Australian National University

# 14 UD Tank Opening Report

# #123

8th July – 31st July 2014

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|---|---|
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# Contents

# 1 Reason for tank opening

This tank opening was required to isolate issues limiting the maximum achievable terminal voltage of the 14UD. Unit 21 was known to have been faulty and had been shorted out for the majority of the period of operation since the last tank opening.

Even with unit 21 shorted, however, users reported issues when operating at terminal voltages above 13 MV (where the nominal maximum voltage with unit 21 shorted was 13.7 MV). The achievable terminal voltage would degrade over the period of a week, with terminal sparks increasing in frequency over that time.

The initial plan of action was to:

- find and rectify faults in unit 21
- test baking/heating of tubes
- check the terminal faraday cup for correct current output on both positive and negative polarities; and
- investigate mechanical oscillations of chain #2. The up trace is extremely noisy despite the fact that chain #2 is new and without twist.

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

Watch list items carried over from the previous tank openings 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;
- 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.
- unit 16, post D, gaps 4 and 8 are known to have small cracks in the ceramic. Gap 8 leaks 0.02 μA; and
- unit 21, tube 2 has a slightly higher than normal current of 7.4 μA when tested at 30 kV (normal entry/exit test)

# 2 Summary of work

## 2.1 8-7-14 Tuesday

- The SF6 was pumped from the 14UD into the storage vessel.
- The porthole doors were opened, and the fresh air ventilation system was run overnight.

## 2.2 9-7-14 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 on the initial pass down of the column, 30kV HV entry tests were performed. We found that:
  - unit 15, tube 1 has an abnormally high current of 7.4 μA
  - unit 16, tube 2 has an abnormally high current of 7.8 μA
  - unit 21 post D gap 4 resistor lead blown out

- Started low-voltage tests from unit 1 to unit 15
  - unit 15 post resistance across gap 6 appears abnormal
  - unit 16 post resistance across gap 9 is almost a short
- Took dust particle measurements as the platform went down the machine.

## 2.3 10-7-14 Thursday

- Completed low-voltage testing on unit 20 through to unit 28. Found a possible issue with unit 26, tube 3 gaps 10 and 11.
- Wiped down the column and the terminal. A greater than normal number of spark marks were observed on rings and the terminal, mainly starting at unit 11.
- Continued dust count tests.
- Looked at watch list items for unit 6 and unit 22. They appear to be in the same condition as in previous tank openings.
- Looked at unit 15 following 30 kV HV entry test results and found a burnt resistor plug across gap 8. Replaced lead and nut on top resistor.
- Found a problem with unit 16 post D. Gap 4 had a leakage current of 0.02 µA, which we were aware of at the last tank opening but gap had a leakage of 85 µA?.
- Mounted heater tape around the tube in unit 15 and unit 16. Tube was heated to around 110-120°C and left overnight. The tube pressures were monitored to check for any bake-out effect.

## 2.4 11-7-14 Friday

- Replaced unit 16 post D. Removed post 2644 and installed post 349. This post was from a refurbished stock with new stainless steel end caps. A 5 kV test was performed across each gap after installation and no issues were found.
- Examined unit 21, which had been problematic during the previous operational period:
  - replaced the completely blown resistor lead across gap 4 on post D. Since the corresponding resistor housings were a bit black from arc marks, the entire resistor assemblies were replaced with good spares (although the nuts did have to be replaced to take a new resistor lead).
  - replaced the shorting rod housing and spring contact on the upper casting and the spring contact in the lower casting – the housing was cleaned but left in place.
  - found a loose post end stringer mount on stringer 3, but we were able to re-clamp tight.
- Looked at unit 26 and performed 5 kV HV test on tube 3. Leakage currents were:
  - gap 5: 0.15 µA
  - gap 10: 0.01 µA
  - gap 11: 2.5 µA
- Set up heater tapes to bake tubes in unit 15 and unit 16 again and left at 100-110°C over the weekend while monitoring tube pressures.

## 2.5 14-7-14 Monday

- Tested for leakage current across all tube gaps on 11-gap tubes in unit 15 through unit 18. No leakage current was found.

- Found a broken resistor (the actual resistor) in unit 15, tube 1, gap 4 (top). This tube passed all low-voltage tests which usually find this sort of problem easily. However, it is not known if the resistor was weakened by the tube baking effort.
- While cleaning unit 15, found damaged thread in the casting used for shorting rod spring housing. It was the screw itself that was found to have eroded, so this was replaced with a new screw. No further repair was required.
- Worked thorough units with known current leakage across tube gaps and remeasured current leakage to compare with previous tank opening. Most were as before, except unit 11, tune 2 gap 9. During TO #120, this showed a 0.2 µA leakage, but as of now, no leakage was found. A summary table is given in section 8.
- Set up heater tapes to bake tubes in unit 17 and unit 18 and left at 110-120°C overnight while monitoring tube pressures.

## 2.6 15-7-14 Tuesday

- Opened units 19 and 20 to check tube resistor leads and perform leakage current tests on 11-gap tube gaps. No leakage currents were observed.
- Ran shafts to check bearing condition. We inexperienced fellows followed a path of rediscovery to find out that the notchy feeling in the high-energy shaft is normal due to the alternator in the high-energy mid-section. Other than that, found suspect beating in unit 27 lower casting and some Perspex dust on the top casting in unit 3.
- Removed shaft bearing in unit 27 lower casting. On removal, there were definitely signs of wear, but probably would have been OK until the next tank opening.
- Shorted unit 16, tube 3, gaps 5 and 11 with dummy resistors and dummy resistors were used on post D, gap 12 and 14 (bottom) to provide balance.
- Tested for leakage current on 11-gap tubes in unit 27 and unit 28. Unit 27 and most of unit 28 was OK, but the record for unit 28, tube 3 after a blow down with nitrogen (in a hopeful attempt to dislodge any debris) is as follows:
    - gap 1: 0.01 µA
    - gap 5: 0.47 µA
    - gap 7: 0.1 µA
    - gap 9: 0.02 µA
    - gap 10: 0.05 µA
    - gap 11: 0.28 µA
- As a side note, the dust count on the platform during the unit 28 blow down went from 0.001 mg/m$^3$ to 0.46 mg/m$^3$.
- Set up heater tapes to bake tubes in unit 19 and unit 20 and left at 110-120°C overnight while monitoring tube pressures.

## 2.7 16-7-14 Wednesday

- Removed dummy resistors from unit 11 that had been shorting tube 2, gap 9 since TO #120. The ceramic insulating gap no longer appears to be leaking current ("It's a miracle!")
- Re-clocked shafts that had been decoupled unit 15, unit 18 and unit 19 to find the "notchy" feeling.
- Tested for leakage current on tubes in unit 10 and unit 12. Found leakage in unit 12, tube 1, gap 2 of 0.25µA @ 5kV.
- Tested for leakage current on 11-gap tubes in unit 21 through to unit 24. All good.
- Cleaned some other units.

- Found “snail trail” marks on the Perspex shaft in unit 11.
- Set up heater tapes to bake tubes in unit 13 and unit 14 and left at 110-120°C overnight while monitoring tube pressures

## 2.8 17-7-14 Thursday

- During an inspection of the service platform drive system, Crook noted that the tensioning system has run out of travel and continued use with slipping cables could cause damage. A risk assessment was performed before repair took place. See section 6 for further details
- Found frayed post resistor lead in unit 14, post D, gap 11. Also found that a number of the resistors on the post were quite loose.
- Set up heater tapes to bake tubes in unit 11 and unit 12 and left at 110-120°C overnight while monitoring tube pressures

## 2.9 18-7-14 Friday

- Removed shaft from unit 11 for skimming to remove “snail trails”. Shaft was skimmed, flanges were cleaned up and the shaft reinstalled.
- Replaced frayed post resistor lead in unit 14 (required replacement of resistor nuts) and remounted other loose resistors on the same post
- Found frayed resistor lead in unit 13, tube 4, gap 3. Replaced lead and nuts.
- Re-checked units 12 through unit 14 and re-ringed units when complete.
- Shaft removed from unit 3 was skimmed. The Perspex dust was not from fretting, but from “seating” of the key. It should be fine into the future.
- Found ring on unit 4 was not seated properly on either post D or post A.
- Checked linearity of current leakage through unit 25, tube 3, gap 10 and unit 26, tube 3, gap 5.
- Noted that the shaft in unit 7 is missing a screw in the top flange (to the bearing housing) due to a stripped thread. This is a known issue as it is marked on the flange itself.
- Also found missing screws on both the top and bottom flanges of the shaft in unit 6.
- Replaced resistor nuts on resistor pair across unit 2, tube 1, gap 8. A new lead had been fitted previously without replacing the nuts.
- Removed top casting cover on low energy mid-section to clean a trace of white powder of unknown origin. A sample was taken for further analysis.
- All low-energy units were cleaned.
- Set up heater tapes to bake tubes in unit 9 and unit 10 (with a bit stretching into unit 8) and left at 110-120°C over the weekend while monitoring tube pressures.

## 2.10 21-7-14 Monday

- Shorted unit 12, tube 1, gaps 2 dummy resistors and dummy resistors were used on post D, gap 5 (top) to provide balance.
- Terminal was opened
- Visitors in the tank from the University of Melbourne, Roland Szymanski and Stephen Gregory
- Reinstalled shaft in unit 3

- Began reinstalling shaft bearing in unit 27
- Set up heater tapes to bake tubes in unit 7 and unit 8 and left at 110-120°C overnight while monitoring tube pressures

## 2.11 22-7-14 Tuesday

- Finished reinstalling shaft bearing in unit 27 and refitting shafts in unit 27 and unit 28.
- Shorted unit 6, tube 1, gaps 2 dummy resistors and dummy resistors were used on post D, gap 5 (top) to provide balance.
- Measured chain leg to tank floor distances:
    - chain 1: 43 mm
    - chain 2: 36 mm
    - chain 3: 62 mm
- Removed 3 links from chain 1, 3 from chain 2 and 2 from chain 3.
- Remeasured chain leg to tank floor distances:
    - chain 1: 118 mm
    - chain 2: 113 mm
    - chain 3: 117 mm
- Replaced DC idler wheels at chain 1 position at terminal due to bearing degradation and wear of the wheel material on the idler on the left side.
- Replaced bearings on the DC idler wheels in chain 2 position at terminal.
- Set up heater tapes to bake tubes in unit 5 and unit 6 and left at 110-120°C overnight while monitoring tube pressures

## 2.12 23-7-14 Wednesday

- Inspected the terminal and while looking the chain pulleys, noted some flakes of what may be wheel material below the wheels. It seemed to be a much bigger issue on chain 3.
- Checked inductor to chain clearances and they were OK
- Checked the insulation of terminal wheel bearing and all three were above 1 MΩ and conductivity to ground through the carbon brush was good.
- Tested the terminal faraday cup electronics
    - Suppressor voltage at the exit of the piston housing was measured to be -435 $V_{DC}$
    - Connected dual polarity current source to current pre-amplifier inside the shielded box. Currents measured correctly and consistently on both polarities.
    - Performed continuity tests on suppressor coax that runs from the cup housing to the body and on the coax from the current pre-amplifier to the cup housing. Both were OK.
- Measured $O_2$ bottle pressure on gas stripper system in terminal. Pressure was 0.275 barg
- Wiped all three chains with ethanol soaked rags to remove black gunk. Chain 3 was the dirtiest, which agreed with previous observations of more wheel material on the chain 3 pulley at the terminal.
- Set up heater tapes to bake tubes in unit 3 and unit 4 and left at 110-120°C overnight while monitoring tube pressures

## 2.13 24-7-14 Thursday

- Installed new corona needles. Something for the newer techs: the manual corona needle position control at level 3 does not care for the limit switches, so be careful! Also, the corona needle position control in the control room will not operate unless the platform override switch is on.
- Retested leakage current in unit 28, gaps 5, 7 and 11. Only gap 11 had changed and was 0.34 µA (was 0.28 µA on earlier test).
- Shorted unit 28, tube 3, gaps 5, 7 and 11 with dummy resistors and dummy resistors were used on post D, gaps 12, 13 and 14 (top) to provide balance.
- Tested oiler drop rate in turn with line pressure at ~108 psig. All three oilers dropped 12 drops in 10 seconds with a delay of about 3 seconds before the first drop appeared. There were also one or two drops after the valve was shut on each. Note: the lines had been pre-charged. That is, these measurements were recorded on the $2^{nd}$ 10 second test on each oiler.
- Cleaned unit 21 through unit 28.
- Tested the tank faraday cup electronics
    - Suppressor voltage at the exit of the piston housing was measured to be -337 $V_{DC}$
    - Connected dual polarity current source to coax inside cup housing. Currents measured correctly and consistently on both polarities.
    - Performed continuity tests on suppressor coax that runs from the cup housing to the body. Was OK.
- Set up heater tapes to bake tubes in unit 1 and unit 2 and left at 110-120°C overnight while monitoring tube pressures.

## 2.14 25-7-14 Friday

- Ran both low-energy and high-energy shafts. Both are good, but the bearing in unit 28 may need attention next tank opening.
- Inspected terminal and tested all terminal functions (shafts were on) in preparation for closing the terminal. All are good.
- Ran chains in turn. Nothing serious is wrong, although they do sound rumbly, presumably because they are running dry at the moment after cleaning. Produced video of running chains through high energy units
- Closed terminal and reinstalled related casting covers
- Helium leak chased low-energy tubes in the tank. The leak detector did not react.
- Set up heater tapes to bake tubes in unit 21 and unit 22 and left at 110-120°C over the weekend while monitoring tube pressures.

## 2.15 26-7-14 Saturday

- Set up heater tapes to bake tubes in unit 23 and unit 24 and left at 110-120°C over the remainder of the weekend while monitoring tube pressures.

## 2.16 28-7-14 Monday

- Closed unit 1 though unit 10

- Performed low-voltage tests on entire low-energy end. No issues were observed and results on tubes with dummy resistors were consistent with expectations.
- Set up heater tapes to bake tubes in unit 25 and unit 26 and left at 110-120°C overnight while monitoring tube pressures.

## 2.17 29-7-14 Tuesday

- Fitted CPO electrodes. Stainless steel CPO electrode is on the left-hand side of the portal. The back of the CPO electrode is 23 mm from the tank wall (this is as far back as the stainless steel CPO can be placed. The aluminium CPO electrode was installed on the right-hand side of the portal.
- Closed units 21 through unit 26.
- Completed low-voltage testing of unit 15 through unit 24. One disconnected resistor lead was found (which had been disconnected for earlier tests) in unit 19, tube 2, gap 11. No other anomalies were found.
- Set up heater tapes to bake tubes in unit 27 and unit 28 and left at 110-120°C overnight while monitoring tube pressures.

## 2.18 30-7-14 Wednesday

- Completed low-voltage tests in unit 25 though unit 28. One resistor in pair across unit 25, tube 1, gap 7 was slightly off (higher resistance), so the pair was replaced with viable spares. Post mortem will work out what was wrong.
- Blew down accelerator column while monitoring dust count
- Started high-voltage tests. There were two issues that were encountered. First, the high-energy ball valve had been shut to allow installation of test gear above the analysing magnet. Unfortunately, the ball valve leaked through slowly, elevating the tube pressure. This played havoc with the high-voltage tests, with sparking inside the tube. Second, unit 1, tube 1 showed higher than normal current even accounting for the beam focus connection. We could hear an arc but could not see it. We tested all ceramic gaps and the post resistors with no solution found. We gave up and went home.

## 2.19 31-7-14 Thursday

- Continued trouble shooting unit 1, tube 1 and now found now problem! We tested the tube resistors to be sure and blew down the unit again. The behaviour was now perfect. Not the solution we were looking for. We did however find a very slightly frayed resistor lead across tube 1, gap 7, so we installed a new lead (and the new nuts required for new leads nowadays).
- Wiped down the column and began working through the tank closing check list.
- Worked through tank closing check list and found no issues.
- Closed the tank and started pumping out.

## 2.20 1-8-14 Friday

- A $SF_6$ leak was found during gas up of the tank. This was through the service platform cable seal closest to the stairs at level 4. This was rectified by repositioning the split flanges and tightening the jack.

# 3 Tube baking exercise

Baking is performed using a flexible fibreglass based tape with an interwoven internal heating element. The tape is flexible enough to be wound around acceleration tubes and between resistors as is seen in Figure 1. Thus, it is possible to bake such unusually shaped object.

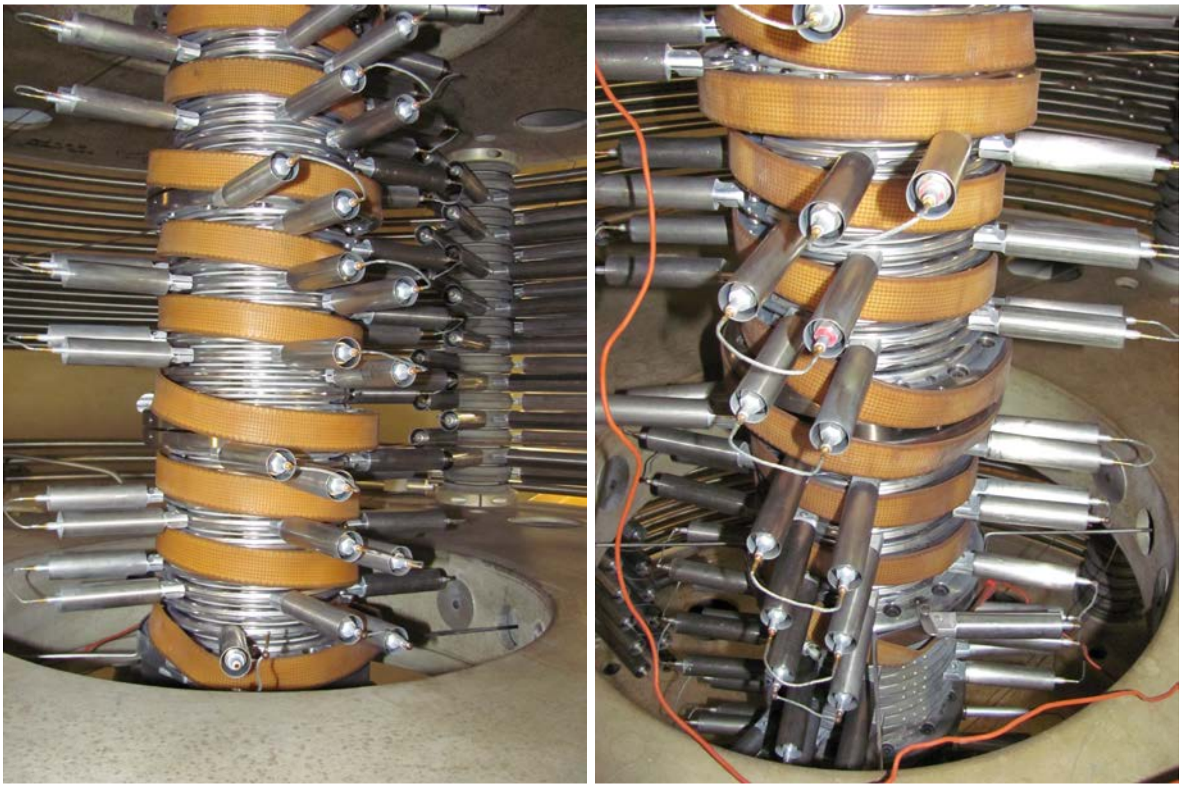

*Figure 1 Heater tapes wrapping the accelerator tube ready for "baking"*

We typically warmed up the tubes up to 110 – 120 °C and kept at this temperature for 16 – 18 hours. The heating power to the tape was controlled by manually adjusting the supply voltage through a controller. The temperature of the tubes and resistors was measured with Infrared Thermometer model QM7226 and with the thermocouples secured to the bare metal. Temperature mapping was also performed with a FLIR thermal imager as shown in Figure 2. During bakeout, vacuum excursion typically occurred during the first hour. Initial vacuum was $4\times10^{-8}$ Torr rising up to $3\times10^{-7}$ Torr and gradually reducing to $8\times10^{-8}$ Torr at the end of the process.

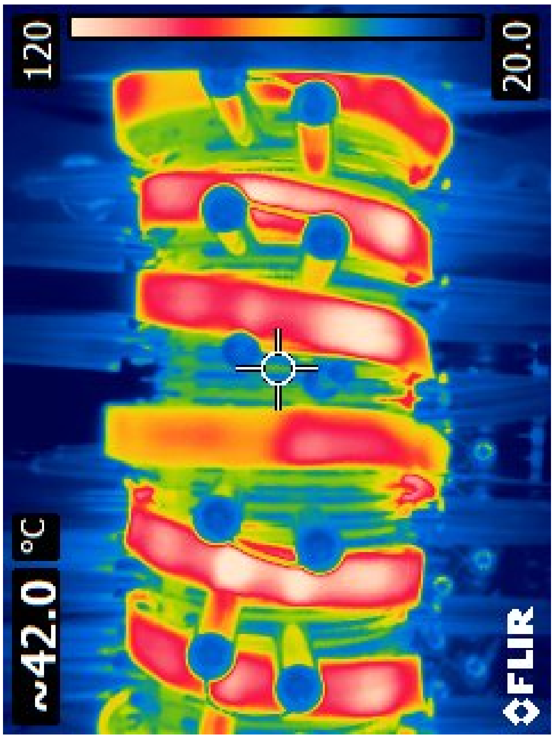


*Figure 2 Thermal imaging of active heater tapes in during baking of units 13 and 14*

# 4 CPO electrodes

As discussed in tank opening reports 118 and 119, we had been experimenting with CPO electrodes that were larger in size than the original electrodes. Unfortunately, the larger, aluminium “mushroom” CPO electrodes installed during TO 118 supported corona currents at higher terminal voltages, which locked up the preamp. They were therefore removed during TO 119.

During this tank opening, we were able to install one stainless steel version of the mushroom-type CPO electrode as shown in Figure 2 Stainless steel “mushroom” CPO electrode. This was installed in the CPO position that is on the left of the door at level three.

An aluminium mushroom-type CPO electrode was installed on the other side so that the same geometry/different material combination could be compared directly.

Both electrodes were mounted 23 mm from the wall (measured from the back of the CPO electrodes), which is as far back as the stainless-steel electrode could be mounted owning to the shallower thread depth on the mount hole.

The sparks gap designed to be installed with these mushroom CPO electrode were originally circular. These were not very convenient to remove. Thus, they were shaved off on two sides as shown in Figure 3. This shape still provides the small spark gap at the top and bottom while making removal simple.

*Figure 3 Stainless steel "mushroom" CPO electrode*

*Figure 4 Modified spark gap behind mushroom-type CPO electrode*

# 5 In-tank dust counts

The levels of dust inside the 14UD tank were measured throughout the tank opening to determine the "base" cleanliness level and to get an idea of where particulates settle. On the initial traversal of the column upon first entry, dust levels at undisturbed locations ranged from 0.002 mg/m$^3$ to 0.006 mg/m$^3$. This compared to other locations

- 0.012 mg/m$^3$ on top yellow support C-beams
- 0.4 mg/m$^3$ next to Nikolai's dust coat
- 0.258 mg/m$^3$ in an open casting disturbed by breath
- 0.056 mg/m$^3$ at platform after wiping platform

As a "control" the dusts levels in the technical office space area was 0.06 mg/m$^3$

The process was repeated during the final column blow down at the end of the tank opening. Levels next to the column were 0.08 – 0.76 mg/m$^3$. At the midway point between the column and the wall, the levels were 0.03 – 0.12 mg/m$^3$.

There were some outliers in the readings, such as 3.27 mg/m$^3$ in unit 12, right next to post B. This was taken right when air was directed into an insulation gap.

# 6 Re-tensioning of primary drive cables of service platform

After many years of service, it was discovered on the 17th July that the primary drive cables of the 14UD service platform had lost sufficient tension to enable safe working use. The platform system was electrically isolated by Gareth Crook at 10:40am. After assessing the system in its entirety, a course of action to repair the system was decided on.

After inspection and re-lubrication of all cable adjustment mechanisms, re-tensioning of drive cables was carried out by our service team. The adjustment made was to allow the spring loaded, tension device to be operating within its designed travel limit, allowing adequate clearance between the drive cables, and the steel cross bar supporting tensioning device.

Tension adjustments have been made at the cable anchor points on both the upper and lower ends of the counter-weight carriage, there is no scope for further adjustment in this system and future repair/service work is being scheduled as a matter of priority.

# 7 $SF_6$ recirculator servicing

The outline of the reactivation procedure of the small dyer on level 3 is outlined below:

- 22/7/14
  - dryer was valved off at vacuum during pump-out of 14UD.
  - started rotary vane pump to warm up. Base 70µ.
  - opened V5 and V4 to pump out drier further.
- 23/7/14
  - vacuum in drier 900µ
  - closed V5 to isolate pump and opened V8 to start nitrogen flow through drier.
  - at 1psig opened V6 to atmosphere and set nitrogen flow @2cfm.
  - heater turned on.
  - Temps:
    - 9:45 65°F
    - 10:00 72°F
    - 11:30 365°F
    - 14:10 270°F
- 24/7/14
  - 13:30 Temp. 300°F
  - turned heater off.
  - continued nitrogen flow @2cfm
- 25/7/14
  - 10:00 Temp. 80°F
  - stop nitrogen flow and opened drier to vacuum pump.
  - vacuum. 23000µ
- 28/7/14

- 10:00 Vac. 990µ
- 30/7/14
    - 11:00 Vac. 650µ
- 1/8/14
    - gas-up of 14UD in progress
    - 10:00 Vac. 400µ
    - valved off roughing pump and opened drier (V1 & V2) to tank @10psig during gas-up.
    - recirculator blower turned on.

# 8 $SF_6$ content and moisture tests

Measurements were taken at level 4 by flowing $SF_6$ from the 14UD tank at 2 l/min through the analyzer until the reading stabilized. All $SF_6$ was captured by the gas bag as shown in Figure 5. Results pre- and post-tank opening are shown in Figure 6 and Figure 7 respectively.

*Figure 5 Gas testing set up.*

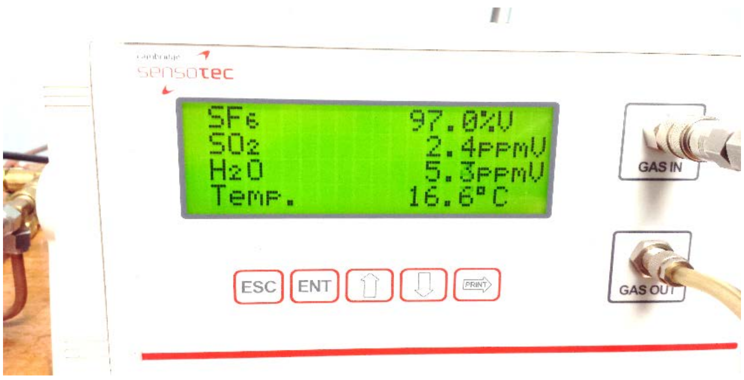


Figure 6 $SF_6$ analysis taken before pump-out of 14UD on 7th July

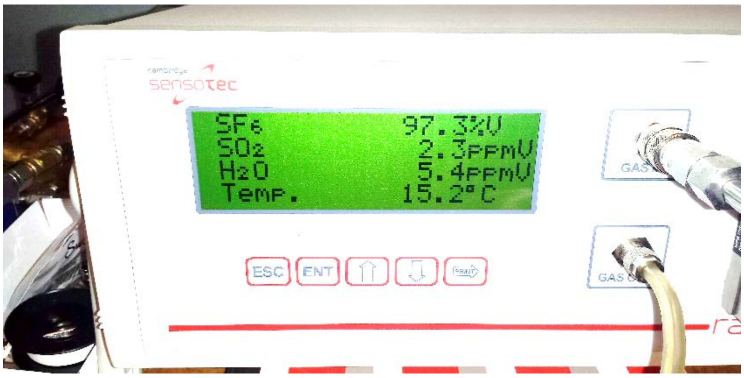


*Figure 7 $SF_6$ analysis after reactivation of drier and gas-up of 14UD on 5$^{th}$ August*

# 9 Tube ceramic insulator current leakage

Reviewing previous tank openings, we realized that we had not recently performed a full sweep of all tube ceramic insulator gaps to determine which exhibit current leakage. This was rectified this tank opening. Ten leaking gaps were found in addition to the six gaps that had been shorted with dummy resistors previously. There were two main points worthy of further discussion.

First, unit 11, tube 2, gap 9 no longer leaks current. Although the miracle is appreciated, the lack of explanation for the self-repair is troubling. Since the accelerator tube has been vented since TO #120, it may mean that there was an issue in the vacuum space.

Second, unit 28, tube 3, appears to be – in the modern parlance – “cactus”. Six ceramic gaps in this tube leak current, three of which where the magnitude was deemed significant enough to warrant shorting. Furthermore, the magnitude of current leakage was the same when tested early and then later in the tank opening, indicating that it is unlikely to be related to moisture absorption from the atmosphere.

The current state of shorted tube ceramic gaps is shown in Table 1

*Table 1 Summary of tube ceramic current leakage in the 14UD*

| Unit | Tube | Gap | Leakage though insulator @5kV (TO #123) | Discov ery | Comment | Repair |
|---|---|---|---|---|---|---|
| 3 | 2 | 2 | 8 µA | TO #121 | | Dummy resistors top and bottom, dummy on post gap ???? |
| 6 | 1 | 2 | 1.1 µA | TO #123 | | Dummy resistors top and bottom, dummy on post gap 5, top |
| 7 | 3 | 10 | 12 µA | TO #120 | | Dummy resistors top and bottom, dummy on post gap 10, top |
| 11 | 2 | 9 | 0 µA | TO #120 | Seems to have “repaired” itself | Dummy resistors removed |
| 12 | 1 | 2 | 0.25 µA | TO #123 | | Dummy resistors top and bottom, dummy on post gap 5, top |
| 13 | 1 | 10 | 0 µA | TO #120 | Suspicious arc mark across gap | Dummy resistors top and bottom, dummy on post gap 3, top |
| 13 | 2 | 1 | 0.05 µA | TO #120 | | Dummy resistors top and bottom, dummy on post gap 8, top |
| 25 | 3 | 10 | 7 µA | TO #120 | | Dummy resistors top and bottom, dummy on post gap 16, top |
| 26 | 3 | 5 | 0.15 µA | TO # 123 | | Dummy resistors top and bottom, dummy on post gap 12, bottom |
| 26 | 3 | 10 | 0.01 µA | TO # 123 | | None, deemed to small. Monitor. |
| 26 | 3 | 11 | 2.5 µA | TO # 123 | | Dummy resistors top and bottom, dummy on post gap 14, bottom |
| 28 | 3 | 1 | 0.01 µA | TO # 123 | | None, deemed to small. Monitor |
| 28 | 3 | 5 | 0.47 µA | TO # 123 | | Dummy resistors top and bottom, dummy on post gap 12, top |
| 28 | 3 | 7 | 0.1 µA | TO # 123 | | Dummy resistors top and bottom, dummy on post gap 13, top |
| 28 | 3 | 9 | 0.02 µA | TO # 123 | | None, deemed to small. Monitor |
| 28 | 3 | 10 | 0.05 µA | TO # 123 | | None, deemed to small. Monitor |
| 28 | 3 | 11 | 0.28 µA | TO # 123 | | Dummy resistors top and bottom, dummy on post gap 14, top |

# 10 Watch list

*Table 2 Watch list of suspect items for review next tank opening*

| Unit | Component | Description | Condition/ Resolution | Retain watch |
|---|---|---|---|---|
| 6 | Post C, gap 10 | May have small subtle cracks in ceramic | No deterioration | Yes |
| 16 | Post D gaps 4 and 8 | Known small cracks with current leakage in gaps 4 and 8 of ~0.02 µA | Gap 8 had deteriorated significantly, with current leakage of 85 µA across. Removed post 2644 and installed post 349 | No |
| 22 | Post C, gap ? | may be a small subtle crack, but also what may be two, small, surface divots at a "nine o'clock" position | No deterioration | Yes |
| 28 | Post B, gap 12 | Marks including metallic deposits | No deterioration | Yes |
| 28 | Shaft bearing | Was OK but may require attention next tank opening | New issue | Yes |

# 11 Machine hour meter readings

*Table 3 Machine hour meter readings*

| | | | | | | |
|---|---|---|---|---|---|---|
| Date compiled | 14-7-2014 | | | | | |
| Team member(s) | PL/TT | | | | | |
| Reading | CHAIN #1 (**1O**) | CHAIN #2 (**2N**) | CHAIN #3 (**3P**) | LE SHAFT | E SHAFT | CH VOLTS |
| Notes | New @TO121 15-1-14 | New @TO121 15-1-14 | New @TO118 | | | |
| Hours at reading | 23001 | 22939 | 23088 | 40640 | 40639 | 24898 |
| Hours at 5-3-2014 (TO#122) | 21556 | 21495 | 21643 | 38372 | 38371 | 23392 |
| Change in hours | 1445 | 1444 | 1445 | | | |
| Accumulated total hours | 1469 | 1469 | 5811 | | | |

# 12 Terminal voltage distribution for period of service

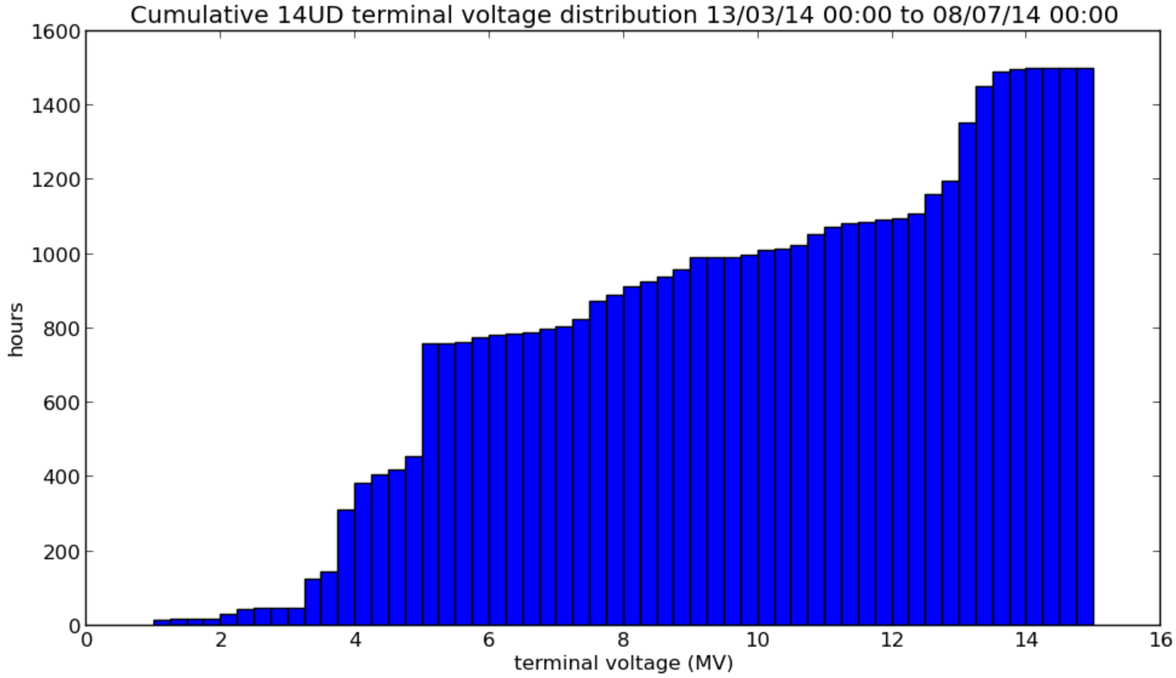


*Figure 8 Cumulative terminal voltage distribution for period of operation from the end of tank opening 122 to the start of tank opening 123*

# 13 Initial performance

The unshorted 14UD conditioned up to 14.4 MV in few days without many sparks. This was followed by an AMS run when it was operated at 4 MV for two weeks. We aim to continue conditioning and achieve 14.7 MV operational voltage during the next month if this is practically possible. The high voltage limit of the 14UD operation is dictated by high energy acceleration tubes with six compromised/shorted ceramic insulators as reported in Table 1.