

# Remote Cooling with the HEC Cooler

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## ABSTRACT

This paper presents the test data for remote cooling using NGST's HEC cooler. Remote cooling technology enables the pulse tube cryocooler to be separated from the cooled object and uses a flexible capillary gas line to cool the object.

In our design, a single compressor provides gas flow to both the pulse tube cooler and the remote cooling loop. This configuration is mechanically simple with excellent reliability. After helium is split from the compressor, it is precooled before flowing to the cooled object. The cooled object can be located meters away from the mechanical cooler. Test data are presented and analyzed to characterize the efficiency of the system.

## INTRODUCTION

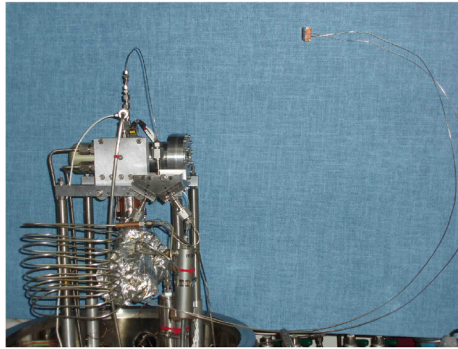
This paper presents the results of experiments conducted to demonstrate remote cooling applications. In these experiments, a single compressor is used to provide precooling and a dc flow to transport heat from the remote location. Experimental data are presented and analyzed to characterize the efficiency of the remote cooling.

Recent progress in cryocooler technology has enabled remote active cooling of the focal planes (FPA). Applications, such as remote cooling for gimbal optics or multiple loads, introduce a new level of flexibility to cryocooler integration and operations. Remote cooling allows remotely locating the pulse tube cryocooler from the cooled items (FPA, shield and optics). The very low mass on the gimbal as well as the very compliant gas lines allows a significantly lower mass for the overall system.

## TEST SETUP

The test setup is shown in Figure 1. The remote cooling test setup consists of two main sections: the HEC pulse tube precooling and the DC flow loop with the recuperator and the remote heat exchanger. The remote heat exchanger is located 1 meter away from the pulse tube cold head.

Gas in the remote cooling loop is bled off the HEC compressor at the compression space. The amount of gas bleed off is less than 5% of the compressor volume. The bleed off gas is rectified by a valve to convert the oscillatory flow into a steady flow. Gas is then precooled to the pulse tube temperature before being directed toward the remote heat exchanger. The remote gas is precooled to the pulse tube temperature by a recuperator and a heat exchanger thermally anchored to the pulse tube cold block. In the recuperator, the warm gas is cooled by the cold gas returning from the remote heat exchanger. The recuperator is designed to recover at least 99% of the energy from the returning low temperature gas. At the exit of the recuperator, gas is cooled to the cold block tem-



**Figure 1** – Remote cooling test setup showing the HEC pulse tube cooler, the recuperator and the remote heat exchanger.

perature before flowing to the remote heat exchanger. Cooling load is applied to the remote heat exchanger to bring its temperature to the designed value. The returning gas then flows through the recuperator before returning to the compressor.

The remote cooling test setup was designed with flexibility to evaluate the different configurations of the remote flow loop, the recuperator and the remote heat exchanger.

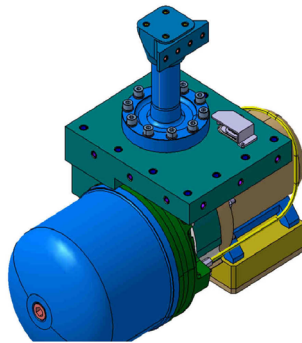
### PULSE TUBE PRECOOLER

The remote cooling gas is precooled by a pulse tube cooler. The Precooler can either be the High Efficiency Cryocooler, HEC<sup>1</sup> or the High Capacity Cryocooler, HCC<sup>2,3</sup> for lower temperature applications. The experiments reported in this paper use the HEC as the Precooler since the remote temperatures are above 85 K.

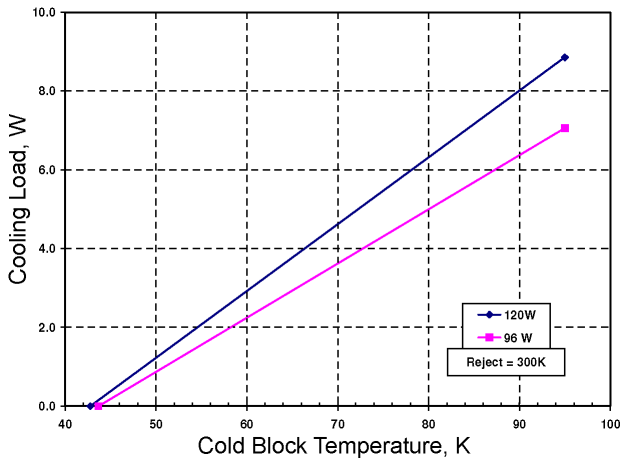
The High Efficiency Cryocooler is a flight qualified TRL-9, low mass, high efficiency cooler which has good cooling capacity for remote cooling demonstration. In this experiment, the HEC was tested with a coaxial cold head. The coaxial cold head shown in Figure 2 offers a flexible configuration for integration with a good thermal performance. The performance of one configuration of the coaxial cold head is shown in Figure 3.

### REMOTE COOLING RESULTS

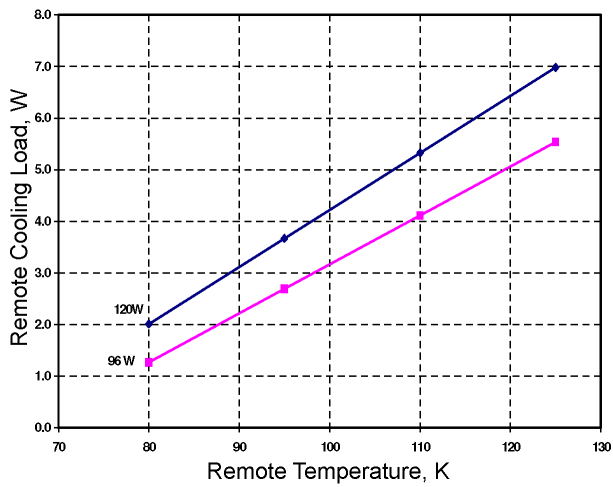
Remote cooling data were collected for different input powers and remote temperatures. Figure 4 shows the remote cooling loads at different temperatures for input powers of 80 and 100 W. The remote cooling system has been modeled analytically and the predicted load lines are com-



**Figure 2** – The HEC cooler was integrated with a coaxial cold head in the remote cooling experiments



**Figure 3.** Load line of one configuration of the HEC coaxial cold head with a cooling capacity of 9 W at 95 K.



**Figure 4.** Remote cooling data as functions of the remote temperature and input power.

pared to the measured data in Figure 5. Figure 5 shows that the analytical model accurately predicts the remote cooling results.

The model has been used to evaluate the effect of different design parameters on remote cooling. The remote cooling load depends on the flow of gas that is diverted into the remote cooling loop. Figure 6 confirms that remote cooling depends on the remote flow rate. For remote cooling applications using a single compressor, the remote flow rate depends on the dynamic interaction between the compressor and the remote flow loop.

The analytical model has also been used to evaluate the effectiveness of the recirculator and the heat exchanger. The existing effectiveness of the system is acceptable but it can be increased to improve the overall efficiency of the remote cooling system.

In a typical remote cooling application, the cold surfaces of the recuperator and the remote cooling lines are exposed to a warm environment. The conduction and radiation parasitics cause a shift in the minimum temperature of the remote cooling load line. In the existing test setup, the extra parasitics on the cold surfaces is estimated to be between 1.5 and 3 watts. A reduction of the extra parasitics will improve the efficiency of the remote cooling results. Different techniques to reduce the parasitics will be evaluated and implemented in the next tests.

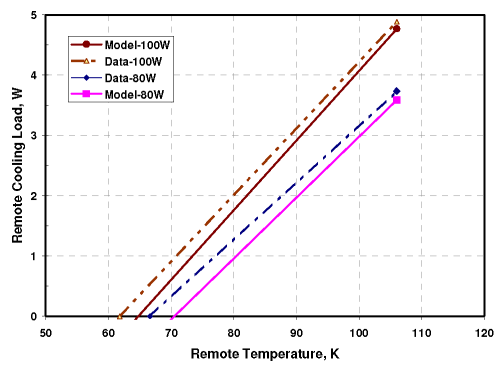


Figure 5. The analytical model of the remote cooling system can accurately predict the test data.

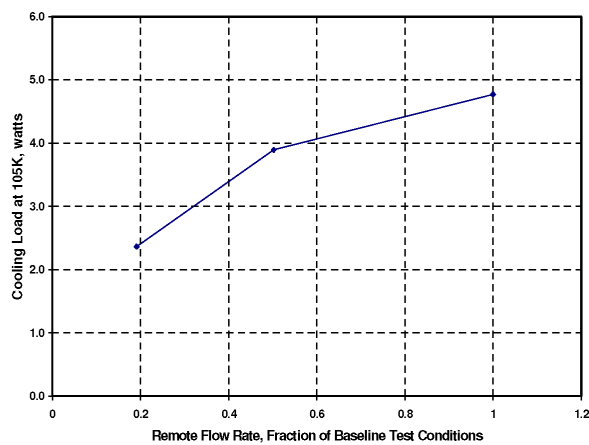


Figure 6. Cooling capability at the remote load depends on the flow rate in the remote cooling loop.

CONCLUSION

Remote cooling using the High Efficiency Cooler (HEC) has been demonstrated. The system efficiency has been analyzed in terms of the effectiveness of the heat exchangers and the parasitics of the cold surfaces. Further study will reduce the parasitics on the system to increase the efficiency of remote cooling applications.

ACKNOWLEDGMENTS

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