LANSCE VACUUM SYSTEM IMPROVEMENTS FOR HIGHER RELIABILITY AND AVAILABILITY*

F.R. Olivas#, M.J. Borden, A. Canabal, J. Chamberlin, J. Harrison, M. Oothoudt, J. Sullivan, T. Tajima, LANL, Los Alamos, NM 87545, U.S.A.

Abstract

The Los Alamos Neutron Science Center (LANSCE) accelerator, an 800-MeV proton linac with a storage ring, has been operated over 30 years since early 1970s. Due to the aging and radiation damage of equipment, cables and connectors, the number of troubles is increasing. In order to reduce the time for unscheduled maintenance, we have implemented a system to catch a symptom of degrading vacuum and send an email automatically. We have been testing this system since July 2006. This paper describes LANSCE vacuum systems, the new alert system and our experience. In addition, we will describe our plan for modernizing the vacuum system in the next few years.

VACUUM SYSTEM AT LANSCE

Figure 1 schematically shows the **Los Alamos Neutron Science Center (**LANSCE [1]) accelerator and experimental areas. The LANSCE consists of several areas and each area has its own unique vacuum characteristics. Starting outside the H- injector and H+ injector source dome beam lines, Transport A (TA) and Transport B (TB) is the beginning of the Low Energy Beam Transport or LEBT. TA and TB is a 2" stainless steel beam line with numerous beam diagnostic boxes and vacuum chambers. Each Transport Line has the capability of acquiring a vacuum range of 3E-7 Torr. To achieve this vacuum range TA has on its system seven 500 L/s ion pumps. Each ion pump has an isolation valve that is tied into run permit via limit switches, which is also tied to beam line isolation valves. TB has a similar arrangement but has only five 500 L/s ion pumps. TA vacuum is monitored by an ion gauge at both ends of the beam line. The ion gauge shown in Fig. 2 is also tied into run permit, meaning that it must be ON for beam delivery.

Figure 2: TA Bayard Albert Ion Gauge (left) and TB Granville Phillips Stabil-Ion Gauge (right).

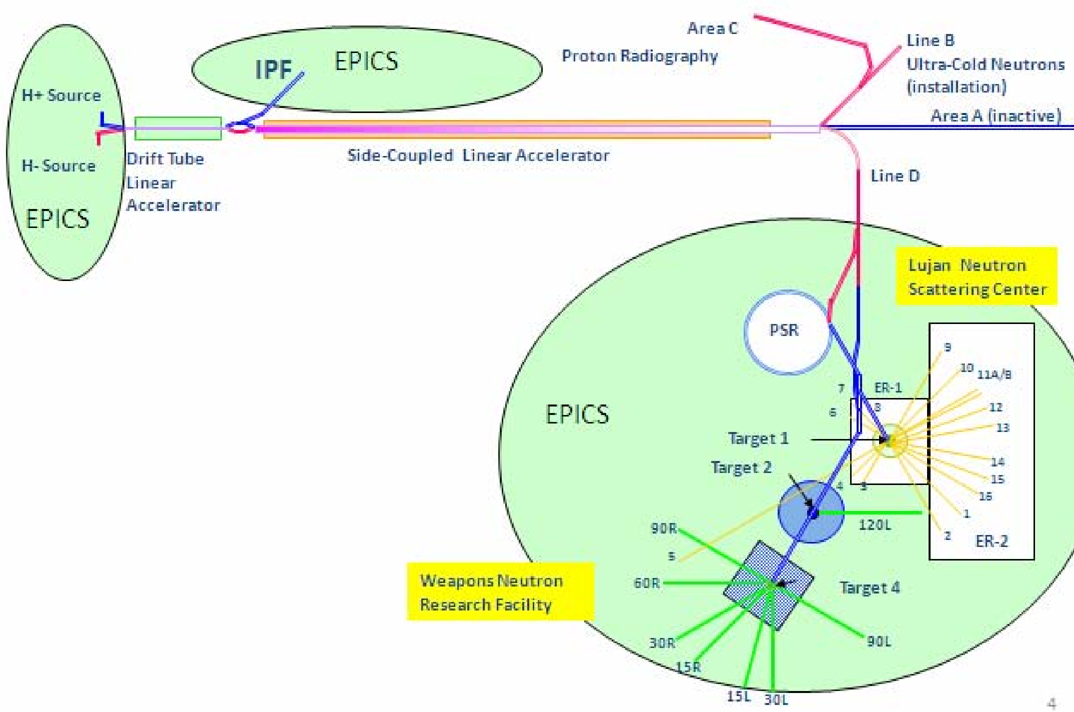

Figure 1: Schematic representation of LANSCE accelerator and experimental areas.

*Work supported by the US Department of Energy.
#folivas@lanl.gov

201 MHz section of the LINAC is the first area downstream actually inside the beam channel (sector A). It contains Drift Tube Linac (DTL) tanks 1 through 4 with tanks 1 and 2 sharing the same vacuum space. Essentially, from a vacuum perspective, DTL tanks 1 and 2 are one tank (the downstream end wall of tank 1 is common with the upstream end wall of tank 2 and there are ports in the common wall to facilitate vacuum throughput). Tanks 2, 3 and 4 are each equipped with a complete resident roughing package, consisting of a large piston pump and 2 inline blowers. These DTL tanks also each have a permanently mounted CTI 10" cryopump. Each cryopump has a dedicated, water-cooled cryo compressor.

Additionally, each tank has an overhead soft vacuum manifold equipped with a CTI 8" cryopump. DTL tanks 1 and 2 soft vacuum 8" cryopump (Fig. 3) shares one cryo compressor. Similarly, tanks 3 and 4 soft vacuum 8" cryopumps also share one cryo compressor.

The soft vacuum cryopump system is set up by a network that allows us to monitor the cryo temperature remotely. Sector A Tank 1 has 1 ion pump, tank 2 has 3 ion pumps, tank 3 has 4 ion pumps and tank 4 has 3 ion pumps (Fig. 3). All "201" ion pumps are either 1200 L/s or 2400 L/s pumps. Vacuum is also gauged by Granville Phillips Stabil-Ion Gauges, which is monitored outside in the equipment racks.

Figure 3: 201-MHz section soft vacuum 8" cryopump (left) and 1200 L/s ion pumps (right).

Transition Region (TR) – The region at the end of the 201-MHz tanks and the beginning of the 805-MHz module. The TR (Fig. 4) has three 500 L/s ion pumps and 1 cryopump. The cryopump is a CTI 8" with an air-cooled model SC compressor. Vacuum is gauged by Granville Phillips Stabil-Ion Gauges, which is monitored outside in the equipment racks.

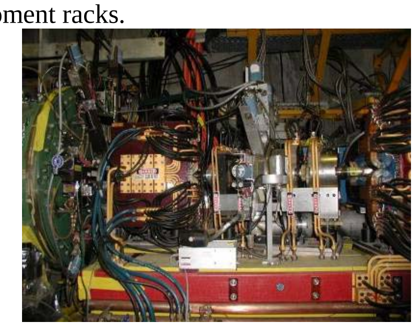

Figure 4: Transition region (TR).

805-MHz Side Coupled Linac (SCL) – Modules 5 through 48 make up the region commonly referred to as the "805". From a vacuum hardware perspective, each module is identical to the next with the exception of some of the beam isolation valves. In the beam channel, each "805" module (Fig. 5) is configured with three 500 L/s ion pumps, an upstream beam line isolation valve and a valve drop for pump-down and leak checking.

Figure 5: 805-MHz Side Coupled Linac (SCL).

As with the beam channel vacuum hardware, the controls hardware and ion pump power supplies are configured identically throughout modules 5 through 48. In the past 5 years we have started to upgrade the "805" section vacuum systems. We have installed new Varian Dual Ion Pump Controllers and Granville Phillips Stabil-Ion Gauges (Fig. 6). The plan is to install a gauge in each of the 44 modules to better monitor and detect vacuum problems; we have already installed 20 ion gauges.

Figure 6: Varian Dual Ion Pump Controller (left) and a Stabil-Ion gauge intalled between SCL modules.

Switchyard – Directly downstream of the "805" after module 48 begins the switchyard. The switchyard is the area that branches off to all other areas of LANSCE. The specific beam lines contained within the switchyard are Line A, Line D, Line X, and Line XD**.** The beam line from this point is made up of stainless steel 304L alloy 4" to 6" diameter and is joined by a site designed flange called LAMPF Standard Flange. This uses a gasket made of 1100 aluminum wire cold welded together.

Line A, which is inactive now, could be resurrected for the anticipated Materials Test Station (MTS) [2]. Line XD, is a combination of Line X and Line D. Line X shoots off to 2 experimental areas, Line B and Line C. Line X uses four 500 L/s ion pumps. Line B is the Ultra Cold Neutrons (UCN) experimental area. This beam line has 1 ion pump and 2 cryopumps with associated vacuum gauging system. Line C also has 1 ion pump and 3 cryopumps for its vacuum system and it is used for the Proton Radiography (PRAD). Line D has two destinations, Line D North and Line D South. Line D is

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the beam path into the Proton Storage Ring (PSR), Ring Injection (RI), Ring Out (RO), Lujan Neutron Scattering Center and Weapons Neutron Research facility (WNR). Line D vacuum pumping scheme consists of sixteen 500 L/s ion pumps. There are 10 beam isolation valves, several roughing ports and vacuum gauges.

Proton Storage Ring- The PSR is a fast cycling high current storage ring designed to accumulate beam over a macropulse from the LANSCE linac by multi-turn injection. The beam is sent through a 4" stainless steel tube and a vacuum system consisting of seventeen 500 L/s ion pumps and 1 cryopump. Isolation valves separate 8 different sections along with vacuum ion gauges and pump-out ports throughout the ring. PSR maintains a vacuum pressure in the low E-8 Torr range.

THE VACUUM ALERT EMAIL SYSTEM

The new Vacuum Alert System, alerts vacuum team members via email when a pump current exceeds the normal set point of 5 mA. This set point corresponds to approximately 7E-7 Torr for a typical 500 L/s ion pump. The set point can be adjusted during beam production until a scheduled maintenance period, or problem requires an earlier response. The email gives us a date, time, pump location and current relative to the set point, e.g., *Mon Jun 04 15:37:01 MDT 2007 Data Watcher: NEW 15:37:01 21IP001W01: 61.45000076293945 > 10.0.*

The email alert system was derived from a larger monitoring system that originated back in the 1970's for use with the SEL 840 Computer System. The primary purpose is to monitor accelerator vacuum system ion pump currents within the LANSCE facility and is programmed to notify system technicians and engineers when abnormal conditions develop in the accelerator vacuum systems, so corrective actions can occur in a timely manner.

Functionality of this program was copied to successive generations of facility computer systems and email notification was added in long after the initial development of this software. The Vacuum Email Alert System was initiated in 2006. The current thresholds are set at 5 mA for the 500 L/s ion pumps and 20mA for the 1200 and 2400 L/s ion pumps. When an ion pump's current goes over a set point it automatically sends out an alert to the vacuum team that a pump or pumps currents are on the rise. Now this could be caused by a number of things. With this alert system we have been able to respond to a vacuum related problem and trouble shoot it before it becomes a more serious one.

System Features

- It has the ability to send out alerts to Center Control Room (CCR) and/or the Vacuum Team via email.
- There are more capabilities within this code that remain as yet untapped. For example, it can be custom tailored to meet the needs of a specific system by altering trip point settings.
- Typical threshold is 5 mA and can be altered to meet the needs of a specific area of the vacuum system.
- The program is basically a large text file that gets edited to make changes but requires a restart to initiate programmatic changes. A newer version is in the works that can be programmatically altered without a system restart.

Experiences

During the period between 22nd of August and 31st of December in 2006, a total of ~2700 email alerts were sent out for 41 ion pumps. Many of these, however, were not real vacuum problem, but caused by output signal noise and/or false reading. When it caught real increase of the vacuum, it has been useful to get us to prepare for the future failures.

One problem we had was the case where the signal fluctuates around the set point. Every time it crosses the set point, it sent out the email and sometimes we received hundreds of emails for the same ion pump. An example of this is shown in Fig. 7. This noisy signal sent 1262 emails during one weekend in November 2006. We were able to solve this kind of problem by fixing the noise or manually adjusting the threshold level whenever we notice the problem, although we have been unable to automate this function so far.

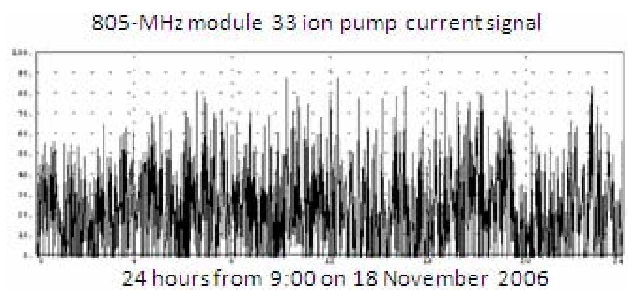

Figure 7: The ion pump current signal that sent out 1262 emails. The vertical scale shows the current from 0 to 100 mA.

Future plan

Future settings will include sending an alert if pump turns off and will not be solely dependent on an amperage reading from the ion pump power supplies.

Also, we would like to give the system more intelligence such as determining the problem whether it is a real problem or signal noise in addition to telling us the rate of pressure rise and automated adjustment of the threshold values.

REFERENCES

[1] P. Lisowski and K. Schoenberg, "The Los Alamos Neutron Science Center," Nucl. Instrum. Methods 562 (2006) 910.

[2] M. Cappiello, "LANSCE materials tests for advanced fuel cycle research," Los Alamos National Laboratory Report LA-UR-03-2315, 2003.

1-4244-0917-9/07/$25.00