

TÜRK LOYDU



RULES FOR THE CLASSIFICATION OF NAVAL SHIPS

Chapter 113 – Air Independent Power Systems for Underwater Use January 2022

This latest edition incorporates all rule changes. The latest revisions are shown with a vertical line. The section title is framed if the section is revised completely. Changes after the publication of the rule are written in red colour.

Unless otherwise specified, these Rules apply to ships for which the date of contract for construction as defined in TL- PR 29 is on or after 1st of January 2022. New rules or amendments entering into force after the date of contract for construction are to be applied if required by those rules. See Rule Change Notices on TL website for details.

"General Conditions" of the respective latest edition will be applicable (see Rules for Classification and Surveys).

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A. Scope of Application

1. These Rules apply to the use of Air Independent Power (AIP) systems permanently installed on submarines or remotely operated underwater vehicles (ROVs) according to Chapter 111 and 112. They describe the technical requirements for the safe operation of these systems.

2. In the case of AIP systems which are used as the sole means of propulsion, for the emergency electrical supply or for the supply of essential consumers in accordance with the TL Rules, the additional requirements will be determined within the scope of an individual examination.

3. Designs which deviate from these Rules or from the applicable Rules may be approved if they are examined by TL for suitability and then approved as being equivalent.

4. For submarines or ROVs with AIP systems conforming to these Rules and having a rated output greater than or equal to 10 % of the rated output of the machinery installation the Class Notation **AIP-xxx** will be assigned. The wild-card symbol "xxx" designates the percentage share of the AIP system in relation to the rated output of the machinery installation. For AIP systems having a rated output lower than 10 % of the rated output of the machinery installation the Class Notation **with AIP** will be assigned.

B. Applicable Rules

1. Rules for Classification and Construction

In addition to these Rules, Chapter 111 and 112 and the following Rules for Classification and Construction shall apply, if applicable:

Chapter 102 – Hull Structures and Ship Equipment
 Chapter 104 – Propulsion Plants
 Chapter 105 – Electrical Installations
 Chapter 106 – Automation
 Chapter 107 – Ship Operation Installations and Auxiliary Systems

Here the following Sections of Chapter 107 apply in particular:

Section 1 - General Rules and Instructions
 Section 7 - Storage of Liquid Fuels, Lubricating and Hydraulic Oils as well as Oil Residues
 Section 8 - Piping Systems, Valves and Pumps
 Section 9 - Fire Protection and Fire Extinguishing Equipment
 Section 16 - Pressure Vessels
 Section 17 - Oil Firing Equipment

2. Other rules

National and international regulations and standards shall be observed, if applicable.

C. Definitions

1. Air Independent Power (AIP) system

An AIP system in terms of these Guidelines can comprise the following components:

- The power generator e.g. fuel cell stacks, internal combustion engine, stirling engine, steam generator etc.
- Arrangements for the transfer and storage of fuel, including the necessary auxiliary equipment (e.g. heating / cooling)
- Arrangements for fuel distribution
- Arrangements for fuel conditioning, including any reformer systems, gas humidifiers etc.
- Installation spaces, including the ventilation systems
- Conditioning and storage of the oxidants (e.g. oxygen)
- Arrangements for the conditioning of residual gas and exhaust gas
- Cooling systems

- Interconnections between the systems
- Safety, regulating and monitoring equipment
- Electrical inverter systems
- Other auxiliary systems
- Other energy converters integrated into the system, e.g. gas turbines in systems with high-temperature fuel cells

The battery system of the submarines or ROVs is not part of the AIP system.

2. Alarm System

System for generating an alarm when the upper or lower limiting values are transgressed. There is no automatic intervention in the system. An energy converter is the subsystem of an AIP converting chemical energy directly to electrical power (fuel cell stack) or to mechanical energy (internal combustion engine, stirling engine, turbine etc.)

3. Energy Converter

An energy converter is the subsystem of an AIP converting chemical energy directly to electrical power (fuel cell stack) or to mechanical energy (internal combustion engine, stirling engine, turbine etc.)

4. Fuel Cell

A fuel cell is a source of electrical power in which the chemical energy of a fuel is converted directly into electrical energy by electrochemical oxidation (also known as "cold combustion").

5. Fuel cell stack

A fuel cell stack (FC stack) is a unit consisting of several fuel cells that are electrically connected in series, with internal interconnections for electricity and gas/liquid. An FC stack in the terms of these Guidelines also includes the pipe connection fittings as well as the connections required to supply the electrical energy.

6. Hazardous areas (Ex zones)

These are areas in which the accumulation of flammable gases or vapours in a hazardous concentration or quantity may be expected. Depending on the probability of an explosive atmosphere, hazardous areas are classed as explosion zone 0, 1 or 2 according to Section 7.

7. Protective devices

Protective devices detect critical deviations from limit values and prevent an immediate risk to persons, ship or machinery. In the event of a failure, protective devices transfer the system into a safe state and prevent uncontrolled restarting.

8. Protective systems

A protective system consists of the grouping of several protective devices to form a functional unit.

9. Safe areas

Safe areas are the zones outside of the hazardous areas of a ship.

D. Environmental Conditions

In the selection, design and arrangement of all components of AIP systems on submarines or ROVs, the environmental conditions described in the TL Rules, Chapter 111 – Section 3, B. or Chapter 112 – Section 3, B. shall be applied.

E. Fuels

1. Fuels in terms of these Rules are the fuels kept in the storage tanks of the AIP system as well as the fuels available after conditioning or distribution.

2. With the corresponding conditioning through the reforming process, AIP systems can be supplied both with conventional marine fuels (flashpoint above 60 °C) and with fuels which have a flashpoint below 60 °C.

The latter fuel types include, for example, methanol, ethanol, liquefied gases such as LPG, the cryogenic liquefied gases LNG and LH2, as well as pressurized gases such as CNG, compressed hydrogen or propane.

3. For the use of fuels with a flashpoint of 60 °C or lower, the technical requirements specified in these Guidelines shall apply. Additional requirements may be stipulated by TL. Furthermore, the consent of the Naval Authority is required.

4. For the use of fuels with a flashpoint above 60 °C, the requirements specified in the TL Rules, Chapter 107 – Ship Operation Installation and Auxiliary Systems, Section 7 and 8, shall apply.

F. Documents to be Submitted for Approval

1. General

The technical documents shall permit an assessment of the compliance of the system and its components with the applicable requirements of these Rules and of other rules that must be met. Insofar as needed for the assessment, the documents shall cover the design, production and functional principles, and shall permit a check that actual construction is in compliance with the documentation.

Once the documents submitted have been approved, they shall be binding. Any subsequent modifications require TL approval prior to implementation.

2. Safety concept

It shall be demonstrated that

- the AIP systems function safely when used for their intended purpose including the maintenance activities
- malfunctions can be prevented with the aid of the monitoring, alarm and protective devices
- dangerous operational situations which according to general experience can arise, even though the time of occurrence cannot

be predicted (e.g. critical deviations from limit values), and/or which occur as a result of possible negligence (e.g. foreseeable misuse) are brought under control

- the effects of damage are limited by appropriate precautionary measures

3. Safety functions

The documents submitted must show what technical safety measures or solutions are effective for the operational situations stated under 2. In addition, it shall be verified that the safety measures were selected according to the following sequence of the criteria:

- directly acting safety functions
- indirectly acting safety functions
- organizational safety precautions

4. Documents

The following documents shall be submitted in triplicate. Before production of the AIP system commences:

- description of the process and function of the AIP system
- piping and instrumentation diagrams, with block circuit diagrams of the overall system, including parts lists or equipment lists
- technical documents of the components, including the fuel cell stacks themselves (descriptions, specifications, verification of suitability according to existing standards and rules, approvals and inspection certificates)
- electrical circuit diagrams, including the circuit diagrams of the alarm system and the protective system
- automation concept
- fire extinguishing concept

- plans of the hazardous areas (Ex zones)
- safety and emergency concept, including a safety analysis according to recognized procedures, e.g. fault tree analysis, see F.2. and F.3.

Before the trials according to Section 10:

- operation manual
- trials programme

G. Testing

1. General

1.1 AIP systems are subject to the construction supervision and acceptance testing by tL. Compliance with the approved documents, the workmanship, the suitability of the material and the documentation of the material characteristics as well as conformance with the specification are checked.

1.2 TL reserves the right to extend the scope of the tests, and also to subject to testing those parts which are not explicitly to be tested according to the Rules. For parts produced in series, the prescribed tests may be replaced by other tests agreed with TL.

2. Tests

The testing of an AIP system by TL comprises the following steps:

- evaluation of the technical concept
- examination of the system documentation, the technical documents for the components subject to mandatory testing, and the technical documents of the alarm and protective systems
- manufacturing tests, pressure tests and – if applicable
- functional tests of parts and components

- factory test of control, regulating and protective devices, and of protective systems, at the manufacturer
- functional test and completeness check of the alarm and protective systems
- functional test and acceptance test of the overall system, including pressure and tightness tests and completeness checks, see Section 10
- determination of the periodical tests, insofar as these are not stipulated by the TL Classification Rules

On successful execution of the above-mentioned test steps, the proper construction and workmanship of the system in accordance with the provisions of these Rules certified, and the Class Notation as given in Section 1, A.4. is assigned.

3. Pressure and tightness test

3.1 The piping systems and components shall be subjected to a hydrostatic pressure test with a test pressure equal to 1,5 times the maximum working pressure as well as a tightness test with a test pressure equal to 0,9 times the maximum allowable working overpressure.

3.2 The shut-off valves must be tested additionally for tightness with 1,1 times the maximum allowable working overpressure.

3.3 A deviating procedure is only permissible if this is necessary for technical reasons and if it has been examined and approved by TL.

H. Power supply of Essential Consumers

If the AIP system is used to supply essential consumers as per TL Rules, Chapter 105 – Electrical Installations, Section 1, B.2., B.3. and B.4., then verification of adequate reliability and fail-safety of the AIP system shall be provided. The scope and type of the required verification is specified in each individual case by TL.

I. Installation

1. AIP systems shall be located in separate spaces. Installation in conventional machinery spaces is not permitted.

The requirement for a separate space can also be met by a suitable form of enclosure for the components transferring the fuel. In such a case, installation in conventional machinery spaces is admissible.

2. Spaces in which fuel storage tanks are located shall be separated from conventional machinery spaces and the other parts of the AIP system.

3. Spaces in which components of the AIP system are installed shall be equipped with a mechanical ventilation system or other suitable ventilation devices of the extraction type as per Section 5. The spaces shall be monitored by gas detection systems as per Section 8, C. Special attention shall be paid to areas with a low rate of air circulation.

Alternative constructions approved by TL as being equivalent are permissible.

BÖLÜM 2**MATERIALS**

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A. General Requirements

The materials shall be suitable for the intended application and shall comply with recognized standards. Their suitability shall be proven to **TL**. The use of flammable materials is not permitted. Exceptions may be approved by **TL** if they are not avoidable for technical reasons. Section 4, B.1. shall be observed.

The **TL** Rules, Chapter 2, Materials, shall be observed.

B. Approved Materials and Material Tests

For pressure vessels, piping, valves and pumps, the following **TL** Rules, Chapter 107 – Ship Operation Installations and Auxiliary Systems shall apply:

- Section 7 – Storage of Liquid Fuels, Lubricating and Hydraulic Oils as well as Oil Residues
- Section 8 – Piping Systems, Valves and Pumps
- Section 15 – Auxiliary Steam Boilers
- Section 16 – Pressure Vessels

Pipes for flammable liquids or gases shall be constructed of suitable metallic materials. The use of other materials requires the consent of **TL**.

SECTION 3**FUEL SYSTEMS**

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A. Fuel Transfer System

1. The fuel transfer systems include all components needed for filling the fuel tanks/containers. The connections to exchangeable tanks/containers shall be regarded as part of the fuel storage system.

Fuel transfer systems shall be permanently installed, completely separated from other pipeline systems, and clearly marked.

2. The bunkering station and fuel transfer pipes shall be provided with shut-off valves located directly at the transfer point and directly before the distribution manifold to the fuel tanks. The shut-off valves shall be designed in a way that they can be closed manually and by remote control. The position of the shut-off valve shall be indicated locally and in the control room.

Remote-controlled valves and the position indicator in the control room are not required in the following cases:

- fuel transfer systems with pipes up to 10 m in length, if the nominal diameter is less than or equal to 12 mm
- systems where a suitable non-return valve is integrated into the pipe at the fuel transfer point

3. A suitable fire extinguishing device shall be provided in the vicinity of the bunkering station.

4. If the fuel transfer system is installed in a safe area according to Section 1, C.8., then measures shall be taken to ensure that the fuel transfer pipe can be gas-freed and separated from the rest of the AIP system by a valve arrangement according to Section 9, D. after use. Equivalent alternative constructions approved by **TL** are permissible.

Openings of blow-off pipes for gas-freeing shall be arranged at points where no sources of ignition exist.

5. During fuel transfer the requirements of zone 1 as per Section 7 shall apply for the immediate vicinity of the bunkering station. The immediate vicinity is defined as the space within a spherical radius of 3 m

around the transfer connection. A reduction of this distance is only permissible with the approval of **TL**.

6. Entrances, ventilation openings and openings leading to accommodation and service spaces, machinery spaces, and control rooms shall be located outside hazardous areas. They shall not face the bunkering station.

7. Openings to spaces which are located up to 10 m away from the transfer connection shall be kept closed during fuel transfer. Appropriate warning notices shall be displayed.

B. Fuel Storage

1. Fuel shall be stored in suitable tanks or containers. Tanks/containers shall be secured against the ship movements occurring during operation at sea. Proof of the suitability of the tanks/containers and their securing arrangements shall be submitted to **TL**.

2. The installation spaces for tanks/containers shall be located outside of accommodation, service and machinery spaces and of control rooms, and shall be separated from such spaces by gastight bulkheads. If the installation space is adjacent to a space with potential fire load, separation by means of an A-60 bulkhead is required. Tanks, which are part of the ship structure, shall be separated from other spaces by means of cofferdams.

If it is necessary to deviate from this provision the approval of **TL** is required.

3. Entrances, openings and ventilation openings to accommodation, service and machinery spaces and to control rooms shall be arranged at a distance of at least 3 m from the openings of the installation space.

If it is necessary to deviate from this provision the approval of **TL** is required.

4. The ventilation and blow-off pipes of the tanks shall be so arranged that the exhaust vapours and gases can be discharged without any danger. Up to a

spherical radius of 3 m around the outlet opening, there shall be no sources of ignition or openings which lead to spaces containing sources of ignition.

Technically equivalent solutions approved by TL are permissible, if it is not possible to vent vapours and gases to the sea or open air.

5. Fuel tanks intended for liquefied and pressurized gases and subjected to overpressure shall be protected against inadmissible temperature increases resulting from a fire in the vicinity. Fire loads are not permissible within the installation space. The installation space shall be protected against inadmissible heating in the event of fire. e.g. through A-60 fire insulation.

If it is necessary to deviate from this provision the approval of TL is required.

C. Fuel Conditioning

1. General

1.1 All components for conditioning the fuel - such as preheaters, compressors, filters, reformers etc. - shall be located in a closed space or a suitable enclosure. This space or enclosure shall be ventilated according to Section 5 and shall be equipped with a gas detection system according to Section 8, C. and Section 9.

1.2 The installation spaces of the fuel conditioning system shall be separated from the spaces used for storage of the fuel. Doors between the spaces used for fuel storage and those used for fuel conditioning are not permitted.

1.3 In the pipes to the fuel conditioning system, remote-controlled shut-offs, which can be closed from outside the spaces, shall be arranged at the bulkheads.

1.4 The installation space shall be situated outside of accommodation, service and machinery spaces and control rooms, and shall be separated from such spaces by means of a cofferdam or an A-60

bulkhead. Installation in a conventional machinery space is admissible, on condition that a suitable enclosure is provided.

1.5 Entrances, openings and ventilation openings to accommodation, service and machinery spaces and to control rooms shall be arranged at a distance of at least 3 m from the openings of the installation space used for fuel conditioning, and shall not face them. If it is necessary to deviate from this provision, the approval of TL is required

2. Requirements for fuel conditioning

2.1 Compressors and pressure reduction devices

2.1.1 It shall be possible to switch off the compressors from a permanently accessible point outside the installation space. In addition, the compressor shall be stopped automatically if the suction pressure is too low. The compressor shall not be restarted automatically before a manual reset has been carried out.

2.1.2 Positive displacement compressors shall be fitted with relief valves routed into the suction line of the compressors. The relief valves shall be so dimensioned that, with the discharge of the compressor in the closed position, the maximum allowable working pressure is not exceeded by more than 10 %.

2.1.3 Pressure reduction devices shall be so designed that failure of a pressure reduction valve cannot endanger the downstream components. In particular, the pipes downstream of the pressure reducer shall be protected by safety valves or shall be designed to a pressure rating corresponding to the maximum allowable working pressure that is permissible before the pressure reducer.

2.2 Evaporators

2.2.1 Heating media for liquefied-gas evaporators or gas preheaters that are routed back into spaces located outside the area of the gas treatment plant shall

be passed through degassing containers which are located within the hazardous area.

2.2.2 A gas detection and alarm system shall be provided within the degassing container.

2.2.3 The outlet opening of the vent pipe of the degassing container shall be located in a safe area and provided with an approved flame arrester.

2.3 Reformer Systems

2.3.1 General

2.3.1.1 Reformer systems shall be designed for automatic operation and equipped with all the indicating and control facilities required for assessment and control of the process.

2.3.1.2 The chemical processes taking place within the unit shall be monitored, see Section 8, C.3.

2.3.1.3 If limit values determined for the control process are exceeded, the unit must be switched off and interlocked by an independent protective device.

2.3.1.4 It shall be possible to switch off the reformer unit from a permanently accessible point outside the installation space.

2.3.1.5 If high surface temperatures may occur, the corresponding insulation or contact protection shall be provided.

2.3.2 Firing equipment

2.3.2.1 For fuels in terms of these Guidelines, the TL Rules, Chapter 107 – Ship Operation Installations and Auxiliary Systems, Section 17 shall be applied as appropriate

2.3.2.2 Firing equipment in reformer systems shall be designed for automatic operation. Manual operation (even for emergencies) is not permissible.

2.3.2.3 The firing equipment shall be equipped with a type-tested burner control box and flame monitoring

devices. Reliable operation of the flame monitoring devices shall be verified for the corresponding type of fuel and mode of combustion.

2.3.2.4 After the firing equipment has been switched off, the combustion chamber and the exhaust gas system shall be purged with air or an inerting medium.

2.3.2.5 Depending on the type of fuel and the burner, TL may define additional requirements for the firing equipment.

2.3.2.6 The use of gaskets and insulating materials which contain asbestos is not permissible.

2.3.3 Catalytic converters

Catalytic converters in reformer units shall comply with the TL Construction Rules in regard of the environmental conditions to be considered, especially the requirements related to vibration loading. The TL Rules, Chapter 102 – Hull Structures and Ship Equipment, Section 1 shall apply.

2.3.4 Gas purification

For installations as per Section 1, A.2., the gas purity required for the operation of the energy converter shall be monitored by suitable methods. If the determined limit values are exceeded, an alarm shall be generated or the system shall be switched off.

If this requirement is not met for installations as per Section 1, A.1., verification shall be provided that no additional hazard can occur through inadmissible impurities.

2.3.5 Exhaust gases

The exhaust gases arising during the reforming process shall be removed safely from the submarine or ROV. The discharge should have adequate distance from openings of the submarine or ROV.

Equivalent technical solutions must be approved by TL.

2.3.6 Residual gases

The recirculation of fuel (residual gas) from the energy converter to the reformer is permissible. The recirculation shall be protected by an automatic shutoff valve as per Section 9, D.

D. Fuel Distribution**1. General**

1.1 Fuel pipes shall be independent of other piping systems. Use for other media than fuel has to be prevented. Through their arrangement, it shall be ensured that they are protected against damage.

1.2 The fuel pipes between the supply tanks, the fuel conditioning system and the machinery space must be as short as possible.

1.3 Fuel pipes shall not be routed through safe areas, such as accommodation and service spaces or control rooms. If, in exceptional cases, fuel pipes have to be routed through a safe area, they shall be constructed either as a double-wall piping system or as a pipe within the ventilation duct, see Section 5.

1.4 Fuel pipes in hazardous areas can be arranged without a double pipe or outside of a ventilation duct, if they are located in a space/area ventilated according to Section 5 or in an enclosed housing which is adequately ventilated and monitored, and if the requirements for explosion protection as per Section 7 are met.

Equivalent technical solutions other than ventilation must be approved by **TL**.

2. Pipes for gaseous fuels**2.1 Direct connections of pipes**

2.1.1 Pipes shall be connected by butt welding with full penetration.

2.1.2 Screw fittings according to standards which are approved by **TL** for this application can be used for pipes with external diameters of 25 mm or less.

2.1.3 Flanged joints shall only be used at locations where this is unavoidable. Only flange types approved by **TL** for that particular application shall be used.

2.2 Flanged joints

2.2.1 If flanged joints cannot be avoided in installation spaces, they are only permissible within ventilated spaces and in areas in which ventilation of the extraction type is provided, see Section 5.

2.2.2 Flanged joints are permissible at the bunkering station.

2.2.3 With regard to type, make and quality assurance, flanges shall comply with recognized standards.

2.3 Inerting

It shall be possible to inert and gas-free the fuel pipes.

SECTION 4

ENERGY CONVERTER and ASSOCIATED COMPONENTS

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A. Installation

1. All parts of the energy converter and the directly associated components containing fuel during normal operation shall be arranged in an enclosed space or suitable enclosure. This space/enclosure shall be ventilated according to Section 5 and equipped with a gas detection system according to Section 8, C.2. The gas detection system shall be independent from the gas detection system of the submarine.

Alternative constructions approved by **TL** as being equivalent are permissible.

2. The installation spaces of energy converters and their directly associated components shall be separated from the spaces used for fuel storage. Doors between the spaces used for fuel storage and the installation spaces of the energy converter are not permissible.

3. The installation spaces of energy converters and directly associated components shall be arranged outside of accommodation, service and machinery spaces and control rooms, and shall be separated from such spaces by means of a cofferdam or an A-60 bulkhead. Installation in a conventional machinery space is admissible, on condition that a suitable enclosure is provided.

4. Entrances, openings and ventilation openings to accommodation, service and machinery spaces and to control rooms shall be arranged at a distance of at least 3 m from the openings of the installation space of the energy converter. The openings of the installation space shall not face the entrances, openings and ventilation openings to accommodation, service and machinery spaces and to control rooms.

If it is necessary to deviate from this provision, the approval of **TL** is required.

5. Exhaust gases and residual fuel gases of the energy converter shall be treated in a way that ignition is not possible and the risk of asphyxiation is excluded.

If exhaust gases and residual gases are removed from the submarine or ROV the discharge openings should be located in a safe horizontal distance from any sources of ignition and openings of the submarine or ROV.

B. Energy converter

1. For energy converters which have a total electrical or mechanical output greater than 1 MW and which contain flammable materials, additional fire protection measures may be required by **TL**.

2. If energy converters are used for supplying essential consumers, then every energy converter shall be subjected to a performance test at the manufacturer's works. The electrical or mechanical output and the thermal output of the energy converter shall be verified by means of a suitable performance test.

3. If energy converters are used for supplying essential consumers, then redundancy shall be ensured.

C. Inverters Following Fuel Cells

If propulsion units or other essential consumers are supplied with electricity from FC systems, then the inverters shall be so designed that reverse power, such as braking power, cannot pass into the fuel cells.

In general, the requirements set out in the **TL** Rules, Chapter 105 – Electrical Installations apply.

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A. General

1. Spaces in which there is a risk that an ignitable gas mixture may be formed must be protected against the accumulation of these mixtures. These spaces shall be equipped with mechanical ventilation systems of the extraction type. Depending on the expected type of fuel release, either the entire space or the hazardous areas must be fitted with suction ventilators.

Alternative constructions approved by TL as being equivalent are permissible.

2. It must be possible to control the ventilation systems from a point outside the ventilated spaces. The spaces must be ventilated before access and before taking the equipment into operation. Notices must be provided outside the spaces, with the warning that the ventilation system must be switched on before entering the spaces.

3. Ventilation systems must be permanently installed. The ventilation systems are not allowed to be connected to those of other spaces in the submarine or ROV.

4. The extracted air must be monitored for fuel constituents. The requirements set out in Section 8, C.2. apply.

5. The suction air of ventilation systems must be monitored for ignitable gases. The permissible limits of ignitable gases in the suction air must be approved by TL.

B. Spaces with Mechanical Ventilation

1. The inlet and outlet openings of the mechanical ventilation system must be arranged in such locations that an adequate flow of air prevents the accumulation of flammable vapours and ensures a safe working atmosphere throughout the entire room.

2. The ventilation system shall be designed for at least 30 air changes per hour with regard to the total geometric volume of the empty space. If the ventilation

system fails, an alarm must be generated. Alternative constructions approved by TL as being equivalent are permissible.

3. Suitable design of the spaces shall ensure that no gas can accumulate in recesses or pockets.

4. Air inlet and outlet openings shall be provided with fire dampers, which must be operable from outside the spaces.

5. Fans shall not form a source of ignition neither within the ventilated space nor within the ventilation system connected to the space. Fans must be of a non-sparking type and must comply with the TL Rules, Chapter 4 – Machinery, Section 15, B.5.3.

6. Fuel pipes that are routed into the ventilated space must be shut-off automatically by means of a safety shut-off valve as per Section 9, C., if the required air flow is not achieved or cannot be sustained, or if a fuel leak is detected.

C. Gases and Vapours Heavier than Air

1. The spaces shall be ventilated by means of mechanically driven exhaust air fans. The supply air shall be introduced into the upper part of the spaces.

2. The exhaust air duct shall be routed as closely as possible to the floor of the space. The space shall be so designed that gases collect at central points from which they are extracted.

3. Alternative constructions approved by TL as being equivalent are permissible.

D. Gases Lighter than Air

1. The spaces shall be ventilated by means of mechanically driven exhaust air fans. The supply air shall be introduced into the lower part of the spaces.

2. The spaces shall be designed in such a way that gases collect at the top at central points from which they are extracted.

3. A suction hood or a suction trunk shall be provided for areas containing flanges, valves etc.

4. The suction hood or suction trunk shall be arranged in such a way that the air flows around the gas-bearing components, and the air/gas mixture can be extracted at the upper part of the suction hood or trunk.

5. Alternative constructions approved by **TL** as being equivalent are permissible.

E. Ventilation Ducts for Fuel Pipes

1. As an alternative to routing the fuel pipe within a double-wall pipe as per F. the fuel pipe can be laid in a tube or tunnel fitted with mechanical ventilation of the extraction type.

2. Electrical cables are not permitted to pass through this tube or tunnel.

3. The ventilated tunnel intended for the fuel pipe shall be routed until a space is reached which is equipped with a ventilation system.

4. The ventilation must be constantly in operation whenever fuel is present in the line. A gas detection unit shall be located in the extracted air stream and be in permanent operation, in order to indicate any leaks and to shut off the fuel supply automatically as per Section 9, C. The safety shut-off valve must close automatically whenever the required air flow is not achieved or cannot be sustained.

5. The ventilation system must be capable of maintaining a pressure below atmospheric pressure. The fan motors shall be arranged outside the ventilated tube or tunnel or be approved for Ex-Zone 1. For the design of the fans, see B.5.

F. Double-Wall Piping System

1. As an alternative to routing the fuel pipe through a ventilation duct as per E. a double-wall pipe can be used. In the case of double-wall pipes, the fuel must be in the inner pipe. The space between the concentric pipes shall be pressurized with inert gas at a pressure between the atmospheric pressure and the fuel pressure. The outer pipe shall be designed for at least the design pressure of the inner pipe. As an alternative to this design for the outer pipe, a pressure relief arrangement for the outer pipe can be approved by **TL**, on condition that proof of equivalent safety is provided. The pressure in the jacket pipe and the triggering of the pressure relief device shall be monitored.

2. In the event of an inadmissible pressure change in the space between the two pipes, an alarm must be triggered.

G. Arrangement of the Supply Air and Exhaust Air Openings

1. To prevent dangerous gases or vapours from being drawn into the vented space again, the supply air and exhaust air openings of the ventilation systems shall be arranged as far away from each other as possible. They shall be located with a safe distance from any sources of ignition and to the openings of accommodation, service and machinery spaces, control rooms and other spaces containing sources of ignition. Alternative constructions approved by **TL** as being equivalent are permissible.

2. Exhaust air openings should be situated as far away as possible from areas in which persons are regularly to be found.

SECTION 6

FIRE EXTINGUISHING SYSTEMS

Page

A. GENERAL..... **6- 1**

A. General

1. The area around the manifold for fuel transfer and the installation spaces for systems in which fuels in terms of these Rules are used shall be equipped with separate fire extinguishing systems of a suitable type. For all other spaces containing parts of the AIP system, **TL** may request that a fire extinguishing system be installed.
2. The supply facilities of the fire extinguishing system shall always be arranged outside the spaces or areas which are to be protected. It must be possible to set off the fire extinguishing system at a permanently accessible point.

SECTION 7**EXPLOSION PROTECTION**

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4. Extended hazardous area, zone 2	

A. Explosion-Protected Systems

1. Electrical equipment is regarded as being explosion-protected if it has been manufactured according to a recognized standard, e.g. the IEC 60079 publications or EN 50014 – 50020, and if it has been inspected and approved by a recognized institution body. Any instructions and restrictions noted in the approval certificates shall be observed.

2. With regard to the explosion protection, the requirements set out in IEC 60079-14 shall be observed. The required explosion group and temperature class of the electrical equipment in the Ex zones depend on the type of fuel, and shall be defined for each individual case.

B. Classification into Zones

1. General

Hazardous areas (Ex zones) shall be classified into zones according to the probability of potentially explosive mixtures, in compliance with IEC 60079-10. Depending on the influence of the ventilation and its availability, an Ex area can be reclassified from its original theoretical zone into an effective zone with a lower hazard level.

2. Hazardous area, zone 0

2.1 Hazardous areas of zone 0 are areas in which an ignitable gas mixture must be expected to be present permanently. These areas include e.g. the inside of tanks or pipes containing flammable liquids with a flash point ≤ 60 °C or with flammable gases.

2.2 Explosion zone 0 also includes the inside of tanks, containers, heaters, pipes etc. for liquids or fuels with a flashpoint above 60 °C, if these liquids are heated to more than 10° C below their flashpoint.

2.3 For electrical installations in these areas, only the following may be used:

- intrinsically safe electrical circuits with the degree of protection Ex ia

- equipment specially approved for use in this zone

2.4 Cables shall have armouring or shielding, or shall be laid in a metallic tube.

3. Hazardous area, zone 1

3.1 Hazardous areas of zone 1 are areas in which an ignitable gas mixture can be expected to be present occasionally. These areas can include e.g. spaces with energy converters, spaces with fuel tanks and pipes, spaces with fuel conditioning systems, ventilation ducts of pipes, and the monitoring space of double-wall pipes.

3.2 The extent of zone 1 shall be defined in compliance with IEC 60079-10.

3.3 For the electrical equipment in this area, only explosion-protected units of a type suitable for shipboard applications shall be used.

3.4 Cables shall have armouring or shielding, or shall be laid in a metallic tube.

4. Extended hazardous area, zone 2

Extended hazardous areas of zone 2 are areas in which an ignitable gas mixture can be expected to be present only very occasionally, and then only for a short period. Areas directly adjacent to zone 1 that are not separated in a gastight manner from zone 1 are assigned to zone 2. The extent of zone 2 shall be defined in compliance with IEC 60079-10.

For electrical equipment in the areas belonging to zone 2, protective measures should be taken depending on the type and application of the equipment. These can comprise the following, for example:

- explosion-protected equipment

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- equipment with the degree of protection Ex n
 - equipment which generates no sparks in normal operation, and where the surfaces exposed to the outside air cannot reach inadmissible temperatures
 - equipment which is contained in a pressurized enclosure in a simplified manner or enclosed in a fume-tight enclosure (minimum protection IP 55), where their surfaces cannot reach inadmissible temperatures. The permissible temperatures depend on the type of fuel, and shall be defined for each individual case.

SECTION 8**CONTROL, REGULATING, MONITORING and ALARM DEVICES**

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4. Monitoring the performance of the energy converter	

A. Control and Operating Devices

1. If at least two control devices suited for the operation of AIP systems are stipulated by the TL Rules, Chapter 106 – Automation, Section 3, H.1., they shall function independently of each other and shall not affect each other in the event of a failure.

2. The effects of the control actions must be indicated at the control panel. If control actions can be taken at several control units (control panels), the following requirements shall be observed:

- conflicting operator actions shall be prevented by means of suitable interlocks
- the control panel which is currently active must be indicated appropriately

3. Control devices should be designed in a way that no serious damage or loss of essential functions can occur in the case of faulty operating actions.

4. It shall be ensured that the fuel cells can be disconnected from the electrical load at any load condition.

B. Automatic Control Devices

1. For the AIP systems, regulating devices shall be provided to keep the process variables within the specified limits under normal operating conditions. The regulating behaviour shall cover the entire range of operation. Parameter changes which can be anticipated must be considered during the design phase. Faults in a regulating circuit shall not affect the proper functioning of other regulating circuits. The power supply to the regulating circuits shall be monitored and an alarm must be generated on failure of the power supply.

2. Regulating devices containing computers shall be designed according to the TL Rules, Chapter 105 – Electrical Installations, Section 10.

3. Regulating devices for fuel cell systems are subject to mandatory type testing.

C. Monitoring and Alarm Devices**1. General**

1.1 Alarm systems shall be provided which indicate unacceptable deviations from normal operating figures by visible and audible alarms.

1.2 Alarm delays shall be kept within time limits which prevent any risk to the monitored system in the event that a limit value is exceeded.

1.3 Visible signals shall be individually indicated.

1.4 In addition, the TL Rules, Chapter 105 – Electrical Installations, Section 9, B. shall be observed.

2. Gas detection system

2.1 Spaces in which gas leaks cannot be ruled out shall be monitored by separate gas detection systems. A lower and an upper concentration limit must be defined and approved by TL. The concentration limits must consider the time delay of conventional gas detectors.

When the lower limit is reached an alarm must be generated at the control station. When the upper limit is reached, a safety switch-off of the affected system must take place, see also Section 9, A.

2.2 Gas sensors must be arranged at all locations where an accumulation of gases can be expected.

2.3 Gas detection systems are subject to approval by TL.

3. Monitoring of chemical reactions

Chemical reactions, such as those taking place during fuel conditioning or within a fuel cell, shall be monitored,

e.g. by means of temperature, pressure or voltage monitoring.

4. Monitoring the performance of the energy converter

4.1 If an AIP system is used to supply consumers as per Section 1, A.2., the power provided by the AIP system shall be monitored.

4.2 In the case of load shedding, it shall be ensured that the AIP system is automatically transferred into a safe condition from which it can be brought to the normal operating state again.

SECTION 9**PROTECTIVE DEVICES and SYSTEMS**

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A. Protective Devices

1. Protective devices shall be as simple as possible, and must be reliable and direct in operation. Where external energy is required for the function of protective devices, the energy supply shall be monitored for possible failure. The suitability and proper function of protective devices must be demonstrated for the given application.

2. Protective devices shall be designed in a way that potential faults such as, for example, loss of voltage or a broken wire, cannot create a hazard to human life, ship or machinery. The occurrence of these faults and also the tripping of protective devices shall be indicated by an alarm.

3. Protective devices shall be designed to be fail-safe.

4. The adjustment facilities for protective devices shall be designed in a way that the last setting can be verified.

5. Protective devices, including sensors and actuators, must be independent of control, regulating and monitoring systems. Faults in one protective device shall not affect any other protective device. Protective devices shall be assigned to the systems which are to be protected.

6. The monitored open-circuit principle shall be used for protective devices. Alternatively, the closed-circuit principle shall be applied where national regulations demand it. Equivalent monitoring principles are permitted.

7. Faults occurring in protective devices must be indicated by an alarm.

8. In case of the following events, the affected AIP system must be switched off with due consideration to safety, and then locked out:

- emergency shutdown (protective device)
- gas detection: when a concentration equal to the maximum value of the lower explosion limit according Section 8, C.2.1 is reached

- fire detection in hazardous areas
- safety switch-off of the system owing to deviations from permissible operating parameters, including chemical reactions

9. It shall be ensured that the electric power output can be switched off at any load condition, see Section 8, A.4.

10. Protective devices are subject to mandatory type testing.

11. The control and regulating devices on the one hand and the protective devices on the other shall be located in separate spaces, so that, in the event of fire or water ingress, both systems are not adversely affected at the same time.

B. Protective Systems

1. General

1.1 A process-related interlinking of protective devices by the protective system shall not result in an impairment of the safety objectives.

1.2 When a protective system demands a requirement class of 4 or higher according to the TL Rules, Chapter 105 – Electrical Installations, Section 10, the following criteria shall be observed:

- The protective system should be of a fault-tolerant design (multi-module).
- The modules should consist of different hardware.
- If the modules contain software, this should be programmed according to different design criteria and by different persons (redundancy through diversity).

1.3 Computers in protective systems shall be designed according to the TL Rules, Chapter 105 – Electrical Installations, Section 10.

1.4 Protective systems for AIP systems are subject to mandatory type testing.

1.5 The control and regulating devices on the one hand and the protective system on the other shall be located in separate spaces, so that, in the event of fire or water ingress, both systems are not adversely affected at the same time.

C. Safety Shut-Off Valves

1. Safety shut-off valves

Safety shut-off valves shall be provided at the following points of the fuel system:

- at the outlets from the fuel storage tanks
- at the outlet from the fuel conditioning unit
- at the inlet of fuel pipes in monitored spaces
- Depending on the structure of the system, additional safety shut-off valves may be required.

2. It must be possible to close the safety shut-off valves by means of the protective devices and also from a constantly manned position. They must be so constructed that they can only be reset manually.

3. In the event of a leak, the fuel supply shall only be taken into operation again when the cause of the leak has been detected and remedied. Instructions on this requirement shall be displayed in a conspicuous position in the installation space.

4. Safety shut-off valves have to be TL type-approved.

D. Automatic Shut-Off Valve of Consumers

1. Each gas consumer (energy converters, burners of reformers etc.) must be fitted with a group of valves consisting of three automatically actuated shutoff valves. Two of these shut-off valves must be located in series in the gas pipe leading to the consumer. By means of the third shut-off valve, it shall be possible to relieve the pressure in the section of gas pipe lying between the two shut-off valves. The vent pipe shall lead to the open air. For the outlet of the vent pipe, the requirements set out in Section 3, B.4. apply.

Alternative constructions approved by TL as being equivalent are permissible.

2. The shut-off valves must be arranged in a way that actuation or failure of the control circuit of the shut-off valves will cause the two series-connected shut-off valves to close automatically and the vent valve to open automatically. Alternatively, the function of one of the series-connected valves and the vent valve can be incorporated into one valve body so arranged that on actuation the flow to the gas consumer will be blocked and the vent line opened. The three shut-off valves shall be constructed in a way that they can only be reset by hand.

3. The shut-off valves must close automatically under the following operating conditions:

- emergency shutdown
- safety shutdown of the system

4. It must be possible to actuate the shut-off valves locally and also from any control panel.

SECTION 10

TEST of the SYSTEM

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A. General

Before the tests commence, a detailed test programme shall be compiled. The test programme is subject to approval by TL, see Section 1, F.

B. Tests of the Entire System

The AIP system shall be subjected to the following tests after installation on board:

1. Functional tests of components

Safety shut-off valves, automatic shut-off valves, level indicators, temperature measurement devices, pressure gauges, gas detection systems and alarm devices shall be subjected to a functional test.

2. Tests of the protective devices and protective system

During the tests, it shall be verified that, in the event of the following faults, the AIP system is automatically transferred into a safe condition:

- alarm of the fire detection devices
- alarm of the gas detection system
- failure of the power supply
- failure of the programmable logic controllers (PLCs)
- triggering of the protective devices
- faults in the protective devices
- faults in the protective system

It shall be verified that the requirements of the safety analysis are met, see Section 1, F.

3. Test of the fire extinguishing system

The functional readiness of the fire extinguishing system shall be verified.

4. Functional tests of the AIP system

The following operating conditions of the AIP system shall be tested (as far as applicable):

- automatic start-up of the AIP system
- operational switch-off of the AIP system
- load change, load steps
- load shedding
- switch-off during system malfunctions that do not endanger the safety of persons and equipment

5. Functional tests of the submarine or ROV

Within the scope of the functional tests, the interaction of the AIP system with the submarine or ROV systems shall be tested as follows (as far as applicable):

- power generation by the AIP system alone
- AIP system together with conventional generation of electrical power
- AIP system together with batteries
- change-over to the emergency source of electrical power
- switching the AIP system online or offline

If the AIP system constitutes the main propulsion system of the ship, it shall be verified that the ship has adequate propulsion power in all manoeuvring situations.