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10.4 Aluminium alloys

10.4.1 General

Not all aluminium alloys are resistant to marine corrosion and careful material selection is required. Appropriate alloys have excellent corrosion resistance in marine environments, but are liable to galvanic corrosion when combined with other materials, including structural steels, stainless steels and copper alloys. Electrical isolation is generally required, often obtained by using insulating packers at connections to carbon steel.

The properties of aluminium alloys can be severely degraded by welding and this shall be allowed for in the design of connections.

Aluminium loses strength and stiffness rapidly when subjected to heat.

Aluminium alloys have found successful applications in the construction of living quarters modules, helidecks, crane boom rests and general decking.

10.4.2 Types of aluminium

The two most common types of aluminium alloy used for offshore structures are the heat-treatable 6XXX series, specifically 6082, and the non-heat-treatable 5XXX series, specifically 5083, which obtains its increased strength from work hardening. Both materials are susceptible to loss of strength in the heat-affected zone of a welded connection.

For welded structures, alloys should be used in the annealed condition and be selected from materials with a strength not exceeding 130 N/mm^2 at the specified 0,2 % strain.

Higher-strength alloys can be considered for non-welded construction.

10.4.3 Material properties

Typical properties of aluminium alloys are as follows:

— density: 2 700 kg/m^3

— Young's modulus: 7×10^4 N/mm^2

— yield strength (6082 alloy): 130 N/mm^2

— yield strength (5083 alloy): 220 N/mm^2

Aluminium has a high heat conductivity and specific heat. It melts at 550 °C and loses 50 % of its strength at 225 °C. Its thermal expansion is twice that of steel.

10.4.4 Thermite sparking

Thermite (aluminium-iron oxide) sparking can occur when iron oxide (rusty steel) comes into contact with aluminium. It requires specific circumstances to produce a thermite spark of appreciable energy; for this to represent a hazard, it has to occur in combination with an explosive gas/air mixture. When aluminium is used for structural applications, the operations manual or other documentation shall contain warnings and advice that precautions should be taken to prevent thermite sparking, and the structure itself shall be labelled with warnings.

NOTE Thermite sparking is also called frictional sparking and incendive sparking.

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10.5 Fibre-reinforced composites

Fibre-reinforced composites can be produced with a wide range of properties, including high strength, and with considerable resistance to fire. A wide range of resin binders and fibres are used and the technology has been developing rapidly.

Due to the large variation in material properties, there is a paucity of design codes for use of these materials and their suitability is usually determined by type-testing to meet performance criteria.

Fibre-reinforced composites have been successfully used in the production of floor grating, hand railing and ladders, lightweight fire and explosion-resistant panels, and for reinforcement and repair of carbon steel sections.

Fibre-reinforced composites are often electrically non-conductive and any conductive and metallic objects attached to fibre-reinforced composites should be independently earthed where necessary.

In fire conditions, fibre-reinforced composites can give off toxic fumes and the risks from such fumes shall be considered.

10.6 Timber

The use of timber in offshore topsides structures has generally been restricted to the protection of weather decks from dropped objects and damage from pipe handling. It has been found effective against dropped objects when sandwiched between two steel sheets.

Because timber is generally flammable, a problem exacerbated by its ability to soak up hydrocarbon spills, it shall not be used in confined hazardous areas.

Timber properties are highly variable and anisotropic. Design should be undertaken in accordance with appropriate codes and standards.

11 Fabrication, quality control, quality assurance and documentation

11.1 Assembly

11.1.1 General

The requirements for fabrication, quality control, quality assurance and documentation given in ISO 19902 shall be followed with the additional requirements given below.

Fabrication, other than welding, shall be in accordance with a national or regional fabrication specification that complements the design code. Fabrication tolerances shall be compatible with design assumptions. In some situations, tighter than normal tolerances are required and these shall be documented on the drawings.

11.1.2 Grating

Joints in grating shall occur only at points of support, unless other appropriate details are specified.

11.1.3 Landing and stairways

Landing elevations and landing and stairway locations shall be within 50 mm in plan of the drawing dimensions unless required to align with other access ways or equipment, in which case the mismatches in elevation and alignment shall not exceed ± 4 mm.

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11.1.4 Temporary attachments

Any temporary attachments to the topsides structure (including crane pedestals), such as scaffolding, fabrication, and erection aids, can create a localized stress rise (even after removal) and should be avoided where practicable. When these attachments are necessary, the following requirements apply.

- Temporary attachments shall not be removed by hammering or arc air gouging. Attachments to leg joint cans, brace joint cans, brace stub ends and joint stiffening rings shall be cut to 3 mm above parent metal and mechanically ground to a smooth flush finish with the parent metal.
- Attachments on all areas that are to be painted shall be removed as above, prior to any painting.
- Attachments to all other areas, not defined above, shall be removed by cutting just above the attachment weld (maximum 6 mm above weld). The remaining attachment steel shall be completely seal-welded.
- Attachments to aid in the splicing of legs, braces, sleeves, piling, conductors, etc. shall be removed to a smooth, flush finish.
- The parent steel shall be tested by magnetic particle inspection (MPI) following removal of temporary attachments.

11.2 Welding

Welding shall comply with the requirements of ISO 19902 with the following additional considerations.

a) Metal thicknesses encountered in topsides structures can exceed those in the associated support structures, particularly at support and lifting points. At such points post-weld heat treatment can be required and shall comply with the requirements of ISO 19902.

b) The sequence of welding can have a significant effect on residual stresses. This is of particular concern when large decks with several levels are fabricated deck by deck with a large number of splices in primary structural columns and braces. The potential for such build-up of residual stress shall be considered by both designer and fabricator and, where appropriate, measures shall be taken to reduce it to a minimum.

c) The use of automatic welding machines on large areas of deck plate or in the fabrication of girders or grillages can significantly increase heat-induced distortion which can result in unacceptable deflections in deck steelwork. Welding procedures shall be assessed for their potential to cause such distortion and modified if necessary.

11.3 Fabrication inspection

The requirements for quality control and fabrication inspection shall follow the applicable clauses of ISO 19902.

11.4 Quality control, quality assurance and documentation

The requirements for quality control, quality assurance and documentation, including drawings and specifications, given in ISO 19902 shall be followed for the topsides structure.

Drawings and specifications shall clearly and unambiguously show the intention of the design. Sufficient information shall be given to define the materials and any special construction methods, tolerances, inspection requirements and operational constraints.

All engineering information necessary for the safe use of the topsides structures shall be made readily available and transmitted to those personnel operating the platform. Such information shall include a topsides load plan defining the maximum carrying capacity of areas used for storage, access and maintenance and the total maximum topsides weight. Areas requiring periodic inspection to ensure the continued safe operation of the structures shall be identified.

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11.5 Corrosion protection

11.5.1 Coatings

The application of coatings shall conform to the manufacturer's recommendations and to any suitable standard specified by the owner or by the designer.

11.5.2 Under deck areas

Splash zone protection, such as monel wrap, steel plate wrap, corrosion allowance, etc., shall be installed as specified and shall cover not less than the areas indicated on the drawings or in the specifications.

12 Corrosion control

12.1 General

Corrosion damage can affect structural integrity in various ways. The primary objective of corrosion control is to prevent loss of strength and changes in fatigue resistance. The presence of corrosion in fatigue-sensitive areas can result in increased stress concentrations and hence the initiation of fatigue damage.

12.2 Forms of corrosion, associated corrosion rates and corrosion damage

Corrosion damage to uncoated carbon steel is associated with oxygen attack and is typically more or less uniform. In typical conditions, the steady-state corrosion rate for carbon steel (i.e. as uniform attack) is around 0,1 mm/year or lower.

Aluminium alloys of the 5XXX and 6XXX series, as used for topsides structural components, are highly resistant to marine atmospheres and suffer only superficial staining or micropitting. However, galvanic coupling (i.e. metallic plus electrolytic coupling) to structural steel, stainless steels and copper alloys shall be avoided. Otherwise, severe galvanic corrosion of aluminium can result at the point of contact. Similarly, structural steel can suffer enhanced corrosion if in galvanic contact with stainless steel or with copper base alloys.

Very-high-strength steels (yield strength in excess of 1 200 MPa) and certain high-strength aluminium, nickel, and copper alloys are sensitive to stress corrosion cracking in marine atmospheres.

NOTE The term "stress corrosion cracking" refers to cracking that is caused by an interaction between static tensile stresses in a material and a specific corrosion medium.

12.3 Design of corrosion control

12.3.1 General

The main systems for corrosion control of topsides structures are

a) coatings, linings and wrappings,

b) corrosion-resistant materials, and

c) corrosion allowance.

12.3.2 Considerations in the design of corrosion control

The initial selection and subsequent detailed design of systems for corrosion control of topsides structures shall take the following factors into account:

a) regulatory requirements;

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b) criticality of the overall system and the functional requirements to individual structural components to be protected;

c) type and severity of corrosion environment(s);

d) design service life (and likelihood of lifetime extension);

e) accessibility for inspection and maintenance, including overall maintenance philosophy;

f) suitability, reliability and economy of optional techniques for corrosion control.

12.3.3 Coatings, linings and wrappings

Coatings are defined as relatively thin (<1 mm) organic or metallic layers, single or multiple, that are applied by spraying, brushing or dipping. Linings and wrappings are defined as thicker (>1 mm) corrosion-protective layers applied with the objective of resisting mechanical wear, protecting against impacts, etc. Organic materials used for linings and wrappings are normally reinforced (e.g. by glass fibres or flakes). Metallic materials are typically copper-based.

Special precautions are required to prevent corrosion under coatings, linings and wrappings, including under fire-protective coatings. Metallic materials should be seal-welded to structural components.

Coating systems include various forms of organic (paint) coatings and certain metallic coatings. Of the latter, zinc layers are applied as hot dipping or thermal spraying. Thermally sprayed aluminium coatings have been used more recently, particularly for more demanding applications.

Coating and lining systems shall primarily be selected based on proven experience for a specific application and environment. Comprehensive field testing is required when practical experience is lacking. Maintainability is a major criterion. Resistance to damage is also required.

The design of all components to be paint-coated shall take into account relevant measures to ease both the initial application and later maintenance. This includes a preference for tubular shapes, rounding of sharp edges, requirements for securing scaffolding, etc. Structural components exposed to sea spray, rain or intermittent wetting, externally or internally, shall be designed to prevent accumulation of moisture, e.g. by using continuous welding and making provisions for drainage.

12.3.4 Corrosion-resistant materials

The selection of corrosion-resistant materials for structural components shall take into account their anticipated corrosion resistance for the intended application, their compatibility with other materials, their mechanical properties and their ease of fabrication.

Precautions shall be taken to prevent galvanic corrosion of less resistant materials; these can include coating components with the higher electrochemical potential or the use of electric insulation.

12.3.5 Corrosion allowance

A corrosion allowance, i.e. extra metal thickness to compensate for loss by corrosion, can be used alone or in combination with a coating. The thickness of any corrosion allowance shall be determined by taking expected corrosivity, design service life and maintenance plans into account.

12.4 Fabrication and installation of corrosion control

12.4.1 General

Fabrication procedures can affect the corrosion resistance of certain materials. All fabrication involving welding or brazing to structural components shall be performed in accordance with ISO 19902, regulatory requirements, applicable codes/standards and approved project-specific procedures and drawings.

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12.4.2 Coatings and linings

Manufacturer's recommendations and any recommendations given in applicable standards and practices for surface preparation, materials, coating application, inspection and repairs should be followed.

Quality control during surface preparation, coating application and repairs ensures consistent performance of coatings and linings. All coating work, from surface preparation to completion, should be inspected by a certified coating inspector.

12.4.3 Corrosion-resistant materials

Work with corrosion-resistant materials shall be performed with due consideration of how the applicable techniques (welding, grinding, etc.) affect their corrosion resistance and mechanical properties. Improper fabrication methods can easily cause staining and incipient pitting of stainless steel and aluminium surfaces.

12.5 In-service inspection, monitoring and maintenance of corrosion control

12.5.1 General

Periodic inspections assess the physical condition and integrity of the corrosion control system(s), or the actual components to be protected, or both. Monitoring of corrosion control refers to regular recording of data associated with corrosion control.

Plans for inspection and monitoring of corrosion control shall take into account the following:

a) criticality of the overall system and of the individual components being protected;

b) type and severity of the corrosion environment(s);

c) potential forms of corrosion damage;

d) capability of inspection and monitoring tools, as well as accessibility for inspection;

e) results and consequences of previous inspections, or monitoring, or both.

NOTE See Clause 14 for in-service inspection and corrosion control requirements for structural integrity management.

12.5.2 Coatings and linings

Inspection of coatings and linings is primarily performed by visual inspection and has the objective to assess the need for maintenance (i.e. repairs). A visual examination will also disclose any areas where coating degradation has allowed corrosion to develop to a degree requiring repair or replacement of structural components.

12.5.3 Corrosion-resistant materials

Inspection of corrosion control based on corrosion-resistant materials can be integrated with visual inspection of the structural integrity of critical components associated with such materials.

13 Loadout, transportation and installation

The methodology for loadout, transportation and installation shall be agreed between the design, fabrication, transportation and installation contractors, taking into consideration any requirements of the owner.

The requirements given in ISO 19901-6 for loadout, transportation and installation shall be followed.

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Any structural components required for loadout, transportation and installation shall be designed following the requirements of this part of ISO 19901 in conjunction with all factors from ISO 19901-6.

14 In-service inspection and structural integrity management

14.1 General

The requirements for in-service inspection and structural integrity management given in ISO 19902 shall apply to all topsides structures covered by this part of ISO 19901, noting the particular considerations applying to topsides structures given in 14.2 and the default inspection scopes given in 14.3.

14.2 Particular considerations applying to topsides structures

14.2.1 Corrosion protection systems

For many parts of topsides structures, corrosion, rather than fatigue or accidental damage, is likely to be the principal cause of deterioration. Topsides structures are generally protected by paint and coating systems to reduce the rate of corrosion (see Clause 12). Corrosion protection systems shall be suitably maintained to retain their effectiveness.

14.2.2 Access routes, floors and gratings

To safeguard personnel for both in-service and accident conditions, the safety criticality of these structures shall be considered and suitable inspection intervals and techniques devised.

14.2.3 Supports for safety-critical equipment, including communications, electrical and firewater systems

Equipment supports can be affected by extreme, abnormal and accidental actions, including consequent strong vibration. Inspection scopes and techniques shall be determined accordingly.

14.2.4 Control of hot work (e.g. welding and cutting)

Hot work in service to attach appurtenances, pipe supports, cable trays, etc., or to cut access holes, shall be carefully controlled to prevent damage to the integrity of safety-critical parts of the structure. Hot work shall be minimized as far as possible by considering possible future requirements at the design stage.

14.2.5 Accidental actions

Arrangements shall be made in drawing up the structural integrity management plan for the topsides structure to inspect, assess and implement any necessary remedial measures and evacuation procedures as quickly as possible after an incident.

14.2.6 Change control

Any changes, or the cumulative effect of changes, that can significantly affect the actions on and structural response of safety-critical structural components, or of the entire structural system, shall be assessed at the planning and design stages of the proposed alterations. As-built inspections shall be undertaken to assess the impact and extent of any potential modifications.

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14.3 Topsides structure default inspection scopes

14.3.1 General

The default inspection scope for the baseline inspection and for the subsequent periodic inspections given in 14.3 shall apply to the topsides structure unless an in-service structural inspection strategy has been prepared and implemented in accordance with ISO 19902.

14.3.2 Baseline inspection

A baseline inspection, to provide a benchmark of the installed condition of the topsides structure, shall be undertaken as soon as possible after installation and commissioning of the topsides, and no later than one year after installation.

The objective of this inspection is to identify any defects which have the potential to impair the integrity of the topsides structure and equipment, so as to allow these defects to be assessed and repaired before having an effect on integrity.

The minimum scope of inspection shall include the following items.

a) A general visual inspection (GVI), without removal of paint and coatings, of all parts of the topsides structure, including equipment support structures, to check that

   1) all parts of the topsides structure are intact and undamaged,

   2) all fixings between structures and between structures and equipment, including gratings and handrails, are secure, and

   3) paintwork and protective coatings are not damaged.

b) A walk-down survey to assess the vulnerability of safety-critical equipment and supports to damage from impulsive actions and strong vibration induced by actions from extreme environmental events or accidental actions, unless this survey was undertaken at the fabrication site (see 6.9).

c) An examination to determine the integrity of any installed passive fire protection systems.

d) An assessment of any vibration caused by operating equipment or by local vortex-induced vibration.

14.3.3 Periodic inspection

The inspection intervals described in ISO 19902 shall apply to topsides structures. They may be simplified for topsides as described below.

a) In Level I inspection, the minimum scope shall consist of a visual survey to determine

   1) the continued effectiveness of coating and passive fire protection systems,

   2) any signs of excessive corrosion, and

   3) the existence of any bent, missing or damaged structural components.

   The survey shall identify indications of obvious overloading, design deficiencies and any operational usage that is inconsistent with the original design intent for the topsides structure. The survey shall include a GVI of all areas of topsides structure that have been identified as safety-critical. Should the Level I survey indicate that damage can have occurred, a Level II inspection shall be conducted as soon as conditions permit.

b) In Level II inspection, the minimum scope shall consist of

   1) a GVI without removal of paint and coatings of all parts of the topsides structure including equipment support structures (as described above for a Level I inspection),

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2) a close visual inspection (CVI) of all structural components identified as safety-critical, and

3) a detailed non-destructive examination of a selection of safety-critical structural components and comprising not less than 10 % of all safety-critical structural components.

If damage is detected, 100 % non-destructive testing of the suspect area shall be used where visual inspection alone cannot fully determine the extent of the damage.

c) In Level III inspection, the minimum scope shall consist of

1) a GVI without removal of paint and coatings of all parts of the topsides structure including equipment support structures (as described above for Level I and Level II inspections),

2) a CVI of all structural components identified as safety-critical, and

3) a detailed non-destructive examination of all safety-critical structural components.

d) There is no requirement for a Level IV inspection of topsides structures.

14.3.4 Special inspections

Special inspections shall be performed where necessary, as follows:

— to assess the performance of repairs undertaken to ensure the continuing fitness-for-purpose of the topsides structure: the minimum requirement for such repairs is a GVI conducted approximately one year after completion of the repair;

— to monitor known defects, damage, local corrosion, or other conditions, which could potentially affect the fitness-for-purpose of the topsides structure, risers and J-tubes, conductors, and other safety-critical structures and equipment;

— if the topsides structure is planned for reuse.

See also ISO 19902.

14.3.5 Unscheduled inspections

An inspection shall be conducted as soon as practical after the occurrence of an environmental event (e.g. storm, earthquake or mudslide) exceeding that for which the platform was designed or assessed, or an accidental event (e.g. vessel impact, dropped object, fire or explosion). The minimum scope of inspection shall consist of a GVI of all safety-critical structures and supporting structures, including equipment and pipework supports, conductors, risers, and appurtenances,

— to check for any signs of damage, and

— to confirm the continuing effectiveness of corrosion protection systems.

Where signs of significant damage to the topsides structure or coatings are found, a CVI shall be performed. Detailed non-destructive examination shall be performed as appropriate, depending on the results of the CVI.

15 Assessment of existing topsides structures

The requirements for assessment of existing structures given in ISO 19902 shall apply to all topsides structures covered by this part of ISO 19901, following the assessment of actions and resistances detailed in this part of ISO 19901 where applicable.

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16 Reuse of topsides structure

ISO 19902 gives requirements and guidance on fixed steel structure reuse. Topsides structures present particular problems in this respect as access for inspection is likely to be restricted by the plant and equipment and there is a significant likelihood that modifications to both the topsides structure and the equipment have been made during the platform's original service life.

In addition to survey work, all of the considerations applicable to a new design are likely to be relevant.

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Annex A
(informative)

Additional information and guidance

NOTE The clauses in this annex provide additional information and guidance on the clauses in the body of this part of ISO 19901. The same numbering system and heading titles have been used for ease in identifying the subclause in the body of this part of ISO 19901 to which it relates.

A.1 Scope

No guidance is offered.

A.2 Normative references

No guidance is offered.

A.3 Terms and definitions

No guidance is offered.

A.4 Symbols and abbreviated terms

No guidance is offered.

A.5 Overall considerations

A.5.1 Design situations

No guidance is offered.

A.5.2 Codes and standards

General procedures for the design of fixed steel structures were originally developed and documented by the American Petroleum Institute in earlier versions of API RP 2A-WSD[1], which is only concerned with components formed from tubular sections. Topsides, however, are constructed from a range of structural sections so API RP 2A-WSD[1] provides little design guidance relevant to topsides. As a result, different countries adopted a variety of national codes to effect such designs, e.g. ANSI/AISC 360-05[2] in the USA, the so-called “Eurocodes” in Europe and CSA-S16-09[3] in Canada. These choices were natural, being the building codes for the countries concerned. Only one, however, has been formally adapted for offshore practice. This is ANSI/AISC 360-05[2], which was calibrated as AISC LRFD against API RP 2A-LRFD[4] with resistance factors derived for consistency with the reliability implicit in API. CSA-S16-09[3] was calibrated against land-based steel building practice and the resistance factors were determined for a given set of action factors.

Building code correspondence factors (K_c factors) for codes other than AISC are being developed by some national standards bodies (e.g. Canada) and should be available in the respective national standards version of this part of ISO 19901 when published.

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