Australian National University

14 UD Tank Opening Report

#135

19th June 2023 – 30th of June 2023

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Reason for tank opening

This was an unscheduled opening due to a significant SF_6 leak into the vacuum tubes. The accelerator was successfully run for an AMS-type run for a Masters course for about a week, but the problem became very obvious the following week during a real AMS run.

The first symptom was that the gas stripper pressure would increase rapidly to about 30mTorr with the gas turbos on but the stripper valve still shut. This is not normal. The low and high energy vacuums appeared to be deteriorating and some of this may have been masked by the fact that we were still expecting vacuum to recover after venting the high energy end in TO#134.

An RGA scan in the usual configuration (RGA at low energy end, shafts off over night and 300lps ion pump off for at least an hour) showed an SF_5 peak at 127 AMU at 1×10^{-6} Torr. This is significant and greater than the levels during the SF_6 issues documented in TOR 117 through TOR 124 (which were of the order of 10^{-8} Torr). The RGA scan in shown in Figure 1.

Further investigation showed that there was rapid, order-of-magnitude, degradation in tube vacuums over a four-minute period on the evening of the 10th of July for the low-energy end and on the morning of the 11th July for the high-energy end. This is shown in Figure 2. The machine was not in use at the time, nor were the shafts on.

Reflecting on the history books showed that we had a near identical incident in 2018, as documented in TO129 (editor's note: and perhaps we should have paid attention to that earlier than we did).

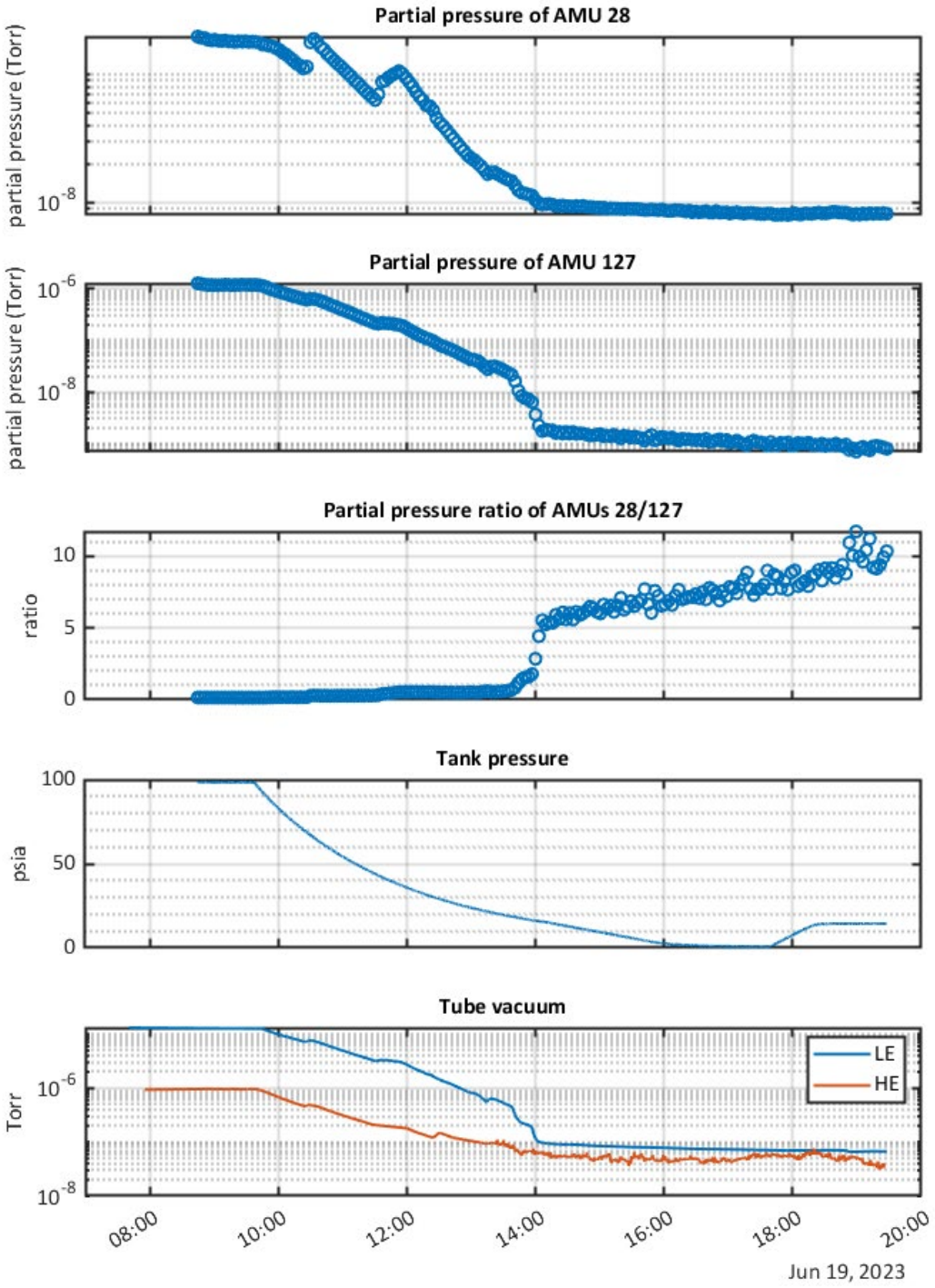

Figure 1 RGA scan over time during the pump out of the 14UD tank. There is nearly a full order of magnitude step reduction in the SF_5 peak (127) just before the tank reaches atmospheric pressure.

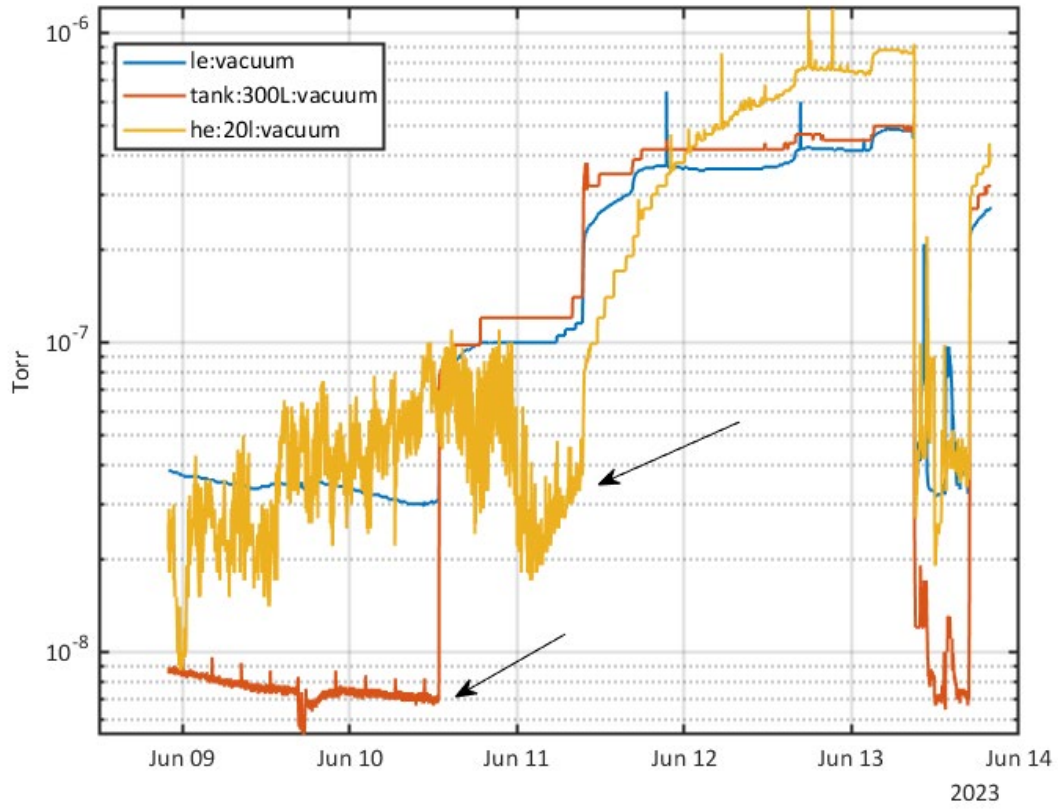

Figure 2 Jump in accelerator tube vacuum observed in two stages over the 10th and 11th of June 2023. The shafts were not on at times indicated by the arrows and no other event can be determined. The shafts were on during the later improvement in vacuum.

Summary of work

Tank opening #135

19/6/23 Monday

- The SF_6 was pumped from the 14UD into the storage vessel.
- The porthole doors were opened and the fresh air ventilation system turned on.

20/6/23 Tuesday

- Platform was deployed and tools loaded on. The air hose was left until required.
- Terminal was opened
- Helium leak detector was installed on the backing side of the multi faraday-cup (MFC) box turbo at the high energy end (after the analysing magnet). This is the same configuration used during the epic SF_6 wars of TO #126 (see report). In this case for initial testing, the low-energy ball valve was shut and all valves and pumps between there and the MFC box were closed/off. The metal gasket seal on the foil stripper was suspect number one, but showed no leak from a base leak rate of 1.5×10^{-9} mbar•l/s.

Other seals and joints that were disturbed during TO #134 were tested similarly did not show any leak.

- The halogen detector was brought onboard and reacted to the inside of the hand valve on the back of the foil stripper (conflat flange was removed). There was a smaller reaction to the top hat covering the Weisser valve.
- Over a period of about 90 minutes, the background leak rate increased to 2.8×10^{-9} mbar•l/s.
- As a sanity check, a calibrated leak was introduced into the interspace on level 5. All pumps between there and the He leak detector on level 1 were off. A reaction to the calibrated leak was detected within seconds, confirming that our leak detection setup was valid.
- With that sad state of affairs, we went home to ponder the next step.

21/6/23 Wednesday

- All vacuum pumps were active and valves were open overnight and the vacuum had recovered nicely into the mid-10^{-8} Torr. Valves were shut and pumps off to start a more targeted leak chase.
- Leak chased the terminal again, including the gas stripper box. Nothing.
- Powered up the terminal with mains. Found the lower 60lps ion pump wasn't plugged in. Oops.
- Deactivated the terminal ion pumps are started the gas stripper turbos. The gas stripper pressure read 0.5-ish mTorr and didn't move at all even when the turbos spun up to full speed. This is in contrast to the same test before we opened.
- With nothing else in mind, did a leak chase from the top to the bottom of the machine (without bagging or taping components) just to see if there would be any reaction at all. From a base leak rate of 2.1×10^{-9} mbar•l/s, this only budged once we were about halfway through the high-energy end. A few hours later, after finishing leak chasing, this had crept up to 2.7×10^{-9} mbar•l/s. Does this mean anything? Maybe. Not finding anything definitive is disheartening as dreams of a quick tank opening fade.

22/6/23 Thursday

- Installed a high vacuum gauge at the high energy end in the manifold below the tank. This will give us a reliable high vacuum reading that can be directly compared to the low energy end.
- The 300lps tank ion pump does not want to start. The symptom is a complete open circuit with full voltage and zero current. The behaviour is the same as if no cable is connected at all (tested). Another Terranova ion pump controller was used and the result is the same. Is the pump done?
- Opened the gas stripper valve was opened to 16.42% while running an RGA scan. The 127 AMU SF_5 peak stayed in the region of 1×10^{-9} to 3×10^{-9} Torr while the 28 AMU N_2 peak definitively rose to 1×10^{-5} Torr. The gas stripper pressure started at 0.36 mTorr and rose to 6.56 mTorr. From this, we deduce that there is no significant amount of SF_6 upstream of the gas stripper leak valve and therefore the leak is unlikely to be in that region.

23/6/23 Friday

- Not much progress today. We have decided that we need to close the Weisser valve and regas the tank to at least deduce which end of the machine the leak is in. To do this, the Weisser valve needs modification as in TO129 so that it can be capped while closed. Bits were machined to allow this.

- While the Weisser valve was shut, sprayed helium around to see if there was any reaction on the He leak detector when it was opened. We did get a reaction up to 3.5×10^{-9} mbar•l/s from a base of 1.5×10^{-9} mbar•l/s. This could have been just the change in volume, but gave us enough reason to bag all the Weisser valve flanges to test.
- We did that and guess what, no reaction on the leak detector and in fact the background rate improved.
- We're going to take the weekend to regroup and not rush into an error today. All caps etc were replaced in preparation for closing the tank as is.
- A new 300lps ion pump was fished out the cupboards and early preparations were made to get an adaptor and supports made.

26/6/23 Monday

- We're a bit reluctant to regas without exhausting other options, o we went in the tank and did some more helium leak chasing. The gas stripe turbos were bagged and leak chased with the leak chaser at the high energy end.
- From a base of 1.5×10^{-9} mbar•l/s we saw a reaction to 1.2×10^{-8} mbar•l/s sixteen minutes after injecting into the lower turbo bag. Repeated again but we'd now lost our low background rate. Still thought we saw a small peak up to 1.9×10^{-8} mbar•l/s. Closing the Weisser valve makes the background drop pretty quickly. Closing the gas tripper feed valve had no effect on the background leak rate.
- With this, it suggests that maybe the issue is in the low energy end, so we moved the leak chase to level 5 on the back of the MSNICS turbo. The base leak rate was 8.3×10^{-8} mbar•l/s at this point. Also ran the RGA in P vs T mode looking at He, N_2 and SF_5 peaks. Weisser valve was shut. Sprayed into bottom turbo bag and got a response on both leak detector and RGA with a peak of 1.8×10^{-7} mbar•l/s ten minutes after spraying. Repeated into top turbo bag and saw a small response. Up to 1.1×10^{-7} mbar•l/s from a base of 8.3×10^{-8} mbar•l/s. Repeated again in bottom turbo bag and saw nothing. What does it all mean?!

27/6/23 Tuesday

- Doctor Nik ("Hi everybody!") is back on deck and after a bit of a round table we've made the decision to pull off the gas stripper turbos and manifold, blank off the ports and gas up. Are we sure the leak is in the turbos? No. Are we sure we won't see a SF_6 leak on gas up? No. But on the balance of probabilities from what we have seen, yes. The gas stripper turbos and manifold contain the only *exposed* rubber seals in the machine. Removing them will give us time to investigate and resolve the issue while getting the machine running for those groups more partial to foil stripping.
- So with that, the Weisser valve was shut and the low energy of the machine vented to atmosphere (with N_2 of course).
- The gas stripper turbos and the entire trap manifold were removed and blanked off. Valves to the N_2 feed system were shut as was the N_2 cylinder itself.
- Vacuum was restored in the low energy end of the machine and the Weisser valve opened.
- By the way, the 300lps was turned on and left alone and after a good number of minutes it came to life and started pumping. It seems it is operational.

28/6/23 Wednesday

- Tidied up and secured cables that normally run to the gas stripper turbos.
- Leak chased the blanks installed yesterday. All OK.
- Leak chased under the tank where the new cold cathode gauge was installed. All OK.

- Did preliminary terminal checks (whatever is left anyway) and all OK.
- Closed the terminal.
- Performed 10kV HV tests with the Megger down entire machine. All OK.
- Unloaded tools etc. at level 2.

29/6/23 Thursday

- Did exit function tests. All OK.
- Unloaded the platform completely and buttoned up.
- We're done, we hope.
- Set for RGA monitoring of SF_6 while pumping out and gassing up.

30/6/23 Friday

- Gassed up
- So far, so sign of a large amount of SF_6. There is a definite signal at 127 AMU of about 6×10^{-10} Torr on the RGA scan, but this is not unusual and no performance degradation has been observed at this level.

SF_6 levels during gas up

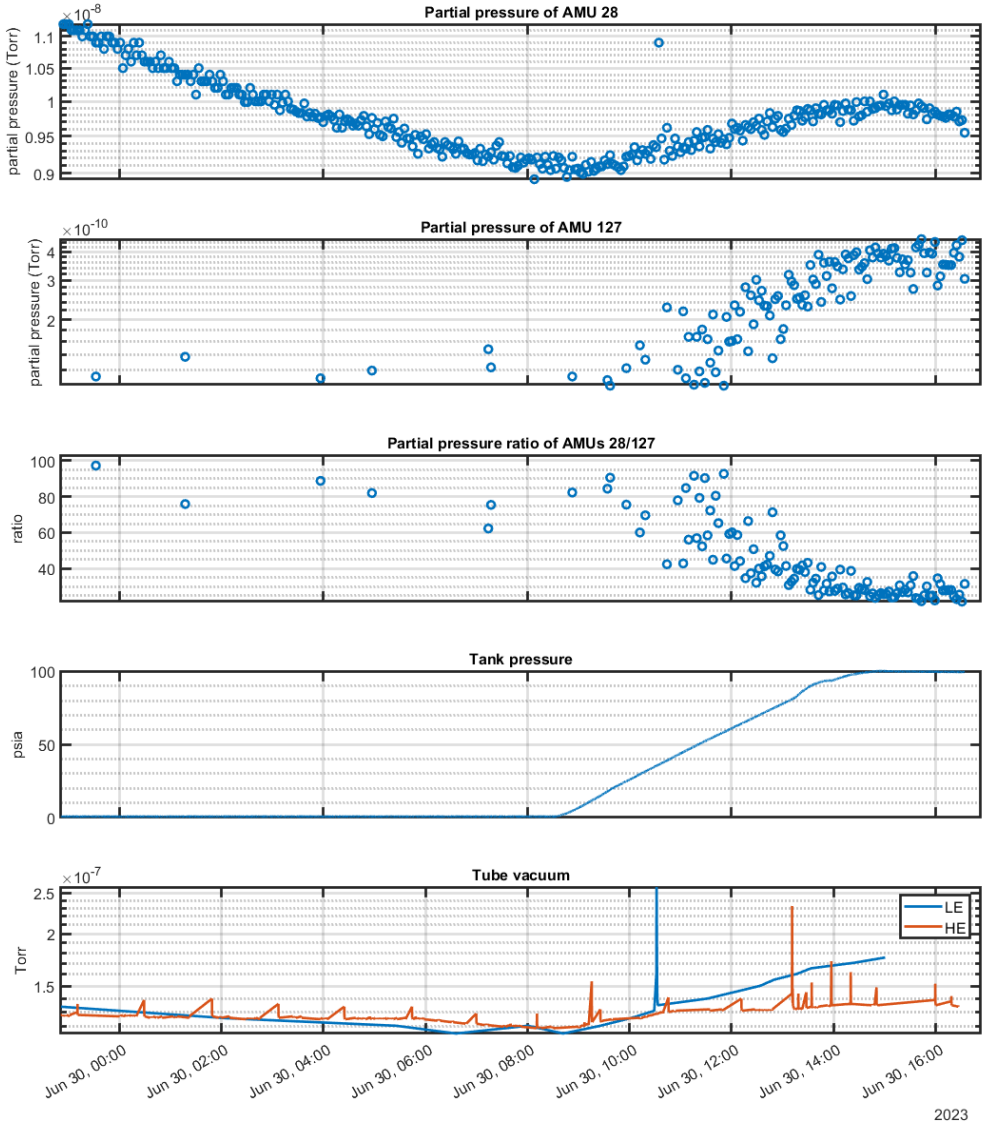

Figure 3 N_2, SF_6 and tube vacuums during tank gas up. A small amount of SF6 is evident from about 50 psia. It is not at levels of concern, but it is there. IN any case, this is a marked improvement compared to levels shown before the tank opening in Figure 1

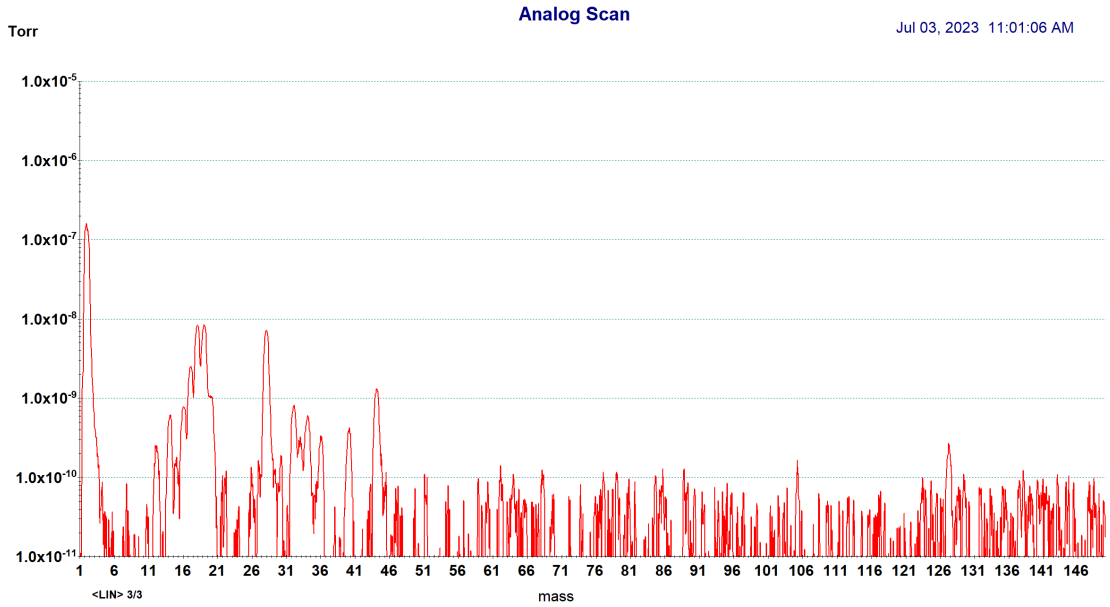

Figure 4 RGA Trace on Monday 3rd July following the tank gas up the previous week. The SF_5 peak is at mid 10^{-10} Torr, which is considered a low background level. Thus, levels have remained static compared to Figure 3.

Initial performance

Machine was conditioned up to 12.5 MV exhibiting few sparks. Limiting factor still remains HE pressure low 10^{-7} due to: (a) HE tube was vented and (b) HE sublimer is due to refurbishment. The conditioning will continue when opportunity arises.