AUSTRALIAN NATIONAL UNIVERSITY

DEPARTMENT OF NUCLEAR PHYSICS

14 UD TANK OPENING REPORT # 113

7th June to 20th July 2010

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REASON FOR TANK OPENING

This was a scheduled opening for a number of reasons, including there being a shortage of terminal stripper foils and to install six new, precision tube sections in Units 1 and 2. There were significant alignment activities undertaken in conjunction with the tube replacement and transmission to and through the Linac loop.

Install a new chain, chain wheels and sheaves, casting idlers and DC idlers in position #3.

Investigate why the LE vac readout was not working.

Investigate why the HE stripper suppressor isn't working.

Perform more individual resistor value checks.

Perform initial 30kV insulation test of the column.

Perform electrical and mechanical tests and inspect all idlers, chains, pulleys, bearings, shafts and resistors.

SUMMARY OF WORK: 7-06-10 to 20-07-10

7-06-10 Monday

- Pump out tank, open doors and start ventilation system.
- The ventilation system was run overnight.
- The two major sub assemblies of the new chain were joined using drive rivets. The screw together pins of the minor sections of chain were replaced with drive rivets also.
- The new chain was then hung in the tower stair well to observe if there was any twist.

8-6-10 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.
- Completed the initial 30kV insulation test of the column.
- The column was wiped with RBS and water.
- The HE and LE shafts were run. The only issue requiring attention was a noisy bearing set in the bottom of Unit 7.
- The chains were run and there operations observed as generally being normal.
- The terminal spinnings were moved clear to access the terminal area.
- We opened Units 2, 4 and 6 to read the record numbers from the 8 gap tubes. These ID numbers would allow us to select the best 8 gap tube to use between U1 & U2.
- Chain #3 was removed along with both upper and lower main wheels.

9-6-10 Wednesday

- Opened Unit 1, 2 and 3 and moved the rings from these down to Unit 4 to provide access to the tubes being removed.
- The mounted resistors, where accessible, in Units 1 and 2 were tested individually with the HV tester to assess any change from their original values.
- New bearings were fitted in used plumber blocks and assembled onto the new chain wheels ready for installation into position #3.
- We removed the terminal stripper foil counter box to investigate why the illumination of the counter had failed. The lamp was found to be OK. The only evidence of a problem was a slightly loose screw connection on the lamp screw terminal strip. The supply voltage would be checked.

10-6-10 Thursday

- In chain position #3 we fitted the new chain wheel and bearings assemblies.
- Plumb bobs were used to checked relative alignment of the terminal chain wheel referencing fixture to the lower fixture. No adjustments were required.
- The new chain was loaded into position #3 at the terminal. Even with three people, we felt it was a bit like wrestling a python might be.
- Chain #3 was joined and in anticipation of the initial chain stretch three pellets/links were removed.

13-6-10 Friday

- The three chain drive motors were inspected. We disengaged their drive couplings and ran motors. The front bearing of Motor #3 was noisy and was noted for replacement.
- LE Unit #7 lower alternator bearings were replaced. Installation to be completed on Tuesday (Monday holiday)
- Tested the terminal 60 l/sec ion pump supplies with dummy load. Both tested OK and displayed readouts back to the control room.
- The terminal foil counter lamp power supply output tested OK, 6.5Volts.
- The new tubes were baked using two heater tapes, one tape of 300 watts per three tubes, and turned off at 16.20 at 4.6 X 10-6 Torr.

14-6-10 Monday - Public holiday

15-6-10 Tuesday

- The 8 gap tube designated Unit1, Tube 4, positioned symmetrically in the casting between Units 1 and 2 was deemed to be of acceptable accuracy and will be retained in this location.
- Units 1 and 2 were stripped of tube resistors.
- The accelerator tube was vented slowly from Level 5.
- The beam tube above the tank at Level 4 was removed to allow the alignment fixture to be mounted.
- The bellows from the top of the LE accelerator tube was removed. This allowed a target to be fitted to the top of Unit 1, Tube 1 and its position was recorded.
- Outside the tank the 20l/s ion pump on the back of HE Sublimer was replaced with a rebuilt unit.

16-6-10 Wednesday

- The telescope was setup above the tank and the Theodolite below at the inflection magnet. Both set to look at the terminal carbon foil stripper canal.
- A sighting was taken of the tube target fitted to the top flange of the Unit 1, Tube 1. The target was 0.018" towards the right slit blade.
- The tank BPM was removed as its operation had been noisy. Investigations found it only required new bearings to be fitted to the "in vacuum" spindle.

17-6-10 Thursday

- The BPM was re-installed after being fitted with new bearings from stock we had in store supplied by NEC. Testing showed we had a weak fiducial signal. This required further investigation
- A new lamp was fitted to the terminal stripper counter as a precautionary measure and the assembly refitted into the machine.
- The noisy Chain #3 drive motor was disassembled. We chose to leave the chassis and inner end casing in position and only removed the outer end housing and the rotor from the tank for the fitment of new bearings.
- Cooper was unsuccessful with trying to look through the whole machine from the bottom to L4.

18-6-10 Friday

- Further testing the tank BPM was undertaken. The amplitude of the output from the fiducial marks was poor. As a test we swapped in the pickup from the unit on the gas source. This gave a better signal. We again removed the BPM for investigation.
- Cooper established sight of the target at the analysing magnet from the top of the tank (L4). This required increasing the contrast of the details on the target and good illumination.
- Sighted again the tube target on U1, T1 at the top of the machine.
- Weisser removed the now unused multi wire feedthrough fitting from the top flange of the 14UD. A perspex window and flange was fitted in its place.
- Casting idler assemblies from Chain #3 were disassembled, degreased and fitted with new idler wheels.
- Started to reinstall the casting idler assemblies for chain #3.
- A new observation was taken of the target on Unit1, Tube 1. The telescope at L4 was aligned with target at the analysing magnet.

21-6-10 Monday

- Re-sighted the position of the target at the top of Unit 1, T1 and found it to be in close agreement with Fridays sightings.

- The seven tube sections from Unit1 and 2 were removed, including the 8gap tube.
- The tube sections were taken to a clean lab and separated at the bolted flange to retrieve the "V" electrodes.
- The BPM required the fiducial magnet wheel to be adjusted along it's shaft to better align the trigger outputs with the sensor. Bench testing showed a significant improvement.

22-6-10 Tuesday

- The tank BPM was refitted to the 14UD and finally tested OK .
- The new single tubes were bolted together as sub-assembles. Two lots of three tubes were assembled. Remembering to fit the previously removed V electrodes between the bolted flange joints.

  Unit1, T1 T2 and T3.

  Unit1, T4 (8 gap), U2, T1 and T2.
- Leak testing of the tube subassemblies was done on the bench. The complete bagging technique was used. No leaks found.
- Tube resistor value tests were completed on the bench. Those with a change of more than ~5% were replaced. A total of eight resistors were found outside of range and replacements were fitted.
- Chain motor #3, rotor had been fitted with new bearings. The motor end housings cleaned and the assembly completed in the accelerator.

23-6-10 Wednesday

- Refitted casting idler assemblies in U19
- Refitted the casting idler petals that were removed to allow access to the idlers.
- The new 11gap tube identified for position U2, T3 was installed as a single piece.
- The accelerator tube alignment/support spokes were fitted to the tube flanges level with the Unit 2 bottom casting and the alignment completed. The aluminium target mount that fits over the OD of the tube flange was used instead of the target carrier that fits over the tubes internal ceramic. It would appear that the tube ceramic in this location is slightly oval as the target carrier when partially fitted would grip and wobble across one orientation. We were nervous of this target carrier breaking the ceramic we used the target holder that fits over the tube flange.
- The piece of beam tube in the lower terminal above the HE tube was removed. This provided access to the Ta aperture disc trapped in the bellows

flange. An 11.9mm dia target was inserted in the beam hole of the Ta disc. An alignment sighting showed the Ta disc was in sympathy with the displaced stripper canal.

- Started to open the HE midsection deck plates and found some particulates on the top of the second stripper, suppressor power supply box. These particulates were from spark damage to the PFA tube that carries and protects the optic fibres through to the terminal.
- Some of the crew working outside completed the vac leak testing of the accelerator tube subassemblies. No leaks were found.

24/6/10 Thursday

- We straightened the column to correct the position of the stripper canal back onto the optical axis sighted from L4 to the analysing magnet.

This was achieved by tightening (elongating) of casting support jacks in the column. The greatest correction required was from the jacks near the terminal in vertical alignment with Post "C" and some of Post "B".

- Checked and adjusted the alignment of tube section Unit 2, T3 after the column straightening exercise.
- We installed the first subassembly of accelerator tubes identified for positions, Unit1, T4 (8gap), U2, T1 and T2. A spacer type "Vee" electrode was installed under this first subassembly (between Unit 2, T2 and T3), the same as it was previously.
- Visit by David Garton and Tony Mowbray from ANSTO.

25/6/10 Friday

- The second accelerator tube subassembly was installed. These positioned in Unit 1, T1, T2 and T3. The alignment spokes were fitted and the alignment completed using the target holder that fits over the internal ceramic at the open tube end.
- In Unit1, the bent ends of the alignment spokes were shortened by ~5mm to increase the clearance to nearby tube mounted resistor assemblies. We had seen evidence of sparking from the spoke end as reported in TO#112.
- The bellows was bolted to the top of the LE tube with the "Vee" electrode type spacer ring under it. The "Vee" electrode is removed in this case at the top of Unit 1, T1.
- New optic fibre was ordered for the Group3 control system in the terminal (delivery within a week).
- The charging chain #3 was refitted with its inductor stacks and they were set with the gauge tool.

- The chain motor couplings were reconnected on all three drive motors. Some adjustments were made to improve the alignment of the couplings by moving the motor slightly.

28/6/10 Monday

- The installation of the bellows at the top of the LE accelerator tube was done and this completed the installation of the new tubes.
- A close examination was made of the spark damaged PFA tube in the HE mid-section. The damage is adjacent to the edge of the second stripper's suppressor power supply box. The new routing of the new PFA tube would include increasing the separation to the box whilst imposing bends in the PFA to ground the fibres inside it.
- The bellows at the top of the HE tube, within the bottom of the terminal was removed to improve the fit and improve the grounding of the Ta aperture holder. We were concerned it wasn't positively grounded nor accurately located in the flanged joint.
- The column post resistors were tested and some replaced in Unit 1 and 2 that were outside our tolerance from their specification.

These include the lower resistor in Unit 1, gap 2 and the top resistor Unit 2, gap 6.

29/6/10 Tuesday

- The alignment of the entrance of the HE tube was checked using a target fitted in the "Vee" electrode immediately above the accelerator tube. Some small adjustments were made to the alignment spokes to correct the tube back on axis.
- The HE 2nd stripper suppressor hadn't been working. The power supply was tested and the output OK.

30/6/10 Wednesday

- Continuing investigation of the 2nd stripper suppressor found that the HV output cable assembly had been inappropriately fitted with a BNC type connector at the vacuum feedthrough end. The insulation of this assembly had failed at the BNC connector.

The cable was fitted with the correct MHV type connector. It was also confirmed after removing the vacuum feedthrough flange that the mating feedthrough was of the correct MHV type.

- We reinstalled the Chain #3 terminal inductor set after they were cleaned.

- The HE second stripper was repopulated with new foils. Only replacing those damaged or broken.

1/7/10 Thursday

- Fortunately we found a problem with the HE 2nd stripper not experienced whilst loading news foils onto it on the previous day. Something in the rotating drive system had become tight.

All the foils were removed from the HE 2nd stripper to facilitate investigation of this problem.

2/7/10 Friday

- The problems with the HE 2nd stripper mechanism were understood to be a binding of a bearing under axial load. Minor disassembly and reassembly soon saw it tuned up and working well.
- The reloading of the 2nd stripper with foils was completed and it was now ready for installation.
- The tank slits were being set to the optical axis and the read back potentiometers zeroed.

5/7/10 Monday

- The second stripper was installed with the counter set at #999 to time the first foil to be "in beam" position #1 and subsequent "odd" numbers.
- Alignment today - The remaining three tanks slits were adjusted to be on the optical axis and their read back potentiometers reset to match this.
- The LE triplet was opened to assess its alignment. This required a new target to be made.
- An audible rattle within the triplet that is energised during the operation of the chains and shafts could now be investigated. We found it to be the loose fit of two components supporting the HV electrodes. The loose fit of the shaft in a hole, once understood, was deemed not to be of any further concern.
- We observed spark and crack marks in the nylon pucks used in the top mounts of the terminal RF protection enclosures. No further attention was put into these during this opening but should not be forgotten.
- The tank cup mechanism and pneumatic actuator was removed from the beam manifold above the LE tube to check that the cup vane orientation was intercepting the beam properly.
- The LE ion pump vacuum readout receiver box inside the main terminal RF enclosure had failed and a blown fuse was found. A resettable fuse was fitted to replace the glass cylinder type fuse.

As a precautionary improvement, to better protect the receiver circuit board it was decided to relocate it to the inside of the inner shielded box. Some rerouting of the optic fibre was required to achieve this.

6/7/10 Tuesday

- The terminal stripper assembly was repopulated with foils and refitted to the accelerator. See foil list.
- The tank cup beam sensing vane was slightly rotated off centre by about 10º. An adjustment was made by loosening and rotating the drive magnet on the pneumatic drive mechanism. A new spacer, 0.060" longer was also added to the vane mounting. This was done to improve the overlap of the sensing vane and the suppressor.
- The LE Triplet was adjusted some 0.012" to correct it's alignment. The triplet was closed and the bellows and fast valve above it refitted.
- The gridded buncher was sighted (looking up) from Level 4 as a check that no debris had been collected on it that may affect beam transmission.

7/7/10 Wednesday

- A bracket was made to mount the LE mid-section vacuum relay receiver board within the terminal inner RF enclosure.
- We removed and cleaned the casting idler assemblies from Unit 16. Mounted new idler wheels and refitted them in the machine.
- The LE mid-section vacuum relay system transmitter board was mounted in its' diecast box.

8/7/10 Thursday

- Started working on pulling in two new optic fibres that run from the bottom of the 14UD to the terminal.
- We pulled in a new fibre from the LE mid-section to the terminal as we had accidentally broken the existing fibre. This fibre sends the LE mid-section ion pump vacuum readout to the Group 3 system.
- All the dismantled joints on the vacuum systems had been closed and we were now ready for pumping.
- The initial attempt to evacuate the accelerator tube from level 5 was unsuccessful due an overlooked opening. Being late in the day anyway, it was thought best to start this work with a clear mind next morning.

9/7/10 Friday

- The level 5 isolation valve was found open. Now that we had a “completely” closed system, slow evacuation with a portable roughing system was comenced.
- The Le and He sublimer pumps were opened to the roughed down system to assist pumping when the pressure was low enough.
- The evacuation of the tube progressed well and was opened to the turbo pumps at level 5 and the ground level Line 0.
- The terminal gas stripper turbo pump backing line traps were baked for 2.5 hours during the pumping procedure once the turbo pumps were on line.
- The HE tube thermocouple gauge was not working. The EU repaired a fault within the controller and it was promptly returned to service.
- The optical fibre end plugs were glued to all the new fibres ready for final polishing.

12/7/10 Monday

- Leak testing commenced with the leak tester backing the Level 5 Gas Source turbo pump. Initial testing of the many new vacuum joints resulted in no leaks being found.
- A problem was found with the leak tester connection valve at the backing line. It was not opening, though the spindle was screwed out.

Initial test results were discarded and further leak testing was thwarted until the background of helium was pumped away.

- Refitted the heavy wire “owl” paper clip like pieces to the PFA tube where it passes through the terminal. These impose a series of deflections to the PFA tube over a short distance to deliberately impose grounding contact of the fibre with the bore of the PFA tubing.
- Closed the HE mid-section stripper suppressor power supply box.
- The PFA tube within U19, HE mid-section carrying the optic fibres had more bends imposed in it to improve the deliberate contact of the fibre with the PFA tube.

13/7/10 Tuesday

- There was a signing ceremony in Melbourne for The Australian Collaboration of Accelerator Science, ACAS. The collaborators are the ANU, Melbourne Uni, ANSTO, and the Australian Synchrotron - Melbourne.
- Repeated the leak testing of the tube and all other disturbed gasket joints.
- A leak was found and repaired on a gasket joint above the tank at level 4.
- A leak across the seat was also found on the roughing valve on the HE sublimer pump. For the sake of moving forward this valve was simply capped

off with another valve and the offending unit opened to be included as part of the system.

14/7/10 Wednesday

- Installed two new DC idlers, located in the terminal on Chain #3.
- Testing of the completed the installation of modified circuit board of the LE ion pump vac repeater system showed there was still had a problem. The EU technician took the boards away and returned them for reinstallation.

15/7/10 Thursday

- Completed testing of the LE vac readout. The computer display in the control room shows sensible values.
- Closed the LE mid-section shielded box that contains the LE ion pump vacuum readout transmitter box inside it.
- Refitted resistors to Units 1 and 2.
- In U19 we replaced the wire loop and the resistor assembly end nuts due to discovering burnt banana plugs and sockets on some column resistors. Gap 6 lower resistor and gap 12 lower resistor.
- Closed Unit 19 including the split disc capturing the PFA tube as it passes through the casting.

16/7/10 Friday

- Tested chain operations and strobed the DC idlers.
- Slight oiling of chain #2 smoothed out the signal from chain inductive pickoffs.
- The LE Mid section was closed.
- More casting covers were fitted.
- Cleaned and closed some HE units that were open.

19/7/10 Monday

- The terminal was closed.
- More casting covers were refitted.
- Chain #3 was run over the weekend. It was deemed necessary to shorten the chain by two pellets/links following this initial operation.
- Chain #3 had a small amount of oil applied to it by hand with similar effect seen with chain #2.
- Chain #2 "up" pickoff wire broke off at the fixed end cable connection. This was soldered back together.
- The column was blown down as part of our exit cleaning procedure.

- A loose stringer was found in Unit 18, tube end during the blow down and was fixed immediately.
- The column was wiped down with chamois, water and RBS detergent.
- The 30kV grouped column gap testing was completed. This test did find we had neglected to install one wire loop between a pair of resistors in Unit19.
- Chain charging tests and were completed and the machine was closed.
- The tank was evacuated overnight ready for gassing up the next day.

NEW PRECISION NEC ACCELERATOR TUBES

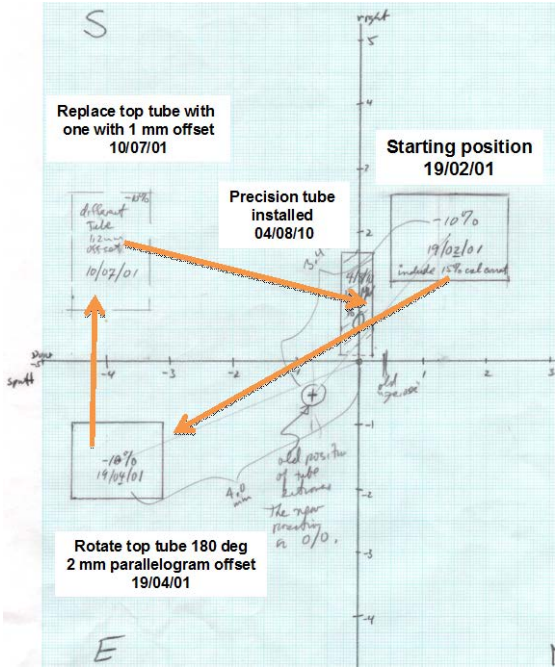
It has been necessary for many years to present the beam with several mm of offset as it enters the accelerator. The transmission has never been better than ~70%.

We hoped to correct these problems by replacing the first two units of the accelerator tube sections with new NEC Precision tube sections.

Six new tube sections were installed during this opening.

The geometrical accuracy of the current generation of NEC tubes is significantly improved over the old tubes. The old tubes had been measured to have an eccentricity, end to end, of up to two millimetres.

Several attempts to resolve these problems have been made in the past. The illustration shows the beam position with the tank slits clipping the beam by 10%.



In April 2001 the first accelerator tube section (11-gap), was rotated 180º deg. This changed the offset position by ~180º also.

The first tube was then replaced in July 2001 with one with a 1mm eccentricity.

This resulted in a change of the beam position, but did not move it any closer to the geometric axes.

Post opening tests show the new precision tubes have significantly changed the position of the beam entering the accelerator to be much closer to the geometric

axis. Disappointingly, the expected improvement to the beam transmission through the accelerator does not match favourable change in the beam position.

TUBE IDENTIFICATION NUMBERS - NEC TUBE SECTIONS

NEC tube section's are allocated and identified by a QA and Tube Number. The tubes geometrical accuracy is recorded against these numbers. The geometry recorded is the non-parallel value and the skew. The sum of these two in thousands of an inch is used to give a "score" number. The smaller the score number the more accurate the tube. The non parallelism of each tube is alternated to compensate with each other. See NEC page below.

NEC SUPPLIED TUBE DATA AND NOTES FOR INSTALLATION

CANBERRA 11 GAPS 2FA025540 (P/0RDER 2010-00186)
PROPOSED RUBE CONFIGURATION

	QA (S.N.)	SKEW	NON PARALLEL	TOTAL "SCORE"	LOCATION IN THE 14UD
LONG	4105	0.003"	0	0.003"	UNIT1, T1
SHORT	4103	0.004"	0.003"	0.007"	U1, T2
LONG	4108	0.004"	0.003"	0.007"	U1, T3
8 GAP	1898	0.005"	0.010"	0.015"	U4, T4
SHORT	4109	0.006"	0.001"	0.007"	UNIT 2, T1
LONG	4104	0.005"	0.003"	0.008"	U2, T2
SHORT	4106	0.005"	0.003"	0.008"	U2, T3

- ALL THE TUBES ARE ETCHED ON BEAM ENTRANCE END.
- TUBES MARKED LONG ARE ETCHED AT THE RED DOT, "LONG" SIDE OF THE TUBE.
- "SHORT" TUBES ARE ETCHED 180 FROM THE RED DOT.
- TUBES SHOULD BE ALTERNATING LONG AND SHORT AND ALL ETCHING ON THE SAME SIDE.
- TUBES WILL BE ASSEMBLED USING CUSTOMERS END SHIMS

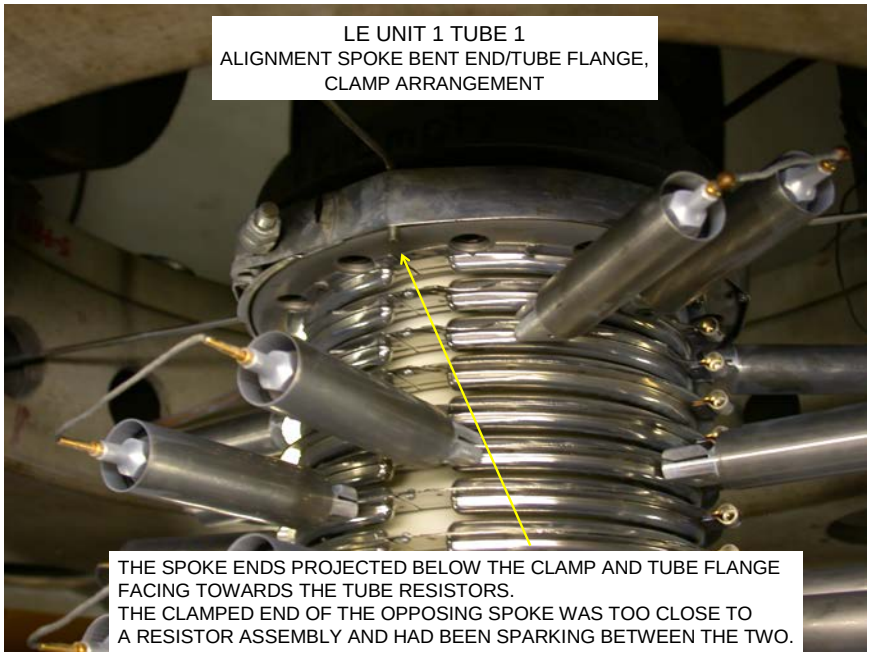
The identifying numbers for the first three 8 gap tubes in the 14UD column were sent to NEC. NEC confirmed from their records the "score" value of each tube. This identified the suitability of an eight gap tube to be used in conjunction with the six new 11 gap tubes for Units 1 & 2.

All three of the accessible 8 gap tubes we had selected were of acceptable accuracy.
The installation, alignment and the arrangement as per NEC instructions of the new tubes was completed. The eight gap tube retrieved from U1-2 was put back in the location it was removed from but with consideration of matching it to the alternating of "long-short-long-short-long-short-long" markings on the new tubes.

TUBE ALIGNMENT SPOKES, UNIT 1

Most tube alignment/support spokes are clamped where there are two tubes end flanges bolted together. The paired flanges provide a wide surface to clamp the bent over spoke end against. In this situation the spoke end doesn't project beyond the flange face nor is it too close to any resistor assemblies.

The Unit1 Tube 1 arrangement is different. The alignment spoke attachment to the top tube flange of the first tube in Unit 1 is clamped to a single tube flange only. The clamp is positioned symmetrically over this single flange and the typical spoke end projects below the tube flange. The downward facing spoke end in one position, around this tube, had been too close.



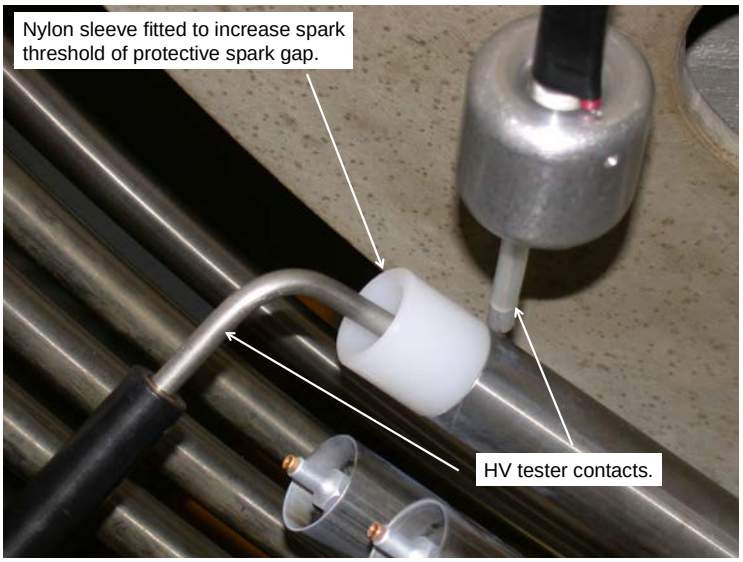
This allowed spark discharge to the resistor assemblies mounted across the first two gaps, although, possibly only during abnormal column or terminal voltage discharges.
At this location the bent spoke end was shortened by ~5mm.

TUBE BAKING

The six new tubes were baked under vacuum for almost two hours.
Two 300 watt tapes, one tape per three tube sections, were turned on with the vacuum at ~5 X 10-6. Immediately, the pressure was seen to rise toward 6 X 10-6. The heat was left on until the pressure was seen to be 4.6 X 10-6.

HIGH VOLTAGE TESTING OF RESISTORS

HV resistor testing of the column and tube resistor groups was performed first thing on entering the tank.
No abnormal current values where recorded during the test done on entering the machine. We have tended to record the test value and only compare it to previous test results. There are some resistor group test values like in U26 T3 = 7.5µA that we have overlooked that are a little outside the trend of 7.1µA. We chose to conduct individual resistor testing of the resistors in the U26 T3 group. They tested with acceptable values no worse than a 1% deviation from their specification. Some individual resistor testing was done with the resistors still fitted to the tube.



Where we were removing the tubes in Units 1 and 2, all the tube resistors would be removed and could be tested outside the machine at the workbench.
The original resistor specified tolerance of our resistors is 2%.
We had a maximum deviation from the specified value of +3.2% and – 11.3% for the tube resistors of which the worst five were replaced and for the column resistors a deviation of +8.55% and -1.52% of which two were replaced.

COLUMN POSTS

There were no refurbished posts ready for installation during this opening.

STRAIGHTENING UP THE COLUMN

We pursued the idea that the column is slightly curved like a banana and that adjusting the casting jacking screws on the concave side of the column to expand its length would move the stripper canal back to the optical axis. The optical alignment axis used for this is from the telescope at L4 looking to the target at the analysing magnet.
The idea is to preferentially extend the length of the column post stacks by tightening the casting jacking screws one at a time whilst observing the change

with the telescope until we have the stripper canal back on axis. This was achieved!!
The degree of tightening imposed by each jack is done by "feel" and the goal was for them to be "Tight". An adjustment would only be done where they were less than tight. Comments made during several individual tightening operations include starting with "loose", tightening to "firm" to "tight".
The jacks adjusted were noted in the order of which they were adjusted.
Post "C", Top U15, Bottom U14, Top U13, Top U17 Top U20, Top U9 and Top U19. Post "B", Bottom U14, Top U15, Top U17
Post "C", Top U17, Tup U18, Bottom U14, Top U13, Top U10, Top U9.

The program of refurbishing individual column post assemblies has been underway for many years. The post removal requires the removal and replacement of the casting support jacking screw to access the post end to casting fasteners. The jacks are installed in line with the axis of the column posts and extend to support between the casting plates. The resetting of the casting jacking screws is not a precise process. Therefore, it is unlikely that uniform compression is maintained within the post stack. We had thought for years that we would have accumulated many small changes that would degrade the straightness of the column.

CHAIN #1
Chain 1 had been operating normally so, other than cleaning and setting of the inductors, no other checks were performed.

CHAIN #2
The twist of ~ 45degrees in the free hanging chain, seen and reported during the last tank opening was not reassessed this opening. Chain 2 appeared to have similar lateral movement, between the guiding casting idlers, and pin movement as last opening.

During the chain charging tests Chain 2 was hand oiled, whereupon, the pickoff traces became smoother. NEC informed us that they use an oil called Krytox® when chain oiling is required.
Chain #2 motor travel stop leg to tank gap measurement was ~30mm and we expect it will require shortening next opening.

CHAIN #3
The new Chain 3O (letter "O") was installed along with new chain wheels, sheaves, casting idlers and DC idlers in the terminal.

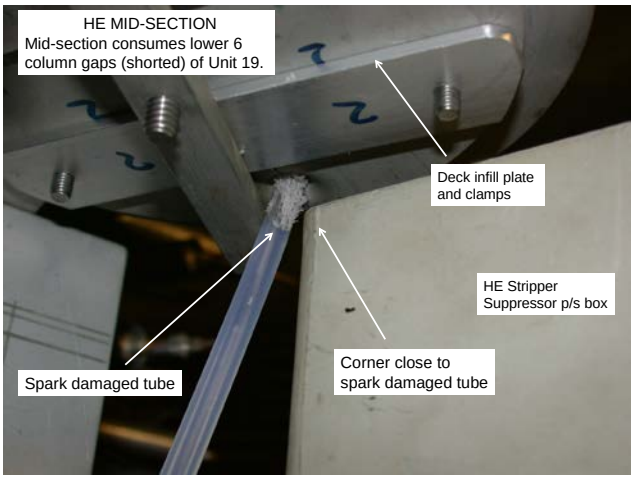
The new set up gives us a second chain running on conductive sheaves without shim stock.
The new chain was supplied in two major assemblies and these are made up of several minor assemblies joined with screw type link pins. We replaced all the screwed link pins with drive rivet type pins in accordance with our usual practice.
The chain was hung in the tower stair well to assess if there was any twist in the assembly. There was a left hand twist of about ~45º over the full length of chain. This is much less than the previous new chain installed during TO# 111 which had a RH twist of ~80º over half its length.
The new chain was installed with a total of five pellet/links removed. Three removed during the initial installation and two after running over a two day weekend.

The old chain was removed to storage and will be kept as a serviceable spare. It is identified as Chain # 3L and has a total of 63.2k hours.
The chain #3 hour meter reading at the time of installing the new chain was 11039 hours.
During the chain charging tests this chain was also hand oiled and, again, the pickoff traces became smoother.
Chain #3 motor travel stop leg to tank gap measurement before closing the tank was ~81mm.

CHAIN DRIVE MOTOR #3
This motor had a noise in the main shaft bearing. Both bearings were replaced. We chose to disassemble the motor in situ leaving the main chassis and front casing in place. This approach saved electrical disconnection and disturbance of the aligned position of the motor. This also saved removing the heavy whole assembly out through the tank port. A small amount of Loctite was applied to the main shaft bearing outer surface as it was deemed too loose a fit.

OPTICAL FIBRE COMMUNICATION

As part of a Group 3 communication and control system installation, during TO #81, a pair of optical fibres were installed to communicate with hardware housed in the terminal of the accelerator. The bare fibres pass through 0.25" Swagelok PFA tube for mechanical protection.



We found spark damage to the PFA tube in the HE mid-section. The communications system was still working without any noticeable problem. The fibres were suspected of being damaged, so they were replaced with new ones. The old fibres were used as "pull throughs" for the new fibre. Temporary joints were made by gluing with superglue and covering with heatshrink. The two joins were offset one above the other so that the pair passed through the PFA tube with a simultaneous pull and push approach.

The new fibre was drawn in up to the mid section to an existing Swagelok joiner in the casting at the bottom of Unit 19. The temporary joint was now cut. This offered a discontinuity of fibre at the mid-section to allow the removal of the damaged PFA tube. A new piece of PFA tube was fitted, bridging one Unit (U19). Nylon Swagelok connectors were used to make joins within the protection of the castings.

The fibres were joined again, and then pulled through to the terminal.

The end plugs where glued and polished in the terminal and the tank bottom.

At the terminal a small torch was taped to the end of a fibre to confirm the transmission/receive ends were correct in the bottom of the 14UD.

All systems were tested thus completing this task.

LE MID-SECTION, VACUUM READOUT

Time constraints during the last tank opening had prevented us from solving an ongoing problem with the LE mid-section vacuum readout.
The LE mid-section ion pump vacuum reading is transmitted to the terminal via a simple optical fibre transmitter and receiver. This in turn is then sent via the Group3 communications from the terminal to the control room for video display.
Initial investigations found the blown fuse on the receive board. Both the transmit and receive boards were removed

HE SHAFT ALTERNATOR POWER SUPPLY
During the last opening the thermal overload unit for the shaft driven alternator power supply had fail and was replaced. A check of the total current drawn from this alternator was not done as we had planned.

TERMINAL FOILS
We were evaluating carbon foils supplied from Micromatter, Canada. Muirhead and Heighway had experienced difficulties floating and mounting the carbon foils from both Germany and Canada.
Collodion was used on the Micromatter carbon to assist the mounting on foil frames. This would appear to be normal practice. A small test sample of German foils has also been mounted using collodion.
The variety of foils for us to use and test is shown in the detailed list as they were loaded in the stripper foil assembly.

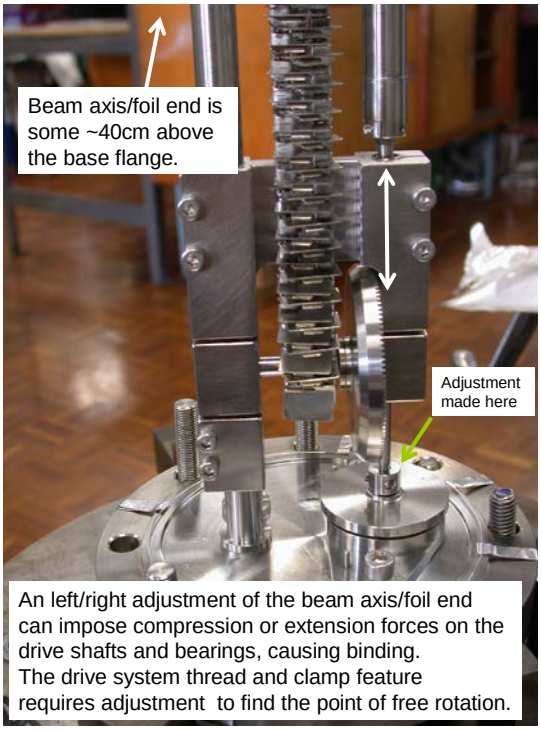
The foil changer was reloaded with a mix of foils as follows.

No. 2 to 6	**4 μg/cm2 Ablation with collodion, baked off**
No 7 to 11	**4 μg/cm2 Ablation with collodion left on**
No 12 to 26	**4 μg/cm2 Micromatter, Canada**
No 27 to 45	**4 μg/cm2 Micromatter, Canada with collodion**
No 46 to 56	**4 μg/cm2 Micromatter, Canada with collodion, baked**
No. 57 to 89	**2.3-3.5 μg/cm2 ANU foils**
No. 90 to 261	**4 μg/cm2 Ablation foils**
No 262 to 280	**2.3-3.5 μg/cm2 ANU foils**

SECOND STRIPPER - SUPPRESSOR (HE MID-SECTION)
The HV suppressor associated with the second stripper wasn't working. Investigations found the HV electrical electrode arrangement.

SECOND STRIPPER - STICKING OPERATION PROBLEM

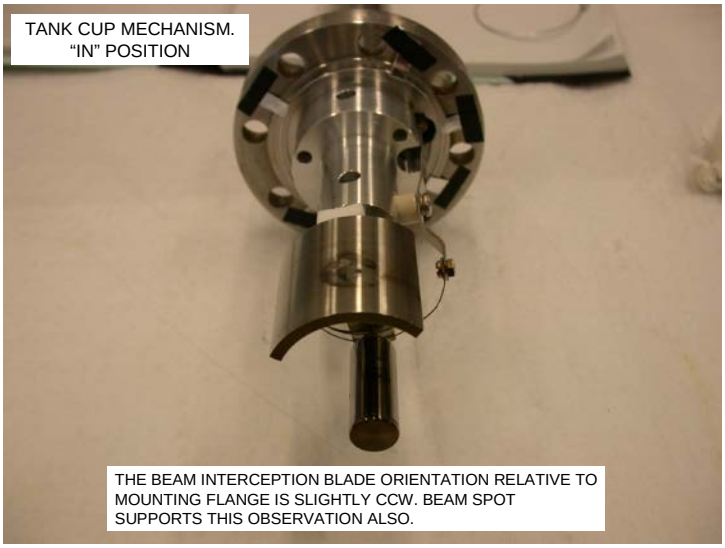
Fortunately, we found a problem with the second stripper before it was reinstalled in the machine. The problem was not evident whilst loading new foils on the previous day. The 2nd stripper mechanism was found to have sufficient drag to actually skip poles of the magnetic drive coupling.
It was thought that there was an adjustment made to displace the end that presents the foil to the beam axis during the last foil replenishment in 2006. Making an adjustment like this will either compress or tension the bearings on the drive line side of the column structure and the tension must be relieved by later adjusting the drive coupling.



An left/right adjustment of the beam axis/foil end can impose compression or extension forces on the drive shafts and bearings, causing binding.
The drive system thread and clamp feature requires adjustment to find the point of free rotation.

THE TANK CUP

The tank cup was examined to confirm the beam interception blade (cup) was mounted correctly to intercept the whole beam.
The rotational relationship of the vane part of the Tank Cup was slightly wrong (~10degrees). An adjustment was made to this by removing the pneumatic cylinder that also carries the external six pole magnetic coupling. The magnet is only held to the drive shaft by a centre bolt. Loosening this bolt allows a rotational adjustment to be easily achieved.



THE BEAM INTERCEPTION BLADE ORIENTATION RELATIVE TO MOUNTING FLANGE IS SLIGHTLY CCW. BEAM SPOT SUPPORTS THIS OBSERVATION ALSO.

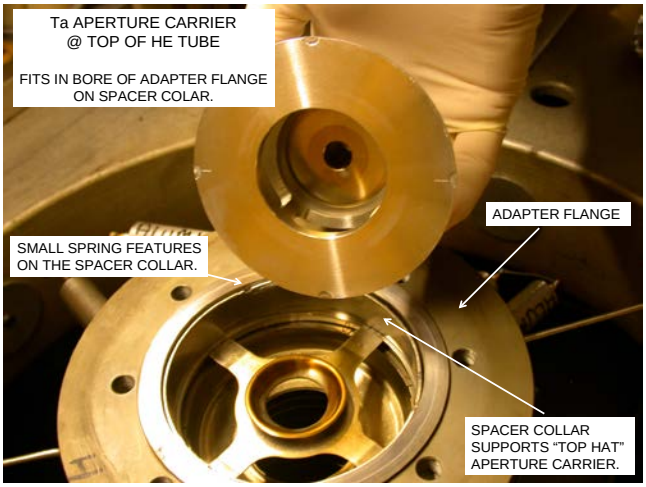
Weisser and others examined the beam spots on the cup and it was decided that the position of the cup element could also be better centred across the beam

axis. This was achieved by fitting a new spacer 0.060" longer than the existing one.

HE Ta APERTURE - ON TOP OF HE TUBE

The bellows bottom flange fastens to a short adapter on the top of the HE tube. The bellows to adapter flange combination captures and aligns an aluminium carrier for a Ta aperture.

The carrier shape is like a “top hat”. The thin flange of the top hat was slightly loose in the bore of the adapter. To rectify this, the thin flange was pinched at 4 points on its periphery to expand small (dia ~8mm) tags. The tags could be machined true and to a slightly larger radius which better matched the counter-bore in the bellows flange. Axial clearance is taken up by the small raised fins on the supporting collar.



7-06-10 AGM	MACHINE HOUR METER READINGS					
READING DATE	CHAIN #1	CHAIN #2	CHAIN #3	LE SHAFT	HE SHAFT	CH VOLTS
7/6/10 TO # 113	11039	11055	11039	20529	20529	12171
25/8/09 TO # 111	9341	9341	9342	17754	17753	10312
CHANGE IN HOURS	1698	1714	1697			
ACCUMULATED TOTAL HOURS (K)	20.2k	1.714k	63.2k			

ALIGNMENT TASKS PERFORMED DURING TANK OPENING 113

7th June- 20th July 2010

Al Cooper, Gareth Crook

Results and diagrams are in Alignment Book #3 7-06-10.

LINAC

07-06-10

Beam tests on the 31st May, through the Linac Image Slits, had confirmed that the beam from the Analysing Magnet needed to be raised in order to maximise transmission along Line C.
Further, it had been found that the beam was required to be steered upwards once through the Super Buncher in order to maximise transmission into the Linac.

The names of alignment target features are generally made up using the initials of their long name. Wall (Wall mounted plate) and Ball (Taylor Hobson Cup) followed by the compass direction is common. Therefore WALLEN is the wall mark on the north end of the east wall of the Linac Hall. WALLNE is on the east end of the north wall. Glad I cleared that up.

The first task was to let up and open the line between the Analysing Magnet and the 90 degree Achromat.

Shielding was removed from Acromat so that there was a line of sight through the vacuum system from the Analysing Magnet (BALLAM) to the Eastern Wall Mark (WALLEN). Bellows were removed at Big Red East (BRE) and adjacent to the Big Red West Wall height datum.

The steel Theodolite tripod was used to hold a Temporary Ball Cup (TBC) in line adjacent to Big Red west wall (BRW) and viewable from BALLAM.

TBC was set at the height of the BRE ball using the Taylor Hobson. The Wild Level was set up between the BALLAM and the Image Slits. It was then zeroed on BRE in order to compare the height of BRE, TBC and BALLAM.

The Wild Level was zeroed to BALLAM and then used to check the horizontal scribe mark on the side of the Analysing Magnet.
The scribe line is marked A at one end and B at the other. A to B is in the direction of beam travel. Viewed from the Wild Level, A is to the left and B to the right of the operator. BALLAM was found to be 0.013” lower than A and B a further 0.013” higher again.
Therefore, B is 0.013” higher than A so, the scribed line is inclined upward at 0.108 degrees. It is not known if this angle is similar when the magnet is swung toward the Linac. This angle would give a height change of 0.220” per 10 feet of travel so the current settings can compensate for the angle adequately.

This angle should be measured as the magnet swings from Linac to 14 UD Target Room.

The Wild Level was then moved to a location that would allow Big Red Pole Datum (BRPD), TBC and the BRW datum to be viewed and heights compared. This is the most direct comparison yet, of BRPD and BRE. The readings put these within 0.002" so, certainly in our preferred tolerance range.

This survey set is the most direct optical data set yet done and measures BALLAM at 0.006" below BR Datum. Notably, the average of water level readings taken in 2009 placed BALLAM 0.004" below BR Datum. BALLAM was raised 0.006" by rotating cup approximately 36 degrees. Note, that this does not change the Analysing magnet in any way.

The Taylor Hobson was placed on BALLAM and zeroed on BALLNE for the purpose of component x axis correction made necessary since BALLNE was moved North EAST during the Acromat correction of
16-02-10.
BRE was found to be 0.020" south (right) and this is approximately proportional with the above mentioned 0.055"move north east of BALLNE.
The Aperture after the Superbuncher, 10-06-10, was found to be 0.050" south so, this was moved north onto the new optical axis.
It was decided to leave the Iris at 0.025" south as it is open most of the time and will not effect transmission.
The Superbuncher was left alone and will be assessed during beam tests.

When the Taylor Hobson is zeroed on BALLNE then BRE appears to be 0.017"low. Since all evidence suggests that the beam needs to be steered upward to optimise line B transmission and also entry into the 90 degree Acromat, the Image Slits will be surveyed with respect to BALLNE.
Further level checks need to be done.

The Top Jaw was brought to micrometer zero, it read 0.009" low.
The Bottom Jaw was brought to micrometer zero, it read 0.010" low.
The Bottom Jaw was found to have 0.008" of play. After being held up against gravity it drops down 0.008" once released. Force on the bellows once vacuum is re established will raise the jaw 0.008" so, this needs to be allowed for. This means that the Bottom Jaw is really 0.002" low.

<u>Setting the Image Slits for the next run.</u>

Since the Top Jaw is open 0.009” with respect to BALLNE and 0.030” open is required. So, 0.009”+ 0.030” = 0.039” on the micrometer.

Now the Bottom Jaw is low 0.010” due to weight. Set it at inwards 0.002”.
Now 0.002”+ 0.008” = 0.000”
Now back it out 0.030” and the micrometer reads 0.028” but the Jaw is open 0.030”.
Summary, Top Jaw open 0.030” reads **0.039”**.
Bottom Jaw, under vacuum, open 0.030” reads **0.028”**.
Above is with respect to BALLNE and based on dubious height readings across the hall. It was convenient and expedient that the apparent error led to raising the Slit settings because it agreed with findings during the test run.

Another point of view on the height of BALLNE.
The Wild level was set up close to the East wall of the Linac Hall so that Ball Temp, BRE and BALLNE could be viewed. This is optically a better sight than the previous sight from BALLAM to BALLNE using the Taylor Hobson.
The Wild was zeroed on BRE and then Ball Temp was found to be the same height whilst BALLNE was 0.008” high. This is approximately half the error of 0.017” found in the previous section. At least it agrees in direction and shows that further work needs to be done on levels.
It is hoped that we can move to Laser Tracking technology in the future.

14 UD TUBE
15-06-10
The Super E Taylor Hobson adaptor was used to mount the telescope.
It can be found in the Super E cupboard.
16-06-10
Zeroed Taylor Hobson on stripper canal and checked the top of Tube #1.
It was realised that a view right through the machine would be necessary so that the Stripper canal could be moved in the same setup as recording the Tube section positions. The target that fits the Theodolite mount at the Analysing Magnet required work. The target rings were widened and blackened. White out was painted on the bottom so that there was a white background for the black rings.
The target could now be seen fairly clearly from Level 4, so the Telescope was zeroed on the Analysing Magnet Theodolite Mount.

21-06-10
The Tube sections were then surveyed.

Tube #1
Unit 2 Tube 3 was aligned into place.
23-06-10
The Terminal Stripper canal was measured to be Left (x) 0.027" and Up (y) 0.015" with respect to the marked Slit directions on top of the tank lid.
The Column post Jacks were tightened to force the Canal into position, first Posts at C then at B.
It was noted that the 12mm Aperture at the top of the High Energy tube was off Right (x) 0.012" and Down (y) 0.033".
The Aperture was removed and it was discovered that the holder was not being held in place securely or accurately. The Holder was machined and the Aperture was reinstalled and found to be satisfactory.

LOW ENERGY QUAD TRIPLET
The Quad was opened primarily to investigate a rattle that has been puzzling staff for quite a while.
It was found that the electrodes are sitting in place rather than clamped or bolted and that they would rattle when pushed back and forth.
Since this is a feature of the design, and difficult to improve, it was left as is for now.
The original top and bottom electrode targets were found to have a 0.009" difference in diameter and since the lower one was the larger of the two it could not be placed in the bottom while working from the top. A new target was made to suit the top and four pads of electrical tape were attached so that it could be slipped past the top electrodes. Once down at the bottom it was rotated 45 degrees so that the electrical tape took up the size difference.
The Quad was aligned to within approximately + or – 0.003".
This work is described in alignment book 3, 06-07-10.

LEVEL 4 OBSERVATION OF BENDING MAGNET TARGET
The Theodolite was set up on the alignment mount at the top of the 14 UD.
The target was placed in the Ball Mount on the Bending Magnet.

The Gridded Buncher was scrutinised for grid shift or foreign material that may impede the beam. No anomalies were found that would explain transmission problems.

It is well understood that the Tower moves relative to the 14 UD due the outside weather conditions. The tower walls that receive sun light are heated

considerably and subsequent expansion of the concrete moves the top of the tower millimetres.
The largest movement appear too be south east at about 2 pm. This will be the subject of further study in the near future.
The present measurements of the position of the Bending Magnet using the Theodolite, mounted on top of the 14 UD, will only be fully meaningful once the Tower movement is fully understood.
Measurements taken 07-07-10 are indicative of the problem.
Results are shown in Alignment book 3 but are mentioned here anyway.
It is not known how vertical the 14 UD is so the result is further clouded by that.
The Magnet Target was found to be 3.03mm south and 0.44mm west at this time.

It is intended that instrumentation be purchased that will allow real time logging of tower movement and even development of computer compensation for use during operations.

LASER TRACKERS
Laser Trackers will change the way we approach alignment. It would allow precision setting of wall marks and ball cups as well as the addition of intermediate ball cups. These will reduce the range of optical through sights thus improving accuracy.
Externally targeted items such, as, magnets and the Linac may be done as well.

Al Cooper

INITIAL PERFORMANCE
The accelerator initially conditioned to 13.8 MV over a one week period and was a bit of a struggle. Spark activity was in the gas space not the vacuum tube.
The tank gas pressure was 100psi at this stage.
We had purchased 1000kg (20 cylinders) of SF^6 to add to the 14UD.
The tank pressure was raised to 104psi and conditioning voltages could now be pushed to 15MV. The tank sparks were now more disturbing to the vacuum.

It is now a month after the tank opening and preparations are under way for the 14UD to inject beam into the LINAC. The stability of the 14UD is not ideal with small sparks disturbing the terminal voltages. For this LINAC run there hasn't been enough time available for conditioning.