AUSTRALIAN NATIONAL UNIVERSITY

DEPARTMENT OF NUCLEAR PHYSICS

14 UD TANK OPENING REPORT # 93

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REASON FOR TANK OPENING

The machine ran reliably until late September when sparking and instability at low as 10 MV interfered with operations. Shorting rods were used to isolate the problem to Unit 14, which was then shorted out. Subsequently the machine met research demands of up 14 MV without problems. Immediately before the tank opening, tests were done by shifting the shorting rod to Unit 13 confirming the diagnosis of the trouble in Unit 14. With Unit 14 live and 13 shorted, voltage instabilities occurred as low as 7.9 MV and the Lost Charge was ~ 70 µA when it should have been zero. Looking through the porthole revealed huge sparking activity casting shadows of the upper three rings in Unit 14 at 8.2 MV. This confirmed the location of the problem if not the cause.

Planned maintenance and other items were

- General inspection and electrical tests. It will be interesting to see if and how the problem shows up during the HV gap test.
- Test run all machinery for mechanical diagnostics.
- Check chain oilers.

PUMP OUT 13-11-02

- Pump out tank, open doors and start ventilation system.
- Oxygen levels were checked at the bottom of the tank prior to staff entering the top port.
- The ventilation system ran overnight for 15.5 hours.

SUMMARY OF WORK 14-11 to 19-11-02

14-11-02

- The initial cruise down the column found the machine very clean with only a very light dusting of breakdown products on the terminal and adjacent units, but heavier near the top of Unit 14.
- The upper and lower rotating shafts were run and a slightly noisy bearing was found at the top of Unit #1.
- The HV gap test confirmed there were problems in Unit 14.
- Visual inspection located a loose stringer at the bottom of Tube 1, Unit 14 and that the resistor at the bottom of the 8-gap tube in Unit 13 had a burnt banana socket and plug.
- The shorting rod clutches were removed for diagnosis and alteration.

15-11-02

The school golf tournament was a fixture prior to the decision to open the tank so while the usual crew were away enjoying themselves the machine was totally ignored.

18-11-02

Detailed electrical diagnosis in Unit 14 revealed that a faulty resistor caused the major problem and this was replaced. Collateral failures, such as, loose connections, faulty resistor leads, plugs and stringer positioning were rectified.

19-11-02

- The upper rotating shaft was test run to check the new bearing installation.
- The charging chains and idlers were checked and found to be stable and smooth running prior to closing the terminal.
- The LE column was blown down with high-pressure nitrogen, the terminal was closed and the HE column was blown down.

- Unit 18 had a loose stringer termination at the tube end.
- Post A and B in the Unit 19 dead section had damaged shorting wire terminations. One wire was eroded due to spark erosion under a loose screw head. The wire was re-looped, to make the new connection, rather than replaced so is now shorter. The other wire had a loose screw. The two termination screws and nuts were replaced and all other terminations checked for tightness.

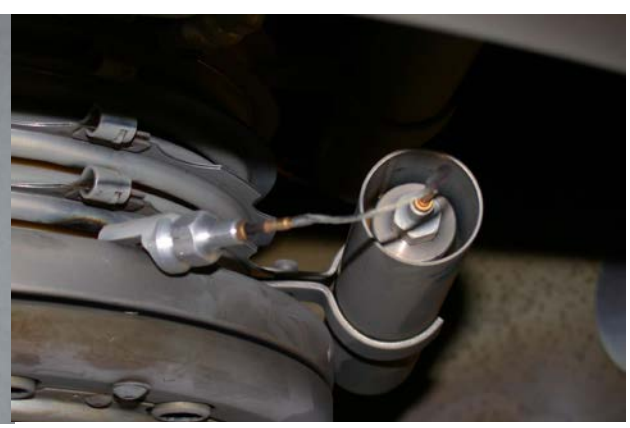
- Unit 26 and 27 shared a historic atypical stringer configuration. It was decided that these units should be set up the same as all other units. This is discussed in the section headed STRINGERS below.

- The column was wiped down with RBS and water.
- The Charging Chain motors and associated equipment in the bottom of the machine were checked and the area cleaned. Chain 3 motor frame had a faulty ground connection. The wire was still attached but the solder had fractured, at both ends, allowing the wire to slide in the lugs. These were resoldered using Eutectic 157.
- The HV gap test found no problems.
- Charging tests found performance normal, the tube and column current circuits were checked and the machine was closed.

UNITS 13/14

The usual 30 kV gap test produced the usual current readings but the second 11-gap group (tube 2) had some noise at the beginning of each test voltage application, indicating a break down. Visual inspection revealed a loose stringer at the bottom of Tube 1 so it was surmised that this was the cause of the noise.

The 8-gap tube between units 13 and 14 (tube 4, unit 13 if you like) protrudes into unit 14. The banana plug and socket at the tube flange end of the tangential resistor lead was burnt out.



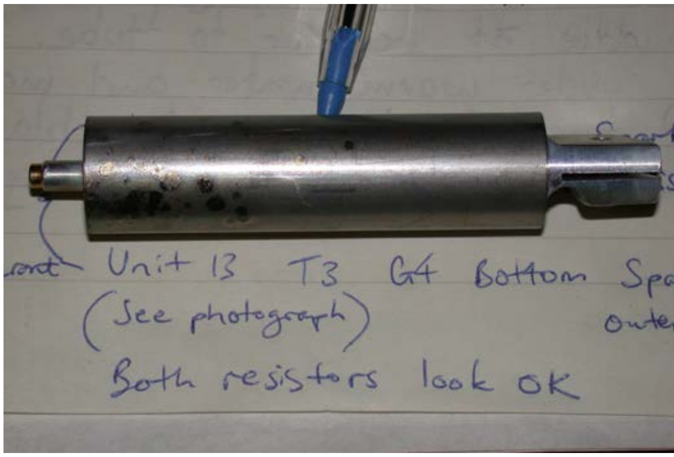
In the past, more minor damage has been put down to column discharges and this was most probably the primary cause. The plug and socket interface, once initially weakened by a spark, had subsequently been subjected to repeated discharges and so suffered cumulative damage way beyond that normally found. These parts were replaced.

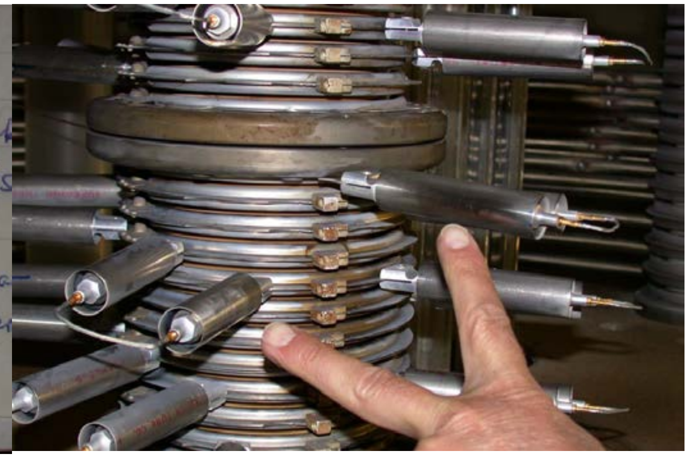
The resistor across Gap 2, Tube 1, Unit 14 was open circuit and found to be thickly coated with white breakdown products. When viewed under a microscope, a deposit of bubbly yellow material was seen along the surface of the resistor. It appeared that a high level of spark activity occurred over a long period, between the resistor and the shield tube near the middle of the resistor. The yellow deposit was removed by washing with warm water and it was found that there were extensive gaps along a substantial length of the conductive spiral.

Given the thickness and extensiveness of the deposits and damage to this one resistor, we speculate that this is a case of infantile failure not discovered until maturity, a case a congenital defect.

Testing this resistor separately at 3kV, the current was 0.56µA in air.

The resistor shields across gaps 1 and 4, Unit 13, tube 3, face each other and there were spark marks on the adjacent shield surfaces. The resistors themselves were OK.





STRINGERS

Ever since the compressed geometry tube installation, castings 13 and 26 both have had a unique stringer set up. Because the 8-gap tube spans a casting, the normal stringer location on its flanges place them closer to the casting than any have ever been. Concern about the consequent higher fields between the stringer and the casting causing problems, led to them being left out as a test at castings 13 and 26. Over the years, there has been no noticeable problem caused by the proximity of the stringers in the other units and no apparent problem associated with their absence at castings 13 and 26. Historically, there had been more white/grey powder breakdown material at casting 13 but we never discovered its cause. Because of the damage to the resistor near casting 13, it was decided to declare the test over and to install standard configuration stringers at 13 and 26.

Experimenters have commented that voltage stability has been excellent, indeed, better than ever experienced. We take that as further evidence that the failed resistor has been a low-grade problem for years.

30 KV POST ELECTRODE GAP TESTS

For many years now, immediately on opening and just prior to closing the tank, the current readings of all 11 and 8 gap electrode groups are recorded.

The initial test, this opening, found a slight break down in tube 2, unit 14 and, once unit 14 was opened for work, a loose stringer was discovered on the flanges of tubes 1 and 2. It is tempting to say that the test breakdown pointed to the loose stringer but caution is advisable. Later, during the column blow down, routine checking located a loose stringer in unit 18 and that certainly had not shown up electrically.

The high voltage gap testing of groups is performed on the column rings so has limited scope for diagnosing problems such as those found in units 13&14. The test does however show up changes in the post resistor chain and can alert the crew of gross problems, such as, loose or displaced equipotential rings.

The gaps associated with atypical stringer configuration in units 13/14, and 26/27, always read approximately half the current of those in the rest of the machine. This has made it more difficult to find problems using the HV test because the lower current readings further masked potential problems. The readings obtained after the stringer configurations were made uniform throughout the column, were consistently 8 μA for all 11 gap sections in the machine.
This consistency will make it much easier to spot discrepancies in future.

UPPER ROTATING SHAFT
The upper shaft bearing set at the top of Unit 1 was removed because it was noisy during tests. Access to this bearing set requires that the upper rotating shaft drive motor be disconnected and raised so there is substantial disturbance than when changing a standard bearing set. The lower bearing of the pair was very slightly dry, if not normal for age, but was changed out anyway. The upper bearing was changed also as a matter of course. The housing was replaced as well due to the feeling, while in the machine, that the bearing had spun in the bore. Later inspection, in the workshop, proved this incorrect so the housing is still a viable spare.

SHORTING ROD CLUTCHES
Modification of these has become a regular feature in recent tank opening reports and will remain so in the immediate future. The resizing of the nylon shorting rods to match the stainless steel ones, reported on in TOR92, required that new o-ring housings be made and fitted at that time. The o-ring grooves were changed to a 45-degree chamfer that faced toward the tank. It was found that the friction between the o-rings and the nylon rods, during their removal, pulled the o-rings into the chamfers. This action resulted in an undesirable

degree of self-locking that sometimes caused movement in the outward direction to be difficult. If this unforseen feature had been modest and repeatable, it would be desirable, as it would help compensate the for the tank gas pressure that tends to drive the rods out of the machine. The o-ring housings were relaced with ones that have square section grooves and it is anticipated that these will serve the purpose until next opening when the seemingly obligatory revisit will be done.

One thought is that the angle of the o-ring seat could be tailored to compensate for the difference in force required, due to gas pressure, between the two directions of shorting rod movement.

INITIAL PERFORMANCE

- The Low Energy Column Current wiring was found to be shorted to ground inside the tank. The disruption caused by shifting the Low Energy Shaft Motor probably moved the Column Current connecting wire spark-gap close enough to ground that when the tank stretched at 105 psia, contact was made that wasn't there during the pre-button up tests. Unfortunately, this is not an unprecedented phenomenon. This lack of column current read out is annoying but not serious enough for the tank to be re-open to repair it.
- The machine stared to condition at 10.6 MV reflecting deconditioning caused by the resistor failure in unit 14. With only units 13 & 14 live, the conditioning threshold was raised form 1.59 MV to 2.3 MV in one hour. With units 11 – 14 live, volts went to 4.75 MV. With all units live, conditioning started at 14.5 MV and after five days of experiments, at 15.2 MV
- Machine stability is arguably the best its ever been as evidenced by the unprecedented ease with which the beam pulsing and chopping could be set up. The stability on the control slits was, one might even say, eerie.