AUSTRALIAN NATIONAL UNIVERSITY

DEPARTMENT OF NUCLEAR PHYSICS

14UD TANK OPENING REPORT No.44

27th to 29th March 1984
(3 days 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

The opening was scheduled in order to attend to an unusual problem which developed with the column.

Notations:

In the first of these reports (1/3) we set out to be unambiguous in our references to units and casting positions. Our notation was based on the energy of a proton travelling through the 14UD when the gradient was 1 MV/unit; thus the casting at the bottom of Unit 8, (the one separating units 8 and 9), was known as the 8 MeV casting. Over the years we have drifted into referring to the castings by numbers. This can be misinterpreted if the casting at the top of the column is regarded as Casting 1; we call it Casting zero and all the castings then fall into place on the energy scale. The rings, the three tube sections in each unit and corona point assemblies, are numbered in the order that a particle travels past them.

PREAMBLE

The 14UD was last closed on 15th February. As the gas was going in, we carried out charging efficiency tests at different pressures in order to compare the results with those determined in the last report (Table 2, 43/5). We recorded the following values at the three indicated pressures:

27 p.s.i.a.				53 p.s.i.a.				83 p.s.i.a.			
Chain 1		Chain 2		Chain 1		Chain 2		Chain 1		Chain 2	
kV	μA	kV	μA	kV	μA	kV	μA	kV	μA	kV	μA
4	15	4	12	4	15	4	16	4	15	4	15
6	21	6	16	6	21	6	22	6	20	6	20
				8	27	8	27	8	26	8	25
				10	32	10	32	10	32	10	31
				15	47	15	45	15	47	15	43

On March 14th, after the machine had operated at 13.3 MV very satisfactorily for the previous four days, a passer by heard a noise in the tank which he described as "ringing clangs". At the time, maintenance was being done on the ion source so that all the chains and rotating shafts were off. Since the passer by was an electronics man, to whom warning sounds usually manifest themselves as frying noises, or fuseholders blowing to bits, his claims were investigated more from a tired sense of duty than alarm. To our consternation, a noise fitting the description was undoubtedly emanating from the tank and we could tell at once that the ringing clangs were caused by clanging rings.

When working on the column, the standard test for loose rings is to run the fingers firmly down each unit, in the way a harp is strummed. If all is well, adjacent rings touch when vibrating and there is a melodious sustained chord in D major. A loose ring produces a distinctive discord in E flat. So far as the present noise was concerned, it was impossible to determine the key from outside the tank and we could not be sure if any rings were loose.

It was soon found that shutting off the new recirculator silenced the clanging, so that the rings were most likely being disturbed by the strong gas flow in the vicinity of the tank input port from the new recirculator and possibly also the output port. The noise had not been noticed before because the new recirculator had not operated for long before the Vivalyme mishap (42/7) and it was left off until just before the following tank opening (43/1). There were few, if any, occasions when the recirculator had been operating with the shafts and chains off.

We looked in a window on the same level as the input to the tank from the recirculator (immediately opposite Casting 21). With 13.3 MV on the terminal and the recirculator operating, sparking could be seen in Unit 22 in synchronism with the clangs. No sparking could be seen through a port level with the input to the recirculator from the tank opposite the lower third of Unit 7.

We shorted out Unit 22 and eliminated the sparking at 13 MV. Because of this high voltage, and the need to control the equilibrium level of breakdown products, the recirculator was run for the remainder of the day and also the following day. From 16th to 22nd March, inclusive, the recirculator was turned off because the low voltage runs in that period implied low b.d.p. production. From 23rd to 25th the recirculator was turned on again and the rings once more clanged. Nevertheless, stable operation at 13 MV was possible for these three days which ended the schedule. The gas was taken out on 26th.

Unit 22 remained shorted from 15th to 25th inclusive. This, together with one third of Unit 19 permanently shorted because of the second stripper, meant that the voltage across the H.E. column corresponded to 14.4 MV for the periods of operation at 13 MV.

We designed some baffles to deflect the gas flow and finished making them on the day the tank was opened.

OPERATIONAL TIME

During the 40 days since the last closure, the 14UD operated for 813 hours. This was 89% of elapsed time, excluding the days for gas transfer.

THE TANK OPENING

When the doors were first opened the smell in the tank was mild and quite acceptable.

Exploratory tour

We cruised down the column and found all well until we reached Unit 7, where rings were recently found off (43/2). This unit is opposite the port through which the circulating gas leaves the tank. There were no rings off, but one of the corona point assemblies on the two electrodes strapped last time (43/6) had dropped onto the one below it. The rings in the vicinity of Casting 21, opposite the input from the recirculator, were also in position; the noises heard outside the tank had not originated from dislodged rings, but were a sound effect due purely to vibration maintained by gas flow.

In Unit 22, the surfaces of rings 6, 7 and 8, opposite each other, had marks which we attributed to the recent vibration and sparking. We did not notice similar marks on any rings above Casting 21; (as we said earlier, no sparking was seen in Unit 21).

There was more oil on the floor of the tank than we have ever seen before, yet no oily patches appeared around chain holes of some units, as had happened in the past. The stain on the terminal was once again (43/2) quite dry and dusty. This we attribute to the dry gas which our recent measurements have indicated. The dewpoint has been maintained at below -60 deg. C.

We gave our standard wrench to the knots (locks?) of two or three cable ties which have been in the tank for some time. They all broke easily at the knot; however, the nylon elsewhere on the broken ties was tough and not in the least brittle as is usually found in failed ties. If this was due to extreme dryness of gas, and not breakdown products, we found ourselves wondering what such gas does to the nylon chain links. We have already reported (37/4) that nylon cable ties, under tension in high vacuum, broke fairly easily at the knot when wrenched.

And so to work!

The first job in the tank was to install the baffles we had just made at the ports to and from the new recirculator. While these devices protrude 3 inches into the tank they are located well outside the high stress region and were smoothly contoured. No welding was necessary because the baffles are held in position by pulling them tightly against a bar slipped sideways into a reducing pipe just outside the tank. When we expressed anxiety about the input baffle being blown off like a cannon-ball at the column, the designer offered to hang on it while we lowered the platform from under him. We accepted this offer without hesitation; the baffle held and we went back to fetch him.

Following our discovery (43/6) of a failed nylon insulator in the terminal cross-over system, we replaced all the d.c. idler insulators with new ones made from delrin, using nylon screws in all 8 positions of each insulator and with pumping holes at each screw position.

The insulators removed were cut in half and we found one of them almost as bad as the first failure (43/6), a photograph of which was enclosed with Report No. 43. Another insulator had distinct breakdown "trees" in the nylon at all screw positions, while a third showed the beginnings of the effect. The complete arboretum indicated nicely how such breakdown trees in insulators begin as saplings and grow until they eventually become gnarled and then get struck by lightning.

We then took a careful look at the insulators which support the cross-over inductors. These are of a different design to the d.c. idler insulators.

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Of the same height, and thinner, the insulators and their electrodes are held together by a central nylon stud instead of the metal screws which are demonstrably a design fault. On the face of it, one would expect there to be no failure with 3 inches of solid nylon insulating, at the very most, 40-50 kV in SF_6. Nevertheless, two of the six inductor insulators bore signs of electrical damage. In the worse case the nylon seemed to have been pierced by a sideways spark, breaking away a little of the nylon. When we cut this insulator across its diameter, at the damaged spot, trails of blackening which penetrated about a quarter of an inch from the outer surface could be seen. Moreover, at a different location, there were black breakdown trails deep within the insulator, bordering on the volume of the tapped hole. There were black marks at the bottom of the hole where the studding had not reached. We noted, with interest, that these insulators all had pumping holes to the base of the studding at each end, whereas the d.c. idler insulators had no such holes. It is quite clear that empty space is undesirable in the volume of block insulators which function as all the cross-over insulators in the terminal do, even if the space is freely open to tank gas. Considering our ten years of experience with these identical insulators, time is probably a more significant parameter than any other in their downfall. That we had the bright idea of putting pumping holes in our new insulators, even with nylon screws, might be commendable in concept, but now that we have seen inside the simple inductor insulators, which have no metal screws, pumping holes do not appear especially effective as a means of inhibiting internal breakdown.

Charging system:

Both chains were examined with the usual care. No cracks were detected in either, but on 10% or more of the nylon links of Chain 2 "white lines" were reported by Alan Cooper, who is our ultimate authority on faults in links. When pressed for a more specific description of the white lines he said that he hadn't seen such marks before and he didn't believe they were cracks, though, of course, they might develop into cracks. It should be noted that these lines were on Chain 2, which is not the hourglass chain, therefore the lines are not related to the new link shape.

Foils

The terminal foils were changed as necessary. We noted that the seals on the Weisser valve leaked rather more this time than on recent occasions. They are probably due for renewal, though tightening the adjustment system might be sufficient.

Shaft bearings

The bearings in the upper main alternator were very bad; they were renewed and the same alternator put back. In casting 15 a shaft bearing cage had broken and mangled bits were removed. The bearing, and one other shaft bearing, were renewed.

Most of the existing shaft bearings have been in the machine since August 1981. The upper ones have operated for 11,300 hours; this is an estimate because of timer failure and it is almost certainly an under-estimate. The lower bearings have operated for over 15,000 hours. Since the lifetime for shaft bearings in the past was of the order of 5,000 hours, and we have vowed never to let them get past 10,000 hours, we are pleased with the success of our efforts to improve bearing lifetimes: (18/1; 26/8; 28/2; 28/5; 39/3).

Points

In Unit 7, where a column point had drooped at the place where we shorted two rings last time, we moved the short from under the point assemblies and put it on another post; this gave more thread to tighten the assemblies on their post. We should have arranged it this way last time, remembering our last experience with short corona assembly screws.

Idlers

We had no evidence that any of the N.E.C. design stabilizing idlers, to which we reverted recently, (42/4,5), had failed, though we did not open any more castings than the work in hand required.

Insulating gas

Monitoring with the conductivity cell throughout the operating period demonstrated the effectiveness of the new recirculating system. The highest equilibrium level observed was 15 kilohm/hr when the total corona current exceeded 100 microamps. The measurements were consistent with a cycle time of 2 hours compared with the original rate of 10 hours.

New cable ties were put in the terminal with standard tension to act as b.d.p. indicators.

Pulsed Beam Update

The beam pulsing apparatus, originally installed, was based on the ANL/FSU system. The gridded buncher provided a pulse every 26.6 ns (37.5 MHz). The experimenters preferred a pulse every 53 or 106 ns. This was accomplished by throwing away alternate pulses, or three adjacent pulses. The latter employed the 9.375 MHz on one plate of the second chopper and 5 kV on the opposite plate. This mode of operation was inconvenient for the experimenters because of the severe steering which occurred as the phase of the beam changed.

As well, because the choppers precede the energy analyzing magnet, altering the phase could lose enough beam for the machine to go out of energy lock. In short, the 106 ns pulse separation was operationally useless and threw away 75% of the beam; the 53 ns mode threw away only 50%, but was a poor compromise. Experiments requiring more than 106 ns between pulses were meant to be accommodated by synchronisation with the slow chopper. This device required a minimum pulse separation of about 100 ns and so was virtually useless as well.

In principle, all the above problems could be overcome if the gridded buncher operated at 9.375 MHz. We hesitated trying this because of Skorka's calculation suggesting debunching would occur in the region outside the grid gap, i.e. in the grid to vacuum wall space. The fact that, at present, we have only bothered with one frequency on the buncher, left the problem of superimposing three or four frequencies of little moment.

As a test, the 9.375 MHz coil from Chopper 2 was put on one grid of the buncher, the other was grounded. The system worked well beyond our expectations. A Gaussian pulse could be produced with 540 ps FWHM with 27% of the D.C. beam

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in 1.8 ns and 32% in 3.6 ns. Tuning the buncher for maximum intensity through a 2 ns window set by Chopper 1, results in an over bunching and a double peak, but 40% of the D.C. beam. These figures are only slightly worse than those achieved with the 37.5 MHz buncher. The far field debunching is less severe than feared, probably because 1). The vacuum housing is large - 150 mm diameter. 2). It is made of stainless steel which, because of its high resistivity, causes the R.F. field to extend far down the beam tubes. Field smoothing electrodes, like those at Heidelberg, have not been used.

Following this success, and because we stole the coil from Chopper 2, a new 4.68 MHz coil was made for Chopper 2. The system is now in use by experimenters who are almost completely happy.

The phase detector is still not performing adequately. When Chopper 1 is turned up to the amplitude necessary, the signal from the phase detector gets confused. It now seems likely that the chopper increases the divergence of the beam sufficiently for it to strike on, or near, the phase detector electrode. This signal, either from secondary electrons or the direct beam, would confuse the proper induced signal from the pulsed beam. The electrode sizes in the phase detector will be increased from 18 mm I.D. to 46 mm.

In spite of not having an operational phase detector, the system works quite well. At the time of writing a group is running 160 MeV ^{32}S, 11+ at 13.36 MeV with few problems, even with 50 microamps lost charge. This is more a testament to the stability of the 14UD than the pulsed beam apparatus.

Miscellaneous

The oilers were found to be very low and were all topped up. We could think of no reason why so much oil had been found on the floor of the tank.

Cleaning

The column was blown with nitrogen and tacragged very cheerfully by students who found that they only had to do it once because of how nice and clean it all was. Our students have become extraordinarily easy to please.

Button-up

We carried out the charging tests with the same observer at the terminal who saw the arcing from chain to d.c. idler when the faulty insulator was discovered (43/5). We reported that there was no sign of an arc and no visible sparking at all. The charging efficiency was excellent for both chains.

Initial performance

The machine performed well and was soon in use at 13 MV. It later conditioned to 14 MV.

T.R. Ophel

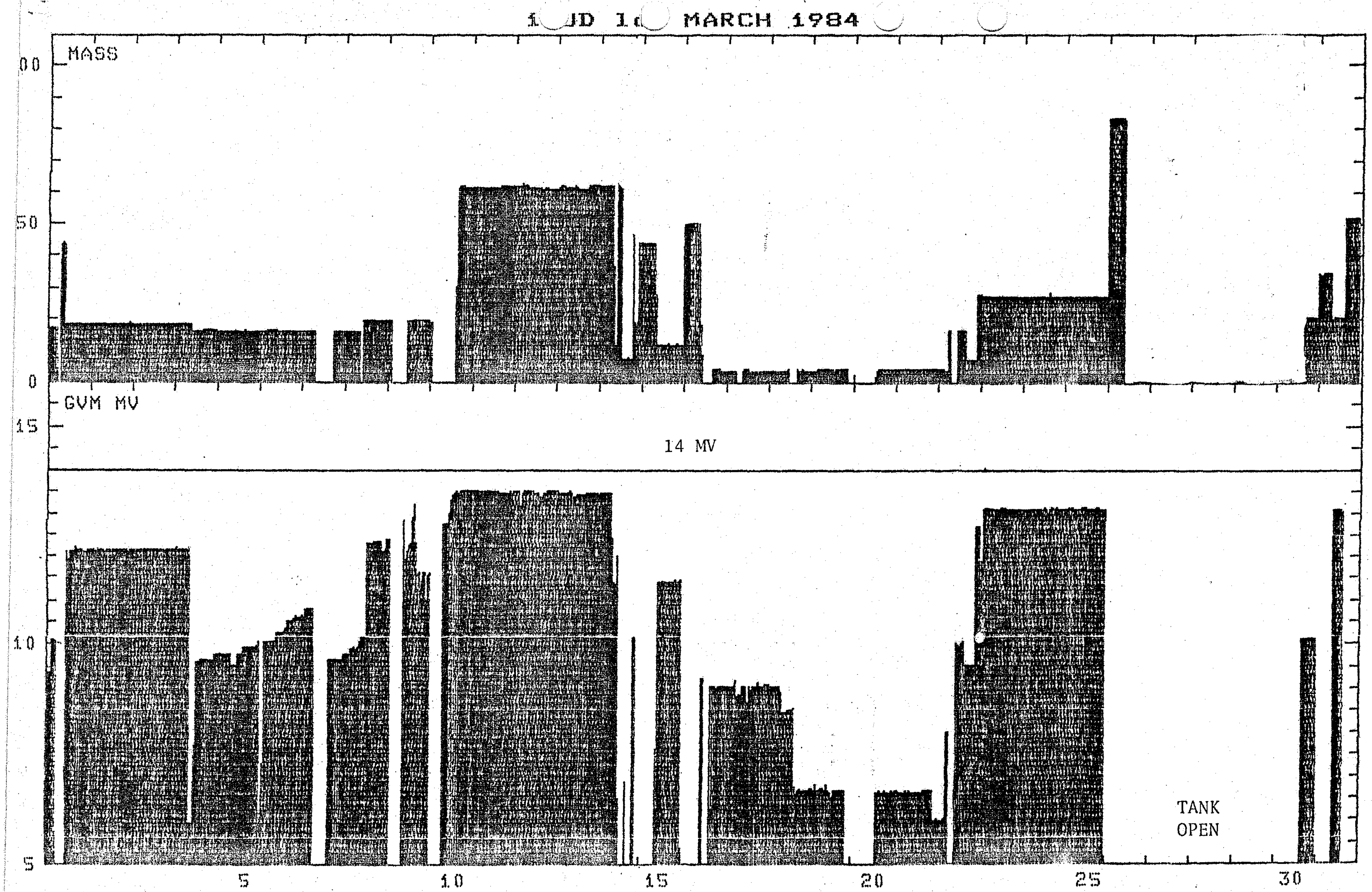
T.A. Brinkley

11th April, 1984.

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.



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