CLASS PROGRAMME

Type approval

DNVGL-CP-0086

Adhesive systems

Edition March 2016
FOREWORD

DNV GL class programmes contain procedural and technical requirements including acceptance criteria for obtaining and retaining certificates for objects and organisations related to classification.

© DNV GL AS March 2016

Any comments may be sent by e-mail to rules@dnvgl.com

This service document has been prepared based on available knowledge, technology and/or information at the time of issuance of this document. The use of this document by others than DNV GL is at the user’s sole risk. DNV GL does not accept any liability or responsibility for loss or damages resulting from any use of this document.
CHANGES – CURRENT

This is a new document.
CONTENTS

Changes – current........................................................................................................................................3

Section 1 General ........................................................................................................................................5
  1 Introduction.......................................................................................................................................5
  2 References........................................................................................................................................6
  3 Documentation..................................................................................................................................7

Section 2 General requirements ..............................................................................................................9
  1 Design requirements.........................................................................................................................9
  2 Requirements to production and quality control arrangement ........................................................................9
  3 Description of type testing............................................................................................................... 9
  4 Requirements to material................................................................................................................ 9
  5 Requirements to rigid adhesives....................................................................................................... 10
  6 Requirements to flexible adhesives................................................................................................. 11
  7 Requirements to sealants.................................................................................................................. 14
  8 Requirements to marking of product............................................................................................. 15

Changes – historic ...................................................................................................................................16
SECTION 1 GENERAL

1 Introduction

1.1 Objective
The objective of this class programme (CP) is to give a description for type approval of adhesive systems.

The general requirements for obtaining DNV GL type approval certificate is given in class programme DNVGL CP 0338 DNV GL type approval scheme.

The procedures and requirements described in this CP are applicable for obtaining the Society's type approval (TA) certificate based on requirements of the Society's rules and standards,

— DNV GL rules, RU SHIP Pt.2 Ch.3
— the standard DNVGL ST 0189, Lifeboats and Rescue Boats
— the standard DNVGL ST 0342, Craft.

Guidance note:
This class programme is not applicable for obtaining EU Marine Equipment Directive (MED) certificates. Visit www.dnvgl.com for information on MED certification.

1.2 Scope
This CP gives a description of the procedures and requirements related to documentation, design and type testing applicable for TA of adhesive systems.

This CP does not set the design requirements to the adhesive systems. TA is based on compliance with design requirements given in the DNV GL rules and/or other regulations and standards. The CP describes how to document compliance with the requirements in order to obtain a TA certificate for the equipment. This includes, where relevant, technical requirements for how the type tests shall be performed.

The scope of this class programme for adhesives is limited to pre-selecting adhesives by:

— carrying out basic performance testing and
— defining mechanical performance data for basic joint design.

One type approval certificate will cover one grade of the actual product with the possibility to include colour variants.

Adhesives with different chemical composition are considered different grades. Minor changes, as colour changes, may be accepted provided that it can be proven no differences in mechanical and adhesive behaviour.

Approval covering different adherends is considered variants. The mechanical and adhesive properties shall be proven for all adherends. Different aluminium series like 5000, 6000, etc. are considered variants.

One type approval certificate is normally limited to one manufacturer at one production site, however, other arrangements may be agreed with the Society.

Type tests as specified in Sec.2 [3], shall be carried out and verified in one of the following ways:

— at a DNV GL laboratory
— at a recognized and independent laboratory or a laboratory accepted by the Society
— at the manufacturer's premises in the presence of a surveyor, after consultation with the the Society's responsible approval centre. It is recommended to test at external testing laboratories due to the long duration of some tests.

The type test results shall be submitted to the Society in form of a test report according to ISO 17025 and the additional requirements of the relevant test standard for evaluation.
1.3 Application

DNV GL rules RU SHIP Pt.2 Ch.3 require that adhesives are type approved in accordance with this CP for equipment to be installed on DNV GL classed vessels.

A TA certificate in accordance with this CP will confirm compliance with the requirements in the rules as specified in [1.1]. The TA certificate will not confirm compliance with requirements in other parts of the rules. In case additional requirements in other parts of the rules shall be covered by the TA certificate, this shall be specified in the application for TA and will be stated in the TA certificate.

1.4 Renewal

For approved manufacturer in accordance with DNVGL CP 0425, Manufacturer of fiber reinforcements, an exemption from the obligation concerning retention and renewal surveys listed in the class programme DNVGL CP 0338 Type Approval scheme will typically apply.

2 References

Standards referred to in this document:

— ISO 34-1:2010, Rubber, vulcanized or thermoplastic -- Determination of tear strength -- Part 1: Trouser, angle and crescent test pieces
— ISO 75-1:2013, Plastics -- Determination of temperature of deflection under load -- Part 1: General test method
— ISO 1675, Plastics -- Liquid resins -- Determination of density by the pyknometer method
— ISO 3219:1993, Plastics -- Polymers/resins in the liquid state or as emulsions or dispersions -- Determination of viscosity using a rotational viscometer with defined shear rate
— ISO 7619-1:2010, Rubber, vulcanized or thermoplastic -- Determination of indentation hardness -- Part 1: Durometer method (Shore hardness)
— ISO 10364:2007, Structural adhesives -- Determination of the pot life (working life) of multi-component adhesives
— ISO 11339:2010, Adhesives -- T-peel test for flexible-to-flexible bonded assemblies
— DIN EN 1465:2009, Adhesives - Determination of tensile lap-shear strength of bonded assemblies
— EN ISO 8340:2005, Building construction -- Sealants -- Determination of tensile properties at maintained extension
— DIN 53504:2009, *Testing of rubber - determination of tensile strength at break, tensile stress at yield, elongation at break and stress values in a tensile test*

3 Documentation

For TA of adhesive systems the following additional documentation shall be submitted by the manufacturer at initial type approval, and updated at renewal (general documentation requirements are given by DNVGL CP 0338). The documentation shall, to the extent possible, be submitted as electronic files. The manufacturer shall keep one (1) copy of type approval documentation in their own file. The documentation that forms the basis for the TA shall be easily available for the Society's surveyor at the TA company's premises. When documentation is submitted in paper format, normally two copies of the documentation shall be submitted to the Society. No documentation will be returned to the company applying for TA.

Please number documentation according to below list to facilitate review:

1) type designation, i.e. product name (grade) with list of variants to be included in and stated on the type approval certificate
2) DNV GL approval of manufacturer certificate, if applicable, (see DNVGL CP 0425 Manufacturer of laminating resins, adhesives and coatings) which is valid for at least one year.

**Guidance note:**
A valid AoM exempts from the obligation concerning retention and renewal procedures listed in the class programme DNVGL CP 0338 type approval scheme.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
3) basis for approval. A reference to applicable rules and standards, which the product shall comply with.
4) product description including:
   — type of adhesive
   — type of curing system (including non-compatibility with other curing systems/ chemicals)
   — information regarding possible lack of chemical resistance to oils, detergents, etc. if applicable
   — environmental limitations on the use of the adhesive, e.g. allowable temperature range or humidity
   — documentation of in-service experience, if available.
5) list of adherends approval is applied for (for aluminium, different alloy groups like 5000-, 6000- series, etc.).
6) procedure for preparation of each adherend
7) procedure for application including:
   — mixing ratio
   — pot life/open time
   — range of:
     — temperature
— humidity
— temperature over dew point
— max. and min. thickness of adhesive joint

8) procedure for curing
9) field of application and special limitations of the product (application procedure and required surface treatment prior to adhesive bonding, compatibility/non-compatibility with other materials, etc.)
10) product specification, including data sheets (TDS and MSDS) for all variants
11) description of production processes, including standard operating procedures (SOP)
12) description of quality assurance system or copy of ISO 9001 certificate
13) quality plan for material intended to be installed on board ships
14) test results (from tests already carried out) with references to standards, methods etc.
15) information regarding marking of the product or packaging
16) any relevant certificates with their issue number and/or date (e.g. quality management system certificate)
17) list of test and measuring equipment, including calibration certificates
18) in-service experience, if available
19) witnessed type test results and initial assessment report by the Society's surveyor shall be submitted when completed.

\[\text{1 Will be verified by initial assessment prior to issuance of type approval certificate}\]
\[\text{2 Will be verified by surveyor during type testing}\]
SECTION 2 GENERAL REQUIREMENTS

1 Design requirements

1.1
The adhesive system shall comply with the relevant requirements given in Sec.1 [1.1].

2 Requirements to production and quality control arrangement
The manufacturer should have a quality system that meets ISO 9001 standards, or equivalent. If this quality standard is not fulfilled, the extent of type testing and assessments will be specially considered.
The quality control arrangement in production will be checked with respect to:
— control of incoming materials
— scope of quality control, i.e. proof that test methods, test quantity and test equipment complies to the applicable standard EN or ISO
— traceability and marking system
— production records
— storage condition and procedure.

3 Description of type testing
Type testing shall be carried out as per [4].

3.1 Definitions
Initial = initial assessment
Retention = periodical assessment, carried out after two (2) years
Renewal = periodical assessment, carried out after five (5) years.

4 Requirements to material

4.1 General
Stress patterns in adhesive joints are highly sensitive to the geometry of the joint, materials used and the type of loading.
The design of each joint shall be evaluated during approval of classed objects, and this evaluation is not included in the type approval.
To obtain approval for an adhesively bonded joint or structure additional tests may be required such as fatigue or impact, etc.
There are many different types of adhesives. For the purpose of this type approval programme adhesives are grouped as follows:
— rigid adhesives: high strength adhesives with high stiffness, one typical example are high performance epoxy adhesives
— flexible adhesives: have low strength, low stiffness and high strain to failure, one typical example is polyurethane adhesives
— sealants: are similar to flexible adhesives with the only exception that they are not meant to transfer loads or moments.
For each type of adhesive, different requirements have been defined. The type of adhesive shall be specified when applying for type approval.

## 5 Requirements to rigid adhesives

### 5.1 General

A general description of the adhesive shall be provided. Basic properties of the cured adhesive shall be verified by the testing.

### 5.2 Properties of the uncured adhesive

In the processing state, the following information shall be provided:

- density, according to ISO 1675
- viscosity, according to ISO 3219.

In the case of two-component thermosetting resins which cure at room temperatures, the pot life, according to ISO 10364, shall also be indicated.

### 5.3 Properties in the cured state

The following mechanical properties shall be verified:

- tensile lap-shear strength
- long-duration tensile lap-shear test
- tensile lap-shear test at elevated temperature
- peeling resistance
- determination of temperature of deflection under load (ISO 75-2)

Tensile test: Measure the tensile modulus $E$ and the Poisson’s ratio $\mu$

- measurement of $pH$: measurement of $pH$ to avoid corrosion problems later on in the joint.
- shear modulus ($G$): shear modulus ($G$) is calculated from Young’s modulus and Poisson’s ratio according to:

\[
G = \frac{E}{2(1 + \mu)} \tag{1}
\]

Glass transition temperature, $T_g$: The glass transition temperature ($T_g$) of the adhesive shall be determined by dynamic mechanical analysis (DMA).

A summary of requirements to testing of rigid adhesives are given in Table 1.

Number of test specimens for each testing to be agreed upon for each specific case.

### Table 1 Requirements to rigid adhesives

<table>
<thead>
<tr>
<th>Property</th>
<th>Test conditions</th>
<th>Test method (^{1)})</th>
<th>Acceptance criteria, data format, and unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile lap-shear test (^{2)})</td>
<td>At RT after 24 ± 1 h curing at 23°C and storage at 50% relative humidity (^{3)})</td>
<td>EN 1465</td>
<td>12 MPa</td>
</tr>
<tr>
<td>Tensile lap-shear test after immersion in water (^{2)})</td>
<td>At RT after 1000 ± 12 h storage in distilled water at 23°C</td>
<td>EN 1465</td>
<td>12 MPa</td>
</tr>
<tr>
<td>Property</td>
<td>Test conditions</td>
<td>Test method</td>
<td>Acceptance criteria, data format, and unit</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>-------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Tensile lap-shear test at elevated temperatures 2)</td>
<td>At 50 °C</td>
<td>EN 1465</td>
<td>12 MPa</td>
</tr>
</tbody>
</table>
| Long-term tensile lap-shear test 2)                                      | At 23/50 at 60% of the mean tensile lap-shear strength for 192 ± 2 h            | EN 1465     | - creep deformation ≤ 0.18 mm for a bondline thickness of 0.5 mm
|                                                                             |                                                                                 |             | - creep deformation ≤ 1.0 mm for a bondline thickness of 3.0 mm |
| T-peel test 2)                                                            | At RT after 24 ± 1 h curing at 23°C and storage at 50% relative humidity 3)     | ISO 11339   | 2 N/mm                                   |
| T-peel test after immersion in water 2)                                   | At RT after 1000 ± 12 h storage in distilled water at 23°C                       | ISO 11339   | 2 N/mm                                   |
| Measurement of pH                                                         | Prepare test specimen according to ISO 527-2, type 1A. Insert test specimen into test tube, fill with de-ionized water and close test tube. Store the test tube in a temperature chamber for 30 days at 40°C. Measure pH value using litmus paper | -           | Document pH. If pH value is outside the allowed range, the adhesive joint must be protected against the impact water. Acceptable levels of pH:
|                                                                             |                                                                                 |             | — aluminium: pH 6 to pH 8
|                                                                             |                                                                                 |             | — polycarbonate: pH 4 to pH 10
|                                                                             |                                                                                 |             | — steel: always to be protected against the impact of water |
| Tensile modulus E_t and Poisson's ratio                                   | At 23/50, test specimen 1B                                                      | ISO 527-1,2 | MPa                                      |
| Shear modulus, G                                                          | Calculate                                                                       | -           | MPa                                      |
| HDT test                                                                  | At RT after 24 ± 1 h curing at 23°C and storage at 50% relative humidity 3)     | ISO 75-1,2 method A | 65ºC                                      |
| HDT test                                                                  | At RT after 1000 ± 12 h storage in distilled water at 23°C                       | ISO 75-1,2 method A | 65ºC                                      |

1) Other standards may be agreed upon with the Society prior to testing  
2) specimens with an adhesive layer thickness of 0.5 mm and 3.0 mm shall be used and the substrate has to be agreed with the Society prior to testing  
3) other curing conditions may be agreed upon with the Society prior to testing.

6 Requirements to flexible adhesives

6.1 General

A general description of the adhesive shall be given. The fundamental properties of the cured adhesive shall be verified by the testing.
6.2 Requirements to testing

*Measurement of pH*: Measurement of pH to avoid corrosion problems later on in the joint.

6.3 Shear modulus

*Shear modulus* (G): Shear modulus (G) is calculated from Young’s modulus and Poisson’s ratio according to equation (1):

6.4 Glass transition temperature, $T_g$

*Glass transition temperature, $T_g$*: The glass transition temperature ($T_g$) of the adhesive shall be determined according to ISO 6721-2.

6.5 Ready to use condition

The following shall be stated for the ready-to-use condition:

- density, according to ISO 1675
- pot-life for two-component products (100 g mixture in a beaker) at 10°C and 30% relative humidity (RH) and also at 30°C and 70% RH
- skin-forming time at 10°C and 30% RH and also at 30°C and 70% RH.

6.6 Curing process

For the curing process, the following shall be given:

- curing distance at 10°C/30% RH and 30°C/70% RH after 24 hours, and also after 3, 7, and 28 days, for single-component systems
- tensile stress at yield according to DIN 53504, measured after 24 hours, and 2, 4, and 7 days, for two-component systems. For one series, storage shall take place at 10°C and for the other at 30°C. Testing climate: 23°C/50% RH
- volume shrinkage, e.g. according to DIN 52451.

6.6.1 The following shall be specified for the adhesive:

- shore A hardness, according to DIN 53505
- qualitative assessment of the resistance to certain media, e.g. against seawater, UV radiation, fuel, mineral oil, hydraulic fluid, grease, acid and alkaline solutions.

6.6.2 For the adhesive, the following properties shall be verified:

- modulus of torsional shear, according to DIN EN ISO 6721-2B (min. temperature range −30°C to + 80°C)
- tensile stress at yield and fracture strain, according to DIN 53504 at −20°C, plus 60°C and standard climate (23°C and 50% RH)
- tear propagation resistance, according to DIN 53515 for the standard climate.

6.7 Bonded Joints

The following shall be determined at bonded joints with an adhesive layer thickness of 3 mm for the standard climate (in deviation from DIN EN 1465, test samples with a test-sample thickness of at least 10 mm shall be used, with an overlap length of 20 mm and a testing speed of 5 mm/min):

- tensile lap-shear test, according to DIN EN 1465
— furthermore, a long-duration tensile lap-shear test (based on DIN EN 1465) shall be performed to determine the strain in creep. Here the samples shall be loaded with an average tensile lap shear stress of 0.25 MPa (class A) in a standard climate and with 0.15 MPa (class A) at 60°C for at least three months. These measurements can be performed in the manufacturer’s own laboratory, if the deformations occurring during the tensile lap-shear tests at 0.25 MPa (class A) and 0.15 MPa (class A) were specified by the accredited testing body and if these correspond to the manufacturer’s own measurements. In the case of adhesives for which an approval according to class B is sought, the manufacturer shall specify minimum properties for 23°C and 60°C, and verify them within the long-duration tensile lap shear test.

— as part of a relaxation test (based on DIN EN 1465), the samples shall be stored for 90 days with a constant elongation of 30% (class B at RT) with conditioning according to DIN 50017-KFW. Temperature-related changes in elongation are permissible. In the case of adhesives for which approval according to class A is sought, a minimum property shall be specified by the manufacturer and verified within the relaxation test.

A summary of requirements to testing of flexible adhesives are given in Table 2.

Number of test specimens for each testing to be agreed upon for each specific case.

### Table 2 Requirements to flexible adhesives

<table>
<thead>
<tr>
<th>Property</th>
<th>Test method 1)</th>
<th>Acceptance criteria, data format, and unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Class A</td>
</tr>
<tr>
<td>Shore A</td>
<td>ISO 7619-1</td>
<td>≥ 45</td>
</tr>
<tr>
<td>Fracture strain at -20°C</td>
<td>DIN 53504</td>
<td>≥ 50%</td>
</tr>
<tr>
<td>Tensile stress at yield for +60°C</td>
<td>DIN 53504</td>
<td>≥ 1.5 MPa</td>
</tr>
<tr>
<td>Tear propagation resistance</td>
<td>ISO 34-1</td>
<td>≥ 4 N/mm</td>
</tr>
<tr>
<td>Tensile lap-shear strength</td>
<td>DIN EN 1465</td>
<td>≥ 2 MPa</td>
</tr>
<tr>
<td>Values for the long-term tensile lap-shear test at:</td>
<td>Based on DIN EN 1465</td>
<td>0.25 MPa 2)</td>
</tr>
<tr>
<td>- 23°C/50% rel. humidity at -60°C</td>
<td></td>
<td>0.15 MPa 2)</td>
</tr>
<tr>
<td>Relaxation test after 90-day conditioning</td>
<td>Based on DIN EN 1465 and ISO 6270-2</td>
<td>Specified by manufacturer</td>
</tr>
<tr>
<td>Measurement of pH</td>
<td>Prepare test specimen according to ISO 527-2, type 1A. Insert test specimen into test tube, fill with de-ionized water and close test tube. Store the test tube in a temperature chamber for 30 days at 40°C. Measure pH value using litmus paper</td>
<td>Document pH. If pH value is outside the allowed range, the adhesive joint must be protected against the impact of water. Acceptable levels of pH: — aluminium: pH 6 to pH 8 — polycarbonate: pH 4 to pH 10 — steel: always to be protected against the impact of water</td>
</tr>
<tr>
<td>Shear modulus, G</td>
<td>Calculate</td>
<td>MPa</td>
</tr>
<tr>
<td>Glass transition temperature (T&lt;sub&gt;g&lt;/sub&gt;)</td>
<td>ISO 6721-2</td>
<td></td>
</tr>
</tbody>
</table>
7 Requirements to sealants

7.1 Lap-Shear – constant elongation
Test specimens shall be prepared with the procedures for:
— preparation of adherend
— application of adhesives
— curing
as referred to in Sec.1 [3].
If the procedures allow for a range (e.g. humidity, temperature, thickness of adhesive, etc.) the least beneficial shall be selected. If there is doubt regarding which condition is the least beneficial, specimens shall be prepared at both conditions.
Testing shall be carried out in accordance with EN ISO 8340 with 10% and 30% extension, while weathered according to ASTM D1183 (procedure D, 4 times).
Note: Test cycle D is modified by testing at -30°C for freezing conditions.
The test specimens shall be loaded to destruction after weathering.
The preparation of adherend, application of adhesive, curing conditions, loading mechanism and weathering conditions shall be verified by a surveyor.

7.2 Glass transition temperature, T_g
The glass transition temperature (T_g) of the adhesive shall be determined according to ASTM E1356 (Differential Scanning Calorimetry).
T_g will be listed on the type approval certificate.

7.3 UV-Resistance
Test specimens shall be aged in QUV for a minimum of 500 hours. Both aged and un-aged specimens shall be tested according to DIN 53504 to determine the elongation at break.

7.4 Measurement of pH
Measurement of pH to avoid corrosion problems later on in the joint.
The measured pH value will be listed on the type approval certificate.
A summary of requirements to testing of sealants are given in Table 3.
Number of test specimens for each testing to be agreed upon for each specific case.
Table 3 Requirements to sealants

<table>
<thead>
<tr>
<th>Property</th>
<th>Test method</th>
<th>Acceptance criteria, data format, and unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lap shear test – constant elongation</td>
<td>Test sample in accordance with EN ISO 8340 with 10% and 30% extension. Weathering according to ASTM D1183, Test cycle D new 28 days, tested to destruction after ageing</td>
<td>Acceptance criterion: adhesive failure occurs in less than 5% of the bonding area. MPa (mean)</td>
</tr>
<tr>
<td>Glass Transition temperature ((T_g))</td>
<td>ASTM E1356</td>
<td>°C</td>
</tr>
<tr>
<td>UV Resistance</td>
<td>DIN 53504, S-2 or ASTM D412 min. 500hrs QUV(^2)</td>
<td>Reduction in elongation at break &lt;30% (compared to un-aged samples)</td>
</tr>
<tr>
<td>Measurement of pH</td>
<td>Prepare test specimen according to ISO 527-2, type 1A. Insert test specimen into test tube, fill with de-ionized water and close test tube. Store the test tube in a temperature chamber for 30 days at 40°C. Measure pH value using litmus paper</td>
<td>Document pH. If pH value is outside the allowed range, the adhesive joint must be protected against the impact water. Acceptable levels of pH: — aluminium: pH 6 to pH 8 — polycarbonate: pH 4 to pH 10 — steel: always to be protected against the impact of water</td>
</tr>
</tbody>
</table>

1) Other standards may be agreed upon with the Society prior to testing
2) 2 mm thick sheet, die cut dumbbell-shaped specimen (ASTM D412 or DIN 53504), aged in QUV

8 Requirements to marking of product

The product or package shall be marked. The marking shall at least include the following information:

— manufacturer’s name and address or trade mark
— production plant
— product name (grade)
— storage instruction
— production date/batch number
— quality guarantee period, if any.

The marking shall be carried out in such a way that it is visible, legible and indelible. The marking of product shall enable traceability to the type approval certificate.
CHANGES – HISTORIC

There are currently no historical changes for this document.
Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter and greener.