AUSTRALIAN NATIONAL UNIVERSITY
DEPARTMENT OF NUCLEAR PHYSICS
14 UD TANK OPENING REPORT # 95

11th to 19th Nov 2003

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REASON FOR TANK OPENING

The machine developed a breakdown in the charging system at 8 MV and, whilst low energy experiments were rescheduled and begun, the breakdown problem deteriorated over days to a point where even they had to be stopped.
The usual metering tests had been performed at tank closure last opening but two metering faults occurred soon after closure. The LE column and charging chain-metering circuits shorted out and so were disconnected in order to get on with experiments.

Even though this opening was a forced one it was decided that a couple of upgrades, that were ready, would be fitted inside the terminal shielded boxes and that the metering problems would be found.
The shaft systems would be checked and a general inspection of the whole machine would be done.

The oxygen level monitor was borrowed from the ANU OH&S section.

PUMP OUT 10-11-03

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

SUMMARY OF WORK 11-11 to 19-11-03, Photos in main body of report.

11-11-02

- Oxygen levels were checked at the bottom of the tank prior to staff entering the top port.
- The confined spaces permit was filled out and signed by the crew prior to the first entry of this opening.
- The initial cruise down the column found the top half of the machine was very clean with only a very light dusting of breakdown products. The terminal and HE units had white spotty deposits adhering to the spinnings and rings. There were a few on the terminal but the density increased toward the bottom of the column. No obvious causes for the breakdown were found above the platform.
- The charging system under the platform was inspected next. The source of the white spots was found to be breakdown products that had been efficiently generated in the gap between chain pulley #1 and the down side inductor. The gap between the inductor and the pulley was approximately 1 mm and broke down in air at about 3 kV. This corresponds approximately with the breakdown at 8 kV in SF6.
- The up side inductor was caked in soft sediment like break down products that were most probably electrostatically deposited and set semi hard by mixing with oil. Many other sites had lighter but similarly built up deposits.
- It was immediately obvious that the main task this opening would be the clean up. Understanding why the inductor moved, as the nylon fastening stud was sufficiently tight, would be a close second.
- The usual wipe down was completed and the lower terminal opened to check the extent of breakdown deposits at the top chain pulley. The terminal had quite a build up of breakdown products and the Chain #1 DC idlers were thickly coated.
- The HE end was deringed and the casting covers were removed to give access for cleaning and were taken outside the machine.
- All the chain #1 idlers and petals were removed and all other idlers inspected.
- The terminal and all the HE units were given a preliminary blow down with high pressure N2 prior to cleaning under the platform.

12-11-03

- The clean up under the platform commenced and while cleaning the inductors the source of the inductor to chain break down was found when the inductor suddenly moved. During the subsequent investigation Howard found that the inductor support pivot pin had worked loose and was partially disengaged. This had allowed the inductor frame to tilt just the right amount to bring the inductor within 1 mm of the chain pulley. The frame carries both inductors but the frame movement only moved the down side inductor close to the wheel. The up side inductor did not move closer to the wheel in the same way but, as it shares the mounting frame, was at a slight angle never the less.
- The offending pivot pin was relocated and the two grub screws retightened.

- The pivots of the two other chain inductor frames were checked and retightened as required. These had not been disturbed since the machine was installed.

- The oilers were filled and tested and all charging system wiring checked for security.
- The cleaned idlers and petals were refitted using a new plastic alignment tool.
- The casting covers were replaced and the upper terminal was opened to allow work inside the shielded boxes.

13-11-03
Whilst looking for the column metering problem, that had persisted since last opening, it was noticed that the flexible upper rotating shaft motor coupling was fractured over about 20% of its drive annulus. This was replaced immediately and then the Group 3 boxes were removed from the terminal before lunch.

- Gordon Foote fitted new chips to the Group 3 boxes and they were reinstalled and all functions tested OK.
- The HE units were cleaned and closed. The upper and lower rotating shafts were run and the upper terminal closed. Casting covers that had been inaccessible were now fitted.

14-11-03

- Chain #1 was removed and cleaned outside the machine. The Karscher high pressure wash in the plating lab was used initially followed by a wash in 2% RBS in water and an alcohol rinse.
- The chain pulley bearing insulation was checked using a mega at 500V.
- The chain was refitted and, after charging tests, the lower terminal and associated casting covers were replaced.

17-11-03

- The complete tank wall was wiped down and, while under the platform,
- the oilers were given a final check and top up.
- One metering wire stand off required refixing using self adhesive foam tape.
- The column was wiped down using RBS and water and during this, while investigating and cleaning oily posts just below the terminal, it was discovered that Post D, Unit 15, Gap 6 had fractured ceramic.
- Refurbished posts had not been completed in time for this unplanned opening so the workshop was asked to machine one urgently.
- While removing the resistors, in preparation to remove the cracked post, it was discovered that there was a burnt resistor lead banana plug at the top of gap 4.

18-11-03

- While waiting for the post to be machined a full set of new resistor leads was made.
- The whole machine was inspected for cracked ceramic and only one, Post C, Unit 20, Gap 1 was found to be worthy of comment. There was a flake or some anomaly visible but no characteristic vertical crack so the post was left in and it will be monitored during future openings.
- Meanwhile the problem with the LE column metering that failed just after the last opening was investigated. This led to the somewhat embarrassing discovery that the shorting rod metering clip was touching ground outside the machine. All agreed that this will be the last such oversight.

19-11-03

- The reconditioned post was on the platform by 11.20 AM and in place by lunch.
- The rings and casting covers were refitted and the RBS wipe down completed.
- The 10 kV gap test found no problems so the charging and metering tests were done. All was well and the machine was closed.

BREAKDOWN PRODUCTS-THE MESS

Typical caking of breakdown products.

Under the bottom casting.

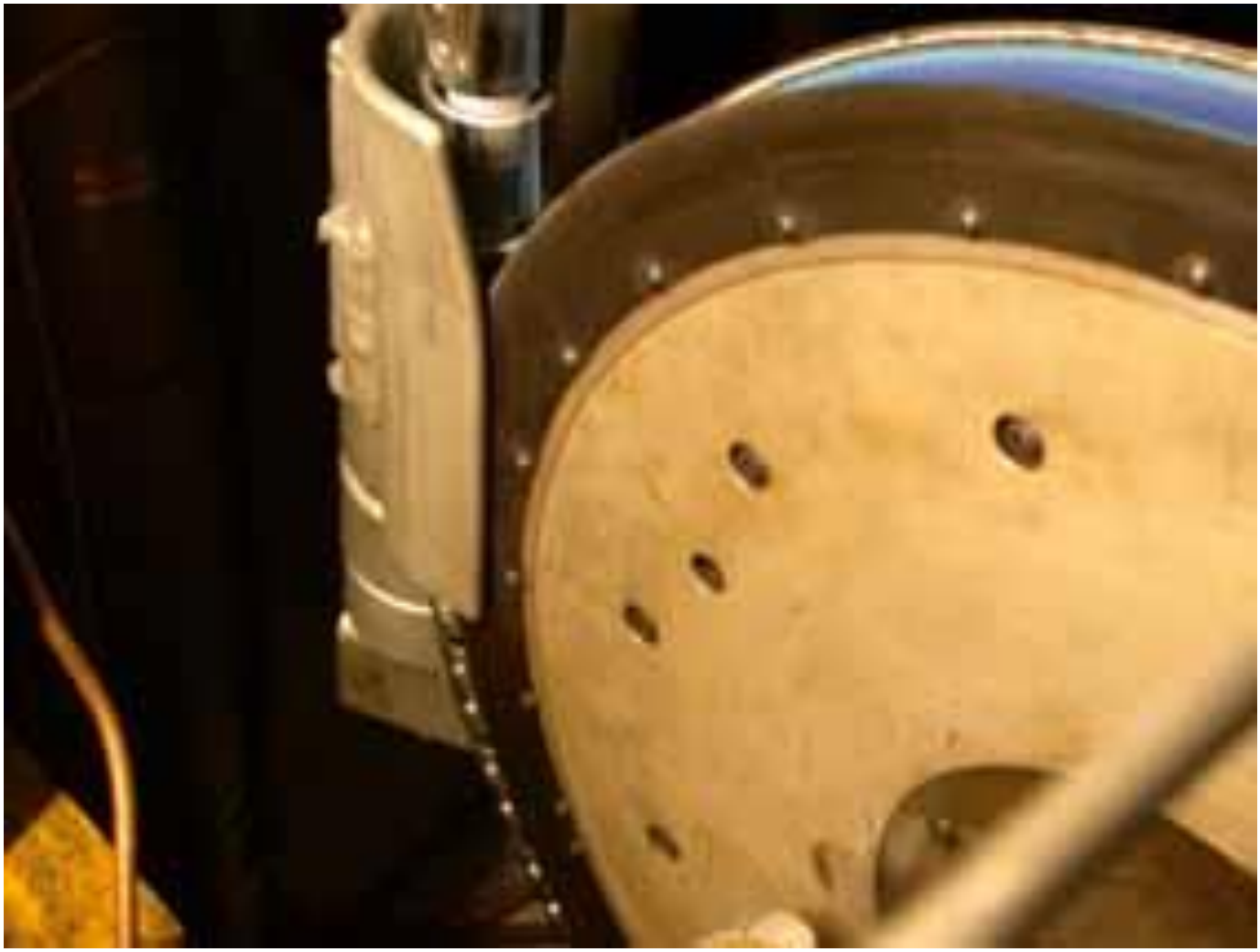
Breakdown products in the terminal

The bottom of the tank.

CHARGING CHAIN # 1
The cause of the electrical break down that led to this tank opening was found to be greatly reduced clearance between the down side inductor and the charging chain. Approximately 1 mm of clearance between inductor and wheel.

The displaced inductor frame pivot pin had allowed the inductor frame to move.
Loss of chain metering early in the run fixes the time of this event and explains why the discharge had generated such a large volume of SF6 break down products.
The pair of chain inductors are mounted on a pivoted 2*2 RHS frame that mounts to the inner side of the chain

motor support arm. The pivot centre is concentric with the motor and chain pulley shaft and close behind the chain metering brush assembly.



The inductor support pivot pin had worked loose and was partially disengaged toward and touching the metering pin and brush as shown in the above photo. This had allowed the inductor frame to tilt just the right amount to bring the inductor within 1 mm of the chain pulley. The frame tilted to the rear and, for an unknown reason, rotated in the horizontal plane about the up side inductor position thus only moving the down side inductor close to the wheel. The up side inductor, being at the centre of rotation, did not move closer to the wheel in the same way but was at a slight angle, never the less, due to the tilt of the frame.

The pin is in double shear, one shear on each side of the 2" RHS frame.
It was fortuitous that the pin had moved out toward the chain wheel. Movement stopped when it contacted the chain pulley current metering shaft shorting the chain metering and leaving only one of the shear points disengaged. The limited the amount of movement prevented possible further mechanical damage. Had the pin moved the other way there would have been nothing, other than cross locking, to prevent it coming all the way out.
The pin had been in place for approximately 30 years. The two grub screws were found to be loose and so was one of the pair on chain#2.
The offending pivot pin was relocated and the all grub screws retightened. These will be routinely checked when under the platform in future.

UPPER ROTATING SHAFT
While at the top of the machine checking the tube and current metering it was noticed that the flexible coupling (modified Browning CFR 5) between the Upper Rotating Shaft and the Drive Motor was damaged.
The coupling was marked with a fitment date of 21-03-01 so must be considered an early failure.

The rubber body was fractured between two opposed pairs of mounting holes; ie 180 deg apart. This represents 25% of the shear strength and prudence dictated replacement.

Cracks at 180 deg

Some of these couplings have been in the spare parts cupboard for many years and this early failure begs the question of shelf life as no mechanical faults such as misalignment or vibration were found.

CRACKED POST CERAMIC
Post D in Unit 15 was found to have a cracked ceramic insulator in Gap 6.
While cleaning the rings just beneath the terminal it was noticed that oil had accumulated on the post end and there was some staining on the first two ceramics. This was typical for all four posts in Unit 15
It was decided to remove 4 rings and wipe the oil and the stains with a cloth moistened in acetone.
The cracked ceramic was seen during the oil clean up even though it was two gaps below the area of concentration.

The reconditioned posts were assembled but had not been machined to length so it was decided to delay closing the machine while waiting for the workshop to finish off one post.

Judging from the blackened appearance of one of the cracks the ceramic must have been cracked for some time, maybe years, and would have reduced the voltage over this particular gap.

POST ELECTRODE GAP TESTS
The cracked post from unit 15 was subjected to a 6kV-gap test outside the machine. This was performed 48 hours after removal from the column.
It showed no current for the good gaps and 40 mA for the cracked ceramic.
This is not a viable way to find cracked ceramic in the machine as past experience shows that with the resistors and rings in place the cracked gap remains electrically transparent.
If a cracked gap is found by visual inspection or suspected to be present then isolation of the posts and individual HV checking of the gaps will most likely confirm the presence of a bad ceramic insulator.

RESISTOR LEADS
Usually faulty leads are found during collateral visual inspection while attending other tasks or when forced to actually remove them to facilitate other tasks.

The most common fault is burnt spots due to spark damage and these are found routinely by visual inspection. Burnt banana plugs and sockets are usually found during disassembly but severe cases can be found visually.

The photo shows an example of a typical burnt banana plug and blackened spotty lead from TO # 93 November 2002.

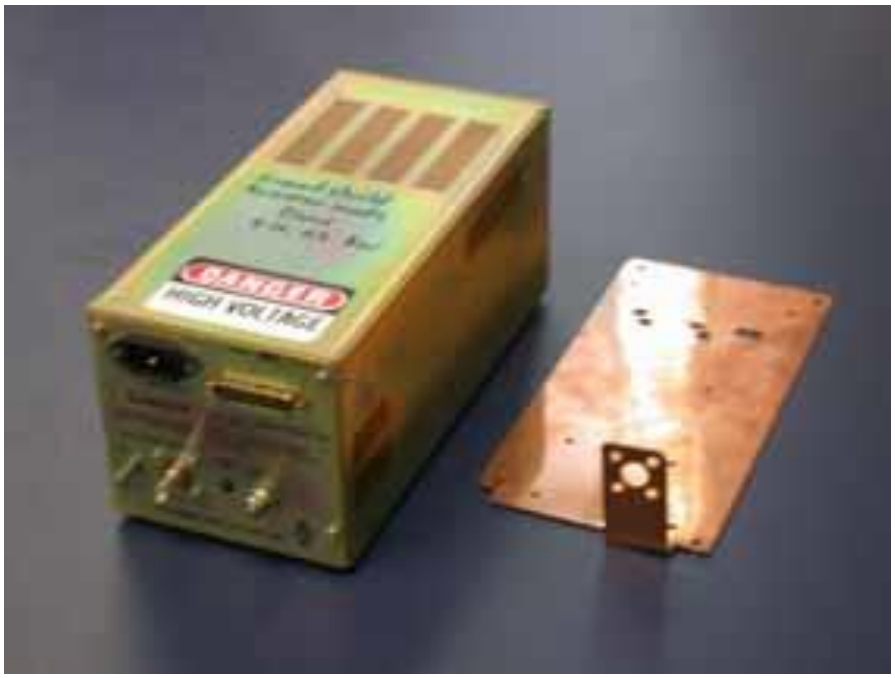
The leads and their connections have not received a dedicated inspection for many tank openings as they have not been a primary reason for machine failure. However the fact that burnt banana plugs are found occasionally during work on post replacement flags the likely presence of poor connections throughout the system. Increased vigilance in this area would be good insurance of reliable resistor chain operation. Maybe a dedicated hands-on inspection, of at least several units, should be scheduled over the next few openings.

GROUP 3 UPGRADE
The group 3 fibre optics boxes were removed so that Gordon could replace the Firmware eprom in order to increase control capacity.

Each time that the electronics packaging in the terminal is accessed it is appreciated for its ease of serviceability and its shielding integrity. All in all a satisfying result from a project that had so many aspects to consider during its design and manufacture.

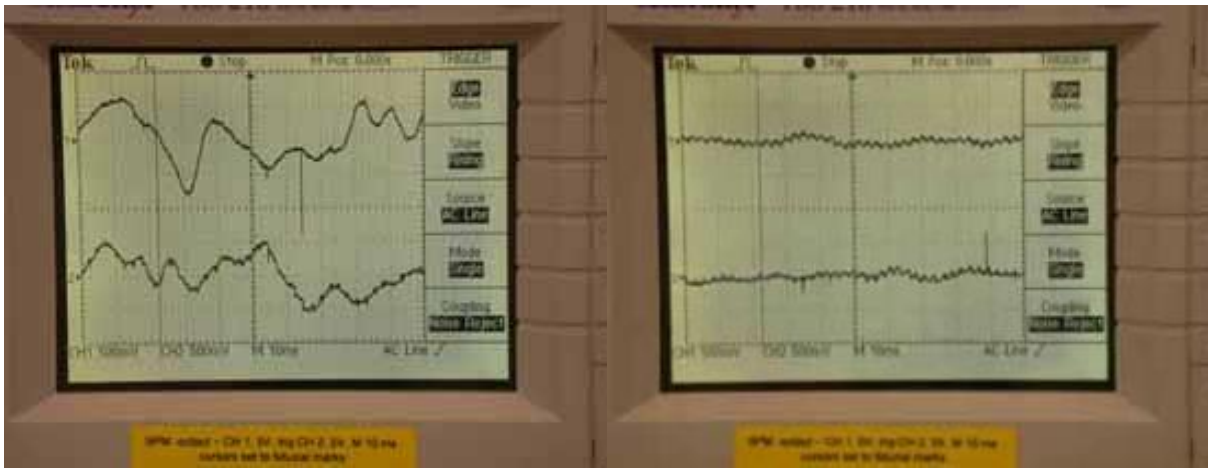
20l/s POWER SUPPLY
The 20 l/s Ion pump power supply was changed over to the new 5kV Glassman that was ordered after calibration tests last opening.

The usual ANU RF protection modifications, such as the installation of a copper ground plane shown in the photo below, were done just prior to the opening.

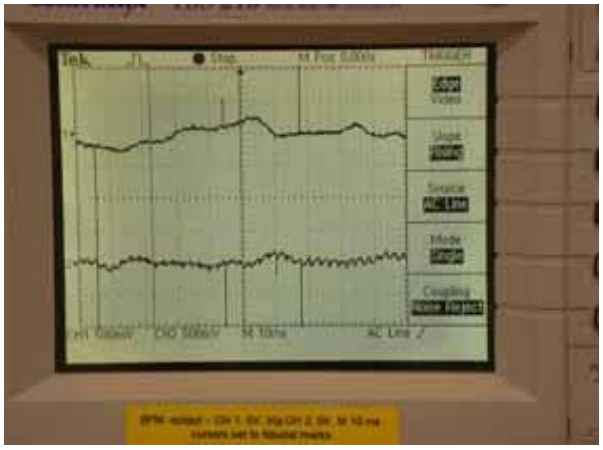


INITIAL PERFORMANCE

- The machine conditioned up to 15.2MV quite quickly and ran quietly at 14MV so the clean up of breakdown products was effective.
- Whilst the machine is running well Chain 1 is carrying20% less charge than the other two. Oiling solves the problem for a short while.
- The pick off traces are unusual and copies of these pictures have been sent to NEC for comment.



Chain 1 Chain 2



Chain 3