AUSTRALIAN NATIONAL UNIVERSITY

DEPARTMENT OF NUCLEAR PHYSICS

14UD TANK OPENING REPORT No.39

5th to 7th April 1983. (3 days open.)

20th April 1983. (1 day open.)

REFERENCES: Earlier Tank Opening Reports are referred to by the notation (12/4) etc, meaning Report No. 12, page 4.

REASON FOR TANK OPENING

A scheduled opening to attend to Chain 2 and to fix the jammed second stripper.

PREAMBLE

The 14UD was last closed on 10th February with two brand new chains, but no chain in position 1. As we reported (38/4 "Button-up" and "Initial performance"), there were peculiarities with Chain 2. Unable to see anything wrong in the bottom of the tank we closed the machine without taking any action - beyond, that is, expressions of piety. A few days after button-up, though the 14UD was holding voltage and performing well, it was clear that something was amiss with Chain 2. The authors remarked that, for the first time, neither had performed the inviolable fussy ritual of presiding over the closure of the terminal. A fault with the cross-over wires came to mind as a possibility.

After two short periods of buncher tests, normal running resumed. On Monday March 7th, the third day of a non-stop run at 13.4 MV, the gas test cell on the clean side of the purifier gave a resistance change of 27 kilohms/hr, a value which indicated that a sharp fall in the effectiveness of the Vivalyme had taken place.

It was estimated that the amount of fluorine compounds produced over the period of 1230 hours at an average charging current of 50 microamps would have used 30% of the Vivalyme. Since the chemical reactions are on exposed surfaces only, the 30% seemed a reasonable result. Measurements made with a test corona assembly suggest a production rate of reactive fluorine in the accelerator of about 3×10^{-5} gm.hr^{-1}.microamp^{-1} for each corona gap.

Measurements were repeated at the top of the tank, here the reading was 92 kilohms/hr. The accelerator was stopped at 9.30 a.m. without deference to the experimental run in progress, or, for that matter, the experimenters; all such factors now are subordinate to gas condition. The old load was taken out by removing a flange near the bottom of the dryer tower and allowing the load to run out into plastic bags. We noticed, with surprise, that the two purifying components filling the bags were remarkably well mixed; at first we attributed this to turbulence from the gas flow and the different particle sizes and weights. Later, we decided that a funnel effect in the falling material during removal was a more likely explanation. The Vivalyme and alumina were replaced by new loads. These had been dried

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earlier by pumping and heating in vessels which we built specially for the purpose. After drying, the vessels are valved off and the material remains sealed until required for use. Again the two components were loaded one on top of the other so that the circulating gas passes first through the Vivalyme, then through the alumina (35/8).

At 2.30 p.m. recirculation through the new load of purifier was begun. The emerging gas was found to be pure and the moisture sensor, after calibration, indicated 6.5 p.p.m. compared with 12 p.p.m. before the change of purifier. This shows that predrying of the materials is sufficient and that little moisture was absorbed during loading. We started the machine up as soon as we established that the new material was effective by testing the output side of the purifier. Instead of waiting 12 hours for a complete pass of the tank gas through the new purifier, the experimental run continued with recirculation in progress. Next day, at 7.30 a.m., the Shaw sensor indicated a moisture level of less than 2 p.p.m.

Our duplicate conductivity cell (37/10) has arrived at N.E.C. We were told by telex that they had tried it on their test machine and measured a resistance change of 200 kilohms/hr. Details will follow and we look forward to results of measurements at Oak Ridge and other accelerators using pure SF_6.

OPERATIONAL TIME

During the 52 days since the last closure, the 14UD operated for 947 hours. This was 79% of elapsed time, excluding the days for gas transfer.

THE TANK OPENING

Exploratory tour.

Immediately the first door was opened an elderly head was put into the tank, the bouquet was sniffed and a deep draught savoured, leading to the verdict: "A cheeky little atmosphere, but much more pleasant to the palate than vintages of the not so distant past". The rest of the author went straight into the bottom of the tank and pottered about among the chains and inductors in search of anything that could explain the misbehaviour of Chain 2. There was nothing to be seen, but the quality of the air was automatically confirmed.

Once on the platform, we found 3 drooped corona assemblies. There were two loose tube to column 'stringers'. When the bottom terminal spinning was lowered the fault with Chain 2 was immediately apparent: the crossover wires from the d.c. idlers to opposite inductors were touching. Possibly they had been pushed together when installing the new chain, or perhaps when the terminal was cleaned.

Generally, the column surfaces had little or no grey powder associated with breakdown products. On the terminal, however, there was a reddish powder. We attributed this to a legacy of the "rust" produced when the gas was very wet (37/8).

And so to work!

Chains.

Before anything else was done, the two chains were examined with great care and no defects of any kind were found. Chain 2 had operated for 654 hours and Chain 3 for 942 hours. These times are certainly not much to be proud of under normal circumstances, but when they are compared with about 40 cracks in each of two new chains which had operated only 1,000 hours (37/6) they are indicative of real progress, attributable to our recent gas impurity detection and related cleansing efforts.

After examination, the chains were shortened by 2 pellets each, then hand oiled. We noted with interest that the chains were much cleaner than we have found chains to be for some time and there was no oil on the castings. This relates to waiting for a few minutes after oiling for the oil to be distributed. It takes this time for the negative self-charge to go. In addition, we have recently switched from Turbo 29 oil to Apiezon C and reduced the oiling time from 10 to 3 seconds to compensate for the lower viscosity of Apiezon C.

In spite of the apparent success with the new chains, we still did not install the third new chain in the vacant No. 1 position; there was no need to since the 14UD has behaved excellently on only two chains for some time. We propose to continue with 2 chains until the improved gas recirculation loop is installed.

Insulating Gas.

The problems with breakdown products and gas purification led us to check yet again the rate of gas flow in our recirculating system. While the blower is rated at 45 ACFM, real flow obviously depends on a variety of factors. We delved into archival papers and unearthed a legacy of neatly set out and voluminous calculations. Unfortunately the Testator had long left the department and it fell to the legatees to find out the source of the formulae used and the validity of the calculations. An hour in the National Library brought to light a variety of publications, among which was "The Measurement of Fluid Flow in Pipes", (British Standards Institution, 1042: Part 1: 1964). It was clear that this document was the origin of the information which had led the aforesaid Testator to devise an orifice, the differential pressure across which established a flow rate. Outlets and valves existing on each side of the orifice enabled us to measure 20 mm Hg which, for the 41 mm orifice, our archival calculations demonstrated to represent 45 ACFM. N.E.C.'s assertion that this flow rate was wrong has just led to the discovery that, instead of reading a number from a curve, our Testator had calculated it from other likely looking numbers, inevitably reaching a value derived from what would be expected for 45 ACFM. By employing the correct value for the parameter in question, flow rate becomes 20 ACFM. The pressure drop across the purifier containing Vivalyme and alumina was measured to be 0.77 p.s.i. at 19 ACFM. The new system, now being designed, will have a gas flow rate near 135 ACFM.

Foils

The accelerator tube was let up to atmospheric pressure and both terminal and second stripper units were taken out and replenished with new foils. About 100 new foils were put in the terminal stripper and 5 in the second stripper. The foil chain in the second stripper was slackened very slightly, after which it moved more freely, thus eliminating the jamming.

Shaft bearings.

These were not tested especially, but were accepted as still serviceable.

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Points

The tube and column corona points are now dull. These points are the ones rebuilt with new sewing needles at A.N.U. (26/2). They were installed in June 1981 (26/4) and to date have operated for 10,100 hours. We are not satisfied with the quality control of manufacture we were able to achieve. Since installation, random point sets have been replaced with new, sharp ones. The wear on the installed points appears non-uniform for various reasons. Together, these effects lead to unacceptably large fluctuation in gradient which could cause locally high electrostatic stresses.

We have ordered a complete set of new assemblies of N.E.C.'s latest design; this incorporates a common holder for both tube and column points into which is attached an appropriate 3-needle insert. The needles are swaged onto their discs and no solder is used. For the sake of simplicity, references that we shall make in future will call these new points "Type 4", since they are the fourth type of corona assembly that we have received from N.E.C. The original points consisted of domes into which were screwed old type gramophone needles. Type 2 were flat discs with 3 cut off sewing needles soldered to the surface. Type 3 were similar to Type 2, but had annular spark gaps. These assemblies were only installed in a few units in June and September 1975 for test; they were removed when all points were changed in February 1976 because they were in no effective way superior to Type 2 points, (Report No. 1, page 2). We continued with Type 2 until the present time.

Chain idlers.

All idlers were examined and tested by hand. None were replaced.

Ion sources

The lithium exchange source, which has been out of commission for a year since the failure of the main turbo molecular pump in February 1982, has been fitted with a new pump. This and the turbo molecular line pump, are controlled and protected with an A.N.U. design vacuum controller of the type used on the sputter source. The rewiring, carried out affectionately, involved removing a panel on which was the last surviving N.E.C. wiring for the direct extraction source, which was replaced by the lithex source.

The lithex source was used for an alpha particle run during the last schedule; it performed excellently after its long rest and rejuvenation; it is now back on line for regular scheduling.

Miscellaneous

Failure to be able to control current in the upper terminal sublimer pump led us to investigate the motors at the top of the column which drive the control rods. Lying in the motor box was a broken nylon coupling. Since very little torque is applied to the control rods, and the rod in question was not jammed, we took the failure to be related to breakdown products. The couplings have been in the machine since installation and thus have been subjected to all contaminated tank gas that has occurred. Unwilling to risk breaking others minutes before button-up, we did not give any of them the standard manual wrench which we apply to cable ties; this test will have to wait until we have spares in readiness. This is the first failure of nylon, other than chain links and cable ties, which we have observed in the machine.

Computer logging

Computer logging of the upcharge has been operating for about a month.

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In future we shall log total corona current and lost charge separately. It is hoped that information about cumulative coulombs in these paths will help us to understand the breakdown products production rate and mechanism.

Cleaning

The column was blown, as usual, by compressed nitrogen and then tacragged. In addition, the inside wall of the tank was tacragged by our usual valiant students, accompanied by a visiting academic who was very anxious to go in the machine. After the difficulties in allocating platform time were courteously explained to him, he gratefully accepted a box of tac rags and worked his passage most industriously. (Ref. Mark Twain, "Whitewashing a Fence.")

Button-up.

The charging tests went smoothly and even if the closure of the terminal had not been superintended as thoroughly as it was, we would still have known that nothing was wrong there!

Initial performance.

The machine went easily to high voltage, achieving 13.78 MV on the second day and 13.92 MV on the third day. Eerie stability was seen for the first time in a long while. In spite of these successes it was not long before problems led us to discover that the suppressor on the second stripper was out of action. This failure might have been provoked when removing the stripper.

We decided to fit in a brief tank opening in order to attend to the suppressor.

The Second Opening

We began pumping out the tank at 8 a.m. on 19th April and the doors were open at 5 p.m. There was no unpleasant smell in the tank and we went in as soon as we had lowered the platform. It took us no more than 10 minutes to open the unit and find that the stripper suppressor measured 300 ohms to ground somewhere inside the tube, leaving us no alternative but to let the tube up to atmospheric pressure. We decided to carry out the repair that evening.

When we removed the second stripper unit we were gratified to discover no broken bits of insulator at the suppressor electrodes. There was no obvious cause of the short so we moved the connecting wire aside to give greater clearance to the foil frames. By 9 p.m. everything was back together and under high vacuum.

On the following day there was no purpose in closing the machine immediately. After testing the suppressor and stripper action we carried out a few small jobs, including replacement of the nylon rod coupling mentioned on page 4. The author with better vision, more supple fingers and greater patience (all attributes of youth), fiddled for half an hour to fit the coupling in an almost inaccessible place. While this was going on the unemployed author poked and pulled instinctively at everything in sight on top

of the column. In doing so, one of the three-inch-wide straps of copper sheet (1/3) which shunt r.f. from the column, fell out of its clamp at the top of the tank; not only had the screw worked very loose, but a neighbouring strap was in much the same state. If one of these three feet long straps worked free from the tank ceiling it would dangle across the first unit with obvious consequences. We report this event to emphasize that even the most guileless and well-established bits and pieces in an accelerator cannot be trusted indefinitely. On many occasions our random assaults have precipitated failures which could not have been far off occurring during operation.

We blew the column and tacragged. The charging tests on the two chains were troublefree and we buttoned up at 3 p.m.

We point out that the terminal voltages of 5.5 MV for 17th and 18th April (enclosed plot) were for real runs, using 8 rods in the L.E. column and only 4 in the H.E. The experimental group reported that the machine stability at this voltage for ^{18}O 4+ was quite satisfactory.

After gassing up, the machine was again required at 5.5 MV and was conditioned with rods to perform at the usual gradient across live units.

Phase detector.

A phase detector was installed between the energy analyzing magnet and image slits. Its purpose is to provide flight time feedback to synchronize the low energy buncher to the high energy choppers. The detector consists of an insulated drift tube sized for beta = 0.1, supported in a stainless steel vacuum vessel by a ceramic feedthrough. With a quarter wave coaxial 37.5 Mc/s resonator attached, it has a Q of about 1000. First tests, sneaked in while the first experimental group was setting up, were very encouraging.

Welcome visitor.

We are very pleased to report that Robert Rathmell, of N.E.C., is to be a Visiting Fellow with us for a month from the middle of June. There is much to talk about and there will be at least one scheduled tank opening specifically for the occasion. We are looking forward, not only to the value which will be derived from the visit, but to the revival of a warm friendship.

D.C. Weisser

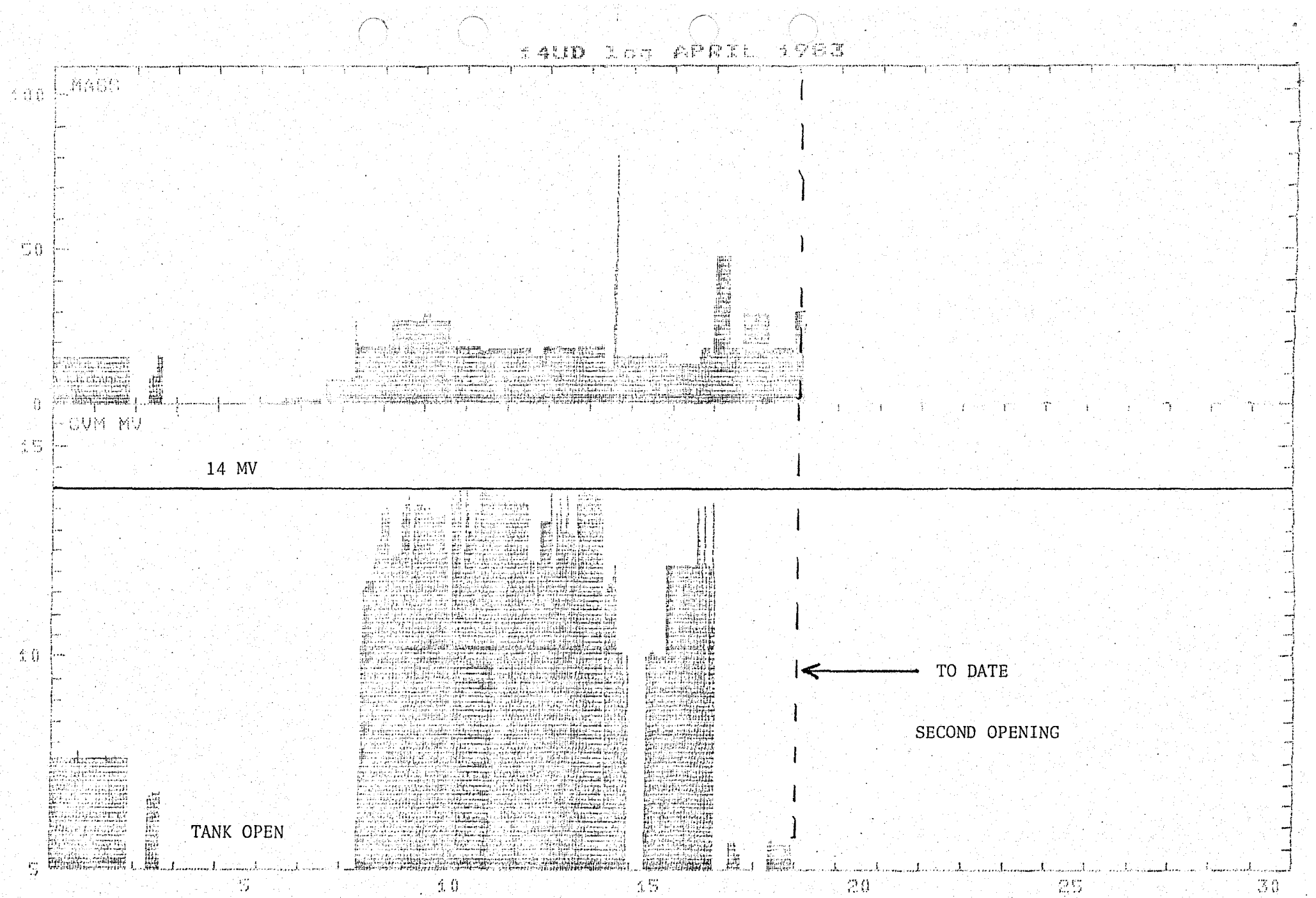
T.A. Brinkley

21 April, 1983.

Enclosures:

Plots of particle masses accelerated, and operating terminal voltages.

NOTE: On the plot of terminal voltages we have drawn a horizontal line at 14 MV for easy reference to performance near the nominal voltage limit of the 14UD.


14UD 2nd APRIL 1983
MASS
100
50
0
CUM MV
15
14 MV
10
5
TANK OPEN
TO DATE
SECOND OPENING
5
10
15
20
25
30