

DESIGN AND DEVELOPMENT OF INTERCEPTING DEVICES AT THE SPALLATION NEUTRON SOURCE*

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Abstract

Beam measurements in the LINAC and transport lines of the Spallation Neutron Source at Oak Ridge National Laboratory utilize a variety of intercepting instruments such as in-line emittance systems, wire scanners, scrapers and scintillation view screens. All of these devices require linear actuators with vacuum feedthroughs. The majority of actuators acquired during the construction phase of the SNS were of commercial origin and have proven unable to meet long-term physics and engineering requirements. The predominant difficulties with these devices were lack of precision, reliability and longevity. Three new families of linear actuators have been developed at the SNS to address these deficiencies. The approach used in their development, has been to utilize a combination of commercially available linear motion components in custom built chassis to address the needs of a given set of applications. This approach has yielded devices that have met or exceeded expectations for accuracy, precision, radiation resistance, longevity and economy. Aspects of the underlying design of these actuators and their implementation will be presented at this conference.

ELECTRIC CYLINDER POWERED ACTUATORS

The first family of custom linear actuators developed for the SNS were created for the Medium Energy Beam Transport System (MEBT) Diagnostics Chamber [1].



Figure 1: Electric Cylinder Powered Actuator Developed for the SNS MEBT Diagnostics Chamber

*"SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy"

To simplify development, commercially available electric cylinders with internal linear potentiometers were used for motive power. These cylinders are capable of excellent resolution and repeatability.

The cylinders drive carriages along 440C stainless steel linear shafts cantilevered from a base plate. Versions of this actuator have been built with base plates suitable for mounting to Conflat type flanges as shown in figure 1 and custom flanges of various shapes. They have been built with travel lengths ranging from 4.00 to 6.00 inches. A scintillation view screen system with 6.00 inch stroke actuators and rectangular vacuum flanges is shown in figure 2.

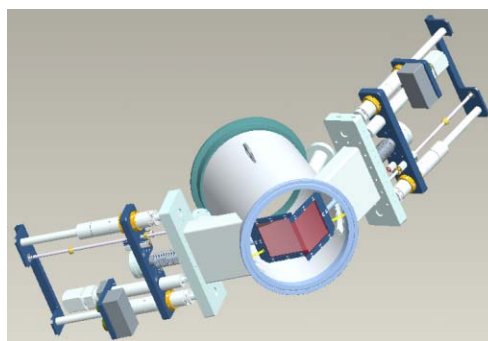


Figure 2: 6.00 inch stroke actuators mounted on rectangular flanges for a scintillation view screen system.

The actuator carriages travel on bearing tubes containing precision, linear ball bearings. If radiation resistance is a concern, the lubricant supplied with the bearings may be replaced with radiation resistant grease and the electric cylinders may be purchased with special preparation to withstand a total accumulated dose of at least 1.0×10^8 RADs of Gamma equivalent radiation.

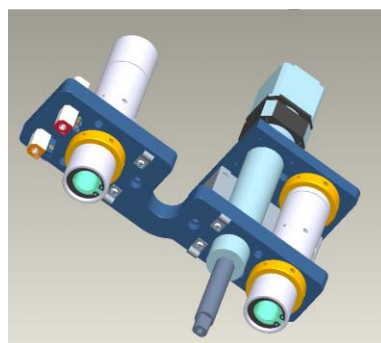


Figure 3: Actuator carriage showing bearing tubes and electric cylinder

LINEAR STAGE ACTUATORS

Long Travel Wire Scanner Actuators

The next family of actuators developed for the SNS began as the result of an initiative to replace the actuators used for wire scanners used throughout the accelerator systems of the SNS. The first actuators were developed for installations in the High Energy Beam Transport System (HEBT) and Ring to Target Beam Transport System (RTBT). Radiation resistance was a key concern in these areas. The design was based on the use of a very reliable linear stage shown in figure 4. The stage is purchased as a radiation hardened unit, complete with stepper motor, reduction gearbox and synchronous resolver for position feedback. High temperature limit switches with excellent radiation resistance are added.

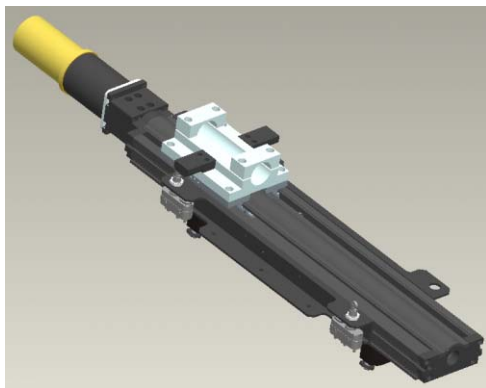


Figure 4: Radiation Hardened Linear Stage with Motor, Gearbox, Resolver and Limit Switch Mounts

A Tubular, monocoque chassis shown in figure 5 was designed to house the stage. The chassis contains adjustable mounting blocks to align the stage with the chassis centerline. Two stiffener ribs are located inside the tube to reinforce an access panel cutout. Two rectangular bosses are located on the exterior of the tube for mounting electrical connector panels. A cylindrical plug closes one end of the tube and serves as the mounting foundation for the chassis.

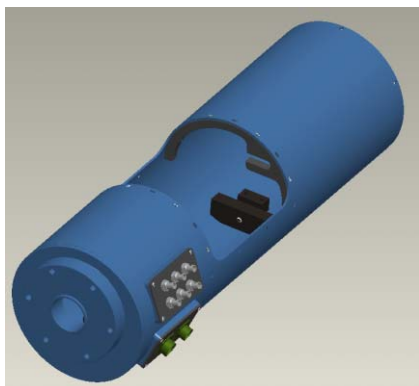


Figure 5: Monocoque Stage Mounting Chassis

The design of all SNS wire scanner beam boxes requires that the vacuum isolation bellows be mounted

internally. This creates the undesirable vacuum envelope condition of atmospheric pressure within the bellows. To prevent instability, the bellows contain guide bushings to center them about an instrument mounting shaft. A complete actuator assembly with bellows is shown in figure 6. The mounting shaft is terminated with a mounting block that accepts a universal holder designed by Los Alamos for the SNS as shown in figure 7.

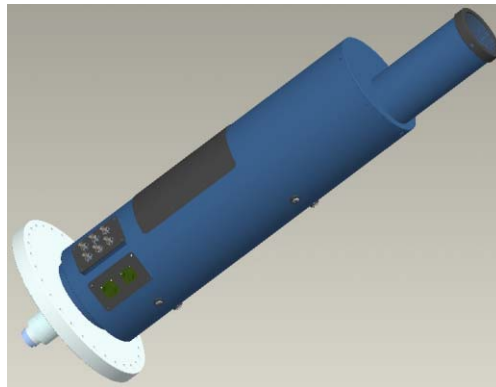


Figure 6: Complete 12.00 inch stroke actuator with bellows.

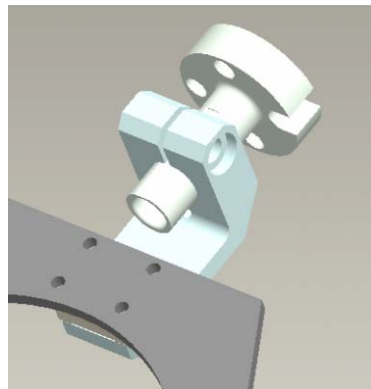


Figure 7: Typical wire scanner fork with universal holder

Short Travel Wire Scanner Actuators

The most recently developed actuators at the SNS were designed as replacements for the wire scanners in the MEBT, Drift Tube LINAC (DTL) and Cavity Coupled LINAC (CCL). The actuators used in these structures had to be much more compact than those in the HEBT and RTBT. A smaller radiation hardened linear stage was located that could use the same motor and resolver as the HEBT and RTBT stages. Reduction gearing was not used with this design. A fully assembled stage is shown in figure 8.

The stage features a very convenient mounting rail for micro limit switches, resulting in a very narrow cross section.

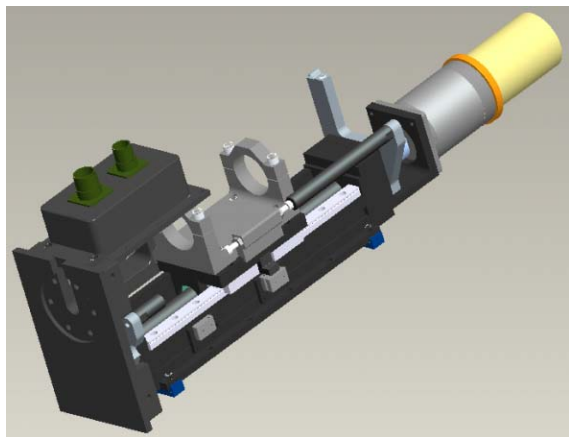


Figure 8: Radiation Hardened Linear Stage with Motor, Resolver and Integral Limit Switches

The concept of a monocoque mounting enclosure was used again and the most compact standard tube section that could be used was found to be a 4.00 x 6.00 inch rectangle with .125 inch wall thickness.

No welding was required for the construction of the rectangular enclosure. A mounting nose block was machined to cap one end of the tube. The same electrical connectors used in the long travel devices were required for the new design but the compact enclosure did not provide enough volume for wire routing. Instead of using surface mounted panels, junction boxes were machined to mate with the nose block, creating the subassembly shown in figure 9.



Figure 9: Nose Block Subassembly

Adjustable travel limit stops were added to the stage to lock the device in the event of a travel limit switch failure.

Wire Scanner beam boxes in the DTL and CCL also require internal bellows. Similar designs with internal

guide bushings were developed to control instability or squirring. The bellows weldments are terminated with identical mounting blocks for use with the Los Alamos type universal holders. A completed CCL wire scanner with bellows and fork is shown in figure 10.

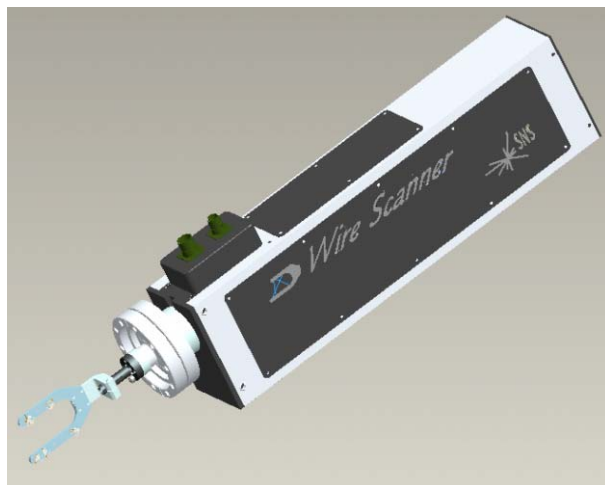


Figure 10: Complete CCL Wire Scanner Actuator with Universal Holder and Fork.

SUMMARY

The need to provide linear vacuum feedthrough positioners for systems that were already designed for the construction of the SNS imposed functional and scheduling constraints that could not be realistically met by acquiring complete, commercially available devices. Our needs have been well satisfied by the “semi-custom” designs presented here. Adaptation of commercially available components with application specific packaging has resulted in three families of devices; that with some minor variations, address nearly every need for operating beam intercepting devices at the SNS.

REFERENCES

- [1] T. Roseberry, S. Assadi & G. Murdoch “Development of a New Beam Diagnostics Platform,” PAC’05, Knoxville, July 2004, <http://www.jacow.org>.