SNS CRYOMODULE PRODUCTION PROGRESS & KEY LESSONS LEARNED*

J. P. Hogan†, E. F. Daly, J. Fischer, J. Preble, T. Whitlatch, M. Wiseman
Thomas Jefferson National Accelerator Facility Newport News, VA 23606, USA

Abstract

Jefferson Lab has been commissioned to design and manufacture one prototype, eleven-.61 Beta and twelve-.81 Beta cryomodules for the Spallation Neutron Source project. The production process is up and running with half of the .61 Beta cryomodules complete to date. This paper will present an overview of the beginning of production, with an emphasis on key lessons learned, that have been used to refine cryomodule production.

INTRODUCTION

The Spallation Neutron Source (SNS) [1] cryomodules were designed [2] with the intent to carry out a multiple unit production run. Assembly considerations were discussed and evaluated with respect to each component, from the cavity helium vessel to the spaceframe and vacuum vessel subassemblies. Production supporting entities such as tooling and travelers were developed in parallel with the cryomodule in order to facilitate production. All of these efforts formed together with the fabrication of the .61 medium beta prototype cryomodule. As with all prototypes, many lessons were learned from this activity about assembly sequencing, component interface and tooling interactions. These lessons will be discussed in more detail along with their feedback into the production run. Additionally, lessons learned during the beginning of the production run will also be presented.

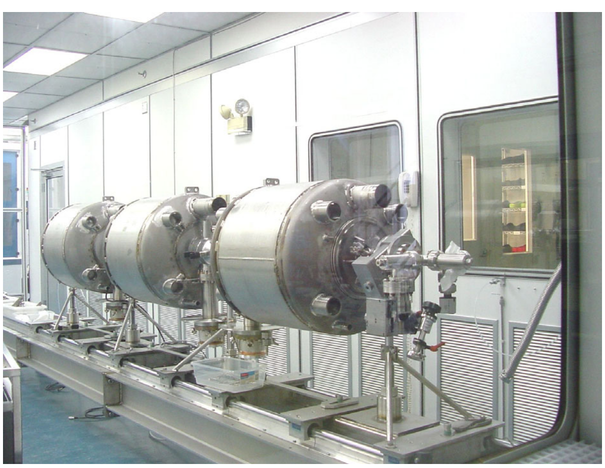

Figure 1: Medium Beta Cavity String in clean room.

* Supported by US DOE Contracts No. DE-AC05-00OR22725
†hogan@jlab.org

PROTOTYPE .61 BETA CRYOMODULE

As stated in the introduction, the fabrication of the prototype was the first opportunity to exercise the cryomodule design, tooling and traveler system. Once the power couplers and cavities have been processed and assembled, the cryomodule begins with the cavity string assembly (see Fig. 1). This takes place inside a clean room environment, where the cavity string is then evacuated and leak checked. Upon completion, the cavity string is transferred to the cryomodule assembly area. The remainder of the assembly is divided into three assembly travelers; the Cold Mass, the Spaceframe with Thermal Shield and the Vacuum Vessel/End Can.

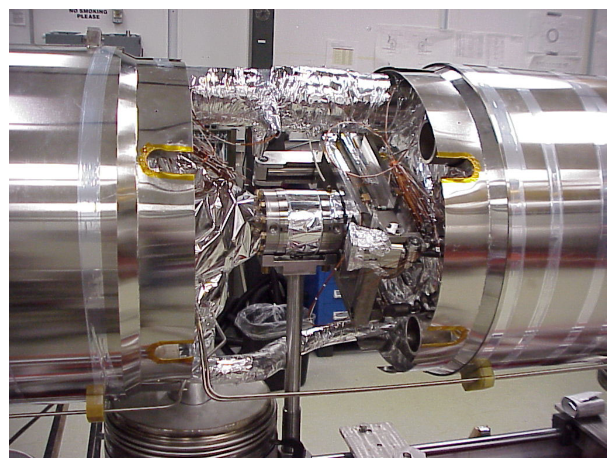

Figure 2: Cavity String Beamline & Instrumentation.

The Cold Mass assembly traveler consists of the 2 K circuits, magnetic shielding, MLI and instrumentation. The bridging area between the cavities was one of the first areas for design optimization (see Fig. 2). The interface of the magnetic shielding and the coupler cooling lines was modified in order to assist the installation of these components. For welding access, we found it was better to install all the coupler cooling lines prior to installing the magnetic shielding. The magnetic shielding was also divided up into smaller parts for ease of assembly. With the actual cavity string to work from, we were able to make up very accurate MLI templates for the more intricate parts of the beamline. The assembly traveler was also modified to reflect these and other minor changes in the assembly sequence.

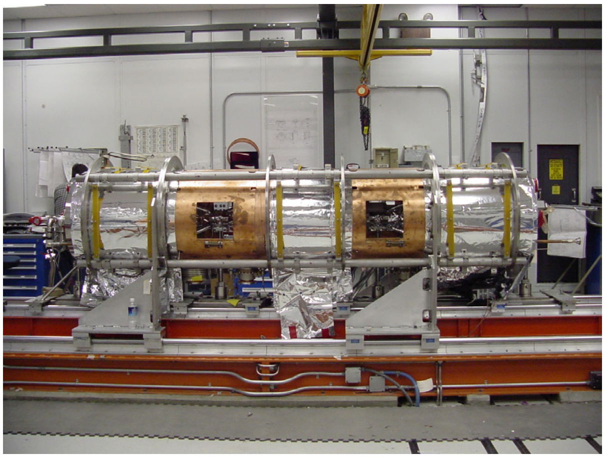

Figure 3: Spaceframe & Thermal Shield MLI.

In addition to its title assemblies, the Spaceframe/Thermal Shield traveler consists of the alignment procedure, installation of the 50 K MLI and outer magnetic shielding. Overall, the installation of the spaceframe with thermal shield went very well as designed.

However, some areas needed improvement, such as the clearances between the spaceframe and coupler bellows. This clearance was increased to aid in leak checking the bellows assembly after welding. The 50 K MLI for the prototype consisted of ten separate sections (see Fig.3). It was determined during the fabrication of the prototype that the number of sections could be reduced to six, which simplifies assembly and minimizes touch labor [3].

The alignment procedure was an area for significant optimization. The alignment tooling and method was new due to the limited access to the cavity beamline flanges. As with any new procedure, being able to utilize it in real time is very rewarding because it is an opportunity to exercise the system. By modifying and adding tooling torque specifications; we were able to improve the repeatability of the procedure. We also discovered it is more expedient to perform the radial alignment first and then position the couplers axially. The assembly traveler was modified to reflect these and other minor changes in the assembly process.

The Vacuum Vessel/End Can traveler consists of its title components as well as the tophats, warm-to-cold beam pipes and the final alignment procedure. As with the Spaceframe assembly, the Vacuum Vessel/End Can assembly went together very well as designed.

Nonetheless, as with the previous assembly, there were areas for improvement. For example, it was decided to increase clearances in a few of the critical interface areas. One example of this was the magnetic shielding, which was opened up an additional 0.64 cm to ensure interference free fit of the tophats. The clearance between the spaceframe lock downs and the vacuum vessel was also increased for ease of assembly. A critical factor of the end can installation is the alignment of the bayonets and warm beampipe assemblies. Orientation must be maintained while meeting the dimensional criteria. This requirement and assembly process underscores the importance of the component inspections (receiving inspections) performed upon arrival at JLab. This will be discussed further in the following section.

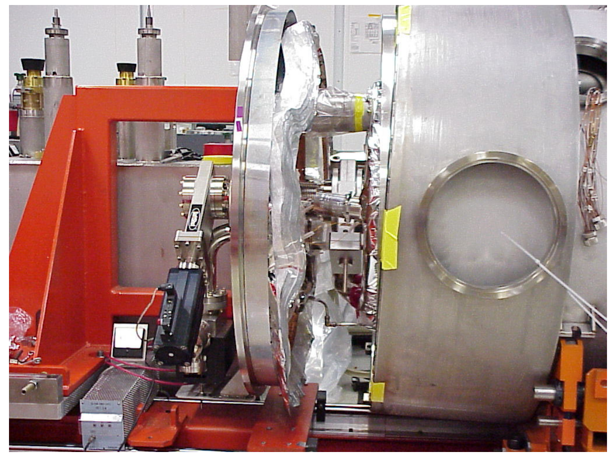

Figure 4: Enc Can Connection to the Cryomodule.

The end can connection to the cryomodule consists of all the process piping, thermal shield, 2 K & 50 K MLI, outer magnetic shield as well as the warm-to-cold beam pipe (see Fig. 4). Initially, the installation of the warm-to-cold beam pipe was identified as a delicate procedure needing particular attention. This need for extra attention was verified after assembling the prototype. Furthermore, it was determined the warm-to-cold beam pipe should be installed prior to any of the other connections. The purpose of this sequencing is to provide as much access as possible, for the installation of this delicate component, in this cramped area.

Since the prototype cryomodule was completed several months prior to beginning the production run, many of these findings were communicated back to the cryomodule component suppliers. As for the production components received in house prior to these findings, they were either sent back to the supplier for rework or were modified in house.

BEGINNING PRODUCTION

Building the prototype cryomodule was very successful and beneficial in preparing for the SNS production run. However, some significant lessons were yet to be learned with respect to component receiving inspections. Cryomodule components tend to be unique; suppliers often are required to provide a first article delivery, in order to qualify the parts, prior to beginning work for the production parts.

It has been our experience in the beginning of the production run, that we need verify the supplier's production components were indeed fabricated to the same specifications as the qualified first article components. The same is true for first article components that fail receiving inspection. Any post inspection modification developed to meet the performance requirements shall be carried into the fabrication of the components for production. An example of this was the cavity tuner motors. The prototype motors were extensively tested and proved reliable. The production motors were not extensively tested until after they were installed inside the cryomodule. These motors proved to be defective. Further investigation found the manufacturer did not fabricate the production motors to the same configuration as the first article motors. When this defect was highlighted, the motor manufacturer replaced all production units with new motors built to the same specification as the first article motors.

CONCLUSION

The importance of building a prototype in advance of a production run cannot be overstated. The ability to feed back assembly information to the design engineers and the suppliers is directly related to the productivity of the project. Highly developed planning is an important foundation for a successful production, however, being able to exercise and work with the components and procedures beforehand will benefit the cost in addition to the quality of the product.

REFERENCES

[1] T. E. Mason, "The Spallation Neutron Source: A Powerful Tool for Materials Research," PAC2001, Chicago, IL, June 2001.

[2] W. J. Schneider et al., "Design of the Spallation Neutron Source (SNS) Cryomodule," PAC2001, Chicago, IL, June 2001.

[3] J. P. Hogan et al., "Thermal Optimization in SRF Cryomodule Production," *Advances in Cryogenic Engineering*, CEC/ICMC 2003, American Institute of Physics, New York