AUSTRALIAN NATIONAL UNIVERSITY

DEPARTMENT OF NUCLEAR PHYSICS

14UD TANK OPENING REPORT NO. 32

8th to 12th February 1982

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

REASON FOR TANK OPENING

Scheduled opening to attend to the Tank Cup, G.V.M., and charging instabilities.

PREAMBLE

The 14UD was last closed on 16th December. Two days later a drift in indicated terminal voltage was traced to the G.V.M. itself. Such drifts have been related to the rotor bearings and grounding brush, though the rotor had been tested by hand during the previous tank opening. Not prepared to take out the gas again we elected to put up with the irritation. The GVM settled down to "consistently" read 100 to 300 kV high.

After closure, the machine went to 13.8 MV very easily; it was then used at about 8 MV for two days, after which it operated effortlessly at 13.84 MV for a non-stop run of five days and nights.

In the middle of January the machine began to spark at 14 MV and there were instabilities associated with Chain 1, which was then kept off. Later instabilities appeared with Chain 3 also, and this, in turn, was isolated when possible. For most requirements Chain 2 alone was capable of taking enough charge to the terminal. Of course, these problems arose directly after we decided to heed Robert Rathmell's advice to always operate all the chains together, in order to minimize electric stress on them.

Pulser: On January 21st initial tests on the new pulser, (30/3), were carried out. The tests highlighted difficulties associated with the pulse detection equipment. Of the four techniques tried, two produced time peaks of about 3nS fwhm instead of the 1nS expected.

After some thought, and modifications, further tests were made on 4th February, and these resulted in the following: Great! Less than 1 nanosecond; detector limited.

OPERATIONAL TIME

During the 52 days since the last closure, the 14UD operated for 907 hours. This was 73% of elapsed time, excluding the days for gas transfer.

THE TANK OPENING

Exploratory Tour

The cruise down the column revealed that the L.E. tube corona metering assembly had come off the tube flange and was hanging by its metering wire. Three tube corona assemblies had drooped and were touching the assembly below; one column assembly at the bottom of a post had drooped likewise.

The patch of stain on the terminal, opposite the triode needles, was marked in 15 places where sparks had exposed the metal below the stain. Moreover, the brown deposit was flaking in a circle around the spark location. (photographs). The triode assembly itself had a number of brown fragments splattered over the mushroom, (photograph). None of these penomena have been seen before. (In the photograph of the mushroom the 7 white circles are reflections from the camera flashgun).

In the bottom of the tank, the bar which prevents motor 1 from falling after a chain break was resting on the floor. Chain 1 was therefore not under correct tension; also Chain 3 would bottom when the chain was run. These factors alone would have caused instabilities.

The chains themselves were extremely dry, though the pulley rims appeared to have an oil film on them. About 18 loose screws were found on the shimstock contact band on Chain 3.

Before proceeding with any work, the chains were all run separately in order to listen for noise at idler positions.

And so to work!

At the last tank opening the tank cup was fixed temporarily (31/3) in order to continue the schedule, and it was now necessary to effect a more thorough cure and enable the cup to be used again. Accordingly the tube was let up to atmospheric pressure with nitrogen. Once again it was decided not to remove the entrance slit assembly, because of the full realignment involved, but to take off the 300 litre/second ion pump and try to make the repair through the pump flange, which is on the body of the tank cup. As found before, (31/3), there was a "dune" of granular material on the floor of the 300 litre/second ion pump. This time we inserted the nitrogen jet into the pump body and blew out a cupful of shotblasting material. Jetting, and collecting with a vacuum cleaner, took half an hour. (Later we found the pump worked well).

There then followed a difficult operation which, could be carried out by touch alone. The younger, and more sensitive author, put on a surgical glove and managed to insert his hand through the pumping orifice. Wearing an expression of pathological concentration he separated the cup from its drive shaft. The cup itself could not be removed because the metering and suppressor connections were inaccessible; it was therefore suspended on a wire while the drive mechanism was withdrawn and serviced. A small ceramic spacer had disappeared; presumably it had broken, and its fragments are now somewhere in the accelerator tube. A new spacer, steel washer and split washer were fitted, and with the same delicacy the reverse manipulation was carried out. When observed through the orifice the cup performed perfectly for about 10 operations.

The generating voltmeter

The unit was removed and dismantled. A nut which clamps the electrical connection from the stator was loose, and the lead could be moved easily. This was the only distinct evidence of the cause of the instability referred to in the preamble. The bearings appeared to be sound, but were renewed nevertheless. They were last changed in July 1979, and had operated for 13,300 hours.

Foils

The terminal foils were renewed, as necessary.

Shaft Bearings

The bearings were listened to, and all sounded satisfactory.

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Points

The four or five drooped points were corrected, but no assemblies appeared to need replacing because of damage or defect. In June 1981, all tube and column corona point assemblies were replaced with a set of old N.E.C. discs which we had ourselves fitted with new needles. (26/2; 26/4). This is the first instance of our refurbishing corona assemblies. They appear to be performing as well as any of their predecessors, although the enthusiastic but inexperienced volunteers, seconded at the time to install the new points, might be progressively letting us down. The points are drooping because they were not screwed tightly enough. All point assemblies in opened units were checked for tightness.

Stabilizing idlers

In all, 6 units were removed for repair. One bearing was seized, and there was enough wear in the shafts of others to merit replacement. These are still of the vintage of plated shafts which we expect to need renewal during the next year.

Chains

Chain 1 was shortened by 5 pellets, and Chain 3 by 3 pellets. The loose contact band screws on pulley #3 were re(?) loctited in, and the other contact bands examined.

Miscellaneous

Measurements were made in the terminal to enable us to think about departing from the see-saw systems for tensioning the chains. This modification was one of the changes which Sao Paulo introduced, leading to improved chain lifetimes.

Cleanup Chopper

We made use of the tank opening to open up the H.E. beam line and put in the cleanup chopper. This also involved moving the H.E. steerers to a new position and reactivating the steering component to the H.E. quadrupole lens which was discontinued some time ago.

Humility

While making one of his well-planned, systematic checks the older author discovered that, since all shaft bearings were changed in August 1981, he has been assiduously recording the number 30,948 on the first of the month and at every tank opening, for the upper rotating shaft. He did not notice that the hour meter for this had not advanced by more than a few milliseconds. This, when shyly admitted in the darkroom, evoked a little kindly banter.

Survey

Prior to the Third International Conference on Electrostatic Accelerator Technology at Oak Ridge in April 1981, D.C. Weisser conducted a survey in order to give a status report on N.E.C. accelerators. A survey form was sent to a number of laboratories and the information received was summarized and discussed at the conference.

In an appendix to this report we list the various N.E.C. machines and conversions.

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We are attempting to determine why chain lifetimes vary so much for different accelerators, and why our own, in particular, are relatively poor. With this report we are sending another form which we would much appreciate having returned to us with information concerning charging chains. We shall collate and circulate the information in a future report.

Cleaning

Thorough, of course, with nitrogen and tac-rags.

Button-up.

Charging tests yielded almost identical results for all three chains, the first time this has occurred for several buttons-up. The doors were closed at 2.30 p.m. and the tank was roughed.

Initial performance

The machine was started up, as usual, on Saturday morning. Beam at the Tank Cup, beyond the entrance quadrupole and L.E. tube isolation valve, was less than 10% of that at the previous faraday cup. The isolation valve was found to be jammed, and we concluded it was cutting off the beam. There was no alternative but to abandon the run scheduled for that day, and let the entire accelerator tube up to atmospheric pressure again, leaving the accelerator unusable for the rest of the weekend.

On Monday morning the valve was found to be open, though jammed. The low beam intensity on the Tank Cup was eventually traced to "one of those things which are sent to try us". During the tankopening someone had taken the opportunity to carry out maintenance on the quadrupole power supplies and had put back the wires wrongly.

The isolation valve was replaced with a home-made 4 inch stainless steel gate valve which was previously tested, and found to be O.K. This exercise involved manufacturing adapters and performing an alignment of the L/E. iris. Since 5 seals were re-made above the valve it was decided to rough out this section rapidly to confirm the seal placements. Unfortunately the valve, which is required to seal against a shock wave of 100 p.s.i. of SF_6, couldn't even hold against less than an atmosphere. Thus we violated our anti-turbulence practice and roughed the tube to some unknown pressure before discovering the valve leaked through. There was no way of confirming, and equalizing, pressure on either side of the valve before opening it. We could not, therefore, avoid compounding inadvertent rapid roughing of the tube with a premeditated sudden blast of turbulence when the valve was opened. All this resulted in a reduction of the conditioning threshold from 14 MV to 7 MV; a very unwelcome confirmation of the need to avoid turbulence in the tube.

The 14UD has, since then, steadily and miraculously conditioned up to 12.5 MV over a few hours. What with sandblasting material percolating into the tube over the past two years and bits of ceramic falling into it, all stirred up by blasts of gas from crummy valves, one must wonder why the 14UD operates as well as it does near 14MV, and not why it hasn't yet achieved 15 MV.

ADDENDUM

Tests of the clean-up chopper put in, (page 3) were very successful. All home-made components are ready for the superconducting buncher.

D.C. Weisser

T.A. Brinkley

23 February 1982

Enclosures:

1). 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 14 UD.

2). Photographs:

a. Spark marks on terminal, general view.

b. Close-up, showing circles of flaking.

c. Deposits on the triode mushroom.

3). Survey form referred to earlier in this report.

Appendix follows:

APPENDIX

PART 1: LIST OF N.E.C. MACHINES AND CONVERSIONS

The year quoted refers approximately to the date of acceptance tests and/or first experimental use of the machine.

The letter "H" in notation for N.E.C. machines means "Horizontal".

In alphabetical order:

* refers to laboratories which either were not contacted, or did not reply to the Weisser survey; we therefore have no dates.

Argonne, U.S.A. FN conversion.

Chains and corona tubes, 1973
N.E.C. accelerator tubes, 1977

Battelle, Washington, U.S.A. 2UDH 1976

* Brookhaven National Laboratory. U.S.A. MP conversion with chains and rotating shaft.

Chalk River Canada. MP conversion. Chains 1976

" " " 2UH 1974

J.A.E.R.I. Japan. 20UR 1980

Lund Inst. of Technology, Sweden. 3UDH 1976

*Max Planck Inst. Heidelberg, MP conversion, with chains.

Melbourne, Australia. 5U 1975

Munich, Germany. MP conversion.

Chains and corona tubes 1971 5
N.E.C. tubes 1976

Rehovot, Israel. 14UD 1977

Sao Paulo Brazil. 8UD 1973

" " " 4U single ended injector.

*Tokyo Inst. of Technology, Japan. 3UH.

Tsukuba Japan. 12UD 1976

*Wisconsin, U.S.A. EN conversion, with chains.

*Yale, U.S.A. MP conversion, with chains.

Part 2 contd. overleaf

Information was also received concerning proposals for machines not yet operating:

Hahn-Meitner Institute, Berlin. Germany. 8UD

C.N.E.A. Argentina. 20UD

PART 2. A few notes in regard to chain lifetimes

While the Weisser survey did not emphasize matters relating to chains, the information returned, valid to early 1981, was sufficient for us to make the following observations.

There are two types of machine using N.E.C. chains,

1). Machines which are entirely N.E.C., both vertical and horizontal,
2). Conversions, which are all horizontal.

The longest-running N.E.C. machine is Sao Paulo, 8UD, vertical. Sao Paulo reports being on its 8th chain, and after various modifications the current chain had achieved 18,000 hours at the beginning of 1981.

The next N.E.C. machine, the first "big" one, was the A.N.U. 14UD. This is fitted with three chains which may be used separately, or together. The lifetimes, in hours, spread throughout the three positions, for new chains until their first break, are:

2,143; 3,610; 7,019; 11,535; 12,446; 16,666. (average 8,900)

The longest life of a repaired chain was the one with 2,143 hours which went on to a total of 9,300.

The three chains at present installed have operated for 800; 2,500; 5,000 hours.

The Tsukuba 12UD has two chains; one broke at 14,300 hours and the other has served 14,500 hours at the time of the survey.

The Rehovot 14UD had no breaks, but only 7,000 hours, well below the ANU average.

The small machines at Battelle, Chalk River and Lund, all horizontal, appear to have chain lifetimes less creditable than A.N.U.

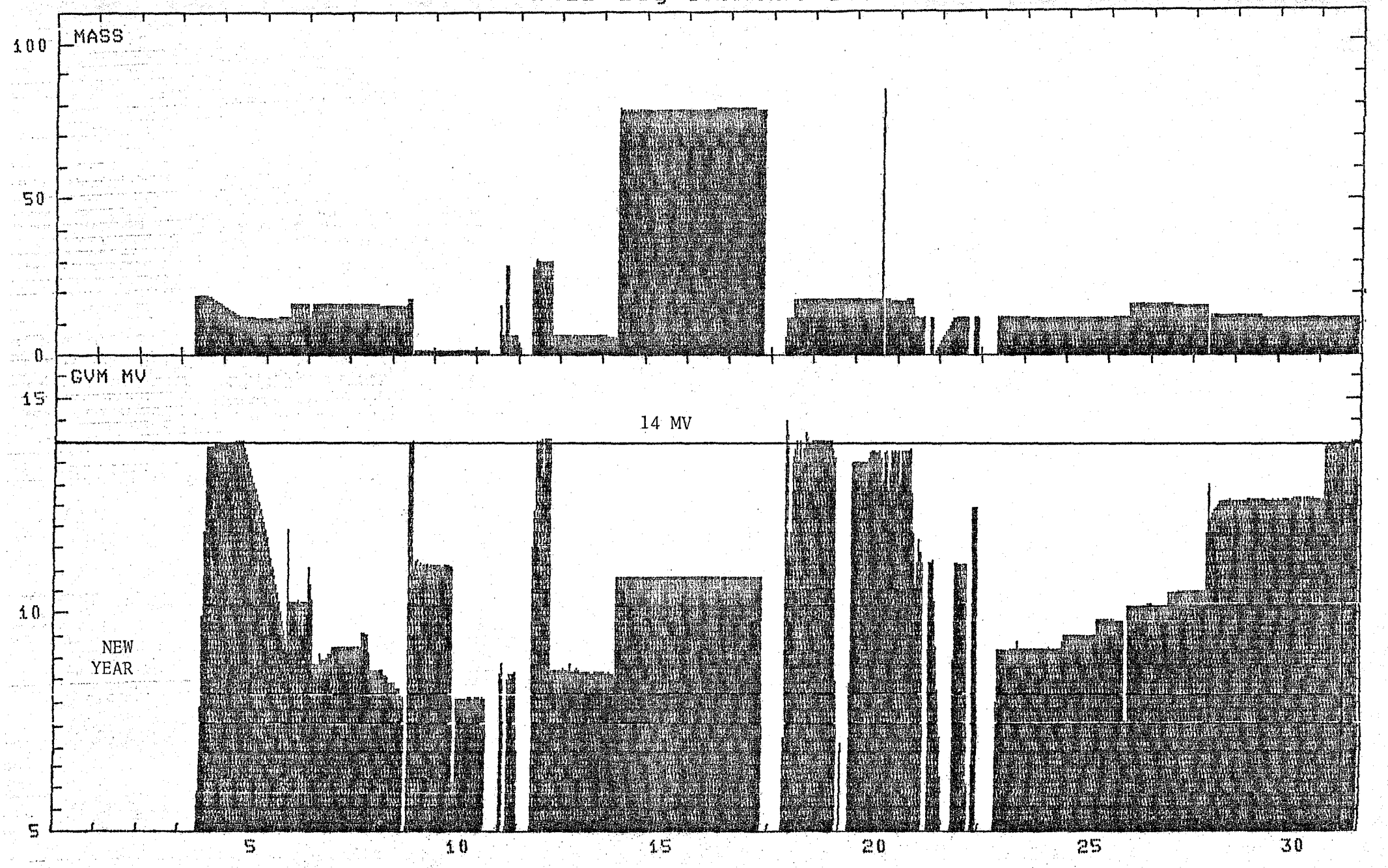
The big horizontal conversions, Argonne, Chalk River, Heidelberg and Munich, have significantly better lifetimes than A.N.U.: of the order of 30,000 hours. Neil Burn reports that the Chalk River conversion chains had accumulated 38,000 hours since 1974. At the time of the survey some conversions had not suffered a chain break.

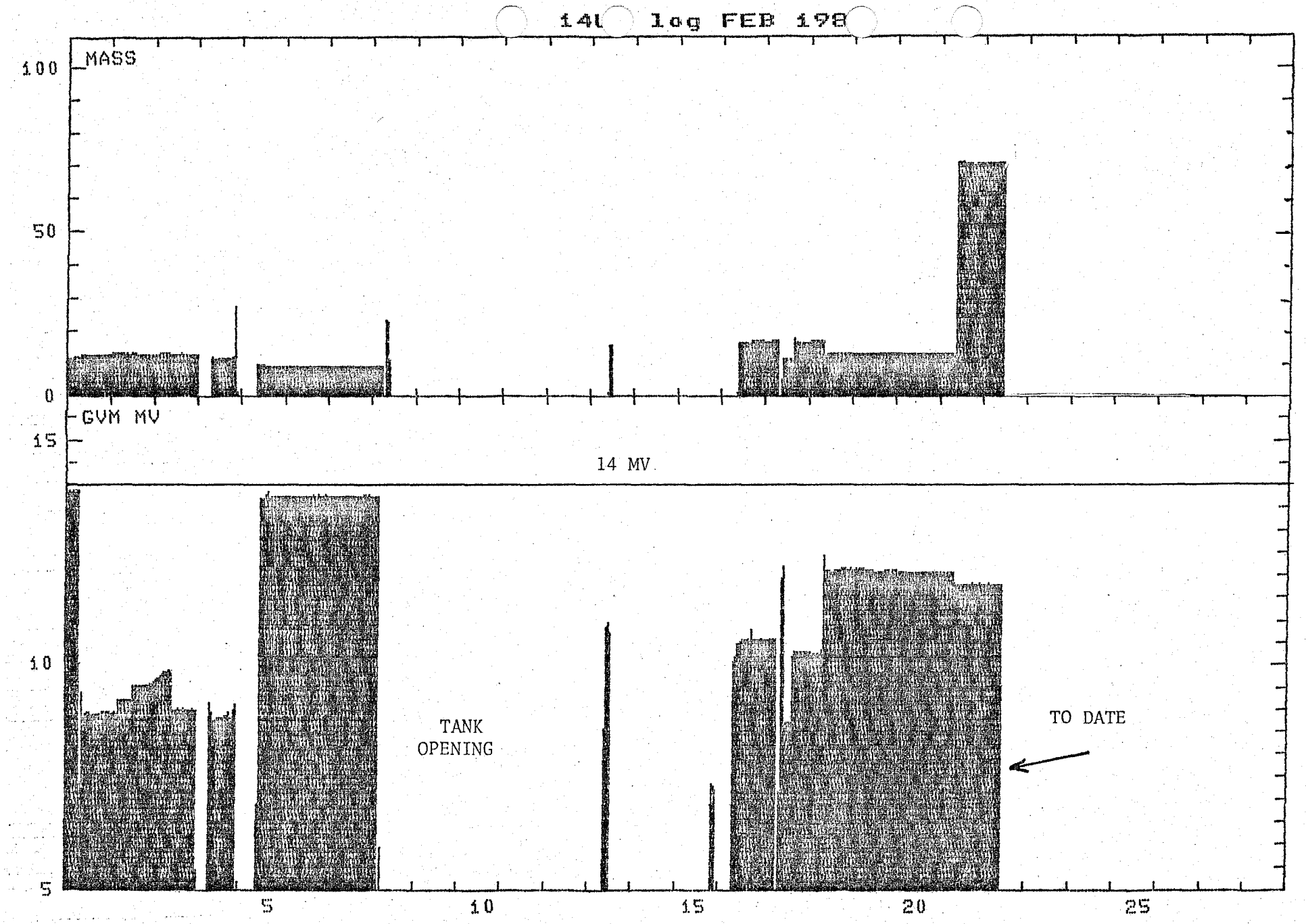
Clearly a number of factors affect chain lifetimes: among them number of starts; tension; stabilizers; breakdown products in the SF6; operating temperature; oiling; column sparking and care in installation.

We hope the response to the new survey will enable us to present a more thorough assessment in a few months.

The address to return the reports is on the survey form. Thank you kindly!

14UD log JANUARY 1982

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TANK
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