AUSTRALIAN NATIONAL UNIVERSITY

DEPARTMENT OF NUCLEAR PHYSICS

14 UD TANK OPENING REPORT # 110

29th January to 19th February 2009

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REASON FOR TANK OPENING

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

Use dust counter to assess dust concentration in machine before cleaning while running shafts and chains.

The Terminal Stripper requires a new inventory of ablation foils and the foil positions are to be recorded in new FoilMap book.

Test the emergency light for battery duration.

Check tank slits operation, note wiring versus slit position.

Check calibration of terminal ion pumps current read out.

Investigate and repair 2nd stripper control and electronics.

Improve spark protection of second stripper electronics.

Clean the machine column and walls thoroughly.

Remove rings from sections, clean accessible surfaces and between rings.
Use dust counter to assess dust concentration in machine after cleaning.

PUMP OUT 28-01-09

- Pump out tank, open doors and start ventilation system.
- The ventilation system was run overnight and the Oxygen monitor was used to check air quality before entering the machine.

SUMMARY OF WORK: 29-02-09 to 19-02-09

29-01-09

- The emergency light at the top of the tank and the platform safety lights were tested and found to be operating.
- The initial cruise down the column found the machine extremely clean. Other than a few spotty leads no obvious faults were found.
- The High Voltage tester was used to perform the usual 30 kV gap test.
- The column was wiped with RBS and water.
- Charging Chains were inspected and it was decided that removal of a link from Chains 1 and 3 would be required to restore motor leg to tank clearance.
- The tube was let up during the initial tests.
- The HE Stripper control box was opened to inspect for evidence of spark damage.
- Dust counter logs #8,9,10,11,12 and 13 performed.
- It was decided to restrain the terminal spinning service brackets that, in the past, had been prone to vibrating out while machinery was test run. Heighway introduced an elegant solution using ¼" nylon hose and an SMC Quick Fit joiner to form a loop around the four brackets.

2-02-09

- The Terminal Stripper was removed. (000) Foils at #203.
- Mid section deck marked out for reshaping to improve anti spark properties.
- Designed new column post anti spark rings for mid section.

- Toured 4 staff through the machine 12:00-12:45.
- The resistors were refitted to the mid section.
- It was noted that the HE Mid Section control box lid gasket had spark marks next to both the inner and outer edges. There was no sign of spark damage inside the box.
- Glynn Whitworth from the OHS Unit toured the machine.

3-02-09

- David Anderson soldered the new 8 pack Pi Filter connector between the 2nd stripper foil changer motor and the control box wall.
- The terminal was inspected and it was found that Chain #1 DC idler on the up side was set too tightly against the chain pellets. This was adjusted to the correct tension. There was no obvious damage to show for the period of tightness, most probably, since last opening.
- The terminal foil changer was reinstalled with the counter showing 000.
- Operation of the LE slits was checked and it was confirmed that the wiring of the read back for slit position was correct. The mix up was put down to a software problem.

4-02-09

- One link was removed from Chains 1 and 3 as the above mentioned elongation had reduced motor leg clearance to an unacceptable 20 mm.
- The resister banana plug ball to wire joint was found to be all but severed in Unit #5, Tube #4, Gap #5 and was repaired.
- The Gas stripper turbo pumps were run up to speed while temperature and speed were recorded. This test was also performed with the controller plugs swapped over pump for pump.
- The column Units 1-8 were deringed and thoroughly cleaned by wiping with RBS and water.

5-02-09

- Unit 9 was cleaned but Units 10-13 were bypassed because they were covered by the parked terminal spinnings.
- Unit 14 was extremely dusty with breakdown product and was closely inspected for possible production sites. Whilst a spark site was found between resistor Tube 1, Gap 1 and the casting nothing particularly stood out.
- It was decided that the unit was usually covered by a spinning during openings and had not been wiped for some time.

6-02-09

- Unit 14 was gap tested using 3kV and the results recorded in the platform book. Details are included in the main body of this report titled, UNIT 14.
- Unit 2, Post D, Gap 4 top resistor had a burned banana plug. The lead and nut were replaced.
- The terminal was cleaned and thoroughly checked for inductor settings and serviceability of all bearings.
- Unit 14 was rechecked in the usual way, after re-measuring, at 30 kV and found to be in the usual range of 7.2 to 7.4 micro amps per 11 gaps.
- Unit 15 had black dust deposits on the top casting at each chain upside position. The deposits are most probably trapped in an oily film. They appear to be deposited in a pattern influenced by electrostatic field as they are sharply defined in a particular pattern. The photos show the different pattern in each chain upside location.
- Unit 15 had a number of damaged column resistor plugs on resistors that face the tube. Gap 8, Top. Gap 10, Bottom. Gap 12, Bottom. Gap14, Top. Gap 16, Top and Bottom.

9-02-09

- The LE tube was vented to facilitate removal of the Gas Stripper Turbo Pumps.
- The pumps were removed and packed to be sent to Javac, the Leybold agent. The contact is Graham Lloyd on 03 9763 7633.

10-02-09

- The new spark resistant radius rings were fitted to the column posts in the HE mid section. The modified deck parts were fitted and all aspects of the anti spark enhancements checked.
- One deck pedestal was removed and radiused to fit in with the new deck geometry.

11-02-09

- The HE mid section was further assembled with particular attention to the spacing of the control box lid with respect to the charging chain.
- The new control box lid gasket was fitted and photographed.
- Further dust measurements were made and recorded. Dust Logs 14 through 19 were performed and the results will be included in the dust log section below.

12-02-09

- The Gas Stripper convectron gauge was tested using the mini rougher pump and the readings entered in the Accelerator log book.

- Closing of units in the HE end began with the Mid Section and all were cleaned in the same manor as the LE end.
- The turbo pump controller was removed to the electronics unit for testing. David Anderson checked the wave-form and found both outputs to be balanced. This will be discussed further under the heading Gas Stripper Turbo Pumps.

13-02-09

- Unit 16 was cleaned and the Tube 3 Stringer was found loose at the tube end.
- Kitchen noticed that the terminal foil counter universal joint grub screw was loose. The counter had been working but could have failed to drive at any time.
- Unit 12 was very dusty with breakdown products and was carefully checked but no obvious or unusual problems were found.
- Unit 13 had a burned banana plug in Tube 1, Gap 11, bottom resistor.
- Unit 10 had a burned banana plug in Tube 2, Gap 11, bottom resistor.
- Unit 11 had a loose stringer at the bottom on the post end.
- The wall of the entire vessel was wiped down by a team of six that included three students.

16-02-09

- The Gas Stripper Turbo Pump Power Supply was refitted.
- The Turbo Pumps arrived and the lower one was fitted.
- The Turbo Pump Trap Heaters were measured for current requirement and wired for baking.
- The upper Turbo was fitted. The RF barrier spring in the electrical plug had been damaged during removal and was carefully refitted as well as possible. Replacement should be obtained for next opening.
- The tube was slowly pumped following the correct written procedure.
- Dust Logs 20 to 22 were performed.

17-02-09

- The Weisser Valve was opened thus connecting the foil changer cavity with the HE and LE tubes.
- Dust Logs 23 and 24 were performed.
- Leak chasing in the terminal was inconclusive due to the operation of the ion pumps so the machine was left to recover overnight.

18-02-09

- Bagging and taping was done and the leak chase resumed.

- No leak response was found after many hours of carefully staged checks.
- The Turbo Pump Heaters were turned on when the tube vacuum was at LE 2.4 x 10^{-7} HE 8.0 x 10^{-8}

19-02-09

- The casting covers were fitted and then the column was blown down using high pressure breathable air. The dust background was measured at every unit during blow down.
- The column was wiped using RBS and water. Three students helped out and found a loose ring in Unit 15 as well as four spark marks, which were polished.
- The 30 kV gap test was done and no problems were found.
- The charging and metering tests were performed and the machine was closed.

UNIT 14

The detailed inspection of this unit included HV testing, at 3 kV, of resistor pairs. The currents ranged from 4.8 to 5.9 micro amps with the average approximately 4.9. The current readings were recorded in the platform book.
The highest reading pair of resistors was Tube 2, Gap 10. at 5.9
The ceramic elements were also checked with all resistors disconnected and it was found that Tube 2, Gap 10, at 0.88 micro amps, was much higher than it's neighbours, typically 0.1 to 0.6.
The highest reading gap was cleaned with water, dried using alcohol and a heat gun. The cleaning removed a faint brown line.
The gap read 0.52 after drying.
Stringer 2 was loose on the tube end and at the rivets on the post.
Stringer 3 was loose on the rivets also.

UNIT 15

The unusual patterns of black dust found at the top of unit 15 demonstrate the part electrostatic fields play in distributing particulates within the machine.
The photos are included for the record and in the hope that comments may be forthcoming as to what is going on here.
The orientation of the chain idlers was not found to be consistent, chain to chain, with these patterns.

CHARGING CHAINS

The initial inspection revealed that chains 1 and 3 had stretched significantly since last opening.

The motor leg to floor clearance, the best indication of chain length, was measured and recorded in the platform book.

Chain 1 35mm, Chain 2 64mm, Chain 3 24mm.

It was decided to take one complete link from chains 1 and 3.

Since two links had been taken last opening it was at first alarming to discover such a large amount of stretch in such a short time.

However, Chain 1 is still quite a low hour chain at around 16000 hours so further elongation is normal. Chain 3 spent many years out of the machine under no tension and, even though it has achieved over 50000 hrs hours, would have shrunk so it is believable that some stretching would take place.

RESISTORS

Spark energy strikes the resistor leads leaving a blackened spot. The spot flags the possibility of a high current having burnt the banana plug and mating socket in the resistor nut. The banana plugs are checked and replaced when there is any sign of degradation of the gold plated surface.

COLUMN POSTS

No refurbished column posts were available for this opening.

The workshop had not completed improvements to the machine jigs.

GAS STRIPPER TURBO PUMPS

The Turbo pumps usually operate in the SF6 atmosphere without fan-cooling. During tests we ran the pumps without forced cooling for less than 30 minutes.

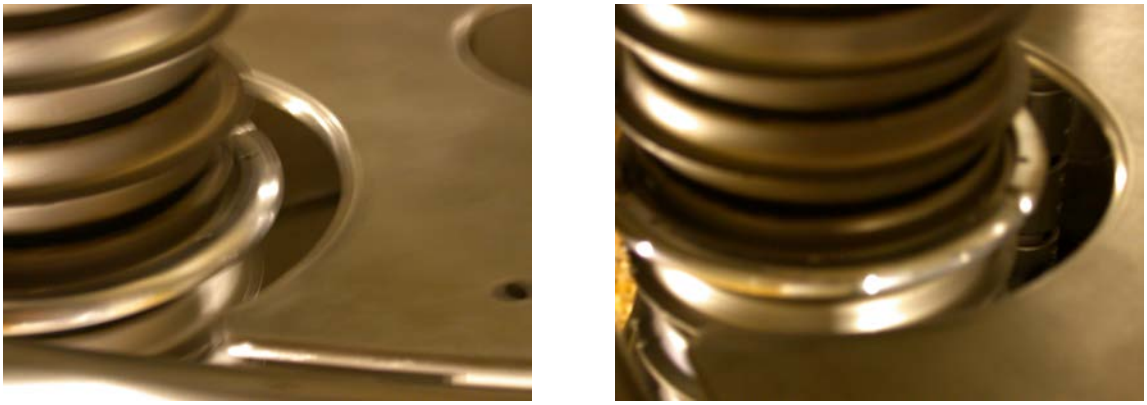
The turbo pumps were removed for overhaul after several run up tests. It was thought that one pump was particularly noisy and that it increased its temperature considerably faster than the other one.
The pumps were shipped to Javac, the Leybold dealer, to have bearing kits fitted and be tested prior to reinstallation in the terminal.
Graham Lloyd of Javac contacted us with the news that, ”they are among the quietest turbos he had heard”. He commented that he was not confident that they would be improved with new bearings. He was requested to run them all day and monitor their condition.
The verdict remained unchanged so it was agreed to reinstall them with the original bearings. It is thought that many more years of service will be achieved.

HIGH ENERGY MID SECTION
The second stripper control had been stunned by a tank spark during the last period of runs. Once again, improvement of the spark protection was required. Apart from fitting Pi Section filters to the, previously assumed safe, last eight wires an open minded approach was required. The obvious strategies were implemented during installation and various not so obvious ones have been employed during several upgrades. This left very little scope for improvement. Closer inspection revealed sparking damage to the plating between the RF gasket and the control box body. Whilst it was not known that one of these, seemingly numerous, breaches of the shield caused the failure, it was an area that should be improved. To that end an RF finger stock gasket was chosen to replace the gauze gasket that had been originally fitted.


SPARK MARKS ON BOX FLANGE


NEW FINGER STOCK RF GASKET

Another area that could be improved and, subsequently altered, was the relationship between the deck and the column posts. All technical witch hunts tend to bring previously unnoticed features to sharp relief.
It was noticed that energy was most probably jumping from the first shorted post electrode over to the deck and from the deck to the control box lid where spark marks were also found the deck and the control box.
The original cut outs in the deck plates were not concentric and the gaps between them and the column posts varied.
It was decided to increase the radius and concentricity of the cut outs. Further, it was decided to add a smoothly radiused ring to the sharp column post electrodes to reduce and smooth field strength between these elements as shown in the photos below. It is hoped that these measures will reduce the incidence of spark energy reaching the deck and therefore the control box.



TWO SHOTS OF THE NEW EDGE RING AND RADIUSED CUT OUT

GAS STRIPPER TURBO PUMP TRAPS
The heated traps are baked out each time the tube is let up.
During the final stages of roughing the tube, at better than 30 microns on a vacsorb, the heaters were turned on. After about 40 minutes they were turned off.
Later, with the shafts on, and pressures of LE 2.4×10^{-7} and HE 8.0×10^{-8} the heaters were again turned on.
The pressure rose over 20 minutes to LE 3.5×10^{-5} and HE 5×10^{-5} and whilst the LE improved to 5.9×10^{-7} within 45 minutes the HE continued to rise to 1.2×10^{-4} when the heaters were turned off.
Recovery to LE 7×10^{-7} and HE 9×10^{-7} occurred within ~3.5 hours.
Predictably, heating the traps at vacsorb pressures was a waste of time.

TANK SLITS

There had been some confusion over the control command and the resultant position of the tank slits.
These were run from the console while observed from the platform.
The wiring was found to be correct therefore the problem was thought to be caused by software.

CLEANING

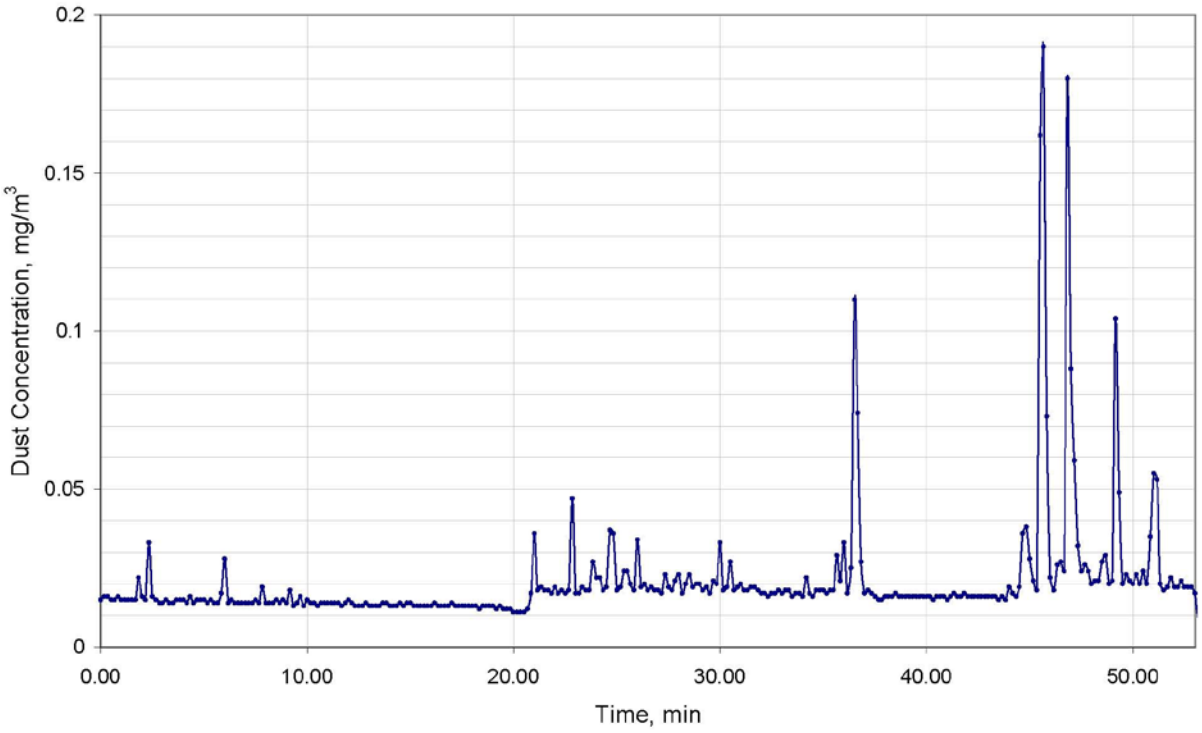
The usual cleaning techniques used during maintenance of the 14 UD, such as, filtered ventilation, blowing down, wiping and vacuuming may be considered as "over the top" in some circles. The policy with the 14 UD has always been to work as cleanly as reasonably practical.

The machine had been sparking more than usual so during this opening the plan was to wipe down the inside wall of the accelerator using RBS detergent in water. It had not been done for many years. This led to a more vigorous than usual cleaning effort throughout the whole machine.
Whenever a sub section of the machine was worked on, or even simply opened, it was blown down and wiped.
All the column units were opened, inspected and wiped down. Wiping was limited to surfaces that could be reached relatively easily and, certainly, inaccessible areas such as tube and post spark gaps were not wiped. Resistors were not dismantled unless they required work so the inside surfaces were not wiped. However, all these inaccessible spaces were blown with compressed breathable air.
During the final blow down, part of the closing procedure, the dust monitor was used to record dust levels at each unit.

DUST MEASUREMENTS

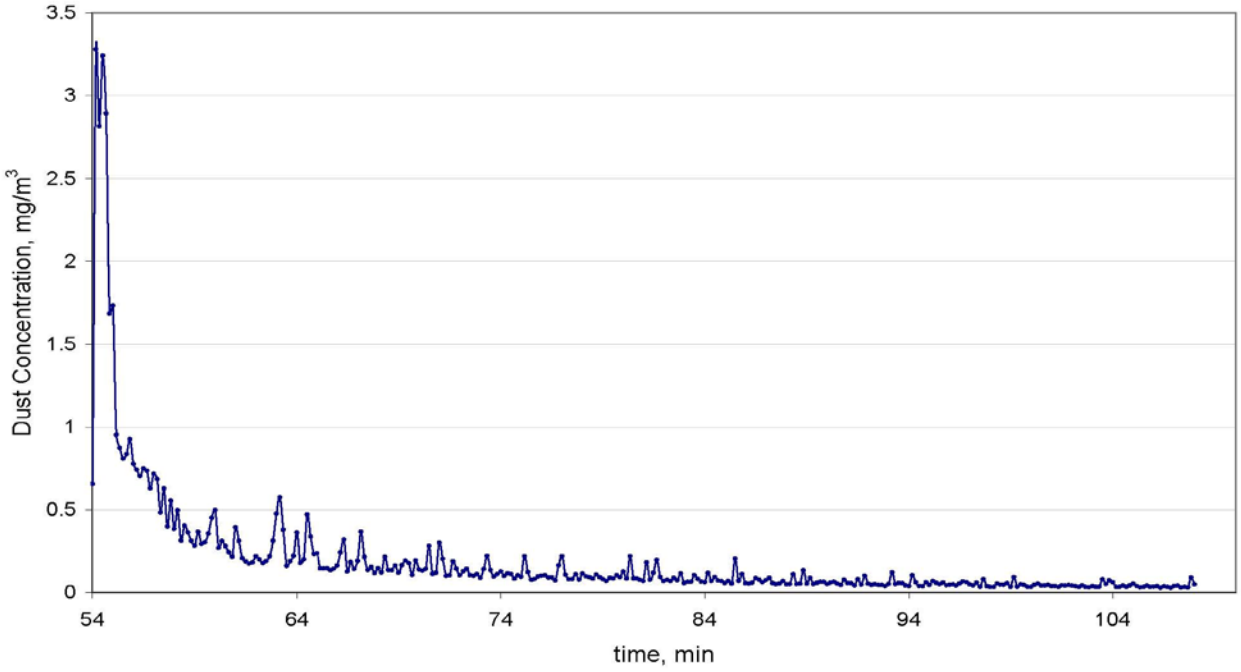
It was planned to use a strong light source such as a film projector to get a feel for the dust load inside the tank.
Fortunately, the OHS Unit loaned us their excellent "Dust Trak 8520 Aerosol monitor" so, quite a few

accurate measurements have now been made.
The above picture shows the dust monitor in use during the final blow down.
The results will be compared with those taken in various clean rooms and other spaces around the lab. Chart below shows dust concentration inside the machine during various operations. Dust measurements were done every 10 seconds.



Zero to 20 mins shows background within the tank, no movement.
Note, a normal office would read approximately 0.01-0.02 mg/m^3
The chart demonstrates just how free of airborne particulates the machine is.
The period, 20 min to 37 min was recorded while blowing air on the tank walls and demonstrates how clean the wall was during test.
The peak at 38 min was taken when blowing a wall recess, eg, view port.
The peaks at 46 min and beyond were due to blowing down Unit 26. Notice the substantial reduction of dust concentration from 0.19 at 46 min to 0.055 mg/m at 51 min as a result of continual blowing down of units.

The chart below records the level of airborne particulates during the blowing down of the column.



The high peak at the beginning records a high dust level caused when the equipment in the top of the machine, above the column, was blown down. The small peaks on graph corresponds to the blowing down of units. Between units the dust concentration reduced to background level. The dust concentration is higher in LE of the machine and lower in HE. This might be explained by the fact that HE section is exposed to oil mist from chains. The surfaces lightly covered by oil act as a trap for dust particles.

The dust concentration then fell as the blow down continued down the column to the last unit.

This reminds that dust accumulates on horizontal surfaces and amongst equipment that is not worked on as often as the column units so these should be cleaned as regularly as the column. Basically the entire dust load liberated from above the column dissipated during the blow down. No further significant peaks, above background, occurred during the blowdown of any of the units.

The machine usually appears to be very clean and this survey now puts numbers to that observation.


AIR CONDITIONING FILTER AT VENTILATOR INTAKE

The above photos show the tank port ventilator that was made and installed in 1978. The fan unit is fixed and the plenum chamber is on rails that attach to the tank port when the machine is open. Sailcloth was used to make a collapsible duct. The plenum chamber is pushed up the rails, to allow staff access, and the fan is controlled by a micro switch at the plenum chamber lock bar.
The filter is air conditioning media found in local fan coil units and is only capable of removing fairly coarse dust particles. The colour of the filter demonstrates that significant air filtering has taken place.
There are heater elements within the fan housing for use in winter.
Note the thick layer of dust on the fan belt shield.
Next opening, the dust monitor will be used to record the particulate background at each tank port.

TERMINAL LEAK CHASING

Flange joints of the Gas Stripper Turbo Pumps were taped and helium leak chased. There was an immediate response of two ranges at the leak chaser and, whilst it recovered one range quickly, further leak chasing was not possible until full recovery was achieved. The system was pumped overnight and found to be recovered by next morning. Terminal components were carefully bagged with plastic and tape so that a very careful release of helium would be contained as well as possible in an attempt to identify leak possible sites. There was no response at the leak chaser. It was decided that the excursion the day before must have been due to a slight helium background, most probably, introduced by operation of the ion pumps, which had pumped away overnight.

MACHINE HOUR METERS 3-03-09

CHAIN 1	CHAIN 2	CHAIN 3	LE SHAFT	HE SHAFT	CH VOLTS
7618	7618	7619	14590	14589	8481

TOTAL HOURS

CHAIN 1 (1N)	CHAIN 2 (2l)	CHAIN 3 (3L)
15.4 K	67.4 K	58.4 K

TOURS

This opening saw many more staff and visitors have a look at the inside of the machine and were given a brief description of how it works.
Groups from our School Machine Shop, Earth Sciences, OHS Unit and the John Curtin School of Medical Research toured the machine.

INITIAL PERFORMANCE

The accelerator sparked at 8.7 MV, 12.8 and 13.4 during conditioning to 14.4 MV over 3 days. The machine has sparked at 14.4 two more times to date.
The extra care in cleaning the machine during this opening appears to have paid of handsomely during the easy attainment of 14.4MV.
The operational voltage is limited to around 14.8 MV at the current tank SF6 pressure of 100 PSIA.

By the 6th of March 2009 the machine conditioned up to 14.9 MV. Majority of conditioning events occurred in LE section as indicated by observing the current in LE and HE Faraday cups. This was consistent with the fact that the only LE section of the machine was exposed to atmosphere during opening.