Australian National University

14 UD Tank Opening Report

#121

6 January – 26 February 2014

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1 Reason for tank opening

This tank opening was scheduled to coincide with other major upgrades to the accelerator facility (splitting analysing magnet for box swap) and the resulting downtime of the 14UD. The opening was also necessary to address a small but problematic leak in the terminal gas stripper system. This leak was significant enough to disrupt AMS applications.

The initial plan of action was to:

- test charging/suppressor at 50 kV just before opening when 14UD at 100 psi[1];
- evaluate and document condition of all old posts visually and with and 5 kV test;
- check consistency of old NEC drawings of posts and installed posts;
- install two new chrome chains from NEC and remove nickel chain from 14UD and prepare to send back to Roxanne Loger at NEC (RMA #121031GAN1);
- install stainless steel mushroom CPOs if available and test response;
- investigate transfer function of actuator based on modulation of voltage applied to acceleration gap of tube adjacent to the terminal;
- investigate and rectify SF_6 leak in the gas striper system;
- continue with Infinitron tests;
- replace short circuited gas stripper 20L/s ion pump with new pump;
- evaluate oiling program by observing lubrication and dust collection;
- install high-energy fast valve[2];
- if time permits, install 24V oiler valves and complete transfer to EPICS control;
- replace corona needles; and
- measure RC of the terminal with 30 kV insulation tester.

The gas stripper system pressure rose from its usual base pressure of about 0.5 mT with valves and turbos off to about 1.5 mT in two relatively sudden jumps on the 3rd and 6th of November. With the turbos on, this pressure steadily rose past 7 mT and caused problems for AMS applications. Residual gas analysis (RGA) at level 4 with the shafts on (terminal ion pumps operational) showed a clear but low-level SF_5 peak. Even with the shafts off over a weekend, the RGA results were much the same, with the expected peaks below the SF_5 peak either being non-existent or buried in the background. The presence of SF_6 was not as clear as similar RGA traces undertaken before TO #118.

As always, additional unplanned tasks were performed as opportunities presented themselves.

2 Preamble

A charging system test was performed on 24th December 2012 in preparation for the tank opening. The charging voltage was increased from zero to 50 kV and both the charging system current and suppressor supply current monitored. At approximately 36 kV, the charging current discontinuously increased to about 40 μA and then to increased again about 65 μA when the charging voltage increased to 38 kV. There were no similar jumps in the suppressor supply current.

[1] A HV supply was required to blow away a short after TO# 120. We need to understand if there is still a problem.
[2] Parts dependent on MWS and splitting analyzing magnet has priority

Another RGA scan was taken at level 4 on 2nd January 2014 after the terminal shafts had been off over the Christmas break. A SF_5 peak can be seen, but it is small and none of the associated peaks at lower AMUs can be distinguished from the background reading. The gas stripper pressure was above its historical level in the same state and although it dipped to as low as 0.8 mTorr when the shafts were first turned on, it increased back up nearer 1.5 mTorr over a few hours. A 0.2 mTorr oscillation in pressure is present with a period of about 20 – 25 minutes. It is unclear if this oscillation was present previously for the same state (turbos off, valve shut and shafts on)

3 Summary of work

3.1 6-1-14 Monday

- Two new chrome plated chains were assembled and hung in the tower stairwell. The angle between pins in the first and the last pellet was observed and no significant angle could be measured. Associated model and serial numbers are:
    - 2DA010142/10841.1653
    - 2DA010142/10842.1654

3.2 7-1-14 Tuesday

- The SF_6 was pumped from the 14UD into the storage vessel.
- The porthole doors were opened, and the fresh air ventilation system was run overnight.
- Monitoring of the gas stripper pressure as the tank pressure decreased showed that the gas stripper pressure decreases and therefore a SF_6 leak is likely.

3.3 8-1-14 Wednesday

- Gas tests showed the atmosphere within the 14UD was OK and compliant with the Confined Space regulations and was safe to enter.
- The in tank platform was deployed and the initial pass down the column completed the 30kV insulation grouped ring tests. The majority of current readings were within specification, however six tubes and resistor assemblies require investigation due to high current readings.
- The column was wiped down and the amount of white dust/breakdown product was greater than usual. The marks on the terminal from the corona needles was particularly bad, with a brown film under the customary white film. Both films wiped off with detergent.
- A RGA scan at level 4 showed definite traces of SF_6, at higher levels than with the tank closed. This may be due to the fact that the tank 300 l/s ion pump was off overnight (as well as the shafts).
- Each casting cover was removed in turn to allow vibration analysis to be performed on the shaft bearings. All but unit 14, the terminal and unit 28 bearings were analysed.
- Observed wobble in coupling body and/or bearing flange in unit 5
- Fond that bottom bearing in unit 17 is rotating left to right within its housing
- Found that bottom bearing in unit 26 is rotating right to left within its housing (but slower than unit 17)

- Observed that the high-energy shaft at the bottom of the terminal is “fluttering” a little and the shaft coupling to bearing set flange is waving a little.
- A significant amount of dust was found on the top the shaft in unit 23 and it appears to be from abrasion of the Perspex. More investigation is required.

3.4 9-1-14 Thursday

- The terminal was opened and preparations were made to power the terminal from mains power and to begin He leak testing of the gas stripper system.
- Leak detection commenced with the system undisturbed aside from the leak detector connection to the stripper roughing valve. No leaks were found anywhere in the top and middle sections of the terminal.
- The gas stripper pressure was observed to be “good” even with the 60 l/s ion pumps off. This was not previously observed (with the tank open) and the only difference was that the leak detector was connected and pumping *but valved off*. The leak detector has been left pumping (again with the valve off) overnight and the gas stripper pressure is being logged via the archiver.

3.5 10-1-14 Friday

- The pressure in the gas stripper remained good overnight. The leak detector was vented, but still no change in the gas stripper pressure, so the theory of a leak through the roughing valve is a bust.
- Shafts were operated to collect more bearing data with the vibration analyser. Also included the gas stripper turbo bearings in the data set.
- Measured the pressure of the O_2 gas stripper bottle and found it to be 1.246 barg. At last fill on 2/11/2012, it was at 0.298 barg. Used a SF_6 detector and showed there was definitely SF_6 present in the bottle.
- The four valves were removed in two subassemblies. That is, two valves and the pipework around the O_2 bottle and two valves and the pipework on the vacuum side. Off they went for pressure leak testing.
- Vented the acceleration tube from top to bottom.
- Replaced shorted terminal 20 l/s ion pump with a new Duniway VA-20-DD-0 (S/N Z1110010)

3.6 13-1-14 Monday

- Removed terminal foil stripper mechanism to allow repopulation with new foils.
- Removed secondary foil stripper mechanism (at high-energy midsection) to allow repopulation with new foils. Observed that there were many pieces of blown foils in the canal. Not sure if this was observed the last time these foils were replenished?

3.7 14-1-14 Tuesday

- Repopulated secondary foil stripper mechanism with new foils where necessary. Note that the mechanism contains 266 foil positions and not the 195 positions suggested by the FOILED log book. Reinstalled mechanism into high-energy midsection after *carefully* vacuuming out pieces of foil. Also tested that the suppressor supply was not shorted before we bolted up. It was fine.

3.8 15-1-14 Wednesday

- New chain (1O, S/N 10841.1653) installed into position 1 to replace Ni plated chain (2M) that will be returned to NEC. One link was removed from the new chain for the pre-operational test run. The motor leg to floor distance at install was 70 mm.
- New chain (2N, S/N 10842.1654) installed into position 2 to replace Cr plated chain (1N) that will act as a viable spare. Two links were removed from the new chain for the pre-operational test run. The motor leg to floor distance at install was120 mm.
- Removed abraded Perspex shaft from unit 23 for further investigation.
- Removed unit 26 bottom bearing for replacement of both bearings

3.9 16-1-14 Thursday

- Repairing shaft from unit 23. It turns out that a previous repair had been undertaken and required a new shim compensating for the skimmed shaft during TO #117 (the shaft was skimmed to removed track marks). However, the shim was too large (too long) and did not allow the end clamp to be tightened sufficiently. A new shorter shim is being made.
- Reinstalled unit 26 bottom bearing after replacement of bearings. New bearing carrier was used, the superfluous alternator hub was removed and a 3/8" UNF thread was tapped into the top to assist with jacking the bearing assembly apart if required in the future. Shaft in unit 27 was reattached and realigned.
- Repaired shaft from unit 23 was reinstalled and aligned. The clamping edge of the Perspex shaft had been re-trued in a lathe and a new shim manufactured.
- Replaced corona needles with a new assembly. Some needles on existing assembly were severely worn.
- Removed and examined charging system feed throughs and found much gungy black grease on the positive feed through, a definite large track mark on the negative supply feed through and some tape on the negative supply feed thru *inside* the box. Yes. Tape. However, the track marks are in the grease only and the Nylon feed through clean up nicely. They will likely be reused. Also, the feed throughs were a little difficult to remove and it may be that the dimensions have changed during service, which would be interesting.

3.10 17-1-14 Friday

- The motor leg to floor distance was remeasured after the initial chain installs. Chain #1 was 47 mm and chain #2 was 95 mm.
- Removed three of the charging system distribution nylon stand offs from the bottom of the tank. Two showed destructive track marks along the surface from metal end to ground and one showed a more localised destruction (see section 4). There was definitely a release of nylon debris.
- Cleaned up the bottom of the tank and the inductors. Checked the alignment of the inductors at the drive end.
- Cleaned the terminal.
- Inspected unit 15 due to abnormal current readings during entry 30 kV HV tests. Tube 3, gap 1 resistor lead was damaged by spark activity (frayed and black). Further inspection revealed that post C is damaged, with ceramic flakes coming off gaps 9 and 11 and two hairline cracks extending between the top and bottom of gap 18. End result: ☹

3.11 20-1-14 Monday

- Reinstalled shaft into unit 26.
- Returned to unit 15 to replace damaged resistor lead and found that banana plug in top resistor was fused in place. Removed and disassembled assembly and found that nut end of the resistor was not square leading to preferential breakdown on one side of the spark gap. Replaced the entire assembly with a good one removed during TO #120. Also had to replace nuts on both top and bottom resistor to accommodate the new resistor leads.
- Found stringer 3 in unit 15 loose at the tube end
- There is some evidence of surface discharges on unit 15, post B, gap 6 with some particulates remaining.
- Had a closer look at unit 15, post C and found more evidence of ceramic flaking and cracks.
- Reloaded terminal foil stripper mechanism with new foils where required
- Reinstalled terminal stripper foil mechanism.

3.12 21-1-14 Tuesday

- Raised bottom terminal spinning to gain access required to remove of unit 17 bearing. Removed bearing.
- Chain 1 and 2 motor leg clearances measured at 45 and 95 mm respectively. Removed an additional link from new chain 1
- Reinstalled unit 17 bottom bearing after replacement of bearings. New bearing carrier was used and as above for the other bearing, the superfluous alternator hub was removed and a 3/8" UNF thread was tapped into the top to assist with jacking the bearing assembly apart if required in the future. Shaft in unit 18 was reattached and realigned.

3.13 22-1-14 Wednesday

- Began unit by unit inspection of posts and made it through from unit 1 to unit 5. Found:
    - Unit 5, post D, gap 1 had ceramic flakes missing
    - Unit 5, post B, gap 4 had multiple cracks in ceramic
    - Unit 5, post B, gap 8 had hairline cracks in ceramic
  - Continued with post inspections in units 6 through 9, 14 and 17
  - Looking at unit 14, we noticed a lot of greenish dust/breakdown product that seemed to be "directionally deposited". From this found that on unit 13, tube 1, gap 2, top resistor, the nut has come loose and has severely eroded the shield. Units 12 to 14 will need to be cleaned up in addition to any repairs.
  - Noticed that in unit 17, the top there gaps of each post seem to be dirty (with oil and black gunge) but the rest of the gaps are fine. The three gaps are associated with an 8-gap tube. They are also near the idlers?
  - Noticed that unit 18 tube 3, gap 1 has some breakdown activity with some strange looking black deposits. This is adjacent to the stringer connection.
  - Unit 18, 2nd stringer was loose at post end. Redressed and replaced fastener with radiused socket head.
  - Notice an internal flaw in the optic fibre in unit 23. Not sure if this is significant.
  - Continued with post inspection in units 19, 21 through 25, 27 and 28. Found:

  - Unit 25, post C, gap 12 had cracks
  - Unit 25, post C, gap 16 had multiple cracks that were dirty, suggesting arc activity
  - Unit 28, post C, gap 13 needs to be looked at again.

3.14 23-1-14 Thursday

- Ran shafts to examine noisy bearing at lower terminal bearing and to retake vibration analyser measurements on new bearings in units 17 and 26. To be able to run shafts with the tube vented, the TUBE VACUUM PROTECTION WAS BYPASSED. The power supplies for the ion pumps and terminal electrostatic quadrupole were turned off.
- Removed lower terminal bearing for repair

3.15 24-1-14 Friday

- Removed gas stripper molecular traps for examination outside the tank. Attached to RGA and pumped and on the initial scan, there is a definite signature of SF_6 even after they had been vented and liberated from the tank. They will be baked next week.
- Attempted to adjust high energy terminal alternator so that its axis was both perpendicular with the casting and concentric with the unit 15 bearing set. However, there was not enough adjustment in the alternator adjustment screws.

3.16 27-1-14 Monday

- Australia Day public holiday.

3.17 28-1-14 Tuesday

- Work continued on rectification of high energy terminal alternator alignment. Mount holes were modified to allow greater alignment adjustment range. Longer bolts were required, so work on this halted for the day
- Began reinstalling new charging system stand-offs with new mushroom design

3.18 29-1-14 Wednesday

- Found yet another charging system stand-off with spark damage. This one was on the negative side.
- Finished reinstalling new charging system stand-offs with new mushroom design (see section 6)
- Work began on replacing 240 V oiler solenoid valves on level 2 with 24 V versions. Valves were prepared with cleaned up adaptors and cabling to level 2 IOC began.
- Loose stringers were found in unit 15 on both tube 1 and tube 3. Tube flange end fasteners.
- Reinstalled the high energy alternator and undertook alignment for both parallelism to casting and axial to unit 15 bearing set. Bearing carrier in lower terminal casting was reinstalled and axially aligned to alternator shaft.

3.19 30-1-14 Thursday

- Work on the high energy alternator was completed. This included fitting three positioning blocks onto the inside of the casting about the periphery of fixed bearing carrier. This is to facilitate to accurate
- Wiring of the 24 V oiler solenoid valves continued.
- Pressure leak testing of the new welded Swagelok valves was completed. They all seem good.

3.20 31-1-14 Friday

- Reinstalled charging system feed throughs in the bottom of the tank.
- Removed the HE BPM as it was reported to be making odd noises.
- Crook was attending to preparation of new parts for the installation of the new HE ball valve.
- The gas stripper traps/manifold was coupled to the LINAC turbo pump system and pumping ready for baking.

3.21 3-2-14 Monday

- HE ball valve preps continue.
- HE BPM was examined and though there looked to be a slight circular mark from the internal magnet drive there was more than enough clearance when checked. The unit was reinstalled.

3.22 4-2-14 Tuesday

- Finished the machining of billet al gasket ring for the gas stripper port connection
- The new HE ball valve was installed. Good planning made this an easy task.
- Some baking of the stripper traps was done to a temp of ~50ºC and turned off as the vacuum deteriorated.

3.23 5-2-14 Wednesday

- The unit 15, post "C", # 2183 was swapped out and replaced with a serviceable used post # 290. Post # 290 required the inclusion of a shim
- Made good the two loose stringer connections to the tubes in U15 with new radiused socket heads. We did the third one for good measure.
- The unit 5, post "B", #2044 was swapped out and replaced with a serviceable used post #238 (no shim required).
-

3.24 6-2-14 Thursday

- The unit 5, post "D", # 282 was swapped out and replaced with a serviceable used post # 265 (no shim required).
- Post # 282 separated into two pieces once the post was released of its fasteners and the compressive load of the column. The failure was at the bond at the top of the

second ceramic. This failure is immediately below the visible crack that initially caught our attention.

- In unit 5, new ring screws were not fitted as by luck the arrangement of the posts installed was such that rotating the ring by 180 degrees the screw lengths matched posts with and without slots.
- Units 5 and 6 were cleaned, stringer attachments checked and closed.
- The unit 25, post “C”, # J1 was swapped out and was replaced with a serviceable spare #340
- Closing unit 15 and looking down onto the unit 16 casting we noticed a dark shadow on the casting of U16 around the shafts lower end flange area. Investigations and the source is from the underside of the unit 15 bearing set above.
  The lower bearing in the unit 15 set had more of its periphery showing and was found displaced through the bearing carrier (this carrier is a radial restraint only). Therefore the shaft/flange piece supported in this bearing is also displaced and the underside of the rotating flange was rubbing on the lower bearing carrier generating dust. This corresponds with the unit 16 shaft top flange set on its Perspex shaft set higher than one would normally expect. It is usually flush with the casting and it was ~1.5mm higher. Not sure if the chicken came before the egg in this case.
- The unit 15 shaft bearing assembly was found to have a rubber coupling component that measure 0.070” shorter than a new piece we had in the cupboard. The old coupling would still be serviceable with a compensation spacer fitted to bring it up to a free height of 1.750” measurement of the new coupling

3.25 7-2-14 Friday

- U15 shaft bearing set was assembled with a new coupling piece and new bearings. This unit also received the treatment of having the redundant alternator hub machined off (diameter 1.750”).
  The upper flanges clamping to the Perspex shafts were released on both the U15 and U16 shafts so as the flange could move freely on the shaft and be without tension during the connection to the casting bearing sets. All was clocked up and secured.
- A loose stringer was found in unit 16 T3 post end and repairs made.
- The casting idlers for all three chains were checked for smooth operation and clearance to the chains. All were OK.
- Fitted some casting covers in the HE end of the machine.
- We removed three pellets from chain #1 and the motor support leg clearance after this is 110mm. No screwed pins remain in this chain.
- We removed two pellets from chain #2 and the motor support leg clearance after this 130mm. No screwed pins remain in this chain.

3.26 10-2-14 Monday

- Re-installed the gas stripper box after extensive leak testing of its components.
- We pumped and filled the gas stripper O_2 bottle from an oxygen cylinder to 0.298 barg (same as previous fill). The filled bottle was fitted in the terminal.

- The gas stripper traps were heated to 125°C and pumped at ~10^{-4} mbar over the weekend. This morning the heat was turned off and in the afternoon they were vented with N_2 and taken for installation in the terminal. Unfortunately this all concluded late and pumping of the whole tube will be undertaken in the morning.
- Plumbed the actuating gas to the HE ball valve and labelled its ports

3.27 11-2-14 Tuesday

- Commenced pumping of the accelerator tube. This was done from the port at L5 before the injection magnet and included the LE and HE tube through to the level zero "hand" valve. Roughing commenced at ~8:55 and we were able to open to the gas source turbo pump at 10:22.
- The leak tester was connected to the pumping port valve of the gas stripper in the 14UD terminal. Testing of the pipework back to the closed fine valve and all was leak tight. The gas stripper system pipework including the leak tester was opened to the accelerator tube and all the freshly made connections of the trap manifold, the turbo pump backing port O-rings were found to be leak tight.
- Leak testing extended to the freshly made joint of the carbon strippers in the terminal and the HE mid-section. No leaks found.

3.28 12-2-14 Wednesday

- In-situ baking of the gas stripper hydrocarbon traps was undertaken at 190°C for 24 hours. Voltage to the traps was incrementally increased so as to manage the degraded vac caused during the outgassing from the traps.
- Leak testing of the following was undertaken whilst the tester was connected to the gas stripper pumping port:
    - HE ball valve installation
    - HE carbon stripper (second stripper)
    - the gas stripper plumbing and its turbo pump manifold/traps pipework
    - the terminal stripper

  All were leak tight
- We put back the deck and closed the HE mid-section.
- We reconnected the HE mid-section alternator wires in the junction box now we have re-established vacuum. (no more risk of powering ion pumps from shaft whilst vented)
- We closed off the gas stripper pumping port valve and vented the leak tester. Turned off the tester and disconnected this unit. This port/valve was fitted with a cap and the handle removed.
- The handle was also removed from the gas stripper isolation valve. The valve open to its maximum, with only slight torque applied.
- The handle was removed from the gas bottle filling valve. This valve is closed and capped.
- From the console the gas stripper fine valve was instructed to close to 0.00 (6.5 displayed as a software minimum).

3.29 13-2-14 Thursday

- Much of the day was dedicated to the survey of posts in the accelerator. This was somewhat of a welcome enforced wait and watch of the slowly improving vacuum through the accelerator.

3.30 14-2-14 Friday

- Work continued

3.31 17-2-14 Monday

- The terminal 60 l/sec pumps were powered up now that the vacuum had improved over the weekend.
- Powering the terminal was swapped back to shaft driven alternators and the many systems tested.
- There was some mystery regards the new 20 l/sec ion pump fitted in the terminal. It turns out the new pump is a Duniway equivalent of a Varian 911-5036, “diode” (+ve power supply) pump and the previous was “triode”(-ve power supply). Therefore, the power supply requires changing to +ve.
- Note: the 60 l/sec pumps in the terminal are ”diode”, +ve power supply.
- The new 24 V EPICS controlled solenoid valves for the chain oilers were tested along with the updated wiring of the terminal faraday cup solenoid valve. Looks good. Oiler control can now be accessed via the Tools → Chains menu in Lodestar.

3.32 18-2-14 Tuesday

- Reinstalled terminal ion pump power supply after Electronics Unit changed the polarity to a +ve supply as required for a diode pump configuration. A document outlining how to convert polarity of Glassman PS has been produced. The role of this pump is to measure pressure in the vacuum space surrounding gas stripper canal and according to AMS group to provide better control of stripper efficiency. During stripper operation, the pressure is in the order of 10^{-6} mbar, which is at the low operational range for an ion pump and may limit its life span. Ion pump works, but may require recalibration for current versus pressure if we need a super accurate readout.

3.33 19-2-14 Wednesday

- All terminal functions were tested
- Top and central terminal spinnings were lowered back into place
- All three chains were run for a short period. Chain #2 was “waving” between casting idlers in units19 and 25, upside. We increased the unit 25 idler wheel to chain clearance and this appears to reduce the wavering. However, chain #2 exhibited excessive noise in the up trace of pick up signal which was measured after closing the machine.

3.34 20-2-14 Thursday

- Cleaned Titanium powder deposits from units 12 and 13 due to eroded resistor assembly in unit 13.
- Replaced eroded top resistor assembly in unit 13, tube 1, gap 2 with assembly that had been removed during TO #120 (and tested and marked as good).
- “Clean and closed” units 1 through 5

3.35 21-2-14 Friday

- Replaced resistor lead on unit 10, tube 1, gap 1. This also required replacing the resistor nuts.
- Unit 19, stringer 1 connection to post was loose but otherwise OK. Was removed, cleaned up and retightened.
- Last resistor pair on high-energy end (unit 28, post B, gap 18) resistor lead replaced due to damage at the top resistor end (the nuts did not need replacing).
- Clean and closed up to unit 14. Cleaned (including checks) 15 through 28.

3.36 24-2-14 Monday

- Closed units 14 through 28
- Wiped down inner walls of the tank
- Blew down column
- Low voltage testing on full column , found issues with
  - unit 3 tube 2 with quite high (on the border line) deviation of voltage distribution on the tube;
  - unit 12 post linked to tube 2 had bad voltage distribution; and
  - unit 19 post associated with tube 1 had an open circuit and could see a banana plug out in resistor installed to the bottom gap.

3.37 25-2-14 Tuesday

- Found leakage current of 8 μA @ 5 kV through unit 3, tube 2, gap 2
- Found leakage current of 4 μA @ 5 kV through unit 12, post C, gap 13. Upon further inspection, found cracking at about a 10 or 11 o’clock position.
- Found resistor lead across unit 19, post D, gap 8 was spark damaged and blown out of the bottom resistor. Top plug was still inserted, but damaged. Replaced both resistor nuts with new, marked nuts and a new lead.
- Removed post 2045 from unit 12, position C and replaced with serviceable, tested, post marked with a star (no number). This post has epoxied end caps.
- Replaced resistors across unit 3, tube 2, gap 2 with dummy resistors (shorting the gap). Also replaced top post resistor with a dummy on gap 8 to compensate.

3.38 26-2-14 Wednesday

- Wiped down the column
- Performed 30 kV HV test and found issue with unit 7, tube 1. Corona was visible in gap 11 top resistor. The current through the gap 11 pair at 5 kV was 7.8 μA. The current across the bottom resistor directly at 5 kV was 68 μA (expect ~60 μA), so this resistor was replaced and retests were all good.

- During tank closing tasks, chain 1 leg distance was found to be 55 mm. Two more links were removed (working from the bottom of the tank) and the gap was then 100 mm. The chain 2 leg distance was 75 mm.
- Oilers were tested and drop count is thus:
    - chain 1, 8 drops per 10 seconds
    - chain 2, 6 drops per 10 seconds
    - chain 3, 4 drops per 10 seconds
- Tank was closed and pumping began

4 Gas stripper leak

Leak chasing gas stripper system was again a priority due to suspected SF_6 leak from the tank into pipework.

Initial leak chasing of the gas stripper box was performed while still installed in the terminal of the 14UD. No leaks were evident, so the box was removed from the machine for further testing of individual components.

The stripper box was disassembled into components small enough to fit into a pressure chamber, shown in Figure 1 and Figure 2. Each component was tested for a good base leak rate before pressurising up to 100 psi of Helium in the chamber, which was read on a digital pressure gauge. The typical base leak rate was ~ 1×10^{-10} mbar·l/s or better and, if there was no change when pressurizing to 100 psi with Helium and leaving for fifteen minutes or more, the component was considered to have passed the test.

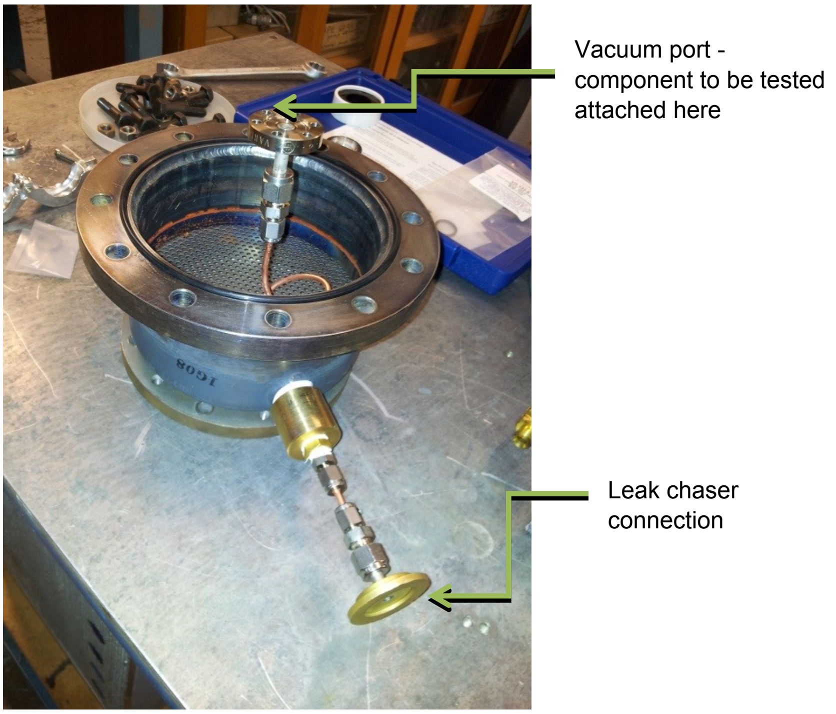


Figure 1 Bottom component of pressure chamber used for pressurised leak testing

Components that passed pressure chamber testing were as follows:

- Swagelok 4BK valves
- Flexible Swagelok lines
- Granville Philips mini convectron gauge
- Granville Philips variable leak valve – inlet and outlet ports, and in closed and open positions
- Pipework in small sections from inside box

New Swagelok valves (4BW, with a welded bellows to body seal) had been ordered with the expectation that the old valves with a gasket seal may be the source of the leak. No leaks were evident when testing the old valves but it was still decided to install the welded style valves as a permanent solution.

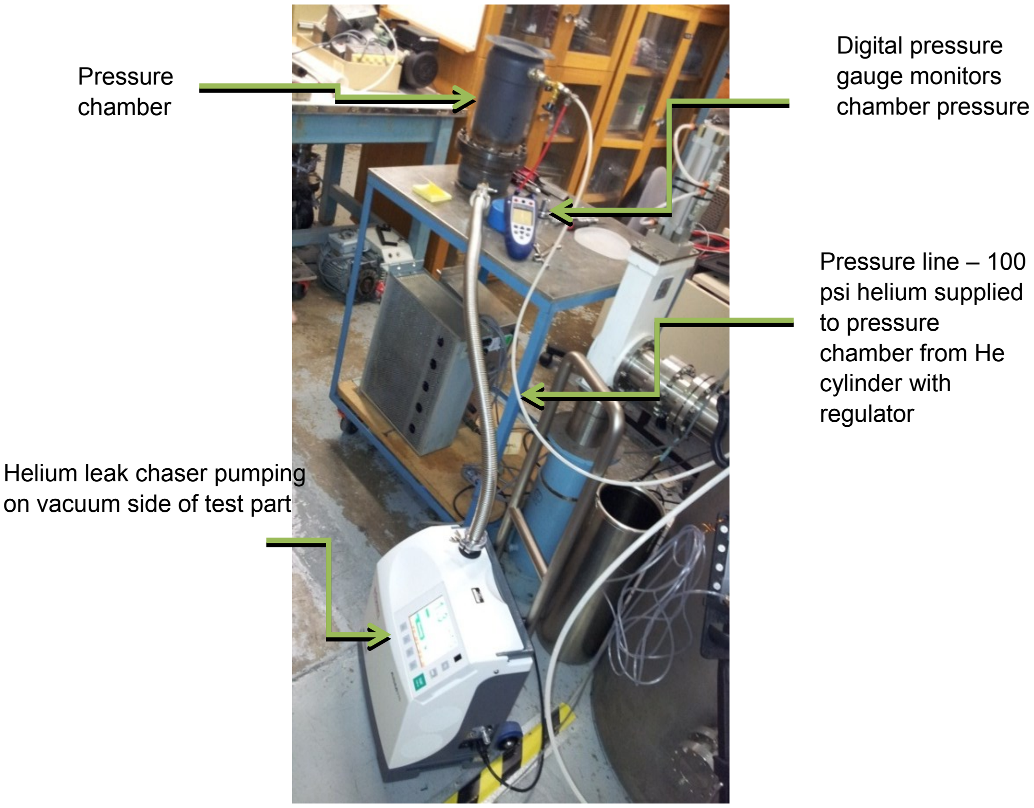


Figure 2 Complete pressurised leak testing setup

All new valves were run through the pressure testing chamber to confirm their leak tightness before installing.

The gas box was reassembled. All Swagelok fittings were measured with a “no-go” gauge for tightness. After assembly, the box was helium tested at atmosphere and was all okay. It was then returned to the machine and reinstalled.

The gas stripper oxygen bottle was too large for the pressure chamber so instead was filled with Helium to 100 psi and the “sniffer” capabilities of the leak chaser used. No leaks were found using this method.

Detailed notes and photos are filed under \Tech Files\030 TANK\GAS STRIPPER\PHOTOS

5 High energy ball valve

Since the acceleration tube was vented, an opportunity presented itself to install a new ball valve at the high-energy end of the tube. The valve itself is much the same as the ball valve at the low-energy end of the tube (see TOR #117 for details)

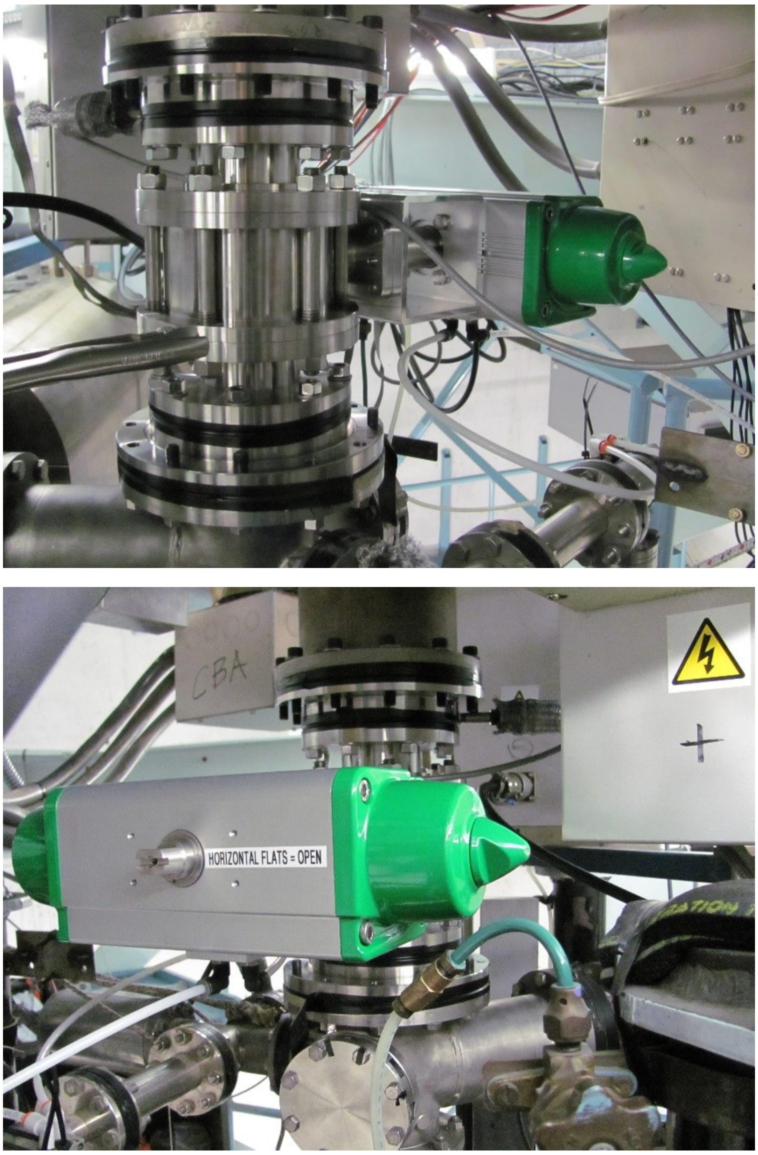


Figure 3 New high-energy ball valve installation below 14UD tank

6 Charging system damage

After issues with the charging system, the nylon feed throughs and the standoff at the bottom of the tank were inspected and/or removed. The silicon grease used on the nylon feed throughs was blackened, with a track mark through the grease on one of the two. This can be seen in 2 and 3. The main nylon components cleaned up well and were reused. However, new cylinders were machined. When the feed throughs were reinstalled, no silicon grease was used.

Three of the charging system standoffs at the bottom of the tank were damaged by arcing as can be seen in Figure 4. A stock of spares was available to replace these. It was also an opportunity to redesign the wire connectors that go on the end of these stand offs to enable them also act as spark gaps in an attempt to protect the nylon. The new design is shown in Figure 7. The design can be improved even further based on classic spark gap concept. It will be done in the future if required.

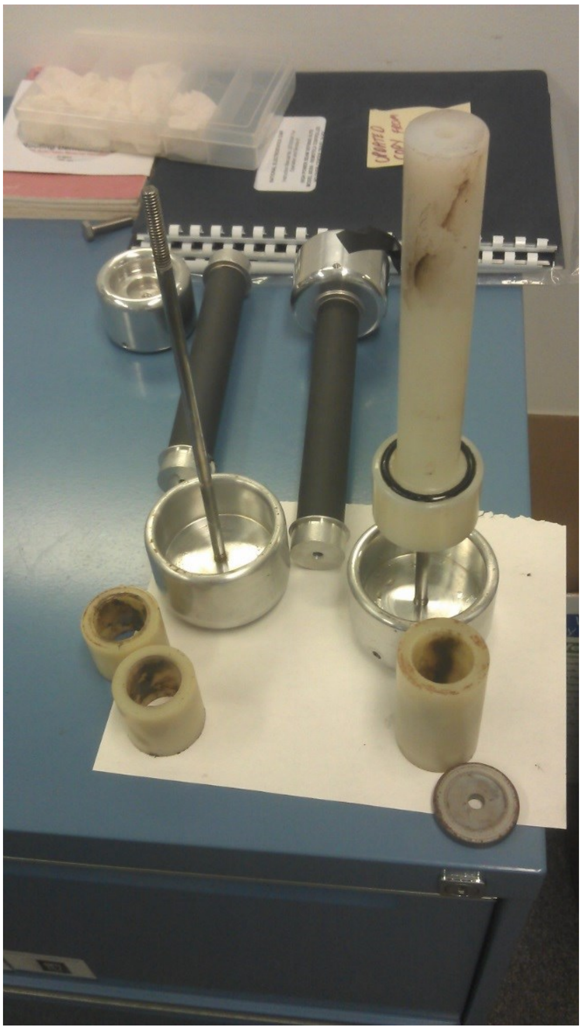
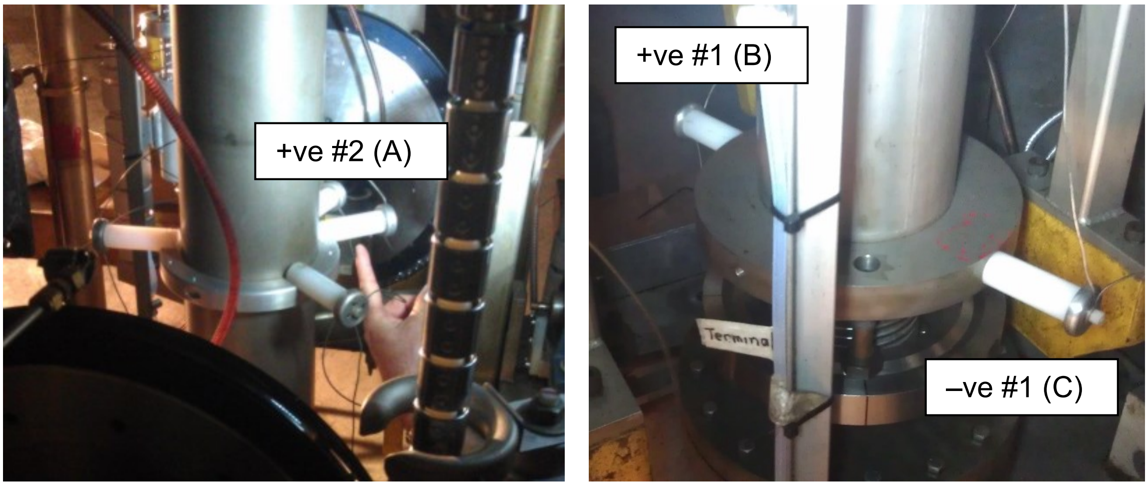
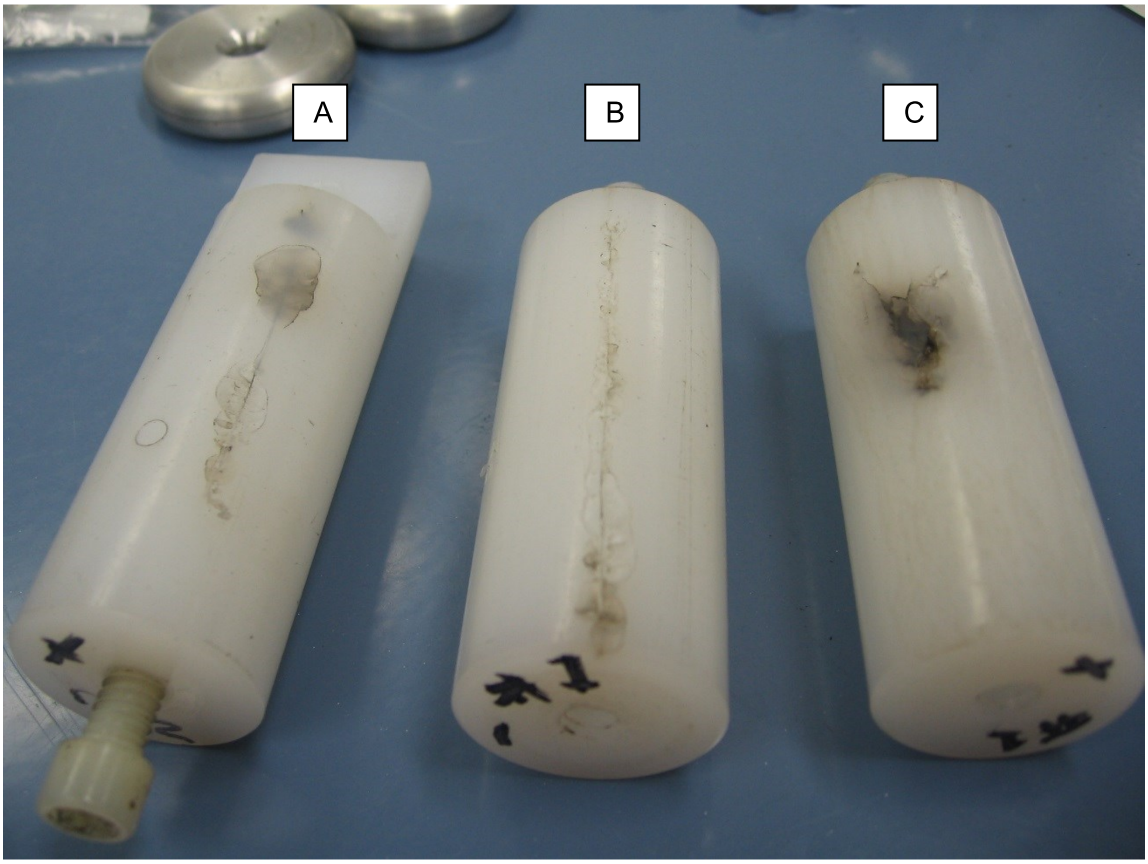


Figure 4 Damage on charging system feed thrus

Figure 5 Damage to –ve (left) and +ve (right) charging system feed thrus



(a)



(b)

Figure 6 (a) Location and (b) details of arc damage on charging system distribution nylon stand offs

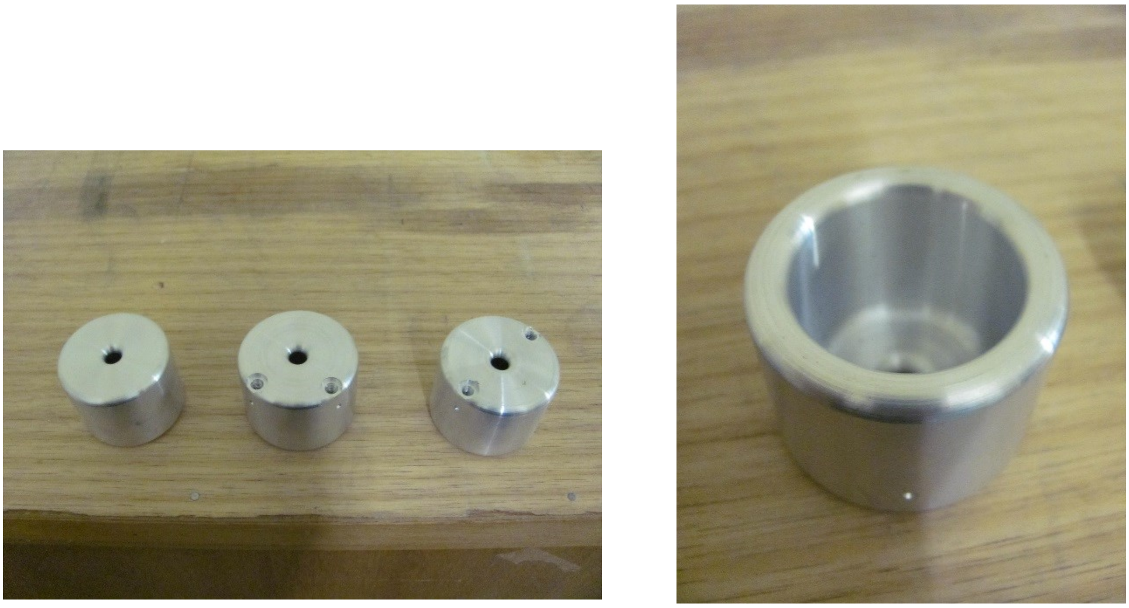


Figure 7 New charging system standoff wire connector/spark gap design

7 Post damage

In total, another five posts were found to have cracks in the ceramic and/or current leakage at 5 kV in air. All of them require replacement. These are listed in Table 1. In addition, another three posts will need to be monitored over time. See Section 8 for details.

The type of cracking/damage varied from surface flaking, hairline cracks, criss-crossed cracks to complete separation of the bond between the ceramic and titanium.

Figure 8 Ceramic damage unit 5, post D, gap 1

Figure 9 Ceramic damage unit 5, post B, gap 4

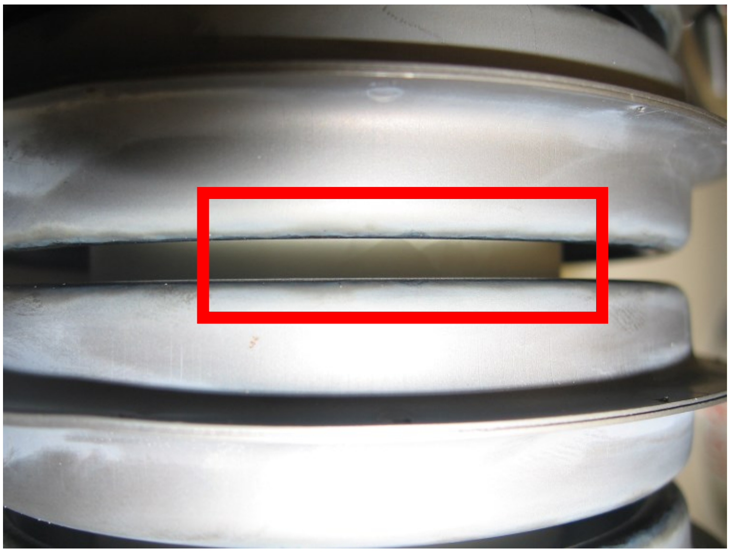


Figure 10 Ceramic damage unit 12, post C, gap 13

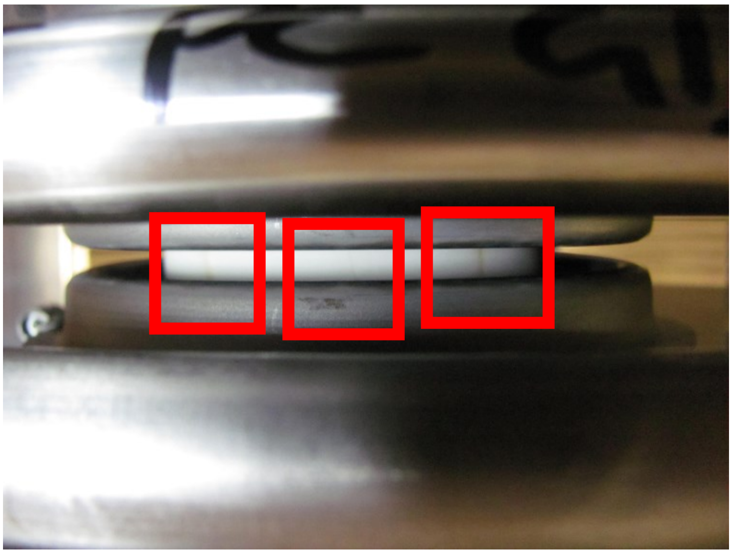


Figure 11 Ceramic damage unit 25, post C, gap 16

Table 1 Serial numbers of posts removed and installed

Unit	Post position	Removed	Installed
5	D	282	265
5	B	2044	238
12	C	2045	“star”
15	C	2183	290
25	C	J1	340

8 Watch list items

There are a number of accelerator components that were examined and passed as OK, but require monitoring over time. These are:

- unit 28, post B, gap 12 has some marks including what looks like metallic deposits. High voltage testing at 6 kV did not show any leakage current;
- unit 6, post C, gap 10 may have very small subtle cracks but cannot definitively say; and
- unit 22, post C, gap also has what may be a small subtle crack, but also what may be two, small, surface divots at a “nine o’clock” position.

9 Chains

Two new chains where supplied from NEC last year, ready for installation at the next available opportunity. These are chrome plated chains as warranty replacements for nickel plated chains. The nickel plating on chains was found to be not as robust to spark damage and therefore discontinued.

One of the nickel plated chains had previously been removed from service from location #3 and returned to NEC. The second nickel plated chain 2M will be removed from location #1 and returned to NEC.

The two new Cr plated chains will be put into service in locations #1 and #2. This will release chain 1N from location #2 and be stored as our spare.

One screwed link was removed from each of these new chains when initially assembling the chain halves. Further links were removed following installation. See sections 3.1and 3.8 for further details.

Without having run the chain we chose to anticipate a good operational length for the two new chains and remove and finalise the assembly with riveted pins. This involved removing three pellets from chain #1 and two from chain #2. See section 3.28.

During tank closing tasks, chain 1 leg distance was found to be 55 mm. Two more pellets were removed and the gap was then 100 mm. The chain 2 leg distance was 75 mm.

10 Machine hour meter readings

Table 2 - Machine hour meter readings

Date compiled	7-1-2014					
Team member	AGM					
Reading	CHAIN #1 (**2M**)	CHAIN #2 (**1N**)	CHAIN #3 (**3P**)	LE SHAFT	HE SHAFT	CH VOLTS
Notes	New @TO111 9-9-09 Swapped from pos 2 @TO#114	New @TO94 12-12-05 Swapped from pos 1 @TO#114	New @TO118			
Hours at 6-1-2014	21532	21470	21619	38264	38262	23383
Hours at 19-7-2013 (TO#120)	19181	19119	19268	35310	35309	20981
Change in hours	2351	2351	2351			
Accumulated total hours	11.881k	30.624k	4342			

11 Terminal voltage distribution for period of service

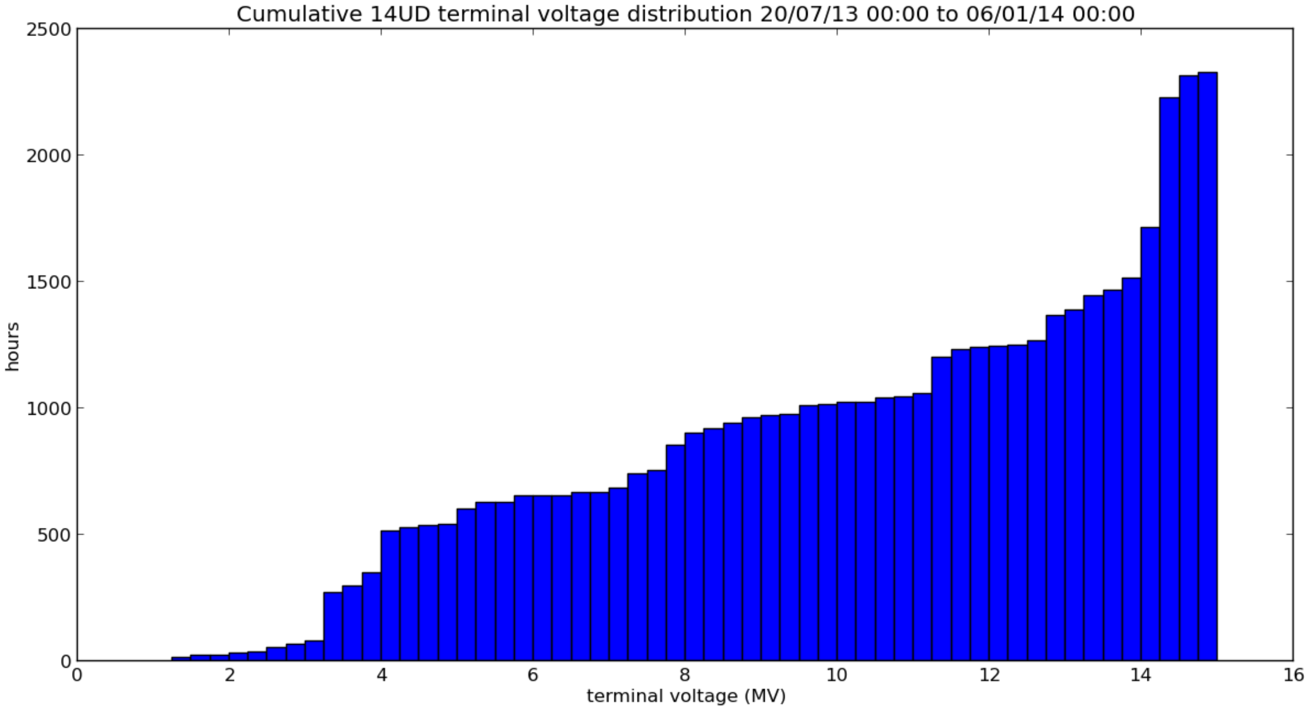


Figure 12 Cumulative terminal voltage distribution for period of operation from the end of tank opening 120 to the start of tank opening 121

12 Initial performance

Upon gas up of the tank, all was going well until the tank pressure reached approximately 65 psia, at which time the gas stripper pressure began to rise (see Figure 13). It reached about 6.5 mT with the tank pressure at about 80 psia. Thus, we had failed in our attempt to repair the leak in the gas stripper system and in fact, had somehow made it worse. Plans were made for another tank opening as soon as possible.

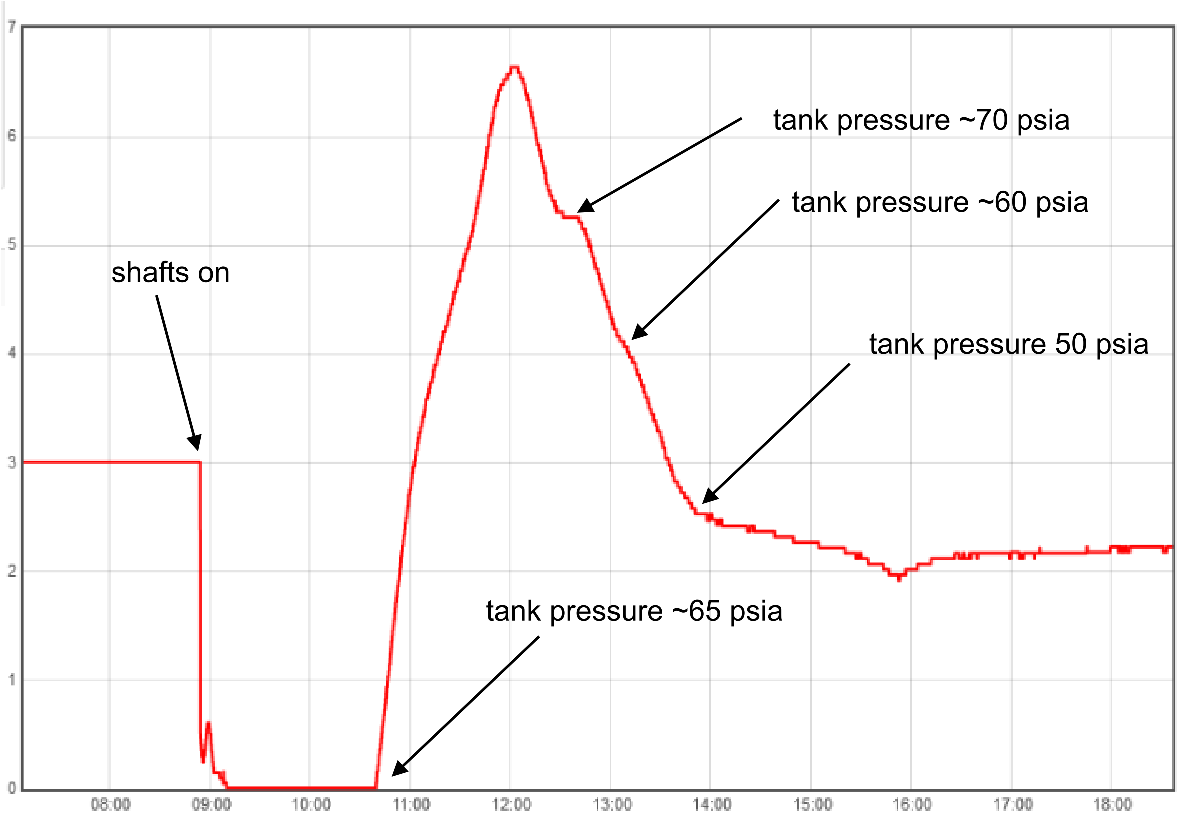


Figure 13 Indication of gas stripper leak during SF_6 gas up