AUSTRALIAN NATIONAL UNIVERTY

DEPARTMENT OF NUCLEAR PHYSICS

14 UD TANK OPENING REPORT # 80

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REASON FOR TANK OPENING #1

The tasks for this opening were to replace terminal stripper foils, fix the persistent low energy column current metering problem and have a final look at details for the gas stripper installation.

PUMP OUT 3-6-97

Pump out tank, open doors and start ventilation system.

SUMMARY OF WORK

4-6-97

Whilst lowering the service platform, we found that the platform seal retaining bolts required service and that the platform motion interlock light system had failed. The usual tour revealed that the machine was quite clean and that there were very few spark marks. Another gas tube in U 15 was sparked through at the top surface of the casting.
And so to work.
The HV test found no faults. The machine did not require the usual pre-work clean with RBS and water. The spark mark survey was completed and then all three terminal sections were moved for gas stripper project checks and to allow removal of the foil changer.

5-6-97

The charging chains, pulleys, idlers and inductors in the terminal were all found to be in good condition. As a preventative maintenance measure all six of the nylon gas tubes were removed. We fitted a test loop of fiber optic into a 12 m length of 1/4" nylon tube, of the same type as the pneumatics lines, ready for installation into the column.

6-6-97

The cause of the persistent column current metering problem was finally found and hopefully rectified.
The fiber optic loop was fitted to the column and runs from outside the tank to the terminal. We began the job of running four new gas tubes to the terminal and two to the H.E mid section.

9-6-97 Public holiday

10-6-97

The installation and termination of the new nylon gas tubes was completed. The terminal foil changer will need to be moved during the gas stripper installation. We spent much of today moving between the terminal and the full size mock up, outside the tank, comparing and considering the many and varied facets of that task. The foil number readout box mounting will need to be modified.

11,12-6-97

These days were, for the most part, devoted to gas stripper project planning and design work. We also de-ringed Units 13 and 14 and removed the resistors from Unit 14 in preparation for the installation of four reconditioned column posts. The sixteen (4*4) platform cable seal flange bolt holes were re-tapped.

13-6-97

During the replacement of the column posts, in Unit 14, it was discovered that the reconditioned posts were not rebuilt to specification and the operation aborted for this opening.

16-6-97

The HE end of the machine was wiped and ringed. The new fiber optic feed through was installed in the base of the tank.

17-6-97

The fiber optics were terminated at the feed through and a metal tube shield fitted between the last casting and the end plate of the tank. Light attenuation levels were recorded, first for the feed through alone and then including the loop to and from the terminal, so that we could monitor any changes in performance that may occur due to spark damage. The operation of the pneumatic foil changers and sublimer switches were checked. No leaks were found but we noted that the upper sublimer did not respond and, since it had run out of pellets anyway and since it would be made redundant by the gas stripper installation, decided not to investigate further. We had noticed that the lower terminal alternator had deposited a light dust layer around its cooling gas outlet and, since metal particles could be seen glistening in the light, correctly assumed that trouble lurked inside. The output end rotor bearing had spun and ruined it's housing. Whilst this was being repaired outside, the LE end was blown down in preparation for final cleaning. We then vacated the machine to allow a photo session that saw the day out.

18-6-97

The reconditioned alternator was reassembled in place and a new flexible coupling installed. There was still a small vibration but the poling noise was gone. The terminal was closed and the HE end was blown down. The usual HV test to all column gaps was performed, and as no problems were found, the four person wipe down was done. Chain and metering tests were completed and the machine was closed.

LE COLUMN CURRENT METERING

The L.E column current metering problem was found to be caused by the rocking, and subsequent shorting to ground, of a stand-off. The lengthwise growth of the pressure vessel, during gas up, was providing subtle movement of the stand-off shorting it to ground at 50 psi but testing OK at atmospheric pressure. The offending part was removed and the wire reshaped slightly to overcome the problem.

LOWER TERMINAL ALTERNATOR

There had always been an historic vibration when the alternator was run but it seemed worse now and we felt we could hear the rotor poling. We dismantled the alternator in place and took the end castings to the machine shop thus leaving the main body with stator aligned in the terminal. We found only very slight evidence of poling but found that the bearing housing was worn oversize approximately 0.008". The bearing housing was bored out to accept a shrink fitted steel ring about 0.100" thick. The steel ring was then finish machined, within the housing, to correct specifications. The alternator was then reassembled in the machine and, during reassembly of the flexible coupling, we noted that the rubber component ran eccentrically. Once the rigid parts were bolted up then the rubber was energized by its eccentricity on each revolution thus causing vibration. We had a new rubber part in stock so we removed the coupling to the workshop and installed it using a lathe to ensure good alignment. The vibration was reduced but not entirely eliminated, however, as we were hoping to close that afternoon we resisted the temptation to try to improve it further at this point.

NYLON GAS TUBES

We had hoped that the nylon tubes, which carry SF6 to the pneumatics in the terminal and HE mid section, would last until the gas stripper installation made some of them redundant. However, another failed tube in U15 forced our hand and in the interests of ensuring reliability we began the job of running four new tubes to the terminal and two to the H.E mid section. We use black 2000psi tube made by Armstrong Nylex and known as blue line grade. The old tube had been in the machine since the mid eighties and it had performed excellently even though it is a relatively inexpensive product.

PLATFORM CABLE SEAL BOLTS

During the deployment of the service platform it was noticed that some of the cable seal bolts were difficult to undo. Upon closer inspection we realized that the offending bolts were close to stripping, due in part to the many times that they have been used but mainly due to excessive tightening. We decided to treat the machine to a new set of bolts and to run a tap down all sixteen holes. The new bolts were coated with moly grease and fitted during the closing ceremony.

COLUMN POST UPGRADE

We aborted the post replacement task for this opening and resolved to reassess the specification and processes involved in the reconditioning of column post.
The original posts suffer from gross spark erosion between the last titanium gap electrode and the aluminium end flange. Some posts have spark eroded column ring seats due to poor contact pressure.
Historically, we have run an ongoing column post reconditioning program but due to other pressures, mainly the LINAC installation, we have not concentrated on this for some time. We reinitiated the program for this opening and planned to install four posts. The process involves removing the original aluminium end caps, glass bead cleaning, fitting of new thicker stainless steel end caps with six screws for improved electrical contact, machining to length and if necessary reorienting the ring attachment position. We use a set procedure with tight tolerancing and so were dismayed to discover, during installation, that something had gone very wrong. We removed the column post from casting position "B" and fitted a reconditioned post. After loosening the old post in casting position "A", and whilst lifting the replacement post, it was noticed that the new post end cap was not seated flush to the end ceramic. Immediate investigation showed that, of four reconditioned posts, only the first one that we fitted in position "B" was to specification. The posts, which are a bonded stack of pressed titanium electrodes and ceramic spacers, are subjected to compressive loadings when installed in the column. The static force that each group of four posts is subjected to varies from a maximum at the bottom of the column to a minimum at the top of the column. Whilst static forces near the terminal are close to the average value the forces due to column bending will cause rise and fall from time to time. The length of individual posts must be held to close dimensional specs (we use 19.250" + - 0.001") otherwise the alignment of the column can be compromised and worse still the other posts in the unit may become over stressed. We noticed that the current batch of posts had an air gap between the ceramic and the end caps the best being 0.000" and the worst being 0.020"(0.5mm). The tank crew were grateful to have noticed this and aborted the installation for this opening. We will investigate the whys and wherefores as soon as time permits so that we can get the program back on track.

GAS STRIPPER PROJECT

This opening was an unexpected bonus from the gas stripper crew's point of view. We had planned to be installing the gas stripper by now but hold ups caused that opening date to slip beyond the reach of our current batch of foils. Many details were checked and planning for the positioning of the present foil changer in the new terminal was finalized, something which we had planned to adlib during the installation. We modified the mounting of the foil number counter and predrilled the terminal gussets in readiness for the fitting of the gas stripper electronics boxes. The fiber optics part of the job received a boost also as mentioned under it's own heading below.

FOIL CHANGER

The foil changer was repopulated with enough stock to allow experiments to continue right up to the scheduled gas stripper installation in August. The ANU foils were replaced with a thinner set of tighter tolerance 2 - 4 microgram per square cm foils. The few unused Munich laser ablated foils were included in the set.

FIBER OPTICS INSTALLATION

The gas stripper project requires the installation and survival of fiber optics for the computer control of terminal equipment. Our installation is will be multiplexed so we require only a single fiber in each direction. We realized that the fiber would not necessarily survive in the always electrically and sometimes mechanically hostile environment of the accelerator column, therefore, much thought was given to the solution of both electrical and mechanical protection. The project requires the manufacture and installation of a pressure proof feed through to the tank floor and the running of a continuous loop of fiber to the terminal. These tasks were not required to be completed until the next opening, when we plan to install the gas stripper, but we realized that an opportunity existed to learn some of life's little surprises ahead of time. We installed the feed through and ran both fibers through a length of nylon tube installed in the same way and location as the present gas tubes. We ensured that the tube was offset by 30mm as it passed through each unit casting bushing thus forcing the fibers to contact the tube wall at least three times in each casting space. We felt that keeping the fibers in close contact with the nylon tube would avoid excessive voltage differentials building between the tube and the fibers and therefore avoid spark damage to the fiber optics. The nylon tube, containing the fibers was shielded between the last casting and the tank floor, a distance of approximately 1300mm, within a metal tube.

SPARK MARK SURVEY

Compared with the last opening spark marks were few and far between. We felt that the data gained was not worthy of the effort of graphing the results, as we did last time, but are listed below for future reference,

Events	LE	11
	TERM	3
	HE	15

INITIAL PERFORMANCE, the reason for opening #2

The machine began sparking at 3MV but conditioned slowly to 8MV where it sparked continually and refused to condition further. We looked through the view ports and saw sparking that was, at times, continuous. We became suspicious that the fiber optics may be spark damaged and tested the loop with our light source and meter. The test confirmed that transmission had ceased. The machine had not only ruined the fiber optics test loop but was also unusable for experiments and so the decision was made to pump out and investigate.

PUMP OUT 20-6-97

During the pump out we began a belated investigation into nylon tube. The doors were open at 5.30 pm and the ventilation system switched on for the weekend.

23-6-97

The units 15 to 28 had at least one or two "exploded" nylon gas tubes. The effected tubes were shredded along their axis and some stringy parts had become unattached and were lying about the castings.
photo
The tube containing the fiber optics was not visibly damaged in any unit. Meanwhile, outside the tank, tests had confirmed that the new nylon tube was unable to sustain the required gradient of 1.25 MV/Unit and a replacement type was ordered. After careful observation of the situation in the machine we removed all the gas tubes and the fiber optics in preparation for their replacement. Late in the afternoon we removed the LE mid section control box so that we could replace a blown QI light globe.

24-6-97

The new PFA tube, a teflon copolymer, had arrived overnight. We fitted a new fiber optic test loop through Units 27 and 28, in PFA tube. The fiber optics tubular shell system, between the bottom of Unit 28 and the tank floor, was replaced with an open one which offset the PFA tubing every 300mm to ensure good electrical contact between fibers, PFA tubing and the metal support. This is analogous with what was done passes through the castings. The gas tubes to the terminal and HE mid section were re-run using the new PFA tube. We refitted the LE mid section control box after modifying the light globe mount so that globe replacement would be easier next time it was required.

25-6-97

The column was re-ringed and blown down with N2. After we performed the HV column gap test the column received the usual four person wipe down with RBS and water. We measured the transmission level of the fiber optic test loop. Metering and charging test were done and we then closed the machine.

NYLON TUBE

The manufacturer was contacted and confirmed that the nylex blue line tube was different to that supplied ten years ago. Firstly the nylon had been changed from nylon 11 to nylon 12 and further the ratio and method of adding *carbon black* had been changed over the years. The column gradient in our machine is 20kV/cm at 1MV/unit. We cut 1 cm lengths of old tube, new tube, teflon tube and any other tube we could find, which we placed between the electrodes of our HV tester. Both nylon samples broke down at 10 kV. The teflon broke down at 27kV. The two nylons were washed in ethanol and blown off with N2. The old black tube now broke down at 24 kV and the new black tube broke down at 20 kV. We had not washed the new tube before installing it in the machine but we did wipe it down in place, after installation, to remove the painted blue line and pressure spec printing. Based on the above mentioned bench tests, we would now expect the tube in the machine to break down at 0.5MV/ unit and in fact the machine achieved only 0.4 MV/ unit so we had a good idea of what we would find upon opening. It was clear that we required an alternative tube to be on hand as soon as possible. We had approximately 11 m of Swagelock PFA (perfluoroalkoxy) in stock so we tested 1 cm of it to in the same way as we had the nylon and teflon. The PFA began to break down at 28 kV, which would be more than adequate for our needs. The local (Sydney) supplier had 60 M in stock, enough to complete the job, so we ordered it for overnight delivery.

FIBER OPTICS

We discovered that the fiber optic was mainly damaged at the point where it exited the nylon tube from where it ran bare, the final 200 mm, to the tank feed through. There were also black marks on the fiber at some of the places where the nylon tube was damaged, including embrittlement in some regions. The transition from nylon tube shielded to bare was, however, contained within the 40 mm diameter metal shield tube. Since the main failures had occurred beneath the column, we concluded that the protection within the column was OK and knew that we needed to redesign the protection near the tank feed through underneath the column. There was not enough fiber to run another test loop to the terminal and we probably would not want to anyway. It would be prudent and adequately "enlightening" to run a test loop through only Units 28 and 27. This strategy would test the new shielding under the column as well as confirm the positive result already found within the column. In the unlikely event of break down within the column we would be able to short Units 27 and 28, then, carry on with nuclear physics experiments until next opening. As well, during tank sparks, there are large over voltages in these units as the spark energy is reflected back on the column.

The tank floor feed through has two stainless steel machined tubes, o ring sealed into the tank flange, in which the fiber is held by potting with epoxy resin (5 min araldite). The feed through fibers are terminated so as to receive standard fiber push on connectors. We decided to do away with the 40 mm tube shield and instead ensure that the fiber was completely shielded by the PFA tube right to the fiber push on connector fitting. The PFA tube is cable tied to a stainless steel post that runs from the bottom of the column down to the tank floor. The stainless steel post has groups, welded at 500 mm centers, of three 12 mm diameter pins around which the tube is bent.

photo

This approximates the situation within each casting where the tube is bent to ensure good electrical contact between the fibers and the tube. The two fibers leave the feed through in separate PFA tubes which join, via a Y fitting, into a single tube about 70 mm above the feed through. The two fibers continue within the single tube through Units 28 and 27 where another Y fitting, in casting 26, separates them forming a loop of single fiber protected in another piece of PFA tube. The Y fittings were drilled, through their sides, to allow ventilation of the tube during tank pump out and gas up operations.

INITIAL PERFORMANCE

The machine ran up to 14.5 MV without problems and there have been a few sparks around 11 MV since then. The fiber optic test loop, at the time of writing, was still transmitting at the same level as when first installed.