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

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

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Subcommittee SC 5, *Nuclear installations, processes and technologies*.

This second edition cancels and replaces the first edition (ISO 10276:2010), which has been technically revised. The main changes compared to the previous edition are as follows:

— The scope is extended to trunnion attachment components (trunnion systems are defined as being the trunnions and their attachment components);

— The normative references have been updated (IAEA TS-R-1 replaced by IAEA SSR-6) and enlarged to the IAEA SSG-26 (Appendix IV-1 - Package stowage and retention during transport);

— Quality Assurance is replaced by Management Systems;

— The load cases are to be defined by use of the minimum acceleration factors given in table IV-1 of the Appendix IV of IAEA SSG-26;

— The calculation methods (analytical and finite element analysis) and the minimum associated criteria are more precisely detailed;

— The bibliography has been updated and enlarged to the most recent recommendations, guidance and standards as acceptable by most of the Competent Authorities;

— The structure of the document has been slightly modified to enhance its legibility and understanding.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document has been produced to enable package owners, designers, users and regulatory organizations to have at their disposal a comprehensive document covering all aspects of trunnion systems. Experience has been drawn from the extensive knowledge of owners, designers, users and competent authorities. This document contains the minimum requirements and makes recommendations covering various aspects of trunnion systems.

Intermediate devices (sometimes referred to as transport frames, supports or cradles) can be used between the packaging trunnions and the transport conveyance to support and secure the package during transport; however, the energy-absorbing effects that may be provided by these intermediate devices are not taken into consideration in this document.

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

1 Scope

This document covers trunnion systems used for tie-down, tilting and/or lifting of a package of radioactive material during transport operations.

Aspects included are the design, manufacture, maintenance, inspection and management system. Regulations which can apply during handling operation in nuclear facilities are not addressed in document.

This document does not supersede any of the requirements of international or national regulations, concerning trunnions used for lifting and tie-down.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IAEA SSR-6, *International Atomic Energy Agency (IAEA) Safety Standard No. SSR-6, Regulations for the Safe Transport of Radioactive Material*

IAEA SSG-26, *International Atomic Energy Agency (IAEA) No. SSG-26, Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material*

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 SSR-6 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1.1
bending stress
variable component of *normal stress* (3.1.10), which might not be linear across the thickness

3.1.2
bolts
fasteners including bolts, screws and studs

3.1.3
designer
organization responsible for the design of the package

3.1.4
independent expert 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

3.1.5
linearized stress
sum of the *membrane stress* (3.1.9) and of the linear component of the *bending stress* (3.1.1)

3.1.6
load case
specific configuration of transport or lifting associated to a total mass (transport or lifting), specified value and direction of acceleration, a given number of acting trunnions, and a given point/area of application of the load on the trunnion

3.1.7
maintenance schedule
document drawn up by the designer that gives, in appropriate detail, the applicable frequency/periodicity of maintenance items and details of methods to be employed; applied by the owner/operator

3.1.8
maximum service load
greater of *total mass (lifting)* (3.1.19) and *total mass (transport)* (3.1.20), subjected to gravity (1 g)

3.1.9
membrane stress
component of *normal stress* (3.1.10) that is uniformly distributed and equal to the average stress across the thickness of the section under consideration

3.1.10
normal stress
component of stress normal to the plane of reference

3.1.11
owner
operator
organization responsible for maintaining the condition of the packaging for transport

Note 1 to entry: The condition of packaging shall be in accordance with IAEA SSR-6.

3.1.12
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

3.1.13
periodic inspection
inspection of the trunnion system during the in-service life of the packaging at predetermined periodicities defined in the *maintenance schedules* (3.1.7)

3.1.14
primary trunnion system
trunnion system provided as a primary means for lifting and/or tilting, tie-down and supporting of the package

3.1.15
quality plan
document, or several documents, that together specify quality standards, practices, resources, specifications, and the sequence of activities relevant for manufacture

3.1.16
removable trunnion
trunnion, on a package secured by non-permanent methods, e.g. bolting

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

3.1.18
tie-down
securing of the package to the conveyance

3.1.19
total mass (lifting)
maximum mass of a package as supported by the trunnion systems during lifting, fitted with all necessary ancillaries and equipment, and including the radioactive material and water as appropriate

3.1.20
total mass (transport)
maximum mass of a package fitted with all ancillaries (shock absorbers, neutron shields, covers, transport frame as appropriate, etc.), as presented for transport and as supported by the trunnion systems

3.1.21
transport cycle
complete round-trip journey of a package between two complete loadings

3.1.22
trunnion
projection, typically cylindrical in shape, attached on a packaging by various means and used for lifting, tilting and/or *tie-down* (3.1.18) of the package; parts permanently attached to the trunnion are considered as being part of the trunnion

Note 1 to entry: A trunnion is an example of an attachment point as defined in IAEA SSG-26, Appendix IV.

3.1.23
trunnion attachment method
method of attaching the trunnion (e.g. welding, bolting, threaded attachment, interference fitting and bolting, or any combination of these methods) to the packaging body

3.1.24
trunnion attachment components
attachment components, e.g. welding to the packaging body, bolts, removable shear discs, female threads or housing in the packaging body, removable baseplates, etc., used to secure the trunnion to the packaging body

3.1.25
trunnion system
assembly of *trunnion* (3.1.22) and *trunnion attachment components* (3.1.24)

3.1.26
welded trunnion
trunnion directly secured to the packaging by welding

3.2 Symbols

K_{Ic} plane strain fracture toughness

$R_e(T)$ guaranteed yield strength or guaranteed 0,2 % proof strength at the operating temperature, T

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

T operating temperature

3.3 Abbreviations

FEA Finite Element Analysis

MT Magnetic particle test

NDE Non-destructive examination

PT Liquid penetrant test

SCC Stress corrosion cracking

UT Ultrasonic test

VT Visual inspection test

4 Regulatory requirements

4.1 General

In this document, 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 to this document, all operations shall be performed in accordance with its requirements, but not necessarily with its recommendations.

The word “can” denotes possibility rather than permission.

4.2 Relevant regulations

The main applicable document is IAEA SSR-6. Other relevant national or international transport regulations should also be considered to ensure that any differences with the IAEA Transport Regulations are taken into account.

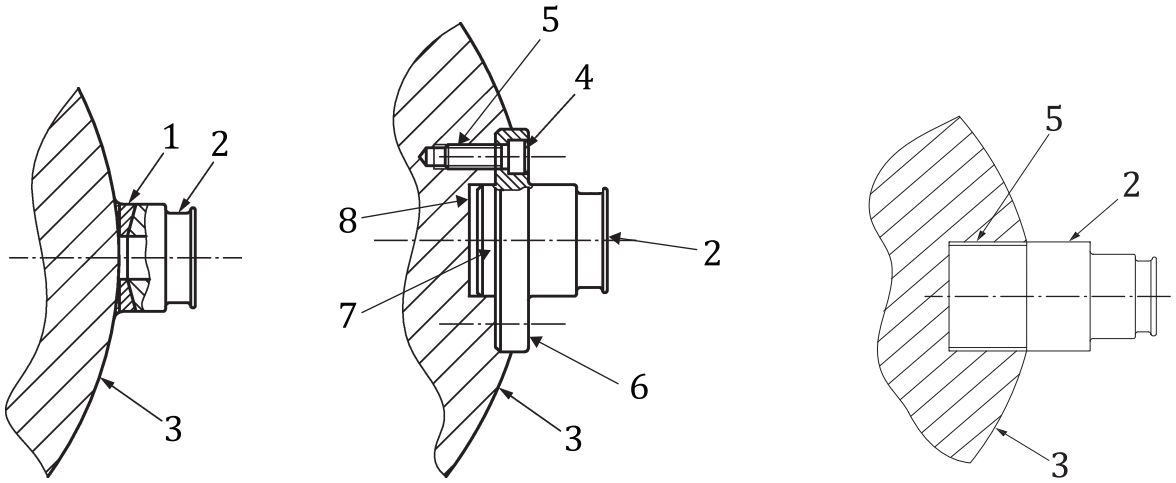
This document does not relieve the relevant parties of the responsibility for compliance with any requirement of the regulations applicable within the nuclear power plants (e.g. KTA 3905[3] or ANSI N 14.6[4]).

5 Design

5.1 General

5.1.1 Trunnion systems as part of a package design shall be designed in accordance with IAEA SSR-6 with consideration of IAEA SSG-26, and in particular its Appendix IV.

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



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

Key

1	weld	5	body thread
2	trunnion	6	removable baseplate
3	packaging body	7	removable shear disc
4	attachment bolt	8	body housing

Figure 1 — Examples of trunnions

5.1.3 Trunnions are fitted to the packaging to provide the following:

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

— a means of providing lifting, or lifting and tilting, the package (with particular designs of package, the trunnions are used in tilting the package from horizontal to vertical position and vice-versa).

5.1.4 The designer shall consider how the package is supported during transport and lifting and/or tilting with respect to the trunnions. For these situations the load distribution for the trunnion system shall be derived. The designer shall consider the number of trunnions on the package required to fulfil a particular function (e.g. lifting, tilting, supporting) and the value, the direction of forces that are imposed on the trunnions and the way they are applied (point of application, width, angle of repartition...). See 5.4 for more details.

The load transferred by the trunnion system to the packaging body needs to be considered but is not part of this document.

5.1.5 The design of the trunnion system shall be capable of performing for a temperature range as defined in the IAEA Transport Regulations. In particular, minimum and maximum operating temperatures due to design heat load and worst case ambient conditions shall be considered. Differential thermal expansion between the conveyance means and the packaging may add stresses to the trunnion system unless specific design arrangements are made to avoid those effects.

5.1.6 The designer should ensure that the combination of environment, component materials, bolt coatings, bolt strength, grade, and tensile stress do not render the trunnion system vulnerable to the

effects of stress corrosion cracking (SCC). Where the effects of SCC are not 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 damage.

5.1.7 Any trunnion systems shall be so designed that, under normal and accident conditions of transport, the forces in those trunnion systems shall not impair the ability of the package to meet the requirements of the IAEA Transport Regulations.

5.1.8 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.

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

5.2 Design methodology

Structural analysis of trunnion systems shall include a strength analysis and a fatigue analysis. If necessary, issues such as brittle fracture and structural stability should be considered.

This analysis can generally be performed by the following methods:

— analytical methods,

— finite element analysis (FEA), or

— a combination thereof.

The applicability of the chosen method shall be checked and justified by the designer.

In the case of trunnion systems with complex geometry and load situation, FEA is preferred as it leads to more detailed stress and strain results for complex structures.

Clarification on method and criteria are given in 5.5.

5.3 Materials

5.3.1 Material selection

Materials used for the trunnion systems shall be selected or treated to avoid corrosion, including SCC effects, as appropriate, during the life of the packaging. This includes, but is not limited to, the following considerations:

— the environment conditions in loading operation (borated water, moisture, protection or decontamination agents which might include demineralized water, oxalic acid, steam, nitric acid, caustic solution, NaOH-tartaric acid, lubricants, or other proprietary products),

— ambient conditions (maritime, rain, snow,…) during transport or storage period,

— bolt grease, sealant (used in the packaging design),

— galvanic interaction (materials shall be chosen to ensure that the electro-potential sensitivity between components is minimal).

It is recommended that trunnions are made from corrosion-resistant steel. For the trunnions, the use of stainless steel cladding of a carbon-alloy-steel substrate can be justified (example of a clad trunnion is in Figure 2), provided the designer has carefully considered all aspects of inspection and maintenance that are likely to be most challenging. For the trunnion attachment system, the use of adapted specific coating, sealants or leaktight additional devices may be sufficient.

