

## Preliminary Structural Stress Evaluation of HCS Piping for HCCP Breeding Blanket

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### 1. Introduction

Helium Cooling System (HCS) is a major ancillary system of the breeding blanket, responsible for removing heat generated in the breeder. The HCS operates under normal conditions at 8 MPa and 300–500°C using helium coolant gas [1]. Due to elevated thermal gradients and high internal pressure, significant thermo-mechanical loads are expected in the HCS piping. As the piping system constitutes safety-relevant components during various operating modes, structural stress evaluation is essential to verify code compliance and to provide design feedback for refinement of piping layout.

In this work, a preliminary structural stress evaluation of the HCS piping was conducted in accordance with pressure piping design codes, ASME B31.3 (Ed. 2004).

### 2. Model and Analysis

A three-dimensional piping model of the HCS was established based on the current piping layout shown in Fig. 1. The piping system consists of DN125, Schedule 80 pipes made of stainless steel 316L. The analytical model includes both the HCS piping and the major connected vessels to account for system-level interaction effects. Load combinations were defined according to the HCS load specifications. Sustained loads include internal pressure and dead weight. Thermal loads arise from the elevated operating temperature, and occasional loads were evaluated by combining sustained loads with the enveloped SL-2 seismic loads (approximately  $3 \times \text{SL-1}$ ).

An initial evaluation under the design condition indicated insufficient stress margins in certain piping segments. Therefore, segmentation of individual piping lines under representative operating conditions was conducted to improve structural margins against thermal expansion and seismic loads.

Structural integrity was evaluated in accordance with ASME B31.3. Moments for sustained, thermal, and seismic load cases were calculated and compared with allowable values defined in the design code.

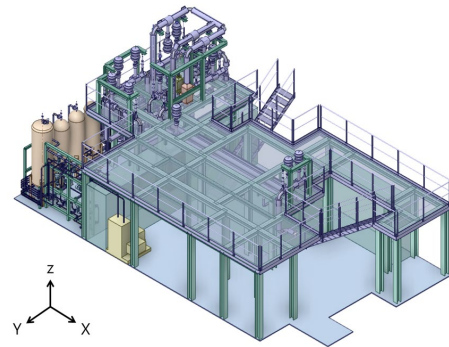


Fig. 1. HCS layout with steel profiles

### 3. Result and Further Works

The analysis results indicate that most piping segments satisfy allowable stress limits under sustained load conditions. Thermal expansion was identified as the dominant contributor to the calculated stresses in the HCS piping layout, as the high-capacity heater is designed to supply elevated-temperature helium to the breeding blanket. In addition, although seismic loads increased stresses under combined load cases, their influence was secondary compared to thermal expansion effects in the present configuration. The results indicate that additional routing modification and support refinement are required to further improve flexibility and structural margins.

As the piping layout evolves toward higher design maturity within the allocated space, further layout refinement and support configuration adjustments will be implemented to ensure structural integrity.

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### REFERENCES

- [1] S. Cho et al., Status of HCCR TBM program for DEMO blanket. *Fusion engineering and design*, Vol. 171, 112553, 2021.