single gas fuel engine stops or a dual fuel engine stops during the gas fuel mode of operation, the exhaust system is to be purged for a sufficient time, to discharge the gas that may be present. The purge time is to be based on a minimum of four air changes of the volume of the exhaust system.

3.6 Auxiliary System Venting

Auxiliary system circuits, such as cooling water or dry/wet sump lubricating oil systems, that are likely to contain gas in normal conditions or abnormal conditions as a result of a component failure (refer to FMEA) are to be arranged in accordance with the following requirements:

- i) Auxiliary system circuits are to be arranged to avoid cross connection between engine systems and to avoid the migration of gas to non-hazardous areas;
- ii) Vent pipes are to be independent and to be led to a safe location external to the machinery space and to be fitted with a flame arrester.

3.7 Control and Monitoring Systems

3.8 Dual Fuel Diesel Engines

- i) Dual fuel diesel engines are to be of the compression-ignition, dual fuel type arranged to use either oil fuel or gas fuel for the main fuel charge and with pilot oil fuel for ignition. The amount of pilot oil fuel fed to each cylinder is to be sufficient to provide a positive ignition of the gas mixture. Gas injection is not to be possible without a corresponding pilot oil injection or controlled ignition of the main fuel charge.
- ii) The engines are to be arranged for easy changeover to either fuel; rapid (emergency) changeover is only required from gas fuel to diesel fuel mode. In the case of changeover to either fuel supply, the engines are to be capable of continuous operation using the alternative fuel supply without interruption to propulsion or power supply.
- iii) Changeover to and from gas fuel operation is only to be possible at a power level and under conditions where it can be done with acceptable reliability and safety as demonstrated through testing. On power reduction the changeover to oil fuel is to be automatic. The changeover process itself to and from gas operation is to be automatic but manually activated shutdown is to be possible in all cases.
- iv) Only oil fuel is to be used when starting the engine and prior to a normal stop. On normal stop as well as emergency shutdown, gas fuel supply is to be shut off not later than simultaneously with the oil fuel. It is not to be possible to shut off the supply pilot fuel without first, or simultaneously, closing the gas supply to each cylinder or to the complete engine. In case of shut-off of the gas supply, the engines are to be capable of continuous operation by oil fuel only.

3.9 Single Gas Fuel Engines

- i) Single gas fuel engines are to be arranged with in-cylinder pre-chamber and high voltage spark ignition or micro-pilot oil fuel injection for ignition of the main gas fuel charge.
- ii) The starting sequence is to be such that fuel gas is not admitted to the cylinders until spark ignition or micro-pilot ignition systems are activated and the engine has reached an engine and application specific minimum rotational speed.
- iii) If spark ignition or micro-pilot has not been detected by the engine monitoring system within an engine specific time after opening of the gas supply valve, the gas supply valve is to be automatically shut-off and the starting sequence terminated. Any unburned gas mixture is to be cleared from the exhaust system.
- iv) On normal stop as well as emergency shutdown, the gas fuel supply is to be shut off not later than simultaneously with the spark ignition or micro-pilot. It is not to be possible to shut off the ignition systems without first or simultaneously closing the gas supply to each cylinder or to the complete engine.
- v) The shut down sequence is to be such that the engine gas supply valve closes at idle speed and that the spark ignition or micro-pilot system is kept active until the engine is at standstill.

3.10 'Pre-Mixed' Gas Fuel Engines

- i) For gas fueled engine types where the gas is mixed with air before the turbocharger (so called 'Pre-mixed system'), the engine components containing the gas/air mixture, such as inlet manifold, turbo-charger, charge air cooler, etc., are to be considered as parts of the fuel gas supply system.

Such engine types are to be installed in a machinery space complying with the requirements for single wall gas fuel piping detailed under Subsection 8/2 of this Guide. Alternative arrangements may be considered on a case by case basis.
- ii) In addition to the requirements for engine component pressure tests given under 4-2-1/Table 2 of the *Steel Vessel Rules*, engine components containing gas/air mixtures during normal operation such as inlet manifolds, charge air coolers, charge air cooler casings, turbocharger compressor casings, etc., are to be pressure tested at 1.5 times the maximum working pressure of the component. These tests are to be carried out by the manufacturer whose certificate of test will be acceptable.

4 Emergency Shutdown

4.1 Automatic Shut Off of Gas Fuel Supply

The monitoring and safety system functions for gas fuel supply systems are to be provided in accordance with Section 5, Table 2 of this Guide.

4.2 Emergency Shutdown of the Engine Compartment

When a gas leakage is detected in a dual fuel diesel or single gas fuel engine compartment, and before the gas concentration detected reaches 60% of the LEL, all the electrical equipment inside the compartment, other than certified safe type, is to be automatically isolated from its electrical supply and all the engines in that compartment are to be shut down. See Section 5, Table 2 of this Guide.

4.3 Power Management

Where dual fuel diesel or single gas fuel engines are used for electric propulsion power generation, a power management system is to be provided to safeguard the power supply system from overloading, which may occur due to the sudden shutdown of an engine compartment.

5 Surveys During Construction

5.1 General

This Subsection pertains to surveys during fabrication at manufacturer's facility and installation and testing of dual fuel diesel engines and single gas fuel engines onboard gas fueled ships. For surveys at the manufacturer's facility, the scope of the Survey will be confined to only those items that are supplied by the manufacturer.

5.2 Surveys at Manufacturer's Facility

See Section 8, Table 2 of this Guide for the ABS certification requirements for dual fuel diesel engines and single gas fuel engines. Survey requirements for equipment components and packaged units at the manufacturer's facility are summarized in relevant sections of applicable Rules/Guides.

Certification of complete dual fuel diesel engines and single gas fuel engines cannot be accepted based only on the ABS Type Approval Program, and therefore ABS Surveyor's attendance is required during fabrication for unit certification. However, component parts of the unit can be certified in accordance with ABS Product Quality Assurance (PQA) Certification system outlined in Appendix 1-1-A3 of the *ABS Rules for Conditions of Classification (Part 1)*.

When Surveyor's attendance at the shop of the manufacturer and at the assembly site is required by the applicable Rules or this Guide, the manufactured/assembled system components will be verified to be satisfactorily in compliance with a recognized standard. Surveyor's attendance is required typically for the following purposes:

- i) To confirm that the facility to manufacture, fabricate or repair dual fuel diesel engines or its components do have and maintain a quality-control program effectively covering design, procurement, manufacturing and testing, as applicable, and meeting the requirements of a recognized standard applicable to their product.
- ii) To qualify or verify welder's qualifications, welding procedure specifications and corresponding weld procedure qualification records to the extent deemed necessary by the attending Surveyor.

- vi) To witness pressure and/or proof-load testing of equipment components and as a unit, as applicable and as called for in the fabrication procedures.
- vii) To witness testing of subassemblies and completed units as called for in the fabrication procedures.
- viii) To verify all certified safe systems, motor controllers, consoles and instrumentation and control panels are in compliance with approved drawings.
- ix) To carry out other inspections and to witness the final Factory Acceptance Test (FAT) as agreed upon during prefabrication meeting.

5.3 Surveys During Installation

The following surveys are to be carried out to the satisfaction of the attending Surveyor on the dual fuel diesel engines or single gas fuel engines and associated systems during installation and testing:

- i) Piping systems are to be visually examined and pressure-tested, as required by the *Steel Vessel Rules*. Pressure tests conducted on Class I piping (see 4-6-1/Table 1 of the *Steel Vessel Rules*) systems should preferably be recorded on test charts for the duration of their tests.
- ii) Electrical wiring and connections are to be in accordance with Part 4 of the *Steel Vessel Rules* and checked for continuity and proper workmanship.
- iii) Instrumentation is to be tested to confirm proper operation as per its predetermined set points.
- iv) Pressure relief and safety valves installed on the unit are to be tested.
- v) Control system and shutdowns are to be tested for proper operation.
- vi) The dual fuel diesel engine or single gas fuel engine is to be checked for proper operation in accordance with the ABS approved installation test procedure.

5.4 Surveys During Trials

During the initial gas trials, the dual fuel diesel engine or single gas fuel engine is to be confirmed for its satisfactory operation, including associated controls, alarms and shutdowns. The tests are to be conducted in accordance with ABS approved testing procedure during sea/gas trials. The dual fuel diesel engine or single gas fuel engine is to be run whilst the vessel is underway at sea and the propulsion system operating over its full range of power.

TABLE 2
Certification of Dual Fuel Diesel and Single Gas Fuel Engines

This Table has been prepared for guidance only and annotated to agree with the *Steel Vessel Rules*, IMO IGC Code and other IMO requirements. The list is not to be considered exhaustive; should additional equipment not listed be fitted onboard, same will be subject to special consideration for compliance with the *Steel Vessel Rules*, the IGC Code and other IMO requirements. This list is not to be considered as substitutive or integrative of the content of the *Steel Vessel Rules* and/or other applicable Regulations. In case of conflict between the content of this list and the applicable *Steel Vessel Rules* and regulations, the latter are to be considered applicable.

<i>Code</i>	<i>Explanation</i>
MD	<i>Manufacturer's Documentation</i> – Manufacturer should supply documentation as evidence that the material or the equipment complies with an acceptable standard (e.g., standard tests reports, ex certification, etc.).
DR	<i>Design Review</i> – Design review required.
MT	<i>Material Testing</i> – Material testing is to be witnessed by the Surveyor.
MS	<i>Manufacture Survey</i> – Product is to be surveyed during fabrication stages by the Surveyor.
FS	<i>Final Survey</i> – Finished product is to be subject to final hydrostatic, nondestructive, operational testing, or any other required tests, and witnessed by the Surveyor at manufacturer's facility.

<i>Equipment</i>	<i>MD</i>	<i>DR</i>	<i>MT</i>	<i>MS</i>	<i>FS</i>
Gas valve enclosure		X			X
Gas storage pressure vessels ⁽¹⁾					
Fuel gas piping system in engine room incl. block and bleed valves		X			X
Dual fuel diesel or single gas fuel engine ⁽³⁾		X	X	X	X
Crankcase, inlet manifold and exhaust manifold explosion protection systems ⁽³⁾					X
Engine compartment ventilation system		X ⁽²⁾			
Fuel gas piping ventilation system		X ⁽²⁾			
Control system		X			X
Engine compartment fire detection system		X			X
Engine compartment fire extinguishing system		X			X
Engine compartment explosion protection arrangements		X			X
Gas detection system		X			X
Automatic shutdown and safety systems		X			X

Notes:

- 1 See Appendix 1, Table 1 of this Guide.
- 2 Design verification only.
- 3 See Section 4-2-1 of the *Steel Vessel Rules*. See also additional requirements for 'Pre-mixed' gas engine components under 8/3.10ii) of this Guide.

3 General

3.1 Gas Turbine Propulsion System

- i) Both liquid fuel and boil-off gas may be used simultaneously.
- ii) Gas turbines are to be capable of operation with a range of gas composition mixtures reflective of that likely to be encountered during service.

4 Plans and Data to be Submitted

In addition to the plans and particulars required as per 4-2-3/1.5 of the *Steel Vessel Rules*, the following plans and particulars for dual fuel applications are also to be submitted:

- General arrangements showing location of the power plant and individual items of machinery, such as the gas turbine units(s), exhaust gas boilers, turbo generators(s), diesel generators and other associated equipment (such as the gas combustion units(s), re-liquefaction plant and the gas supply line to the consumers)
- General arrangement of the gas turbine engine enclosure, including location of the gas detectors, electrical equipment, lighting and ventilation, etc.
- Gas fuel manifold arrangement and details, including design pressure and temperatures, operational schematics, material specifications and bill of materials
- Enclosure, including size and dimensions, gas tightness, entrance and exits and other openings, such as ventilation intakes and outlets
- Ventilation systems details, including inlet cooling air calculations for the enclosure
- Fixed gas detection and alarm systems, and associated shut-off and shutdown systems
- Gas fuel piping systems, including details of pipes and associated components, design pressures and temperatures, operational schematics, flange/joints loadings, material specifications and bill of materials
- Gas compressors, with details such as type, size, mechanical components, materials used and details of alarms, indication, shutdown and control system.
- Mist separators
- Vaporizers
- Heat exchangers, including BOG heaters, BOG coolers, etc.
- Pressure vessels, including recovery tanks, etc.
- Descriptions and schematic diagrams for control and monitoring systems, including set points for abnormal conditions together with control logic for the entire power plant and individual items in the systems.
- Details of the electrical equipment in the turbine engine enclosure
- Failure Modes and Effects Analysis (FMEA) to determine possible failures and their effects in the safe operation of the dual fuel gas turbine
- Electric bonding (earthing) arrangement
- Emergency shutdown arrangements (see 9/13.3 of this Guide)
- Operating and maintenance instructions manuals
- Schematic diagram showing gas and fuel supply lines from the source to the consumers for the entire power plant system
- Forced boil-off and LNG vaporization gas supply system from the tanks to the consumers
- Testing procedures during sea/gas trials

5 Materials of Construction

- i) Materials entering into the construction of gas turbine engine propulsion systems are to comply with the requirements of Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)* and 4-2-3/3 and 5C-8-6/2 of the *Steel Vessel Rules*.
- ii) Materials subjected to low temperatures are to comply with the requirements of Sections 2-3-2 and 2-3-13 of the *ABS Rules for Materials and Welding (Part 2)*.

6 Dual Fuel Propulsion Gas Turbines

6.1 General

- i) Gas turbines as components are to comply with the requirements of Section 4-2-3 and 5C-8-16/8 of the *Steel Vessel Rules*.
- ii) The dual fuel gas turbine is to be fitted within an acoustic gas-tight enclosure providing effective gas detection, fire protection, ventilation and cooling, as per the requirements given in this Section. Alternatively, the gas turbines may be located in a space containing other machinery, provided that the installation arrangements of the gas turbine are in compliance with 9/2.1.2 of this Guide.
- iii) The design of the gas fuel manifold and nozzles is to provide complete venting upon shutdown to prevent gas leakage and fire, unless the manufacturer demonstrates to the satisfaction of ABS by experience with similar installations or test data that the gas manifold evacuation is not necessary.
- iv) The design of the gas turbine is also to provide positive means of evacuating all unburned gas from the combustor, turbine and exhaust collector.

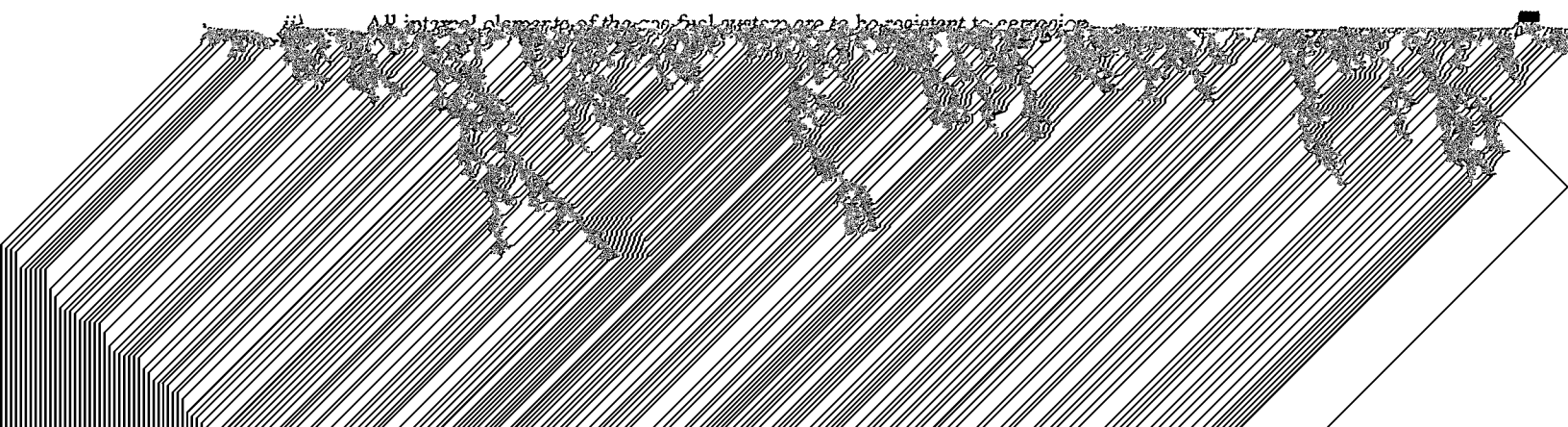
6.2 Gas Fuel Manifold

- i) The gas fuel manifold fitted on the engine is to be designed for the maximum design pressure, temperatures, thermal growth, dominant resonances and vibrations that may be experienced after installation.
- ii) The installation arrangements of the gas fuel manifold, piping and pipe fittings, joints, etc., are to provide the necessary flexibility to accommodate the oscillating movements of the engine without risk of fatigue failure in the piping connections to the engine.
- iii) The gas fuel manifold and piping configuration is to be approved and certified by ABS as per the engine manufacturer's design.
- iv) All metallic gas fuel manifold/lines are to be of corrosion resistant steel.
- v) All mechanical joints are to be of welded type, as far as practicable, and designed to prevent accidental leakage onto hot engine parts and any other source of ignition. Shielding or other means are to be provided to prevent this.
- vi) Non-welded connections will be subject to special consideration.

6.3 Gas Fuel Control Valves

- i) Actuation is to be from the machinery control room, both at local and remote locations. Where the source of power to the actuator is electrical, the electrical source should be from the emergency power supply or provided with a backup power supply. All shut-off valves are to close rapidly and completely. All shut-off valves are to be of fail-safe type.

ii) All internal elements of the gas fuel system are to be resistant to corrosion.



7 Gas Turbine Enclosure

7.1 General

- i) The gas turbine is to be resiliently or rigidly mounted to a structural foundation within an acoustically and thermally insulated enclosure.
- ii) The enclosure design is to maintain all components within their safe working temperature under expected operating conditions to minimize the risk of fire from sources of ignition such as hot spots. This is to prevent damage by heat to the adjacent components by providing effective fire prevention, ventilation and cooling.

7.2 Construction

- i) Unless the fuel gas piping up to the gas turbine inlet is of double wall design and in full compliance with Section 5C-8-16 of the *Steel Vessel Rules*, the enclosure is to be gas-tight.
- ii) The enclosure is to be of steel construction and designed for removal of major components, such as the generator, reduction gear (where fitted) or gas turbine. The manufacturer is to identify maintenance access envelopes for removal of the above major components.
- iii) The enclosure is to maintain structural integrity with the access panels removed.
- iv) The enclosure is to be arranged such that if the removal of the access panels and doors while the turbine may be operating causes an unsafe condition, then the access panels and doors are to be provided with interlocks or other means to automatically secure the turbine prior to removal of the access panel.
- v) The enclosure, including enclosure cooling ducting, is to be designed as airtight, as required by 9/7.2i) of this Guide, and capable of withstanding the pulsation pressure that emanates from the gas turbine during operation.
- vi) The enclosure is to be sized to allow for maximum deflection of the mounted equipment without the equipment striking the enclosure.
- vii) Where one enclosure serves two gas turbines, an internal wall is to be provided.
- viii) Where a gas turbine is located inside a gas-tight acoustic enclosure, the internal space of the enclosure is considered to be a Category A machinery space, hence, the separation of this space from the adjoining spaces and fire protection of this space is to be in accordance with the applicable requirements in the *Steel Vessel Rules* and SOLAS 1974, as amended.
- ix) Each enclosure is to form a gas-tight seal at all piping, ducting and electrical connections that penetrate the enclosure walls.
- x) A suitable means of inspection such as a glass inspection window or a CCTV system is to be installed in the enclosure such that it is possible for operators to observe the engine and its major components, including gearbox accessories, intake, piping and instrumentation, during operation looking for evidence of fluid leakage, fire, smoke or other abnormal operating conditions without entering the enclosure.
- xi) The inspection windows may be installed in the enclosure access doors where the door location meets the internal viewing requirements. Where the enclosure is considered a category A machinery space, the windows are to be of the same fire rating as the bulkhead in which they are installed.
- xii) Interior lighting is to be provided in the enclosure to allow a clear view of all components from the inspection windows. Enclosure access doors are to be provided in locations that will allow maintenance personnel easy access to both sides of all major components within the enclosure. Access to the air intake of the engine is to be provided.
- xiii) The enclosure is to be sound and thermally insulated.
- xiv) Thermal and acoustic insulating material is to be provided with protection to minimize the possibility of absorption of oils, grease and moisture.

- xv) Protective metal guards are to be provided to avoid wear or puncture of exposed insulated areas subject to mechanical abrasion.
- xvi) A temperature sensor is to be placed inside and adjacent to each gas turbine engine compartment entry to indicate compartment internal temperature.
- xvii) A placard stating necessary safety precautions to be taken by personnel is to be provided at the engine space access if entrance to the engine compartment is required after gas turbine engine shutdown.
- xviii) A hazard label is to be placed on or adjacent to each access to the enclosure and internal to the enclosure, located so as to be visible upon entry, and is to provide appropriate personnel warnings.
- xix) Each base and enclosure is to be provided with floor drains to prevent the accumulation of fluids. The floor drains are to be situated to negate any effect of base and enclosure installation rake on drainage. Fluid drains are to be arranged so as to prevent migration of fluids to the gas turbine exhaust area and hot section.
- xx) Means are to be provided for drainage of the enclosure space in a safe manner. Where an enclosure is fitted with a water-based fire protection system, a fixed permanently installed bilge system for the enclosure is to be provided.

8 Enclosure Air Intakes and Exhaust System

8.1 General

- i) The design and arrangement of the system is to minimize pressure drop and back pressure, turbulence, noise and ingestion of water or spray.
- ii) The systems are to be designed and supported to prevent stress loading of the flexible connections and expansion joints.
- iii) The design is to also minimize the transfer of vibration to the supporting structure and withstand stresses induced by weight, thermal expansion, engine vibration, working of the vessel and pressure.

- xiii) The systems, including air filters, moisture separators, intake silencers, exhaust mufflers, water traps and valves, are not to impose a pressure drop or back pressure which will exceed the acceptable values as specified in the engine specifications.
- xiv) The internal surface of ducting is to be as smooth as practicable. Strengthening members are to be on the external surface of the duct.
- xv) Where ducts are large enough to permit entry of personnel for inspection and maintenance access, they are to be provided with removable cover plates and grab rods or access hatch.
- xvi) Gas passages are to be free of internal obstruction, except that grab rods and ladder rungs are to be installed for inspection and maintenance.
- xvii) Ducts too small to permit entry of personnel are to be provided with openings and removable cover plates at the ends of horizontally installed sections for cleanout.
- xviii) The systems are to be provided with drains at the low points. Collected drainage is to be led overboard, if environmentally safe and possible, or connected to a drain system.
- xix) The intakes, cooling air and exhaust duct openings are to be located above the waterline and positioned to minimize the probability of raw water entering the air inlet, cooling air and exhaust systems. These are also to be located to minimize the probability of sea spray being entrained in the air flow and carried into air inlets and cooling ducts.
- xx) Air intake, cooling air and exhaust ducts are to be positioned and designed to minimize the probability that exhaust gases from any engine or any other source are drawn into the air inlet or cooling air duct of gas turbine.
- xxi) The exhaust gases outlet from the gas turbine are to be clear of any ventilation system inlets.

8.2 Combustion Air Intake System

8.2.1 General

- i) The air intake system is to consist of all devices from the weather to the front face of the gas turbine, and is to be in accordance with the requirements of this Section and 4-2-3/11.3 and 5C-8-16/10.3 of the *Steel Vessel Rules*.
- ii) The engine manufacturer is to provide the following performance requirements for compressor inlet airflow:
 - Inlet pressure loss (max.), in mm (inches) of H₂O
 - Air compressor inlet flow distortion (max.), in percent. Alternatively, manufacturer is to approve the design of the aerodynamics of intake.
 - Air compressor pre-swirl angle (max.), in degrees
 - Air compressor counter-swirl angle (max.), in degrees
 - Total pressure fluctuation (max.), in mm (inches) of H₂O
 - Turbulence (max.) in percent, where turbulence is defined as the root mean square of the fluctuating pressure level between 0.5 and 700 Hz as measured by a fast response pressure transducer divided by the steady state (average) total pressure
- iii) Each unit of installed equipment requiring combustion air is to have a separately ducted air system from the weather directly to the gas turbine.
- iv) Combustion air shall be ducted from the weather, through a separator system, directly to each propulsion gas turbine.
- v) The design is to be such that the pressure drop in the gas turbine combustion air intake does not exceed that specified by the engine manufacturer.
- vi) Gas turbine intake systems are to be designed to withstand compressor surging, as specified by the gas turbine manufacturer.

- vii) Ducting material for the gas turbine combustion air intake systems is to be corrosion-resistant alloys or stainless steel.
- viii) Fasteners inside duct assemblies exposed to the weather are to be corrosion resistant and to be of material that will prevent a galvanic reaction with the surrounding material.
- ix) A moisture separator, as described below, is to be installed, unless another effective arrangement is approved. The moisture separator elements are to have separation efficiency, as required by the gas turbine engine manufacturers. The elements are to be readily accessible for inspection and easily removed manually for cleaning or replacement.
- x) Each gas turbine engine intake is to consist of louvers or vanes, moisture separator water wash manifold (if applicable to the moisture separator type).

The following items are also to be provided:

- Moisture separator panels, differential pressure safety system to activate alarms and open blow-in doors, intake support structure, drainage and discharge ducting.
- The piping, wiring and fittings associated with the above are to be provided.

- xi) Moisture separator filters are to be provided and are to be accessible for inspection and removal.
- xii) The moisture separator is to have the capability of being cleaned, both manually or by the moisture separator waterwash system.
- xiii) Filter materials are to be fire resistant and of a consistent material density throughout. Removable moisture separator filters are to be enclosed in a rigid, self-contained frame fabricated of corrosion resisting alloys or stainless steel.
- xiv) The moisture separator filter assemblies are to meet or exceed the salt efficiency requirements as specified by the gas turbine manufacturer.
- xv) A fresh water connection for cleaning the separator filter is to be provided to reduce the pressure drop across the filter.
- xvi) Differential pressure indicators for each intake system are to be provided.
- xvii) The intake system is to withstand compressor surging, as specified by the engine manufacturer.
- xviii) Splitters and turning vanes are to be provided as necessary to meet the engine manufacturer's performance requirements for compressor inlet flow as specified.
- xix) Fasteners on the internal side of the intake system, such as nuts and bolts, are to be secured with some type of locking device, such as lock wire or self-locking nuts, so as not to become adrift.
- xx) The intake system is to be fitted with protective foreign object damage (FOD) screens to prevent entrance of foreign objects. The screens are not to impede or limit the blow-in panels from operating.

8.2.2 Anti-icing Systems

- i) When the intake system is to include an anti-icing system that allows the gas turbine to operate during cold weather conditions, the gas turbine manufacturer's requirements governing airflow temperature distortion, distribution and rate of change is to be complied with in the design of the system that introduces thermal energy into the intake.
- ii) The cold weather protection system for the intake and its filtration system is to provide sufficient thermal energy to prevent ice and snow accumulation from occurring across the face of, and within, any weather opening protected by devices such as louvers or the intake's filtration system, so as to preclude pressure drop growth.
- iii) In addition, any filter drain troughs or drainage related mechanisms are to be heated so that these devices continue to function as intended during cold weather operations.

Section 9 Dual Fuel Gas Turbine Propulsion System

- iii) The ventilation system is to be designed in order provide effective air circulation and cooling as specified by the turbine manufacturer but is not to be less than 30 air changes per hour based on the volume of the space.
- iv) The ventilation system is to be always in operation when the gas turbine is in the gas mode as well as during purging operations prior to maintenance. The gas shut-off valve referred to in 2/6.2.1 of this Guide is to close automatically if the required air flow is not established and maintained by the exhaust ventilation systems.
- v) The ventilation system is to be designed in such a way as to prevent the formation of dead spaces

10.3 Installation

Placement of the detectors is critical to the effectiveness of the gas detection system.

The exact location of the gas detectors is to be determined taking into consideration the sensitivity of gas detectors under the prevailing airflow.

Arrangements will be subject to approval for each application based upon a gas dispersion analysis or physical smoke test.

10.4 Periodic Maintenance and Testing

The gas detection systems and the associated emergency shutdown systems are to be tested and maintained to verify their reliability and are to be recalibrated at regular intervals in accordance with the manufacturer's recommendations.

Tests and maintenance procedures are to be documented and kept onboard for the crews' use.

11 Fire Protection and Fire Extinguishing System

11.1 General

Fire protection and extinguishing systems are to comply with the requirements of Part 4, Chapter 7, and Section 5C-8-11 of the *Steel Vessel Rules*, SOLAS Chapter II-2 and the following requirements:

11.2 Fixed Fire Extinguishing Systems

Spaces containing internal combustion machinery, including dual fuel turbines are to comply with 4-7-2/1.3 of the *Steel Vessel Rules*.

11.3 Portable Foam Applicators, Dry Material and Portable Fire Extinguishers

These are to be in compliance with 4-7-2/1.1.2, 4-7-2/1.1.3, 4-7-2/1.1.4, and the Table specified in Section 4-7-2 of the *Steel Vessel Rules*.

11.4 Fixed Local Application Firefighting Systems

Machinery spaces of Category A above 500 m³ (17,657 ft³) in volume are to be provided with an additional water mist system, complying with the requirements specified in 4-7-2/1.11.2 of the *Steel Vessel Rules*.

11.5 Fire Detection System Requirements

The fire detection system is to comply with the following requirements:

- i) Fire protection arrangements for the one or more gas turbine enclosures or machinery spaces are to be integrated with, and capable of, activation individually or at the same time as, those covering the main machinery spaces.
- ii) A fire detection in the gas turbine enclosure is to shut down gas or liquid fuel supply into the enclosure.

12 Piping and Auxiliary Systems

12.1 General

- i) Piping systems serving the gas turbine, such as gas fuel, liquid fuel, lubricating oil, starting air/hydraulic and exhaust gas systems are to be in compliance with 4-2-3/9, 4-6-5/3, 4-6-5/5, 4-6-5/7

- iv) All equipment (heaters, compressors, filters, etc.) for making-up the gas for its use as fuel, the related storage tanks and associated piping is to comply with the requirements in Section 5C-8-5 and 5C-8-16/4 of the *Steel Vessel Rules*.

12.2 Gas Fuel Supply Piping System to Gas Turbine

- i) High pressure gas supply lines up to the gas turbine or spaces containing the gas turbine are to be of all-welded construction and adequately protected against impact through falling objects, etc.
- ii) Gas fuel piping may pass through or extend into other spaces outside the dual fuel gas turbine enclosure or machinery space, provided they fulfill the requirements of 5C-8-16/3.1 of the *Steel Vessel Rules*.
- iii) All gas lines are to be capable of being vented and subsequently purged with nitrogen. All nitrogen connections to gas lines with pressures greater than that of the nitrogen purge system are to employ a double block and vent valve arrangement to mitigate the risk of contamination and overpressurizing the nitrogen system.
- iv) Where reverse flow of gas supply from gas turbine is possible, a check valve with reverse flow protection is to be provided. This check valve is to be located as close to the gas turbine as practical.
- v) If a gas leak occurs, the gas fuel supply should not be restored to that enclosure or machinery space until the leak has been found and repaired.

12.3 Block and Bleed Valve Arrangement

The block and bleed arrangements are to comply with 5C-8-16/3.6 of the *Steel Vessel Rules*.

12.4 Gas Shut-off Valve

- i) A gas shut-off valve for the gas turbine enclosure is to be provided so as to close automatically in

13 Electrical, Automation, Instrumentation and Control Systems

13.1 General

- i) Electrical equipment for the dual fuel turbine gas propulsion system is to comply with the applicable requirements of Part 4, Chapter 8 (in particular Section 4-8-3) and Section 5C-8-10 of the *Steel Vessel Rules*.
- ii) The instrumentation, monitoring and control systems for gas turbine engines are to comply with the applicable requirements of Part 4, Chapter 9 (in particular Section 4-9-7) and 5C-8-16/17 of the *Steel Vessel Rules*, and all associated electrical systems are to comply with the requirements of Section 5C-8-10 of the *Steel Vessel Rules*.

13.2 Electrical Equipment

- i) Electrical equipment which may create an electrical spark, such as magnetic contactors, circuit breakers, motor starters, switchboards, slip rings or commutators, is to be located outside of the dual fuel gas turbine engine enclosure or machinery space containing the gas turbine unless fuel gas piping is in full compliance with Section 5C-8-16 of the *Steel Vessel Rules*.
- ii) All electronic and electrical equipment in the dual fuel gas turbine enclosure, which is intended to be operational after the dual fuel turbine engines have been shut down due to leakage is to be of certified safe type.

13.3 Alarm and Shutdown System

- i) To confirm that the facility to manufacture, fabricate or repair dual fuel gas turbines or its components do have and maintain a quality-control program effectively covering design, procurement, manufacturing and testing, as applicable, and meeting the requirements of a recognized standard applicable to their product.
- ii) To qualify or verify welder's qualifications, welding procedure specifications and corresponding weld procedure qualification records to the extent deemed necessary by the attending Surveyor.
- iii) To verify material certificates/documentations, particularly for materials of piping, main pressure retaining parts of valves, including safety valves that have flanged or threaded ends or other specialty fittings. Witness of material testing where required by the *Steel Vessel Rules*.
- iv) To survey final weldments.
- v) To witness, as far as deemed necessary, weld nondestructive examination tests and to review records of nondestructive examinations.
- vi) To witness pressure and/or proof-load testing of equipment components and as a unit, as applicable and as called for in the fabrication procedures.
- vii) To witness testing of subassemblies and completed units as called for in the fabrication procedures.
- viii) To verify all certified safe systems, motor controllers, consoles and instrumentation and control panels are in compliance with approved drawings.
- ix) To carry out other inspections and to witness the final Factory Acceptance Test (FAT) as agreed upon during prefabrication meeting.

14.3 Surveys During Installation

The following surveys are to be carried out to the satisfaction of the attending Surveyor on the dual fuel gas turbine and associated systems during installation and testing:

- i) Piping systems are to be visually examined and pressure-tested, as required by the Rules. Pressure tests conducted on Class I piping (see 4-6-1/Table 1 of the *Steel Vessel Rules*) systems should preferably be recorded on test charts for the duration of their tests.
- ii) Electrical wiring and connections are to be in accordance with Part 4 of the *Steel Vessel Rules* and checked for continuity and proper workmanship.
- iii) Instrumentation is to be tested to confirm proper operation as per its predetermined set points.
- iv) Pressure relief and safety valves installed on the unit are to be tested.
- v) Control system and shutdowns are to be tested for proper operation.
- vi) The dual fuel gas turbine is to be checked for proper operation in accordance with the ABS approved installation test procedure.

14.4 Surveys During Trials

During the initial gas trials, the dual fuel gas turbine is to be confirmed for its satisfactory operation, including associated controls, alarms and shutdowns. The tests are to be conducted in accordance with ABS approved testing procedure during sea/gas trials. The dual fuel gas turbine is to be run whilst the vessel is underway at sea and the propulsion system operating over its full range of power.

TABLE 1
Monitoring and Safety System Functions
for Dual Fuel Gas Turbine Engines and Supply Systems

<i>Monitored Parameters</i>	<i>Alarm</i>	<i>Automatic Shut-off of the Individual Master Gas Valve and Automatic Activation of the Block and Bleed Valves</i>	<i>Automatic Switching over to Oil Fuel Mode</i>	<i>Enclosure/ Mach. Space Shutdown (see 9/13.3.1)</i>
Gas Turbine High Exhaust Temperature – High	X			
Gas Turbine High Exhaust Temperature – High-High		X		
Gas Turbine Bearing metal chip detector	X			
Gas compressors low lube oil level	X			
Gas fuel leakage detection at 5% LFL or lower	X	X	X	
Incorrect combustion	X	X	X	

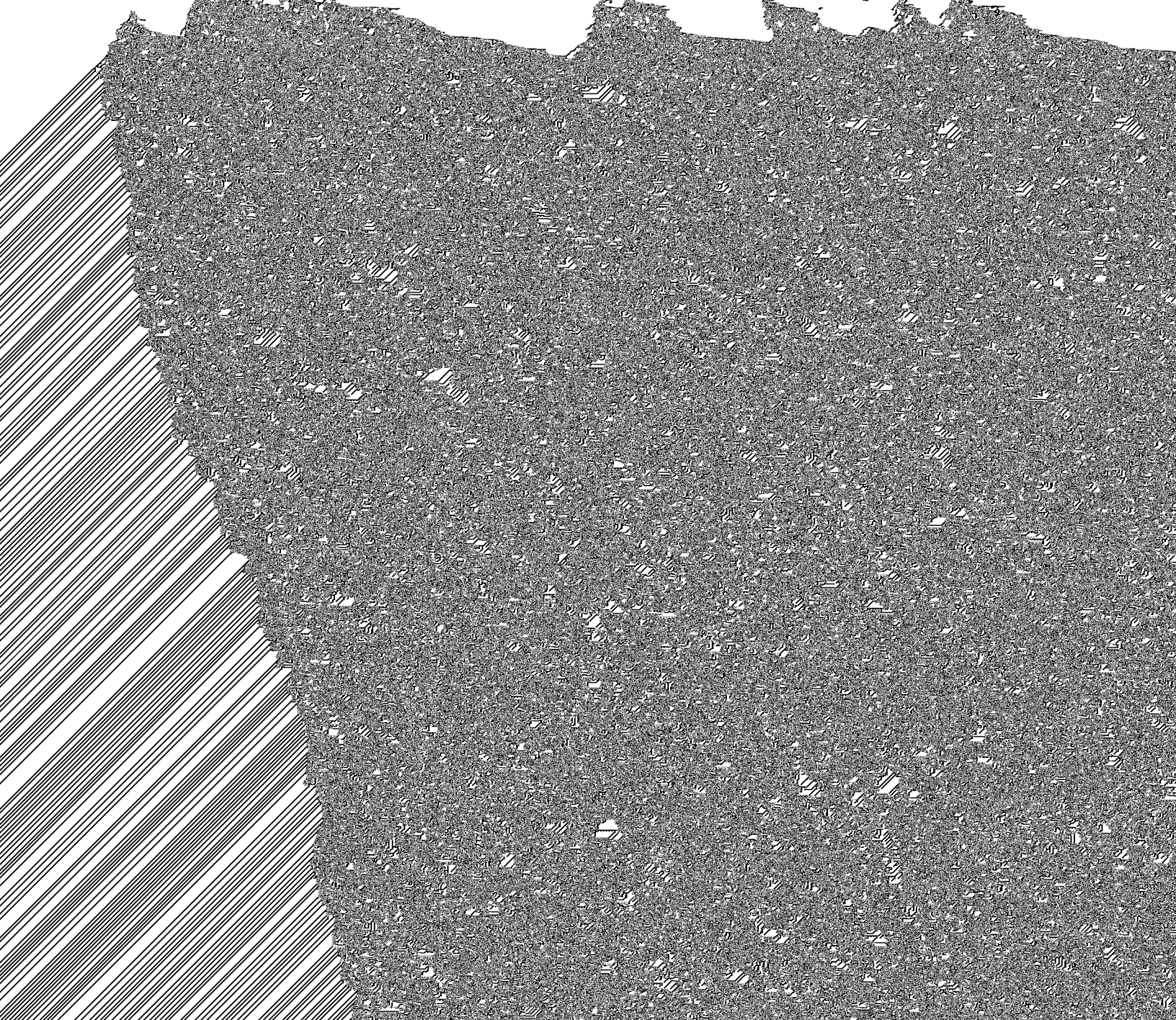


TABLE 2
Certification of Dual Fuel Gas Turbines

This Table has been prepared for guidance only and annotated to agree with the *Steel Vessel Rules*, IMO IGC Code and other IMO requirements. The list is not to be considered exhaustive; should additional equipment not listed be fitted onboard, same will be subject to special consideration for compliance with the *Steel Vessel Rules*, the IGC Code and other IMO requirements. This list is not to be

1.3 Modifications

When it is intended to carry out any modifications to the gas utilization system and associated components, which may affect classification, including substitutions of material differing from that originally installed, the details of such modifications are to be submitted for review. If ABS determines that the modification will affect classification, the affected system or component to be modified will be subject to the review, testing and survey requirements in accordance with this Guide.

2 Survey Intervals

2.1 Annual Survey

An Annual Survey of a gas fueled ship and installed classed systems covered by this Guide is to be carried out within three (3) months before or after each annual anniversary date of the crediting of the previous Special Periodical Survey or original construction date. For gas fueled ships on Continuous Survey, all Continuous Survey requirements for those parts (items) due are generally to be completed each year. The Annual Survey will not be credited and the Certificate of Classification will not be endorsed unless Continuous Survey items that are due or overdue at the time of the Annual Survey are either completed or granted an extension.

2.2 Intermediate Survey

An Intermediate Survey of a gas fueled ship is to be carried out either at or between the second and third Annual Survey after Special Periodical Survey No. 1 and subsequent Special Periodical Surveys.

2.3 Special Periodical Survey

A Special Periodical Survey is to be completed within five years after the date of build or after the crediting date of the previous Special Periodical Survey. The fifth Annual Survey must be credited as a requirement of the Special Periodical Survey. The interval between Special Periodical Surveys may be reduced by the Committee.

The Special Periodical Survey may be commenced at the fourth Annual Survey and be continued with completion by the fifth anniversary date. Where the Special Periodical Survey is commenced prior to the fourth Annual Survey, the entire survey is to be completed within fifteen (15) months if such work is to be credited to the Special Periodical Survey.

A Special Periodical Survey will be credited as of the completion date of the survey but not later than five years from date of build or from the date recorded for the previous Special Periodical Survey. If the Special Periodical Survey is completed within three (3) months prior to the due date, the Special Periodical Survey will be credited to agree with the effective due date. Special consideration may be given to Special Periodical Survey requirements in unusual cases. Consideration may be given for extensions of Rule-required Special Periodical Surveys under exceptional circumstances.

2.4 Continuous Survey Program

At the request of the Owner, and upon approval of the proposed arrangements, a system of Continuous Surveys may be undertaken, whereby the Special Periodical Survey requirements are carried out in regular rotation to complete all of the requirements of the particular Special Periodical Survey within a five-year period. The proposed arrangements are to provide for survey of approximately 20% of the total number of survey items during each year of the five-year period. Reasonable alternate arrangements may be considered as recommended by the manufacturer.

Generally each part (item) surveyed becomes due again for survey approximately five (5) years from the date of the survey and the due parts (items) are generally to be completed each year. For Continuous Surveys, a suitable notation will be entered in the *Record* and the date of the completion of the cycle published.

ABS may withdraw its approval for Continuous Survey if the Surveyor's recommendations are not complied with.

2.5 Survey Based upon Preventative Maintenance Techniques

A properly conducted approved program of preventative-maintenance/condition-monitoring plan may be credited as satisfying the requirements of Special Continuous Survey. This plan must be in accordance with Appendix 7-A-14 "Guide for Survey Based on Preventative Maintenance Techniques" of the ABS *Rules for Survey After Construction (Part 7)*.

3 Surveys

3.1 Annual surveys

3.1.1 General

The following should be carried out during each Annual Survey of the Gas Fuel Storage, Fuel Bunkering System, Fuel Gas Supply System and GAS Utilization Systems unless all the requirements of Subsection 10/4 of this Guide are complied with:

- i) *General.* The logbooks are to be examined with regard to correct functioning of the fuel gas detection systems, fuel gas supply/gas systems, etc. The hours per day of the prime movers, re-liquefaction plant, GCU, as applicable, or the boil-off rate are to be considered together with historical gas detection records.
- ii) *Operating and Maintenance Instruction Manual.* The approved instructions and manuals covering the operations, safety and maintenance requirements and occupational health hazards relevant to gas fuel storage, fuel bunkering, fuel gas supply, gas utilization units and associated systems and use of gas as fuel, are to be confirmed as being aboard the vessel.
- iii) *Instrumentation and Safety Systems.* Gas detection equipment in all compartments containing gas fuel storage, fuel bunkering, fuel gas supply or gas utilization equipment or components or associated systems, including indicators and alarms, is to be confirmed in satisfactory operating conditions. Verification of installed interlocks in the gas detection system is to be verified in working condition. Any piping of the gas detection system is to be visually examined for corrosion and damage and the integrity of the line between suction points and analyzing units is to be confirmed as far as possible. Recalibration of the gas detection systems should be verified in accordance with the manufacturers' recommendations.
- iv) *Fuel Gas Handling Piping and Machinery.* All piping, hoses, emergency shut-down valves, remote operating valves, machinery and equipment for gas fuel storage, fuel bunkering, fuel gas supply and gas utilization such as venting, compressing, refrigerating, liquefying, heating, cooling or otherwise handling the liquefied gas or vapor is to be examined, as far as possible. Stopping of pumps and compressors upon emergency shut-down of the system is to be confirmed.
- v) *Ventilating System.* Examination of the ventilation system is to be made for all spaces containing gas fuel storage, fuel bunkering, fuel gas supply and gas utilization units or components or associated systems, including air locks, pump rooms, compressor rooms, fuel preparation rooms, gas valve rooms, control rooms and spaces containing gas burning equipment. All required portable ventilating equipment is to be examined. Provision of spares for mechanical ventilation fans recommended by manufacturer is to be confirmed. Where alarms, such as differential pressure and loss of pressure alarms, are fitted, these should be operationally tested as far as practicable.
- vi) *Drip Trays.* Portable and fixed drip trays and insulation for the protection of the deck in the event of gas leakage are to be examined
- vii) *Sealing Arrangements.* Sealing arrangements in way of openings and bulkhead penetrations for the gas fuel system are to be examined
- viii) *Fire Protection and Fire Extinguishing Equipment.* The required fire protection and fire extinguishing system contained in areas and spaces where gas fuel storage, fuel bunkering, fuel gas supply and gas utilization units are fitted are to be examined and operationally tested, in so far as practicable.

- ix) *Electrical Equipment.* Electrical equipment in gas-dangerous spaces or zones is to be examined for continued suitability for their intended service and installation area.
- x) *Electrical Bonding.* Electrical bonding arrangements, including bonding straps where fitted, of the piping systems for gas utilization systems located within bunker tanks, ballast tanks, pipe tunnels, cofferdams and void spaces bounding bunker tanks are to be examined.

3.1.2 Gas Fueled Ship (GFS)

The following are to be examined, so far as applicable during each Annual Survey. Insulation need not be removed, but any deterioration or evidence of dampness is to be investigated:

3.1.2(a) Gas Fuel Storage

- i) External examination of the bunker tanks and secondary barrier or gas fuel storage room.
- ii) External examination of main tank and relief valves.
- iii) Testing of tank monitoring system.
- iv) Examination and testing of installed bilge alarms and means of drainage of the compartment.
- v) Testing of the remote and local closing of the installed Main Tank Valve.

3.1.2(b) Fuel Bunkering System

- i) Examination of all bunker stations and the fuel bunkering system during working condition.
- ii) External examination of bunker manifolds.
- iii) External examination of manifold valves and manifold ESD valves.
- iv) Testing of fuel bunkering control, monitoring and shut-down systems as far as practicable, or verification of set-points in accordance with approved test program.
- v) Testing of bunker lines inert and gas freeing system.

3.1.2(c) Fuel Gas Supply System

- i) The fuel gas supply system during working condition.
- ii) External examination of all pressure vessels, heat exchangers, pumps, compressors, filters etc. for making-up the gas for its use as fuel in the system.
- iii) External examination of relief valves, if fitted.
- iv) Location of applicable warning notices.
- v) Where double wall fuel gas piping is provided, means for detecting any leakage should be tested.
- vi) The fuel gas supply system component spares as recommended by the manufacturer.
- vii) Testing of control, monitoring and shut-down systems as far as practicable, or verification of set-points in accordance with approved test program.

3.1.3 Re-Liquefaction Plant (RELIQ)

The following are to be examined, during each Annual Survey so far as applicable. Insulation need not be removed, but any deterioration or evidence of dampness is to be investigated:

- i) The plant during working condition.
- ii) External examination of all pressure vessels in the system
- iii) External examination of relief valves, if fitted.
- iv) The re-liquefaction/refrigeration plant spare gears as recommended by the manufacturer.

- v) Testing of control, monitoring and shut-down systems as far as practicable, or verification of set-points in accordance with approved test program.
 - vi) Examination and testing of installed bilge alarms and means of drainage of the compartment.
- 3.1.4 Gas Combustion Unit (GCU)
- The following are to be examined, so far as applicable during each Annual Survey:
- i) The Gas Burning Unit during working condition.
 - ii) External examination of all pressure vessels in the system.
 - iii) Testing of burner management control system, and flame scanner and installed interlocks.
 - iv) External examination of the combustion chamber and associated refractory
 - v) External examination of exhaust gas piping/ducts.
 - vi) Testing of the remote and local closing of the installed Master Tank Valve and Master Gas Valve for the GCU compartment.
- 3.1.5 Dual Fuel Diesel Engine Power Plant (DFD)
- In addition to the Annual Survey requirements for liquid fuel diesel engines, the following are to be examined, during each Annual Survey so far as applicable. Insulation need not be removed, but any deterioration or evidence of dampness is to be investigated:
- i) External examination of any pressure vessels, heat exchangers, compressors, filters etc. for making-up the gas for its use as fuel.
 - ii) Operational test, as far as practicable of the power management system for the emergency shutdown of the dual fuel engine compartments and testing of the automatic shut-off of gas fuel supply.
 - iii) Where double wall fuel gas piping is provided, means for detecting any leakage should be tested.
 - iv) Verification of redundancy and testing of gas detection system in engine rooms together with any interlocks.
 - v) Testing of alarm for the access doors to the engine rooms.
 - vi) Testing of the remote and local closing of the installed Main Tank Valve and Master Gas Valve for each engine compartment.
- 3.1.6 Single Gas Fuel Engine Power Plant (SGF)
- In addition to the Annual Survey requirements for liquid fuel diesel engines, the following are to be examined, during each Annual Survey so far as applicable. Insulation need not be removed, but any deterioration or evidence of dampness is to be investigated:
- i) External examination of any pressure vessels, heat exchangers, compressors, filters etc. for making-up the gas for its use as fuel.
 - ii) Operational test, as far as practicable of the power management system for the emergency shutdown of the single fuel engine compartments and testing of the automatic shut-off of gas fuel supply.
 - iii) Where double wall fuel gas piping is provided, means for detecting any leakage should be tested.
 - iv) Verification of redundancy and testing of gas detection system in engine rooms together with any interlocks.
 - v) Testing of alarm for the access doors to the engine rooms.
 - vi) Testing of the remote and local closing of the installed Main Tank Valve and Master Gas Valve for each engine compartment.

3.1.7 Dual Fuel Gas Turbine Power Plant (DFGT)

Gas turbines are to be opened and maintained in accordance with manufacturer's recommendations, as appropriate for the actual applicable operating conditions

Owners are to submit for approval maintenance schedules for the type of gas turbine in service, specifying proposed intervals for combustion checks, hot-gas-path examinations and major examinations, see also Subsection 9/4 of this Guide. Upon approval, the schedules will become part of the Special Periodical Survey – Machinery records; see 10/2.4 and 10/2.5 of this Guide.

At each Annual Survey, the attending Surveyor should examine, as far as applicable, the following:

- i) Verify compliance with the approved maintenance schedule and manufacturers recommendations, taken into consideration the “in-service” records for the unit and applicable hours of running time for each type of fuel.

- iii) *Pressure Vessels.* Internal examination and thickness measurement of the fitted pressure vessels in the fuel gas storage, fuel gas supply and gas utilization units as deemed necessary by the Surveyor.
- iv) *Electrical Equipment.* Examination and testing of electrical equipment. This examination is to include the physical condition of electrical cables and supports, intrinsically safe, explosion proof, or increased safety features of electrical equipment, functional testing of pressurized equipment and associated alarms, testing systems for de-energizing electrical equipment which is not certified for use in gas-hazardous areas, and insulation resistance readings of circuits. Where a proper record of testing is maintained, consideration may be given to accepting recent readings.
- v) *Gas Combustion Unit.* Internal examination of the gas combustion unit, combustion chamber and associated refractory.
- vi) *Gas Turbines.* For dual fuel gas turbine units in continuous service, at least one hot-gas-path examination is to be scheduled each survey cycle and is to include an examination of turbine rotors, fixed blading, combustors, inlet casings (including demisters and filters), exhaust casing (including regenerator), air control valves and protective apparatus.

Other parts of the dual fuel gas turbine and associated equipment, as may be deemed necessary by the attending Surveyor, are to be opened up for examination

Where units are arranged such that the unit is removed from the vessel in accordance with the approved plans and the maker's recommendations, and dismantled at another facility, the internal examination may be carried out at the facility in the presence of the Surveyor. Upon reassembly/reinstallation, all fuel lines, lube oil piping, the unit itself and exhaust system are to be checked under full speed and its range of operational conditions for leakage.

4 Alternative Surveys

ABS is at all times ready to consider alternative survey arrangements which can be shown, through either satisfactory service experience or a systematic analysis based on sound engineering principles, to meet the overall safety, serviceability and standards of the *Steel Vessel Rules* and this Guide. Alternative to requirements particularly contained in Subsection 10/3 of this Guide, an In-Service Inspection Plan (ISIP) may be developed by the Owner and submitted to the Assistant Chief Surveyor's office for review. Stamped copy of the ISIP placed onboard the gas fueled ship is to be referenced during all of the scheduled surveys.

4.1 Inspection Plan

The ISIP is to utilize the technical information available in the Operating and Maintenance Instruction Manuals that have been reviewed by ABS. The ISIP may contain, but not be limited to the following:

- Maintenance records for gas fuel storage, fuel bunkering, fuel gas supply and gas utilization equipment.
- Operational Procedures of all gas fuel storage, fuel bunkering, fuel gas supply and gas utilization equipment.
- Details of the Continuous Survey Program.
- Details of any Preventative Maintenance Program including manufacturer recommendations for overhaul and condition monitoring.
- Records of any Risk Based evaluations.
- Details of maintenance agreements with sub-contractors.

A note in the vessel's record will denote the approved survey plan and associated alternative survey requirements.

4.2 Application

Based on the information contained in the ISIP and any possible review of records of sister vessels in the same fleet, ABS may consider special arrangements such as alternative survey techniques and/or frequency of surveys, provided this is not less effective. These arrangements may also require the approval of the flag Administration, in which case this must be included in the approved ISIP. A note in the vessel's record will denote the approved survey plan and associated alternative survey requirements contained. The ISIP will no longer be valid if the vessel is sold or otherwise changes owner or management.

