AUSTRALIAN NATIONAL UNIVERSITY

DEPARTMENT OF NUCLEAR PHYSICS

14 UD TANK OPENING REPORT # 112

16th November to 19th November 2009

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REASON FOR TANK OPENING

This was an unscheduled opening due to a failure in the accelerator that prevented the machine being able to operate above 14.4 MV.

The AMS group running at the time (Friday, the 13th) reported a spark event whilst operating at 14.6 MV. Following this event the terminal was limited to 14.2 MV where the accelerator would repeatedly spark. Conditioning could not improve beyond this value either.
Tests prior to the opening of the 14UD were done by operating with pairs of units shorted out in an attempt to isolate the location of the problem. The problem was isolated to Units #1 and #2 where it was found these units would only achieve 1.045 MV per unit whilst the average voltage per unit prior to this event was 1.1 MV.

The LINAC had been cooled during the previous two weeks and waiting for beam from the 14UD. The intention was for this tank opening to be as quick as possible but thorough as usual.

- Test the emergency lights

- Perform electrical and mechanical tests and inspect all idlers, chains, pulleys, bearings, shafts and resistors.
- Perform initial 30 kV insulation test of the column.
- Wipe down column
- An inspection would be undertaken of the sealant applied last opening to the gap at the top flange of the 14UD pressure vessel. Sealant was applied in an attempt to eliminate SF6 leakage past the o-ring seal.

PUMP OUT 16-11-09 Monday

- Pump out tank, open doors and start ventilation system.
- The ventilation system was run overnight.

SUMMARY OF WORK: 17-11-09 to 19-11-09

17-11-09 Tuesday

- Gas tests showed the atmosphere within the 14UD was OK and compliant with the Confined Space regulations.
- The platform was deployed and an initial visual survey down the column found nothing of concern.
- The initial 30 kV insulation test of the column was completed.
  There were no abnormal current values and particularly noted none in Units #1 and #2.
- The refining of our HV testing of Units #1 and #2 by testing across individual column/ring gaps found nothing unusual.
- Testing of pairs of tube resistors in Units #1 and #2 was undertaken.
  The Unit #1, Tube #1 - The downward facing edge of the support spoke hose clamp on the tube top flange was sparking to the nearby protection tube of bottom resistor assembly on gap 1. It was sparking at 5.5 kV

We also saw at Unit#1, Tube #1, sparking between the clamped, bent end of one of the alignment/support spokes to the protection tube of the gap two top resistor. See picture.

- By close visual inspection a black metallic like mark on a column post insulator was noticed on Post B, Gap 10. This was believed to be the problem limiting voltage across Unit #1.

This post was replaced.

- The remaining three Unit #1 column post aluminium end flange to their mating titanium electrodes had evidence of spark activity in the form of blackening at the joint interface. It was decided to swap these for other used posts.

18-11-09 Wednesday

- The three other column posts in Unit#1 due end cap problems were swapped out.
- The position of the tube alignment spoke clamp and spoke ends on the Tube #1 top flange were adjusted to provide greater clearance to neighbouring tube resistors.
- It was noticed within the resistor assembly of the Unit #2, Tube 1, Gap 4, top resistor that the resistor spark cap was slightly eccentric in its protection tube. The resistor end nut was loosened and spark cap reset using the setting tool.
- The LE end of the machine was wiped clean.

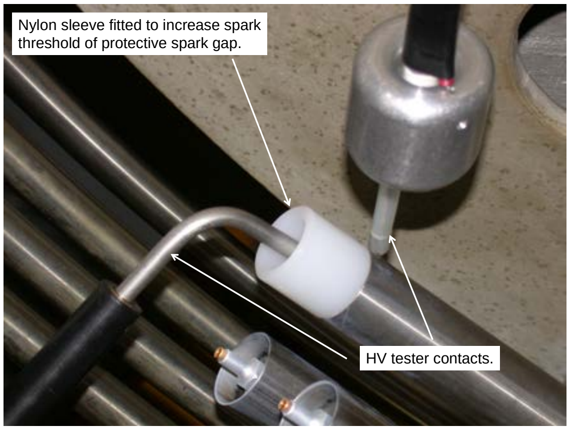
19-11-09 Thursday

- The chain drive motors, wheels and charging system inductors in the bottom of machine were inspected.
- Chain #2 was shortened by two links/pellets.
- Chain #2 was checked for twist compared to when it was new.
- HV testing (@30 kV) of individual column resistors in Unit#1 and Unit#2 was undertaken. Also tested some individual tube resistors in Unit#2.
- Some investigation work was done on why the LE and HE mid-section ion pump readouts weren't working.
- The remaining column was blown down using high pressure air.
- The column was wiped using RBS and water.
- The 30 kV grouped gap test was completed. No problems were found.
- The charging and metering tests were performed and the machine was closed.

HIGH VOLTAGE TESTING OF RESISTORS

The usual initial 30kV testing across groups of accelerator ring gaps matching and linked by "stringers" to the tube sections (11 tube gaps and 8 tube gaps) didn't find any unusual current values in the whole column.
In pursuit of finding a fault in Units 1 or 2 the HV testing was refined to testing across single ring gaps. With nothing unusual found.
Further refinement was done, testing individual pairs of resistors across insulating gaps on the post and tubes.
A spark would occur across the tube spark protection gap at ~7 kV
This testing in air is voltage limited to ~1/7th that of the 100psi atmosphere of SF^6 in the 14UD.

To raise the spark-over threshold in air a nylon sleeve was interposed into the resistor tube's spark protection gap. Testing could now be done at 30kV

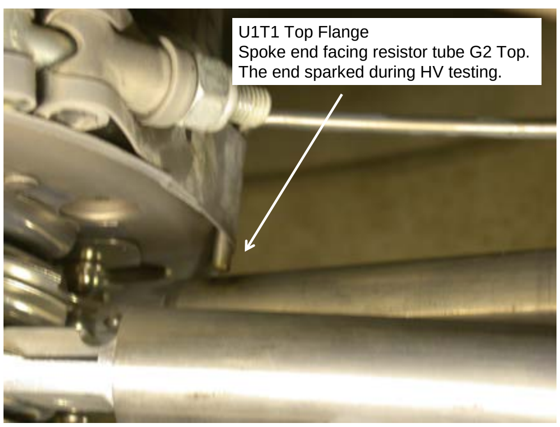


and the current noted. The testing of individual column post resistors in Unit#1 was undertaken. There was up to 6% variation in the current values. The original resistor specification was 2%.

Time did not permit more extensive testing. We plan to do more and hope to better understand these initial observations.

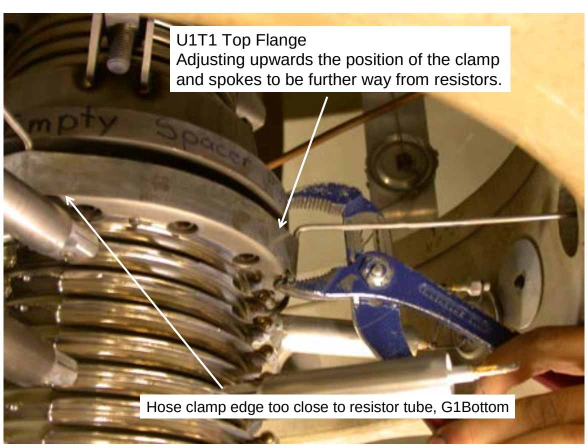
ALIGNMENT CLAMP AND SPOKE SPARKING IN UNIT#1

Unit 1, Tube 1 - The alignment and support spokes for the tube have a 90° bent leg clamped to the tube flange with a hose clamp.



One of the downward facing ends of a spoke was facing the top resistor tube of the resistor pair across gap two. Spark breakdown would occur between the spoke end and resistor tube at ~5.5 kV in air.

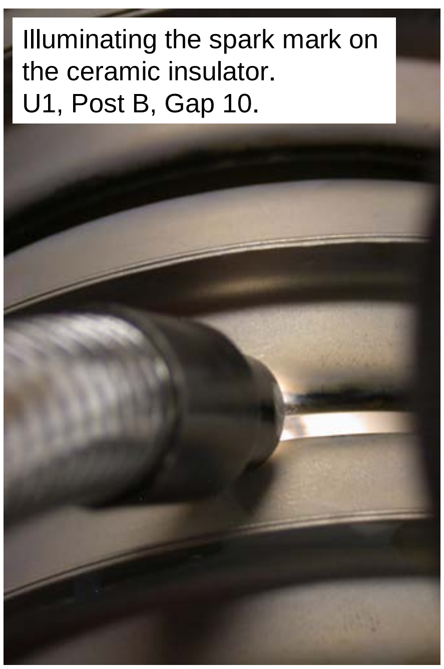
A second location for sparking was the edge of the hose clamp. This would spark at ~7kV. Both these issues were rectified by moving the clamp and spoke ends upwards away from the resistors by squeezing with multi grip pliers.

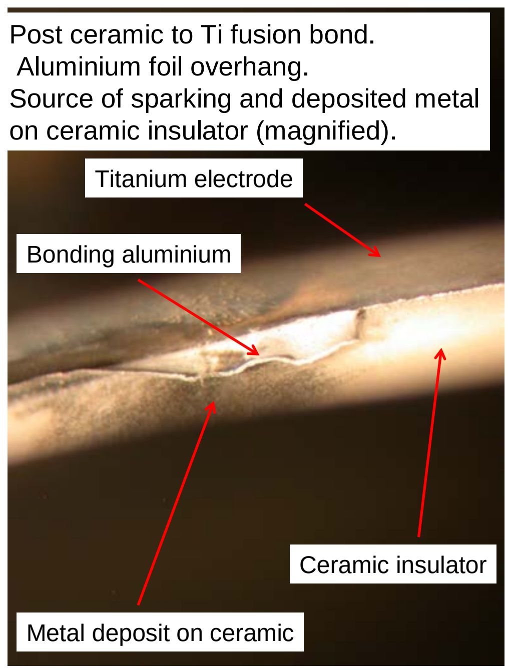


A measurement survey of the position of the tube flange was done before and after adjusting the clamp position. No discernable change in the flange position occurred.

In operation any discharge across these components would contribute to an irregular voltage gradient in this unit.

COLUMN POST - SPARK DAMAGED INSULATOR, UNIT #1
A visual inspection was concentrated on Unit #1 and Unit #2 as pre tank opening testing showed one these to be hosting a fault of some kind that limited the voltage these units could carry across them.
A spark mark in Unit#1, Post B, Gap 10 was found and investigated. Viewing this mark and the nearby area under magnification found that there was a remnant of aluminium foil from the fusion bonding of the ceramic insulator to the titanium electrode. The aluminium foil edge projected towards the opposing titanium electrode. Spark activity was evident from the al foil with a burnt metallic deposition on the surface of the insulator.
The spark activity across this gap would explain the reduced capacity of U1. This post was replaced with a serviceable spare.





COLUMN POST END FLANGES
Some history first
Numerous posts have been processed through a refurbishment and improvement program that has been active for many years. The program was initiated to improve the electrical contact of the post end flange to it's mating titanium electrode. These mating elements are nominally of the same potential but column spark events can cause sparking across this interface.

The earliest method of improvement to this junction was to bond the aluminium flange to the titanium electrode interface using silver loaded epoxy resin. This method was superseded as the epoxy junction in some cases was showing some sparking activity and the new idea was deemed superior again.
Now the refurbishment involves fitting of new stainless steel end flanges and screw-fixing the mating titanium electrode. NEC has adopted screw connections but to aluminium flanges.

Following close examination of one post in Uni #1 we found significant spark activity on the remaining three posts between the column post upper aluminium end flanges and their mating titanium electrodes
This resulted in all four posts in Unit #1 being swapped out and replaced with serviceable posts removed during TO#111. The serviceable posts fitted had not been refurbished after their removal during TO#111 due to other commitments of staff normally involved.

CHAIN INSPECTION
The chain drive motors are mounted on individual counterweighted arms that provide tension to the chains whilst adjusting to variations in chain length during operation.
The clearances to the tank floor of the end of travel support leg of the chain drive motor mounts were assessed on the three chain positions. Chain position #1 and #3 were assessed as having enough clearance. The clearance for chain position #2 measured 15-18mm indicating the chain requires shortening.

CHAIN #2
Chain #2 had two pellet/links removed and the end of travel support leg to tank floor clearance measurement was ~62mm. It is deemed normal, early in the life of a chain to require some shortening.
The previously reported twist of ~ 45degrees in the free hanging chain when new, was reassessed during the shortening process. The same method of securing the chain at the terminal and allowing it to hang unrestricted was used. Only a few degrees of twist were still evident. Observations of the running chain were not made this time.

LE AND HE MID-SECTION VACUUM READOUTS
The vacuum signals and hardware within the 14UD for both the LE and HE mid-sections were to be tested for their proper operation.

Both mid-sections and their RF enclosures were opened.
The LE mid-section vacuum, ion pump current, transmits to the terminal via fibre optics. The "send" indicator light in the LE mid-section box was ON. The receipt of a signal in the terminal from the LE wasn't checked due to the pressure to close the accelerator.
The HE mid-section Group 3 communicates via a separate fibre optic loop to the outside of the accelerator, though in normal operations it is in series with the terminal Group 3 communications. This provides the ability to separate the two optical fibre circuits for diagnostics.

The secondary enclosure, housing the HE mid-section Group 3 box was opened. There was no output from channel 2 of the ADC, which is the Glassman power supply ion pump current readout. Foote swapped the input wires from channel 2 to 3 and channel 2 came to life again. This may have been due to disturbing a dry joint, a loose connection or such by the pressure applied with the screw driver to the terminal strip. The incoming signal wire was returned to channel 2 and this part of the system was working again but under suspicion.

Testing of the HE mid-section functions was disrupted as the thermal overload unit of the casting mounted alternator power system had failed. A replacement was located and quickly fitted to allow completion of the mid-section testing.
The total current draw for all the electrical services of the HE mid-section should be checked during the next opening.

INITIAL PERFORMANCE

Conditioning was undertaken over the next couple of days and terminal voltages around the 14.4MV were being achieved. The log book records that on the 23rd Nov, the machine was running in "condition" mode at 15.1MV. Injecting beam into the Linac had resumed and data from a beam on target was about to be collected when a major water leak from the chilled water system was flooding through ceilings etc of labs adjacent to the control room.
Fire authorities, ANU security and the press were on site to "deal" with the problem.
The Linac cryogenic plant, though on another cooling water system was at risk of being disturbed by this event. It was decided to abort experiment and the Linac operations including the cryogenic plant were shut down.