DNV·GL

CLASS GUIDELINE

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Metal coating and clad welding

DNV GL AS

FOREWORD

DNV GL class guidelines contain methods, technical requirements, principles and acceptance criteria related to classed objects as referred to from the rules.

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

CHANGES – CURRENT

This is a new document.

CONTENTS

SECTION 1 GENERAL

1 Objective

This class guideline describes the Society's requirements for metal coatings and clad welding, used as techniques in creating coatings with special properties (corrosion- or wear-resistant) and also for restoring lost material or repairing damaged surfaces. The metal coating techniques employed include thermal spraying and hot galvanizing deposition.

This class guideline specially addresses to the repairing by metal coating and clad welding. For example, Sec.6 Table 1 is meant to show which solutions are acceptable for typical applications.

SECTION 2 NORMATIVE REFERENCE

1 General

This class guideline incorporates references from other publications. These normative references are cited at the appropriate places in the text and constitute provisions of this class guideline. Latest edition of the publications shall be used unless otherwise agreed. Other recognised publications may be used provided it can be shown that they meet or exceed the requirements of the publications referenced below.

ISO 1461	*Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods*
EN 1395-1	*Thermal spraying - Acceptance inspection of thermal spraying equipment - Part 1: General requirements*
EN 1395-2	*Thermal spraying - Acceptance inspection of thermal spraying equipment - Part 2: Flame spraying including HVOF*
EN 1395-3	*Thermal spraying - Acceptance inspection of thermal spraying equipment - Part 3: Arc spraying*
EN 1395-4	*Thermal spraying - Acceptance inspection of thermal spraying equipment - Part 4: Plasma spraying*
EN 1395-5	*Thermal spraying - Acceptance inspection of thermal spraying equipment - Part 5: Plasma spraying in chambers*
EN 1395-6	*Thermal spraying - Acceptance inspection of thermal spraying equipment - Part 6: Manipulator systems*
EN 1395-7	*Thermal spraying - Acceptance inspection of thermal spraying equipment - Part 7: Powder feed systems*
EN 1274	*Thermal spraying - Powders - Composition, technical supply conditions*
ISO 14232	*Thermal spraying - Powders - Composition and technical supply conditions*
EN 13507	*Pre-treatment of surfaces of metallic parts and components for thermal spraying*
EN ISO 14918	*Thermal spraying - Approval testing of thermal sprayers*
EN ISO 14919	*Thermal spraying - Wires, rods and cords for flame and arc spraying - classification - Technical supply conditions*
EN ISO 14921	*Thermal spraying – Procedures for the application of thermally sprayed coatings for engineering components*
EN ISO 14923	*Thermal spraying - Characterization and testing of thermally sprayed coatings*
IACS Rec. No. 47	International Association of classification societies - Recommendation No. 47, *Shipbuilding and repair Quality Standard*
EN ISO 8503-1	*Preparation of steel substrates before application of paints and related products - Surface roughness characteristics of blast-cleaned steel substrates - Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces*
DVS Work Sheet 2301	*Thermische Spritzverfahren für metallische und nicht metallische Werkstoffe*
DVS Work Sheet 2304	*Gütesicherung beim thermischen Spritzen*

ISO 15614-7	*Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 7: Overlay welding*
ASME-IX	ASME Boiler and Pressure Vessel Code (BPVC), *Section IX: Welding, Brazing, and Fusing Qualifications: Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing and Fusing Operators*

SECTION 3 HOT GALVANIZING

1 General

Metallic coatings by hot galvanizing shall comply with the requirements set out in ISO 1461. Hot galvanized components should always be protected additionally by a coating (duplex coating).

SECTION 4 THERMAL SPRAYING

1 Surface preparation and application conditions

Prior to further coating works, renewed surface preparation by abrasive-blasting is needed. The surface quality grades specified in the corresponding coating material/system documentation of the manufacturer shall be complied with. If not otherwise specified the blasting area shall extend at least 25 mm into the adjacent coated surfaces.

A dry blasting process should be used.

Guidance note:

Pressurized water blasting with solid blasting agents should be limited to the areas that cannot be processed by dry blasting process. This work shall be performed according to an approved specification, which shall be matched to the coating system by the coating manufacturer.

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As the blasting agents, copper works' slag (MCU), fused corundum (MKE) as well as iron or steel blasting agents can be considered. The use of silica sand (MQS) shall be avoided.

Guidance note:

MCU = synthetic mineral blasting medium, made of copper works' slag

MKE = synthetic mineral blasting medium, made of fused corundum

MQS = natural mineral blasting medium, made of silica sand

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Dust, salts or other impurities shall be minimized in the blasting agents.

The surface roughness Rz should have the roughness grade "medium" or Ry5 50μm to 85μm according to ISO 8503-1.

Welding spatter, rough-rolled ends, laminations, rolling flaws etc., which have only become apparent immediately before or during the blasting work, shall be remedied. Edges and welding seams shall be treated according to the *Shipbuilding and Repair Quality Standard* of the IACS.

At points at which extensive repair work shall be carried out after blasting, the blasting shall be repeated after the repair.

For blasting purposes, the surface temperature shall lie at least 3°C above the dew point and the relative atmospheric humidity should be a maximum of 85%. To prevent impairments by dust or blasting agents, the blasting activities should not be performed at places near which coating work is being done or near which coatings have not yet dried properly.

Mechanical grinding is limited to smaller areas on which coating damages have to be repaired or where, because of the local conditions, no blasting can be performed. A surface condition as per "Sa2½" or one that is in accordance with the specifications of the coating manufacturer shall be achieved.

The mechanical treatment shall not cause any excessive polishing or roughening of the surface. The grinding shall extend at least 25 mm into the adjacent coated surfaces if not otherwise specified.

Surface preparation of cast iron

For cast iron as a coating substrate, the same prerequisites as for steel apply in principle. However, in contrast to rolling scale, the relatively thin casting skin need not be removed. The surface roughness is greater than for steel.

Surface preparation of stainless steels

Blasting shall be performed with ferrite-free blasting agents (proportion of metallic iron: max. 0.1%). The blasting agents shall not have been used on ferritic materials beforehand. All adherent welding spatter, welding beads and welding cinders shall be removed. Brushes, pick hammers, spatulas and scrapers shall be made of stainless austenitic steel. Non-metallic brushes are permissible. Abrasive media shall be ferrite-

free and shall not contain an insert of steel wire. Abrasive disks or belts shall not have been used on ferritic components beforehand. For the purity not achieved by blasting, a metallic smooth surface on the basis of surface quality grade "Sa2½" is required.

Annealing colours shall generally be removed by pickling or blasting. Grinding is permissible in exceptional cases. The pickling solution shall not contain any hydrochloric acid. After pickling, the surface shall be neutralized by thorough washing with fresh water, especially in crevices. As a matter of principle, it shall be ensured that components that are no longer to be subjected to surface treatment are protected against ferritic abrasion, e.g. during storage: rust films, sparks from flame-cutting, welding or grinding. If foreign contamination cannot be removed by the above-mentioned procedures and agents, suitable measures shall be taken after agreement has been reached.

Further notes and recommendations are given in EN 13507 *Pre-treatment of surfaces of metallic parts and components for thermal spraying*.

With regard to the application conditions, the following points shall be observed:

— The interval between preparation and spraying shall be selected so that the surface to be coated remains clean and dry and does not visibly oxidize. This interval should be less than 4 hours.
— The steel temperature shall lie at least 3°C above dew point.

2 Coating materials for Thermal Spraying:

The coating is produced by the spraying of spray materials, which can be in powder, wire, rod, or cord form.

The technical delivery conditions of the spray additives are specified below:

— powder in EN 1274 or ISO 14232;
— wire, rod and cord in EN ISO 14919.

The following information shall be available with regard to the filler metal that is used:

— material datasheet
— material test certificate
— manufacturer's designation
— standard used
— production or batch number
— chemical analysis
— wire diameter
— net weight
— production date.

The suitable materials for corrosion resistance coatings:

— aluminium: Al 99.5
— Al-Mg alloy: AlMg5
— zinc or alloys of zinc

3 Spraying technique

— Each layer shall be applied uniformly to the entire surface. The metallic coatings shall be applied in several crossed layers.
— Equipment and units for thermal spraying shall comply with the requirements set out in corresponding parts of EN 1395.
— For parts which are to be welded after spraying, an area 5–10 cm around the welding groove shall remain uncoated.
— The protective film shall adhere properly. Spraying layers shall exhibit a uniform surface appearance that is not too coarse. They shall be free from bubbles, voids, loosely adherent spray metal, discolorations, damages and uncoated spots.

— Before a subsequent layer is applied, any damage that may have occurred to the previous layer shall first be repaired.
— Sealing (subsequence coating) is essential after metallic coating and can be achieved either by a chemical transformation (through phosphatizing, reactive compacting agents, etc.) or through the use of a suitable painting system which covers up the pores.

Guidance note:

The sealer shall fill the metal pores. It shall be applied until absorption is complete. There should not be a measurable overlay of sealer on the metallic coating after application. The materials for sealing the metal coating shall be two-component epoxy for operating temperatures below 120°C and aluminium silicone above 120°C.

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The minimum thickness of the metallic coatings shall not be less than the values as given in Table 1:

Table 1 Minimum thicknesses of corrosion resistance sprayed coatings

Spraying material		*Minimum film thickness [µm]*	
		without painting	*with painting*
Aluminium	Al99.5	200	150
AlMg alloy	AlMg5	250	200

Guidance note:

Experience demonstrates significant reduction of the fatigue strength for sprayed coating with more than 0.3 mm thickness.

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4 Quality assurance for spraying

Procedures for the application of thermally sprayed coatings shall record all parameters, required by ISO 14921. DVS Work Sheet 2301 and 2304 can be used as the basis for performing of the thermal spraying.

The testing of thermal spraying layers should be performed according to ISO 14923.

The responsible personnel should be checked according to ISO 14918.

Spraying shops in the sense of this guideline may apply for approval by the Society. Through personnel with suitable training and equipment that is in good working condition, the shop shall show that the requirements for the processing of the thermal spray materials are ensured. An existing quality management system with defined working sequences and the envisaged company-internal quality checks shall be verified. The examination of the conditions existing on site, with a positive result, shall be viewed as a fundamental requirement. This examination shall be carried out before work starts; spot checks should also be made during the application process, to confirm the initial conditions. The Society may specify further requirements as found applicable, necessary or relevant. If all requirements are met and if the examinations yield a positive result, a certificate, similar to Welding Workshop Approval (WWA), is issued by the Society.

The acceptance of thermal sprayed repair, carried out by approved spraying shops, shall be based on the requirements Sec. 6 of this class guideline and shall be considered only on a case by case basis.

SECTION 5 CLAD WELDING

1 Welding procedure specification for overlay and clad welding

Welding procedure specification for overlay- / clad welding shall be qualified according to ISO 15614-7 or ASME-IX or another recognized standard.

Guidance note:

When the clad welding is not contributing to strength (e.g. not load bearing), tensile testing and Charpy V-Notch testing of the weld overlay material are not required. When the weld overlay is considered as a part of the design, such mechanical testing of the clad welding is required.

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SECTION 6 REPAIR AND BUILD-UP BY METAL COATING AND CLAD WELDING

1 Basic viewpoints

Experience, including general engineering considerations demonstrates that a metal-coated component cannot, in general terms, be considered equivalent to what it is supposed to replace, namely, solid metal.

Therefore, discussions on such components, must be limited to fitness for purpose, consideration for a given coat type, coating procedure and application.

The following general guidance may be given:

— Where the stresses are low and the consequences of failure are moderate, repair by use of metallic coating may be considered.
— Where the stresses are high, and the consequences of failure are serious, repair by use of metallic coating shall be avoided.
— For components subjected to special load conditions, for example contact loads (bearings) or thermal loads, special care must be taken before repair by metal coating is accepted. Loads during manufacturing, transportation, assembly and loads in service must be considered.

2 Evaluation of special components

Based on the general considerations given above, the following table states the Society's position on where metallic coating and clad welding repairs may be accepted for typical components for classed vessels:

Table 1 Evaluation of special components

Component [1]	*Hot galvanizing*	*Thermal spray*	*Clad weld*
Crankshaft	No	No	No
Tailshaft [2]	No	No	Dependent upon stress
Intermediate shaft - main propulsion [2]	No	No	Dependent upon stress
Pintle / Rudder-stock water side [3]	N.A.	No	Yes
Shafts in gear - shrink fit position [4]	Dependent upon stress	Dependent upon stress	N.A.
Hub / gear wheel - shrink fit position	Yes	Yes	N.A.
Gear casings / Bores	Yes	Yes	N.A. (due to distortions)
Cylinder head / Piston crown	N.A.	No	Yes
Piston rod in diesel engines [5]	No	No	N.A.
Seal areas, low or moderate consequence of leakage.	Dependent upon stress	Dependent upon stress	Dependent upon stress

Interpretations:	
No:	Repair is in general not acceptable
Yes:	Repair is in general acceptable (provided compatibility regarding thermal expansion and E-modulus)
Dependent on stress:	Repair is acceptable if the working stresses are low (typically less than 50% of the allowable stress for the component according to the rules), and unacceptable if the stress is higher

Component [1)]	*Hot galvanizing*	*Thermal spray*	*Clad weld*
N.A.	Not applicable, i.e. for this application the use of repair is not considered relevant for practical or other reasons		

1) The table may be extended/revised based on experience and technical development.
2) Metal coating other than clad welding is not qualified by experience on tailshafts. A test program for qualifying a method for this application might be feasible but would probably become so comprehensive and time consuming that it would render it impracticable in a repair situation.
3) Hot Galvanizing coating is considered "not applicable" for the deposit thickness that will be in question for rudderstocks.
4) In the free end (non-driving end) of a shaft, metal coat repair is usually acceptable, even on the shaft side. In the driven end, and at the gear wheel/shaft intersection, the use of metal spray, as a repair method should be restricted to the hub (female) side.
5) Poor experience is observed when using metal coat repair on the piston rod in bearing / sealing area.

3 Requirements for repair product and repair procedure

In order to satisfy the requirements for repair procedures, it must be confirmed that the experience and or test data, used as evidence, are representative of the product to be supplied. This means that a procedure must be established in such detail that the quality of the end product is reasonably well defined through the specification of the procedure.

Furthermore, it must be assured that both the references and the product to be supplied are produced in compliance with the procedure.

A procedure for metal coating repair should comprise, as a minimum, the following items:

— requirements for parent material (including limitations of allowable chemical composition and hardness)
— requirements for pre-treatment before applying the coat (including requirements for cleaning, moisture and temperature under application and tolerance band for surface roughness)
— type of deposit (chemical composition, mechanical properties and trade name)
— thickness limitations
— suppliers specification for process data (tolerance bands)
— suppliers specification for personnel qualification
— suppliers specification for limitations to areas of application.

Repair procedures by clad welding (including WPS) and by metal coating techniques shall be approved by the Society.

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