

Stress Analysis of IPS Lower bracket

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1. Introduction

The 3-Pin Fuel Test Loop (FTL) is a facility which could conduct fuel irradiation test at HANARO. It is composed of and In-Pile test Section (IPS) and an Out-of-Pile System (OPS).

Restraint of the IPS from self-weight and seismic loads is achieved by its support system. The one is box beam in pool-wall and the other is lower bracket on the mounting plate. This study describes the lower bracket stresses for seismic loading and the design & manufacturing of mounting plate mock-up for the as-built measurement of the HANARO reactor.

2. Model and Code Requirements

The lower bracket (Fig 1) is mounted on the top plate of the reflector tank and its arm locates around the IPS to limit movement of it. The arm is hinged so that it can be moved out of the way to allow adequate access to the reactor core for reactor fuel element changes.

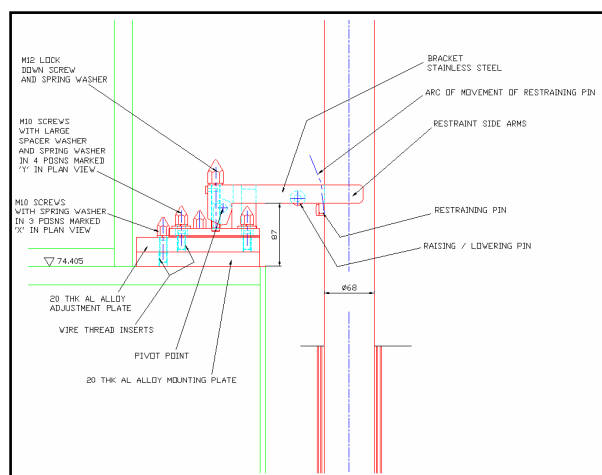


Fig.1 Lower Bracket of IPS

The supports considered are treated as “Linear-Type” supports (NF-1213) because they are acting under essentially a single component of direct stress. Linear type supports can be analyzed elastically based on maximum stress theory (NF-3143). When seismic loading is present the situation is somewhat more complicated but generally the predominant loads are

bending in two axes and the two components of tensile bending stress can be added. Where shear (direct and torsion) stresses are significant the rules of NF-3300 have been supplemented by checks on the equivalent stress comparing it with an allowable stress of 0.6 x Yield Stress. Thus for acceptability:

$$\text{Equivalent stress} = \sqrt{(\sigma^2 + 4\tau^2)} \leq 0.6 \sigma_y$$

ASME III NF requires design by analysis, with stresses in components satisfying acceptance criteria. Table 1 summarizes the relevant paragraphs which specify the stress limits applicable to the supports for linear type supports.

Table 1 Code Paragraphs specifying Stress Limits

	Design by Analysis	Bolting	Weld Joints
Class 3 Piping Support	NF-3360 NF-3653 F-1334	NF-3324 NF-3655 F-1335	NF-3324 NF-3556 F-1334

Allowable stresses are based on yield stress and tensile strength at temperature. Table 2 below gives the relevant values of yield stress and tensile strength for the main support materials from Table U and Table Y-1 of ASME II.

Table 2 Material strength of 316L

Yield Strength (Sy)	Tensile Strength (Su)	Stress Intensity (Sm)
146.9 MPa	469.5 MPa	89.6 MPa

The normal temperature of the supports is in the range 40°C to 50°C, but a maximum pool water temperature of 93°C (200°F) under accident conditions is assumed and used for the assessment.

3. Service Loadings

The principal loadings on the IPS Support Frame are:

- Weight of the IPS Support Frame and IPS
- Seismic loads
- Pipe break loads

In order to simplify the analysis, two enveloping load cases were considered:

- Case 1 where the Service Level B OBE loads (assumed identical to the SSE load) were combined with Service Level A loads and the Level C Room 1 pipe break load, with acceptance based on code allowable stresses for Service Level A.
- Case 2, in which the loadings for the Service Level D in-pool pipe break event was combined with Level A loads, with acceptance based on code allowable stresses for Service Level D as defined in ASME III Appendix F.

REFERENCES

- [1] ASME Boiler and Pressure Vessel Code, Section III NF, 2001
 [2] Design Report for Supports (for IPS & Piping), HAN-FL-E-320-RT-R002, Rev. 0, 2005.
 [3] Hydraulic Loads on In-Pool Piping, HAN-FL-E-340-RT-R003, Rev. 0, 2005.

4. Conclusion

The only load for Service Level A is approximately 100 N upward hydraulic thrust due to the flow of reactor coolant water which does not give rise to any significant stress in the lower bracket components.

The only significant loading on the lower bracket support is the lateral seismic load due to seismic movement of the IPS. A single case is considered; that due to a SSE, which envelopes the loading from an OBE. The analysis assumes that this load could act in any direction in the horizontal plane. The results for the locations with the smallest margins relative to code allowable are given in Table 3 below.

Table 3 Lower Bracket Stress for Seismic Loading

Location	Type of Stress	Calculated Stress	Service Level B	Service Level D
Bracket Arm	Tensile	22.3 MPa	148.5 MPa	223.3 MPa
Bracket Pin	Tensile bending	119.7 MPa	163.4 MPa	223.3 MPa
	Shear	20.1 MPa	99.0 MPa	134.0 MPa
	Equivalent stress (tensile & shear)	126.3 MPa	148.5 MPa	223.3 MPa
Bracket Plate Guide	Tensile bending	26.1 MPa	163.4 MPa	223.3 MPa
	Shear	14.4 MPa	99.0 MPa	134.0 MPa
	Equivalent stress (tensile & shear)	38.9 MPa	148.5 MPa	223.3 MPa
Pivot Support	Tensile bending	76.9 MPa	163.4 MPa	223.3 MPa
	Equivalent stress (tensile & shear)	78.4 MPa	148.5 MPa	223.3 MPa
Bracket Plate Dowel Pins	Shear	60.3 MPa	99.0 MPa	134.0 MPa
Bracket Plate Screws	Tensile	137.1 MPa	175.9 MPa	268.9 MPa
	Shear	18.5 MPa	72.7 MPa	161.3 MPa
Adjustment Plate Screws	Tensile	61.6 MPa	175.9 MPa	268.9 MPa
	Shear	60.1 MPa	72.7 MPa	161.3 MPa
Adjustment Plate Dowel Pins	Shear	59.5 MPa	99.0 MPa	134.0 MPa