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VACUUM ISSUES WITH ARGON GAS IN THE LANSCE ACCELERATOR*

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Abstract

In the Los Alamos Neutron Science Center (LANSCE) accelerator, there are about 220 500-L/s ion pumps running all the time. The oldest pumps recorded in the current system were installed in 1983. All the ion pumps are diode type ion pumps. In 2017, we started to suffer from ion pumps trips in an accelerator module 15 (M15) that includes 3 500-L/s ion pumps and they caused beam down times of the accelerator during the production run cycles. This paper reports the details of these trips, how we found it was argon gas that was causing the trips and how we tried to reduce it.

INTRODUCTION

The 800 MeV H+/H- accelerator, which was initially called Los Alamos Meson Physics Facility (LAMPF) and presently called Los Alamos Neutron Science Center (LANSCE), at LANL has been operated since early 1970s [1]. The major vacuum system consists of 229 ion pumps and 16 cryopumps [2]. The section from 100 MeV to 800 MeV includes 44 805-MHz side-coupled accelerator modules (M05-M48) with 3 500-L/s diode-type ion pumps attached to each module. The average pressure of the module is <5E-8 Torr.

We knew the existence of current pulses with quite a few ion pumps and it might be due to argon instability [3, 4], but we did not pay much attention until it started to cause trips of pumps during the accelerator run cycle in 2017. We did not know what was causing the trips initially, but we found in 2019 when we were running a residual gas analyser (RGA) that it was argon gas that was causing it. This paper reports the trips, how we found it and what we did to stop or reduce the argon gas bursts.

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ION PUMPS TRIPS

Figures 1, 2 and 3 show the currents of 3 ion pumps on M15 in 2017, 2018 and 2019, respectively. The pump current of 0.7 mA corresponds to ~1E-7 Torr and 0.06 mA corresponds to ~1E-8 Torr. Note that the average total pressure for all 3 pumps is <1E-7 Torr before it starts to rise. In 2017, we had a total of 9 trips and it stopped when we changed out a pump 15IP01 (Fig. 1), which made us think that it was this pump that was causing the trips. In 2018, however, the trips started again on May 14th and there were a total of 7 trips until July 27th (Fig. 2). It is unknown why it stopped. In 2019, the trips started again on Sept. 19th and there were a total of 4 trips until Dec. 1st (Fig. 3). We leak checked the module at an early stage with no leaks found and it was rather easy to recover vacuum by pumping down the module with a pump cart, then turn on the ion pumps, but they were significant disturbance to the accelerator users. As an attempt to mitigate it, we vented the module with UHP nitrogen gas and left it for a few hours to change the condition of the surfaces of the ion pump elements. It sometimes reduced the pump current, but it did not help prevent the trips much as shown in Fig. 3.

It seems that these trips occur only during the accelerator run cycle, and not during the extended maintenance period

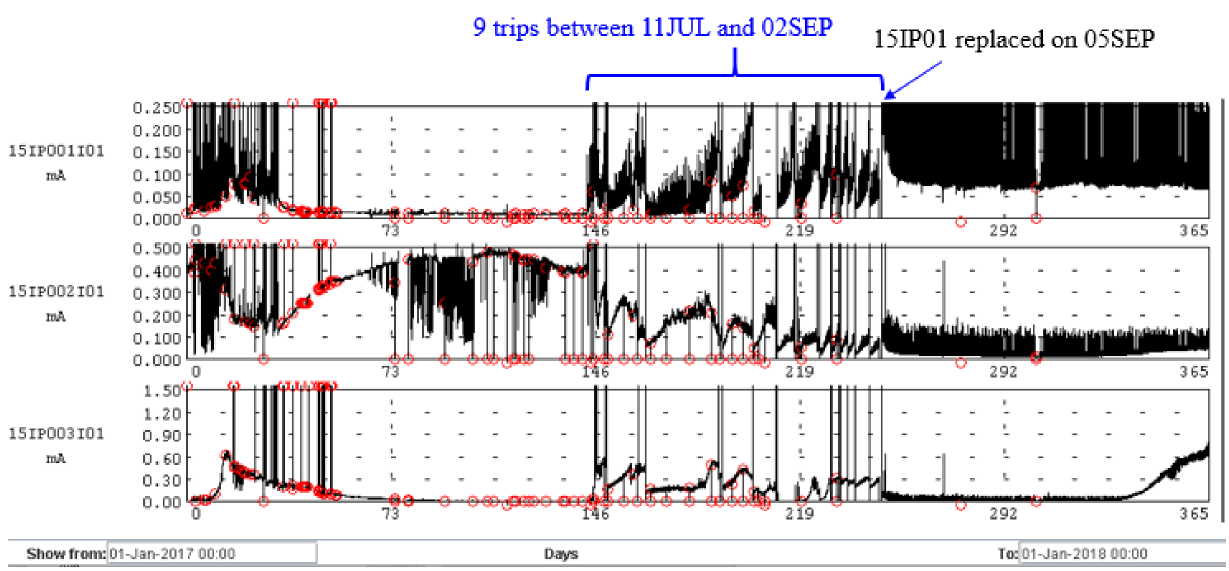

Figure 1: The currents of 3 500-L/s ion pumps on M15 in 2017. A total of 9 trips occurred between 11 July and 02 September during the run cycle. It stopped when 15IP01 was replaced. Red circles show lost data.

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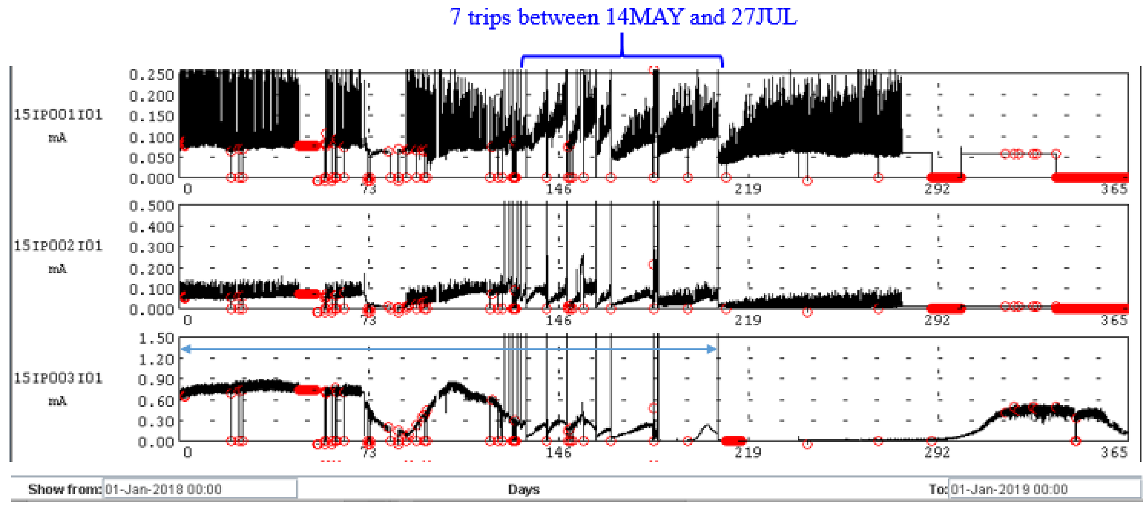

Figure 2: Ion pumps currents in 2018. A total of 7 trips occurred. The reason why there was no trip after 27 July 2018 is unknown.

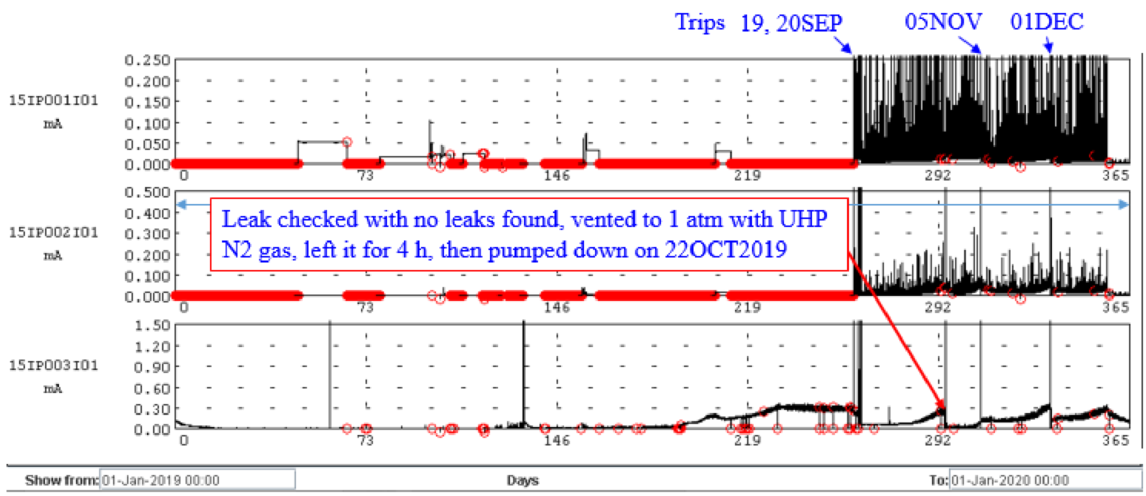

Figure 3: Ion pumps currents in 2019. A total of 4 trips occurred in 2019.

which is usually from January through April, but this is just an anecdotal observation and no evidence for that so far. We replaced 15IP03 that was baked in February 2020 during the extended maintenance period with a new pump in January 2021 and we will see if that will affect something.

RGA DATA

We use 835 VQM from MKS Instruments, Inc. as our RGA [5]. We have installed RGA sensors at some sections of the accelerator, especially where we had vacuum issues such as pressure spikes and suspected water-to-vacuum leaks. We normally do not run it constantly. Figure 4 shows the RGA data that captured the rise in argon gas partial pressure right before the ion pumps tripped in M15 on September 20th, 2019.

The partial pressure of argon gas started to rise rapidly about 4 minutes before all the ion pumps tripped. Since then, we obtained similar RGA data with argon gas causing the ion pump trips a couple more times in 2019.

BAKING OF AN ION PUMP

We rarely bake our vacuum systems in the LANSCE accelerator since we do not need ultra high vacuum. The pressure of the accelerator modules, however, has gone down to low E-8 to E-9 Torr range at some sections since they have been pumped down continuously for decades. Since we had not had any issue with argon gas until 2017, we had not considered to replace our Diode type ion pumps with other types of ion pumps such as Noble Diode and StarCell [4] that have better pumping on argon before. As an attempt to mitigate this argon issue, we decided to bake out one ion pump to see if it helps eliminate or reduce the number of trips. We chose 15IP03, the oldest pump in module 15 that was installed in 1996. We raised the temperature up to 150 °C while watching the RGA data. We started to see a rise in argon partial pressure in ~4.5 hours after raised the temperature from 135 °C to 150 °C as shown in Fig. 5.

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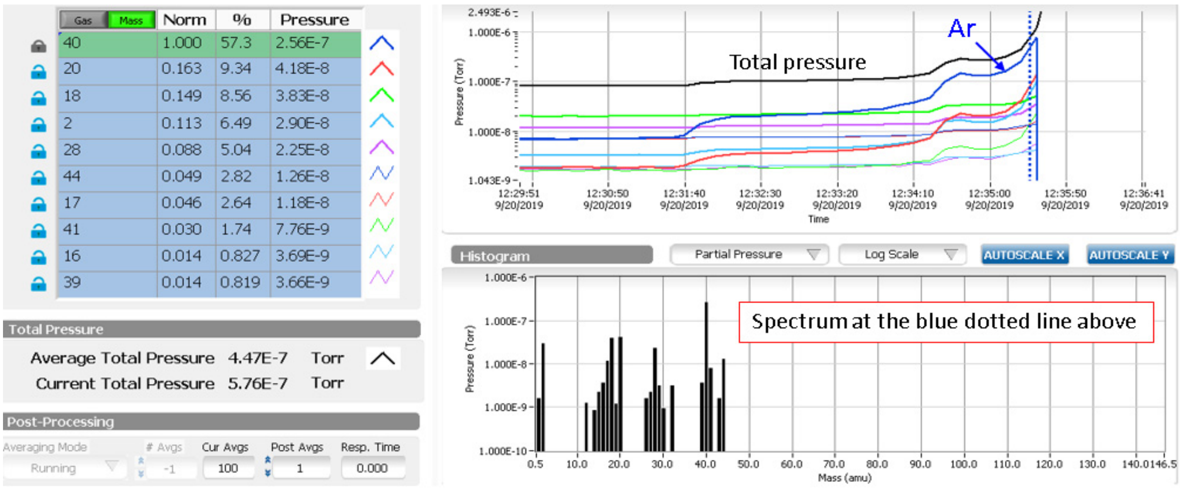

Figure 4: RGA data right before ion pumps tripped on 20 September 2019.

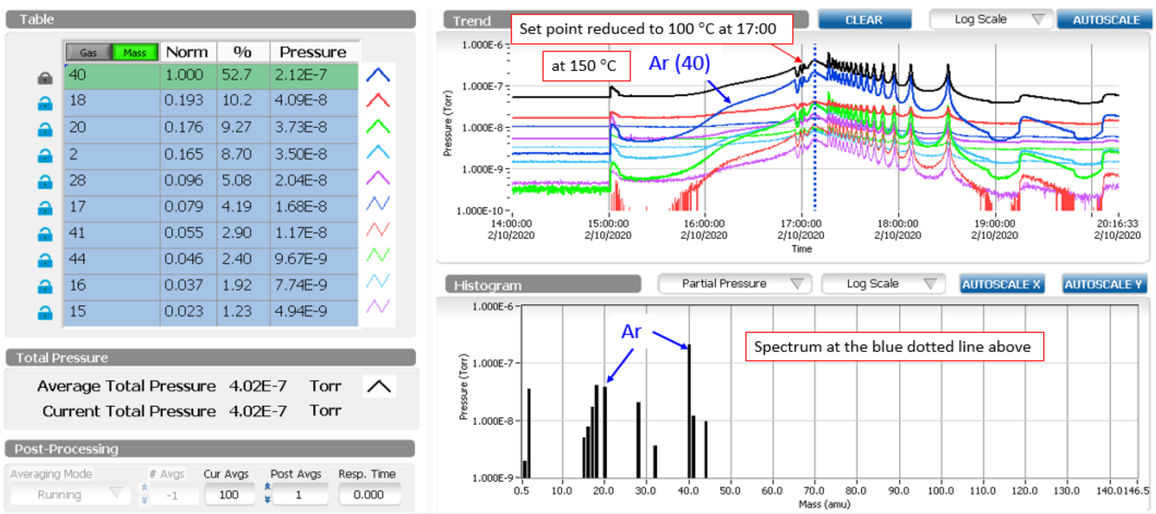

Figure 5: Detailed RGA data from 14:00 to 20:17 on 10 February 2020. At 15:00, something triggered the increased level of gas release and the pressure was going up fast. We decided to reduce the temperature to prevent RGA from tripping at 1E-5 Torr.

To remove this released argon gas, we attached a turbo molecular pump and pumped down at 150 °C for about 6 days. We had not had any trips of M15 ion pumps since this pump was baked in February 2020 until 15IP03 was replaced in January 2021. Determining whether baking out the pump is an ultimate solution or not will require more time to monitor the ion pumps currents and take RGA data for a longer period of time, but it seems to have helped reduce the change of trips by removing some argon gas from the pump elements by baking. We hope there will be no trips of any ion pump due to argon gas during this upcoming run cycle.

CONCLUSION

The problem with argon gas in the LANSCE accelerator was reported. We plan to continue monitoring the current spikes of ion pumps and bake out or replace the pumps that show a sign of argon gas bursts in the future.

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