BS ISO 10276:2010

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Nuclear energy — Fuel technology — Trunnions for packages used to transport radioactive material

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee NCE/9, Nuclear fuel cycle technology.

A list of organizations represented on this committee can be obtained on request to its secretary.

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ISBN 978 0 580 53235 1

ICS 27.120.30

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2010.

Amendments issued since publication

Date	Text affected

BS ISO 10276:2010

INTERNATIONAL STANDARD

ISO 10276

First edition
2010-08-01

Nuclear energy — Fuel technology — Trunnions for packages used to transport radioactive material

Énergie nucléaire — Technologie du combustible — Tourillons pour colis de transport de matières radioactives

Reference number
ISO 10276:2010(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10276 was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Subcommittee SC 5, *Nuclear fuel cycle*.

Introduction

This International Standard has been produced to enable package owners, designers, users and regulatory organizations to have at their disposal a comprehensive document covering all aspects of trunnions. Experience has been drawn from the extensive knowledge of owners, designers, users and competent authorities. Contained herein are the recommended minimum criteria covering various aspects of trunnions.

It is intended that quality assurance, although referred to separately in Clause 8, be applied during the application of part or all of this International Standard.

No account is taken in this International Standard of any intermediate device that can be used between the packaging trunnions and the transport vehicle with respect to the relevant energy-absorbing effects. Intermediate devices (sometimes referred to as transport frames, supports or cradles) are used to support and secure the package to the transport vehicle.

INTERNATIONAL STANDARD ISO 10276:2010(E)

Nuclear energy — Fuel technology — Trunnions for packages used to transport radioactive material

1 Scope

This International Standard covers trunnions fitted to radioactive-material transport packages that are subject to the approval and licensing by competent authorities in accordance with the IAEA No. TS-R-1. Aspects included are design, manufacture, maintenance and quality assurance.

Subject to agreement between the interested parties, it can also be applied to packages that are not subject to the approval by competent authorities.

This International Standard covers trunnion systems used for tie-down during transport and trunnions used for tilting and/or lifting.

This International Standard does not supersede any of the requirements in the IAEA No. TS-R-1, nor any of the requirements of international or national regulations, concerning trunnions used for lifting and tie-down.

This International Standard is applicable to new package design.

2 Normative references

International Atomic Energy Agency (IAEA) No. TS-R-1, *Regulations for the Safe Transport of Radioactive Material*, 2009

3 Terms, abbreviated terms, symbols and definitions

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IAEA No. TS-R-1:2009, Section II, and the following apply.

3.1.1
areas of special concern
areas defined by the designer as exhibiting the highest risk of failure of the trunnion and attachment system, taking into account stress concentrations, fatigue, stress intensity, etc.

3.1.2
bending stress
variable component of normal stress, which might or might not be linear across the thickness

3.1.3
independent competent organization
organization administratively and managerially separate from the designers, manufacturers or owners of the subject package, constituted of specialized experts, or an insurance organization used to verify, oversee, witness or check

3.1.4
linearized stress
sum of the membrane stress and of the linear component of the bending stress

3.1.5
membrane stress
component of normal stress that is uniformly distributed and equal to the average stress across the thickness of the section under consideration

3.1.6
normal stress
component of stress normal to the plane of reference

3.1.7
owner/operator
organization responsible for maintaining the condition of the packaging for transport in accordance with IAEA No. TS-R-1

3.1.8
peak stress
maximum stress that occurs in a component by reason of geometry, local discontinuities or local thermal stress, including the effects, if any, of stress concentration

3.1.9
periodic inspection
inspection of the trunnion system at predetermined periodicities during the “in-service” life of the packaging

3.1.10
periodic testing
testing at predetermined periodicities of the trunnion system, provided as a primary means for the lifting, tie-down, supporting or tilting of packages

3.1.11
primary stress
normal or shear stress developed by an imposed loading that is necessary to satisfy the laws of equilibrium of external and internal forces and moments

NOTE The basic characteristic of a primary stress is that it is not self-limiting.

3.1.12
primary trunnion system
trunnion system provided as a primary means for the lifting, tie-down, supporting or tilting of packages

3.1.13
relevant indication
indication specified by the designer that can lead to an unacceptable reduction in safety factor

3.1.14
removable trunnion
cylindrically shaped projection on a package secured by non-permanent methods, e.g. bolting

3.1.15
schedule
⟨maintenance⟩ document that gives, in appropriate detail, the applicable frequency/periodicity of maintenance items and details of methods to be employed

3.1.16
secondary stress
normal or shear stress developed by the constraint of adjacent material or by self-constraint of the structure

NOTE The basic characteristic of a secondary stress is that it is self-limiting (e.g. general thermal stresses, bending stress at a gross structural discontinuity).

3.1.17
secondary trunnion system
trunnion system provided as an additional or alternative means for the lifting, tie-down, supporting or tilting of packages

3.1.18
shear stress
component of stress tangent to the plane of reference

3.1.19
significant
⟨damage⟩ ⟨corrosion⟩ specified by the designer as possibly leading to an unacceptable reduction in the safety factor

3.1.20
stress intensity
maximum mechanical and thermal stress, calculated according to von Mises's theory

3.1.21
tie-down
securing of the package to the transport vehicle

3.1.22
total mass (lifting)
maximum mass of a package during lifting, fitted with all necessary ancillaries and equipment, and including the radioactive material and water as appropriate

3.1.23
total mass (transport)
maximum mass of a package fitted with all ancillaries (shock absorbers, neutron shields, covers, transport frame as appropriate, etc.), as presented fully laden for transport

3.1.24
transport cycle
complete round-trip journey of a package between two complete loadings

3.1.25
trans-shipment
change of transport vehicle at any time during a transport cycle, e.g. from road to rail

NOTE This applies also when a vehicle is substituted, e.g. from one rail vehicle to another rail vehicle.

3.1.26
trunnion
cylindrically shaped projection on a packaging, attached by various means and used for lifting, tie-down, supporting or tilting packages from horizontal and vertical modes

3.1.27
trunnion attachment
method of attaching the trunnion (e.g. welding, bolting, interference fitting and bolting, or any combination of these methods)

3.1.28
trunnion attachment components
trunnion attachment components excluding the trunnion, e.g. bolts, threads in the packaging body, baseplates, etc.

3.1.29
trunnion system
assembly of trunnion and components to the packaging, including the trunnion attachment components to the packaging and the female threads in the packaging body, as appropriate

3.1.30
welded trunnion
cylindrically shaped projection on a packaging, directly secured to the packaging by welding

3.2 Symbols

K_{Ic} plane strain fracture toughness

$R_e(T)$ clearly defined yield point or minimum yield strength of 0,2 % of residual elongation (0,2 % proof stress) at the operating temperature, T

$R_m(T)$ guaranteed minimum tensile strength at the operating temperature, T

S stress intensity

T operating temperature

3.3 Abbreviations

IAEA International Atomic Energy Agency

ILO International Labour Organization

IMO International Maritime Organization

ISO International Organization for Standardization

MT Magnetic particle test

NDE Non-destructive examination

PT Liquid penetrant test

RE Radiographic examination

SCC Stress corrosion cracking

UN ECE United Nations Economic Commission for Europe

UT Ultrasonic test

4 Regulatory requirements

4.1 General

In this International Standard, the word “shall” denotes a requirement; the word “should” denotes a recommendation; and the word “may” denotes permission, i.e. neither a requirement nor a recommendation. Imperative statements also denote requirements. To conform with this International Standard, all operations shall be performed in accordance with its requirements, but not necessarily with its recommendations.

The words “can” and “could” denote possibility rather than permission.

The word “will” denotes that an event is certain to occur rather than a requirement.

4.2 Relevant regulations

The main applicable document is IAEA No. TS-R-1.

Other relevant national or international regulations should also be considered to ensure that any differences with the IAEA regulations are taken into account. This International Standard does not relieve the relevant parties of the responsibility for compliance with any requirement of the government of any country through or into which the package is being transported, including regulations applicable within the nuclear power plants.

4.3 Quality assurance

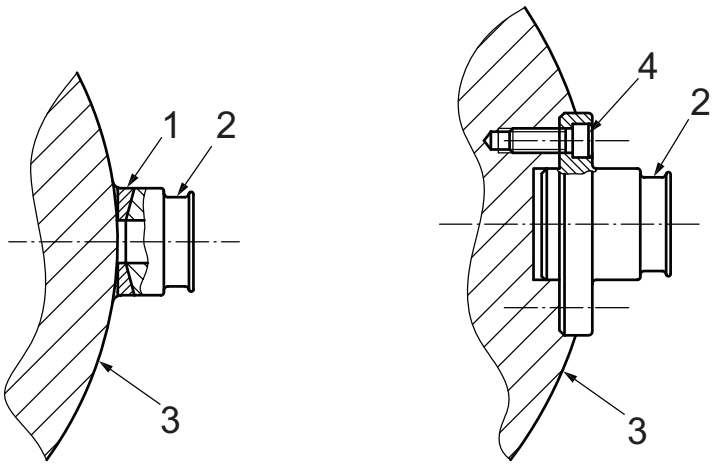
Quality assurance, although referred to separately in Clause 8, shall be applied during the application of parts or all of this International Standard.

5 Design

5.1 General

5.1.1 Trunnion systems shall be designed so that, under routine, normal and accident conditions, in accordance with IAEA No. TS-R-1, the forces in the trunnions and trunnion attachments shall not impair the ability of the package to meet the requirements of those regulations.

5.1.2 Trunnion attachment to a packaging may be carried out by welding, bolting, interference fit and bolting, or any combination of these methods. This International Standard applies to these methods of trunnion attachment; see Figure 1 a) and 1 b).



a) Welded trunnion **b) Removable trunnion (bolted)**

Key

1 weld
2 trunnion
3 packaging body
4 attachment bolt

Figure 1 — Examples of trunnions

5.1.3 Trunnions are fitted to the packaging to provide

a) a means of tie-down of the package during transport; and/or

b) a means of providing lifting, or lifting and tilting (with particular designs of packages, the trunnions are used in tilting from horizontal and vertical modes).

5.1.4 The design aspects in this International Standard take account of both uses of trunnions. Each aspect is dealt with separately to enable the designer to design for tie-down, lifting/tilting or a combination of both.

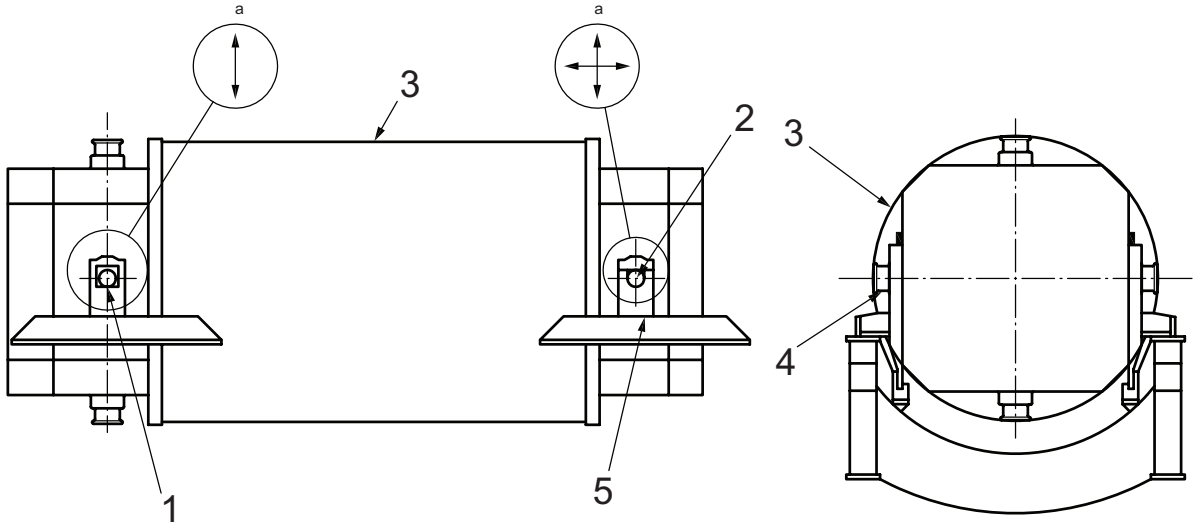
5.1.5 Although this International Standard applies only to trunnion systems, the designer shall consider how the package is supported during transport and lifted with respect to the trunnions. The design considerations to be taken into account include the number of trunnions on the package required to fulfil a particular function (e.g. lifting, supporting) and the value and the direction of forces that are imposed on the trunnions.

5.1.6 Consideration should be given to surface finish, which can be included in fatigue analysis.

5.1.7 Designers should anticipate the possibility of wear in service and consider the inclusion of a “wear allowance” in calculations. This facilitates the re-machining of the trunnions, as required, without invalidating the calculations or safety case.

5.2 Design for tie-down

5.2.1 Designers may consider using different numbers of trunnions on packages to suit different operational or transport requirements. Where trunnions are used for tie-down, the total number of trunnions in any one plane may be restrained unequally. Consideration should be given to alignment on both the package and the tie-down equipment when four (or more) trunnions share a load. Local positioning imperfections or variations in tolerances can lead to high variations in the loads acting on each trunnion. Therefore, in the absence of justification, it shall be considered that the load is supported by only the two opposite trunnions.



Key

1 vertical restraint by four trunnions
2 vertical and longitudinal restraints by two trunnions
3 packaging
4 trunnion
5 packaging support
a Restraint directions.

Figure 2 — Example of trunnion restraints

5.2.2 The designer shall consider the different modes of transport the package is intended for. It is possible that the directional orientation of a package can differ between different modes of transport, e.g. the orientation of a package during sea transport may be at right angles to the orientation of the same package during rail transport. The designers shall consider all reasonably foreseeable methods of package orientation during transport to ascertain the most exhaustive requirements.

5.3 Stress intensity on trunnion systems during package tie-down

5.3.1 At the most severely stressed point, the stress intensity, S, considering the primary linearized stresses, shall not exceed $R_e(T)$ when the conditions in 5.3.2, 5.3.3 and 5.3.4 apply. The values of $R_e(T)$ shall be specified in the design criteria. There is no reduction factor for welded joints/interfaces in the following load cases. A safety factor shall be included for welded joints/interfaces. Consideration should be given to the method of welding, controlling method and NDE methods, if a weld safety factor is being included.

5.3.2 The following load cases may be assumed to act on the packaging (including the mass of the packaging, when applicable):

a) in the direction of transport: four times the total mass (transport), except for railway transport with hump switching, in which case it is six times the total mass (transport);

b) at right angles to the direction of travel: twice the total mass (transport);

c) in the vertical direction: three times the total mass (transport).

NOTE These load cases are conservative compared to those considered in the IMO/ILO/UN ECE guidelines for packing cargo transport units of Reference [3].

Other values may be used subject to appropriate justification.

5.3.3 It shall be considered that the above loads in the three main directions can act simultaneously.

5.3.4 The designer shall take into account the fact that the trunnion system shall be capable of operating from the minimum temperature, as defined in the regulations [– 40 °C for a type B(U) package] and/or certificate of approval, to the maximum temperature of the trunnion system during package transport, based on regulatory conditions of ambient temperature and insolation.

5.3.5 When the trunnion attachment includes bolts, the preload of the bolts shall be appropriate to avoid any loosening during operation.

5.3.6 The criteria in 5.3.1 to 5.3.4 apply to the trunnion system, not to the body of the packaging.

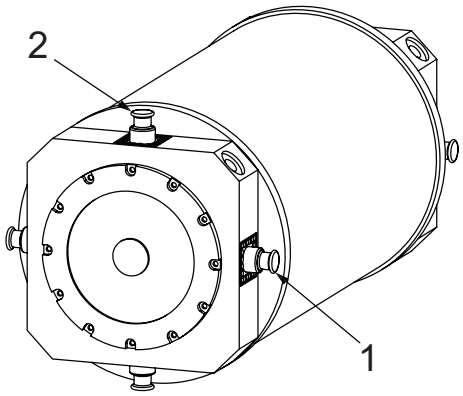
5.3.7 The criteria in 5.3.1 to 5.3.4 do not apply to the transport frame, which shall be separately assessed according to the regulations that apply to the transport mode.

5.4 Design for lifting and tilting

5.4.1 Depending upon the design for operation, the package may have the capability of being lifted and/or tilted on the same trunnions. In some cases, packages might not be designed to be tilted. Whichever case applies, the stress intensity, S, shall be calculated taking into account the total mass (lifting) that applies at any time to the minimum justified quantity of trunnions.

5.4.2 In some cases, the designer shall be required to design packages fitted with secondary trunnion systems; see Figure 3. The designer shall design the primary and secondary trunnion systems independently of each other. The primary and secondary trunnion systems shall be designed so that they also act independently of each other.

Where trunnions are used for lifting and/or tilting, the total number of trunnions in any one plane may be restrained unequally. Consideration should be given to alignment on both the package and the lifting and/or tilting equipment when four (or more) trunnions share a load. Local positioning imperfections or variations in tolerance can lead to high variations in the loads acting on each trunnion. Therefore, in the absence of justification, it shall be considered that the load is supported by only the two opposite trunnions.



Key

1 primary trunnion

2 secondary trunnion

Figure 3 — Packaging having primary and secondary trunnions

5.5 Stress intensity on trunnion systems during package lifting or tilting

5.5.1 At the most severely stressed point, the stress intensity, S, considering the primary linearized stresses, shall not exceed $R_e(T)$ when the conditions in 5.5.2. and 5.5.3. apply. The values of $R_e(T)$ shall be specified in the design criteria. A duty factor shall be included for welded joints, depending on the methods of welding and inspection.

5.5.2 A safety factor shall be assumed along the lifting axis on the total mass acting on the trunnions. The safety factor shall normally be 2, but may vary depending on the applicable national requirements and the consequences of failure; see 4.2.

5.5.3 The designer shall take into account the fact that the trunnion system shall be capable of operating from the minimum temperature as defined in the regulations [– 40 °C for a type B(U) package] and/or certificate of approval, to the maximum temperature of the trunnion system during package transport, based on regulatory conditions of ambient temperature and insolation.

5.6 Fatigue analysis of trunnion system

5.6.1 The designer shall take into account the fact that the life can be reduced due to the effects of fatigue caused by cyclic stresses during transport, lifting or a combination of both.

5.6.2 Fatigue analysis shall consider peak stresses, and any weakening due to welds and features that can induce stress concentrations, and appropriate fatigue curves for the material that is used.

5.7 Design for manufacture, inspection, testing and assembly

5.7.1 The designer shall aim to achieve simplicity and repeatability in determining the requirements for inspection, testing and assembly.

5.7.2 To facilitate the evaluation of surface cracks and damage, the designer may specify that the inspection criteria incorporate a “brittle fracture” analysis of the trunnion using a fracture-mechanics-based approach.

5.8 Design for operation

5.8.1 Operating aspects, such as safety, relationships to interface operating equipment (e.g. lifting equipment and package supports) and ease of decontamination shall be taken into account.

5.8.2 The design of the trunnion systems should, where possible, be integrated with the design of interfacing lifting equipments or, otherwise, the trunnion and interfacing equipment proposed should be assessed for mutual compatibility of geometry and material.

5.8.3 Specific surface finish limits shall be specified by the designer. Smooth surfaces and gradual changes of section aid decontamination and are also beneficial for fatigue properties. Liquid traps shall be avoided. Applying sealant or using gaskets can prevent the ingress of liquids.

5.8.4 As far as practicable, ease of decontamination shall be considered in the design of trunnion systems, particularly with regard to the bolted attachments.

5.8.5 Where the trunnion is attached to the package by bolting, the designer shall consider carefully the strength grade specified for the bolt and any requirement for the attachment system to withstand the effects of water, for example reactor-pond water.

In cases where exposure of attachment bolts to reactor-pond water cannot be avoided, the designer should ensure that the combination of bolt strength grade and preload stress do not render the bolts vulnerable to the effects of stress corrosion cracking (SCC). Where the effects of SCC cannot be avoided by design, the designer shall specify a regime of inspection to detect the early effects of SCC and to allow for bolt replacement before there is serious damage.

5.9 Design for maintenance (periodic inspection, periodic testing, component replacement and repairs)

5.9.1 During design, consideration shall be given to the methods of maintenance that shall be employed during the in-service life of the trunnion systems. Insufficient thought given to design with respect to these factors can cause difficulties in carrying out maintenance.

Inspection, maintenance and repair of welded trunnions present greater difficulties than bolted trunnions, and consideration should be given to the availability of enabling tools and techniques.

5.9.2 Periodic inspection

Periodic inspection shall be carried out in accordance with 7.4 during the in-service life of the trunnion system. The areas requiring regular inspection are areas of special concern and surfaces subject to damage as well as screws and threaded holes. These areas should be easily accessible and designed to facilitate inspection.

Full as-built dimensional records of each trunnion shall be retained as part of the manufacturing record/lifetime quality record as a basis for comparison during inspection.

5.9.3 Periodic testing

The designer shall specify testing methods during manufacture that can be repeated during in-service life. The designer shall ensure that there are no physical features on packaging that can inhibit repeatable tests.

5.9.4 Component replacement

The designer shall ensure that the removable components of the trunnion system can be replaced as simply as possible and in accordance with 7.5.

5.9.5 Repair

5.9.5.1 The life of a trunnion system can be increased if repair is possible to recover non-conforming trunnions, attachments or components. Consideration may be given to the inclusion of an allowance within the design criteria to enable the recovery of non-conforming items.

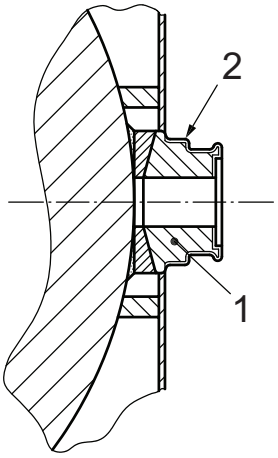
5.9.5.2 Where welding is considered a feasible repair solution, the designer shall ensure that the materials chosen for the design can be welded satisfactorily without detrimental effect upon the original material properties.

5.10 Trunnion materials

5.10.1 Material selection

5.10.1.1 The material chosen shall meet all the requirements detailed in this International Standard.

5.10.1.2 It is recommended that trunnions be made from a corrosion-resistant steel. There can be cases where the use of stainless steel cladding of a carbon-alloy-steel substrate can be justified, provided the designer has carefully considered all aspects of inspection and maintenance that are likely to be most challenging.



Key

1 base material

2 stainless steel cladding

Figure 4 — Example of a clad trunnion

5.10.1.3 In order to minimize corrosion, materials shall be chosen to ensure that the electro-potential sensitivity between components is minimal.

5.10.1.4 Materials chosen for the sealant shall be compatible with the materials of the trunnion system (including bolts, gaskets, etc.).

5.10.1.5 Materials chosen for cleaning in operation shall be compatible with the materials of the trunnion system (including bolts, gaskets, sealants, etc.).

5.10.2 Mechanical properties and material testing

5.10.2.1 The mechanical properties of the materials shall meet the requirements of 5.3 and 5.5 regarding stress intensity.

5.10.2.2 The material shall be capable of achieving the following:

a) Charpy impact test properties of 23 j minimum at − 40 °C for a type B(U) or a type C package as defined in IAEA No. TS-R-1;

b) tensile test elongation to failure of 14 % minimum at 20 °C.

5.10.2.3 Where trunnions are not wholly stainless steel, but are stainless-steel covered, the mechanical properties shall be those of the base material. The mechanical properties of the stainless steel should be ignored.

5.10.2.4 Consideration shall be given to the hardness of the trunnion, attachment and component materials to minimize any surface incompatibility that can arise due to the material hardness of interface equipment.

5.10.2.5 The designer shall specify that relevant properties, such as K_{Ic}, of the materials shall be obtained to enable a fracture mechanics analysis of the trunnion system when this is required.

5.10.2.6 The designer shall specify the performance of intercrystalline corrosion tests when this is relevant.

5.10.2.7 Lubricants and decontamination agents shall be compatible with the materials of the trunnion system (including the potential effects on stress corrosion cracking).

6 Manufacture

6.1 General

6.1.1 Manufacture of trunnion systems, assembly and attachment to the packaging, shall be carried out by competent organizations, qualified to carry out various aspects of manufacture, materials testing, NDE, assembly and attachment.

6.1.2 In the specification of the material by the purchaser, the purchaser shall refer to material standards wherever possible, including any relevant additional information, e.g. where a modified material is required.

6.1.3 Manufacture shall be carried out, in all cases, to a predetermined quality plan. The quality plans shall be agreed and approved by the manufacturer/designer/purchaser or independent competent organizations as appropriate, prior to manufacture commencing.

In practice, the quality plans may detail the status of the referenced documents and have provisions for material traceability and for controlling signatories responsible for the verification of quality.

6.1.4 The NDE methods described in 6.3.2 are given as examples. Other methods may be used and are not precluded if considered as suitable and accurate.

6.1.5 The manufacturing methods and routes shall be agreed between the designer, purchaser and the manufacturer, including special manufacturing routes, i.e. forging, stress relieving, etc.

6.1.6 Manufacture shall include assembly, inspection and testing.

6.2 Assembly

Depending on the design and sizes of the trunnion components, positioning or location fixtures may be used to assist assembly. Assembly shall be carried out and reported in accordance with the procedures and standards as specified on the quality plans.

For bolted trunnions, it can be necessary to specify a sequence and range of torque application for the bolts or screws, leading up to the application of the final torque.

For welded trunnions, all root and filler runs shall be adequately specified. Where dissimilar materials are being welded, the types of materials being used shall be specified. Only competent and qualified welders shall be used. Welders shall be qualified to a recognized national or International Standard. It can be deemed necessary to carry out NDE at various steps of the welding process.

6.3 Inspection during manufacture and assembly

6.3.1 Dimensional and visual inspection

6.3.1.1 Dimensional inspection shall be carried out on the trunnion system. Each item shall be fully inspected to ensure conformity with design drawings, including but not limited to

a) feature dimensions and tolerance;

b) surface finish;

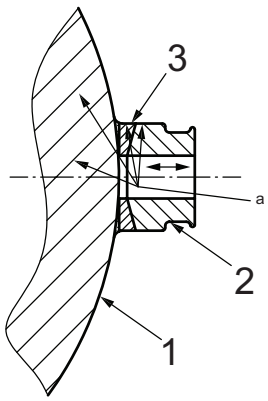
c) thread gauging.

6.3.1.2 Dimensional and visual inspection shall be carried out and reported in accordance with the procedures and standards as specified in the quality plans. Reporting shall compare dimensional inspection results with the acceptance criteria stated on the approved design drawings.

6.3.2 Non-destructive examination

6.3.2.1 Non-destructive examination, NDE, shall be carried out during specified steps of the manufacture to verify the material condition at that step. It is advised that all material (except plate and pipe) should be scanned for internal indications using UT methods before any significant fabrication is commenced. If considered necessary by the purchaser, further UT or RE scanning should be carried out on trunnions and trunnion components after final machining. Additional UT scanning is advised if further hot working is carried out during the manufacturing process. In the case of trunnions attached by welding, the welds and the heat-affected zones should be UT-scanned after completion of welding and any subsequent treatment steps involving heat, i.e. stress relieving, lead pouring, etc.; see Figure 5. In addition to scanning by UT methods, all trunnions, trunnion attachment welds and trunnion attachment components should be surface-crack-detected by PT or MT methods. This should be carried out on completion of manufacture, i.e. after final machining of components, final welding run, stress relieving, lead pouring, etc. NDE shall be carried out and reported in accordance with the procedures and standards as specified in the quality plan.

Reporting shall compare test results with the acceptance criteria quoted. Other NDE methods may be used as an alternative to those recommended above, if considered more appropriate (see 5.9.3 and 6.3.2.3).



Key

1 packaging body

2 trunnion

3 trunnion/cask weld

[a] UT scanning.

Figure 5 — Example of UT of a trunnion/packaging weld

6.3.2.2 The NDE specified in 6.3.2.1 shall also apply in the case of other welded attachment designs that have highly stressed welds. This includes trunnions welded to baseplates and trunnion baseplates welded to the packaging.

6.3.2.3 For the trunnion and the bolts (when the trunnion is attached to the body by bolting), some or all of the NDE shall be repeated during the in-service life of the packaging. In this respect, adequate records of surface or internal indications, including reference data, orientation of indications, trunnion serial number and trunnion attachment component serial numbers, as appropriate, shall be retained for comparison purposes. The same NDE procedures used during manufacture shall be used during maintenance. In the case of UT scanning, adequate records of the equipment used shall be retained for comparison purposes.

6.4 Testing during manufacture and assembly

6.4.1 Testing during manufacture and assembly shall include, but not be limited to:

a) chemical analysis;

b) mechanical testing of material properties;

c) static testing.

6.4.2 Chemical analysis

Chemical analysis shall be performed before any fabrication work is carried out. The analysis shall be carried out to determine whether or not the material contains the constituents specified by the purchaser, and whether or not those constituents are within the tolerances specified. One analysis per batch or cast of material shall be carried out. Analysis and reporting shall be carried out in accordance with the procedure or standard as specified in the quality plans. Reporting shall compare the analytical results with the acceptance criteria quoted.

6.4.3 Mechanical testing of material properties

6.4.3.1 Testing to verify the material properties, with the exception of material properties in accordance with 5.10.2.5. and 5.10.2.6, shall be carried out during specified steps of the manufacture to verify the finished condition of the material, where no further treatment, fabrication or manufacturing steps can alter the material properties. Test samples are normally used to verify material properties. Test samples shall be representative of the materials being used and the tests shall be carried out per batch or cast of material. Any test samples that the purchaser requests be archived shall be suitably identified.

The testing mode shall take account of the geometry and orientation of trunnions and trunnion attachments on the packaging to ensure that representative data are obtained. Testing and reporting shall be carried out in accordance with the procedure or standard as specified in the quality plans. Reporting shall compare test results with the acceptance criteria quoted. Consideration shall be given by the purchaser to specifying the number of tests to carry out per test type to ensure that meaningful data are obtained.

6.4.3.2 The material properties, in accordance with 5.10.2.5 and 5.10.2.6, shall be obtained for each material type/grade.

6.4.4 Static testing

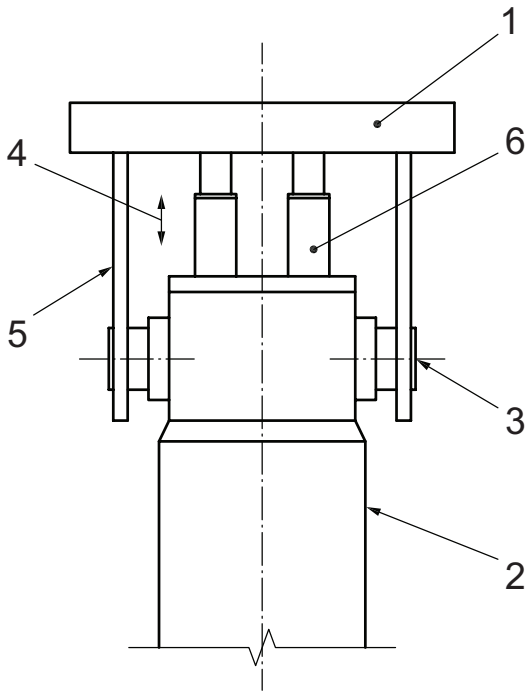
Static testing of trunnion systems shall be carried out to verify the assembled condition. Testing shall be carried out on the pairs of trunnions that are used together. Testing shall be carried out by lifting, using weights attached to a packaging, or by using hydraulic jacks between a yoke and a pair of trunnions positioned on a packaging to exert an equivalent load; see Figure 6. Testing, where possible, should simulate the mode in which the trunnions normally operate.

Trunnions shall be tested for a minimum of 10 min. A minimum factor of 1,5 times the maximum service load (lifting, tilting or tie-down) shall be applied. It should be recognized that longer durations and higher load factors may be demanded according to local or national regulations, or the requirements of the licensing authorities. The designer shall take adequate steps to address these requirements.

Trunnions and trunnion attachments shall be surface-crack-detected using PT (stainless steel) or MT (carbon steel) methods after static testing. Static testing shall be carried out in accordance with the procedures and standards quoted in the quality plan. Reporting shall compare static test results with acceptance criteria quoted in terms of residual deformation, UT indications and bolt torques, as appropriate.

With welded trunnions, the trunnion-to-packaging weld and the heat-affected zone shall be UT-scanned after static testing as a comparison against the UT scan after welding.

With bolted trunnions, the torques of the bolts or screws shall be rechecked after static testing. The designer shall identify the most highly stressed bolt, either on the appropriate drawing or in the testing specification. The most highly stressed bolt in a bolted trunnion system shall also be removed for dimensional analysis to ensure that the trunnion system has not been overstressed during static testing.



Key

1	yoke	4	load
2	packaging	5	yoke arms
3	trunnion	6	hydraulic jack

Figure 6 — Example of trunnion static testing using hydraulic jacks

7 Maintenance

7.1 Preparation of maintenance schedule

The designer shall prepare a maintenance schedule, taking into account the requirements of 7.2 to 7.7.

7.2 General

7.2.1 Maintenance shall be carried out by competent persons, qualified to carry out all methods of the maintenance recommended by the designer, or qualified to carry out the maintenance required to meet the designer's recommendations.

7.2.2 Maintenance shall be comprised of one or more combinations of periodic inspection, periodic testing, component replacement or repairs. The content of the maintenance shall be dependant upon the frequency at which maintenance is being carried out and the feature being maintained.

7.2.3 Maintenance shall be carried out in accordance with a maintenance schedule; see 7.3.

7.2.4 Regular periodic inspection at predetermined frequencies shall be carried out to ascertain if the in-service limits have been approached or an unacceptable rate of wear or damage has taken place.

7.2.5 Periodic testing shall be defined to ensure that the system is in compliance with the in-service limits.

7.2.6 Repair of trunnion systems can be considered necessary if wear, corrosion or damage have resulted in the in-service limits being exceeded.

7.2.7 Maintenance shall be carried out to predetermined quality plans. The plans, maintenance methods and routes shall be approved by the designer, owner/operator, maintenance organization, independent competent organization or competent authority, as appropriate, prior to any maintenance commencing. Repair plans shall be required for each unique type of repair.

7.2.8 Particular care shall be taken if solvents/chemicals are used during the cleaning of trunnions and components during maintenance. The solvents/chemicals shall be checked to ensure that they are compatible with the trunnions and trunnion components, including bolts, gaskets, sealants, etc.

7.2.9 Particular care shall be taken to prevent water intrusion into the space between the trunnion system and the body of the packaging, depending of the sensitivity of the materials (high-tensile bolts susceptible to SCC, etc.) to the presence of water.

Where trunnion systems are designed to include sealed areas, those areas shall be examined to ensure the integrity of the sealed area. A functional test of the seals should be considered, if appropriate.

7.3 Maintenance schedule

The content and frequency of maintenance schedules shall be agreed between the designer, owner/operator, maintenance organization, independent competent organization and/or competent authority, as appropriate.

7.4 Periodic inspection

7.4.1 General

The features for periodic inspection and the types of periodic inspection shall depend on the type of trunnion system and the periodicity at which it is being carried out. The following features shall be inspected in accordance with a maintenance schedule; see 7.3.

7.4.2 Removable trunnions

The following features for removable trunnions shall be inspected:

a) accessible trunnion surfaces;

b) attachment threads in the packaging body;

c) attachment screws or bolts (this applies only to attachment screws or bolts that are not being discarded);

d) trunnion assembly (bolt torque, etc.);

e) sealing areas;

f) feature dimensions.

7.4.3 Welded trunnions

The following features for welded trunnions shall be inspected:

a) accessible trunnion surfaces;

b) weld areas;

c) sealing areas;

d) feature dimensions.

7.4.4 Trunnion surfaces

7.4.4.1 The surfaces of the trunnions shall be checked to ensure they are in a condition that is not detrimental to any interface equipment in connection with which the trunnions are used, or to the design strength, e.g. by having damage or corrosion that can lead to collapse or fatigue failure of the trunnion system.

7.4.4.2 Trunnion surfaces shall be examined visually and by PT methods. Visual examination shall be complemented by any measuring techniques necessary to determine the height, depth, length and width of any surface damage present on the trunnions.

7.4.5 Attachment threads in packaging body

7.4.5.1 The attachment threads in the packaging body, used in conjunction with retaining screws or bolts, shall be checked to ensure they are capable of carrying out their design function of retaining the trunnion in its position on the packaging body under all envisaged design stresses (shear, bending and tensile, as appropriate).

7.4.5.2 Attachment threads in packaging bodies shall be examined visually and by using thread-plug gauges.

7.4.6 Attachment screws or bolts

7.4.6.1 Attachment screws or bolts that are being removed and re-used shall be checked to ensure that they are, in conjunction with attachment threads in the packaging body, capable of carrying out their design function of retaining the trunnion in position on the packaging body under all envisaged design stresses.

7.4.6.2 The screws shall be examined visually, dimensionally and by using thread-ring gauges.

7.4.6.3 The trunnion assembly shall be examined visually for any sign of missing components, abnormalities, significant damage or corrosion.

7.4.6.4 The inspection requirements for attachment bolts shall be more rigorous where it is shown that the bolts are vulnerable to the effects of SCC. This may include, for example, inspection by UT at intervals more frequent than normal maintenance intervals, or the routine replacement of bolts after a fixed number of handling operations.

7.4.7 Feature dimensions

The dimensions of major features of the trunnion system shall be checked to ensure compliance with the in-service limits.

7.5 Periodic testing

7.5.1 Types of testing

Periodic testing of trunnion systems shall include relevant non-destructive testing and may include static testing. Periodic testing shall be carried out in accordance with a maintenance schedule.

7.5.2 Trunnion system

7.5.2.1 The trunnion system shall be examined at specific maintenance periodicities (this may be comprised of a static test) and the torque of the attachment screw/bolt shall be checked.

7.5.2.2 A static test, when it is mandated or otherwise justified (for example in the case of damage or deterioration through corrosion), may be carried out on the pairs of trunnions that are used together. Testing may be carried out by lifting, using weights attached to a packaging, or by using hydraulic jacks between a yoke and a pair of trunnions, positioned on a packaging to exert an equivalent load. Testing shall simulate the mode in which the trunnions normally operate.

7.5.2.3 After static testing, the trunnion surfaces shall be examined visually and by PT or MT methods according to material.

7.5.2.4 After static testing, the attachment screw or bolt torques shall be re-checked.

7.5.3 Weld areas

7.5.3.1 For welded trunnions, the welds attaching the trunnion to the packaging body shall be checked to ensure that they do not contain any flaws (including internal flaws) that can be detrimental to the design strength. The weld shall be checked by a full volumetric UT examination. Depending on the shape of the packaging body, the trunnion and the weld, various angles and types of transducers shall be used to assist in obtaining a three-dimensional picture. Test blocks shall be used to assist in calibrating. Ideally, one test block, manufactured from material similar to the trunnion and welded to the packaging, shall simulate the shape of the trunnion. This test block shall also contain a series of holes to simulate various flaws. Other NDE methods may be used as an alternative to those recommended above if considered more appropriate; also see 5.9.3 and 6.3.2.3.

7.5.3.2 The NDE specified in 7.5.3.1 shall also apply to the case of other welded attachment designs that have highly stressed welds. This includes trunnions welded to baseplates and trunnion baseplates welded to the packaging.

7.5.3.3 Depending on the design of the trunnion system, there can be additional welded areas that require checking. These areas can be in addition to the trunnion/packaging body welds, being low-stress areas but still part of the trunnion system. These areas shall be checked by PT methods.

7.6 Component replacement

7.6.1 It may be considered appropriate to replace in-service components, such as trunnions or attachment screws, at specific periodicities instead of periodically inspecting those components. Where components are dismantled during maintenance, consideration shall be given to replacement of components with new ones each time the components are dismantled.

7.6.2 Any damaged component should be removed and replaced with a new one. Damaged components, e.g. trunnions, may be repaired (see 7.7) and refitted to the trunnion system provided that the characteristics of the repaired component fall within the in-service limits stipulated by the designer.

7.6.3 Fatigue can invisibly deteriorate attachment screws or bolts, in which case replacement shall be in accordance with a fixed schedule.

7.7 Repairs

7.7.1 At any time, damage can occur that results in a trunnion system being rendered unfit for further use and requiring immediate repair or repair within a specified time-scale. Wear and corrosion can also result in a trunnion system whose in-service limits have been exceeded. Damage, wear or corrosion can be identified during periodic inspection or at any other time during operation of a package.

7.7.2 All repairs shall be designed, carried out, tested and verified to ensure that all requirements of the trunnion design criteria are achieved.

7.7.3 Features to be repaired and methods

7.7.3.1 Trunnions used for lifting and tilting are liable to be damaged on the lifting/tilting diameters. Damage can also be caused during the fitting and removal of lifting equipment to the trunnion. Localized damage shall be removed by faring the damaged area into the remaining surfaces by hand dressing.

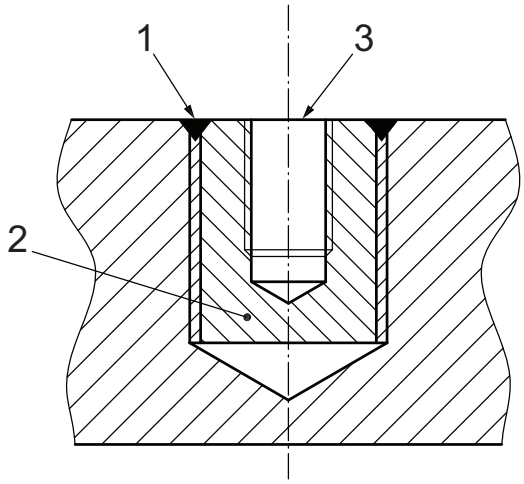
7.7.3.2 More extensive damage can require a weld infill of the damaged area followed by local faring or machining of the original surfaces. Only qualified weld processes and weld operators shall be used. Weld materials shall be compatible with the original trunnion-system materials. Consideration shall be given to post-weld heat treatment to achieve the material properties of the original trunnion system.

7.7.3.3 Reduction of lifting and tilting diameters by machining, within in-service limits, may be considered if local repair is impractical. Consideration shall be given to interfacing equipments.

7.7.3.4 Threaded holes in packaging bodies can be subject to corrosion, wear or damage. Repair of threaded holes shall be carried out by one of the following methods:

a) fitting of a wire thread insert;

b) fitting of a threaded bush to return thread to original size; see Figure 7.



Key

1 retaining weld
2 threaded bush
3 original thread size and form

Figure 7 — Example of a threaded bush repair

7.7.3.5 In the case of major damage to welded trunnions, consideration may be given to removal of the trunnion completely and replacement by a bolted trunnion system.

7.7.4 In all cases where a repair has been carried out or where major components (e.g. trunnions) are replaced, or where new trunnions are fitted, testing and NDE shall be defined to ensure that the system is in accordance with the in-service limits.

8 Quality assurance

IAEA No. TS-R-1:2009, paragraph 306 states: “Quality assurance programmes based on international, national or other standards acceptable to the competent authority shall be established and implemented for the design, manufacture, testing, documentation, use, maintenance and inspection of all (…) packages”.

The term “quality assurance programme” may be related or equated to “quality management system/programme” as defined in ISO 9001:2008[1].

NOTE 1 IAEA No. TS-G-1.4[2] provides advice on acceptable ways of achieving and demonstrating compliance with the quality assurance criteria from package fabrication to transport use.

NOTE 2 References [1] and [2] contain provisions which, through reference in this International Standard, constitute provisions of this International Standard. Subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the documents indicated above. Members of ISO and IEC maintain registers of currently valid International Standards.

Bibliography

[1] ISO 9001:2008 — *Quality management systems — Requirements*

[2] International Atomic Energy Agency (IAEA) No. TS-G-1.4, *The Management System for the Safe Transport of Radioactive Material*

[3] IMO/ILO/UNECE, Guidelines for packing of cargo transport units. In: *International Maritime Dangerous Goods Code, Supplement*. London: International Maritime Organization, 2008

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