GUIDANCE CHANGE NOTICE No.4

Part 1 Seagoing Ships

GUIDANCE FOR THE APPROVAL AND TYPE APPROVAL OF MATERIALS AND EQUIPMENT FOR MARINE USE

Volume W

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Foreword

This Guidance Change Notices (GCN) No. 4 provide amendment and corrigenda to the Guidance for The Approval and Type Approval of Materials and Equipment for Marine Use (Pt.1, Vol.W) 2022 edition along with effective date from which these changes are applicable. The amendments in this GCN refer to IACS UR M82 and UR W31 Rev.3.

Amendments to the preceding edition are marked by strikethrough, red color, and expanded text. These new additions and amendments are to be read in conjunction with the requirements given in GCN No.1, 2, 3 and the 2022 Edition of the Guidance.

The summary of current amendments for each section including the implementation date are indicated in *Table 1 - Amendments Incorporates in This Notice*.

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Any quires or comments concerning these Guidance are welcomed through communication with BKI Head Office.

Guidance Changes Notice No. 4 – September 2023

Table 1 – Amendments Incorporates in This Notice

These amendments will come into force as indicated in the Table.

Paragraph	Title/Subject	Status/Remark
Section 2 – Approval for Manufacturing Process *These amendments apply to applications for approval of manufacturer is dated on or after 1 July 2024*		
B.	Rolled Steels	
IV	YP47 Steel	
3.1.1	Extent of the approval tests	Added new requirements regarding the thickness of product to be chosen in the product testing as per Annex 1 of IACS UR W31 Rev.3
3.3.2	Y-shape weld crack test (Hydrogen crack test)	Updated the reference standards to ISO 17642-2:2015 as per Annex 1 of IACS UR W31 Rev.3
VII	Brittle Crack Arrest Steels	
3.1.1	Extent of the approval tests	Added a limitation for the extent of the approval test of YP47 steels with brittle crack arrest properties and new requirements regarding the thickness of product to be chosen in the product testing as per Annex 2 of IACS UR W31 Rev.3
3.3.4	-	Added new requirements regarding the judgement of acceptance for repeated brittle crack arrest test as per Annex 2 of IACS UR W31 Rev.3
6.	Renewal of approval	Deleted the word 'alternative' from the phrase 'small-scale alternative test results' in the Note
IX	Small-Scale Test Methods for Brittle Crack Arrest Steels	
all	–	Added new requirements regarding the approval scheme for small-scale test methods for brittle crack arrest steels as per IACS UR W31 Rev.3
Section 3 – Type Approval *These amendments apply to internal combustion engines using gas as fuel when the applications for certification of an engine dated on or after 1 July 2024 or to be installed in new ships for which the date of contract for construction is on or after 1 July 2024*		
I.	Explosion Relief Devices	
–	–	Changed the title of subsection I
I.	Crankcase Explosion Relief Valves	
–	–	the old I subsection changed into sub-subsection I
II.	Other Explosion Relief Devices	
all	–	Added new requirements regarding explosion relief devices to be installed in air inlet manifold and exhaust gas manifold of gas-fuelled engine as per IACS UR M82

Section 2 Approval for Manufacturing Process

B. Rolled Steels

IV. YP47 Steel

3. Approval tests

3.1 General

Approval test items, test methods and acceptance criteria not specified in these requirements are to be in accordance with B.I.

3.1.1 Extent of the approval tests

For reduction of the indicated number of casts, steel plate thicknesses, and grades to be tested requirements in B.I.3.4 are applied, except for 3.4.2 and 3.4.3.

The products for testing are to represent the maximum thickness for approval. If the target chemical composition changes with the thickness, the maximum thickness for each specified chemical composition specification shall be tested.

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3.3 Weldability test

3.3.1 Charpy V-notch Impact Test

1) Charpy V-notch impact tests are to be taken at a position of 1/4 thickness from the plate surface on the face side of the weld with the notch perpendicular to the plate surface.
2) One set of the specimens transverse to the weld is to be taken with the notch located at the fusion line and at a distance 2, 5 and minimum 20 mm from the fusion line.
3) The fusion boundary is to be identified by etching the specimens with a suitable reagent.
4) One additional set of the specimens is to be taken from the root side of the weld with the notch located at the same position and at the same depth as for the face side.
5) The impact test temperature is -40°C.
6) Additionally at each location, impact tests are to be carried out with appropriate temperature intervals to properly define the full transition range.

3.3.2 Y-shape weld crack test (Hydrogen crack test)

1) The test method is to be in accordance with recognized national standards such as ~~JIS Z 3158-2016 or CB/T 4364-2013~~ ISO 17642-2:2015.
2) Acceptance criteria are to be as deemed appropriate by BKI.

3.3.3 Brittle fracture initiation test

1) Deep notch test or CTOD test is to be carried out.
2) Test method and results are to be in accordance with 3.3.2 ~~of these requirements~~.

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VII. Brittle Crack Arrest Steels

3. Approval tests

3.1 General

Approval test items, test methods and acceptance criteria not specified in these requirements are to be in accordance with B.I.

3.1.1 Extent of the approval tests

The extent of the test program is specified in 3.2, 3.3 and 3.4.

If the manufacturing process and mechanism to ensure the brittle crack arrest properties for the steels intended for approval are same, the requirements in B.I.3.4. are to be followed for the extent of the approval tests except for YP47 steels with brittle crack arrest properties, 3.4.2 and 3.4.3 are not applied.

The products for testing are to represent the maximum thickness for approval. If the target chemical composition changes with the thickness, the maximum thickness for each specified chemical composition specification shall be tested.

The number of test samples and test specimens may be increased when deemed necessary by the BKI, based on the in-house test reports of the brittle crack arrest properties of the steels intended for approval specified in 2.1).

3.2 Type of tests

3.2.1 Brittle crack arrest tests are to be carried out in accordance with 3.3 in addition to the approval tests specified in B.I. and/or B.IV.

3.2.2 In the case of applying for addition of the specified brittle crack arrest properties for YP36, YP40 and YP47 steels of which, manufacturing process has been approved by BKI (i.e. the aim analyses~~,~~ and method of manufacture ~~and condition of supply~~ are similar and the steelmaking process, deoxidation and fine grain practice, casting method and condition of supply are the same), brittle crack arrest tests, chemical analyses, tensile test and Charpy V-notch impact test are to be carried out in accordance with this sub section and B.I.

3.3 Test specimens and testing procedure of brittle crack arrest tests

3.3.1 The test specimens of the brittle crack arrest tests are to be taken with their longitudinal axis parallel to the final rolling direction of the test plates.

3.3.2 The loading direction of brittle crack tests is to be parallel to the final rolling direction of the test plates.

3.3.3 The thickness of the test specimens of the brittle crack arrest tests is to be the full thickness of the test plates.

3.3.4 The test specimens and repeat test specimens are to be taken from the same steel plate. Where the brittle crack arrest properties are evaluated by K_{ca}, and the brittle crack arrest test result fails to meet the requirement, further brittle crack arrest tests may be carried out. In this case, the judgment of acceptance is to be made on the arrest toughness value K_{ca} of all test specimens (results of the initial test, failed tests and additional tests shall be included in the testing report.).

3.3.5 The thickness of the test specimen is to be the maximum thickness of the steel plate requested for approval.

3.3.6 In the case where the brittle crack arrest properties are evaluated by K_{ca}, the brittle crack arrest test method is to be in accordance with Annex 4 of Rules for Materials (Pt.1, Vol.V). In the case where the brittle crack arrest properties are evaluated by CAT, the test method is to be in accordance with Annex 5 of Rules for Materials (Pt.1, Vol.V).

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6. Renewal of approval

The manufacturer is also to submit to BKI actual manufacturing records of the approved brittle crack arrest steels within the term of validity of the manufacturing approval certificate.

Note:

Chemical composition, mechanical properties, brittle crack arrest properties (e.g. brittle crack arrest test results or small-scale ~~alternative~~ test results) and nominal thickness are to be described in the form of histogram or statistics.

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IX. Small-Scale Test Methods for Brittle Crack Arrest Steels

1. Application

1.1 This sub-section specifies the approval scheme of small-scale test methods which are used for product testing (batch release testing) of brittle crack arrest steels as specified in Rules for Materials (Pt.1, Vol.V) Sec.4, Table 4.28.

1.2 Unless otherwise specified in this sub-section, the requirements in B.IV and/or B.VII are to be followed.

2. Approval application

2.1 The manufacturer is to submit to BKI the following documents:

1) Application for approval of small-scale test procedure specification
2) Small-scale test procedure specification including the following items at least:
   - Applicable material grades, thickness range, deoxidation practice, heat treatment, etc.
   - Types and methods of small-scale tests
   - Sampling positions in plate thickness direction and final rolling direction of test specimens
   - Size and dimension of test specimens
   - Number of test specimens
   - Test conditions, such as test temperature
   - Acceptance criterion
   - Example of format of test report
   - Example of product inspection certificate including small-scale test results
   - Handling of the products when small-scale test results do not satisfy the criterion
3) Mechanism of achieving the brittle crack arrest properties of brittle crack arrest steels

4) Technical background for enabling the evaluation of brittle crack arrest properties by small-scale test methods considering the mechanism specified in above 3)

5) Procedure of the evaluation for the brittle crack arrest properties of brittle crack arrest steels by small-scale test results

6) Data records which validate the correlation between small-scale test results and the large brittle crack arrest test results of brittle crack arrest steels whose number can satisfy the requirement for minimum data number given in 3.3

7) Proposed test plan for approval

2.2 Small-scale test procedure specification is to be prepared in accordance with 3.

2.3 Where the manufacturer proposes to change any part of the approved small-scale test procedure specification, then the manufacturer is to submit to BKI the documents which can cover all items specified in 1.

2.4 The documents confirming the reason for the change shall be submitted to identify the impact of those changes on the existing procedure, and the proposed actions to address any such impacts.

3. Establishment of procedure specification for small-scale testing

3.1 General

3.1.1 Small-scale test methods are to be determined based on the manufacturer's own technical philosophy with regard to achieving the brittle crack arrest properties of brittle crack arrest steels. Furthermore, description of an appropriate correlation between large scale brittle crack arrest properties and small-scale test results is to be required, and the acceptance criterion of the small-scale test are to be determined, based on the followings:

- Mechanism of achieving the suitable brittle crack arrest properties
- Sampling position and direction
- Frequency of sampling
- Small-scale test methodology
- Demonstrated correlation between brittle crack arrest test results and small-scale test results
- Derivation of small scale testing acceptance criterion based on the statistical analysis

3.1.2 The manufacturer shall prepare the small-scale test procedure specification in accordance with the following 3.2 through 3.5.

3.2 Types and methods of testing

3.2.1 Types, methods, dimension and positions as well as direction of test specimens, etc. of small-scale tests are to be specified by the manufacturer, and approved in accordance with this sub-section.

3.2.2 In general, the test method should reproduce the crack initiation, propagation and arrest feature by such as the following test method.

- Combination of test methods, e.g. NRL drop weight test and V-notch Charpy impact test
- One test method, e.g. press-notch Charpy impact test or side-section drop weight test

3.2.3 In general, brittle crack arrest properties of brittle crack arrest steels are to be predicted using a regression equation on the relationship between small scale test result (e.g. transition temperature obtained by small scale tests) and large scale brittle crack arrest test result (e.g. K_{ca} or temperature

corresponding to the specific brittle crack arrest properties). Other approaches can be used subject to the approval of BKI.

NOTE:

Table 2.6a, Table 2.6b and Table 2.6c give the examples of small scale test methods.

3.2.4 For determination of test methods, the manufacturer should confirm the applicability of these test methods to their brittle crack arrest steels theoretically taking into account the methodology of test methods, their own mechanism of achieving the brittle crack arrest properties, and sampling positions of test specimens (See 3.1.1). Then, the manufacturer should also submit the technical background for determination of small-scale test methods to BKI as given in 2.1.

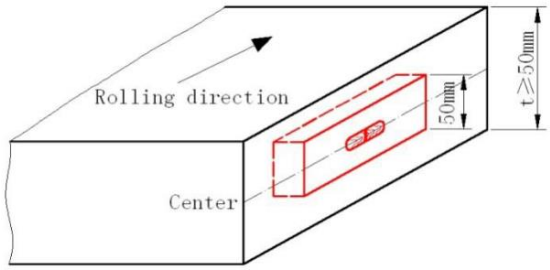
Table 2.6a Example of small-scale test method using NRL drop weight test and V-notch Charpy impact test (Informative)

Test type:	NRL drop weight test and V-notch Charpy impact test
Standard:	ASTM E208:2020 and ISO 148-1:2016
Sampling positions of test specimens:	NRL drop weight test: at surface V-notch charpy impact test: 1/4 of thickness
Length direction of test specimen:	Parallel to the final rolling direction of test plate
Regression equation:	$T_{Kca} = \alpha \cdot (NDTT + 10) + \beta \cdot vTrs + 153\,(t - 5)^{1/13} - 170{,}5$ T_{Kca} : Temperature at K_{ca} of 6000 N/mm$^{3/2}$ or K_{ca} of 8000 N/mm$^{3/2}$, (°C) NDTT : Nil-ductility transition temperature (°C) $_vT_{rs}$:Transition temperature of the absorbed energy (°C) t : thickness α, β(1) : constant
Notes:	(1) α and β are determined by comparing small-scale test results with brittle crack arrest test results.

Table 2.6b Example of small-scale test method using pressed-notch Charpy impact test (Informative)

Test type:	Pressed-notch Charpy impact test
Standard:	Dimension, shape, introducing method of notch: Manufacturer's proposal Others: ISO148-1:2016
Sampling positions of test specimens:	1/2 of thickness
Length direction of test specimen:	Parallel to the final rolling direction of test plate
Regression equation:	$T_{Kca} = \alpha\ {}_pT_{E\gamma J} + \beta$ T_{Kca} : Temperature at K_{ca} of 6000 N/mm$^{3/2}$ or K_{ca} of 8000 N/mm$^{3/2}$, (°C) $_pT_{E\gamma J}$:Test temperature at absorbed energy of γ (J), (°C) α and β : constant γ : Absorbed energy at brittle fracture surface ratio of δ (%), (J)
Notes:	α, β, γ and δ are determined by comparing small-scale test results with brittle crack arrest test results.

Table 2.6c Example of small-scale test method using Side-section drop weight test (Informative)

Test type:	Side-section drop weight test
Standard:	Dimension: P-2 type of ASTM E 208 2020
Sampling positions of test specimens:	1/2 of thickness and side-section 
Length direction of test specimen:	Parallel to the final rolling direction of test plate
Regression equation:	$T_{Kca} = \alpha + \beta \cdot T_{NDT}^{side} + \gamma \cdot t^{1,5}$ T_{Kca} : Temperature at K_{ca} of 6000 N/mm$^{3/2}$ or K_{ca} of 8000 N/mm$^{3/2}$, (°C) T_{NDT}^{side} : Nil-ductility transition temperature obtained by side-section drop weight test, (°C) t : thickness α, β, γ : constant γ : Absorbed energy at brittle fracture surface ratio of δ (%), (J)
Notes:	α, β, and γ are determined by comparing small-scale test results with brittle crack arrest test results.

3.3 Testing data

3.3.1 Selection of test plates

.1 Brittle crack arrest tests and small-scale tests are to be conducted for each material grade (including all suffixes) of brittle crack arrest steels.

.2 Brittle crack arrest tests and small-scale tests are to be carried out on at least 12 test plates, in accordance with .3, by which these test results can reliably estimate brittle crack arrest properties of brittle crack arrest steels.

NOTE:

"One test plate" means "the rolled product from a single slab or ingot if this is rolled directly into plates" as defined in Rules for Materials (Pt.1, Vol.V) Sec.4.

.3 In order to ensure appropriate correlation between small-scale test results and brittle crack arrest properties with various manufacturing conditions of steel plates, the steel plates should be representative for each combination of thickness range and heat sample to include:

- The intended maximum and minimum plate thickness
- Different heats are to be chosen for each thickness

Furthermore, the above test plates are to include a fixed number of steel plate(s) whose brittle crack arrest properties (i.e. brittle crack arrest test results) do not comply with the requirements specified in Rules for Materials (Pt.1, Vol.V) Table 4.28. Such a number should be at least one, but not exceeding one quarter of all test plates. Manufacturing process of these test plates can be different (or intentionally altered from the approved manufacturing process) from that of the brittle crack arrest steels to which the small-scale test method is applied. It is recommended that the strength grade of these test plates (non-compliant with

the relevant requirements of brittle crack arrest properties) are similar to that of the brittle crack arrest steels.

Where the manufacturer has requested approval for only a single thickness, the thickness of test plates can be only a single thickness. In this case, at least four steel plates for each combination of thickness (single thickness) and heats (three different heats) should be used, and the applicable thickness of the small scale test is only that single thickness condition.

.4 Brittle crack arrest steels used for the approval test of manufacturing process of these steels (and its approval test results) can also be used as the test plates specified in .3.

.5 Brittle crack arrest test specimens and small-scale test specimens are to be taken from the same test plate.

.6 A decrease of the total of the indicated number of test plates may be accepted by BKI in the following a) or b) cases:

a) When the manufacturer applies a small-scale test procedure specification to multiple material grades, and the manufacturing process and mechanism to ensure the brittle crack arrest properties of these different material grades are the same.

b) When a small-scale test procedure specification is already approved by BKI for one or some material grades, and the manufacturer applies similar small-scale test procedure specification to the other material grade(s), and the manufacturing process and mechanism to ensure the brittle crack arrest properties of these different material grades are same.

3.3.2 Brittle crack arrest tests

.1 Brittle crack arrest tests are to be carried out for each test plate in accordance with B.VII 3.3.

.2 Where brittle crack arrest tests are carried out for evaluation of K_{ca}, K_{ca} at a specific temperature is to be obtained in accordance with Rules for Materials (Pt.1 Vol.V) Annex 4, C.

.3 Where brittle crack arrest tests are carried out for evaluation of CAT, deterministic (actual) CAT is to be obtained in accordance with Rules for Materials (Pt.1 Vol.V) Annex 5, H.3.

3.3.3 Small-scale tests

.1 Small-scale tests are to be carried out in accordance with small-scale test procedure specification to be approved for each test plate.

.2 In general, the test specimens of small-scale tests are to be taken with their longitudinal axis parallel to the final rolling direction of the test plates.

.3 The test specimens of small-scale tests are to be taken from the specified positions in plate thickness direction of the test plates, as given in 3.2.3.

3.4 Validation of correlation

3.4.1 A regression equation on the relationship between brittle crack arrest property obtained from brittle crack arrest test and single or multiple small-scale test results is to be established. For brittle crack arrest properties, a specific temperature (e.g. $T_{Kca6000}$ in BCA1, $T_{Kca8000}$ in BCA2 or CAT) or the K_{ca} value at –10 °C may be used.

3.4.2 The validity of the regression equation shall be examined to predict brittle crack arrest properties with enough accuracy. The correlation in brittle crack arrest properties between the calculated values from small scale tests and the brittle crack arrest test results shall be assured by using the value of twice the

standard deviation (2σ). When using temperature for brittle crack arrest property, 2σ shall not be greater than 20°C. In other cases (e.g. K_{ca} value at -10°C), an upper limit of 2σ shall be established with the agreement of BKI.

NOTE:

Calculation procedure of the standard deviation (σ) is given as follows:

$$\sigma = \sqrt{\frac{1}{(n-1)}\sum_{i=1}^{n}(y_i - x_i)^2}$$

n : number of test plates

y_i *: brittle crack arrest property obtained from brittle crack arrest test for one test plate*

x_i *: brittle crack arrest property estimated from small scale tests for one test plate*

3.5 Acceptance criterion

3.5.1 Acceptance criterion of brittle crack arrest steels by the small-scale tests is to be proposed by the manufacturer based on the regression equation which is assured in the correlation with brittle crack arrest properties in 3.4 above. The criterion is to be determined so that regression equation can predict brittle crack arrest properties on safety side, considering the scatter of brittle crack arrest properties from the predicted value by the regression equation.

3.5.2 Unless otherwise agreed by BKI, an acceptance criterion of small-scale tests is to be determined by following procedures:

a) For correlation by means of temperature

i) The required temperature (see Fig 2.3a) is obtained by subtracting 2σ (°C) from the brittle crack arrest steel specification in Rules for Materials (Pt.1, Vol.V) Table 4.28, that is -10 – 2σ (°C), where 2σ is given in 3.4.2.

$T_{Kca6000}$ and $T_{Kca8000}$ in Fig. 2.3a are the temperatures at which the K_{ca} value of steel plates equals 6000 N/mm$^{3/2}$ and 8000 N/mm$^{3/2}$, respectively.

ii) The temperature predicted from the small-scale test results through the regression equation shall be no higher than the value of -10 - 2σ (°C).

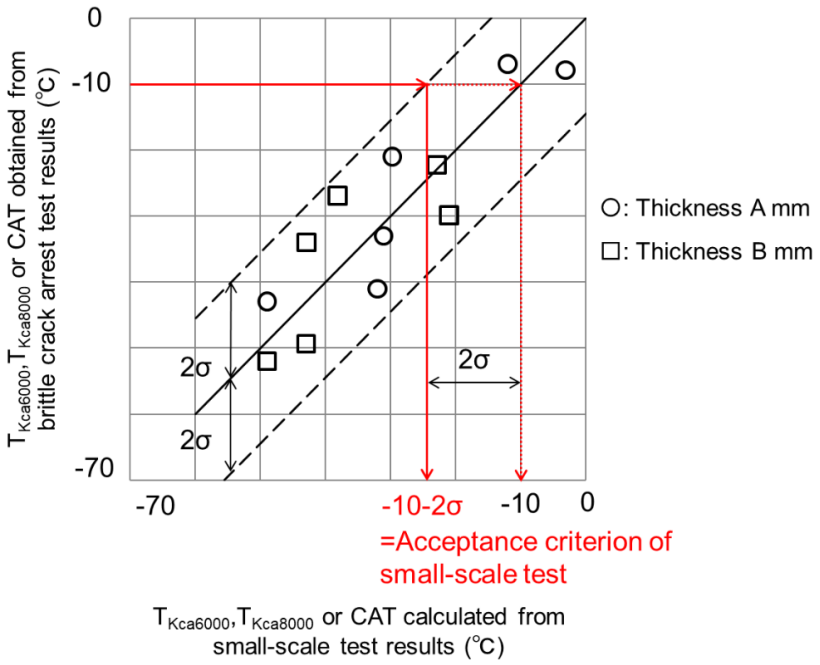


Fig. 2.3a Example for determination of acceptance criterion of small-scale test for correlation by means of temperature
(Note: This is only a schematic and may not represent the actual data obtained)

b) For correlation by means of brittle crack arrest toughness (K_{ca}):

i) The required K_{ca} (see Fig. 2.3b) is obtained by adding 2σ (N/mm$^{3/2}$) to the brittle crack arrest steel specification in Rules for Materials (Pt.1, Vol.V) Table 4.28, that is either 6000 + 2σ (N/mm$^{3/2}$) in BCA1 or 8000 + 2σ (N/mm$^{3/2}$) in BCA2, where 2σ is given in 3.4.2.

ii) The K_{ca} value predicted from the small-scale test results through the regression equation shall be no smaller than the value of 6000 + 2σ (N/mm$^{3/2}$) for BCA1, or 8000 + 2σ (N/mm$^{3/2}$) for BCA2.

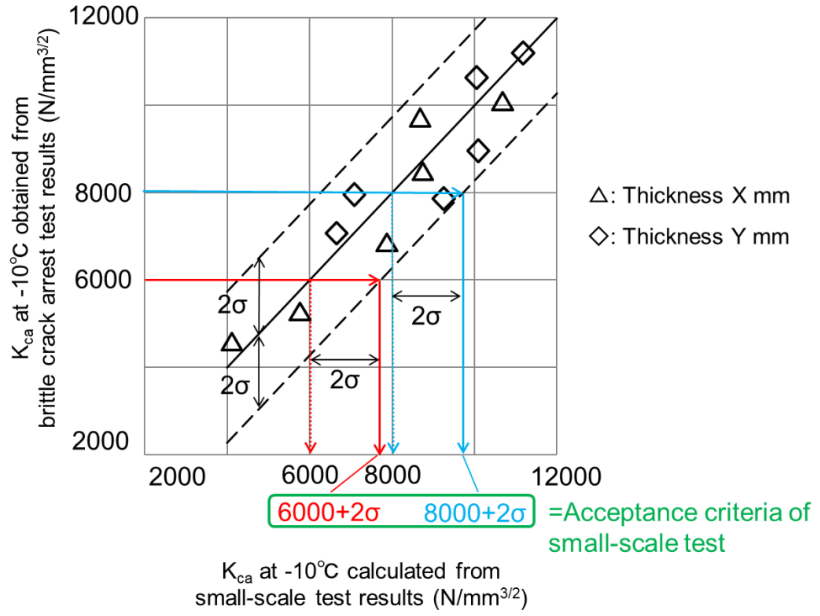


Fig. 2.3b Example for determination of acceptance criteria of small-scale test for correlation by means of brittle crack arrest toughness (K_{ca})
(Note: This is only a schematic and may not represent the actual data obtained)

4. Approval Tests

4.1 General

4.1.1 In order to confirm the validity of the submitted technical documents specified in 2.1, approval tests are to be carried out.

4.1.2 Approval test plan is to be approved by BKI prior to testing.

4.1.3 Considering the contents of the submitted technical documents specified in 2.1, BKI may require additional tests in the following cases:

a) When BKI determines that the number of brittle crack arrest tests or small-scale tests is too few to adequately confirm the validity of the acceptance criterion of small-scale tests (See 3.3.1);

b) When BKI determines that the testing data obtained for setting the acceptance criterion of small-scale tests varies too widely (See 3.4.2), or that the data is clustered producing a biased correlation curve;

c) When BKI determines that the validity of brittle crack arrest test results or small-scale test results for setting the acceptance criterion of small-scale tests is insufficient, or has some flaws during tests and/or for test results (See 3.3.2 and 3.3.3); and

d) Others as deemed necessary by BKI.

4.2 Extent of the approval tests

4.2.1 Extent of the approval tests is to be in accordance with B.IV 3.1.1 and B.VII 3.1.1.

4.3 Type of tests

4.3.1 Brittle crack arrest tests

.1 Brittle crack arrest tests are to be carried out in accordance with B.VII 3.3.

.2 Where brittle crack arrest tests are carried out for evaluation of K_{ca}, K_{ca} at a specific temperature ($T_{Kca6000}$ or $T_{Kca8000}$) is to be obtained in accordance with Rules for Materials (Pt.1 Vol.V) Annex 4, C.

.3 Where brittle crack arrest tests are carried out for evaluation of CAT, deterministic CAT is to be obtained in accordance with Rules for Materials (Pt.1 Vol.V) Annex 5, H.3.

4.3.2 Small-scale tests

.1 Small-scale tests are to be carried out in accordance with 3.3.3.

5. Results

5.1 Results of test items and the procedures shall comply with the test program approved by BKI.

5.2 For the brittle crack arrest test results, the manufacturer is to submit to BKI the brittle crack arrest test reports in accordance with Rules for Materials (Pt.1 Vol.V) Annex 4 for K_{ca} and Annex 5 for CAT.

5.3 For small-scale test results, the manufacturer is to submit to BKI the small-scale test reports in accordance with the example of format of test reports submitted as specified in 2.1 2).

6. Approval

Upon satisfactory completion of the survey and tests, and satisfactory confirmation of the submitted technical documents, the approval for small scale test procedure specification is granted by BKI.

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Section 3 Type Approval

I. Explosion Relief Devices

I. Crankcase Explosion Relief Valves

1. Application

The requirements in this sub-section apply to tests and inspections for the type approval of crankcase explosion relief valves intended to be fitted to engines and gear cases in accordance with the requirements of Rules for Machinery Installations (Pt.1, Vol.III) Sec. 2. F.3.1 and O.8.3.2. This test procedure is only applicable to explosion relief valves fitted with flame arresters.

2. Document to be submitted

The following reference data are to be submitted to BKI in addition to those specified in A.2.

- Accreditation certificate of test house
- Details of test vessel and attachment
- Test data performed previously at the manufacturer's works

3. Type tests

3.1 Test houses

The test houses where testing is carried out are to be accredited to a recognized standard, e.g. ISO/IEC 17025:2017, and the test facilities are to be equipped so that they can perform and record explosion testing in accordance with the requirements in this Sub section.

3.2 Valves to be tested

3.2.1 The valves used for type test shall be selected from the manufacturer’s normal production line by the Surveyor witnessing the tests and three valves for each size shall be selected. However, in case where the valves produced in series comply with the requirements specified in 3.4., type test may be exempted.

3.2.2 The valves selected for type testing are to have been previously tested at the manufacturer's works to demonstrate that the opening pressure is in accordance with the specification within a tolerance of ±20% and that the valve is air tight at a pressure below the opening pressure for at least 30 seconds.

3.2.3 In case where the orientation of installation could be changed, the valves are to be tested for each intended installation orientation.

3.3 Approval tests are to comply with the requirements given in Table 3.11.

Table 3.11 Type test and acceptance criteria of crankcase explosion relief valve

Kinds	Requirements
Explosion test process	1) All explosion tests to verify the functionality of crankcase explosion relief valves are to be carried out using an air and methane mixture with a methane concentration of 9,5% ±0,5%. The pressure in the test vessel is to be not less than atmospheric and not exceed 0,2 bar. 2) The concentration of methane in the test vessel is to be measured in the top and bottom of the vessel and is not to differ by more than 0,5%. 3) The ignition of the methane and air mixture is to be made at the centreline of the test vessel at a position approximately one third of the height or length of the test vessel opposite to where the valve is mounted. 4) The ignition is to be made using a maximum 100 joule explosive charge.
Test vessel for explosion testing	1) The test vessel for explosion testing is to have documented dimensions. The dimensions are to be such that the vessel is not "pipe like" with the distance between dished ends being not more than 2,5 times its diameter. The internal volume of the test vessel is to include any standpipe arrangements. 2) The pressure measuring equipment is to be capable of measuring the pressure in the test vessel in at least two positions, one at the valve(P2 in Fig. 3.5) and the other at the test vessel centre (P1 in Fig. 3.5). The measuring arrangements are to be capable of measuring and recording the pressure changes throughout an explosion test at a frequency recognising the speed of events during an explosion. The result of each test is to be documented by video recording and if necessary by recording with a heat sensitive camera. 3) The test vessel is to be provided with a flange, located centrally at one end perpendicular to the vessel longitudinal axis, for mounting the explosion relief valve. The test vessel is to be arranged in an orientation consistent with how the valve will be installed in service, i.e., in the vertical plane or the horizontal plane. 4) A circular plate is to be provided for fitting between the pressure vessel flange and valve to be tested with the following dimensions: A) Outside diameter of 2 times the outer diameter (D2 in Fig. 3.5) of the valve top cover. B) Internal bore having the same internal diameter (D1 in Fig. 3.5) as the valve to be tested. 5) The test vessel is to have connections for measuring the methane in air mixture at the top (G2 in Fig. 3.5) and bottom (G1 in Fig. 3.5). 6) The test vessel is to be provided with a means of fitting an ignition source at a position approximately one third of the height or length of the test vessel opposite to where the valve is mounted. 7) The test vessel volume is to be as far as practicable, related to the size and capability of the relief valve to be tested. In general, the volume is to correspond to the requirement for the free area of explosion relief valve to be not less than 115 cm^2/m^3 of crankcase gross volume. This means that the testing of a valve having 1150 cm^2 of free area, would require a test vessel with a volume of 10 m^3. Where the free area of relief valves is greater than 115 cm^2/m^3 of the crankcase gross volume, the volume of the test vessel is to be consistent with the design ratio. In no case is the volume of the test vessel to vary by more than +15% to -15% from the design cm^2/m^3 volume ratio. 8) The test facilities are to have equipment for controlling and measuring a methane gas in air concentration within a test vessel to an accuracy of ± 0,1%.

Table 3.11 Type test and acceptance criteria of Crankcase Explosion Relief valve *(continued)*

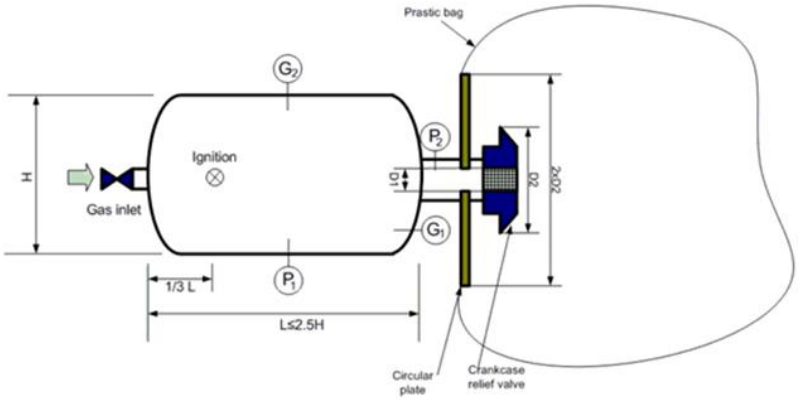
Kinds		Requirements
Test vessel for explosion testing		 Fig 3.5 test vessel for explosion testing
Explosion testing	General	1) Where valves are to be installed on an engine or gear case with shielding arrangements to deflect the emission of explosion combustion products, the valves are to be tested with the shielding arrangements fitted. 2) Successive explosion testing to establish a valve's functionality is to be carried out as quickly as possible during stable weather conditions. 3) The pressure rise and decay during all explosion testing is to be recorded. 4) The external condition of the valves is to be monitored during each test for indication of any flame release by video and heat sensitive camera. 5) For obtaining the type approval, the explosion testing for each valves shall be done for three stages respectively.
	Stage 1	Two explosion tests are to be carried out with the flange opening fitted with the circular plate covered by a 0,05 mm thick polythene film. These tests establish a reference pressure level for determination of the effects of a relief valve in terms of pressure rise in the test vessel
	Stage 2	1) Two explosion tests are to be carried out on three different valves of the same size. Each valve is to be mounted in the orientation that it requires approval for installation i.e., in the vertical or horizontal position with the circular plate located between the valve and pressure vessel mounting flange. 2) The first of the two tests on each valve is to be carried out with a 0,05 mm thick polythene bag, having a minimum diameter of three times the diameter of the circular plate and volume not less than 30% of the test vessel, enclosing the valve and circular plate. Before carrying out the explosion test the polythene bag is to be empty of air. The polythene bag is required to provide a readily visible means of assessing whether there is flame transmission through the relief valve following an explosion. (During the test, the explosion pressure will open the valve and some unburned methane/air mixture will be collected in the polythene bag. When the flame reaches the flame arrester and if there is flame transmission through the flame arrester, the methane/air mixture in the bag will be ignited and this will be visible.) 3) Provided that the first explosion test successfully demonstrated that there was no indication of combustion outside the flame arrester and there are no visible signs of damage to the flame arrester or valve, a second explosion test without the polythene bag arrangement is to be carried out as quickly as possible after the first test. During the second explosion test, the valve is to be visually monitored for any indication of combustion outside the flame arrester and video records are to be kept for subsequent analysis. The second test is required to demonstrate that the valve can still function in the event of a secondary crankcase explosion.

Table 3.11 Type test and acceptance criteria of Crankcase Explosion Relief valve *(continued)*

Kinds		Requirements
Explosion testing	Stage 2	4) After each explosion, the test vessel is to be maintained in the closed condition for at least 10 seconds to enable the tightness of the valve to be ascertained. The tightness of the valve can be verified during the test from the pressure/time records or by a separate test after completing the second explosion test.
	Stage 3	Carry out two further explosion tests as described in Stage 1. These further tests are required to provide an average base line value for assessment of pressure rise recognising that the test vessel ambient conditions may have changed during the testing of the explosion relief valves in Stage 2.
Assessment and Records		1) The valves to be tested are to have evidence of design appraisal/approval by BKI 2) The designation, dimensions and characteristics of the valves to be tested are to be recorded. This is to include the free area of the valve and of the flame arrester and the amount of valve lift at 0,2 bar. 3) The test vessel volume is to be determined and recorded. 4) For acceptance of the functioning of the flame arrester there is not to be any indication of flame or combustion outside the valve during an explosion test. This should be confirmed by the test laboratory taking into account measurements from the heat sensitive camera. 5) The pressure rise and decay during an explosion is to be recorded, with indication of the pressure variation showing the maximum overpressure and steady under pressure in the test vessel during testing. The pressure variation is to be recorded at two points in the pressure vessel. 6) The effect of an explosion relief valve in terms of pressure rise following an explosion is ascertained from maximum pressures recorded at the centre of the test vessel during the three stages. The pressure rise within the test vessel due to the installation of a relief valve is the difference between average pressure of the four explosions from Stages 1 and 3 and the average of the first tests on the three valves in Stage 2. The pressure rise is not to exceed the limit specified by the manufacturer. 7) The valve tightness is to be ascertained by verifying from the records at the time of testing that an under pressure of at least 0,3 bar is held by the test vessel for at least 10 seconds following an explosion. This test is to verify that the valve has effectively closed and is reasonably gas-tight following dynamic operation during an explosion. 8) After each explosion test in Stage 2, the external condition of the flame arrester is to be examined for signs of serious damage and/or deformation that may affect the operation of the valve. 9) After completing the explosion tests, the valves are to be dismantled and the condition of all components ascertained and documented. In particular, any indication of valve sticking or uneven opening that may affect operation of the valve is to be noted. Photographic record of the valve condition are to be taken and included in the report.

3.4 Design series qualification

3.4.1 The qualification of quenching devices to prevent the passage of flame can be evaluated for other similar devices of identical type where one device has been tested and found satisfactory.

3.4.2 The quenching ability of a flame arrester depends on the total mass of quenching lamellas/mesh. Provided the materials, thickness of materials, depth of lamellas/thickness of mesh layer and the quenching gaps are the same, then the same quenching ability can be qualified for different sizes of flame arresters subject to (a) and (b) being satisfied. However, valves which could not be subjected to this method shall be verified by the method as deemed appropriate by BKI.

(a) $$\frac{n_1}{n_2} = \sqrt{\frac{S_1}{S_2}}$$

(b) $$\frac{A_1}{A_2} = \frac{S_1}{S_2}$$

Where:

n_1 = total depth of flame arrester corresponding to the number of lamellas of size 1 quenching device for a valve with a relief area equal to S_1

n_2 = total depth of flame arrester corresponding to the number of lamellas of size 2 quenching devices for a valve with a relief area equal to S_2

A_1 = free area of quenching device for a valve with a relief area equal to S_1

A_2 = free area of quenching device for a valve with a relief area equal to S_2

3.4.3 The qualification of explosion relief valves of larger sizes than that which has been previously satisfactorily tested in accordance with this Sub section can be evaluated where valves are of identical type and have identical features of construction subject to the following:

1) The free area of a larger valve does not exceed three times + 5% that of the valve that has been satisfactorily tested.
2) One valve of the largest size, subject to 1), requiring qualification is subject to satisfactory testing required by 3.2.2 and stage 2 explosion testing specified in Table 3.11 except that a single valve will be accepted in item 1) of stage 2 explosion testing and the volume of the test vessel is not to be less than one third of the volume required in item 7) of test vessel specified in Table 3.11.
3) The assessment and records are to be in accordance with the requirements specified in Table 3.11 noting that item 6) will only be applicable to Stage 2 for a single valve.

3.4.4 The qualification of explosion relief valves of smaller sizes than that which has been previously satisfactorily tested in accordance with this Sub sections can be evaluated where valves are of identical type and have identical features of construction subject to the following:

1) The free area of a smaller valve is not less than one third of the valve that has been satisfactorily tested.
2) One valve of the smallest size, subject to 1), requiring qualification is subject to satisfactory testing required by 3.2.2 and stage 2 explosion testing specified in Table 3.11 except that a single valve will be accepted in item 1) of stage 2 explosion testing and the volume of the test vessel is not to be more than the volume required in item 7) of test vessel specified in Table 3.11.
3) The assessment and records are to be in accordance with the requirements specified in Table 3.11 nothing that item 6) will only be applicable to Stage 2 for a single valve.

3.4.5 Valves passed the type tests specified in this Sub section and valves having sizes between valves qualified according to the requirements in 3.4.3 and 3.4.4 may be qualified without type tests provided that calculation result of 3.4.2 is satisfactory.

3.5 Test report

The test facility is to deliver a full report that includes the following information and documents:

- Test specification.
- Details of test pressure vessel and valves tested.
- The orientation in which the valve was tested, (vertical or horizontal position).

- Methane in air concentration for each test.
- Ignition source
- Pressure curves for each test.
- Video recordings of each valve test.
- The assessment and records stated in Table 3.11

II. Other Explosion Relief Devices

1. Application

The requirements in this sub-section apply to tests and inspections for the type approval of explosion relief devices for combustion air inlet manifold and exhaust gas manifold of internal combustion engines using gas as fuel in accordance with the requirements of Rules for Machinery Installations (Pt.1, Vol.III) Sec. 2. O.8.3.3.

Explosion relief device (ERD) means a device to protect a component against a determined overpressure in the event of a gas explosion. The device is fitted with a flame arrester and may be a valve, a rupture disc or other, as applicable.

2. Document to be submitted

The following documents are to be submitted to BKI for approval in addition to those specified in A.2.

- Drawings (sectional drawings, details, assembly etc.)
- Specification data sheet including operating conditions and design limits such as:
  - maximum permissible operating pressure, resulting from maximum charging air or exhaust gas back pressure
  - maximum permissible operating temperature, resulting from maximum charging air or exhaust gas temperature
  - static opening pressure, resulting from maximum charging air or exhaust gas back pressure
  - maximum explosion pressure, i.e. maximum pressure that the device can withstand
  - geometric relief area
- Product marking
- Installation and operation manual
- Test program
- Specification of test vessel

3. Type tests

3.1 Test specimens

The ERD used for the explosion test is to be selected from the manufacturer's production line by a representative of BKI:

- as a finished certified component itself, or
- on samples taken from earlier stages in the production of the component, when applicable.

If necessary, an additional ERD may need to be selected for the demonstration of the opening pressure. The selected ERD has to be clearly marked.

If applicable, the selected ERD shall be representative for the type range and operating conditions, for example:

- kind of ERD (valve, rupture disc, etc.),
- mounting orientation (vertical, horizontal)
- design of ERD (e.g., spring design, sealing)
- design of flame arrester
- ERD intended to be fitted to the air inlet or exhaust gas manifold of an engine having a turbocharger with characteristics as per the testing conditions in 3.3.2.

The selection of the representative ERD is subject to approval by BKI.

3.2 Demonstration of opening pressure

The ERD which has been selected is to be subjected to a pressure test at the manufacturer's works to demonstrate that the static opening pressure is kept within the manufacturer's specification and that the ERD is air tight at the maximum permissible operating pressure for at least 30 seconds.

3.3 Explosion test

3.3.1 Test facility

The test facilities are to be accredited to a national or international standard, e.g. ISO/IEC 17025:2017, and are to be acceptable to BKI.

The test facilities are to be equipped so that they can perform and record explosion testing in accordance with this procedure.

The test facilities are to have equipment for controlling and measuring a methane gas concentration within a test vessel to an accuracy of ± 0,1%.

The test facilities are to be capable of effective point-located ignition of a methane/air mixture.

The test facility arrangements are to be capable of measuring and recording the pressure changes throughout an explosion test at a frequency recognizing the speed of the events during an explosion (10 kHz or above).

The explosion test (3.3.5) is to be documented by high speed (250 frames/s or above) video recording. The video recording shall be provided with a time stamp.

3.3.2 Test vessel

The test vessel is a simplified model of the air inlet or exhaust gas manifold. The free area of the connected turbo charger (compressor or turbine wheel) is to be considered.

The test vessel shall comply with the following requirements:

- The shape of the test vessel is to correspond to a pipe with L/D = 10.
- The test vessel is to be equipped with a rupture disc at one front end to simulate the turbocharger. The relief area of the rupture disc shall be in relationship to the test vessel diameter based on turbocharger manufacturer data for an equivalent free area of compressor or turbine wheel. The opening pressure shall be ± 10% of the static opening pressure of the ERD.
- The volume of the test vessel is to comply with the specific relief area of the ERD of 700 cm^2/m^3 ± 15%.

- The test vessel is to be provided with all necessary flanges and connection to mount the ERD in the intended position, to mount a rupture disc as turbocharger simulation, to connect the methane-air mixture supply and the measurement equipment.
- The ignition is to be made at the middle of the test vessel.
- The test vessel is to be designed to verify a homogeneous air/methane mixture inside the vessel.
- The test vessel is to have connections for measuring the pressure in the test vessel in at least two positions, one at the ERD and the other at the test vessel center.
- The test vessel is to have a design pressure of not less than the maximum explosion pressure of a stoichiometric air/methane mixture at test conditions in 3.3.6.
- The test vessel configuration is subject to approval by BKI.

Typical test vessel configurations:

All test vessel configurations to be equipped with a rupture disc (1) (turbocharger simulation) at one front end. The ignition is in the centre of the test vessel (↯). The pressure sensors are mounted at the valve flanges (p1) and at the test vessel centre (p2). The measuring of the methane concentration to verify a homogeneous air/methane mixture can be performed at both ends of the test vessel, e.g. (c1) and (c2).

Fig. 3.5a Configuration without ERD (flanges for ERDs closed (2))

Fig. 3.5b Configuration with ERD (3) mounted at the front end of the test vessel

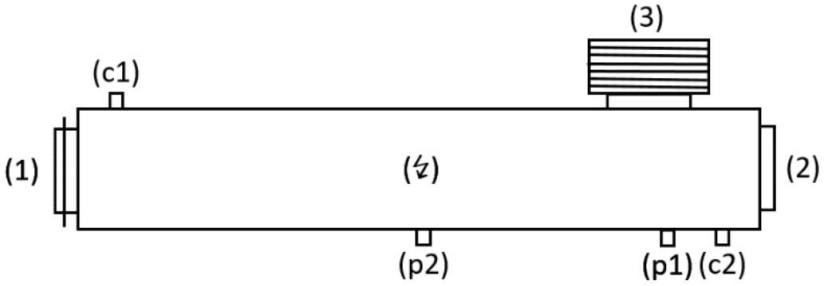


Fig. 3.5c Configuration with ERD (3) mounted on top of the test vessel

3.3.3 Explosion test process

The explosion testing is to be performed in two stages according to 3.3.4 and 3.3.5 for each ERD that is required to be approved as type tested. The explosion testing is to be witnessed by a BKI surveyor.

Calibration records for the instrumentation used to collect data are to be presented to, and reviewed by, the attending surveyor.

3.3.4 Reference test – Explosion test without ERD

Two explosion tests are to be carried out in the test vessel without ERD. The test vessel configuration is shown in Fig. 3.5a.

The aim of this test is to establish a reference pressure level in the test vessel which can be used for determination of the capability of a relief valve in terms of pressure relief.

3.3.5 ERD test – Explosion test with ERD

Two explosion tests are to be carried out in the test vessel with the same ERD at the required position. If the ERD is a rupture disc with flame arrester, the rupture disc shall be replaced.

If shielding arrangements to deflect the emission of explosion combustion products at the ERD are intended, the ERD are to be tested with the shielding arrangements fitted. The test vessel configuration is shown in Fig. 3.5b or Fig. 3.5c.

3.3.6 Explosion test method

The test conditions shall comply with the intended use of the ERD, such as:

- pipe diameter
- operating pressure
- operating temperature
- installation orientation.

All explosion tests are to be carried out using an air and methane mixture with a volumetric methane concentration of 9,5% ± 0,5%. A homogeneous air / methane mixture inside the test vessel is to be verified. The concentration of methane shall not differ by more than 0,5%.

The initial pressure in the test vessel is to be the specified maximum operating pressure of the ERD.

The initial temperature in the test vessel is to be the specified maximum operating temperature of the ERD.

If the initial pressure and/or initial temperature deviate from the design limits, the ERD manufacturer shall prove the acceptability of this deviation either using standards or generally applicable calculation methods.

The ignition is to be made using an explosive charge of 50 - 100 Joule.

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

The pressure rise and decay during all explosion testing is to be recorded.

The effect of an ERD in terms of pressure relief following an explosion is ascertained from maximum pressure recorded at the centre of the test vessel during the two stages. The pressure relief within the test vessel due to the installation of an ERD is the difference between average pressure of the two explosions of the reference test (3.3.4) and the average of the two explosions of the ERD test (3.3.5).

For acceptance of correct functioning of the flame arrester, there is to be no indication of flame or combustion outside of the ERD during its testing (3.3.5). This is to be monitored by a high-speed video camera (3.3.1), for which ambient light conditions are to be considered to maximise the potential for

flame/combustion detection. The use of a dark, ideally matt finish, background and an avoidance of direct light onto the video camera monitored area are recommended.

After each ERD test (3.3.5), the external condition of the flame arrester to be examined for signs of damage and/or deformation that may affect the operation of the ERD.

3.4 Check of ERD components

After completing the explosion tests, the ERDs are to be dismantled and the condition of all components are to be ascertained and documented.

4. Test report

A complete test report has to be submitted to BKI for

- the demonstration of opening pressure (3.2) and
- the explosion test (3.3).

The reports shall include respective information according to the requirements in 3., as applicable:

- test specimens
- test facility, including measuring equipment and test vessel
- measuring results (pressures, temperatures, flame velocities, volumetric methane concentration, ambient conditions etc.)
- video documentation of explosion tests
- photo documentation of ERD components

5. Assessment

To verify compliance with this requirement the assessment has to address the following:

- Function and mechanical integrity of the ERD.
  - After dismantling of the ERD, the flame arrester shall not show signs of damage or any deformation that may affect the operation of the ERD.
  - If a valve is used any indication of valve sticking or uneven opening during the explosion that may affect subsequent operation of the valve has to be considered.
  - The mechanical integrity of the ERD is proven up to a maximum explosion pressure (as average of the two explosions) of the ERD tests in 3.3.5.
- The functioning of the flame arresters is considered satisfactory if there is no indication of flame or combustion outside the ERD during the explosion tests.

6. Approval

The approval of an ERD is based on the appraisal of plans and particulars and the test report of type testing.

The type approval is valid only for an ERD fitted to the air inlet or exhaust gas manifold of an engine having a turbocharger with compressor or turbine wheel characteristics corresponding to those required in 3.3.2 for the test vessel rupture disc in terms of free area.

---------- *end* ----------