Type Approval for Explosion Relief Devices Provided for Combustion Air Inlet Manifolds and for Exhaust Gas Manifolds Composing Exhaust Systems of Reciprocating Internal Combustion Engines Using Gas as Fuel

Amended Guidance

Guidance for the Survey and Construction of Steel Ships Parts GF and N
Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use

Reason for Amendment

SOLAS Reg. II-1/27 requires the installation of pressure relief valves as safety measures against crankcase pressurisation for reciprocating international combustion engines (including those engines using gas as fuel). In addition, type approval procedures for pressure relief valves are specified in IACS UR M66.

For engines using gas as fuel, regulation 10.2 of the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code) further requires the installation of suitable pressure relief devices in scavenging rooms, exhaust systems and other locations as safety measures to prevent their pressurisation. Furthermore, regulation 16.7 of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) also requires the installation of the same pressure relief devices. However, because there were no procedures for the type approval of such devices, IACS adopted UR M82 in March 2023 to specify procedures for type approval of explosion relief devices provided for the combustion air inlet manifolds and exhaust gas manifolds of engines using gas as fuel.

Accordingly, relevant requirements are amended in accordance with the UR M82.

Outline of Amendment

Specifies guidelines for the testing and procedures related to the type approval of explosion relief devices provided for combustion air inlet manifolds and for exhaust gas manifolds composing exhaust systems of reciprocating internal combustion engines using gas as fuel.

"Guidance for the survey and construction of steel ships" has been partly amended as follows:

Part GF SHIPS USING LOW-FLASHPOINT FUELS

GF10 POWER GENERATION INCLUDING PROPULSION AND OTHER GAS CONSUMERS

GF10.2 Functional Requirements

Paragraph GF10.2.2 has been amended as follows.

GF10.2.2 Additional Requirements

1 In applying **10.2.2-2, Part GF of the Rules**, air inlet manifolds and scavenge spaces which are not capable of withstanding a pressure 7 *times* the design pressure are to be provided with pressure relief systems approved by the Society in accordance with **Chapter 6, Part 13 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

2 In applying **10.2.2-2, Part GF of the Rules**, pressure relief systems are not to continuously discharge exhaust gas into enclosed spaces.

GF10.3 Internal Combustion Engines of Piston Type

Paragraph GF10.3.1 has been amended as follows.

GF10.3.1 General

1 In applying **10.3.1-1, Part GF of the Rules**, explosion relief ventilation provided for exhaust gas manifolds composing exhaust systems are to be approved by the Society in accordance with **Chapter 6, Part 13 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

2 An example of means provided to "monitor and detect poor combustion or misfiring" specified in **10.3.1-6, Part GF of the Rules** is sensors fitted to monitor the exhaust gas temperature and the status of knocking.

Part N SHIPS CARRYING LIQUEFIED GASES IN BULK

N16 USE OF CARGO AS FUEL

N16.7 Special Requirements for Gas-fired Internal Combustion Engines

Paragraph N16.7.1 has been amended as follows.

N16.7.1 Arrangements

1 In applying **16.7.1-4, Part N of the Rules**, pressure relief systems are not to continuously discharge exhaust gas into enclosed spaces.

2 A suitable pressure relief system is to be provided for air inlet manifolds, scavenge spaces and exhaust systems which are not designed to accommodate the worst-case overpressure due to ignited gas leaks or justified by the safety concept of the engine. Pressure relief systems provided for air inlet manifolds, scavenge spaces and for exhaust gas manifolds composing exhaust systems are to be approved by the Society in accordance with **Chapter 6, Part 13 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use.** A detailed evaluation regarding the hazard potential of overpressure in air inlet manifolds, scavenge spaces and exhaust systems is to be carried out and reflected in the safety concept of the engine. In the case of crankcases, explosion relief valves, as required in **2.4.3, Part D of the Rules**, are considered suitable for the gas operation of the engine. For engines not covered by **2.4.3, Part D of the Rules**, a detailed evaluation regarding the hazard potential of fuel gas accumulation in the crankcase is to be carried out.

"Guidance for the approval and type approval of materials and equipment for marine use" has been partly amended as follows:

Part 6 MACHINERY

Chapter 13 has been added as follows.

Chapter 13 APPROVAL OF USE OF EXPLOSION RELIEF DEVICES PROVIDED FOR COMBUSTION AIR INLET MANIFOLDS AND FOR EXHAUST GAS MANIFOLDS COMPOSING EXHAUST SYSTEMS FOR RECIPROCATING INTERNAL COMBUSTION ENGINES USING GAS AS FUEL

13.1 General

13.1.1 Scope

This chapter applies to the tests and inspections required for the approval of use of explosion relief devices provided for air inlet manifolds, scavenge spaces (hereinafter referred to collectively in this chapter as "combustion air inlet manifolds") and for exhaust gas manifolds composing exhaust systems for reciprocating internal combustion engines using gas as fuel in accordance with **10.2.2-2** or **10.3.1-1, Part GF** or **16.7.1-4, Part N of the Rules for the Survey and Construction of Steel Ships**.

13.1.2 Terminology

1 The terminology used in this chapter is as specified in **1.4, Annex 1.1.3-3, Part GF** or **1.4, Annex 16.1.1-3., Part N of the Rules for the Survey and Construction of Steel Ships**.

2 "Explosion relief device" (*ERD*) refers to devices for protecting components against determined levels of overpressure due to gas explosions. Such devices are fitted with flame arresters and may be valves, rupture discs or something else, as applicable.

13.2 Application

13.2.1 Application Forms

Manufacturers who intend to obtain approval of use are to submit a completed appropriate application form (**Form 6-13**) to the Society's Head Office.

13.2.2 Documents

The following documents listed in **(1)** through **(9)** below, each in triplicate, are to be submitted together with the application forms specified in **13.2.1**.

(1) Drawings of *ERD* (sectional drawings, details, assembly, etc.)

(2) Specification data sheets including the operating conditions and design limits listed in **(a)** through **(e)** below.

- (a) Maximum permissible operating pressures resulting from maximum charging air or exhaust gas back pressures
- (b) Maximum permissible operating temperatures resulting from maximum charging air or exhaust gas temperatures
- (c) Static opening pressures resulting from maximum charging air or exhaust gas back pressures
- (d) Maximum explosion pressures (i.e. maximum pressures that devices can withstand)
- (e) Geometric relief areas

(3) Product marking (such as labels indicating the items specified in **13.5**)

(4) Installation and operation manuals

(5) Test programs (including information about test locations and test dates)
(6) Specifications for test facilities (including test vessels)
(7) Information on manufacturing and quality control standards
(8) Records of manufacture and delivery
(9) Other information considered necessary by the Society

13.3 Approval Tests

13.3.1 General

1 *ERD* are to be tested in accordance with **13.3.2**.

2 Test specimens are to comply with the following:

(1) *ERD* used for explosion tests are to be selected from manufacturer production lines and be confirmed by Society surveyors and are to be either of the following **(a)** or **(b)**. *ERD* selection is to be witnessed by the Society's surveyor.
  (a) Finished certified components
  (b) Samples (semifinished components) taken from earlier stages of production of the components, when applicable

(2) If necessary, additional *ERD* may need to be selected for demonstrations of opening pressures. The selected *ERD* are to be clearly marked.

(3) If applicable, selected *ERD* are to be representative for the following **(a)** through **(e)** type ranges and operating conditions.
  (a) *ERD* kind (valves, rupture discs, etc.)
  (b) Mounting orientation (vertical or horizontal)
  (c) *ERD* design (spring design, sealing, etc.)
  (d) Flame arrester design
  (e) *ERD* intended to be fitted to air inlets or exhaust gas manifolds of engines provided with turbochargers with special characteristics as per the testing conditions of explosion tests

3 Test facilities for explosion tests are to comply with the following.

(1) Test facilities are to be accredited for *ERD* testing in accordance with national or international standards (e.g. *ISO ISO/IEC* 17025:2017) and be acceptable to the Society.

(2) Test facilities are to be equipped so that they can perform and record explosion testing in accordance with this chapter.

(3) Test facilities are to have equipment for controlling and measuring methane gas in the air concentrations within test vessels to an accuracy of ±0.1 %.

(4) Test facilities are to be capable of effective point-located ignition of methane and air mixtures.

(5) Test facilities are to be capable of measuring and recording pressure changes throughout explosion tests at frequencies recognising the speeds of events during explosions (10 *kHz* or above).

(6) The explosion tests (*ERD* tests) specified in **13.3.3(2)** are to be documented by high speed (250 frames/s or above) video recording. Such video recordings are to be provided with time stamps.

4 Test vessels for explosion tests are to comply with the following.

(1) Test vessels are to be simplified models of air inlets or exhaust gas manifolds. In addition, the free areas of connected turbochargers (compressors or turbine wheels) are to be considered.

(2) Test vessel shapes are to correspond to pipes with $L/D \geq 10$, where L represents overall test vessel length and D represents test vessel diameter.

(3) Test vessels are to be equipped with rupture discs at one front end to simulate turbochargers. The relief areas of the rupture discs are to be decided in relationship to test vessel diameter based on turbocharger manufacturer data for the equivalent free areas of compressors or turbine wheels. Opening pressures are to be ±10 % of *ERD* static opening pressures.

(4) Test vessel volumes are to comply with the specific relief area of an *ERD* of 700 cm^2/m^3 ±15 %.

(5) Test vessels are to be provided with all necessary flanges and connections for mounting *ERD* in their intended positions, for mounting rupture discs as turbocharger simulations, for

connecting methane and air mixture supplies and for measurement equipment.

(6) Ignition is to be made at the middles of test vessels.

(7) Test vessels are to be designed to verify homogeneous air and methane mixtures inside the vessel.

(8) Test vessels are to have connections for measuring their internal pressure at least the following two locations: one near *ERD* mounting positions and the other at test vessel centres.

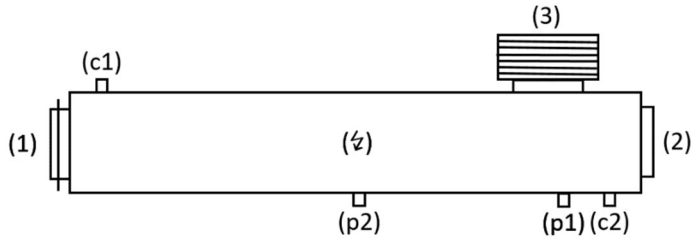
(9) Test vessels are to have design pressures of not less than the maximum explosion pressures of stoichiometric methane and air mixtures under the explosion test conditions specified in **13.3.4**.

(10) Test vessel configurations are subject to approval by the Society. Some typical test vessel configurations are shown in **Figure 6.13-1**.

Figure 6.13-1 Typical test vessel configurations

Case 1. Configuration without *ERD*
(flanges for *ERD* closed (2))

Case 2. Configuration with *ERD* (3) mounted at the front end of the test vessel



Case 3. Configuration with *ERD* (3) mounted on top of the test vessel

Notes

(1) Test vessel configurations are to be equipped with rupture discs for turbocharger simulations at one front end ((1) in the figure).

(2) The ignition is to be at test vessel centres ((ϟ) in the figure).

(3) Pressure sensors are to mounted at near *ERD* mounting positions ((p1) in the figure) and at test vessel centres ((p2) in the figure).

(4) The measuring of methane concentrations to verify homogeneous air and methane mixtures can be performed at both ends of test vessels ((c1) and (c2) in the figure).

13.3.2 Opening Pressure Demonstrations

ERD which have been selected in accordance with **13.3.1-2** are to be subjected to pressure tests at manufacturer works to demonstrate that static opening pressures are kept within manufacturer specifications and that the *ERD* are airtight at their maximum permissible operating pressures for at least 30 *seconds*.

13.3.3 Explosion Tests

Explosion testing is to be performed in two stages according to following **(1)** and **(2)** for *ERD* that requires approval of use. Explosion testing is to be witnessed by the Society's surveyor. Calibration records for instrumentation used to collect data are to be presented to attending surveyor for review.

(1) Reference test (Explosion testing without *ERD*)
  (a) The test vessel configuration is to be **Case 1** in **Figure 6.13-1**.
  (b) Two explosion tests are to be carried out in test vessels without *ERD*.
  (c) The aim of this test is to establish reference pressure levels for test vessels which can be used for determining the capabilities of relief valves in terms of pressure relief.

(2) *ERD* test (Explosion testing with *ERD*)
  (a) The test vessel configuration is to be either **Case 2** or **Case 3** in **Figure 6.13-1**.
  (b) Two explosion tests are to be carried out in test vessels with same *ERD* at the required positions (i.e. cases in above **(a)** that are required).
  (c) In cases where *ERD* are rupture discs with flame arresters, the rupture discs are to be replaced.
  (d) In cases where shielding arrangements to deflect the emission of explosion combustion products by the *ERD* are intended to be provided, *ERD* are to be tested with such shielding arrangements fitted.

13.3.4 Test Details

1 Test conditions are to comply with the intended use of the *ERD* such as the following **(1)** through **(4)**.

(1) Pipe diameters (diameters of combustion air inlet manifolds or exhaust gas manifolds)
(2) Operating pressures
(3) Operating temperatures
(4) Installation orientation

2 Explosion testing is to be carried out using air and methane mixtures with volumetric methane concentrations of 9.5 ± 0.5 %. Homogeneous air and methane mixtures inside test vessels are to be verified. Methane concentrations in test vessels are not to differ by more than 0.5 %.

3 Initial pressures in test vessels are to be the specified maximum operating pressures of the *ERD*.

4 Initial temperatures in test vessels are to be the specified maximum operating temperatures of the *ERD*.

5 In cases where initial pressures or initial temperatures deviate from design limits, *ERD* manufacturers are to prove the acceptability of such deviations either using standards or other applicable calculation methods.

6 Ignition is to be made using explosive charges of 50 to 100 *Joule*.

7 Successive explosion testing to establish *ERD* functionality is to be carried out as quickly as possible during stable weather conditions.

8 Pressure rise and decay during explosion testing are to be recorded.

9 The effects of *ERD* in terms of pressure relief following explosions are ascertained from the maximum pressures recorded at test vessel centres during the two stages of explosion testing specified in **13.3.3**. Pressure relief within test vessels due to *ERD* installation is the difference between the average pressures of the two explosions of the reference tests specified in **13.3.3(1)** and the averages of the two explosions of the *ERD* tests specified in **13.3.3(2)**.

10 There are to be no indications of flame or combustion outside *ERD* during testing for flame arresters functioning to be accepted as correct.

11 The confirmation specified in **10** above is to be monitored by high-speed video cameras, for which ambient light conditions are to be considered to maximise the potential for flame or combustion detection. The use of dark, ideally matt finished, backgrounds and the avoidance of direct light onto the video camera monitored areas are recommended.

12 After the *ERD* tests specified in **13.3.3(2)**, external conditions of flame arresters are to be examined for signs of damage or deformation that may affect *ERD* operation.

13 After completing explosion testing, *ERD* are to be dismantled and the conditions of their components are to be ascertained and documented.

13.3.5 Test Reports

Manufacturers are to prepare test reports for the demonstration tests specified in **13.3.2** and the explosion tests specified in **13.3.3**. Such reports are to include the following information and relevant documents are to be verified by attending surveyors and then submitted, in triplicate, to the Society after completion of the tests.

(1) Test specimens
(2) Test facilities (including measuring equipment and test vessels)
(3) Measuring results (pressures, temperatures, flame velocities, volumetric methane concentrations, ambient conditions, etc.)
(4) Video documentation of explosion tests
(5) Photo documentation of *ERD* components

13.3.6 Assessments

Consideration of the following **1** and **2** is to be given when verifying compliance with this chapter.

1 *ERD* function and mechanical integrity as specified in the following **(1)** through **(3)**.

(1) After dismantling the *ERD*, flame arresters are not to show signs of damage or deformation that may affect *ERD* operation.
(2) In cases where valves are used, indications of valve sticking or uneven opening during explosions that may affect subsequent valve operation is to be considered.
(3) *ERD* mechanical integrity is proven up to maximum explosion pressures (the average of the two explosions) of the *ERD* tests specified in **13.3.3(2)**.

2 Flame arrester functioning is considered satisfactory in cases where there are no indications of flame or combustion outside the *ERD* during explosion testing.

13.3.7 Validity of Approval

ERD approved in accordance with this chapter are valid only for the combustion air inlet manifolds or exhaust gas manifolds of engines using gas as fuel provided with turbochargers with the characteristics specified in **13.3.1-4**. Such "characteristics" refer to compressors or turbine wheels corresponding to test vessel rupture discs in terms of free area.

13.4 Approval

13.4.1 Notification of Approval

The Society, when satisfied upon examination of the documents submitted in accordance with **13.2** and **13.3** and the attending surveyor's report, will issue a certificate of approval specifying the approval number, approval date, items of approval and approval conditions. In addition, the Society will stamp on the documents submitted in accordance with **13.2.2** and **13.3.5** that it deems necessary with approval stamps and return them back to applicants.

13.4.2 Renewal of Approval

1 The valid term of the approval referred to in **13.4.1** is 5 *years*.

2 In cases where renewal of validity is intended, manufacturers are to submit copies of existing certificates along with new copies of the materials required by **13.2**. In such cases, however, the data required per **13.2** may be limited to only that which has been modified.

3 When approval has been granted for applications with partial changes in the content of approval, the Society may require additional approval tests.

4 Manufacturers whose renewal is approved are to return the old "Certificate of Approval" to the Society as soon as possible after receiving the new certificate and the term of validity of the old certificate expires.

13.4.3 Revocation of Approval

In cases where either of the following **(1)** through **(4)** applies, the Society will revoke type approval, and then notify manufacturers of such.

(1) In association with the implementation or revision of international conventions, laws, and regulations, equipment for which the approval was granted no longer meets the conditions for approval.

(2) In cases where the validity of approval is overdue and no application for renewal of approval is submitted.

(3) When serious shortcomings are found in the structure or quality of equipment already approved after being installed on ships.

(4) When applications for revocation are submitted by manufacturers.

13.5 Marking

Manufacturers are to mark approved devices before shipment to allow for identification of such approval. In addition, at least the following items are to be marked at the suitable locations on devices.

(1) Manufacturer name and address

(2) Designation and size

(3) Month and year of manufacture

(4) Approved installation orientation