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Design Evaluation of Beam Tubes in a Research Reactor

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1. Introduction

The beam tube is a common component of research reactors, which provides neutron path from the core to experimental facilities. It is generally submerged in the pool and installed as penetrating the pool wall. For suppressing the activation along the neutron path, its inside is filled with inert gas such as helium or is kept as vacuum, generally. Depending on the purpose of reactor, it is sometimes connected with other systems. Therefore, design of a beam tube should consider several types of loadings from external or internal media, and neighboring components. In this paper, beam tubes which are designed for future application in a research reactor are evaluated for various loadings in accordance with the related safety standards.

2. Description of Beam Tubes

Two different types of beam tubes are developed for future application. One is a stand-alone beam tube for a general neutron path and another is a connected beam tube with a neighboring system for special purpose.

2.1 Type A Beam Tube

The type A consists of one blind beam tube and one easy manipulating clamp assembly as depicted in Figure 1. The blind beam tube is stand-alone, which is fastened only into the embedded part of beam facility in the concrete pool wall with the clamp assembly. The inside of the beam tube will be charged with the inert gas, helium. So, the external pressure from the pool water and the internal pressure from the charging gas should be considered as loadings for design evaluation.

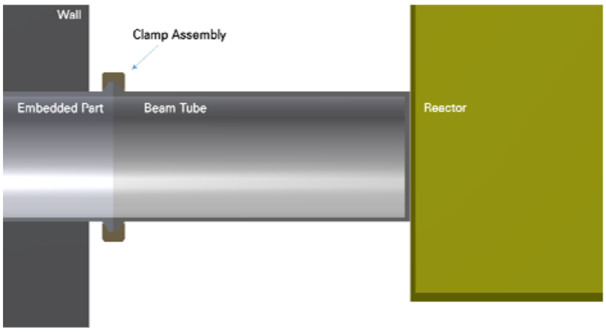

Figure 1 Configuration of Type A Beam Tube

2.2 Type B Beam Tube

The type B consists of one blind beam tube and two easy manipulating clamp assemblies, as depicted in Figure 2. It is connected with a neighboring system with one clamp assembly and also fastened into the embedded part of beam facility in the concrete pool wall with another clamp assembly. The inside of the beam tube will be charged with inert gas, helium. Since it is tightly joined with the neighboring system, it is affected by thermal expansion of the system during normal operation or accidental condition. It means that loadings from the system as well as loads from the media should be included for design evaluation.

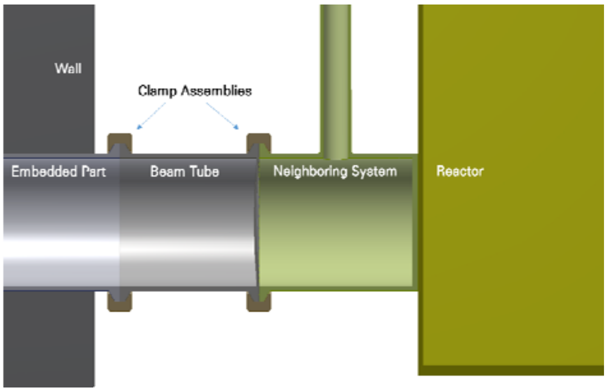

Figure 2 Configuration of Type B Beam Tube

2.3 Materials

The materials of the blind beam tube and the clamp assembly are aluminum 6061-T6 and stainless steel, respectively. Some parts of the clamp assembly are made by high strength alloy steel.

3. Evaluation Methods and Results

The beam tubes are evaluated in accordance with the ASME code sec. III subsection ND, since they are classified into safety class 3 pressure boundary following the design bases. The loads that are taken into account are pressure load, dead load, buoyancy, thermal load and imposed load.

3.1 Design Evaluation by Rule

It is mandatory to verify dimensions of the design following the specific equations, when the subsection ND is applicable for safety class 3 components. The wall and blind thicknesses, and dimensional details of clamp connection shall be validated.

The wall thickness and blind thickness shall not be less than the required minimum thickness computed by the rules of ND-3112.4 (c) as follow.

ND-3112.4 (c): The wall thickness of a component computed by the rules of this Subsection shall be determined so that the general membrane stress, due to any combination of mechanical loadings listed in ND-3111 which are expected to occur simultaneously during a condition of loading for which Service Level A is designated for the component, does not exceed1 the maximum allowable stress value permitted at the Design Temperature.

Since design pressure is the external pressure, the wall and blind thicknesses under design pressure shall be verified in accordance with ND-3133. The wall and blind thicknesses under test pressure also shall be checked in accordance with ND-3300.

The clamp connections used are not typical flange connection stipulated in ASME B16.5. Therefore, the clamp connections shall be verified according to the ASME Sec. III, Appendix Q.

It is found that each thickness is not less than the required minimum thickness from the equation of the code. It is also concluded that the clamp assemblies are designed properly under all kinds of loadings. Stability of type A beam tube under axial compression is ensured according to ND-3133.6.

3.2 Design Evaluation by Analysis

Pressure vessel design in accordance with ND-3300 shall meet the stress limits of Table ND-3321-1 under design and service loadings. In this evaluation, since the only design loadings which envelop all the service loadings is assumed, stress limits for design and level A loadings shall be applied as acceptance criteria for stress analysis. In the criteria, stress means the maximum normal stress as defined in ND-3321.1.

From the results, it is clear that stress limits for design and service loadings are satisfied for all regions.

4. Conclusions

It is completely verified that all the components of beam tubes conform to requirements of the applicable code, ASME Sec. III, ND.

The wall thickness and blind thickness of beam tube assemblies meet the criteria under both external and internal pressures. The design of hub and flange in clamp connections satisfy the criteria of ASME, Sec. III, Appendix Q which stipulate “Design Rules for Clamp Connections”. The verification of clamp connections for the type B beam tube is performed including the imposed load induced due to the thermal expansion of the neighboring system during accidental condition which is most severe postulated accident of a research reactor.

Results of stress analysis for the blind beam tubes show that the beam tubes maintain their structural integrity under design loadings which envelope all operational conditions.

ACKNOWLEDGEMENT

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REFERENCES

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