Newsletter of The Association of Professional Engineers of Nova Scotia
Volume 21, No. 1, SPRING 2009

# The ENGINEER

Engineers NOVA SCOTIA

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# Spallation Neutron Source: Sequoia Detector Vessel

*Submitted by Richard M. Grant, M.Eng., P.Eng.*

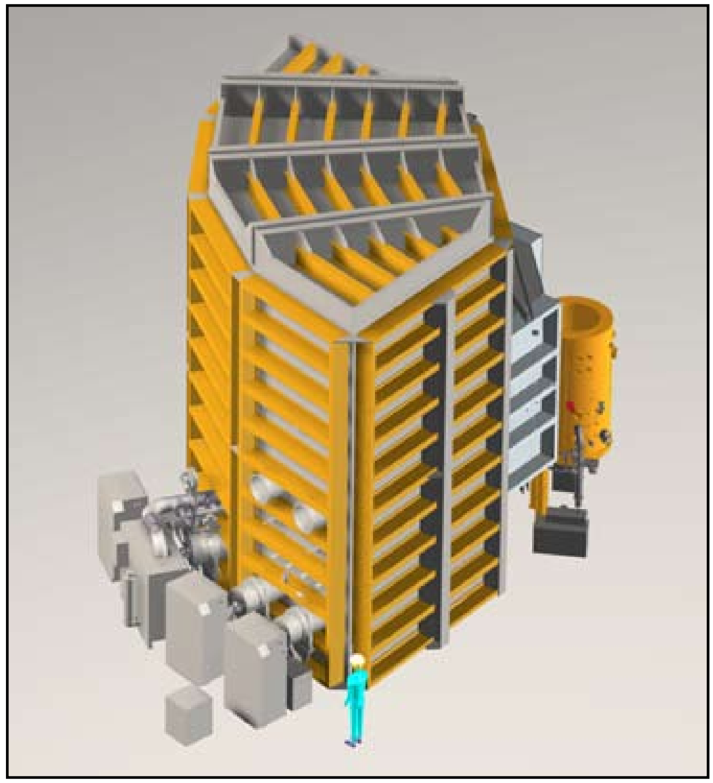
*The Spallation Neutron Source (SNS) site on Chestnut Ridge, Oak Ridge, Tennessee. The curved building in front-left is the Central Laboratory and Office Building (CLO). The rectangular building behind the CLO is the Target Building. Most of the accelerator systems are underground (photo courtesy of Oak Ridge National Laboratroy, ORNL).*

The Spallation Neutron Source (SNS) project in Oak Ridge, Tennessee is an accelerator-based neutron source that provides the most intense pulsed neutron beams in the world for scientific and industrial research and development. Ground breaking for the project occurred in 1999. Funded by the U.S. Department of Energy Office of Science, SNS is considered the world's foremost facility for the study of materials and neutron science. SNS will provide opportunities for experts in practically every scientific and technical field.

The neutrons at SNS are produced by accelerating H- ions through a linear accelerator to 90% the speed of light. The electrons are stripped off the proton before entering the accumulator ring where 60 times a second they are released to strike the liquid mercury target to produce neutrons through "spallation" (Spallation is a German word for geological breakup of rock using a hammer. Scientifically this is what is being done at the atomic scale to produce neutrons at SNS.).

Neutrons were first produced at SNS on April 28, 2006. At the end of 2007 the SNS was listed in the Guinness Book of Records as the most powerful neutron source in the world.

The research instruments at SNS, located on the eighteen beam lines from the neutron source, will make possible neutron scattering studies of complex materials that are of interest to a great range of industries. This research will lead to the development of lighter alloys to make airplanes more fuel efficient, better lubricants to make car engines more efficient with less emissions, the development of manufacturing processes for plastics that don't harm the environment, cures for diseases through better understanding of how proteins work in the human body, characterization of newly synthesized nano structural materials, and many other important advancements.



*SNS Sequoia Detector Vessel. Cryogenic and vacuum pumps shown on left and Sequoia Sample Vessel shown on right.*

One of the research instruments at SNS is the Sequoia Fine-Resolution Fermi Chopper Spectrometer, a direct geometry time of flight chopper spectrometer with fine energy transfer and wave vector resolution. The Sequoia instrument uses neutrons to measure excitations (motions of atoms or spins) in various materials such as magnetic materials, novel oxides, and high temperature superconductors.

During 2006, Grantec Engineering Consultants Inc. of Halifax, Nova Scotia, was engaged to perform the mechanical and structural design of the Sequoia Detector and Sample Vessels, the primary neutron containment envelopes for the Sequoia Spectrometer instrument. The Sequoia Detector Vessel is considered to be one of the largest vacuum chambers in North America and is the largest vacuum chamber at any neutron scattering facility in the world.

The design requirements specified by the SNS Project for the design of the detector and sample vessels were very comprehensive. The specifications included requirements for the maximum deflections under vacuum, as well as the maximum relative deflections between critical reference points within the two vessels (such as between the sample position within the sample vessel and the detector arrays located at the back wall of the detector vessel). As well, strict requirements were specified for the level of the vacuum to be achieved. Strength requirements, including fatigue and collapse resistance, were typically to the ASME codes and seismic resistance requirements included those as defined by the US Department of Energy's Standard DOE-STD-1020-2002 "Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities" which in turn cite ASCE 4-98; "Seismic Analysis of Safety Related Nuclear Structures". A range of other standards were employed as guidance including: UBC; IBC; and CSA for specific materials. The analysis performed included advanced finite element analysis in the areas of stress, collapse resistance, fatigue, penetrations, vibration and seismic (earthquake). Due to the unique geometry of the detector vessel, structural deflection under vacuum resulted in local areas of high compressive stress between the vessel and the foundation. As a result, restraint relief was incorporated.

The Sequoia Detector and Sample vessels were successfully pumped down to the required vacuum during July 2007. Following this, Grantec was engaged to perform assessment of the detector and sample vessels, as well as the selected neutron shielding material, for a higher safety level Performance Category 3 (PC-3) seismic event. On October 7, 2008, the neutron beam line was turned on for the Sequoia instrument producing a successful start-up of the instrument.

Grantec was pleased to have contributed to this very important project. I would like to take this opportunity to thank David Vandergriff (SNS Sequoia Lead Engineer at ORNL) for the assistance that both he and his colleagues provided during the development. I would also like to note that a good friend and fellow Nova Scotian engineer, Jack Hobbs, M.A.Sc., P.Eng, contributed highly to the success of this project with his expertise in the area of weld engineering and weld distortion control. I would also like to thank ORNL's David Vandergriff, Garrett Granroth and Charlie Horak for their contributions to this article.

Richard M. Grant, M.Eng., P.Eng., is the President of Halifax based Grantec Engineering Consultants Inc. ●

*SNS Sequoia Detector Vessel wall section in way of cryogenic and vacuum pumps (pumps shown in the foreground)*