

HJ

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Safety Design Guidelines for the Prevention of Brittle Fracture in the Transport Containers of Radioactive Materials (English Translation)

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1 Scope of application

This standard specifies the safety design evaluation method for brittle fracture prevention of radioactive material transport containers.

This standard applies to radioactive material transport container containment systems made of ferritic steel, austenitic stainless steel, ductile iron and other metal materials the anti-brittle fracture design of, the anti-brittle fracture design of non-contained system can be implemented by reference.

2 Normative references

This standard refers to the following documents or clauses thereof. For dated references, only the dated version applies to this standard.

For undated references, the latest edition (including all amendments) applies to this standard.

GB 11806 Regulations for Safe Transport of Radioactive Materials GB 150 Pressure Vessels GB/T 229 Charpy Pendulum Impact Test Method for Metallic Materials GB/T 4161 Metallic Materials Plane Strain Fracture Toughness KIC Test Method GB/T 5482 Dynamic tear test method for metallic materials GB/T 6803 Drop weight test method for non-plastic transformation temperature of ferritic steel GB/T 8363 Steel drop test method GB/T 21143 Unified test method for quasi-static fracture toughness of metallic materials

3 Terms and Definitions

The following terms and definitions apply to this standard.

nil-ductility transition temperature when tested according to the standard method of drop weight test, the maximum temperature at which the drop weight specimen breaks, expressed as TNDT.

fracture toughness

A general term that usually refers to crack propagation resistance under quasi-static single loading conditions, denoted by K_{Ic} .

dynamic fracture toughness Characterizing the ability of a material to resist crack propagation is a quantitative index to measure the toughness of a material under dynamic loading, expressed by K_{Id} .

stress intensity factor the magnitude of the ideal crack tip stress field, denoted by K , for a homogeneous linear elastic body under a specific crack propagation type.

yield strength

When a metallic material exhibits the phenomenon of yielding, the stress at which plastic deformation occurs during a test without an increase in force. A distinction should be made between upper yield strength and lower yield strength. The upper yield strength is represented by ReL and the lower yield strength is represented by ReH . Yield strength is usually measured at a quasi-static loading rate.

The lower yield strength is obtained.

dynamic yield strength Yield strength measured at a dynamic loading rate (eg impact), expressed as σ_{mayd} .

net section stress

The mean stress on the net section. The net section is equal to the gross section (gross section) minus the area of the holes in the section.

4 Selection of design method for brittle fracture prevention

4.1

In order to meet the safety requirements for the transport of radioactive materials in the transport container under the normal transport conditions and transport accident conditions specified in GB 11806, Limit external radiation, ensure containment of radioactive materials, and prevent nuclear criticality, and radioactive materials transport containers should be designed to prevent brittleness Sexual rupture.

4.2

The designer may use any of the following methods to evaluate the brittle fracture resistance design.

The first method is to exempt the evaluation of anti-brittle fracture by selecting materials, and the exemption condition is to select materials within the required operating temperature range (including as low as $-40\text{ }^{\circ}\text{C}$) can maintain relatively high ductility and toughness materials.

The second method is to evaluate the fracture resistance of ferritic steels by testing material toughness indicators such as the non-plastic transition temperature.

The third method is to use the theory of fracture mechanics to evaluate the fracture resistance of the structure.

The first two methods are guidelines based only on material testing requirements, and it is necessary to demonstrate that certain material parameters (such as impact absorbed energy) are not lower than their allowable limits.

value, the material has good toughness. The third method is based on the fracture mechanics method and is applicable to all materials, requiring justification of calculated transport There is a sufficient margin between the stress intensity factor of the container containment system and the measured fracture toughness of the material.

4.3

Other alternative methods can be used in actual work, but their rationality should be demonstrated.

5 Exemption conditions for brittle fracture prevention evaluation

5.1

When designing and selecting materials, select them under the normal transport conditions and transport accident conditions specified in GB 11806, and within the required operating temperature range.

Materials capable of maintaining high ductility and toughness in the range (including down to $-40\text{ }^{\circ}\text{C}$), such as austenitic stainless steels, are exempt from brittle fracture evaluation.

5.2

For cast austenitic stainless steel, the evaluation of brittle fracture resistance cannot be exempted, and the mechanical test described in 6.2 shall prove that it has sufficient ductility and fracture toughness.

6 Method for evaluating ferritic steel by material toughness index such as non-plastic transition temperature

6.1 Overview

The basis for determining the non-plastic transition temperature is to determine a temperature at which the standard drop weight test will not occur at the welded joint.

Brittle fracture. 6.2 provides methods for evaluating ferritic steels based on impact absorbed energy or lateral expansion values, and 6.3 provides methods for evaluating ferritic steels based on nonplastic transformation.

Any method of temperature evaluation of ferritic steel can be used. This method is applicable to the evaluation of base metals for transport containers, as well as welds and thermal Evaluation of the affected area.

6.2 Evaluation method using impact absorbed energy or lateral expansion value as acceptance index for ferritic steels (including bolts), a large number of impact absorbed energy (Charpy V-notch impact test) and fracture toughness relationships have been established database, shock absorption energy can be used as an indirect indicator of material toughness. It is based on the determination of the plastic-free transition temperature method, and the acceptance criteria are the impact absorbed energy (or lateral expansion value) measured by the Charpy V-notch impact test at the specified temperature is greater than the limit specified in the standard. at low temperature the impact absorption energy limit below can refer to the corresponding standard, and the temperature should include at least the required operating temperature range (including as low as -40 °C).

6.3.1 Evaluation basis

This chapter specifies the fracture toughness evaluation criteria to be met by ferritic steels of different package grades and different section thicknesses. None of the materials required by the guidelines the minimum temperature difference between the plastic transition temperature and the lowest service temperature (-40 °C) under accident conditions is a function of section thickness. The temperature difference is no Based on the relationship between plastic transition temperature and fracture toughness. 6.3 Evaluation of brittle fracture resistance applicable to type B package containment systems, type C packages may the evaluation shall be carried out with reference to the Type B package level I, and other packages other than the Type B or C package may be evaluated with reference to the Type B package level III, or according to Evaluate according to other standards such as GB 150. The failure theory used for the combined stress of the Class I containment system of the Type B package is the maximum shear stress theory, which controls the control stress is the stress intensity; the failure theory used for the combined stress of the B-type package Class II and Class III containment system is the maximum stress theory, and the control should be the force is the first principal stress. The stress analysis in Chapter 7 can be carried out with reference to this article.