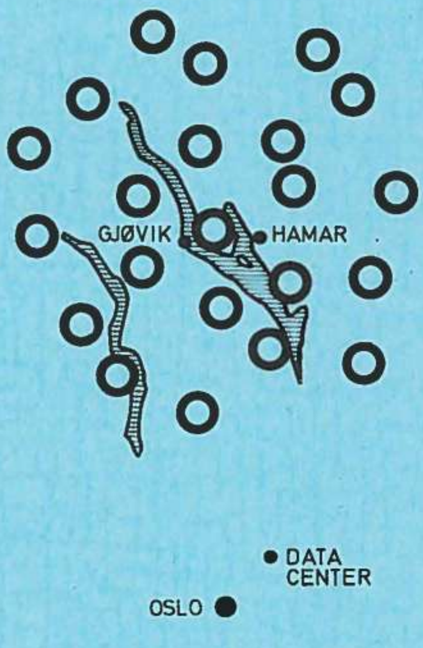
Royal Norwegian Council for Scientific and Industrial Research

TECHNICAL REPORT

Field Maintenance Report
1 January - 30 September 1971

1 October 1972



NORWEGIAN SEISMIC ARRAY

NORSAR

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TECHNICAL REPORT

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This report has been reviewed and is approved.

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FOREWORD

This report covers installation and field maintenance of the NORSAR array for the period 1 January - 30 September 1971. Although most of the equipment was installed by the start of the report period, some installation work and substantial testing remained to be done; this is reflected in the report. Also, results of a number of special tests, partly performed in earlier periods, are included in the report, these results not having been published before.

The report is mainly prepared by the subcontractor for field work, NORATOM-NORCONTROL A/S. The reason for the 9-month period (rather than a 6-month period) is that the subcontract with Noratom-Norconsult A/S was terminated at the end of September, and it was natural to include the last 3 months of the contract in the same report.

C O N T E N T S

A3 SP-SEISMOMETER DAMPING RATIO WITH DIFFERENT DAMPING RESISTORS
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A4 SP-SEISMOMETERS
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NORSAR PHASE III - FIELD OPERATION AND MAINTENANCE

1 JANUARY TO 30 SEPTEMBER 1971

ABSTRACT

This report covers the Field Operation and Maintenance (FO&M) of the NORSAR system during the period 1 January to 30 September 1971, and succeeds Technical Report "NORSAR Phase III - Field Operation and Maintenance, 1 July to 31 December 1970", later refered to as (1).

This reporting period of 9 months constituted the second and final part of the FO&M contract between NTNF/NORSAR and NORATOM-NORCONTROL A/S under phase III of NORSAR.

1 INTRODUCTION

During the preceding period, the first 6 months of phase III, the NORSAR field installations were completed with the integration of the Seismic Short and Long Period Electronic Modules (SLEM) units, and the break-in period started. For further details refer to (1), and also to Technical Report NORSAR Phase III - Operations 1 July to 31 December 1970", later referred to as (2).

Although all the technical equipment had been checked out at time of installation, scores of adjustments and corrections had to be carried out during this period.

The hectic installation period had not left ample time for preventive maintenance, and as it now turned out, some of the equipment had suffered from not being attended to for a long time. Apart from subarray 01C, which was constructed in 1967 and which was in operation up to June 1969, the rest of the subarrays, which were equipped during 1968, 1969 and 1970, had only to a very little extent been used for any kind of operation before the SLEMs were installed.

1.1 Field Operation and Maintenance (FO&M) Tasks.

As the SLEM installations were completed and the NORSAR system went into the break-in period, which actually lasted throughout the whole of this reporting period, field maintenance now became the essential task of our organization.

The SLEMs were all installed at the end of the previous period, but they were not all operating due to discrepancies disclosed during check-out and due to lack of spare parts. Those SLEMs would have to be made operative and given final field tests as soon as the parts arrived.

The maintenance of the SLEMs was now, after acceptance, our responsibility as was the maintenance of the rest of the field installations apart from the data transmission lines.

Operation of the system soon disclosed that many adjustments were needed: LP seismometers needed adjustments for Free Period (FP) and Mass Position (MP), scores of SP seismometers were operating outside the tolerance limits for Natural Frequency (NF) and Damping coefficient (D), RA5 amplifiers (for SP seis) would have to be adjusted, to mention the most significant items.

Discrepancies with LP seismometers, which made it neccessary to open the tanks for adjustments revealed the rather shocking situation that in many places a large degree of moisture was present and had in some instances started corrosion on the instruments. It then became a major task to clean up the LP installations and make arrangements for prevention of further damage of this kind.

It also became a major task to find better ways and means of servicing and adjusting the SP seismometers, which during the installation period had caused a lot of trouble because of relatively high temperature sensitivity.

As the last period did not leave any time for activity at the MC, various test equipment previously started on, had to be completed now. In addition, the SLEM Test bed which had been moved to the MC after completion of the SLEM Pre-field Test at NDPC would have to be made operational soon.

Other tasks were temperature registrations and various modifications and maintenance work on the field installations. As also mentioned before, the hectic installation period had not left enough time for the necessary preventive maintenance of the installations.

Figure 1.1 shows the geographical area of interest for this report.

2 SLEM

2.1 Field Tests and Final Acceptance.

Spare parts for the SLEMs were not available at the end of the installation period and as a result of this, four of the SLEMs were lacking Analog/Digital Converters (A/DC) while a fifth had some other discrepancies. The A/DCs had been returned to the manufacturer for repair/replacement. For more details of SLEM installation refer to (1) and (2).

Repaired A/DCs were received in January and installed. Field Tests were performed, and the rest of the SLEMs were all finally accepted 24 January.

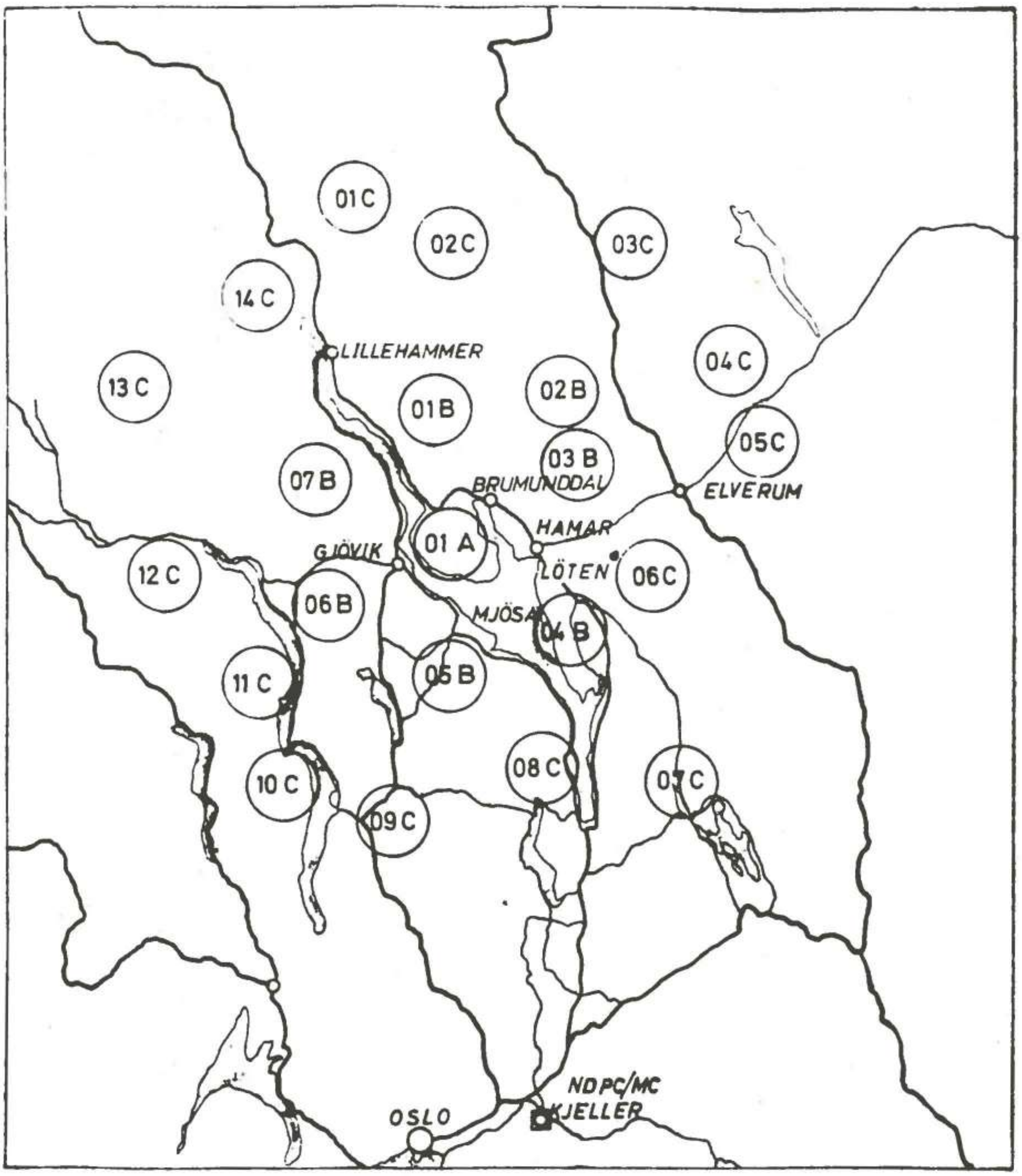


Figure 1.1 Geographical area of interest for the FO&M group

2.2 Spare Parts.

The SLEM spare parts were delivered in two shipments, one at the end of February 1971 and the second shipment was delivered 10 May. All parts were then checked, registered and stored at the MC. All major parts, like spare cards, were functionally tested in the spare SLEMs at the MC. Two of the A/DCs were found unacceptable and returned under warranty.

2.3 SLEM Test Bed at the MC.

As reported in (1) a data line was installed between the MC and the Data Processing Center (DPC), and the SLEM Test Bed and the two spare SLEMs were moved to the MC when the SLEM Pre-field Tests were completed. It took some time, however, before this data line could be utilized effectively, due to various problems like distortion on the line and difficulties with the Modems. Check-out of the line was the task of DPC.

The Test Bed, which is shown partly in figure 2.1, physically consists of two 19" equipment racks with shelves for necessary portable test equipment fixed between them. From top to bottom one rack holds the LOOP CONTROL LOGIC PANEL and the MODEM which are both part of the data line, while the other rack holds two 28V DC POWER SUPPLIES, one for each SLEM. Below this, in each rack, the special purpose SLEM TEST PANEL is mounted, on which the SLEM cables are terminated.

Then finally in the lower half there is space for one complete SLEM in each rack. At the back of each rack there is an outlet for 220V AC power.

In addition to the two-way data line there is also a direct telephone line between the SLEM Testbed and the DPC Modem room.

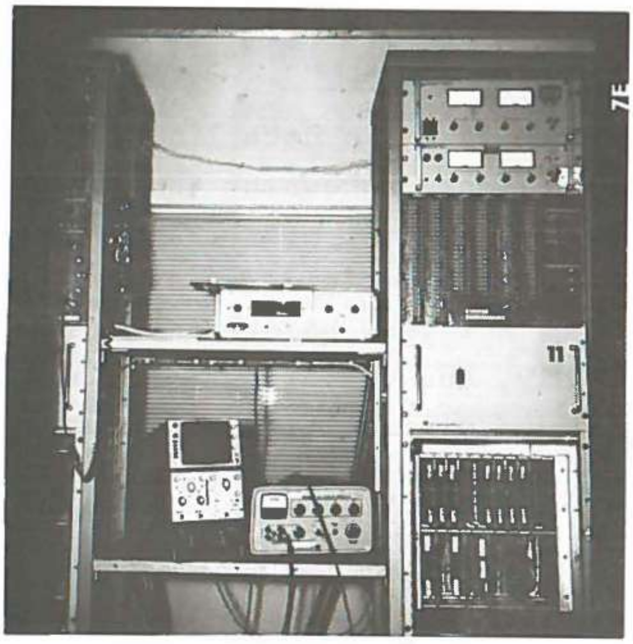


Figure 2.1 SLEM Test-bed.
(The left rack which is only partly shown, is identical to the right except that it holds the line-terminating equipment at the top instead of the power supplies. The SLEM Digital Unit at the bottom is not shown).

2.4 Service on the SLEMs.

During this break-in period there have been a number of adjustments to and retesting of the SLEMs in the field, and some cards and units had to be changed and brought to the MC for repair.

The following checks/repairs on SLEM parts have been performed at the MC:

a) 11 LTA cards repaired.
   - 8 IC RC741 changed
   - 3 IC LM308 changed

b) 3 Test Generator cards repaired.
   - 2 IC F5-61 changed
   - 1 IC RC741 changed

c) 1 Power Regulator card repaired.
   - 1 IC LM304 changed

d) 7 A/DCs returned to the manufacturer under warranty with the following faults.
   - 2 Missing numbers.
   - 2 Unstable gain and DC offset.
   - 1 Faulty potentiometer R 14.
   - 1 Faulty A/D clock.
   - 1 Wrong A/D reference voltage.

   The two last ones have both been returned to the factory three times with the same faults.

e) 2 Power Units repaired.
   - 1 A bad diode in the 5V circuit changed.
   - 1 Two transistors in the regulator circuit changed.

f) 2 Digital Units repaired.

28V DC was connected to a Digital Unit by mistake during field service, and four modules were destroyed and had to be replaced.

Another Digital Unit was serviced in field. A module FF-08 was changed.

3 THE LP SYSTEM

As a guidance for the FO&M work the DPC started to list the array status in a "Discrepancy Report" based on the array monitoring carried out at the computer. This revealed a large number of seismometers and amplifiers as operating outside the parameter tolerances.

The LP seismometers need to be very precisely levelled in order to perform correctly, and adjustments which must be performed from time to time can be conducted remotely from the DPC as well as from the adjacent Central Terminal Vault (CTV). The intention was to run these adjustments automatically under the array monitoring program, but it took a long time before this program was performing adequately, and the tests from DPC very often resulted in instruments getting stuck in one or another of the outer positions and had to be released by the field personnel.

This could usually be corrected by remote operation from the CTV, but necessitated in some instances the opening of the seismometer tanks to get at the levelling devices.

3.1 Dampness in LP Tanks and Reconditioning of Tanks and Seismometers.

A certain amount of moisture had been noticed in LP tanks on various occasions and had led to some scepticism, but no action had been taken. Dehydrating substance is placed inside the seismometers as well as outside in the tanks, and it was thought that this would be ample to take up the moisture that would come out of the concrete until it was completely dried out.

As more attention was given to the LP system, indications of a disturbing degree of increase in the moisture in the tanks soon appeared. One seismometer that had too high damping was opened, and the cause of the damping was rust on the magnets in the narrow air gap between the magnet and the data coil. The dehydrating substance in the tank as well as inside the seismometer was completely saturated, so the moisture had started the corroding action on the untreated surfaces inside the magnets. A large amount of moisture was apparent also in the two other tanks.

It should be noticed in this connection, that the Long Period Vaults (LPV) in general contained a very high degree of moisture. The vaults are hermetically sealed and would normally not be opened very often.

The matter was discussed anew at a meeting 15 April, and a checking/cleaning/reconditioning action was initiated. It was decided to check the 8 subarrays 01A to 07B first, since those were the oldest installations, apart from 01C, and also the sites in the B-ring were more easily accessible. Further decisions concerning the rest of the subarrays would then be taken upon review of the results from these first subarrays.

The seismometers were given a performance check before the work in the LPV started. Next the tanks were opened, and the seismometers lifted out and checked visually. The tanks were then cleaned and thoroughly dried with electric heaters, they all had moisture inside, and then finally they were painted white inside, floor and wall. The seismometers were reinstalled and checked out after having been reconditioned with new magnets, if necessary.

In order to keep these sensitive instruments clean, it is essential that the LPV floor outside the tanks also be kept to a high degree of cleanness, and the floors were therefore washed and vacuum-cleaned. In some places there were filings around the tanks and even inside, left from the adjustments of tank and lid during installation! Such filings have previously been found on the magnets of seismometers which were physically damped!

The work on these first 8 sites started 26 April and was completed 25 June, and the results were as follows:

> All the LP-tanks had moisture inside, to a varying degree. 7 seismometers in all had rust on the magnets, which were replaced and afterwards reconditioned at the MC. In one case the whole seismometer was brought to the MC for reconditioning; in addition to rust on the magnets there was also corrosion on the pivot assemblies. The remainder of the equipment in the LPVs like Ja-, Jb- and Lb boxes were generally in fair condition.

The results from these checks were so alarming that already before the work was completed on these first 8 sites, it was decided to continue the work on the rest of the array in the same manner.

At the end of this reporting period the subarrays 01C and 08C had undergone the LPV check, and the work had started on two more subarrays, 09C and 10C. Meanwhile necessary work on the SP system had received higher priority during the summer months, and the LP work was therefore slowed down.

3.2 Other Reconditioning Work at the LPVs

As discussed in the previous section, the floors of the LPVs were cleaned well, but the finish of the floors was not sufficiently good. It was therefore later decided to give them another coat of paint, and at the same time the wall-mounted steel ladder was also painted.

The fine-grained sand that is placed around the manhole-opening in the LPV entrance has had a tendency to come down on the floor. As another step in the cleanness-line various approaches for prevention of this drawback were discussed. The solution reached was to cover the sand with a layer of "Leca" gravel which is a lightweight insulating material casted into small spheres, but large enough not to hang onto clothes or shoes.

As the final approach in this cleanness-line, shoe coverings for use in the LPVs were made for the field personnel to prevent sand and dirt from being brought into the vault.

The wooden roof over the LPV entrance also showed signs of moisture at some places. To cope with this problem, the ventilation has been improved.

The locking mechanism on the manhole lids at the LPVs had started to get rusty, and they were difficult to operate at certain places. Greasing of these locking devices was therefore added to the check list for the LPV.

During the LP check at 03B in May, it was noticed that water was penetrating through the walls of the LPV. This was at the very end of the snow-melting period, and it was ascribed to poor drainage. No leakage has been noticed later, but it would be advisable to check this again next spring.

3.3 Improvements of LP Installations. Heated LP Tank Experiment.

Based on information from the previous seismic station at Ringsaker, which utilized installations of somewhat the same kind as at NORSAR, we proposed to introduce an electric heating element in the LP tanks to increase the air temperature somewhat, in an effort to reduce the moisture in the tanks.

It was of course difficult to foresee how much difference this would make, and also if it would bring in unforeseen disturbances. It would therefore have to be tested out at one site over a period of time.

Heating the air in the tanks very likely would allow us to remove the insulating pads which now are stowed around the seismometers. These pads which are made of thin fiberglass are a nuisance to the seismometers. Lots of those small thin, almost invisible fibers will inevitably come off the pads during handling, in and out of the tanks, and further find their way into the delicate parts of the seismometers when they are opened for service.

It was decided to go ahead with such a test, and later on the site 01B was selected as it earlier had shown a relatively high degree of moisture and also was easily accessible.

In the beginning of July 1971 a heating element of 22W was installed underneath the top of the tank lid and connected to the 28 VDC source in the CTV via a spare pair in the data cable. The insulation pads were put back in.

During the following weeks measurements were made at the DPC for noise and performance. The heating was switched on and off, the noise level being monitored and compared with the adjacent seismometer, which was for the occasion mounted parallel to the first. No deterioration of performance caused by the heating could be detected, and repeated inspections in the tanks showed largely reduced humidity in the heated tank.

Figure 3.1 shows the NS and the EW tanks opened, the NS tank filled up with insulating pads around and on top of the seismometer, while the pads are removed from the EW tank. A bag of dehydrating substance can be seen beside the seismometer. The technician is returning the thermometer before the lids are put back on.

Figure 3.2 shows the heating element as it was placed underneath the lid.

Figure 3.1 The NS and the EW tanks opened, the NS tank with insulating pads in.

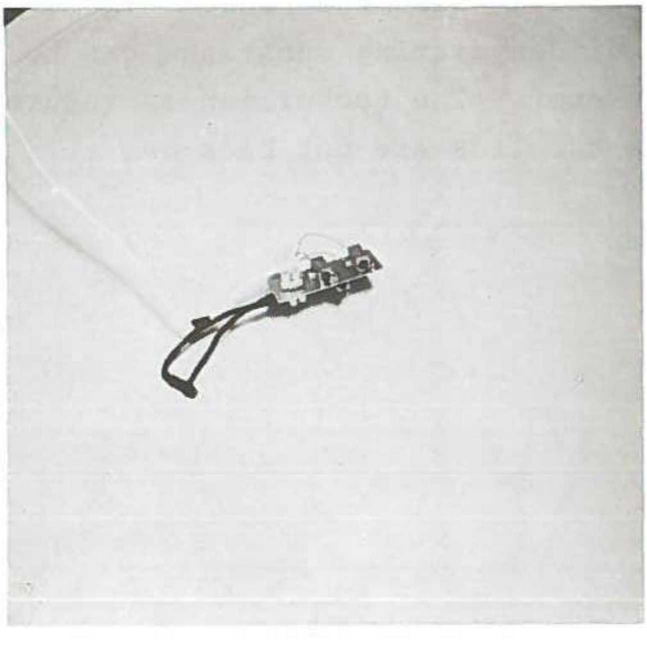


Figure 3.2 The heating element as it was installed underneath the tank lid.

3.4 Service on LP Seismometers and Accessories.

Apart from all the adjustments in the field that became necessary because of the difficulties with the array monitoring programs, we also had to replace some faulty seismometers or parts thereof. The repair list from the MC is as follows:

a) 4 LP seismometers repaired
for the following faults:

1 Broken Hairwire
3 Corrosion on pivot assemblies, of which one was completely broken
1 rusty

b) 6 pairs of rusty magnets reconditioned

The magnets were cleaned and remagnetized.

c) 3 remote centering devices repaired

All of them had rusty bearings.

4 THE SP SYSTEM

Because both the SP seismometers and the SP amplifiers are very temperature sensitive, it was, as earlier mentioned, decided to leave them as much as possible the way they were until the spring and concentrate the field work on the LP system until then. A review of the situation in June/July concluded with the decision to stop the LP work and utilize the summer months for SP work.

All the SP points would have to be visited, and various general tasks were already on the list of necessary SP work. These were as follows:

a) The general condition of the SP points, both electrical and structural would have to be checked.

b) A number of seismometers were operating outside the parameter tolerances and would have to be replaced.

c) The SLEM specifications had made it necessary to change the gain-setting of the RA5 amplifiers to 74.7 dB (8V p-p output).

d) A modification on the RA5 Input Card, located in the Ja-box, for suppression of 50 Hz noise in the Cal Amp mode had been decided. This was a result of tests conducted earlier by Teleplan A/S, the instrumentation consultant. By the end of the report period, this modification had been carried out at a total of 13 subarrays.

e) A modification for suppression of 50 Hz noise in the Cal.Seis. mode, which was needed at some places with high-tension overhead powerlines in the area, had been started before and some 9 points remained to be modified. Five of these were modified during the report period. (Ref.: (1) Technical Report "NORSAR Phase II - Installations 1969 and 1970", Section 10.4, and (2) Special Report "Suppression of SP Channel Noise".)

4.1 Variations in Natural Frequency (NF) and Damping Ratio (D) of the SP-seismometers.

The SP-seismometers had caused a great deal of trouble in the past, that is during the installation, mainly because of instability with regards to the NF. This problem was at long last defined to be caused mostly by a very high degree of temperature sensitivity.
(Refer to Technical Report "NORSAR Phase 2 - Field Operation and Maintenance 1 June 1969 to 30 June 1970").

We therefore decided to make an investigation of the NF and D data available for all the seismometers before we started the SP-work in the field.

On the basis of earlier Field Checkout data and "Chanev" data acquired from the DPC for the period April/May 1970 to January 1971 we listed NF and D for all the seismometers and calculated the variations for the period. The list, dated 24 May 1971, appears in Appendix 1 of this report. The conclusion was that although a large number (46) of the seismometers (35% of the total number) had NF outside the tolerance limits in January 1971, they had been relatively stable over this period. 10% of the seismometers showed no variation at all, while 73,5% showed variations between 0,01 and 0,05 Hz.

The total number of seismometers with NF outside the tolerance limits in May 1970 was 51, while it had been reduced to 46 in July 1971. With regards to the D of the seismometers the situation seemed to be somewhat worse. The total number of seismometers with D outside the tolerance limits was 19 in May 1970, while it had increased to 69 in January 1971. Theoretically the NF and D values should be very much related to each other as they are mechanically interlocked inside the seismometer. 68 seismometers or 51,5% of the total number showed an increase in NF over the period, and the same seismometers should then theoretically show a decrease in D over the same period, but we counted 105 seismometers or 79,7% with decreasing D value. However, in the past the D of the seismometers had not been reacted upon in the same manner as the NF, so this phenomenon was registered, but nothing more was done about it at the time.

4.1.1 Field Adjustment of the SP seismometers' D.

Later on when the SP Field work started in July, another situation appeared which again brought up the matter of disproportion between the D and the NF of some seismometers. Measurements of NF and D carried out in the field and at the DPC very often did not coincide, and the differences were more than could be credited to measuring inaccuracy. We therefore proposed to make a series of parallel measurements at the DPC and in the field for an investigation of the matter. The report of this test, dated 20 August 1971, appears in Appendix 2 of this report. The result of the measurements which were carried out for all SP points of the 6 subarrays 09C to 14C, clearly indicated that the measurements in the field of the seismometers'D to a great extent showed higher values than the corresponding measurements at the DPC, and vice versa for the NF measurements. Two series of measurements were conducted a few days apart, and in general there was not much difference between the parallel measurements at the DPC and at the parallel field measurements.

We did not immediately have the explanation to this phenomenon , but after a closer investigation of the measurements it became apparent that there very often was a disproportion between the NF and D values compared to what one could expect theoretically. Far more seismometers were outside the tolerance limits for D than for NF. The results also showed that by far the majority of the seismometers had NF above 1 Hz and D below 70%, which are the nominal values. After tests at the MC we came to the conclusion that the damping resistor R 1 of 240 Kohm on the RA5 Input Card, located in the Ja-box beside the RA5 amplifier, would have to be adjusted to each seismometer individually. This would make it possible to adjust the D in the field to the correct value without having to take out the seismometer, and thereby reducing the number of seismometers that would have to be taken out for service to the ones with NF outside the tolerance limits. These seismometers in turn would generally have to be adjusted further down in NF. The variation of the damping resistor would theoretically have no influence on the NF.

A short test was carried out at 04B 24 August for verification of this "variable-damping-resistor" theory. The result was exactly as predicted. The seismometers' D could easily be adjusted and apparently without any side effects. There was no noticeable change in NF. The detailed results are attached in Appendix 3 of this report.

The test mentioned above also revealed another interesting thing, namely, that the method used in the field for measuring D apparently is accurate enough in an area near 70%, but not any longer when the D goes higher or lower. This may well explain the differences of measured values between the DPC and the field in the past.

These experiments had by now received the highest priority, and an extended test was next conducted with all the SP-seismometers at the two subarrays 04B and 06C.

The damping resistors on the RA5 Input Cards were exchanged with potentiometers which were adjusted in the field to get a D on or near enough 70%. The test was a complete success, and the decision was taken to modify the whole array. The detailed results of this test will be found in Appendix 4, while Appendix 5 holds the final report on "FIELD ADJUSTMENT OF THE SP SEISMOMETER'S DAMPING RATIO" submitted 8 August 1971.

Figures 4.1 and 4.2 show modified RA5 Input Cards of respectively "Type used at 01C" and "Type used throughout the array except at 01C". Apart from the damping resistor R1 modification, the cards are also modified as earlier mentioned for suppression of 50 Hz noise in Cal.Amp. mode. The resistor R6 of 200 ohm is replaced by two resistors of 100 ohm in series and grounded over a 1 uF capacitor. Figure 4.3 shows a technician adjusting damping resistor at the WHV, while figure 4.4 shows the test setup in the CTV. By cooperation between WHV and CTV two technicians can now easily adjust the D to proper value.

4.1.2 The SP-seismometers' NF with Respect to the Temperature Sensitivity.

While the various tests regarding the SP seismometers' D took place in the field, we also explored the NF problem a bit further. This was done at the MC.

As already mentioned we knew from previous tests that the NF varied greatly with varying environmental temperature. In most cases the NF would increase with decreasing temperature, and the worst part about it, the individual seismometers would vary differently. What we did not know exactly, and what could be interesting to know, was whether the seismometers would have the same NF with the same temperature during temperature cycling.

A test was conducted with 6 seismometers which were adjusted to NF between 0.9 and 1.0 Hz at + 20°C. The seismometers were then cooled off to + 6°C and the NF was measured, whereupon the temperature again was raised to +20°C, lowered to +6°C and finally raised again to +20°C, and each time the NF was measured. The results are shown in table 4.1 and in the graph figure 4.5.

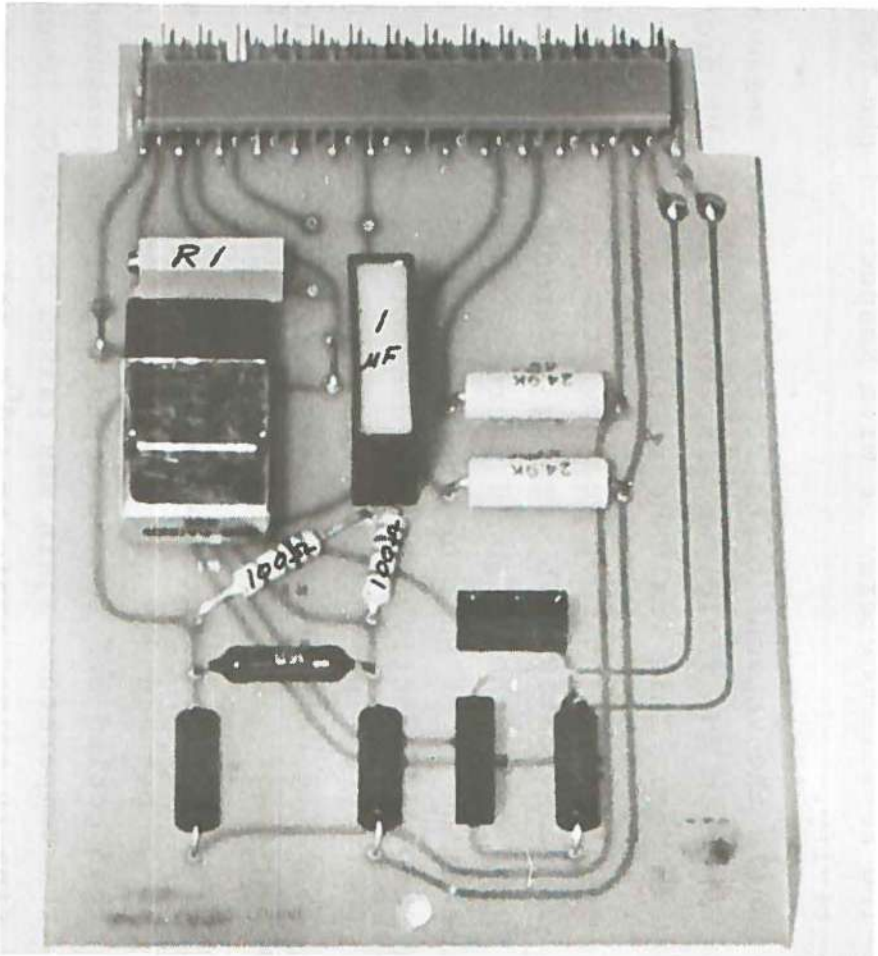


Figure 4.1 Modified RA5 Input Card Type used at 01C.

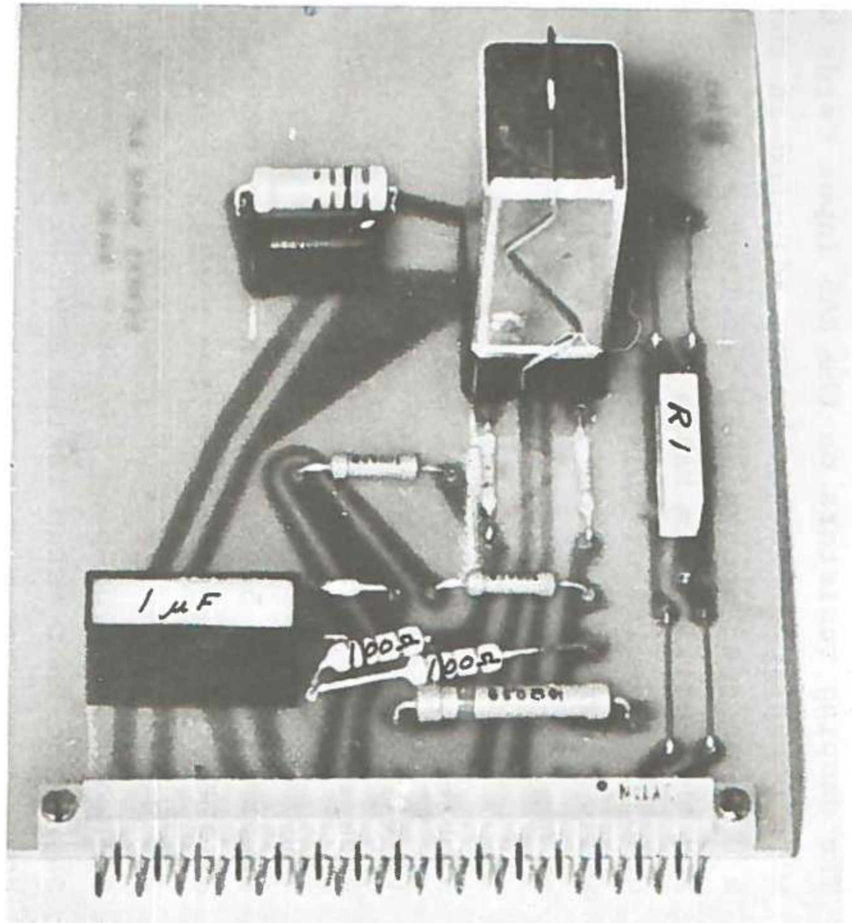


Figure 4.2 Modified RA5 Input Card Type used throughout the array except at 01C.

Figure 4.3 Technician adjusting damping resistor at the WHV.

Figure 4.4 Test setup in the CTV for field test.

Seis. Ser.No.	Natural Frequency in Hz				
	1. +20°C	2. +6°C	3. +20°C	4. +6°C	5. +20°C
299	0,99	1,01	1,01	1,01	1,01
517	0,94	1,35	0,97	1,37	0,99
428	0,92	0,84	0,97	0,89	0,98
400	0,91	1,23	0,92	1,20	0,93
505	0,91	1,16	0,99	1,16	0,91
30	0,91	1,12	0,90	1,10	0,91

Table 4.1 Natural Frequency of SP seismometers in relation to environmental temperature.

The variations in NF with changing temperature and the spread between the various seismometers were about as we had experienced before. But in addition this test showed us, with the uncertainties around the test taken into account, that the NF seems to follow the temperature fairly steadily through the cycles. In other words each individual seismometer seems to end up with about the same NF at the same temperature after a temperaturecycling of this nature which should be fairly realistic.

The normal working temperature at the MC would be +20°C and + 6°C would be near the operating temperature for the seismometers in the bore holes. Because of the great variation in NF between these two temperature levels we felt that it would be most correct to adjust the seismometers at a temperature as near as possible to the operating temperature. This would be inconvenient and time consuming at the MC, since the seismometers would have to be brought back and forth between the temperature chamber and the testbed. The conditions at the temperature chamber are not stable enough for adjustment of the seismometers. So, for the time being, with great demand for seismometers in the field, we decided to do the adjustments in the 01A LPV, whereafter the seismometers could be brought (carefully) to the Brumunddal Field Base for cablefitting and potting.

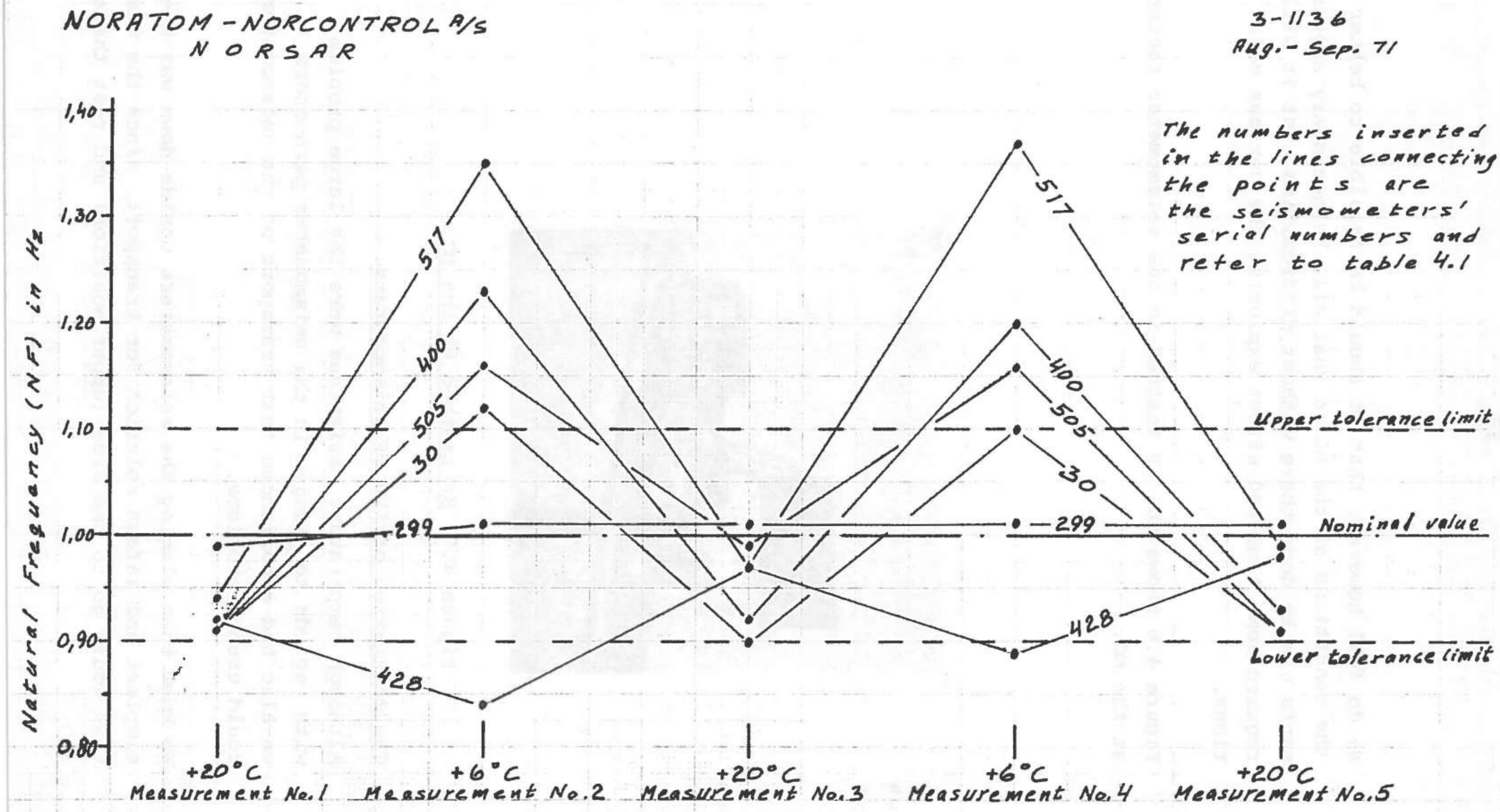


Figure 4.5 Natural Frequency of SP-seismometers in relation to environmental temperature.

We do feel however, that it should be feasible to better the conditions at the MC so that all the necessary adjustments can be done there without difficulties. But it will require some time and effort exploring the various solutions.

Figure 4.6 shows the SP testbed in the seismometer testroom at the MC.

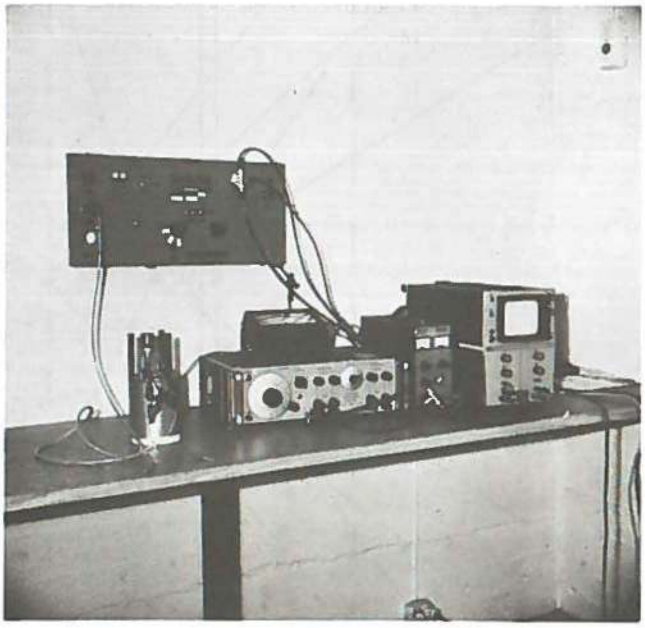


Figure 4.6 SP testbed at the MC.

4.2 Transportation of the SP seismometers.

Although temperature variations were the large problem with regards to changes in the seismometer parameters, we also had experienced that transport of the seismometers could create problems.

We knew that placing the seismometers upside down was the simplest and safest solution for transport, since the mass then would go to one side (upper position) and rest there, but this was of course not always the most practical way of doing it. Another means of locking the seismometer mass during transportation is to apply a DC Voltage of proper value over the datacoil. For testing purposes we had earlier made such a seismometer transport unit which, simply enough, consisted of a small box with a 67,5 V battery connected to a socket, matching the seismometer plug.

We now made up 10 such units, so that we could have some for seismometer transport between the MC and the Field Base as well as for transport into the field. The unit is plugged onto the seismometer at the start of any transport, and the battery is so connected that the seismometer mass goes to the upper position, which is equal to placing the seismometer upside down. When a seismometer is transported into the field, the battery unit stays on continuously until the seismometer rests down in the bore hole.

Later on we had one rucksack fitted with a bracket for transport of seismometers in the upside down position, as an extra precaution.

The figures 4.7, 4.8 and 4.9 show respectively, a seismometer connected to a transport unit, technician with seismometer tightened upside down in the rucksack, and with transport unit connected, and finally a technician at a WHV lowering down a seismometer into the bore hole, note that the transport unit is still connected to the seismometer.

4.3 The RA5 SP amplifier.

As the preceding sections may have indicated, a great deal of activity has been concentrated around the various seismometer problems, LP and SP, during this reporting period. But we also have another critical link in the system, namely the SP amplifier, the RA5. Located in the Ja-box in the WHV it is exposed to large changes in environmental temperature, and is inevitably influenced thereby.

Figure 4.7 SP seismometer with transport unit connected.

Figure 4.8 Technician with SP seismometer tightened in the rucksack.
(The seismometer is placed upside down and has a transport unit connected to it).

Figure 4.9 Technician lowering an SP seismometer down into the bore hole.
(Note that the transport unit is still connected).

In a search for better ways and means of handling and adjusting these amplifiers, we conducted a series of tests which will be described in section 5, Temperature Investigations.

As mentioned earlier, the SLEM specifications had made it necessary to change the gainsetting on the RA5s to 74,7 db (8 V p-p). The gain was previously, at the time of installation, set to 80 db (10 V p-p). This adjustment was carried out in the field as the various SP-points were visited.

Meanwhile, the need for amplifiers for replacement in the field were increasing, and the special RA5 Testbed, which we had started on earlier, was completed. It is shown in figure 4.10. The testbed is built into a mobile equipment rack and made in such a manner that the circuit cards from the RA5 can be mounted on a panel and tested individually, or the complete amplifier as such, mounted in the Ja-box, can be tested and adjusted.

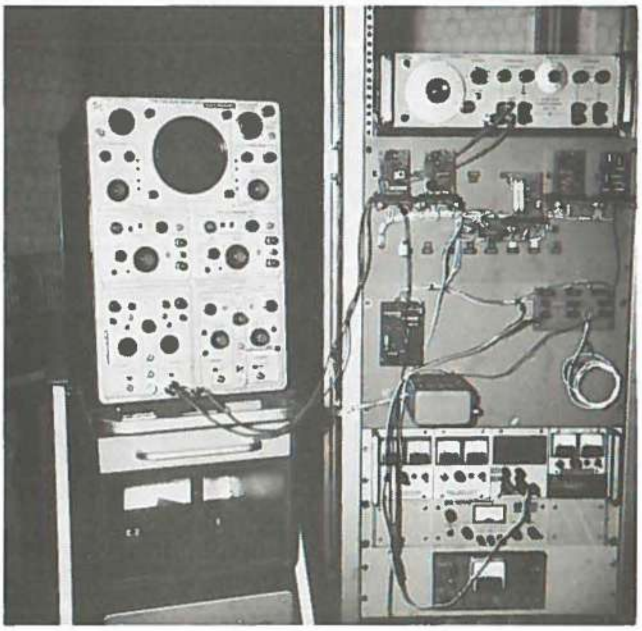


Figure 4.10 RA5 Testbed.
(Circuit cards from an amplifier are mounted in the sockets on the front).

The Ja-boxes with RA5 amplifiers at the 60 m experimental holes at the B-ring subarrays were removed in August and used as spare units. (The seismometers have also later been removed).

4.4 Service on SP seismometers and Amplifiers.

The repair list from the MC is as follows:

a) 27 SP seismometers repaired.
Some of these seismometers have been in for repair a number of times and in the great majority of the cases the cause has first of all been the NF and secondly the D. Other errors have been located to the data coil, the calibration spring, the main springs or other mechanical faults. A number of the seismometers have also been equipped with the new type of cable, while they were in for service.

The new cable has separate shields for cal coil and data circuits, helping to reduce 50 Hz noise in the system. (Ref.: Report "Suppression of SP Channel Noise".)

b) 13 RA5 amplifiers repaired

The batteries were replaced in all of them, and in addition a few of them had other faulty components like transistors and capacitors.

5 TEMPERATURE INVESTIGATIONS

5.1 1968/69 Temperature/Humidity Recordings at 01C

Temperature/humidity recordings were performed for periods of time during 1968/69 at the 01C CTV. The results are included here, as they have not been published before. It has been certified that the variations recorded in the end of January/beginning of February 1969 are caused by visits in the vault. The recordings are shown in Appendix A6.

5.2 Minimum - Maximum Temperature Registrations.

Minimum-maximum thermometers were in January 1970 placed at a number of selected SP points to get a general picture of the extreme temperatures within the array. Thermometers were placed down in the bore holes as well as in the amplifier boxes in the WHVs. The details of the registrations, the minimum and maximum temperatures through 1970 are reported in (1).

The thermometers were left in and with a few exceptions we have also this year gathered the minimum and maximum temperatures within the array. The winter's low temperatures at the various points were read off in June, while the high temperatures of the summer were read off during September and October and at the same time the thermometers were retracted as it was felt that enough information of this kind had been gathered.

The readings for 1971 are submitted in Table 5.1 and also shown graphically in Figure 5.1. The layouts of both the table and the graph are identical to the comparable ones for 1970.

5.3 Preliminary Temperature Investigation 06B02 Jan 21-22nd 1970

A preliminary temperature investigation was performed at 06B02 on January 21-22nd 1970.

The main purpose of this test was to determine the possibility of monitoring the DET output of the RA5 from the CTV. This will enable the maintenance crew to determine

N O R S A R - MINIMUM / MAXIMUM TEMPERATURES 1971

Min.temp. September 70 - June 71. Max.temp. June - October 71.

Temperatures in degrees C.

Site	WHV(Ja-box)		Shallow hole		Deep hole		LPV/CTV	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
01A CTV							4,5	18,0
01A LPV							1,0	13,0
01A 03	- 1,5	18,2			3,0	9,5		
01A 04	- 1,0	19,0	2,0	10,5				
01A 05	- 1,5	20,6	4,0	10,0				
04B LPV (Note 3)								
04B 02 (Note 3)								
04B 03 (Note 3)								
04B 05 (Note 3)								
03C 01	- 2,0	18,0			5,0	6,3		
03C 05	- 1,5	? 26,0			2,5	Note 2		
03C 02	- 2,0	21,0	1,0	11,3				
05C LPV								18,0
05C 02	0,0	19,0	1,5	9,8				
05C 04	- 1,5	? 26,3	1,5	10,2				
05C 05	1,5	21,0			3,5	5,0		
09C 04	- 3,6	16,0	1,3	8,0				
09C 00	- 1,0	20,8	1,3	11,0				
09C 01	- 1,6	18,0	1,5	8,5				
13C 04	1,5	18,0	2,0	10,0				
13C 05	1,0	13,8	2,0	8,0				
01C 04(Fl)	-10,9	? 6,0			1,5	Note 1		
01C 00(OY)	- 6,2	19,0			Note 2	" 2		
01C 05(Al)	- 7,8	12,0			3,4	" 1		
02C 05 (Note 3)	- 1,5	14,0			2,0	5,0		
02C 01 (Note 3)	- 5,0	13,0			2,0	4,0		
02C 02 (Note 3)	0,5	12,0	1,5	7,0				

Notes:

1) Thermometer previously removed by mistake.

2) Thermometer accidently broken during maintenance work.

3) Thermometers moved from 04B to 02C September 1970.

Table 5.1 <u>NORSAR minimum/maximum temperature readings 1971</u>.

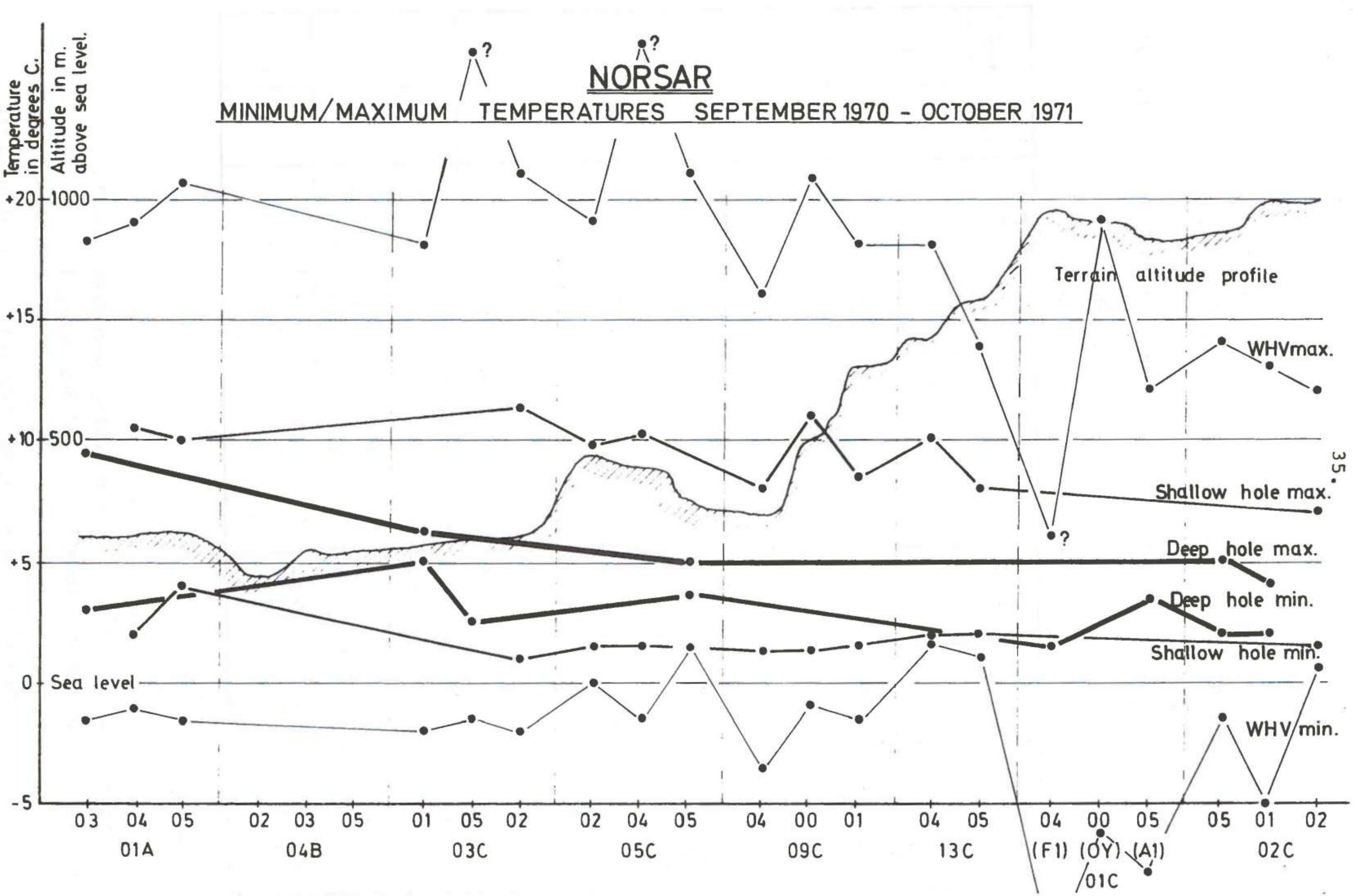


Figure 5.1 NORSAR minimum/maximum temperatures 1971 in relation to terrain altitudes.

during the CTV inspection if a WHV visit is necessary to adjust the RA5 bal and gain.

The detector terminals of the RA5 were connected to the telephone line and a termistor placed in the JA box and connected to one of the power pairs and recording started at CTV at 1610 on the 21st.

WHV was opened for cooling.

On the next day the vault was heated to 27^{O} C.

The recorder used for detector and temperature recording was a newly purchased piece of equipment and had during the night started to spill ink which spoiled all recording after 0400 on Jan 22nd. However, detector output and temperature were monitored in parallel at WHV during heating and noted.

The attached curve indicates the decrease in detector voltage with decreasing temperature from 7.1 Volt at 0 degrees to 5.2 Volts at -8^{O}C. (Table 5.2, Fig 5.2, 5.3).

It was found that connecting the RA5 detector terminal to the telephone did not have any influence on the RA5 performance.

<u>Continuous Registration</u>.

Registration period:	March 1970 to June 1971
Bore hole:	First half: Through Plan D equipment to DPC where results were noted at fixed intervals.
	Second half: Local recording at 06B CTV.

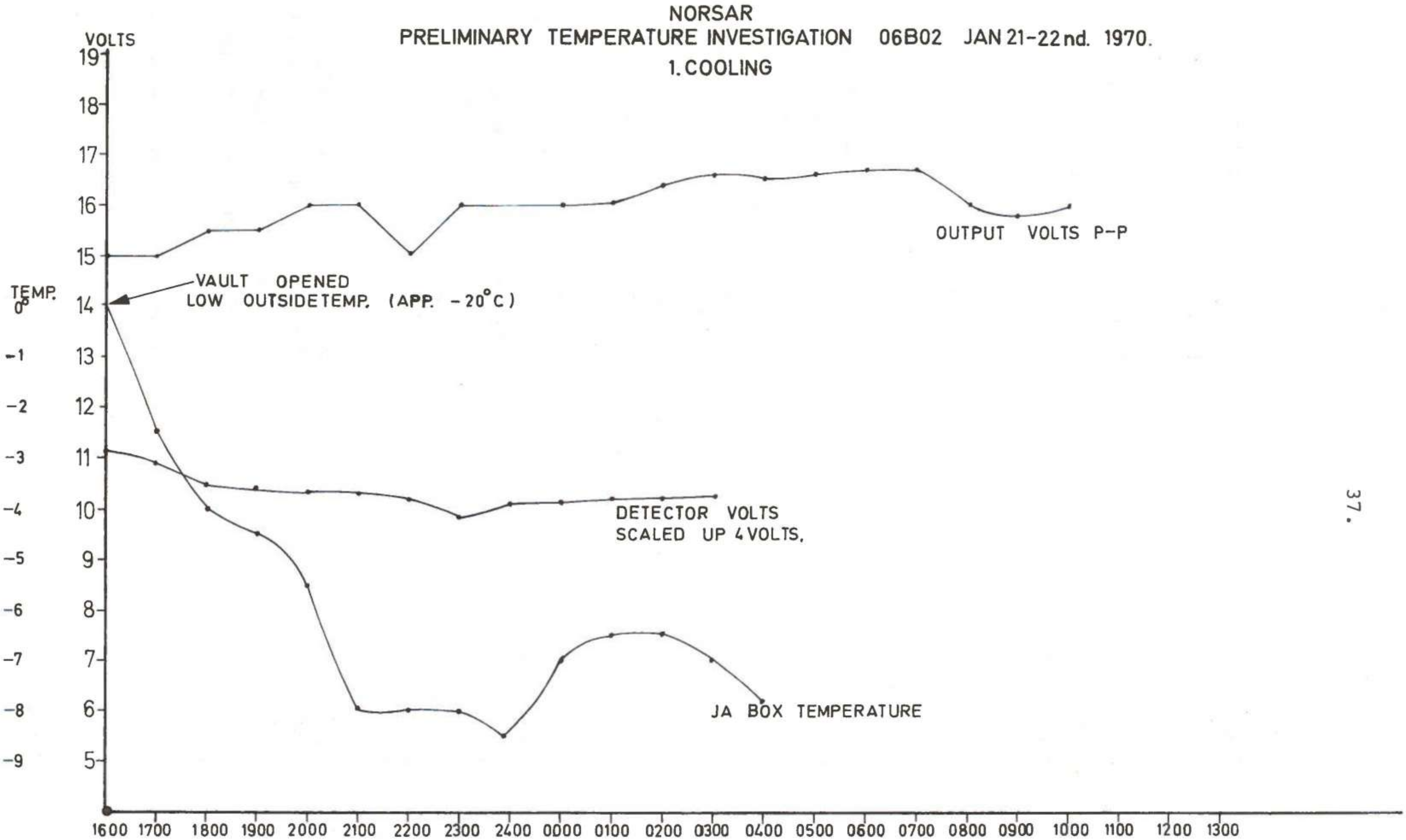
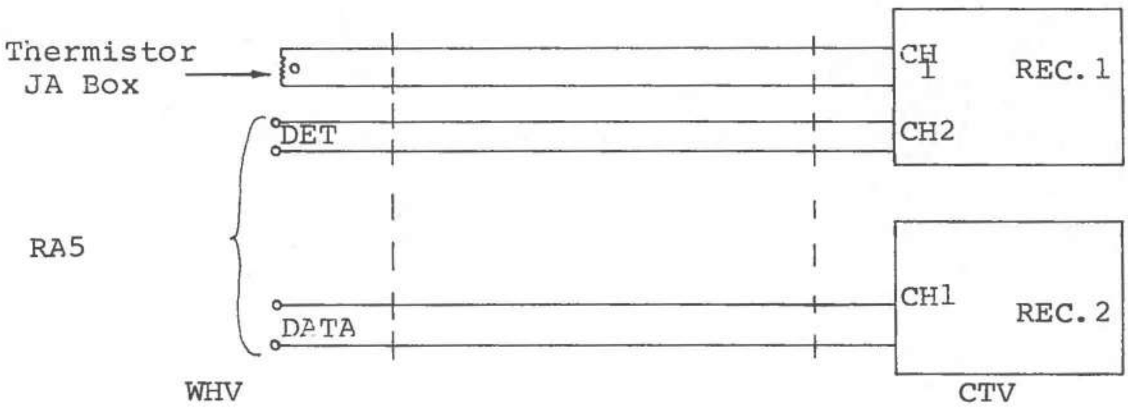

NORSAR
PRELIMINARY TEMPERATURE INVESTIGATION 06B02 JAN 21-22nd. 1970.
1. COOLING
VOLTS
TEMP.
VAULT OPENED
LOW OUTSIDE TEMP. (APP. -20°C)
OUTPUT VOLTS P-P
DETECTOR VOLTS
SCALED UP 4 VOLTS.
JA BOX TEMPERATURE
1600 1700 1800 1900 2000 2100 2200 2300 2400 0000 0100 0200 0300 0400 0500 0600 0700 0800 0900 1000 1100 1200 1300

Figure 5.2

TEST RESULTS 06B02 21-22 Jan 1970



TIME	OUTPUT	TEMP °C	DET.	
1610	15V	0	7.1	WHV OPEN - COOLING
1710	15V	- 2,5	6,9	
1810	15,5V	- 4,-	6,5	
1910	15,5	- 4,5	6,4	
2010	15,5	- 5,5	6,35	
2110	16,0	- 8,0	6,30	
2210	15,0	- 8,0	6,20	
2310	16,0	- 8,0	5,85	
0010	16,0	- 7,0	6,10	
0110	16,05	- 6,5	6,10	
0210	16,40	- 6,5	6,20	
0310	16,60	- 7,0	6,20	
0410	16,50	- 7,8	6,20	
0510	16,60			
0610	16,70	RECORDING DESTROYED BY INK.		
0710	16,70			
0810	16,00			
0910	15,80			
1010	16,0			
1105		↓	5,2	
			6,65	HEATING
			4,85	
			5,35	
		+ 27°	5,55	
1237			5,80	

Table 5.2

NORSAR

PRELIMINARY TEMPERATURE INVESTIGATION 06B02 JAN 21-22nd. 1970.

2. HEATING.

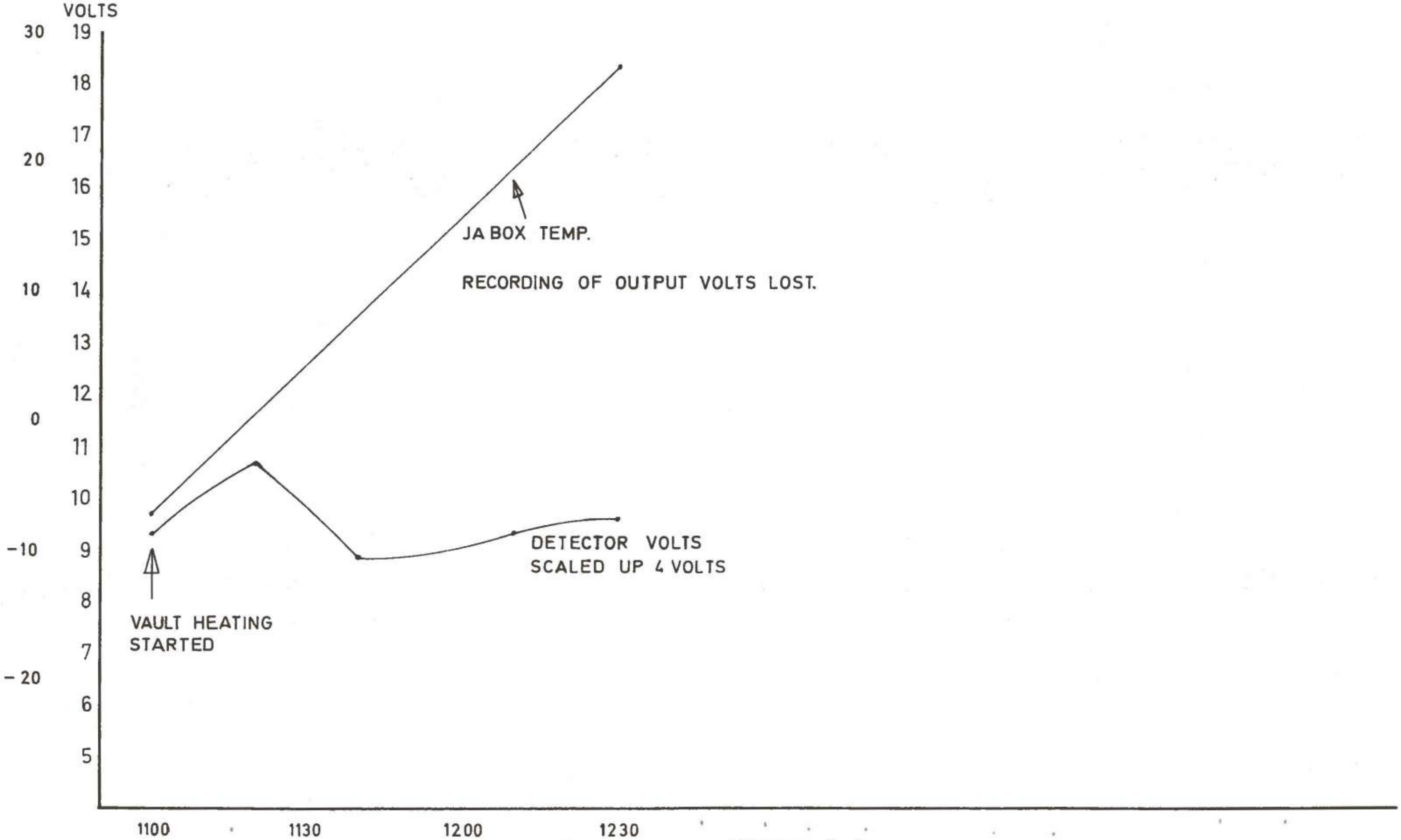


Figure 5.3

RA5 Amplifier:	August 1970 to June 1971 Through local recording
Equipment at WHV:	Fenwal thermistors connected to the CTV through telephone pair and one of the power pairs
Equipment at CTV:	Temperature bridge network with power supplies.
	Brush 2-channel recorder replaced by a Sanborn 2-channel recorder for last part.

Results plotted on graph paper.

As no provision was available to record the outside air temperature, contact was taken with the Meteorological Institute. This institution supplied printouts of the observations from the nearest observation point, Østre Toten, about 20 km from 06B02. This data is plotted on the same graph paper sheets as the recording to facilitate comparison.

On a separate sheet the average of the bore hole temperature, the RA5 temperature and the outside air temperature are plotted for the complete period. (Fig 5.4)

Detailed registrations are to be found in Appendix A7.

5.4 Influence of Temperature Changes on the RA5 Amplifiers.

Temperature investigation Villa Sole Jan 14-15,1971.

RA5 S/N 820 which had been kept at room temperature for a long time, was adjusted for optimum gain and balance. A thermistor was installed inside the RA5 and another in the JA box. Test equipment was connected through a

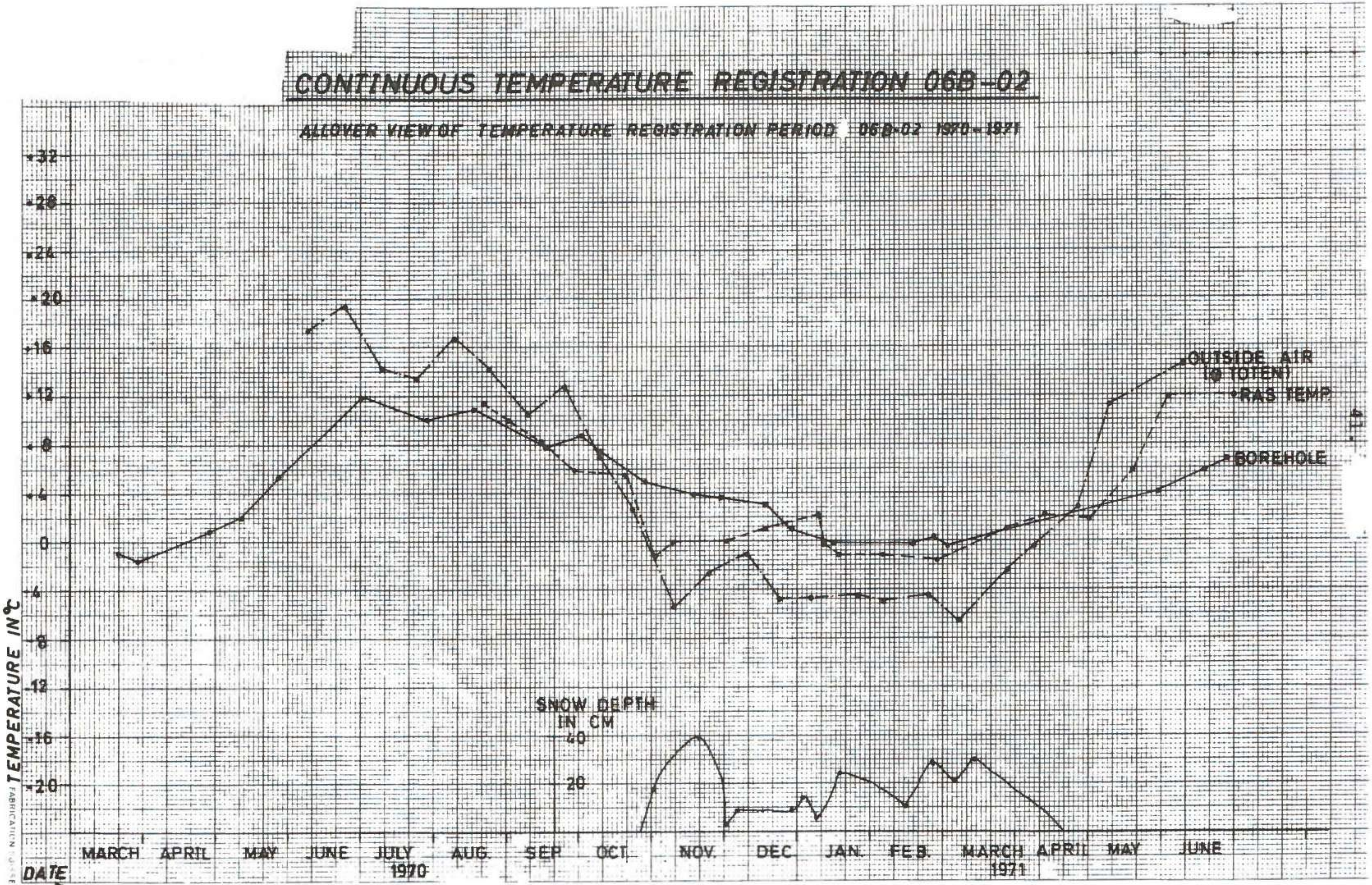

CONTINUOUS TEMPERATURE REGISTRATION 06B-02
ALLOVER VIEW OF TEMPERATURE REGISTRATION PERIOD 06B-02 1970-1971
+32
+28
+24
+20
+16
+12
+8
+4
0
-4
-8
-12
-16
-20
TEMPERATURE IN °C
OUTSIDE AIR (@ TOTEN)
RAS TEMP.
BOREHOLE
SNOW DEPTH IN CM
40
20
MARCH APRIL MAY JUNE JULY AUG. SEP. OCT. NOV. DEC. JAN. FEB. MARCH APRIL MAY JUNE
1970
1971
DATE

Figure 5.4

length of cable and the JA box moved outside to cool down. The amplifier and box were therefore subject to a slow decrease in temperature. Measurements were made every 5 minutes with longer intervals towards the end of the period. The results are plotted on Figure 5.5, and are listed in Table 5.3.

This test gives a good picture of the thermal characteristic of the JA box and RA5 and detector voltage and gain variation vs. temperature.

As seen from the attached table, the temperature in the RA5 lags the temperature in the JA box by ½ hour at start (temp. difference 25°C) and 45 mins. at the end of the period (temp. difference 6-7°C).

The JA box was then moved back in the workshop for heating to room temperature and results monitored again (Table 5.4.). These tests were used as a guide for further temperature chamber tests

Temperature chamber test report

During phase I of NORSAR's operation it was noted that the RA5 amplifier performance to a large extent was dependent upon variations in temperature and/or humidity. During the snow-covered period the operation was considerably better. All later temperature investigations in the field were attempts to clarify this.

When the temperature chamber was installed, it was expected to aid further investigation of the RA5 amplifier. The temperature chamber was installed at the NORSAR maintenance center Feb 12th, 1971. The experience with this type of chamber did not conform with expectations.

TIME	RA5 TERMISTOR °C		JA BOX TERMISTOR °C		DET.	OUTPUT
2123	13.33K	+19.0°	13.30K	+18.95°	5.33	
2230	13.63K	18.0°	13.95K	17.7°	5.015	
2235	13.80K		15.4K	15.4°	4.79	15.6
2240	14.20K	17.4°	17.3K	13.0°	4.74	15.75
2245	14.55K	16.75°	18.55K	11.5°	4.66	15.68
2250	15.35K	15.50°	20.5K	9.4°	4.56	15.82
2255	15.97K	14.7°	21.3K	8.3°	4.49	15.80
2300	16.84K	13.5°	22.34K	7.6°	4.41	16.0
2305	17.75K	12.4°	23.40K	6.6°	4.32	16.0
2310	18.60K	11.4°	24.40K	5.8°	4.26	16.0
2315	19.63K	10.3°	25.38K	5.0°	4.16	16.0
2320	20.60K	9.3°	26.30K	4.26°	4.09	16.1
2325	21.60K	8.4°	27.60K	3.26°	4.01	16.1
2330	22.20K	7.8°	28.20K	2.90°	3.98	16.06
2335	23.20K	6.8°	29.00K	2.3°	3.91	16.08
2340	24.20K	6.0°	29.60K	1.8°	3.85	16.03
2345	25.00K	5.3°	30.20K	1.4°	3.80	16.13
2355	26.50K	4.2°	31.18K	0.84°	3.76	16.00
0000	27.30K	3.3°	31.70K	0.5°	3.72	16.00
0007	28.00K	3.0°	32.20K	0.2°	3.68	15.97
0010	28.50K	2.6°	32.60K	-0.3°	3.65	15.92
0015	29.20K	2.2°	33.20K	-0.4°	3.62	16.00
0030	30.83K	1°	34.41K	-1.0°	3.53	16.00
0035	31.34K	.8°	34.84K	-1.35°	3.515	16.06
0040	31.94K	.4°	35.20K	-1.60°	3.50	16.02
0045	32.40K	.1°	35.50K	-1.75°	3.46	16.10
0050	32.90K	- .2°	35.90K	-1.95°	3.46	16.05
0055	33.30K	- .4°	36.10K	-2.0°	3.43	16.00
0100	33.70K	- .6°	36.30K	-2.1°	3.425	15.95
0117	24.90K	-1.4°	37.20K	-2.6°	3.37	15.97
0130	35.80K	-1.8°	37.90K	-3.0°	3.35	16.00
0145	36.50K	-2.25°	38.20K	-3.1°	3.33	15.95
0200	37.30K	-2.80°	38.70K	-3.4°	3.30	15.88
0215	37.90K	-3.0°	39.00K	-3.6°	3.29	15.92
0230	38.23K	-3.10°	39.30K	-3.75°	3.26	15.92
0245	38.63K	-3.4°	39.40K	-3.8°	3.27	15.94
0300	39.02K	-3.6°	39.80K	-4.0°	3.27	16.00
0315	39.30K	-3.75°	39.90K	-4.05°	3.27	15.96
0330	39.50K	-3.85°	40.00K	-4.10°	3.26	16.00
0400	39.90K	-3.87°	40.23K	-4.20°	3.25	16.00
0550	40.00K	-4.10°	40.4K	-4.25°	3.26	16.00
0710	40.00K	-4.10°	39.54K	-3.83°	3.27	16.00
0925	39.34K	-3.76°	39.14K	-3.6°	3.30	15.92

TABLE 5.3 - COOLING

NORSAR

Temperature investigation V. Sole- Jan 14.-15.1971.

TIME	RA5 TERMISTOR		JA BOX TERMISTOR		DET	OUTPUT
0930	38,70K	- 3.4°	35,10K	- 1,5°	3,34	15,90
0945	36,70K	- 2,4°	30,60K	+ 1,2°	3,44	16,01
0950	36,00K	- 2,0°	28,50K	+ 2,6°	3,48	15,93
0955	34,30K	- 1,0°	27,20K	+ 3,6°	3,55	15,99
1000	33,00K	- .2°	26,10K	+ 4.45°	3,60	15,97
1005	32.00K	+ .3°	24.80K	+ 5.40°	3,65	15.91
1010	30.90K	+ 1.0°	23.70K	+ 6.40°	3.69	15.92
1015	29.70K	+ 2.2°	23.30K	+ 6.70°	3.75	15.95
1020	28.50K	+ 2.6°	22.60K	+ 7.4°	3.81	16.0
1025	27.73K	+ 3.2°	22.13K	+ 7.8°	3.85	15.95
1030	26.73K	+ 4.1°	21.50K	+ 8.4°	3.90	15.91
1050	23.88K	+ 6.3°	19.98K	+ 9.96°	4.06	15.94
1055	23.00K	+ 7.0°	19.50K	+10.4°	4.09	15.94
1100	22.50K	+ 7.5°	19.20K	+10.8°	4.12	15.92
1115	21.00K	+ 8.9°	18.40K	+11.2°	4.18	15.98
1215	17.6 K	+12.6°	16.60K	+13.8°	4.42	15.96
123o	17.2 K	+13.0°	16.4 K	+14.0°	4.45	15.86
1240	16.92K	+13.4°	15.8 K	+14.95°	4.47	15.92
1300	16.22K	+14.4°	15.13K	+15.8°	4.54	-
1327	15.23K	+14.9°	14.10K	+17.4°	4.63	-
1355	14.20K	+15.6°	13.42K	+18.4°	4.71	-

TABLE 5.4

HEATING

NORSAR

TEMPERATURE INVESTIGATION VILLA SOLE JAN 14-15-1970.

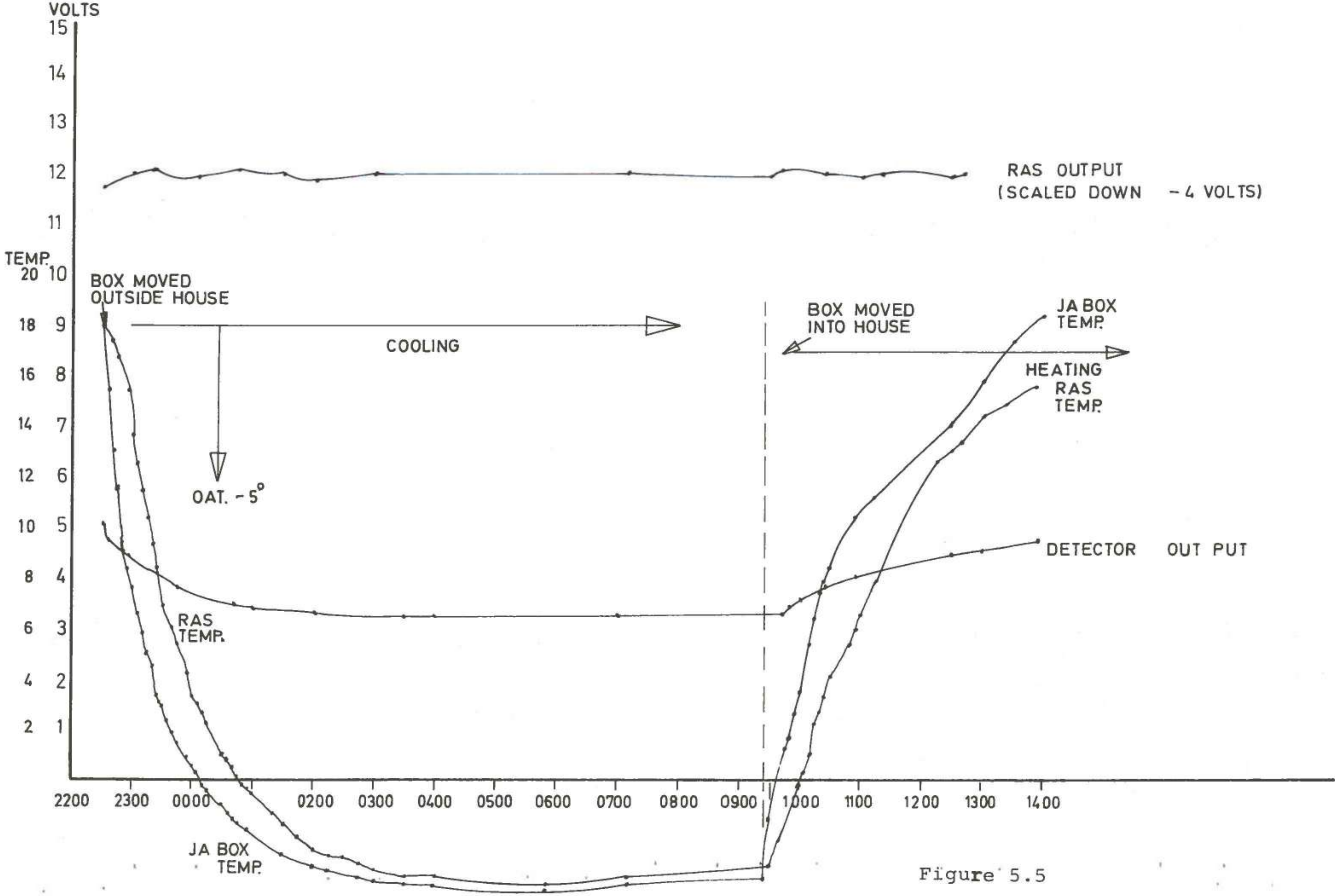


Figure 5.5

Temperature and humidity were controlled by cutting and installing plastic cams which were driven by a timer motor. No provision was made for de-activating this motor to run constant temperature checks. To run such checks, the cam followers had to be locked mechanically at the right temperature. This was a time-wasting and troublesome procedure.

Tests

Two RA5 amplifiers were installed in the chamber, SN 226 and SN 820.

During the starting period some overall tests were run. During these tests it was found that the RA5 is extemely sensitive to changes in the temperature, but performed distinctly better upon stabilization of the temperature. Some experience of this fact had been obtained earlier during the phase I operation at Øyer.

Most of the test runs were planned before the chamber arrived.

The plan was to investigate whether it would be of advantage to adjust the amplifiers at some temperature closer to what could be expected in the field. To clarify this, the test was divided in 3 parts.

Check no. 1: RA5 performance with amplifiers adj. at room temperature.

Check no. 2: RA5 performance with amplifiers adj. at $-5^{o}C$.

Check no. 3: RA5 performance with amplifiers adj. at $+12,5^{o}C$.

($12,5^{o}C$ represents the average temperature derived from the min-max temperature readings in the array.)

As the tests progressed, it was evident that it was not convenient for later work to adjust the RA5 in the temperature chamber. This is due to (1) the difficult method of adjusting the chamber temperature, and (2) the fact that the chamber has to be opened to do the adjustment and the RA5 then immediately is subject to a quick temperature change. However, it is recommended to adjust the RA5 amplifiers in a cellar room with a temperature closer to +12,5^{o}C rather than at room temperature (+20^{o}C).

Frequency response of the RA5 is run for each test at various temperatures, the results being presented in tables, Appendix A8, together with voltage/gain/temp curves.

6 OTHER TASKS

Apart from the matters already discussed we have also dealt with a number of other, less significant tasks. The major items of these will be commented on in the following.

6.1 CTV Standby Power-system.

6.1.1 Faulty Time Delay Relays.

The CTV standby power-system consists of a 28 V Ni-Cd battery and a controlled charger. In case of mains interruption, the battery will carry the load until it reaches a low voltage of 24V. The load will then automatically be cut off. Upon recurrence of the main power, the automatic charger will control the battery recharging within preset limits. As an additional safeguard, in case the automation should fail, a "Time Delay Relay" will, after a preset time, change the charging condition from "HIGH" (32,5V) to "NORMAL (29,4V) or maintenance charging.

These Time Delay Relays showed a number of failures during check-out in 1970 and were all returned under warranty to the manufacturer for repair/modification and the greater portion of them did not get back until spring 1971. They were then reinstalled at the various CTVs as other work necessitated visits.

6.1.2 Time-setting of the Time Delay Relays.

A request to the manufacturer of the battery chargers about the most correct time-setting of the Time Delay Relays brough forth some uncertainties about overcharging and gassing of the batteries, so a test was conducted to investigate these circumstances. The test was carried out in May/June at 09C and can naturally be divided in 3 parts as follows:

PART 1 Discharging of Fully Charged Battery.

The main power was disconnected, and the normal load was carried by the battery. The result is shown in figure 6.1.

The time lapses to "BATTERY LOW" - indication was recorded to 48 hours and to "LOAD OFF" to 61 hours. The load current was 6,3 A.

PART 2 Normal Charging Condition from "LOAD OFF"-level of Battery.

The main power was reconnected and normal charging-progress went on. The result is shown in figure 6.2.

The automatic changeover from "HIGH" to "NORMAL" or maintenance charging took place after approximately 9.3/4 hours.

The "LOAD ON" condition was established less than 10 seconds after reconnection of main power.

PART 3 Forced "HIGH" Charging.

The monitoring circuit of the charger was disconnected and the system set to "HIGH" charging (32,5V) for 5 hours to determine the charging current and the gassing effect.

The current diagram is shown in figure 6.3.

The charging rate started with 40A, dropping quickly to 12-14A and had come down to 8.75A after 5 hours.

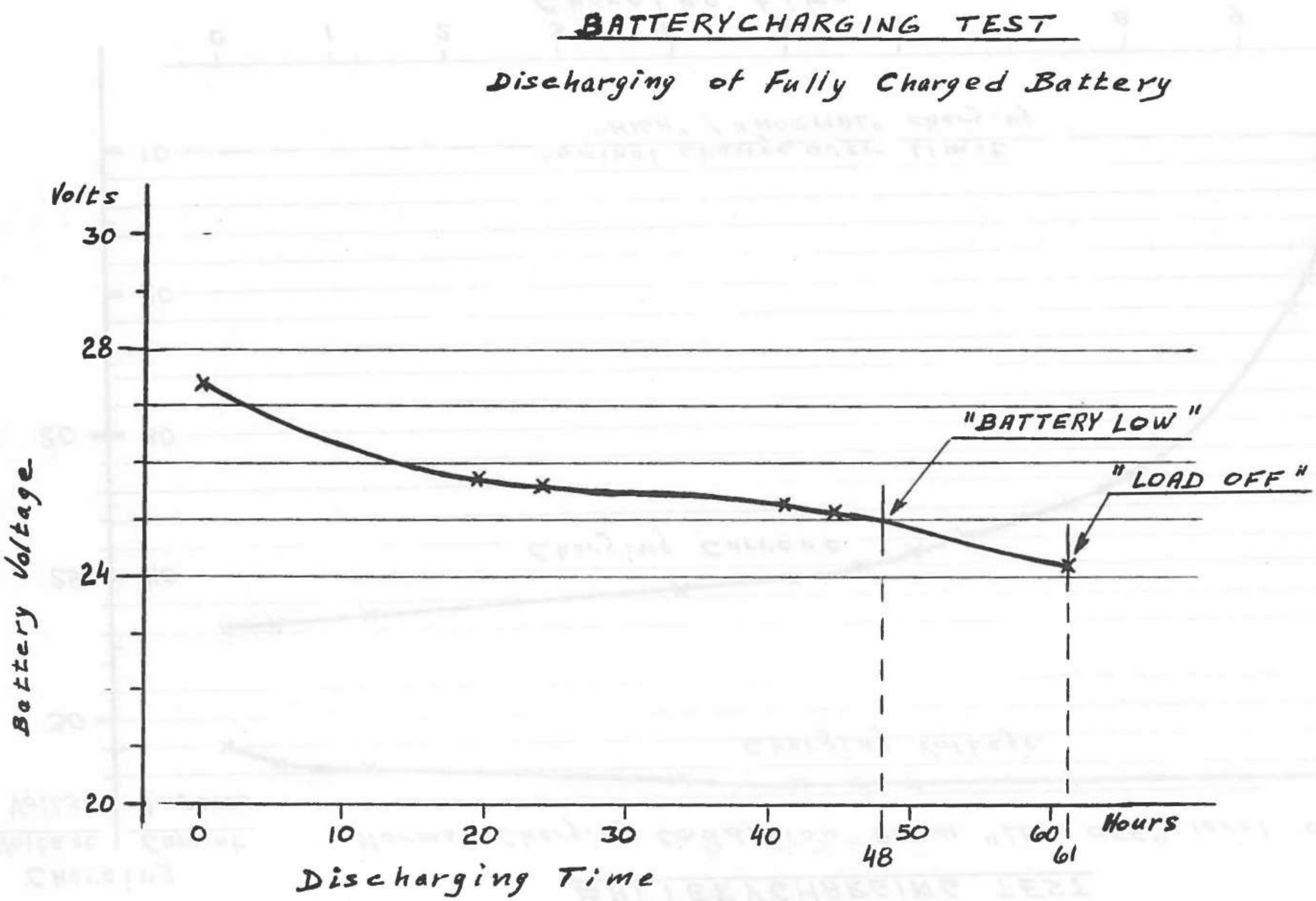


Figure 6.1 Discharging of Fully Charged Battery.

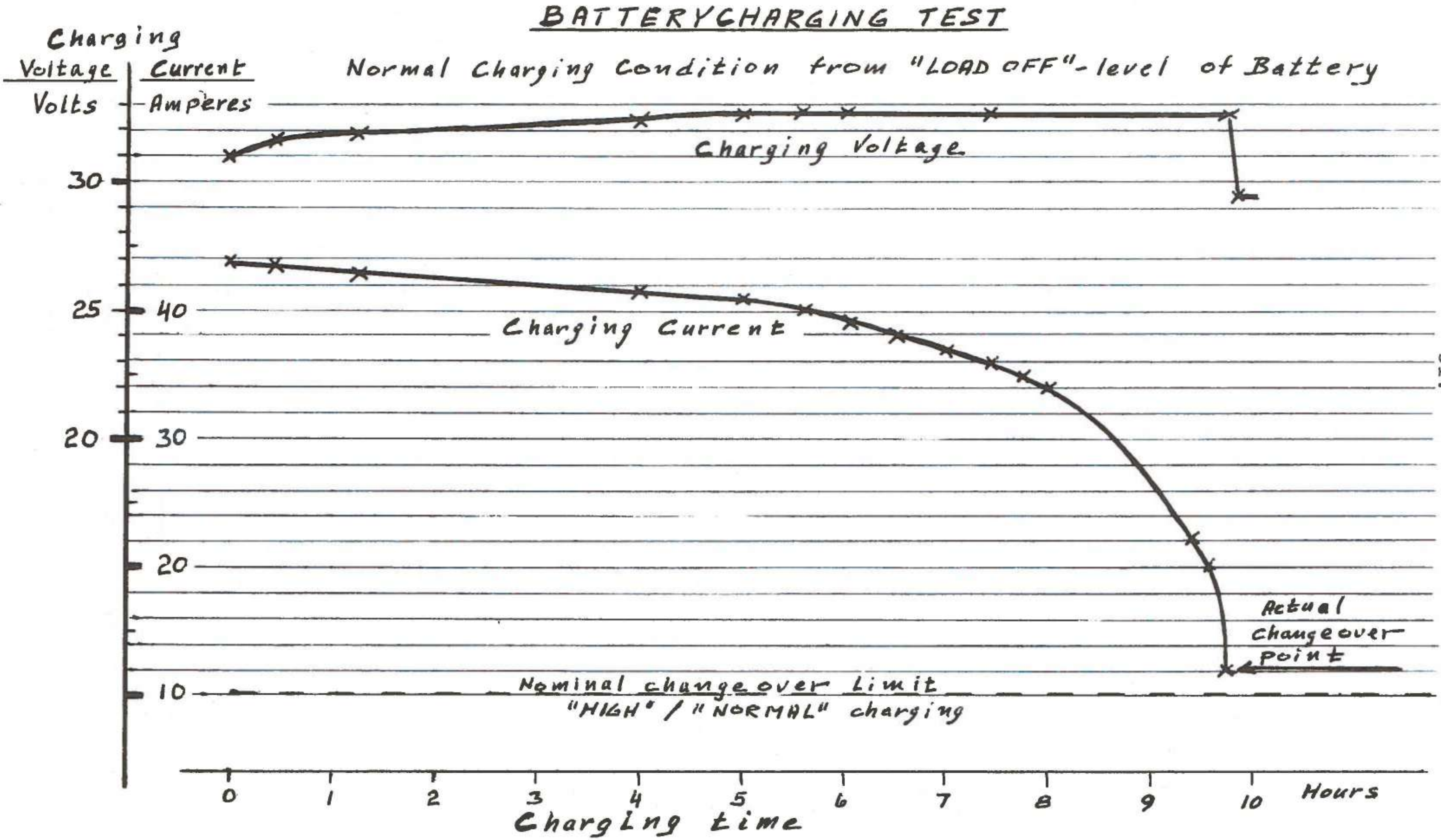


Figure 6.2 Normal Charging Condition from "LOAD OFF"-level of Battery.

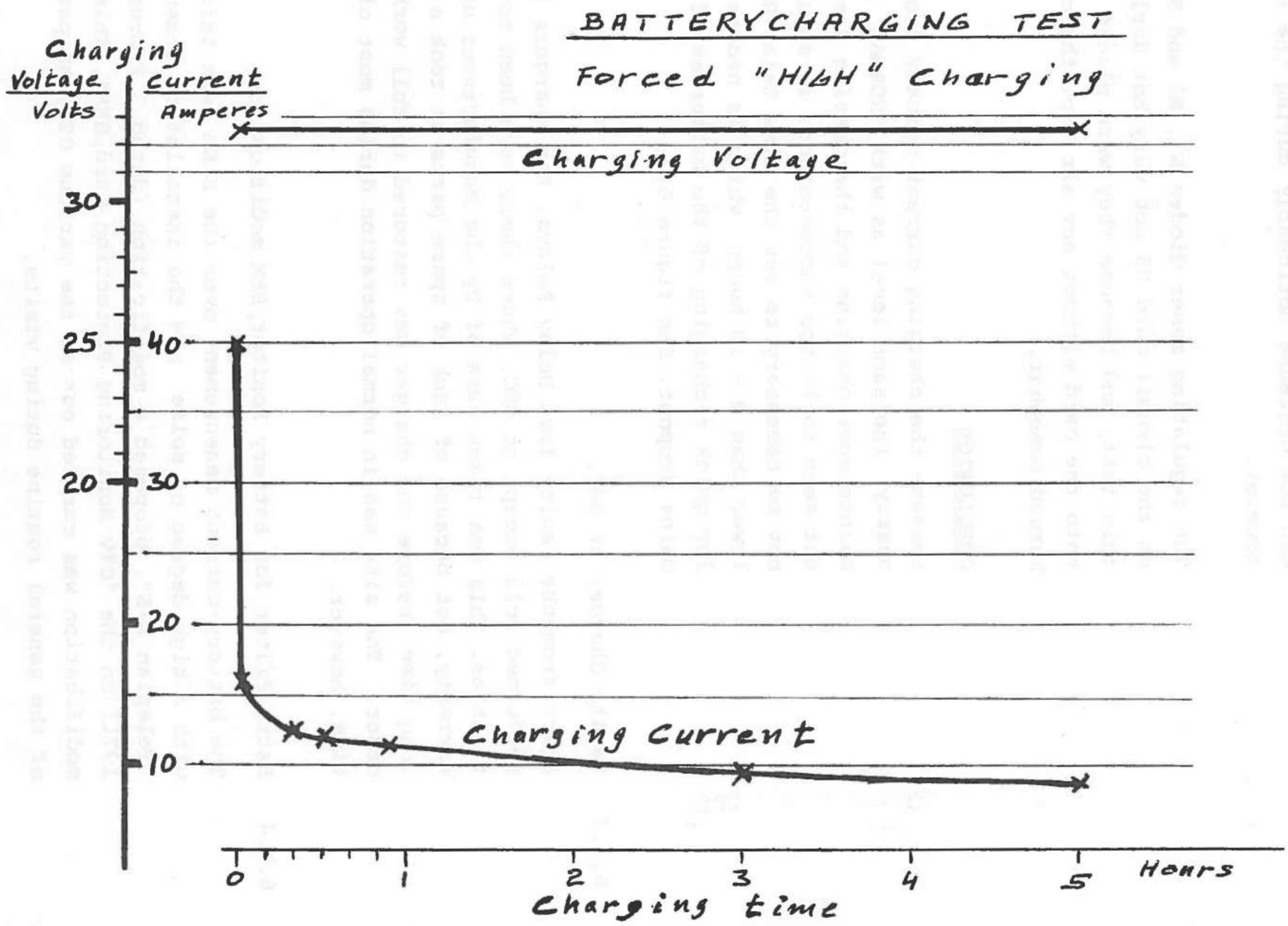


Figure 6.3 Forced "HIGH" Charging.

Gassing started 3 - 4 minutes after start of the test and was increasing towards the end of the period. The electrolyte level did not decrease noticeably during the test, however.

The regulating zener diodes N1, N2 and N3 on the circuit card U3 got very hot during this test, and because they were placed onto the card without any air gap, the card burned somewhat.

CONCLUSION

Because the charging current quickly drops to nearly the same level as with "NORMAL" or maintenance charging and the gassing does not seem to be too unconvenient, it should not be necessary to set the Time Delay Relays lower than 9 - 10 hours, which is necessary for quick recharging of the batteries after mains dropout. See figure 6.2.

6.1.3 Faulty Charger at 08C.

Apart from the faulty Time Delay Relays, the chargers have performed well except at 08C, where there have been some troubles. This was taken care of by the manufacturer under warranty, but because of lack of spare parts it took a long time before the charger was restored to full working order. The site was in normal operation during most of this time, however.

6.1.4 Extra Filter for Battery Monitor, BEM modification.

The battery-current measurement over the SLEM were infested with a high degree of noise and the installation consultant, "Teleplan A/S", proposed a modification (dated 2 February 1971) on the "CTV Monitoring Protection Card, BEM". This modification was carried out at the various CTVs as part of the general routine during visits.

6.1.5 Maintenance of the Batteries.

Although they had not been used much before the installation of the SLEMs, the batteries had been installed since 1968/69 and started to show corrosion of varying degrees. In some places mould had also started to grow on the wooden boxes, this of course was due to moisture in the CTVs, which had no source of heating.

Upon request, the manufacturer recommended cleaning off the corrosion, which appears as a white fluffy substance on top of the batteries, and cover the poles with acid-free vaseline.

The vaseline was purchased and cleaning of the batteries has been carried out as time has permitted.

Routine checks of the batteries also revealed deviations from the nominal density-value, which should be 1.17-1.19.

The manufacturer recommended that this should be regulated with adjustment of the charging voltage, and such procedure was incorporated in the maintenance routines.

6.2 <u>Breakdown of 4V Power Supply at 10C</u>.

Discrepancy with the EW Mass Position (MP) adjustment was detected on a visit to 10C 19 July, but other tasks did not leave time enough for localization of the fault. Later, the cause was found to be with the MP-lamps' power supply, which delivered 16V instead of 4V, and by now all the MP-lamps were burned out.

The power supply was brought to the MC for repair. It was heavyly corroded inside on the circuit cards, probably because of moisture at some earlier stage. The power supply was cleaned, repaired and later reinstalled.

Other suspect sites, like 11C, were later checked for the same fault, but no trace of corrosion on the power supplies has been found.

6.3 Clean-up in CTVs.

Frequent visits to the CTVs during the SLEM installation and check-out period, and by many people, necessitated a cleanup at many sites. This task was initiated in the middle of March at a time when other work slowed down a bit. The cleanup task, however, was only carried out as other tasks of higher priority permitted and in connection with various other repair and modification work of lower priority.

6.4 Electric Heaters in the CTVs.

The CTVs are well ventilated but being underground structures there will naturally be some moisture present at times, as also has been registered. The equipment installed does not give off much heat.

As a test, electric heaters of 350W were placed in two CTVs, 08C and 09C, over the winter 1970-71, and these two CTVs were in noticably better condition than the rest of the CTVs last spring.

On the background of these observations, we therefore suggested that fixed heaters be installed in all CTVs.

This was accepted, and the final solution was installation of a 1000W heating panel adjustable in steps and thermostatically controlled.

The heater is mounted on the wall behind the equipment racks, as this is thought to give the best distribution of the heat with the cold air intake underneath the heater on the same wall and the warm air outlet on the opposite wall. The immediate impression was also that this solution gave an even,well distributed heating.

6.5 Cable Repairs.

6.5.1 Training.

All cable repairs in the field had prior to this period been carried out by an electric company in Hamar, but it was now decided that this should be a task for the field maintenance personnel in the future.

Arrangements for training were made with "Standard Telefon og Kabel" (STK), which had supplied all the ground cable for the NORSAR installations. Two groups of two from the field personnel group received 2 days each of training in STK's workshop in Oslo at the end of January and in the beginning of February.

6.5.2 Cable Faults.

03B. 25 May a cable fault was registered on the 6-pair data cable between the SP points -00 and -04. Later,the break was localized to the shooting range near Rødsætervollen,where some construction work had taken place and where we also had a break on the same cable in the preceding period. The cable ditch had to be made deeper, and the cable was finally spliced 11 June.

09C. The 6-pair data cable to 09C - 04 had to be cut and the ditch made deeper because of roadwork. The cable was cut 3 June and finally spliced again 30 June.

11C. The power cable to 11C CTV/LPV was broken 14 June. This cable is the responsibility of the local electricity company, but we assisted with localization of the break.

It turned out that the fault was caused by rough handling of the cable during the installation. There have also been troubles earlier of the same nature with this cable in the same area.

The power was restored 22 June.

6.6 Various General Maintenance Work in the CTV/LPV areas.

Although most of the CTV/LPV-areas are well landscaped, some of the places still had little grass growing 2-3 years after the completion of the construction works. It was therefore decided to put in new grass seed at two sites, 01B and 03B, which were special eye sores. This was done in June. It seems to grow well at 01B after this, while the result is rather negative at 03B.

The NORSAR access road to the CTV/LPV area at 01B was in bad shape last spring and had to be supplied with some gravel, with which we assisted.

The snow melting last spring revealed a spare cableduct in the 07B CTV, which was not properly covered on the outside (underground), permitting water to get into the CTV, although in small amounts Each CTV has two such spare cableducts, and all the CTVs were therefore checked and 3 more such open ducts were discovered. They were all properly tightened during the summer.

Doormats have been placed in the CTV-entrances, as a means of preventing too much dirt from getting down in the CTVs during visits.

6.7 Break-in at 06B - LPV.

At a visit to 06B 19 May, it was discovered that the LPV-lid had been opened by force. No other damage was registered.

7 STAFF AND ORGANIZATION

7.1 Staff.

The staff has been the same as in the preceding period, with 10 members assigned as follows:

1 project leader
1 project leader assistant
2 technicians assigned to the MC
6 technicians assigned to the field group

The technicians in the field group lived in the Hamar region and operated in general from the Field Base at Brumunddal.

7.2 Working Schedule.

At the end of the preceding period we initiated a rotating work schedule for the field personnel. We have continued with the same system throughout this period.

The system is based upon the philosophy of having two equal groups of two technicians in the field simultaneously, both groups with all the necessary test equipment at their disposal, while a third group will be stand-by for other assignments, as for instance assistance to the MC-staff, if required. One goal set for the plan was to keep the complete rotating period as short as possible. This plan has a cycle of 6 weeks, with each of the technicians working 4 weeks in the two main groups, group 1 and group 2, which equally would be assigned to general field maintenance work, and 2 weeks in the standby group, group 3.

Each technician will always work two consecutive weeks in either of the main groups, to maintain the continuity in the work from one week to another, in case a task should require it.

Figure 7.1 shows an example of the Rotating Plan for the field personnel. Although the text is in Norwegian, it should indicate the main scope of the plan just as well.

The colours indicated underneath the group numbers in the plan refer to the colour markings on the equipment assigned to the various groups, viz.

Red	-	Group 1
Green	-	Group 2
Blue	-	Standby equipment, Brumunddal (like the Cable Fault Location Equipment)
Yellow	-	MC.

7.3 The Continuous Reporting System.

As mentioned in section 3, the DPC started to list the array status in a "DISCREPANCY REPORT" based on the array monitoring carried out at the computer.

To match this with return information about the field work we worked out, in cooperation with the DPC, a set of report forms which have been very useful.

Figure 7.2 shows the "MAINTENANCE CHECKLIST CTV-LPV", which is a checklist to be filled in at every visit to a CTV/LPV area.

Figure 7.3 shows the "OPERATIONAL CHECKLIST", which is referred to on the MAINTENANCE CHECKLIST and which should be filled in with operational data concerning the various equipment serviced or checked during the visit. The text is held in Norwegian, but the form should nevertheless indicate clearly enough the purpose of it.

RULERINGSPLAN
FELTGRUPPER

PROSJEKT NR: 3-1136
DATO: 1. KV. 1971 / 14-1-71

MÅNED	D70	JANUAR				FEBRUAR				MARS				A
UKE *Week*	1	2	3	4	5	6	7	8	9	10	11	12	13	14
GRUPPE 1 (RÖD) *Red*	F L	S L	S F	W F	W H	F H	F L	S L	S F	W F	W H	F H	F L	S L
GRUPPE 2 (GRÖNN) *Green*	W P	W H	P H	P S	L S	L P	W P	W H	P H	P S	L S	L P	W P	W H
GRUPPE 3 (BLÅ-GUL) *Blue-Yellow*	S H	F P	L W	L H	F P	S W	S H	P F	L W	L H	F P	S W	S H	P F

F = Falch
H = Halvorsen
L = Larsen
P = Pettersen
S = Solbakken
W = Westby

Figure 7.1 Rulating Plan for the field personnel

NORATOM-NORCONTROL A/S
N O R S A R

SITE: ....
DATE: ....

MAINTENANCE CHECKLIST

CTV - LPV

ARR.TIME: ....
DEP.TIME: ....

SIGN.: ....

[x] = Check Performed	Remarks if unnormal condition
1.0 SITE AREA GENERAL [ ] .1 Private access road condition [ ] .2 NORSAR access road condition [ ] .3 CTV/LPV-area in general	
[ ] 2.0 CONTACT NDPC ABOUT VISIT If possible, don't disturb operation before contact is made, and operator has flagged down the station.	Time: ....
3.0 CTV GENERAL [ ] .1 Condition of building, entrance, etc. [ ] .2 Lights [ ] .3 Telephone [ ] .4 Inventory [ ] .5 Check for moisture and mould	
4.0 LPV GENERAL [ ] .1 Condition of entrance structure [ ] .2 Condition of manhole-cover and seal [ ] .3 Check interior for moisture and mould	
5.0 BATTERY AND CHARGER [ ] .1 Check battery for cleanliness [ ] .2 Check electrolyte level and density [ ] .3 Visual inspection of charger interior. Dust of components if necessary [ ] .4 Switch to "High charge". Charging voltage should be 32,6 V (adj. R 1) Observe current rise. [ ] .5 Check that charger returns to "Normal" when current falls below 8 A. Normal charging voltage 29,4 V (adj. R 2)	
[ ] 6.0 TS CUBICLE Check interior for burned components, loose connections, etc.	
[ ] 7.0 OPERATIONAL CHECK Ref. "Discrepancy Report" and NDPC	Ref. "OPERATIONAL CHECK-LIST"
[ ] 8.0 RESTORE NORMAL SITE OPERATION	
[ ] 9.0 CONTACT NDPC FOR VERIFICATION	
[ ] 10.0 MAKE ENTRY IN STATION LOG	

REMARKS:

WHITE COPY: NDPC AM/C DEP.
GREEN COPY: O & M OFFICE
YELLOW COPY: O & M OFFICE
RED COPY: O & M FIELD GR.

Figure 7.2 Maintenance checklist CTV-LPV.

NORATOM-NORCONTROL A/S
N O R S A R

STASJON: ....
DATO. ....

OPERASJONS-SJEKKLISTE

SIGN.: ....

NAT.FREKVENS	-NF	MEK.DEMPN.	-MD	OFFSET	-O	SP KALIBR.	-SPC
FORVRENGNING	-DIS	MASSE POS.	-MP	COM.MODE REJ.	-CMR	LP KALIBR.	-LPC
FORSTERKNING	-G	FRI PERIODE	-FP	ADC KLOKKE	-CL	BB KALIBR.	-BBC
BALANSE	-B	MP MOTOR	-MPM	FULL SKALA	-FSC	ANDRE FEIL	-X
ELEKTR.DEMPN.	-ED	FP MOTOR	-FPM	X4 FORST.	-X4	UTSKIFTING	-U

SP SEIS.	NAT.FREKV.	DEMPNING
-00		
-01		
-02		
-03		
-04		
-05		

UTSTYR TATT UT		UTSTYR SATT INN	
TYPE	USP NO.	TYPE	USP NO.

RA5 FORST.	FORSTERKN.	F.JUSTERT	BALANSE	B.JUSTERT	MERKNADER
-00					
-01					
-02					
-03					
-04					
-05					

LP SEIS.	MASSE POS.	MP.JUSTERT	FRI PER.	FP.JUST.	MERKNADER
V					
NS					
EW					

LTA	FORSTERKN.	F.JUSTERT	ANDRE JUST.	MERKNADER
SP-01				
-02				
-03				
-04				
-05				
-06				
LP-01				
-02				
-03				

JUSTERINGER / MÅLINGER	
M U X	
ADC/RSA	
TEST GEN.	

MERKNADER:

HVIT KOPI : NDPC AM/C AVD
GRØNN KOPI: O & M KONTOR
GUL KOPI : O & M KONTOR
RØD KOPI : O & M FELTGR.

Figure 7.3 Operational checklist.

NORATOM-NORCONTROL A/S
N O R S A R

STASJON: ....
DATO: ....

VEDLIKEHOLDS-SJEKKLISTE
WHV - KABEL

ANK.TID: ....
AVR.TID: ....

SIGN.: ....

[x] = Sjekk utført	Merknader hvis unormal tilstand
1.0 WHV GENERELT ☐ .1 Adkomst ☐ .2 Område generelt	
2.0 WHV - BRØNN ☐ .1 Lokk ☐ .2 Ramme for lokk ☐ .3 Murkonstruksjon ☐ .4 Drenering ☐ .5 Festering for gummilokk ☐ .6 Gummilokk m/isolasjon ☐ .7 Tønne	Husk: notat om eventuell fuktighet
3.0 WHV - ELEKTRONIKK ☐ .1 Seismometer ☐ .2 JA-boks ☐ .3 RA-5 forsterker ☐ .4 JB-boks ☐ .5 Telefonforbindelse	Husk: notat om eventuell fuktighet
4.0 WHV - VANN/TEMPERATUR ☐ .1 Vann i borehull? Oppgi nivå. ☐ .2 Hvis termometere er installert, noter min. og maks. temp. samt temp. under besøk og nullstill term.	Minimum temp.: .... Maksimum temp.: .... Temp. ved besøk: ....
5.0 KABEL/KABELTRASE ☐ .1 Merking ☐ .2 Planering ☐ .3 Feilsøking ☐ .4 Reparasjon	

MERKNADER:

HVIT KOPI : NDPC AM/C AVD
GRØNN KOPI: O & M KONTOR
GUL KOPI : O & M KONTOR
RØD KOPI : O & M FELTGR.

Figure 7.4 <u>Maintenance checklist WHV-cable</u>.

Figure 7.4 shows the "MAINTENANCE CHECKLIST WHV-CABLE", which equals the CTV/LPV checklist for WHV and cable checks. The text on the form is again in Norwegian.

All these forms were meant for internal use FO&M-DPC only, which is the reason for the Norwegian text on them. They are here only shown as examples of the FO&M-DPC information flow.

Another form,very similar to the CTV/LPV checklist, has been used for inspection reports from the FO&M project leader to the DPC.

7.4 Field Discrepancy Survey Display Boards.

As a means of keeping track of the various field discrepancies and as a help in the organization of the field maintenance work, we developed a survey board, which we produced two of, one for use at the FO&M-office and one for the Field Base in Brumunddal.

The boards have room for notes for each and every SP-point in the array as well as for the CTVs and the LPVs, and also for notes to the individuals of the staff, and in addition the notes can have different colours for various priorities.

By keeping both the boards up to date all the time, it proved to be a good help in the organization of the field work, and it was a good reminder for the field groups, whenever they started out on missions.

7.5 Transportation.

The special purpose vehicles at our disposal were, as in the previous period:

1 Land Rover, 109.
Stationed at the Field Base.

1 Snow-track, Aktiv Beltetraktor ST4.

Stationed at Øyer, for eventual use to 01C. It was overhauled in February, but was never used last winter.

2 Snow-scooters, Evinrude Wide-Track 20.

Stationed at the Field Base. These scooters were, as in the past, very useful during the wintertime. Both scooters have, however, as mentioned on various occasions, passed the stage when they should have been exchanged with new ones. Due to very good service at the local repair shop in Brumunddal, they have nevertheless served us well.

By far the greatest part of the transportation, however, has been accomplished by means of the personnel's private cars. A total of 151.000 km were driven by the FO&M staff during the period.

7.6 Communication.

The communication link between the CTVs and the DPC has been bettered greatly by the use of the data lines for telephone communication and will also decrease the telephone expenses extensively. It is planned to modify the call system to allow two-way calling.

We should also like emphasize the benefit we have had through the use of radio telephones in the cars. All the cars have been equipped with PYE Westminster, type 10/W15FMD/V.

8 ARRAY STATUS 30 SEPTEMBER 1971

As this has been the first period with the NORSAR system completed and in more or less full operation, and as this report also terminates our participation in the NORSAR project, we shall in the following refer to the status of the NORSAR field installations per 30 September 1971, as earlier submitted in special reports.

8.1 Status of Planned Maintenance Work.

Figure 8.1, 8.2 and 8.3 show the status of the various tasks not completed by 30 September, grouped together respectively as the "LPV-CHECK", the "CTV-CHECK" and the "SP/WHV-CHECK".

8.2 General Status of the CTV/LPV Installations.

The inspection reports mentioned in section 7.3, last paragraph, reflected the current situation, other than the operational capability of the system, with the CTV/ LPV installations at the specific sites referred to.

Such inspections were carried out at every site from time to time by the FO&M project leader.

The following gives a summary of the general situation, based upon the last inspections of the array through the summer and fall 1971.

ARRAY-STATUS 30-9-71 LPV-CHECK

Work performed \ Site	01A	01B	02B	03B	04B	05B	06B	07B	01C	02C	03C	04C	05C	06C	07C	08C	09C	10C	11C	12C	13C	14
LP-seis. checked	X	X	X	X	X	X	X	X	X							X	X	X				
Seis. reinstalled	X	X	X	X	X	X	X	X	X							X						
Tanks painted	X	X	X	X	X	X	X	X	X							X	X	X				
Floor & ladder painted									X							X						
Cover-lock greased								X	—	—	—	—	—		—		X			X		
Entryway ventilated	X			X		X		X	X	—	—		—	—	—		—					
"Leka"-gravel in entryway									X							X						
LPV-report submitted	X	X	X	X	X	X	X	X	X													
Completed									10/9 -71													

X = spesified work performed — = OK on resent inspection

Remarks:

Figure 8.1 ARRAY-STATUS 30 SEPTEMBER 1971 LPV-CHECK.

ARRAY-STATUS 30-9-71 CTV-CHECK

Work performed \ Site	01A	01B	02B	03B	04B	05B	06B	07B	01C	02C	03C	04C	05C	06C	07C	08C	09C	10C	11C	12C	13C	14C
Time delay relay installed	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X
Electric oven installed									X			X										
Door mat	X	X			X	X	X		X		X	X		X		X	X	X	X	X	X	X
Spare mains fuses	X	X		X	X	X	X		X	X	X	X	X	X		X	X	X	X	X	X	X
Cleaning of battery	X	X				X	X	X	X			X	X			X	X					
Gen. cleaning of CTV	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		X	X	X	X
Completed									22/9-71			27/9-71										

X = Spesified work performed

Remarks:

Figure 8.2 ARRAY-STATUS 30 SEPTEMBER 1971 CTV-CHECK.

ARRAY-STATUS 30-9-71 SP/WHV-CHECK

Work performed \ Site		01A	01B	02B	03B	04B	05B	06B	07B	01C	02C	03C	04C	05C	06C	07C	08C	09C	10C	11C	12C	13C	14C
Mod. for suppression of SP-channel noise (Cal. seis.) (Insul'n. of seis. & Ja-box)	-00	X	–	–	–	–	–	+	X	–	–	–	–	–	–	–	–	–	–	–	–	–	X
	-01	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–
	-02	+	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–		–		–	–	+
	-03	+	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–		–	–	–	–	–
	-04	+	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–		–	–	–	–	–
	-05	+	–	–	–	+	–	+	X	–	–	–	–	–	–	–	–		–	–	–	–	–
Mod. for suppression of Cal. amp. noise (RA5 input card)						X				X	X	X	X		X		X	X	X	X	X	X	X
Mod. for field adj. of SP-seis. damping (RA5 input card)						1				X	X	X	X		1								
Check & adj. of seis. & RA5 ampl.						X				X	X	X	X		X		2	2	2	2	2	2	2
Completed						1/9-71				22/9-71	22/9-71	24/9-71	27/9-71		2/9-71								

X = spesified work performed + = Modified 1970 – = No nead for modification

Remarks:

1. Prototype of mod. Permanent mod. to be performed later
2. Check & adj. performed during July/Aug. this year, but new check neaded in connection with damping mod.

Figure 8.3 ARRAY-STATUS 30 SEPTEMBER 1971 SP/WHV-CHECK.

1 SITE AREA GENERAL

1.1 The private access roads are generally in fair condition, except the road to 11C which is in bad condition.

1.2 NORSAR's own access roads are all good, but at some places the roads are liable to be washed out during the snow-melting season. This is particularly the case at sites 11C, 13C and 14C.

1.3 The CTV/LPV areas in general look fairly good. At some places the area is landscaped with finely broken stones or gravel and thus grass will never grow again on these places. Meanwhile, this does not disturb the natural balance too much at these particular places.

1.4 Site markings are missing at some places. The necessary materials for this exist at the Field Base, and markers are being re-erected.

2 CTV GENERAL

2.1 The wooden structures at the entrances of both the CTVs and LPVs need a new coat of impregnating paint.

The insulation rubber strip for the inner door was actually glued to the doors and was OK on all sites except at 04C and 05C where it was attached to the frame and had partly loosened.

At some sites the water drain pipe out of the CTV entryway is missing.

The staircases are generally in fair condition.

In one instance the water condensation pipe underneath the air outlet pipe was filled to overflowing. Otherwise, the ventilation was OK all over.

The spare cable ducts are all closed.

Some minor damages on the inventory are registered, especially on the work benches, caused in transport, or from moisture in the CTVs. They can all easily be corrected.

At a few places the telephones are still not properly installed.

4 BATTERY AND CHARGER

There is corrosion on the batteries to a varying degree in all places. The density of the electrolyte should be checked frequently and corrected if necessary.

Some of the battery chargers are much noisier than others probably due to screw joints which are not properly tightened.

5 LPV GENERAL

The LPVs are in general in good condition.

A P P E N D I X   1

VARIATIONS IN NATURAL FREQUENCY & SYSTEM DAMPING OF SP-SEISMOMETERS

Seismometers outside tolerances are underlined.

Nat. Freq. tol.: 0.90 - 1.10 Hz.

Syst. Demp.tol.: 0.65 - 0.75.

SITE	NATURAL FREQUENCY (Hz)			DAMPING			REMARKS
	MAY 70	JAN.71	VAR'N	MAY 70	JAN.71	VAR'N	
01A-00	1,05	1,03	-0,02	0.69	0.70	+0,01	
01	1.08	1.11	+0.03	0.72	0.67	-0,05	
02	1.00	1.04	+0.04	0.68	0.68	0.00	
03	1.11	1.08	-0.03	0.67	0.66	-0.01	
04	1.02	1.04	+0.02	0.68	0.61	-0.07	
05	1.00	1.05	+0.05	0.75	0.68	-0.07	
01B-00	1.11	1.13	+0.02	0.66	0.57	-0.09	
01	1.12	1.13	+0.01	0.68	0.66	-0.02	
02	0.97	0.97	0.00	0.70	0.66	-0.04	
03	1.09	1.10	+0.01	0.68	0.63	-0.05	
04	0.86	0.90	+0.04	0.71	0.71	0.00	
05	1.10	1.15	+0.05	0.62	0.50	-0.12	
02B-00	1.04	1.02	-0.02	0.71	0.67	-0.04	
01	1.07	1.04	-0.03	0.65	0.66	+0.01	
02	1.02	1.02	0.00	0.70	0.72	+0.02	
03	1.11	1.09	-0.02	0.68	0.69	+0.01	
04	1.09	1.10	+0.01	0.68	0.63	-0.05	
05	1.15	1.14	-0.01	0.68	0.61	-0.07	
03B-00	0.99	0.98	-0.01	0.69	0.62	-0.07	
01	1.05	1.06	+0.01	0.68	0.66	-0.02	
02	0.98	0.99	+0.01	0.70	0.70	0.00	
03	1.05	1.09	+0.04	0.72	0.65	-0.07	
04	0.98	1.02	+0.04	0.70	0.70	0.00	
05	1.04	1.01	-0.03	0.68	0.65	-0.03	

VARIATIONS IN NATURAL FREQUENCY & SYSTEM DAMPING OF SP-SEISMOMETERS

Seismometers outside tolerances are underlined.
Nat. Freq. tol.: 0.90 - 1.10 Hz.
Syst. Damp.tol.: 0.65 - 0.75.

SITE	NATURAL FREQUENCY (Hz)			DAMPING			REMARKS
	MAY 70	JAN.71	VAR'N	MAY 70	JAN.71	VAR'N	
04B-00	0.96	0.96	0.00	0.73	0.71	-0.02	
01	1.07	1.07	0.00	0.70	0.69	-0.01	
02	0.96	1.03	+0.07	0.75	0.74	-0.01	
03	1.03	1.04	+0.01	0.67	0.64	-0.03	
04	0.97	0.95	-0.02	0.70	0.80	+0.10	
05	1.03	1.07	+0.04	0.72	0.67	-0.05	
05B-00	1.22	1.28	+0.06	0.65	0.59	-0.06	
01	0.99	1.02	+0.03	0.67	0.71	+0.04	
02	1.00	1.02	+0.02	0.69	0.68	-0.01	
03	1.14	1.16	+0.02	0.65	0.60	-0.05	
04	1.01	1.05	+0.04	0.70	0.69	-0.01	
05	1.00	1.04	+0.04	0.69	0.67	-0.02	
06B-00	0.96	0.98	+0.02	0.67	0.48	-0.19	
01	1.02	1.02	0.00	0.76	0.72	-0.04	
02	1.13	1.19	+0.06	0.63	0.51	-0.12	
03	1.09	1.08	-0.01	0.70	0.67	-0.03	Apr. 71 NF = 0,99 D = 0,56
04	1.13	1.10	-0.03	0.66	0.62	-0.04	Apr. 71 D = 0,66
05	1.07	1.07	0.00	0.68	0.65	-0.03	
07B-00	0.88	0.86	-0.02	0.73	0.80	+0.07	
01	1.06	1.08	+0.02	0.68	0.66	-0.02	
02	0.97	1.04	+0.07	0.71	0.68	-0.03	
03	0.98	0.94	-0.04	0.74	0.75	+0.01	
04	1.06	1.11	+0.05	0.68	0.63	-0.05	
05	0.93	0.91	-0.02	0.74	0.77	+0.03	

VARIATIONS IN NATURAL FREQUENCY & SYSTEM DAMPING OF SP-SEISMOMETERS

Seismometers outside tolerances are underlined.

Nat. Freq. tol.: 0.90 - 1.10 Hz.

Syst. Demp.tol.: 0.65 - 0.75.

SITE	NATURAL FREQUENCY (Hz)			DAMPING			REMARKS
	MAY 70	JAN.71	VAR'N	MAY 70	JAN.71	VAR'N	
01C-00	1.11	1.11	0.00	0.68	0.61	-0.07	
01	1.05	0.98	-0.07	0.69	0.61	-0.08	
02	0.96	0.96	0.00	0.69	0.68	-0.01	
03	1.08	1.14	+0.06	0.68	0.58	-0.10	
04	1.10	1.16	+0.06	0.70	0.63	-0.07	
05	1.02	0.96	-0.06	0.70	0.71	+0.01	
02C-00	0.97	0.94	-0.03	0.71	0.65	-0.06	
01	1.12	1.13	+0.01	0.68	0.62	-0.06	
02	1.26	1.16	-0.10	0.64	0.65	+0.01	
03	1.04	1.08	+0.04	0.70	0.67	-0.03	
04	0.88	0.90	+0.02	0.75	0.86	+0.11	
05	1.01	0.98	-0.03	0.70	0.70	0.00	
03C-00	0.99	1.03	+0.04	0.82	0.80	-0.02	
01	1.02	0.99	-0.03	0.72	0.64	-0.08	Apr. 71 D = 0.70
02	0.90	0.94	+0.04	0.78	0.65	-0.13	Apr. 71 D = 0,72
03	1.21	1.20	-0.01	0.59	0.46	-0.13	
04	0.98	1.07	+0.09	0.71	0.59	-0.12	Mar. 71 NF = 0,95 D = 0,(
05	1.11	[x]1.21	+0.10	0.68	[x]0.58	-0.10	[x]Mar. 71
04C-00	1.08	1.08	0.00	0.67	0.60	-0.07	
01	1.02	1.09	+0.07	0.64	0.53	-0.11	
02	0.97	1.01	+0.04	0.73	0.68	-0.05	
03	1.05	1.03	-0.02	0.66	0.61	-0.05	
04	0.97	1.00	+0.03	0.69	0.68	-0.01	
05	0.96	1.08	+0.12	0.67	0.59	-0.08	

VARIATIONS IN NATURAL FREQUENCY & SYSTEM DAMPING OF SP-SEISMOMETERS

Seismometers outside tolerances are underlined.

Nat. Freq. tol.: 0.90 - 1.10 Hz.

Syst. Demp.tol.: 0,65 - 0.75.

SITE	NATURAL FREQUENCY (Hz)			DAMPING			REMARKS
	MAY 70	JAN.71	VAR'N	MAY 70	JAN.71	VAR'N	
05C-00	0.94	0.96	+0.02	0.72	0.71	-0.01	
01	1.23	1.28	+0.05	0.60	0.51	-0.09	Kompansation Nettwork
02	1.12	0.98	-0.14	0.65	0.67	+0.02	introduced after Jan.71.
03	1.11	1.11	0.00	0.68	0.65	-0.03	Apr. 71 NF = 1.09
04	1.10	0.98	-0.12	0.72	0.76	+0.04	Apr. 71 NF = 1.11 D = 0.61.
05	1.02	1.06	+0.04	0.63	0.58	-0.05	
06C-00	1.05	1.09	+0.04	0.70	0.67	-0.03	
01	0.81	0.81	0.00	0.74	0.73	-0.01	
02	1.02	1.08	+0.06	0.69	0.67	-0.02	
03	1.16	1.18	+0.02	0.67	0.60	-0.07	
04	1.05	1.06	+0.01	0.68	0.61	-0.07	
05	1.16	1.21	+0.05	0.65	0.56	-0.09	
07C-00	1.00	0.98	-0.02	0.71	0.80	+0.09	
01	1.16	1.19	+0.03	0.67	0.66	-0.01	
02	1.04	1.01	-0.03	0.69	0.70	+0.01	
03	1.01	1.04	+0.03	0.71	0.70	-0.01	
04	1.13	1.07	-0.06	0.67	0.64	-0.03	
05	1.12	1.12	0.00	0.67	0.61	-0.06	
08C-00	1.14	1.11	-0.03	0.69	0.67	-0.02	
01	1.12	1.11	-0.01	0.65	0.55	-0.10	
02	1.00	1.01	+0.01	0.65	0.64	-0.01	
03	1.02	1.07	+0.05	0.70	0.66	-0.04	
04	1.43	1.44	-0.04	0.58	0.50	-0.08	
05	1.15	1.20	+0.05	0.65	0.58	-0.07	

VARIATIONS IN NATURAL FREQUENCY & SYSTEM DAMPING OF SP-SEISMOMETERS

Seismometers outside tolerances are underlined.
Nat. Freq. tol.: 0.90 - 1.10 Hz.
Syst. Demp.tol.: 0.65 - 0.75.

SITE	NATURAL FREQUENCY (Hz)			DAMPING			REMARKS
	MAY 70	JAN.71	VAR'N	MAY 70	JAN.71	VAR'N	
09C-00	0.99	0.99	0,00	0.68	0.69	+0.01	
01	1.17	1.14	-0.03	0.68	0.64	-0.04	
02	1.14	1.13	-0.01	0.69	0.65	-0.04	
03	1.09	1.10	+0.01	0.67	0.63	-0.04	
04	1.02	0.97	-0.05	0.74	0.72	-0.02	
05	1.19	1.17	-0.02	0.63	0.63	0.00	
10C-00	1.12	1.15	+0.03	0.64	0.58	-0.06	
01	1.17	1.21	+0.04	0.62	0.49	-0.13	
02	1.24	1.22	-0.02	0.60	0.51	-0.09	
03	1.06	1.09	+0.03	0,67	0.62	-0.05	Apr. 71 D = 0.65
04	1.11	1.17	+0.06	0.69	0.63	-0.06	
05	1.03	1.07	+0.04	0.69	0.66	-0.03	
11C-00	1.05	1.10	+0.05	0.68	0.73	+0.05	Apr. 71 NF = 0.98
01	0.96	0.94	-0.02	0.65	0.58	-0.07	
02	1.20	1.19	-0.01	0.71	0.69	-0.02	
03	1.05	1.03	-0.02	0.73	0.71	-0.02	
04	1.08	1.07	-0.01	0.70	0.65	-0.05	
05	1.00	1.02	+0.02	0.71	0.69	-0.02	
12C-00	1.12	1.08	-0.04	0.67	0.62	-0.05	
01	1.33	1.32	-0.01	0.62	0.58	-0.04	
02	1.28	1.25	-0.03	0.63	0.52	-0.11	
03	1.45	1.49	+0.04	0.55	0.43	-0.12	
04	1.05	1.04	-0.01	0.68	0.62	-0.06	
05	0.88	0.83	-0.05	0.69	0.75	+0.06	

VARIATIONS IN NATURAL FREQUENCY & SYSTEM DAMPING OF SP-SEISMOMETERS

Seismometers outside tolerances are underlined.

Nat. Freq. tol.: 0.90 - 1.10 Hz.

Syst. Demp.tol.: 0.65 - 0.75.

SITE	NATURAL FREQUENCY Hz			DAMPING			REMARKS
	MAY 70	JAN.71	VAR'N	MAY 70	JAN.71	VAR'N	
13C-00	1.06	1.03	-0.03	0.68	0.69	+0.01	
01	1.00	0.99	-0.01	0.69	0.64	-0.05	
02	0.95	0.91	-0.04	0.73	0.72	-0.01	
03	1.14	1.08	-0.06	0.59	0.62	-0.07	Apr. 71 D = 0.65
04	1.15	1.21	+0.06	0.68	0.61	-0.07	
05	1.14	1.13	-0.01	0.66	0.64	-0.02	
14C-00	0.97	0.97	0.00	0.71	0.78	+0.07	
01	1.13	1.15	+0.02	0.68	0.60	-0.08	
02	1.11	1.07	-0.04	0.63	0.60	-0.03	
03	1.11	1.17	+0.06	0.62	0.58	-0.04	
04	1.30	1.40	+0.10	0.67	0.56	-0.11	
05	1.28	1.29	+0.01	0.59	0.54	-0.05	

A P P E N D I X 2

DIFFERENCES IN MEASURED VALUES OF DAMPING AND NATURAL FREQUENCY OF SP-SEISMOMETERS CARRIED OUT AT NDPC ("CHANEV") AND AT CTV'S (MANUALLY BY O & M-CREW)

Earlier measurements carried out at NDPC and at various CTV's from time to time have showed some degree of difference in the results.

In order to analyze further these differences a test was carried out with the 6 subarrays 09C to 14C. The measurements at NDPC and at the sites were conducted a few days apart.

In the following summary of the results a + indicates a higher measured value at CTV than at the NDPC and a - the opposite, while a 0 indicates equal values at both places. The values give the difference between the measurements.

	Damping			Nat. Freq.		
	-	0	+	-	0	+
	0,02	0	0,03	0,04	0	0,02
	0,01	0	0,06	0,02	0	0,04
	0,02	0	0,04	0,01	0	0,02
	0,01		0,03	0,06	0	0,02
	0,03		0,07	0,02	0	0,01
	0,01		0,01	0,02	0	0,02
			0,01	0,01	0	0,02
			0,04	0,02		0,02
			0,03	0,02		0,01
			0,06	0,03		
			0,06	0,02		
			0,07	0,02		
			0,01	0,04		
			0,03	0,02		
			0,01	0,02		
			0,08	0,06		
			0,06	0,02		
			0,04			
No. of measurements	6	3	18	17	7	9
Everage of measured difference	0,017	0	0,041	0,026	0	0,020

This table clearly indicates that the measurements of damping in the field to a great extent shows a higher value than the NDPC-measurements and visa versa for the nat. freq. results.

We have no immediate explanation to this phenomenon.

Two series of measurements were taken a few days apart. The above results are from the last serieS. The difference between the two measurements at NDPC are very small except from a few caseS.
The CTV-measurement also differs very little in general, but some of the measurements from the first seriesare invalid, because they were taken shortly after handling or change of seismometers.

SP - DAMPING & NAT. FREQ. MEASURED AT DPC & CTV

SITE	DAMPING (Tol. 0,65 - 0,75)								NAT. FREQ. (Tol. 0,90 - 1,10)								REMARKS
	DPC			CTV			Diff. DPC-CTV		DPC			CTV			Diff. DPC-CTV		
09C	4/8	11/8	Diff.	29/7	16/8	Diff.	4/8-29/7	11/8-16/8	4/8	11/8	Diff.	29/7	16/8	Diff.	4/8-29/7	11/8-16/8	F/H/S / F/L
00	0,72	0,72	0	0,71	0,70	-0,01	-0,01	-0,02	0,93	0,93	0	0,91	0,93	+0,02	-0,02	0	
01	0,63	0,63	0	0,68	0,66	-0,02	+0,05	+0,03	1,13	1,13	0	1,06	1,09	+0,03	-0,07	-0,04	
02	0,71	0,71	0	0,69	0,77	+0,08	-0,02	+0,06	1,05	1,05	0	1,05	1,07	+0,02	0	+0,02	
03	0,62	0,63	+0,01	0,66	0,67	+0,01	+0,04	+0,04	1,08	1,08	0	1,07	1,08	+0,01	-0,01	0	
04	0,64	0,64	0	0,67	Inv.	—	+0,03	—	1,07	1,08	+0,01	1,08	1,06	-0,02	+0,01	-0,02	
05	0,68	0,66	-0,02	0,66	0,66	0	-0,02	0	1,08	1,08	0	1,07	1,07	0	-0,01	-0,01	
10C	5/8	11/8	Diff.	20/7	16/8	Diff.	5/8-20/7	11/8-16/8	5/8	11/8	Diff.	20/7	16/8	Diff.	5/8-20/7	11/8-16/8	F/H/U / F/L
00	0,59	0,61	+0,02	0,66	Too much background noise	—	+0,07	—	1,09	1,08	-0,01	1,06	1,08	+0,02	-0,03	0	
01	0,75	0,77	+0,02	0,73		—	-0,02	—	0,92	0,91	-0,01	0,93	0,91	-0,02	+0,01	0	Nytt S.
02	Inv.	Inv.	—	0,64		—	—	—	Inv.	Inv.	—	1,09	1,10	+0,01	—	—	Ny Ja.
03	0,71	0,72	+0,01	0,69		—	-0,02	—	0,97	0,96	-0,01	0,96	1,00	+0,04	-0,01	+0,04	
04	0,66	0,67	+0,01	0,63		—	-0,03	—	1,10	1,09	-0,01	1,09	1,03	-0,06	-0,01	-0,06	
05	0,62	0,62	0	0,69		—	+0,07	—	1,10	1,10	0	1,06	1,08	+0,02	-0,04	-0,02	
11C	10/8	12/8	Diff.	10/8	16/8	Diff.	10/8-10/8	12/8-16/8	10/8	12/8	Diff.	10/8	16/8	Diff.	10/8-10/8	12/8-16/8	F/P / P/S
00	0,79	0,65	-0,14	0,65	0,68	+0,03	-0,14	+0,03	0,94	1,10	+0,16	1,06	1,08	+0,02	+0,12	-0,02	
01	0,57	0,56	-0,01	0,65	0,63	-0,02	+0,08	+0,07	0,94	0,94	0	0,98	0,96	-0,02	+0,04	+0,02	
02	0,66	0,73	+0,07	0,72	0,72	0	+0,06	-0,01	1,11	1,01	-0,10	1,09	1,00	-0,09	-0,02	-0,01	
03	0,70	0,70	0	0,74	0,68	-0,06	+0,04	-0,02	1,04	1,04	0	1,02	1,02	0	-0,02	-0,02	
04	0,64	0,66	+0,02	0,68	0,67	-0,01	+0,04	+0,01	1,05	1,05	0	1,04	1,03	-0,01	-0,01	-0,02	
05	0,64	0,65	+0,01	0,66	0,66	0	+0,02	+0,01	1,06	1,06	0	1,02	1,03	+0,01	-0,04	-0,03	

+Diff. = Second measurement higher than the first one or CTV measurement higher than DPC

Underlined measurements = outside of toleranses

SP - DAMPING & NAT. FREQ. MEASURED AT DPC & CTV

SITE	DAMPING (Tol. 0,65 – 0,75) DPC			CTV			Diff. DPC–CTV		NAT. FREQ. (Tol. 0,90 – 1,10) DPC			CTV			Diff. DPC–CTV		REMARKS
12C	7/8	16/8	Diff.	26/7	16/8	Diff.	7/8–26/7	–16/8	7/8	16/8	Diff.	26/7	16/8	Diff.	7/8–26/7	–16/8	F/H/S/U P/S
00	0,66	0,67	+0,01		0,66	—	—	-0,01	1,03	1,02	-0,01	0,98	1,04	+0,06	-0,05	+0,02	
01	0,55	0,56	+0,01		0,60	—	—	+0,04	1,00	0,99	-0,01	1,04	1,00	-0,04	+0,04	+0,01	Nytt S. 22-7
02	0,59	0,55	-0,04		0,58	—	—	+0,03	1,25	1,23	-0,02	1,06	1,21	+0,15	-0,19	-0,02	Nytt S. 22-7
03	0,63	0,62	-0,01	0,66	0,68	+0,02	+0,03	+0,06	1,01	1,02	+0,01	0,98	1,00	+0,02	-0,03	-0,02	Nytt S. 26-7
04	0,63	0,62	-0,01	0,71	0,68	-0,03	+0,08	+0,06	1,04	1,04	0	1,05	1,04	-0,01	+0,01	0	
05	0,69	0,70	+0,01		0,70	—	—	0	0,97	0,97	0	1,08	0,99	-0,07	+0,11	+0,02	Nytt S. 22-7
13C	8/8	12/8	Diff.	4/8	17/8	Diff.	8/8–4/8	–17/8	8/8	12/8	Diff.	4/8	17/8	Diff.	8/8–4/8	–17/8	F/P/(N) P/S
00	0,71	0,72	+0,01	0,71	0,69	-0,02	0	-0,03	0,99	0,99	0	1,00	0,99	-0,01	+0,01	0	
01	0,61	0,61	0	0,69	0,68	-0,01	+0,08	+0,07	1,02	1,01	-0,01	1,01	1,03	+0,02	-0,01	+0,02	
02	0,73	0,71	-0,02	0,70	0,71	+0,01	-0,03	0	0,90	0,90	0	0,93	0,92	-0,01	+0,03	+0,02	
03	0,68	0,67	-0,01	0,70	0,66	-0,04	+0,02	-0,01	1,03	1,02	-0,01	1,03	1,02	-0,01	0	0	
04	0,63	0,64	+0,01	0,67	0,65	-0,02	+0,04	+0,01	1,16	1,16	0	1,10	1,12	+0,02	-0,06	-0,04	
05	0,67	0,66	-0,01	0,66	0,69	+0,03	-0,01	+0,03	1,08	1,08	0	1,09	1,06	-0,03	+0,01	-0,02	
14C	8/8	12/8	Diff.	2/8	13/8	Diff.	8/8–2/8	12/8–13/8	8/8	12/8	Diff.	2/8	13/8	Diff.	8/8–2/8	12/8–13/8	F/P/(N) F/P/S
00	0,79	No Data	—	0,74	0,73	-0,01	-0,05	—	0,96	No Data	—	0,98	0,97	-0,01	+0,02	—	
01	Inv.	Inv.	—	0,67	0,63	-0,04	—	—	Inv.	Inv.	—	0,98	0,93	-0,05	—	—	Nytt S.
02	0,64	0,65	+0,01	0,65	0,66	+0,01	+0,01	+0,01	1,00	0,99	-0,01	1,01	1,00	-0,01	+0,01	+0,01	
03	0,51	0,52	+0,01	0,66	0,60	-0,06	+0,15	+0,08	1,15	1,14	-0,01	0,99	1,12	+0,13	-0,16	-0,02	Nytt S.&Ja.
04	0,53	0,50	-0,03	0,69	0,56	-0,13	+0,16	+0,06	1,35	1,36	+0,01	0,97	1,30	+0,33	-0,38	-0,06	Nytt S. 3-8
05	0,56	0,56	0	0,66	0,60	-0,06	+0,10	+0,04	1,07	1,07	0	1,02	1,05	+0,03	-0,05	-0,02	Nytt S. 3-8

+Diff. = Second measurement higher than the firstone or CTV measurement higher than DPC

Underlined measurements = Outside of toleranses

SP-SEISMOMETER DAMPING RATIO WITH DIFFERENT DAMPING RESISTORS

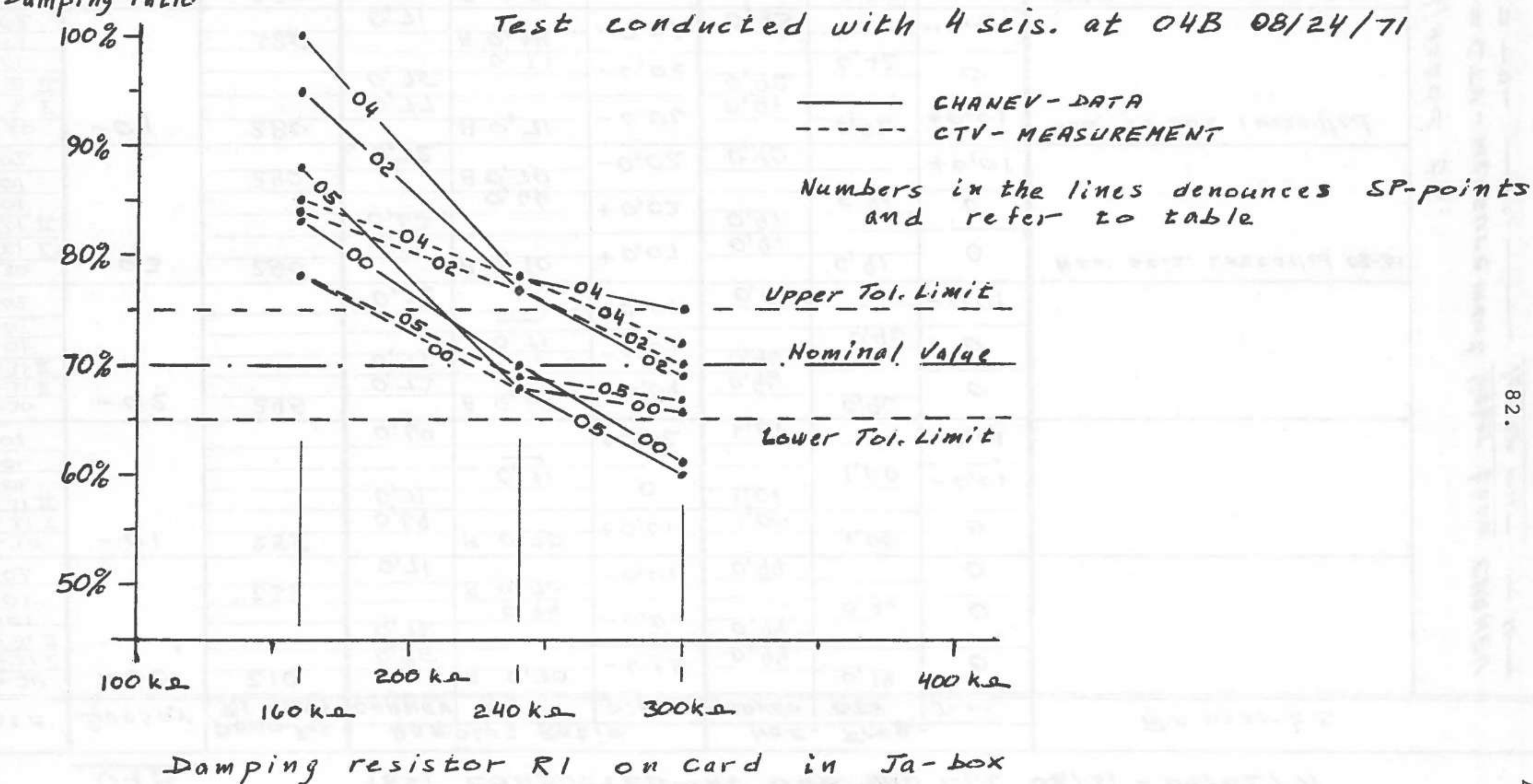
Test conducted with 4 seismometers at 04B 08/24/71

Damp. resistor R1	-00			-01			-02			-03			-04			-05		
	CHANEV	CTV	Diff.	CHANEV	CTV	Diff.	CHANEV	CTV	Diff	CHANEV	CTV	Diff.	CHANEV	CTV	Diff.	CHANEV	CTV	Diff.
Open cct.	0,31	0,52	+0,21	—	—	—	0,36	0,55	+0,19	—	—	—	0,37	0,55	+0,18	0,31	0,52	+0,21
300kΩ	0,61	0,66	+0,05	—	—	—	0,69	0,70	+0,01	—	—	—	0,75	0,72	-0,03	0,60	0,67	+0,07
CHANEV 08/23 240kΩ	0,70	0,68	-0,02	0,72	0,73	+0,01	0,77	0,77	0	08/14 0,58	0,58	0	0,78	0,78	0	0,68	0,69	+0,01
160 kΩ	0,83	0,78	-0,05	—	—	—	0,95	0,84	-0,11	—	—	—	1,00	0,85	-0,15	0,88	0,78	-0,10
Nat. Freq.	0,99	0,99	0	1,01	1,00	-0,01	0,96	0,96	0	1,16	1,14	-0,02	0,92	0,92	0	1,06	1,05	-0,01

+ Diff = CTV measurement higher than CHANEV
- Diff = " " lower " "

APPENDIX 3

SP-SEISMOMETER DAMPING RATIO WITH DIFFERENT DAMPING RES'S



SP- SEISMOMETERS

DAMPING RATIO PROPORTIONATE TO DAMPING RESISTOR RI

TEST CONDUCTED AT 04B AND 06C 08/31 - 09/02/71

04B

Date	Sensor	Damp. Res. RI (kΩ)	Damping Ratio CHANEV	Damping Ratio CTV	Damping Ratio Diff.	Nat. Freq. CHANEV	Nat. Freq. CTV	Nat. Freq. Diff.	Remarks
08-30	-00	210		A 0,70	-0,05		0,99	0	
08-31 I			0,75			0,99			
08-31 II			0,76		-0,02	0,99			
09-01				0,74			0,99	0	
09-01		233		A 0,70	-0,01				
09-02			0,71			0,99		0	
08-30	-01	255		A 0,70	+0,01		1,00	0	
08-31 I			0,69			1,00			
08-31 II			0,71		0	1,01			
09-01				0,71			1,00	-0,01	
09-01									
09-02			0,69		+0,02	1,01		-0,01	
08-30	-02	295		A 0,69	-0,04		0,96	0	
08-31 I			0,73			0,96			
08-31 II			0,72		-0,01	0,96			
09-01				0,71			0,96	0	
09-01									
09-02			0,72		-0,01	0,97		-0,01	
08-30	-03	280		A 0,70	+0,07		0,91	0	New seis. installed 08-30
08-31 I			0,63			0,91			
08-31 II			0,63		+0,03	0,91			
09-01				0,66			0,91	0	
09-01		240		A 0,70					
09-02			0,72		-0,02	0,90		+0,01	
08-30	-04	280		A 0,71	-0,06		0,92	+0,01	New Ja-box installed
08-31 I			0,77			0,91			
08-31 II			0,75		-0,02	0,92			
09-01				0,73			0,92	0	
09-01		320		A 0,69	-0,02				
09-02			0,71			0,93		-0,01	
08-30	-05	220		A 0,70	-0,05		1,05	-0,01	RAS not adjustable
08-31 I			0,75			1,06			
08-31 II			0,73		-0,01	1,05			
09-01				0,72			1,05	0	
09-01		231		A 0,70					
09-02			0,72		-0,02	1,05		0	

A = Adjusted to.

+Diff. = CTV - measurement higher than CHANEV

— " = — " — lower — " —

SP- SEISMOMETERS

DAMPING RATIO PROPORTIONATE TO DAMPING RESISTOR R1

06C — TEST CONDUCTED AT 04B AND 06C 08/31 - 09/02/71

Date	Sensor	Damp. Res. R1 (kΩ)	Damping Ratio CHANEV	Damping Ratio CTV	Damping Ratio Diff.	Nat. Freq. CHANEV	Nat. Freq. CTV	Nat. Freq. Diff.	Remarks
08-31	-00	220		A 0,70	+0,02		1,08	-0,02	
08-31 II			0,68			1,10			
09-02 I.			0,67			1,10			
09-02				0,67	0				
09-02		202		A 0,70	-0,03				
09-02 II			0,73			1,10			
08-31	-01	200		A 0,70	+0,03		0,95	-0,01	
08-31 II			0,67			0,96			
09-02 I			0,68			0,96			
09-02				0,69	+0,01				
09-02					+0,01				
09-02 II			0,68			0,96			
08-31	-02	220		A 0,70	+0,02		1,07	0	
08-31 II			0,65			1,07			
09-02 I			0,65		+0,01	1,07			
09-02				0,69					
09-02		215		A 0,70	-0,01				
09-02 II			0,71			1,08			
08-31	-03	215		A 0,70	0		1,06	-0,01	
08-31 II			0,70			1,07			
09-02 I			0,69			1,08			
09-02				0,70	+0,01				
09-02					+0,01				
09-02 II			0,69			1,07			
08-31	-04	218		A 0,70	+0,05		1,02	+0,01	
08-31 II			0,65			1,01			
09-02 I			0,66			1,00			
09-02				0,66	0				
09-02		200		A 0,70	0				
09-02 II			0,70			1,01			
08-31	-05	217		A 0,70	+0,04		1,05	-0,01	
08-31 II			0,66			1,06			
09-02 I			0,67			1,06			
09-02				0,68	+0,01				
09-02		200		A 0,70	-0,01				
09-02 II			0,71			1,06			

A = Adjusted to.

+Diff. = CTV-measurement higher than CHANEV

− —"— = —"— —"— lower —"— —"—

A P P E N D I X 5

N O R S A R P H A S E I I I

REPORT ON

FIELD ADJUSTMENT OF THE SP SEISMOMETER'S DAMPING RATIO

Since the Array Monitoring Program started, a large number of the SP-seismometers have been registered as out of tolerance with respect to both Damping Ratio (DR) and Natural Frequency (NF).

In May this year we made a comparison review of the DR and NF results as measured during the Seismic Recheck in May 1970 and the "CHANEV"-results from Jan. 1971 (Ref. VARIATIONS IN NATURAL FREQUENCY & SYSTEM DAMPING OF SP SEISMOMETERS 3-1136/24 May 1971). Conclusions at that time were that the seismometers in general were relatively stable as installed in the field, while we had a large number of seismometers out of tolerance (o.o.t.). It was also noticed that the DR tolerances were exceeded to a much higher degree than the NF tolerance. We have later experienced that the field measurements do not always coincide with the "CHANEV" data, so the comparison data in the above mentioned review may not be as valuable as originally thought, but the trend is clear enough.

In the beginning of July this year a review of the latest "CHANEV"-results (Ref. SP SEISMOMETER - NAT.FREQUENCY/DAMPING - Updated 04/18 - 06/27) showed 70 seismometers registered as o.o.t. with respect to DR compared to 47 with respect to NF. Some of these seismometers were o.o.t. on both parameters. The total number of seismometers o.o.t. were 80. (60% of the complete installation).

In order to analyze further the differences in measurements carried out at NDPC ("CHANEV") and at various CTV's (Manually by the O & M crew) a test was conducted with the 6 subarrays 09C to 14C. (Ref. DIFFERENCES IN MEASURED VALUES OF DAMPING AND NATURAL FREQUENCY OF SP-SEISMOMETERS CARRIED OUT AT NDPC AND AT CTV's).

The results were interesting. It was clearly indicated that the measurements of DR in the field to a large extent showed a higher value than the "CHANEV" results and vice versa for the NF measurements. Two series of measurements a few days apart showed little difference in the results. The test also showed that the great majority of the seismometers have NF above 1,0 Hz and DR below 70%. (This has also been notized in previous tests and reviews.)
The test further revealed that very often a disproportion exist between the NF and the DR of the seismometers. (An ideal seismometer has NF of 1 Hz and DR of 70% and these two parameters have mechanical relations to each other in the seismometer).
At the same time far more seismometers had DR o.o.t. than NF o.o.t.
After a review of various literature in this field and tests at the Maintenance Centre, we therefore suggested that the damping resistor R1, 240 kΩ, located on the RA5 input card in the JA-box should be exchanged with a variable resistor. This would allow field adjustment of the DR.

A test to verify this theory was conducted with 4 seismometers at 04B (Ref. SP-SEISMOMETER DAMPING RATIO WITH DIFFERENT DAMPING RESISTORS - 3-1136/08-25-71) The seismometers were measured with Open circuit (No damping resistor), damping resistor of 300 kΩ, 240 kΩ and 160 kΩ. The results were exactly as predicted. The DR could easily be adjusted, and apparently without any side effects.
At the same time the test showed that the method used in the field for measuring DR has its limits. It is apparently accurate enough in an area around 70%, but not any longer when the DR is higher or lower. This may explain some of the differences in measured values between CTV and CHANEV in the past.

An extended test was now conducted 30 August to 2 September with all SP-seismometers at 04B and 06C. The damping resistors were adjusted in the field to get a DR on or near 70%. (Ref. SP SEISMOMETERS DAMPING RATIO PROPORTIONATE TO DAMPING RESISTOR R1 - 3-1136/08-03-71).

For some of the seismometers it was necessary to go back a day later for readjustment in order to get the CHANEV results near enough 70%.
After reviewing the results and discussing this particular problem of having to go back for readjustment with the personnel involved in the test, we feel that under normal conditions (without too much noise) it should be possible to get well within the tolerance area (as for this last test) on the first visit.
It should be mentioned that this method of adjusting the DR has absolutely no influence on the seismometer's NF.
It is also verified from NDPC that according to CHANEV data it does not cause any other drawbacks either.

CONCLUSION / RECOMMENDATION

It is quite feasible to adjust the DR of the SP seismometers in the field by means of adjusting the damping resistor R1 on the RA5 input card in the JA-box. The only physical modification necessary is to exange the fixed resistor of 240 kΩ with a pot.meter of 500 kΩ . The Helitrim 89P or 79P is recommended. It is shelf item in Oslo, and the cost is n.kr. 9,- to n.kr. 10,- depending on quantity.
This modification and adjustment of the DR has no other noticeable influence on the system. However, if a seismometer is too far out of toleranse, say outside the area of 60% to 80% and still within tolerance limits of NF, it should be considered whether the seismometer should be brought in for service, because the mass position may then be too far out.

This modification will for the whole array amount to an investment of pot.meters of n.kr. 1.600,-. Considering the results in better performance we will encounter and the fact that a large number of seismometers do not have to be taken out for service to adjust the DR, we will strongly recommend that the array should be modified as mentioned.

This modification could of course be introduced only in the worst cases. But since it is already established that we shall modify <u>all</u> the RA5 input cards for Cal. Amp. noise and considering the future advantage of uniform circuits for this low price, we do recommend that the modification will be introduced throughout the array.

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