PROTOTYPE HB650 CRYOMODULE HEAT LOADS SIMULATIONS

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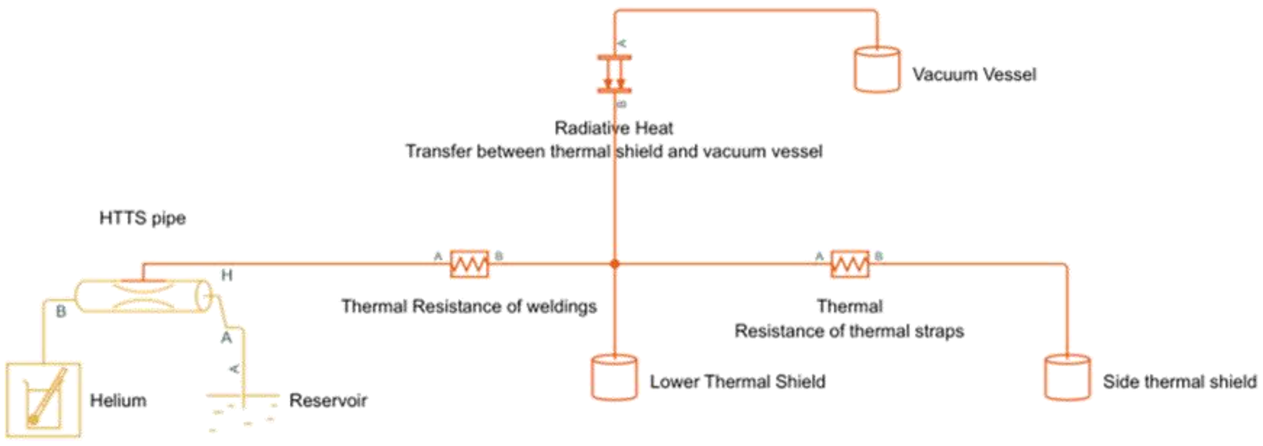
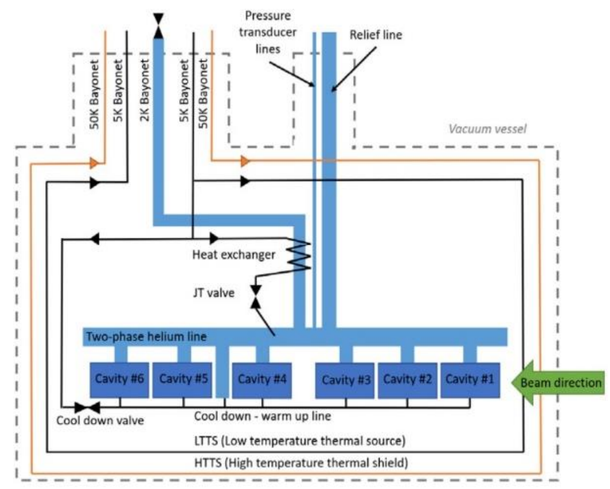
INTRODUCTION

During the design phase, analytical calculations and FEA were performed to estimate cryomodules heat loads. To better analyze the prototype HB650 cryomodule cold tests, simulations have been performed with MATLAB to determine the temperature of the main components during cool-down and to determine the heat loads of the cryomodule.

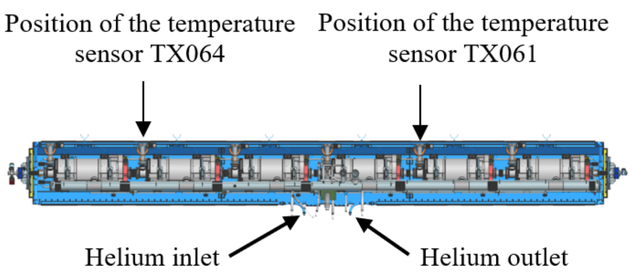
HB650 PROTOTYPE CRYOMODULE MODEL

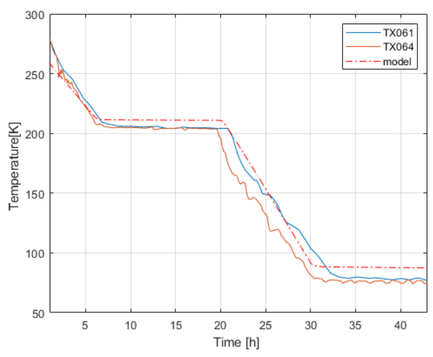
The Simulink/Simscape model adopts a 0D approach, where each component is treated as a thermal mass. The focus is on considering the mass and specific heat of the components, as well as establishing thermal resistances to connect the components together. For validation, the model results have been compared to the 1st phase of the HB650 prototype cryomodule cool-down: During this phase only the thermal shield is being cool-down.



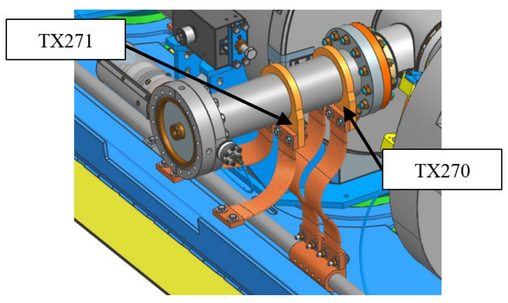


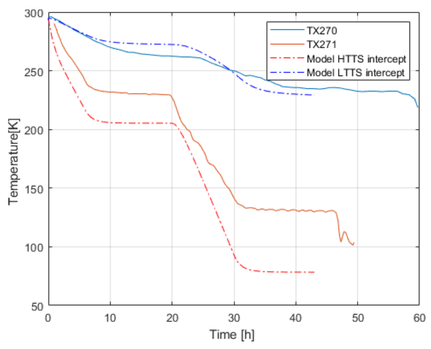
Lower thermal shield:



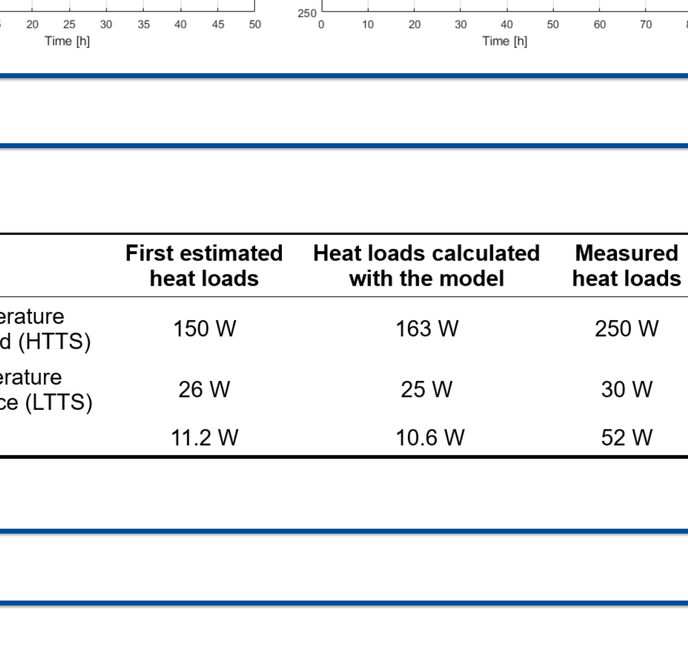


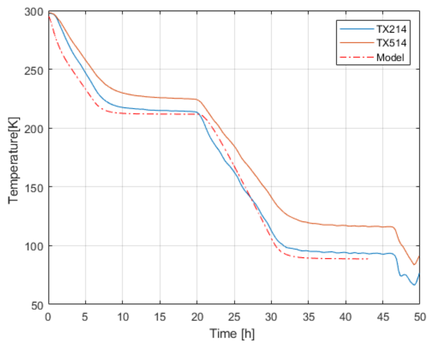
Coupler:

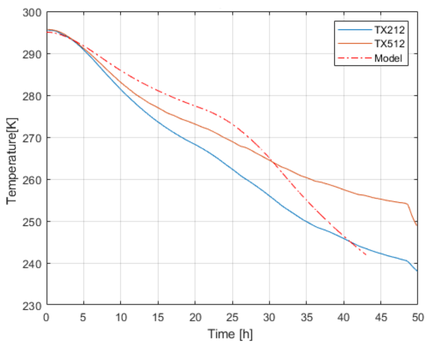


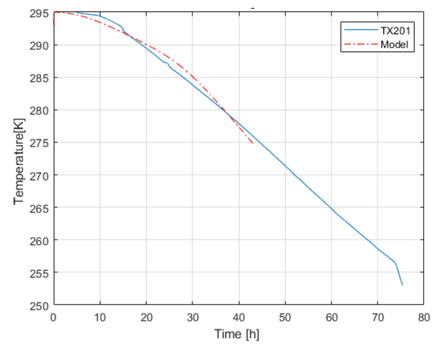


G11 Support Posts, Cavity Supports & Cavities:









HEAT LOADS RESULTS

Overall, the heat loads are very close to the one estimated analytically and by FEA. HTTS heat loads are slightly higher because an approach using emissivity and view factors are using whereas a coefficient of 1.5 W/m^2 was using previously. There is an important discrepancy with the heat loads measured during the 1st cool-down of the prototype cryomodule. However, the heat loads analysis of the 1st cool-down has identified addition heat sources that explain this discrepancy.

	First estimated heat loads	Heat loads calculated with the model	Measured heat loads
High Temperature Thermal Shield (HTTS)	150 W	163 W	250 W
Low Temperature Thermal Source (LTTS)	26 W	25 W	30 W
2K	11.2 W	10.6 W	52 W

SUMMARY

The Simulink/Simscape model of the prototype HB650 cryomodule is validated. The transient analysis matches with the model predictions, and the heat loads during operation at 2K issued from the model match the heat loads estimated with analytical calculations.

The next step is to continue optimizing this model with the 2nd cool down of this prototype cryomodule and then to transpose this work to the SSR1, SSR2, and LB650 cryomodules.

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