



# CR

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## **GUIDELINES FOR SELECTIVE CATALYTIC REDUCTION SYSTEMS 2015**

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## CONTENTS

<b>CHAPTER 1</b>	<b>GENERAL .....</b>	<b>1</b>
1.1	Application .....	1
1.2	Definitions .....	1
1.3	Plans and data to be submitted.....	1
<b>CHAPTER 2</b>	<b>DESIGN REQUIREMENTS.....</b>	<b>3</b>
2.1	General requirements.....	3
2.2	Materials .....	3
2.3	Failure Modes and Effects Analysis (FMEA).....	3
<b>CHAPTER 3</b>	<b>SCR SYSTEMS .....</b>	<b>4</b>
3.1	SCR Chambers .....	4
3.2	Reductant injection systems .....	4
<b>CHAPTER 4</b>	<b>REDUCTANT AGENTS.....</b>	<b>6</b>
4.1	Urea solutions .....	6
4.2	Ammonia solutions.....	7
<b>CHAPTER 5</b>	<b>EXHAUST GAS HEATING DEVICES .....</b>	<b>11</b>
5.1	General .....	11
5.2	Construction and arrangement .....	11
5.3	Installation considerations .....	12
5.4	Safety devices and alarm devices .....	12
<b>CHAPTER 6</b>	<b>GAS DETECTION AND ALARM SYSTEMS .....</b>	<b>13</b>
6.1	Installation requirements .....	13
<b>CHAPTER 7</b>	<b>CONTROL, MONITORING, AND SAFETY SYSTEMS.....</b>	<b>14</b>
7.1	General .....	14
7.2	Control and monitoring system .....	14
7.3	Safety shutdown system .....	15
<b>CHAPTER 8</b>	<b>ADDITIONAL REQUIREMENTS FOR PERIODICALLY UNATTENDED MACHINERY SPACES .....</b>	<b>17</b>
8.1	General .....	17
8.2	Requirements for CAS or CAU ships.....	17
<b>CHAPTER 9</b>	<b>SAFETY AND PROTECTIVE EQUIPMENT .....</b>	<b>18</b>
9.1	General .....	18
<b>CHAPTER 10</b>	<b>SURVEYS DURING CONSTRUCTION.....</b>	<b>19</b>
10.1	General .....	19
10.2	Surveys at manufacturer’s facility .....	19
10.3	Surveys during installation .....	19
10.4	Surveys during trials.....	19



## CHAPTER 1 GENERAL

### 1.1 Application

1.1.1 These guidelines are applicable to the Selective Catalytic Reduction (SCR) systems, reductant agent tanks and piping systems of reductant agents, etc. used to reduce NO<sub>x</sub> emission from diesel engine. In principle, the reductant agents covered under these guidelines are ammonia solutions (limited to those of 28% by mass or less) and urea solutions. In cases where agents other than those mentioned above are to be used, they are to be as deemed appropriate by the Society.

1.1.2 In addition to the requirements in these guidelines, the construction, control systems, tests, inspections and certification procedures related to SCR systems are to comply with IMO Res. MEPC.198(62) "2011 Guidelines Addressing Additional Aspects to the NO<sub>x</sub> Technical Code 2008 with regard to Particular Requirements related to Marine Diesel Engines fitted with Selective Catalytic Reduction (SCR) Systems".

1.1.3 Additional notation **SCR** may be assigned to ships equipped with SCR systems in accordance with the requirements given in these guidelines.

### 1.2 Definitions

The terms used in these guidelines are defined as follows:

1.2.1 "SCR system" means a system consisting of an SCR chamber and a reductant injection system.

1.2.2 "SCR chamber" means an integrated unit, which contains the catalyst block(s), into which flows exhaust gas and reductant, and which receives the reductant agent supply from the reductant agent injection system.

1.2.3 "Catalyst block" means a block of certain dimension through which exhaust gas passes and which contains catalyst composition on its inside surface to reduce NO<sub>x</sub> from exhaust gas.

1.2.4 "Reductant injection system" means a system which consists of the pump(s) to supply reductant to the nozzle(s), the nozzle(s) spraying reductant into the exhaust gas stream and control device(s) of the spray.

### 1.3 Plans and data to be submitted

1.3.1 Following plans and specifications covering the SCR arrangements are to be submitted:

- (a) General arrangement of the SCR installation, layout, and systems
- (b) Documentation detailing the SCR specification, including details of the SCR catalyst reaction chamber and catalysts, reductant specifications, exhaust system components/modifications, mixing arrangements, reductant injection nozzles/injectors, and soot blowing details
- (c) Analyses demonstrating compatibility of the SCR system with the engine
- (d) Hull plans showing the foundation and attachments to the vessel's structure including scantlings, welding details, and foundation details of principal components

- (e) Material specifications for the SCR unit, pumps, valves, reductant tanks, piping, distribution systems, filters, and associated components, including a corrosion assessment detailing the corrosive effect of system liquids, vapors, and gases on the materials used in the exhaust emission abatement system
- (f) Arrangement and capacity of reductant storage tanks
- (g) Details of all piping systems, including details of piping and associated components, pumps, reductant dosing systems, air supply systems, design pressures, temperatures, insulation, and drip trays
- (h) Descriptions and schematic diagrams for the control and monitoring systems, including set points for abnormal conditions and details of the location and position at which exhaust emission monitoring probes are to be located
- (i) Details of all electrical equipment installed for the SCR unit and associated systems, including computer-based systems
- (j) Failure Modes and Effects Analysis (FMEA) to determine possible failures and their effects in the safe operation of the SCR exhaust emission abatement system.
- (k) Emergency shutdown arrangements
- (l) SCR FMEA integration test report
- (m) Operating and maintenance instruction manuals, including MSDS sheets and details for handling of hazardous and non-hazardous chemicals used in the SCR exhaust emission abatement system
- (n) Testing procedures during installation and commissioning trials

## CHAPTER 2 DESIGN REQUIREMENTS

### 2.1 General requirements

2.1.1 In addition to the requirements in these guidelines, pipes, valves, pipe fittings, auxiliaries, etc. are to satisfy corresponding requirements of the Rules for the Construction and Classification of Steel Ships (hereinafter referred to as the Rules). For the application of those requirements, ammonia solution pipes are to be classified as Group II, and urea solution pipes are to be classified as Group III.

### 2.2 Materials

2.2.1 Structural materials used for SCR systems and reductant agent tank construction, together with associated piping, pumps valves, vents and their jointing materials, are to be suitable at the temperature and pressure for the reductant agent to be carried to the satisfaction of the Society.

2.2.2 Materials with highly corrosive properties (copper, zinc, cadmium, or their alloys) and materials containing mercury are not to be used at locations where they may come into contact with ammonia.

2.2.3 Materials used for exhaust gas heating devices are to be deemed appropriate by the Society.

### 2.3 Failure Modes and Effects Analysis (FMEA)

2.3.1 The system is to be designed such that a single fault of a component will not lead to a potentially dangerous situation for human safety and/or the vessel. An FMEA, or equivalent, demonstrating the safety system design basis is to be submitted.

2.3.2 An integration test is to be undertaken on the first SCR unit in a particular design series to verify that the operation and response of the complete SCR mechanical and electrical systems are as predicted for all operational modes. The scope of these tests is to be determined based on the FMEA required by 2.3.1.

## CHAPTER 3 SCR SYSTEMS

### 3.1 SCR Chambers

#### 3.1.1 Exhaust Gas Allowable Back Pressure

- (a) SCR chambers are to be arranged so that the back pressure of the exhaust pipes connecting the chamber to the diesel engine does not exceed the allowable back pressure recommended by the engine manufacturer.

#### 3.1.2 Changeover of exhaust gas pipes

- (a) For diesel engines whose exhaust gas pipe system can be changed over from ordinary exhaust gas pipes to pipes connected to an SCR system, a changeover damper is to be fitted at the branch position of the pipes.
- (b) The changeover damper specified in (a) above is to be fitted with interlock devices, etc. to prevent the closing of both the exhaust gas pipe of ordinary use and the pipe supplying exhaust gas to the SCR chamber so that the operation of the diesel engine discharging the gas is not impaired in any way.
- (c) The changeover damper specified in (a) above is to be fitted with an indicator which specifies which exhaust gas pipe is being used.

#### 3.1.3 Maintenance

- (a) Catalyst blocks are to be arranged so that they can be easily replaced.
- (b) Sufficient space for replacing catalyst blocks is to be provided on board ship.
- (c) Consideration is to be given to SCR chambers so that the degradation of catalytic reactions by the adherence of soot, etc. is prevented.

### 3.2 Reductant injection systems

#### 3.2.1 Injection controls.

- (a) Reductant injection systems are to be fitted with interlock devices so that the reductant solution can't be injected in cases where the temperature of exhaust gas at the inlet of the SCR chamber is below the design temperature specified by the manufacturer.
- (b) The amount of injected reductant is to be capable of being appropriately controlled depending upon the load of the engines or quantity of NO<sub>x</sub> emissions in consideration of the temperature of the exhaust gas at the inlet of the SCR chamber and the sulphur content concentration in the fuel oil.
- (c) The amount of injected reductant is to be capable of being appropriately controlled so that any ammonia slip due to an excessive amount of reductant being injected into the system can be avoided.

#### 3.2.2 Injection monitoring

- (a) Devices to monitor the amount of reductant injected during use of the SCR system are to be installed at engine monitoring stations.

### 3.2.3 Injection position

- (a) The reductant is to be injected at the proper position in the exhaust gas pipe so that the ammonia gas is able to inflow uniformly.

### 3.2.4 Safety devices and alarm devices

- (a) The reductant injection system is to be fitted with alarm devices and safety devices to stop the injection of reductant when the temperature at the outlet of engines or the inlet of the SCR chamber exceeds the preset level in order to avoid any self-ignition of ammonia gas caused by an abnormal rise in exhaust gas temperature.

## CHAPTER 4 REDUCTANT AGENTS

### 4.1 Urea solutions

#### 4.1.1 Construction and arrangement

- (a) Compartments where reductant agent storage tanks (excluding solid urea storage tanks, as the case may be) and reductant injection systems, etc. are installed are not to be adjacent to accommodation spaces, service spaces or control stations.
- (b) Drip trays of a sufficient depth are to be provided under reductant agent storage tanks and reductant injection systems, etc. to hold any spillage of the reductant agent.
- (c) Piping for the supply, transfer, injection or discharge of the reductant agent is not to pass through accommodation spaces, service spaces or control stations.
- (d) Piping for the supply, transfer, fill or discharge of the reductant agent is not to pass through liquid storage tanks. However, in cases where deemed appropriate by the Society, this requirement may be dispensed with.
- (e) The supply and transfer lines of reductant agents, excluding those near reductant agent injection nozzles, are not to be located immediately above or near units of high temperature such as boilers, steam pipelines and exhaust manifolds, etc. which are required to be insulated. As far as practicable, such lines are to be arranged far apart from hot surfaces, electrical installations and other sources of ignition.

#### 4.1.2 Closing devices and shut-down systems in the event of fire

- (a) Reductant agent piping, which, if damaged, would allow reductant agent to escape from a storage tank situated above the double bottom, is to be fitted with a cock or valve directly on the tank capable of being closed from a safe position outside the space concerned in the event of a fire occurring in the space in which such tanks are situated. In the special case of deep tanks situated in any shaft or pipe tunnel or similar space, valves on the tank are to be fitted, but control in the event of fire may be affected by means of an additional valve on the pipe or pipes outside the tunnel or similar space.
- (b) Stopping devices are to be provided for reductant agent supply pumps. Such devices are to be installed outside of the space concerned, where they will not be cut off in the event of fire in the space they serve, in addition to being installed inside such space.
- (c) In cases where exhaust gas heating devices which are fitted with burners and blowers are installed, stopping devices for burners and air supply systems are to be installed outside the space concerned, where they will not be cut off in the event of fire in the space they serve, in addition to those installed inside the space.

#### 4.1.3 Ventilation systems

- (a) A mechanical ventilation system is to be installed in the compartment where the independent urea solution storage tanks and urea injection systems, etc. are installed so that gas does not accumulate in the compartment.

- (b) In cases where urea solution is carried in a tank which forms part of the ship's hull, mechanical ventilators operable from outside the spaces are to be provided for the enclosed spaces (excluding water tanks and oil tanks) adjacent to the urea solution tanks.
- (c) A venting system is to be installed for the urea solution storage tank.
- (d) The position of vent outlets for urea solution storage tanks are to be arranged at exposed areas where the crew does not normally approach in consideration of the emission of ammonia gas from the vent outlets in the event of fire near the tanks.

## 4.2 Ammonia solutions

### 4.2.1 Construction and arrangement

In addition to the requirements stipulated in subparagraph 4.1.1, following requirements are also to be complied with.

- (a) Compartments where independent ammonia solution storage tanks or ammonia solution injection systems, etc. are installed (hereinafter referred to as ammonia solution installation compartment) are to be special compartments isolated by gastight bulkheads and decks from all other compartments so that leaked ammonia does not enter other compartments. The ammonia solution installation compartment is to be provided with access doors which comply with the following requirements:
  - (i) At least two access doors are to be provided in the ammonia solution installation compartment as far apart as possible from each other. At least one access door is to lead directly to the weather deck. However, if it is not possible to provide an access door directly to the weather deck, then at least one access is to have air-lock type doors.
  - (ii) Access doors not leading to weather deck are to be of a highly sealable and self-closing type.
  - (iii) Access doors are to be capable of being operated easily and are to open outward.
- (b) Passages leading to the ammonia solution installation compartment are to comply with the following requirements:
  - (i) If a passage is adjacent to accommodation spaces, service spaces or control stations, it is to be isolated by gastight bulkheads and decks.
  - (ii) The passage is to be isolated from passages to accommodation spaces, and led directly to the weather deck.
- (c) Penetrations on gastight bulkheads and decks where cables and piping from the ammonia solution installation compartment pass through are to be of a gastight construction.
- (d) A system to lead the leaked ammonia solution from the drip trays specified in 4.1.1(b) to a drain tank is to be provided in the ammonia solution installation compartment.
- (e) An independent drainage system in the ammonia solution installation compartment is to be provided so that the drainage of this compartment is not discharged into open bilge wells or the bilge ways of other compartments.

- (f) In cases where ammonia solution is carried in tanks which form part of the ship's hull, the following are to be complied with:
- (i) Tanks are to be located inboard from the moulded line of the bottom shell plating at centreline not less than  $B/15$  or  $6m$ , whichever is less ( $B$  is breadth of ship), and nowhere less than  $760mm$  from the shell plating.
  - (ii) Tanks are to be segregated from accommodation, service and machinery spaces and from drinking water and stores for human consumption by means of a cofferdam, void space, cargo pump room, pump room, empty tank, oil fuel tank or other similar space.
  - (iii) The quantity of ammonia solution is not to exceed  $3,000m^3$  in any one tank.

#### 4.2.2 Closing devices and shut-down systems in the event of fire

The requirements stipulated in subparagraph 4.1.2 are to be complied with.

#### 4.2.3 Ventilation systems

- (a) A mechanical ventilation system of the extraction type, which as a rule complies with the following requirements, is to be installed in ammonia solution installation compartments and spaces (excluding water tanks and oil tanks) adjacent to ammonia solution tanks which form part of the ship's hull so that the space can be ventilated at all times.
- (i) The ventilation system is to have adequate capacity to ensure at least 8 air changes per hour in the space.
  - (ii) The ventilation system is to be independent of other ventilation systems on board the ship, and is to be capable of being operated from outside the compartment.
  - (iii) Exhaust outlets are to be installed at a horizontal distance of more than  $10m$  from the nearest air intake or openings of accommodation spaces, service spaces and control stations, and at a vertical distance of more than  $4m$  from weather decks.
  - (iv) The air intake opening is to be provided at a low position and the exhaust opening is to be provided at a high position in the space so that gas does not accumulate in the space and the exhaust ducts.
  - (v) Ammonia solution supply pumps are to stop automatically and main valves of ammonia solution tanks are to close automatically, if the required air flow is not established and maintained by the exhaust ventilation system.
- (b) Independent ventilation systems are to be installed in passages leading to the ammonia solution installation compartment or the spaces adjacent to tanks (excluding water tanks and oil tanks) which form part of the ship's hull. However, if the ventilation system specified in (a) above is provided with ducts so that it can be used for exhausting the air in the passages, then an independent ventilation system need not be installed.
- (c) A controlled venting system is to be installed in each ammonia solution storage tank in order to control the pressure or vacuum in the tank.
- (d) Controlled venting systems are to consist of a primary and a secondary means to prevent over-pressure or under-pressure in the event of the failure of one means.

- (e) Positions of the vent outlets of a controlled tank venting system are to be arranged as follows:
  - (i) at a height of not less than 6m above the weather deck or above a raised walkway if fitted within 4m of the raised walkway;
  - (ii) at a distance of at least 10m measured horizontally from the nearest air intake or openings of accommodation, service and machinery spaces.

#### 4.2.4 Ammonia solution piping systems

- (a) Piping is to comply with corresponding requirements in Part VI of the Rules.
- (b) Piping is to be full penetration butt welded, and fully radio-graphed except in the following cases:
  - (i) Slip on welded joints may be used for pipes arranged within ammonia solution installation compartments or double wall piping systems.
  - (ii) Screwed connections acceptable to the Society may be used for pipes with external diameters of 25mm or less within double wall piping systems.
- (c) Flange connections in the piping are to be permitted within ammonia solution installation compartments and double wall piping systems as well as at the shore connection and the pipe fittings such as valves.

#### 4.2.5 Drain tanks

- (a) Drain tanks which comply with the following are to be installed at a lower position than ammonia solution installation compartments.
  - (i) In cases where the drainage accumulated in the tank is to be discharged overboard, it is to be diluted or neutralized before discharge.
  - (ii) An appropriate drain trap is to be provided to prevent the reverse flow of the gas from the tank.
  - (iii) All the vent pipes of the tank are to be connected to the exhaust pipe of the ventilation system.

#### 4.2.6 Ammonia solution supply systems

- (a) Pipes for ammonia solution supply may be arranged in spaces other than ones specified in 4.1.1(c) if they are arranged within pipes or ducts which are equipped with a mechanical exhaust ventilation system and they comply with the following:
  - (i) The spaces enclosed with ammonia solution supply pipes and external pipes or ducts are to be ventilated by a system with the capacity of eight air changes per hour. This ventilation system is to be arranged so that a pressure lower than atmospheric pressure can be maintained.
  - (ii) Exhaust outlets are to be installed at the locations specified in 4.2.3(a)(iii).
  - (iii) The ventilation system may double as the one required for ammonia solution installation compartments. In this case, the capacity of the system is to be of eight air changes per hour for both the ammonia solution installation compartment and the space specified in (i) above.

- (iv) Continuous gas detection and alarm systems are to be provided to indicate leaks and to shut down the ammonia solution supply to the machinery space.
  - (v) Ammonia solution supply pumps are to stop automatically and main valves of ammonia solution tanks are to close automatically, if the required air flow is not established and maintained by the ventilation system.
  - (vi) Ammonia solution leaked from ammonia supply pipes is to be led to dedicated drain tanks. This drain tank can double as tanks which accumulate ammonia solution leaked from ammonia solution installation compartments.
- (b) The ammonia solution supply pipes arranged in ammonia solution installation compartments need not comply with the requirements specified in (a) above.

#### 4.2.7 Ammonia solution discharge systems

- (a) Ammonia solution supply line is to be equipped with a means to temporarily discharge ammonia solution remained in the pipes to tanks on board the ship taking into consideration the need to remove ammonia solution in pipes for repairs to any leaking areas of the pipes.
- (b) In cases where a drain tank is used as a means specified in (a) above, the followings are to be complied with:
  - (i) A discharge line is to be installed from the bottom of ammonia supply line to a drain tank, and a stop valve is to be fitted for the discharge line.
  - (ii) The capacity of the drain tank is to be enough for storing the maximum volume of ammonia solution which can remain in the pipes from the main valve of ammonia solution tank to the injection nozzle.

#### 4.2.8 Ammonia solution filling systems

- (a) Ammonia solution filling pipes from outboard are to be used exclusively for ammonia solution, and the open ends of these pipes are to be led to the open deck and to be provided with a shutoff valve and a blank flange. The piping is to be fitted at least 760mm inboard on the open deck and to be identified definitely.
- (b) A fixed drip tray or a portable drip tray is to be installed below the open end of the ammonia solution filling piping.
- (c) The ammonia solution filling line is to be fitted on top of the ammonia solution storage tank or in close proximity to it.
- (d) Arrangements are to be made to avoid the emission of gas remaining in the line after use or when not in use.

## CHAPTER 5 EXHAUST GAS HEATING DEVICES

### 5.1 General

5.1.1 In cases where exhaust gas heating devices are installed with the purpose of raising the temperature of the exhaust gas from engines, the requirements in this chapter are to be complied with. Exhaust gas heating devices which are not equipped with burners are to conform to requirements deemed appropriate by the Society.

### 5.2 Construction and arrangement

5.2.1 Exhaust gas heating devices are to be arranged so that the pressure in exhaust gas pipes does not exceed the allowable back pressure recommended by the engine manufacturer.

5.2.2 An appropriate measure is to be taken to prevent the frame of the burner from coming in direct contact with the exhaust gas from the engines.

5.2.3 Appropriate measures to avoid the accumulation of unburnt fuel from engines in exhaust gas heating devices when the SCR system is not in use or to prevent the unburnt fuel from engines from exploding when the burner is injected are to be taken. In cases where an on-off damper is installed in the flue gas line of the exhaust gas heating device, an indicator which shows the condition of the damper is to be provided.

5.2.4 Temperature measurement devices of the combustion gas at the outlet of the exhaust gas heating device or of the exhaust gas at the inlet of SCR systems are to be provided.

5.2.5 An air supply system of adequate capacity is to be provided so that the temperature of the exhaust gas rises to the required level

5.2.6 Combustion chambers and gas flue lines of exhaust gas heating device are to be constructed in accordance with the following requirements:

- Main parts of combustion chambers are to be constructed with suitable materials.
- Means to inspect and clean the combustion chambers and the flue lines are to be provided.

5.2.7 The construction and control of burners are to comply with the requirements in the following:

- The fuel supply is to be appropriately controlled so that the temperature of the exhaust gas from engines is heated to a temperature on which the catalytic agent is able to activate effectively.
- They are to be arranged so that the combustion chamber is pre-purged by air before ignition.
- They are to be arranged so that the fuel supply does not precede the ignition spark in cases where an automatic ignition system is adopted
- They are to be capable of controlling the amount of fuel supplied in cases where an automatic fuel supply system is provided.

- The main burner and pilot burner, etc. are to operate in accordance with designed procedures in cases where an automatic combustion control device is provided.

### 5.3 Installation considerations

5.3.1 Exhaust gas heating devices are to be so installed as to minimize the effects of the following loads or external forces:

- Ship motions or any vibrations caused by machinery installations
- External forces caused by the piping or any other supports fitted onto the exhaust gas heating device
- Thermal expansions and contractions due to temperature fluctuation

### 5.4 Safety devices and alarm devices

5.4.1 Each exhaust gas heating device is to be fitted with a safety device which is capable of automatically shutting off the fuel supply to all burners in any of the following cases:

- When the temperature of combustion gas at the outlet of the exhaust gas heating device or exhaust gas temperature at the inlet of SCR chamber exceeds the preset temperature of the normal operation of the SCR system.
- When the flame vanishes.

5.4.2 Each exhaust gas heating device is to be fitted with an alarm device which operates in any of the following cases:

- When the temperature of combustion gas at the outlet of the exhaust gas heating device or exhaust gas temperature at the inlet of SCR chamber exceeds the preset temperature of the normal operation of the SCR system.
- When the flame vanishes.
- When the power supply to the alarm device stops.
- When the fuel supply pressure to the furnace falls, in the case of pressure atomizing.
- When the combustion air supply system, if any, stops.
- Other cases considered necessary by the Society.

## CHAPTER 6 GAS DETECTION AND ALARM SYSTEMS

### 6.1 Installation requirements

6.1.1 Gas detection and alarm systems complying with the following requirements are to be provided in ammonia solution installation compartments, spaces adjacent to ammonia solution storage tanks which form part of the ship's hull and the empty spaces in the double wall pipes or ducts specified in 4.2.6(a)(i):

- (a) Fixed gas detectors complying with the requirements given below are to be installed on the upper-side of each ammonia solution installation compartment or at the ventilation outlet of the double wall pipes or ducts.
  - (i) The detectors are to activate an alarm when the gas concentration exceeds *25ppm*.
  - (ii) When the gas concentration exceeds *300ppm*, the detector is to automatically stop the ammonia solution supply pumps, automatically close the main valves of ammonia solution storage tanks, and activate the alarm.
- (b) Regardless of (a) above, in cases where a mechanical ventilation system for double wall pipes or ducts doubles as the one for the ammonia solution installation compartment, the gas detection and alarm system required for the double wall pipes or ducts may double as the one for the ammonia solution installation compartment.
- (c) At least one portable gas detection instrument is to be provided for each ammonia solution installation compartment.
- (d) Alarm systems are to generate visible and audible alarms at both inside and outside locations near the doors of ammonia solution installation compartments and at monitoring locations.
- (e) A manually-operated transmitter for leakage warnings is to be provided at an outside location near the doors of ammonia solution installation compartments.

6.1.2 Gas detection and alarm systems complying with the following requirements are to be provided in passages leading to the ammonia solution installation compartment:

- Gas detectors are to activate the alarm system when the gas concentration exceeds *25ppm*.
- Alarm systems are to generate visible and audible alarms in the passage and near the doors of the ammonia solution installation compartment.

6.1.3 The fixed gas detectors are to be capable of continuous detection of any gas leakages.

6.1.4 Gas detectors are to be those considered to be appropriate by the Society.

## CHAPTER 7 CONTROL, MONITORING, AND SAFETY SYSTEMS

### 7.1 General

7.1.1 The control system for the SCR system may be connected to an integrated control system or may be a standalone system. Where the SCR control system is integrated in the base engine design, the control system is to be integrated with, or in direct communication with, the engine control system.

7.1.2 The system is to be designed such that a single fault of a component will not lead to a potentially dangerous situation for human safety and/or the vessel. An FMEA, or equivalent, demonstrating the safety system design basis is to be submitted.

7.1.3 Exhaust emissions monitoring systems, where fitted, are to be subject to special consideration by the Society.

### 7.2 Control and monitoring system

7.2.1 Automatic control, alarm, and safety functions are to be provided for the SCR system so that operations remain within preset parameters for all diesel engine and SCR system operating conditions. For vessels with **CAS** or **CAU** notations, the alarm and monitoring systems are to be integrated in the vessel's centralized monitoring systems that conform to the requirements for **CAS** or **CAU** notations.

7.2.2 The temperatures, pressures, and flows in the SCR system and associated systems are to be controlled and monitored as follows:

- (a) A local control and monitoring system for the SCR system is to be provided to enable safe operation, maintenance, and effective control in the event of an emergency or failure of any remote controls. This may be integrated with the engine control system and/or be a standalone system.
- (b) The design of the control system is to provide identification of faults in the equipment, as well as the process system. The control and monitoring systems are to comply with the requirements of the Rules, as applicable.
- (c) Indications of parameters necessary for the safe and effective operation of the exhaust emission abatement process are to be provided at the local and, as applicable, remote control station(s), as per Table 9-1 and are to include the following parameters:
  - (i) SCR system pump/fan/motor operational status
  - (ii) Status of any SCR system valves
  - (iii) SCR system parameters for operational safety
  - (iv) Level indication of SCR system tanks
  - (v) Status of any SCR system alarms, shutdowns and emergency stop

(d) Injection of reductant solutions outside the exhaust gas temperature limits specified by the catalyst manufacturer is to be prohibited by the control system, and control strategies are to minimize ammonia slip.

(e) The computer-based control systems are to comply with the applicable requirements of the Rules.

7.2.3 The power supply arrangements for the control and monitoring system are to meet the requirements of the Rules.

### **7.3 Safety shutdown system**

A shutdown system is to be provided. This safety shutdown system is to be based on the following principles:

7.3.1 Means are to be provided to indicate the parameters causing shutdown.

7.3.2 Upon activation of the safety shutdown system, alarms are to be given at the normal control position and at the local control position.

7.3.3 In the event where shutdown by the safety shutdown system is activated, the restart should not occur automatically, unless after the system is reset. Monitoring and safety shutdowns are to be in accordance with Table 7-1.

**Table 7-1 Monitoring and Safety System Functions for SCR Systems**

Monitored Parameters	Display	Alarm Activated	Automatic SCR Shutdown and Automatic SCR Bypass <sup>(1)</sup>
Exhaust fan motors	Running	Stop <sup>(2)</sup>	
Exhaust bypass or isolation valves, where provided	Position		
Control-actuating medium of the exhaust bypass or isolation valves, as applicable	Running	Failed	
Exhaust gas temperature before SCR chamber	X	High	X (High-High)
Exhaust gas temperature after SCR chamber	X	High	X (High-High)
Exhaust gas backpressure after the engine	X	High	X (High-High)
Differential pressure across SCR chamber	X	High	X (High-High)
Reductant dosing pumps	Running	Stop <sup>(2)</sup>	
Reductant system supply pressure	X	Low	X (Low-Low)
Reductant storage tank temperature	X	Low/High	X (High-High)
Reductant storage tank level	X	Low/High	X (Low-Low)
Reductant tank drip tray level <sup>(3)</sup>		High	X (High-High)
Pneumatic supply pressure, injector and soot blowing systems	X	Low	X (Low-Low)
Control power supply	Running	Failed	
Emergency shutdown	X	X	X

## Notes:

1. Automatic bypass of the SCR unit is only applicable to those SCR units fitted with exhaust gas bypass arrangements.
2. Failure of essential SCR system motors driving pumps or fans is to activate the standby units, where fitted.
3. Urea storage tanks of 500 liters and above only.

## CHAPTER 8 ADDITIONAL REQUIREMENTS FOR PERIODICALLY UNATTENDED MACHINERY SPACES

### 8.1 General

Ships registered with the notation **CAS** or **CAU** affixed in accordance with the Rules are to satisfy the requirements in the following as well as Chapter 2 to Chapter 7.

### 8.2 Requirements for CAS or CAU ships

- 8.2.1 For ships registered with the notation **CAS** or **CAU**, the following devices are to be supplied.
- The monitoring devices of reductant injection systems and the changeover dampers of exhaust gas pipes which comprise the SCR system
  - The monitoring devices of the on-off damper for the exhaust gas heating device
  - An alarm system which signifies the activation of the safety devices specified in 3.2.4, 5.4 and 7.3

## CHAPTER 9 SAFETY AND PROTECTIVE EQUIPMENT

### 9.1 General

9.1.1 In cases where ammonia solution is used as the reductant agent, safety and protective equipment as given below is to be provided, and is to be stored at locations outside the ammonia solution installation compartment so that it can be easily retrieved in the event of any ammonia solution and gas leakages. Storage locations are to be marked with signs so that they can be identified easily.

- Protective clothing (helmet, safety boots, gloves, etc.) x2
- Self-contained breathing apparatus (capable of functioning for at least 30 minutes) x2
- Protective goggles x2
- Eye washer x1
- Boric acid
- Stretcher x1

## CHAPTER 10 SURVEYS DURING CONSTRUCTION

### 10.1 General

This subsection pertains to surveys during fabrication at the manufacturer's facility and installation and testing of SCR units onboard. As applicable, these surveys may be incorporated with the certification, shop test, and shipboard tests required by the applicable aspects of the Rules.

### 10.2 Surveys at manufacturer's facility

Survey requirements for equipment components and packaged units at the manufacturer's facility are to be in accordance with applicable requirements of the Rules. Reference can be made to Table 10-1.

### 10.3 Surveys during installation

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

- Inspection and verification that the foundations and attachments of the principal components of the SCR abatement unit and associated systems are in accordance with the approved plans and particulars.
- Piping systems are to be visually examined and pressure-tested, as required by Part VI of the Rules.
- Electrical wiring and connections are to be in accordance with Part VII of the Rules and checked for continuity and proper workmanship.
- Instrumentation is to be tested to confirm proper operation as per its predetermined set points.
- Pressure relief and safety valves installed on the unit are to be tested.
- Control system and shutdowns are to be tested for proper operation.
- The SCR unit is to be checked for proper operation in accordance with the installation test procedure.

### 10.4 Surveys during trials

During the initial commissioning trials, the SCR 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 testing procedure during sea trials approved by the Society.

**Table 10-1 Certification of SCR systems at the manufacturer's facility**

<b>Code</b>	<b>Explanation</b>
DR	Design Review – Design review required.
MS	Manufacture Survey – Product is to be surveyed during fabrication stages by the Surveyor.
FS	Final Survey – 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.

<b>Equipment</b>	<b>DR</b>	<b>MS</b>	<b>FS</b>
SCR unit	X	X	X
Exhaust piping	X		
Exhaust bypass or isolation valves	X		
Exhaust fans/motors	X		X
Heat exchangers	X		X
Reductant system piping	X		
Pneumatic systems	X		
Control system	X		
Automatic shutdown and safety system	X		

Notes:

1. This table has been prepared for guidance only and annotated to agree with the Rules. 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 Rules. This list is not to be considered as substitutive or integrative of the content of the Rules and/or other applicable regulations. In case of conflict between the content of this list and the Rules and other applicable regulations, the latter are to be considered applicable.