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GROUND MOVEMENT MONITORING AT VAL D'OR EXPERIMENTAL MINE I. EQUIPMENT INSTALLATION

G. Herget, K. Judge and D. Granger

MRL 93-062(TR) August 1993

GROUND MOVEMENT MONITORING AT VAL D'OR EXPERIMENTAL MINE I. EQUIPMENT INSTALLATION

by

G. Herget[1], K. Judge[2] and D. Granger[3]

SUMMARY

Five locations at the Val d'Or experimental mine have been instrumented with ground movement monitoring equipment to identify possible ground movement and assess the long-term stability of sensors and read out equipment. Vibrating wire sensors are used to determine borehole convergence and potentiometers are used in extensometers to measure axial deformation of 75.7 mm (2.98 in.) drill holes. Most of the readings are taken and stored with automatic data logging equipment and should be reviewed every six months. Most of the connections are hard wired from sensor locations to data logger, but in two cases encoding radio transmitters are used to transmit the sensor output to a receiver station/data logger. Manual readings need to be taken for the extensometers located in holes number one and four.

In total, seventeen instruments containing 52 sensors were installed in five boreholes. To read and store the output automatically, five RBR (Richard Brancker Research Ltd.) eight channel data loggers and two multiplexers were installed. In addition, two radio receiver/data logger systems were supplied receiving the output from twelve radio transmitters.

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SURVEILLANCE DES MOUVEMENTS DE TERRAIN

À LA MINE EXPÉRIMENTALE DE VAL D'OR

I. INSTALLATION DU MATÉRIEL

par

G. Herget[1], K. Judge[2] et D. Granger[3]

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À cinq emplacements de la mine expérimentale de Val d'Or, on a installé un matériel de surveillance des mouvements de terrain afin d'enregistrer tout mouvement de terrain possible et d'évaluer la stabilité à long terme des capteurs et du matériel d'extraction des données. Des capteurs à fil vibrant sont utilisés pour déterminer la convergence des trous de sondage et des extensomètres ont été équipés de potentiomètres pour mesurer la déformation axiale des trous de sondage de 75,7 mm (2,98 po). La plupart des enregistrements, réalisés et stockés par un enregistreur automatique de données, doivent être analysés tous les six mois. La plupart des connexions sont câblées entre les capteurs et les enregistreurs de données, mais, dans deux cas, des émetteurs de codage sont utilisés pour transmettre les données enregistrées par les capteurs à un récepteur-enregistreur de données. Les enregistrements à partir des extensomètres situés dans les trous numérotés un et quatre sont manuelles.

Au total, dix-sept instruments contenant 52 capteurs ont été installés dans cinq trous de sondage. Pour lire et stocker les données de sortie automatiquement, cinq enregistreurs de données à huit canaux RBR (Richard Brancker Research Ltd.) et deux multiplexeurs ont été mis en place,. De plus, deux systèmes combinant un récepteur radio et un enregistreur de données ont été fournis pour recevoir les données de sortie de douze émetteurs radio.

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MONITORING LOCATIONS AND DRILLHOLE DESCRIPTIONS

In May 1992 five holes were drilled at the locations shown in Figures 1 and 2 and listed in Table 1.

Table 1. Drillhole location for Ground Movement Monitoring

Hole #	Easting	Northing	Elevation	Azimuth	Dip	Hole Length (meters)
1	2947.2	4017.4	4960	277	0	9.65
2	2975.2	4099.8	4967	003	0	9.24
3	3088.8	4010.8	4917.2	150	0	9.2
4	3155.2	4251.7	4916.4	330	0	9.2
5	2838.5	4197.8	4916.7	-	-90	9.2

The coordinates are surveyed with tape and compass and are given in meters from a 5000 m reference point on surface.

Denis Walsh supplied the data in Table 1 and the drillhole descriptions with photographs reproduced below. For each hole the equipment installed is listed. Details of equipment installed and calibration charts are provided in appendices A and B.

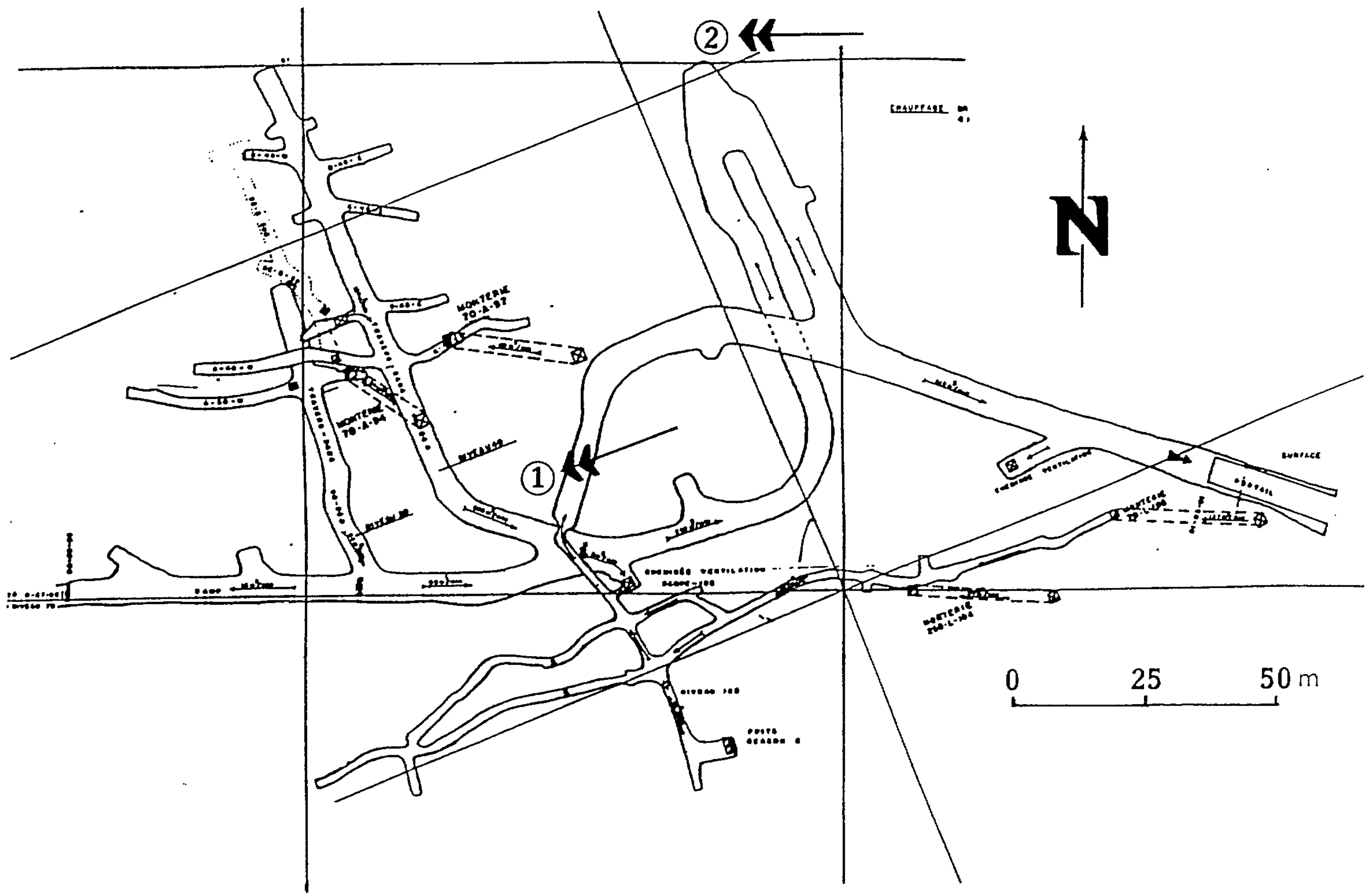

Figure 1. Surface, ramp and upper levels at Val d'Or experimental mine.

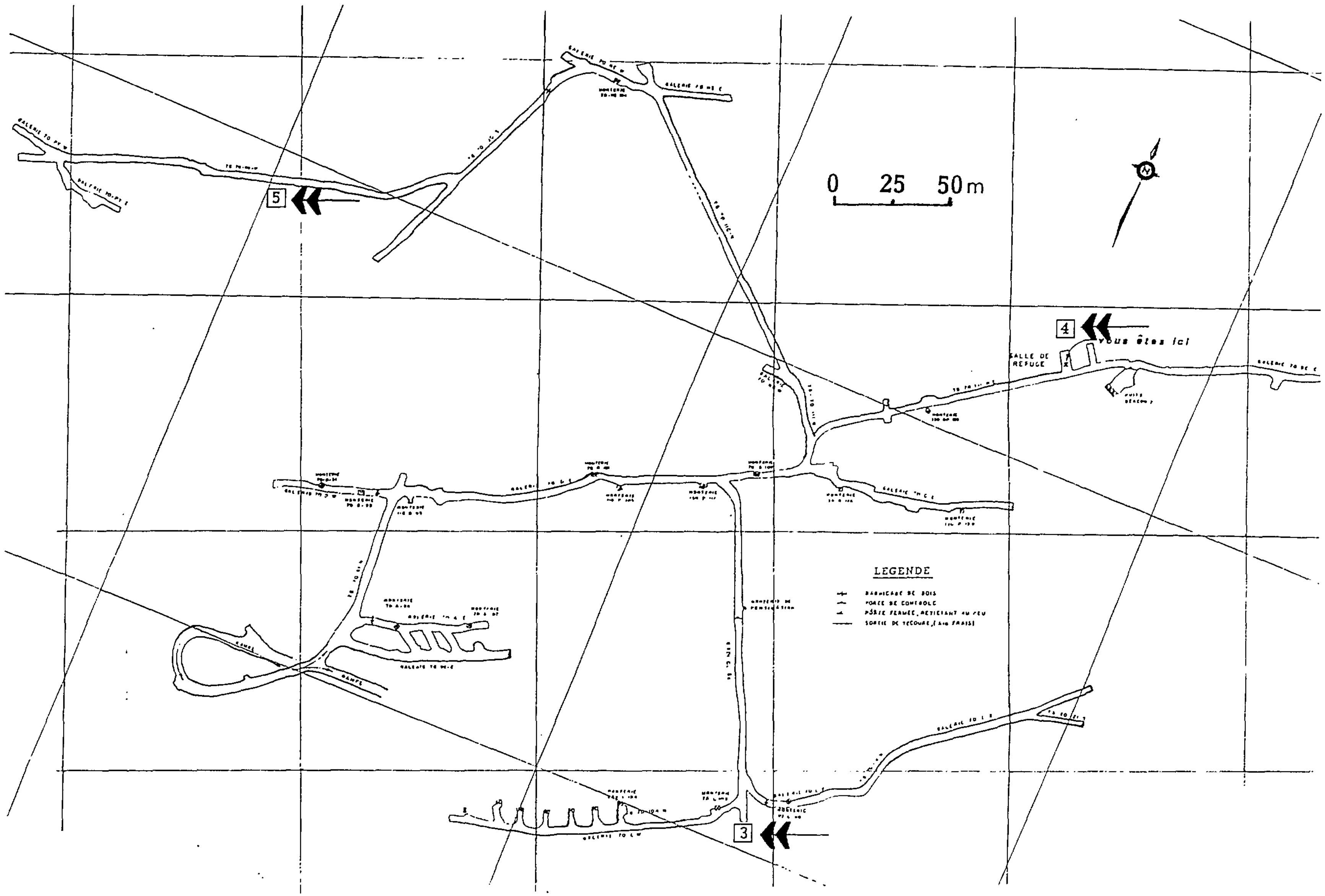

Figure 2. 70 m level at Val d'Or experimental mine.

Hole Number 1

Drillhole # 1 is located near the bottom of the ramp at the 40 meter level. The coordinates at the collar are east 2947.2, north 4017.4, elevation 4960 meters. The hole is flat at an azimuth of 277°. The rock type for the full length of the core is a monotonous green-grey and white porphyritic granodiorite.

Figure 3. Photograph of core from hole number 1.

At this site two three component CANMET hard rock vibrating wire strain monitors were installed at the deepest point of the hole, followed by one biaxial soft rock gauge. The hole was closed off with a 1.8 meter long extensometer. This is to be read manually across the black and white leads. The 8 other channels are read with a CL800 data logger with multiplexer. Data are to be reported with the attached program SPLIT. Further details are given in Table 2.

Table 2. Instrumentation in Hole Number 1

Inst Type	Ser#	Far/Near/Axial (1)	Orientation	Inst Depth	Tare Freq	Inst Freq	Pot Res	Conn Type	Logger	Multiplex
*HNM	141	Far	Vert	9.1 m	1339	1646		Stereo	4283-1	4648-A1
*HNA	22	Axial			644	658		Stereo	4283-2	4648-A2
*HNM	127	Near	Horizontal		1587	1558		Stereo	4283-3	4648-A3
*HNM	126	Far	45 CCW	8.5 m	1509	1506		Stereo	4283-4	4648-A4
*HNA	27	Axial			825	660		Stereo	4283-5	4648-B1
*HNM	125	Near	45 CW		1446	1901		Stereo	4283-6	4648-B2
+ML	48	Far	Vert	7.9 m	1149	1101		Stereo	4283-7	4648-B3
+ML	47	Near	Horizontal		1163	1129		Stereo	4283-8	4648-B4
EPOT	9201	Extens		1.8 m			2662Ω	Manual		

[*] Hard Rock Triaxial

[+] Soft Rock Biaxial

[E] Extensometer

Orientation: 45 CW = 45 degrees clockwise from vertical
45 CCW = 45 degrees counter-clockwise from vertical

Inst Depth: distance from collar to far end of instrument

(1) Relative position of instrument components to borehole collar

Hole Number 2

Drillhole #2 is located in the ramp at the big turn where the grotto is located. The coordinates at the collar are east 2975.2, north 4099.4, elevation 4967 meters. The hole is flat at an azimuth of 003°. The rock type for the first 3.5 meters is quartz veins and sheared granodiorite. From 3.5 meters to the end of the hole, the lithology is consistently coarse to medium grained granodiorite.

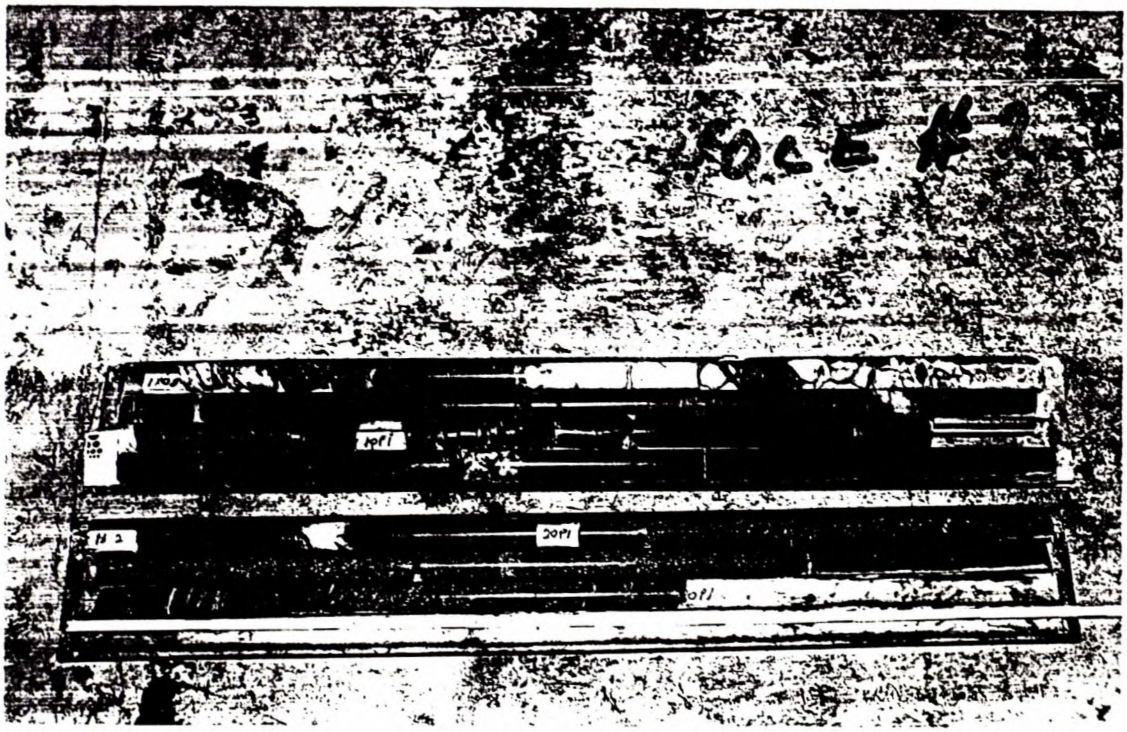

Figure 4. Photograph of core from hole number 2.

At this site two three component CANMET hard rock strain monitors were installed in the deepest part of the hole, followed by two biaxial soft rock vibrating wire units. A 1.8 meter long extensometer with a 101.6 millimeter stroke was installed at the collar. All instruments were connected to automatic data loggers and all but the second-deepest unit were connected via radio transmitter. Details are provided in table 3.

Table 3. Instrumentation in Hole Number 2

Inst Type	Ser#	Far/Near/Axial (1)	Orientation	Inst Depth	Tare Freq	Inst Freq	Conn Type	Logger	TM Ch
*HNM	135	Far	Vert	9.1 m	1487	2461	Stereo	4459-1	1
*HNA	19	Axial			757	727	Stereo	4459-2	2
*HNM	134	Near	Horizontal		1584	2254	Stereo	4459-3	3
*HNM	84	Far	45 CCW	8.5 m	1652	2148	MWC	4280-1	
*HNA	18	Axial			892	733	MWC	4280-2	
*HNM	83	Near	45 CW		1687	1873	MWC	4280-3	
+ML	44	Far	Vert	7.9 m	1229	1165	Stereo	4459-4	4
+ML	43	Near	Horizontal		1174	1118	Stereo	4459-5	5
+ML	60	Far	45 CCW	7.0 m	1240	1170	Stereo	4459-6	6
+ML	59	Near	45 CW		1233	1166	Stereo	4459-7	7
E HNA	31	Extens		1.8 m	1159	1325	Stereo	4459-8	8

* Hard Rock Triaxial

+ Soft Rock Biaxial

E Extensometer

Orientation: 45 CW = 45 degrees clockwise from vertical
45 CCW = 45 degrees counter-clockwise from vertical

Inst Depth: distance from collar to far end of instrument

TM Ch: transmitter channel number

(1) Relative position of instrument components to borehole collar

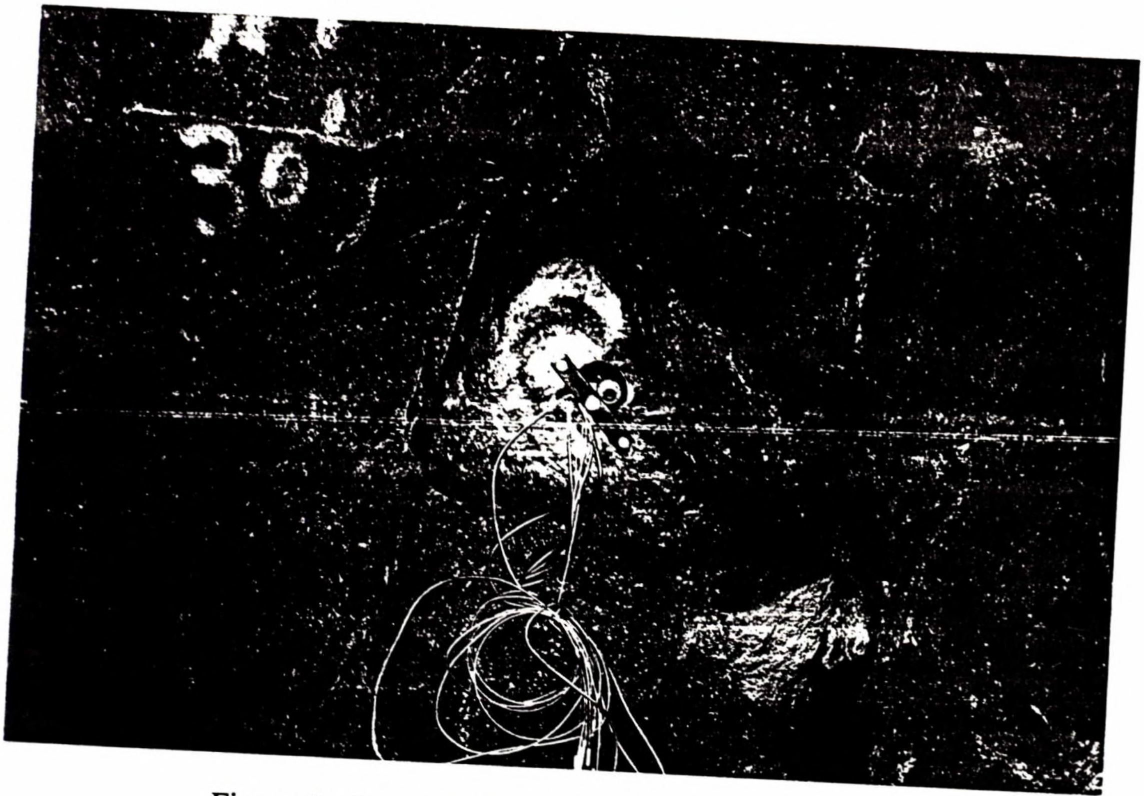

Figure 5. Borehole installation at hole number 1.

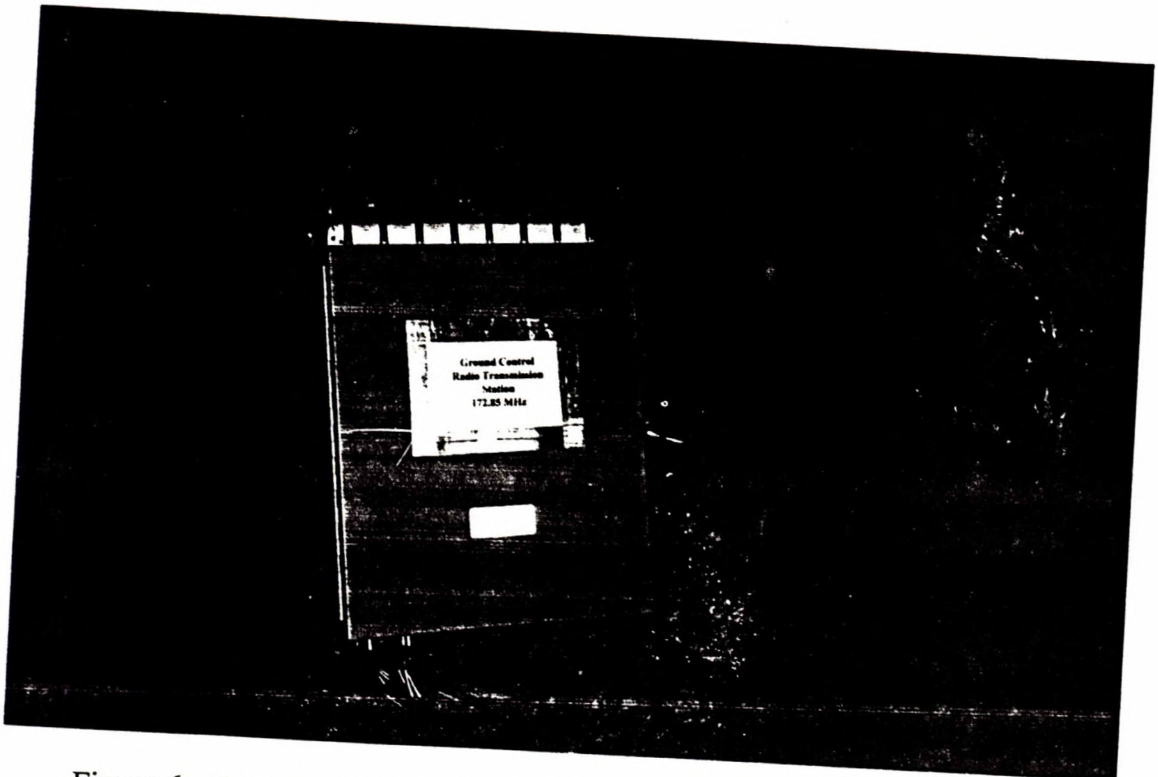

Figure 6. Borehole installation and transmitter station at hole number 2.

Hole Number 3

Drillhole #3 is located near the pump station on the 70 meter level at the end of TB 70108 S. The coordinates at the collar are east 3088.8, north 4010.8, elevation 4917.2 meters. The hole is flat at an azimuth of 150°. The lithology is a fine grained volcanic rock, probably a lapilli tuff, with bands of white quartz and carbonate.

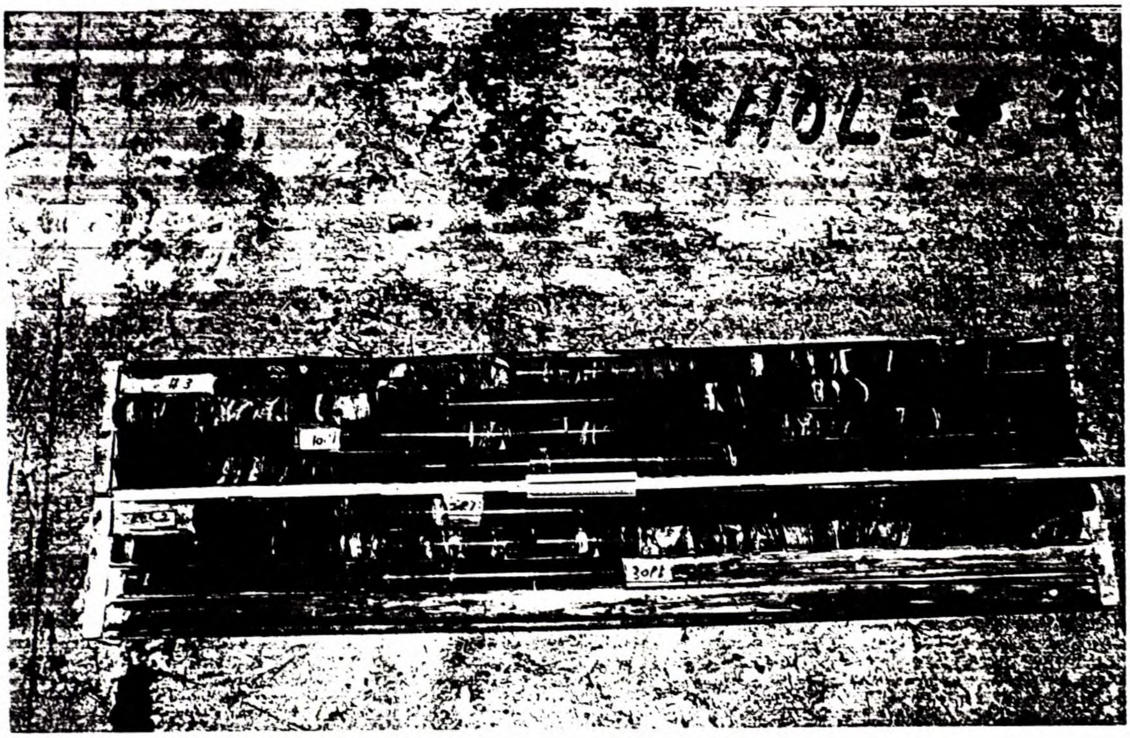

Figure 7. Photograph of core from hole number 3.

At this site, a three component vibrating wire hard rock strain monitor was installed at the bottom of the hole, followed by two biaxial soft rock monitors. The triaxial unit was hard wired into data logger number 4285 and the two triaxial units were connected to encoding transmitters for wireless transmission as described in Table 4.

Table 4. Instrumentation in Hole Number 3

Inst Type	Ser#	Far/Near/Axial (1)	Orientation	Inst Depth	Tare Freq	Inst Freq	Conn Type	Logger	TM Ch
*HNM	114	Far	Vert	7.6 m	1576	1911	MWC	4285-1	
*HNA	24	Axial			835	2867	MWC	4285-2	
*HNM	137	Near	Horizontal		1827	3075	MWC	4285-3	
+ML	42	Far	Vert	7.0 m	1143	1089	Stereo	4458-1	1
+ML	41	Near	Horizontal		1156	1062	Stereo	4458-2	2
+ML	66	Far	45 CCW	6.1 m	1119	1038	Stereo	4458-3	3
+ML	65	Near	45 CW		1157	1020	Stereo	4458-4	4

[*] Hard Rock Triaxial

[+] Soft Rock Biaxial

[E] Extensometer

Orientation: 45 CW = 45 degrees clockwise from vertical
45 CCW = 45 degrees counter-clockwise from vertical

Inst Depth: distance from collar to far end of instrument

TM Ch: transmitter channel number

(1) Relative position of instrument components to borehole collar

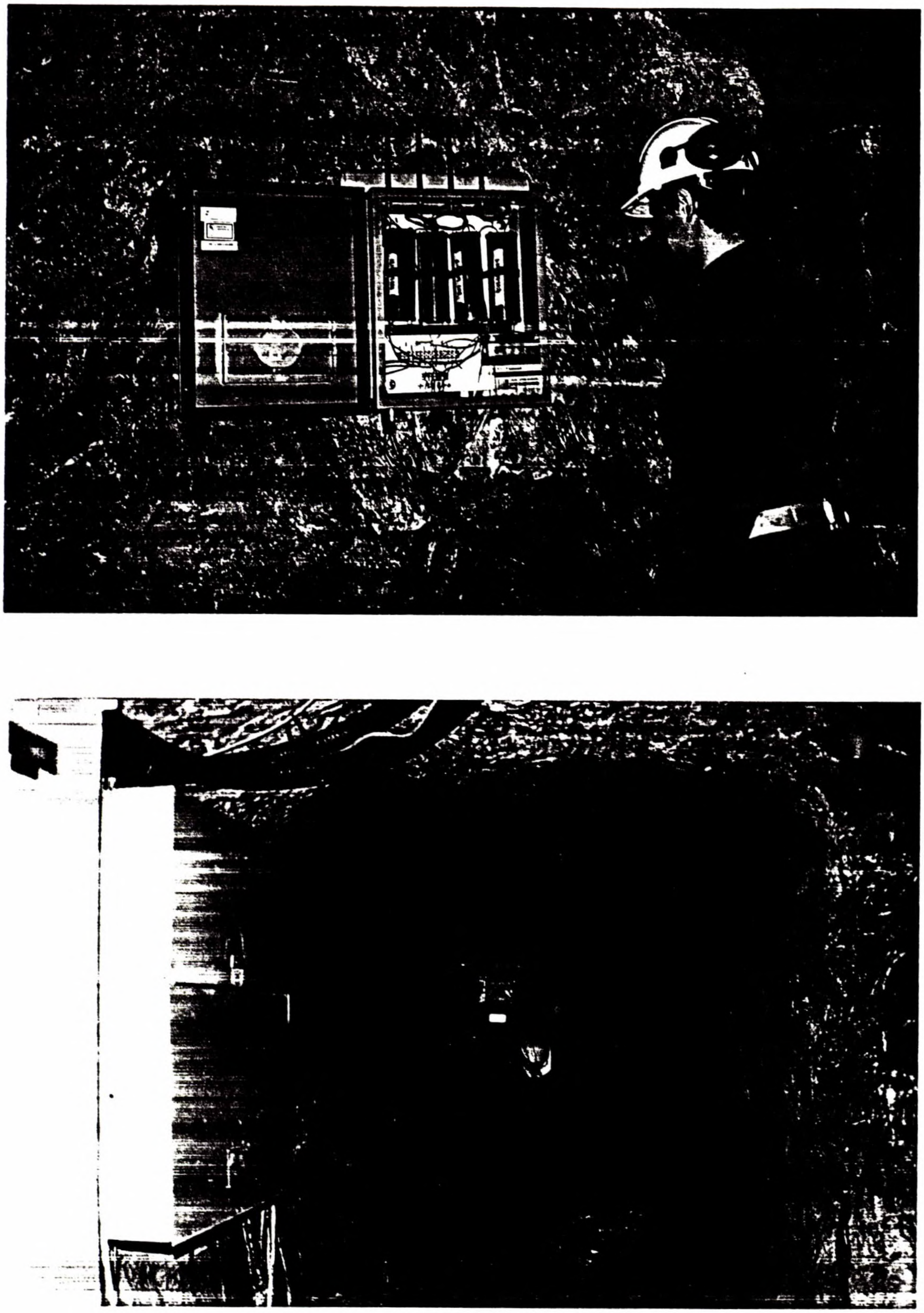

Figure 8 (A&B). Transmitter system of hole number 3.

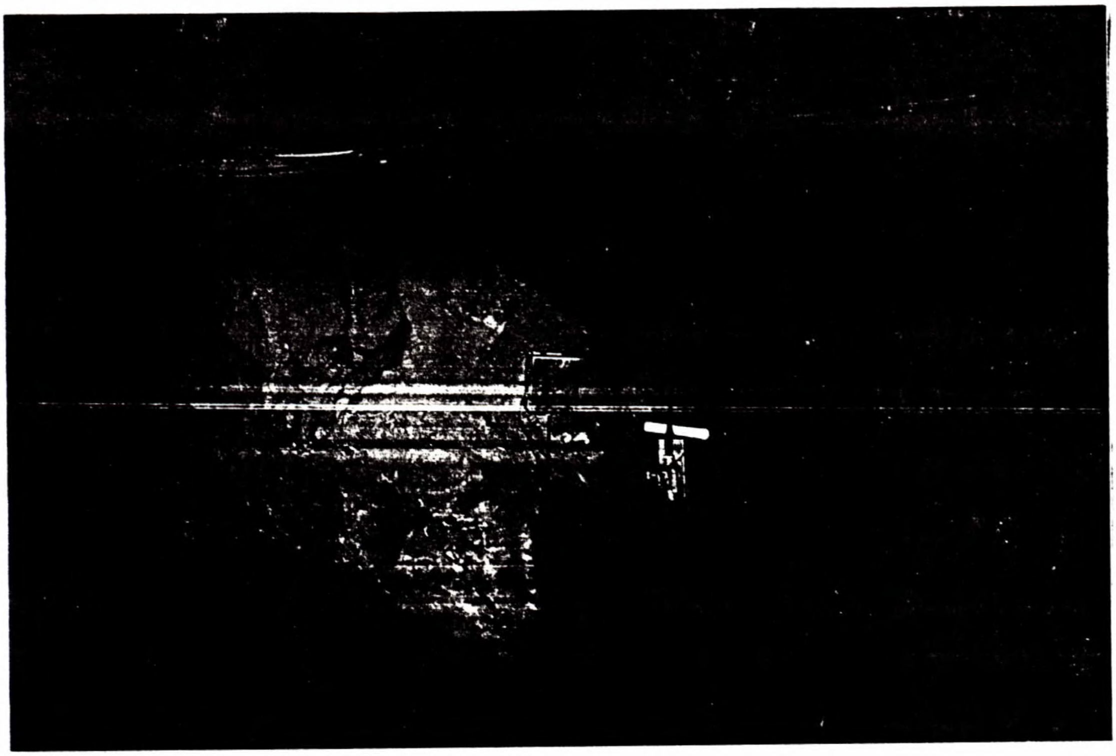

Figure 9. Receiver station for borehole number 2.

Figure 10. Receiver station for borehole number 3.

Hole Number 4

Drillhole #4 is located near the Beacon #2 shaft on the 70 meter level. The coordinates at the collar are east 3155.2, north 4251.7, elevation 4916.4 meters. The hole is flat at an azimuth of 330°. The first 5 meters of the core are sheared granodiorite with several narrow quartz veins. From 5 meters to the end of the drillhole the rock type is silicified granodiorite.

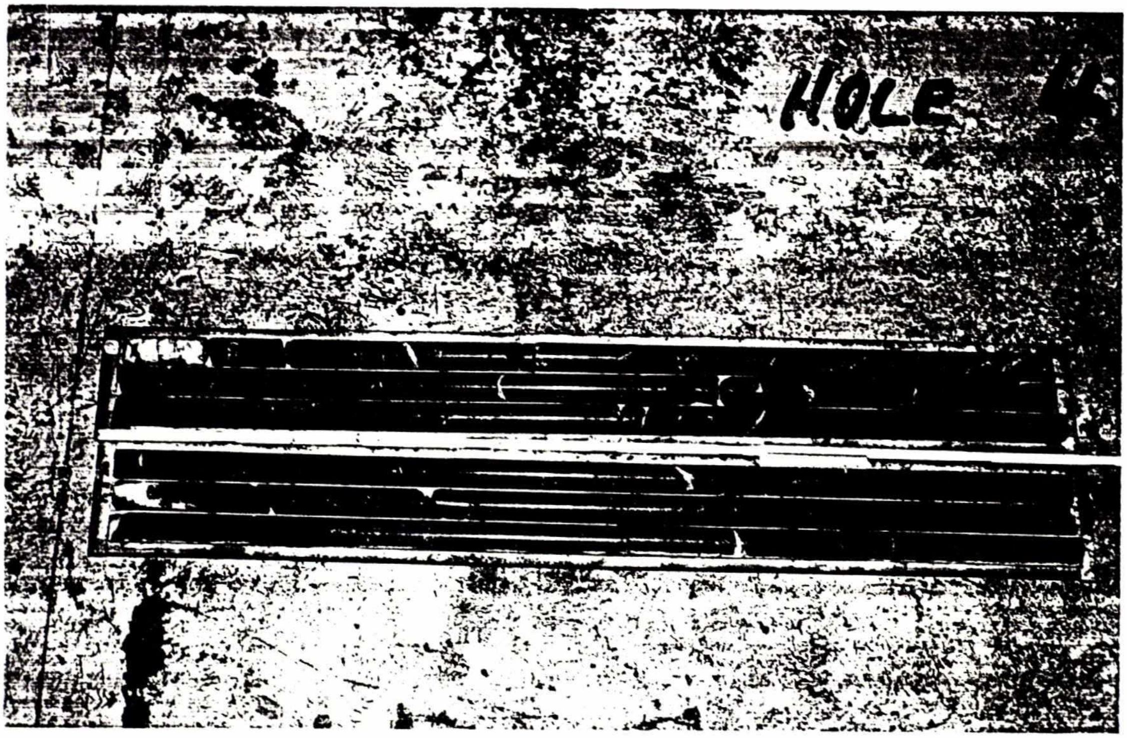

Figure 11. Photograph of core from hole number 4.

At this site two three component hard rock strain monitors were installed, followed by one biaxial soft rock gauge. At the collar a six foot deep extensometer was installed which is to be read manually across the black and white leads. Details are given in table 5.

Table 5. Instrumentation in Hole Number 4

Inst Type	Ser#	Far/Near/Axial (1)	Orientation	Inst Depth	Tare Freq	Inst Freq	Pot Res	Conn Type	Logger	Multiplex
*HNM	140	Far	Vert	9.1 m	1628	1727		Stereo	4286-1	4762-A1
*HNA	26	Axial			752	2559		Stereo	4286-2	4762-A2
*HNM	129	Near	Horizontal		1330	1621		Stereo	4286-3	4762-A3
*HNM	139	Far	45 CCW	8.5 m	1788	1775		Stereo	4286-4	4762-A4
*HNA	21	Axial			812	1420		Stereo	4286-5	4762-B1
*HNM	124	Near	45 CW		1519	1887		Stereo	4286-6	4762-B2
+ML	50	Far	Vert	6.1 m	1262	1197		Stereo	4286-7	4762-B3
+ML	49	Near	Horizontal		1189	1076		Stereo	4286-8	4762-B4
EPOT	9208b	Extens		1.8 m			8.610Ω	Manual		

| * | Hard Rock Triaxial

| + | Soft Rock Biaxial

| E | Extensometer

Orientation: 45 CW = 45 degrees clockwise from vertical
45 CCW = 45 degrees counter-clockwise from vertical

Inst Depth: distance from collar to far end of instrument

(1) Relative position of instrument components to borehole collar

Hole Number 5

Drillhole #5 is located near in TB 70-96 W approximately 60 meters from the intersection of the cross-cut with TB 70-100 S. The coordinates at the collar are east 2838.5, north 4197.8, elevation 4916.7 meters. The hole was drilled vertically into the floor. The lithology for the full length is silicified granodiorite with a few small quartz, tourmaline veins in the first 2.6 meters.

Figure 12. Photograph of core from hole number 5.

This vertical hole is filled with water to the top, and only a biaxial vibrating wire hard rock strain monitor was installed at a depth of 9.1 meters. The instrument was connected to a RBR eight channel data logger.

The far ring was orientated approximately North-South and the near ring was orientated East-West. The calibration charts are provided in appendix 2.

APPENDIX A

Description of Borehole Monitoring Equipment

CANMET
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Hard Rock Strain Monitor for Boreholes

PRODUCTS AND SERVICES

Hard rock strain monitors have been developed specifically for applications in:
- mines operating in hard rock
- concrete hydro dams
- large construction

The CANMET strain monitors use the highly stable and very sensitive vibrating wire principle to monitor radial deformations in boreholes in the elastic range. Important features are:
- combination of axial and radial sensors;
- **very high precision (resolution 0.0002 mm, 0.000008 in.)**, enables measurement of very small deformations for hard, high-modulus material in the elastic range (E>20GPa);
- **highly stable performance, without recalibration**, provides reliable data for months or years, for long-term monitoring and surveillance;
- **rugged, waterproof design** provides reliability and versatility, including vertical, water-filled boreholes;
- **remote or automated data logging** - sensor output may be obtained with an automated transmitter/receiver/data logger, or a portable readout.

CANMET's Mining Research Laboratories provides a service to industry which includes advice on instrumentation requirements for hard rock strain monitor applications; custom instrumentation packages (e.g. to resist acid waters, or to resist pressure under water) can be designed for new applications.

MINING INDUSTRY APPLICATIONS

The CANMET hard rock strain monitors provide solutions to problems of mining layouts, support, and stability. They provide high-quality data to:
- determine rock mass stability
- monitor the effect of excavation activities on underground and surface structures
- check modelling predictions
- confirm planning assumptions

Continuous monitoring through remote data logging provides accurate and timely information on stability, which can result in:
- reduced maintenance costs
- greater mining efficiency
- continued access to ore
- improved mine safety

The gauges have been demonstrated in hard rock mines in the Arctic, and in deep mines in the Canadian Shield.
- The extent of excavation influence on sensitive structures such as a **shaft pillar** can be measured directly. The very high sensitivity of the CANMET strain monitor enables confirmation of predictions of stress redistribution in the rock mass at an early stage of excavation activity, so that planning for additional openings may be carried out with confidence. Consistent, reliable responses to blasting with changed excavation geometry have been demonstrated.

- Strain energy buildup in rockburst prone areas can be monitored using CANMET strain monitors, and very good results have been demonstrated. The advantage of this method is that it monitors the rock in the elastic range, rather than in the failure and post failure range when using extensometers or seismic event detectors.

- Waterproof in-the-hole data loggers with small battery packs have been recording data for six months unattended in deep mines and under Arctic conditions. CANMET strain monitors were used to monitor production blasts at a depth of 2000 m below surface. Four sensors had been installed. Calculations of the biaxial stress ellipse with one redundant reading showed that calculated stress changes agreed within ±0.03 MPa and ±0.5°. The one redundant reading also gives confidence in the data and the reliability of the equipment.

CIVIL ENGINEERING APPLICATIONS

Several features of the CANMET strain monitor are expected to provide advantages over existing methods, during construction and continued surveillance:

- Measure deformation directly, giving data that are straightforward to interpret;
- Immediately responsive following installation, with no waiting period for equalization of formation pressure;
- Provide much greater sensitivity than available extensometers;
- Can be removed for periodic calibration verification;
- Easily adaptable for automated surveillance through remote data logging.

SELECTED SPECIFICATIONS AND FEATURES

- Borehole strain monitors with optional short base, high precision extensometers:

System	Hole Size (mm)	Deformation Range (mm)	Resolution (mm)
HNM	76	0.20	0.0002
H5M	118	0.25	0.0003
H6M	153	0.38	0.0004
AX	200 (length)	10.00	0.008

- Easy installation of single and double radial sensors with axial sensors
- Redundant measurement enhances reliability and ensures accurate data
- Borehole diameters 76 mm, 118 mm or 153 mm (nominal)
- Guided installation wedges activated by a hydraulic
- Stable calibration enabled by precision wedge system
- Generous clearances allow easy recovery
- Portable readout or automated data acquisition with wireless readout over 4 km
- Complete transmitter/receiver/data logger system designed for use with these gauges
- Temperature compensation within range -20°C to +50°C (optional)
- U.S. and Canadian patents

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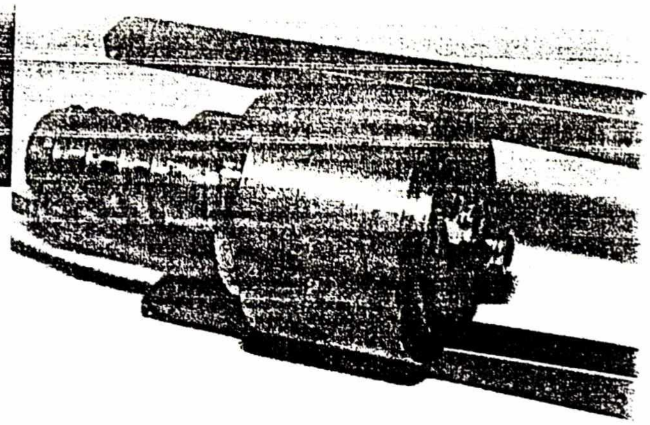
HARD ROCK STRAIN MONITOR FOR BOREHOLES



APPLICATIONS

The CANMET strain monitor has been developed to:

- measure the deformation of boreholes in hard rock,
- check finite element predictions,
- confirm planning assumptions,
- determine rock mass stability,
- monitor the effect of mining activites on excavation walls.

DESCRIPTION

The CANMET strain monitor consists of a steel proving ring mounted with a wire perpendicular to the loading direction. The resonant frequency is detected by a built-in exciter unit. The frequency changes with ring deformation and is virtually unaffected by temperature and humidity changes. The ring has two inclined slots cut for wedges which are set with a hydraulic installation tool. Wedges are placed on the ring and wired to the installation tool prior to insertion. Once the unit is at the desired borehole location, it is wedged against the borehole wall by activating the hydraulic pump. The pre-stress to the sensor is required in order to maintain contact with the borehole wall during extension or blast vibrations of the borehole. Pre-stress is in the vicinity of 14 MPa (2000 psi).

The sensors are available for 76 mm (2.98 in.), 118 mm (4.66 in.) and 153 mm (6.00 in.) diameter boreholes. Output may be recorded by a portable self-powered readout unit, a borehole datalogger or a data acquisition system. The sensors are recoverable, and have a stiffness of about 140 MN/m (800 000 lbs/in.)

U.S. Patent 4858472   Canadian Patent 1240851

CANMET Strain Cell with Installation Wedges

FEATURES

- **High precision, high resolution sensing system with rugged design.**
- **Units can be removed at end of investigation or for recalibration, if required.**
- **Combination of axial and radial units.**
- **Stable calibration because of precision wedge system.**
- **Vibrating wire mounted at right angles to loading direction with autoresonance or plucking exciters.**
- **Portable readout or automatic data acquisition.**
- **Range of 0.2 mm (0.008 in.) with a resolution of 0.0002 mm (0.000008 in.).**
- **Wireless readout over 4 km.**

GROUND CONTROL INSTRUMENTATION

CANMET
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MODELS:	HNM	H5M	H6M
Nominal Borehole Diameter: Standard Diameter Range:	76 mm (2.98 in.) 73 - 80 mm	118 mm (4.66 in.) 116 - 126 mm	153 mm (6.00 in.) 149 - 169 mm
Cell Diameter Without Wedges:	63.5 mm (2.500 in.)	98.4 mm (3.875 in.)	127.0 mm (5.000 in.)
Cell Height:	44.5 mm (1.750 in.)	57.8 mm (2.275 in.)	57.8 mm (2.275 in.)
Cell Stiffness:	160 MN/m	145 MN/m	130 MN/m
Deformation Range:	0.20 mm	0.25 mm	0.38 mm
Resolution:	0.0002 mm	0.0003 mm	0.0004 mm
Exciter Unit (specify):	Autoresonance or IRAD type Plucking Coil		
Onsite Readout:	• Pocketsize CANMET frequency meter for autoresonance exciters • SR-11 or similar for IRAD type Plucking Coils		
Data Logging:	• RBR waterproof dataloggers • SENS-LOG or CAMPBELL scientific data acquisition systems		

INSTALLATION

The wedge system is designed for specific ranges of borehole diameters. The strain cells are preferably installed in diamond drilled holes but percussion drilled holes reamed to the required diameter will also be suitable. Special wedge sizes may be provided on request for different hole sizes.

The assembled unit is pushed down the borehole to its location and rotated to the required orientation. As an adequate pre-load is achieved by the hydraulic pump, the connecting wires shear and the installation tool can be withdrawn from the borehole. An integrated thermistor is recommended when large temperature variations are expected on site (e.g. more than ± 8 °C).

For the cells removal, an EW Box coupling is mounted on retrieval rods and connected to the EW Pin on the sensor with a centering guide. From the retrieval kit a threaded rod is connected to the last retrieval rod and fed through a plate across the borehole. Tightening a nut against the plate will pull the sensor off its wedges.

INTERPRETATION

At an underground mine the following readings were obtained after a stope blast from 4 sensors in a 118.4 mm diameter borehole:

Sensor orientation	⊖ = 0°	⊖ = 45°	⊖ =90°	⊖ =135°
Frequency change (H2)	+22	0	-11	+12
Calibration factor (mm/H2)	0.00025	0.00018	0.00028	0.00018
Change of diameter (mm)	0.0055	0	-0.0031	0.0022
Change of strain (10-6)	46.5	0	-26.0	18.2

One redundant diameter reading allows the calculation of the maximum and minimum secondary stresses four times. Results are given below for an elastic modulus of 58 GPa and a Poisson's ratio of 0.3:

Strain direction (⊖)	Maximum stress (MPa)	Minimum stress (MPa)	Angle of maximum stress to horizontal
0°, 90°, 135°	2.50	-0.81	-6.2°
45°, 90°, 135°	2.38	-0.86	-7.2°
0°, 45°, 90°	2.52	-0.83	-7.8°
135°, 0°, 45°	2.47	-0.95	-6.8°
Average:	2.46 ± 0.06	-0.86 ± 0.06	-7.0° ± 0.7°

ACCESSORIES

- Readout Unit / Data Acquisition System
- Installation Tool / Self-Oriented Rods
- Additional or Oversize Wedges
- Retrieval Kit/Centering guide

ORDERING INFORMATION

Please specify:

- Borehole diameter
- Cable length (standard : 10 m)
- Installation tool
- Exciter type (P = plucking, C = continuous, T = thermistor)

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Deformation Gauges for Soft Rock and Backfill

PRODUCTS AND SERVICES

Borehole deformation gauges have been developed specifically for applications in:

- monitoring stability in potash, salt and coal mines
- settlement and consolidation of backfill in underground openings
- civil engineering foundations, tunnels and earth dams

The soft-rock deformation gauges measure creep rates for soft rock through radial deformation of boreholes, providing data to:

- determine rock mass stability;
- monitor the effect of excavation activities on underground structures;
- check modelling predictions;
- confirm planning assumptions.

The gauges have been demonstrated as consolidation meters, to measure settling properties of the working surface of a backfilled stope.

Sensor output may be obtained with an automated transmitter/receiver/data logger, or a portable readout.

CANMET's Mining Research Laboratories provides a service to industry which includes advice on applications and instrumentation requirements for soft-rock borehole sensors; custom instrumentation packages can be designed for new applications.

MINING INDUSTRY APPLICATIONS

The CANMET borehole deformation gauges provide solutions to problems of mining layouts, support, stability and backfilling. Continuous monitoring through remote data logging provides accurate and timely information on stability, which can result in:

- reduced maintenance costs
- greater mining efficiency
- continued access to ore
- improved mine safety

- Hanging wall stability of a cut-and-fill potash mining operation is continuously monitored to ensure that backfill is providing support as designed. An early warning of potential instability indicates that more slurry backfill needs to be pumped in to maintain support. Financial benefits result from uninterrupted operation and improved mine safety.

- Tailings placed into mined-out stopes will provide roof support, thereby reducing the requirement for large pillars. The integrity of this support function is continuously monitored using the CANMET deformation gauge with remote data logging. With confidence in the integrity of this roof support, resources that would otherwise be wasted can be recovered, providing economic benefits to the mining operation.

- Maintenance costs and ore dilution can be reduced through early warnings of potential roof instability and preventative maintenance of roof support. CANMET's deformation gauge provides a reliable and more convenient guide than room conversion measurements, because it measures deformation between two fixed points within the rock itself and is suitable for automatic datalogging. The gauge is easy to install, and requires no further maintenance or adjustment.

- Long-term excavation performance can be predicted using CANMET's deformation gauge. A low deformation rate indicates that long-term continued access may be expected, whereas a high deformation rate suggests that this area should not be relied upon for long-term access.

CIVIL ENGINEERING APPLICATIONS

- **Deformation measurements in tunnels and foundations**

The CANMET borehole deformation gauges provide a direct measurement of the deformation of material behind the tunnel lining or excavated foundation surface.

Canada

- Measure radial or axial deformation directly, giving data that are straightforward to interpret
- Immediately responsive following installation, with no waiting period for equalization of formation pressure
- Easily adaptable for automated surveillance through remote data logging.

- **Settlement measurements in earth dams, tunnels and foundations**

The CANMET settlement gauge (demonstrated for underground mining operations) provides several advantages over existing civil engineering settlement gauges:

- The gauge does not need permanent access to an exposed surface; the gauge can be completely buried, leading to greater versatility and more meaningful measurements
- Data collection is automated through wireless, remote data logging, with the transmitter built into the settlement gauge
- It provides a fast turnaround time for data presentation, saving time and further reducing surveillance costs.

SELECTED SPECIFICATIONS AND FEATURES

- Deformation gauges with optional extensometers
- Deformation range and resolution:

System	Axial	Radial	Range (mm)	Resolution (mm)
SV (Vibrating Wire)	yes	yes	6	0.003
SS (Strain Gauge)	yes	yes	20	0.05
SP (Potentiometer)	yes	no	150	0.2

- Range of borehole diameters 75.7 mm to 153 mm
- Instruments can record up to 4 diameters per borehole
- Portable readout or automated data acquisition
- Wireless readout over 4 km
- Complete transmitter/receiver/data logger system designed for use with these gauges
- Transmitter can be an integral part of the instrument, if required (e.g. for consolidation meter)

For additional information contact:

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Ottawa, Canada, K1A 0G1
Tel: (613) 996-4027
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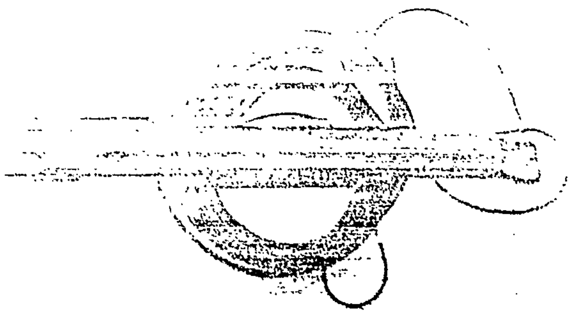
SOFT ROCK BOREHOLE DEFORMATION GAUGE

A-23



APPLICATIONS

The Soft Rock Gauge has been developed to:

- measure the radial deformation of boreholes in potash, salt and coal
- determine creep rates for soft rock
- check finite element predictions
- confirm planning assumptions
- determine rock mass stability
- monitor the effect of excavation activities on structures

DESCRIPTION

The CANMET soft rock borehole gauge consists of two steel yokes, where each arm is fitted with a vibrating wire. The resonant frequency is detected by a built-in exciter unit. The frequency changes with ring deformation and is virtually unaffected by temperature and humidity changes. The mobile arm is in contact with the borehole wall through a swivel contact and the unit is placed in contact with the borehole wall through a hand-pulled wedge. The two sensors are mounted at 90° to each other so that in a horizontal hole the vertical and horizontal diameter can be measured. The housing is stainless steel and the end plugs are made of Delrin

The sensors are available for 76 mm (2.98 in.) diameter boreholes. Output may be recorded by a portable self-powered readout unit, a borehole data logger or a data acquisition system. The sensors are recoverable, and have a stiffness of about 0.40 MN/m (2400 lb./in.)

U.S. Patent 4858472 Canadian Patent 1240851

Biaxial Soft Rock Borehole Deformation Gauge

FEATURES

- **High precision, high resolution sensing system with rugged design.**
- **Units can be removed at end of investigation or for recalibration, if required.**
- **Vibrating wire mounted at right angles to loading direction with autoresonance or plucking exciters.**
- **Portable readout or automatic data acquisition.**
- **Range of 3.2 mm (0.125 in.) with a resolution of 0.003 mm (0.0001 in.)**
- **Instruments to record up to four diameters per borehole.**
- **Wireless readout over 3 km.**

GROUND CONTROL INSTRUMENTATION

CANMET

Dr. G. Herget, MRL
Phone: (613) 996-4027
Fax: (613) 995-3456

SPECIFICATIONS

Nominal Borehole Diameter Required: 76 mm (2.98 in.)		
MODELS:	SD Single Diameter	D 90 Double Sensor Spaced 90°
Length of Sensor:	32.5 cm (12 3/4 in.)	58 cm (22 7/8 in.)
Diameter of Sensor:	48.2 mm (1.9 in.)	48.2 mm (1.9 in.)
Range of Diameter:	73.7 mm (2.9 in.) to	80 mm (3.15 in.)
Sensor Stiffness:	0.420 MN/m (2400 lb/in.)	0.420 MN/m (2400 lb./in.)
Resolution:	0.003 mm (0.0001 in.)	0.003 mm (0.0001 in.)
Range:	3.2 mm (0.125 in.)	3.2 mm (0.125 in.)
Exciter Unit (specify):	Autoresonance or	Plucking Coil
Onsite Readout:	Pocket Size CANMET Readout	
Data Logging:	RBR Waterproof Loggers, SENS-LOG, CAMPBELL Scientific Data Aquisition Systems, etc.	

INSTALLATION

The wedge system is designed for specific ranges of borehole diameters. The strain cells are preferably installed in diamond drilled holes, but percussion drilled holes reamed to the required diameter will also be suitable. Special wedge sizes may be provided on request for different hole sizes.

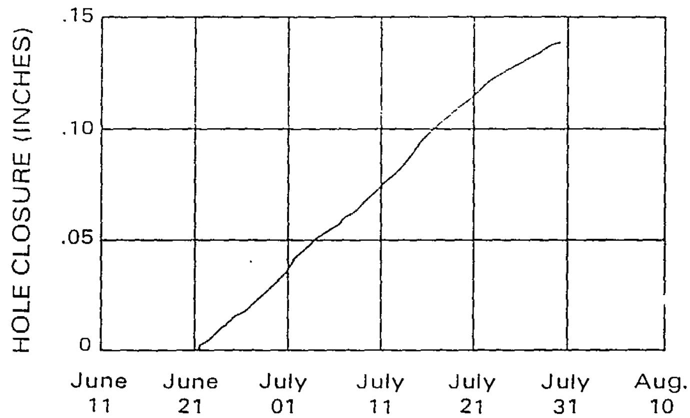
The assembled unit is pushed down the borehole to its location and rotated to the required orientation. Aircraft cable connected to the wedge is pulled by hand to preload the swivel contact by 200 to 300 Hertz.

For the cells' removal, an EW Box coupling is mounted on retrieval rods and connected to the EW Pin on the sensor with a centering guide. A sharp pull will remove the sensor.

An integrated thermistor is recommended when large temperature variations are expected on site (e.g. more than ±8°C).

INTERPRETATION

At a potash mine in Saskatchewan borehole closure was measured for a horizontal borehole in a 18.9 m (62 ft.) ribpillar as a 7.9 m (26 ft.) path was cut beside the pillar. The record shown below indicates a strain rate of 0.0013 per day which amounts for a 4.9 m (16 ft.) high opening to a convergence rate of 6.3 mm (0.25 in.) per day.



ACCESSORIES

- Readout Unit / Data Acquisition System
- Installation Tool / Self-Oriented Rods
- Additional or Oversize Wedges
- Centering Guide

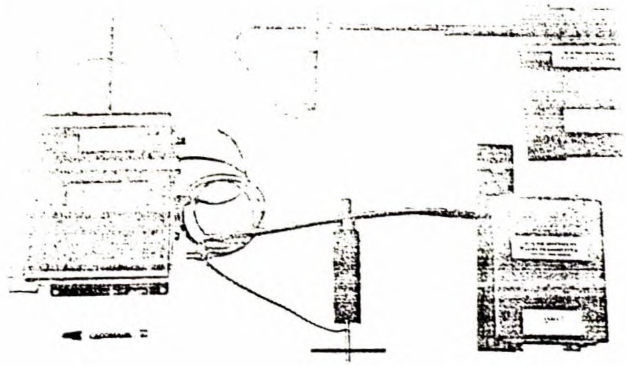
ORDERING INFORMATION

Please specify:

- borehole diameter
- cable length (standard : 10 m)
- installation tool
- exciter type (P = plucking, C = continuous, T = thermistor)

RADIO TRANSMITTER EQUIPPED GROUND MONITORS

A-25



APPLICATIONS

The one-way radio transmitter/receiver system records sensor output from hard or impossible to reach extensometer locations or from consolidation meters buried in fill.

DESCRIPTION

The transmitter/receiver system has been built to transmit outputs from variable resistors such as extensometer deformations or consolidation meter movements, and from vibrating wire sensors such as found in CANMET strain monitors. Transmitters carry a battery pack for 18 months and output is 0.15 W with a line of sight range of 3 km. The transmitters take one reading per day at preprogrammed times and transmit for 10 seconds with a carrier frequency of 172 MHz. They transmit with a DTMF signature so that the receiver does not record stray signals. Receivers are 110 V AC powered with a back-up battery supply for four weeks. Valid signals are downloaded to an eight-channel datalogger. To transmit through fill or solid rock, leaky cable technology is used.

Receiver/Logger Unit with Two Sensors and Transmitters

FEATURES

- **Three km range.**
- **Safe and efficient data transmission from difficult or impossible to reach monitoring locations.**
- **Low-cost custom-built disposable transmitters.**
- **DTMF signature for signal screening.**
- **18-month transmission capability.**
- **Leaky cable technology allows to pass obstacles.**
- **One transmission per day.**
- **Up to eight transmissions per 24 h period per receiver station.**

GROUND CONTROL INSTRUMENTATION

CANMET

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Fax: (613) 995-3456

	Model Number	Battery Life	Capacity
Encoding transmitter for variable resistors with DTMF signature	TX - 50	18 months	0.15 W
Encoding transmitter for autoresonance vibrating wire sensors	TX - 20	18 months	0.15 W
172 MHz receiver	RS - 40 B	110 VAC with 1 month back-up	
RBR pipe logger for output storage	TF -800	6 months	64 kb

INSTALLATION

In case of an extensometer the transmitter may be mounted beside the extensometer head or inside the borehole if protection against fly rock is required. In case of a consolidation meter the transmitter is either an integral part of the instrument or is placed beside the consolidation meter.

To ensure that the signal will penetrate the fill, a piece of copper wire is wrapped around the transmitter antenna or placed close to the transmitter. If this cable distorts or breaks, the radio wave will jump this gap.

For free air transmission the receiver antenna is best placed in line of sight of the transmitter, but guidance of the transmitted signal around or through obstacles is relatively easy. Signal quality at the receiver must, however, be tested before the system can be considered serviceable.

INTERPRETATION

Transmitter signals received at the receiver station are screened for a special signature to ensure that stray signals are rejected. Valid signals are placed in one of the eight channels of the data logger according to the time of transmission set in each transmitter. The software available for the logger contains calibration files so that sensor outputs are automatically displayed in mm or other desired dimensions.

ACCESSORIES

Software for plotting data from data logger, computer cable.

ORDERING INFORMATION

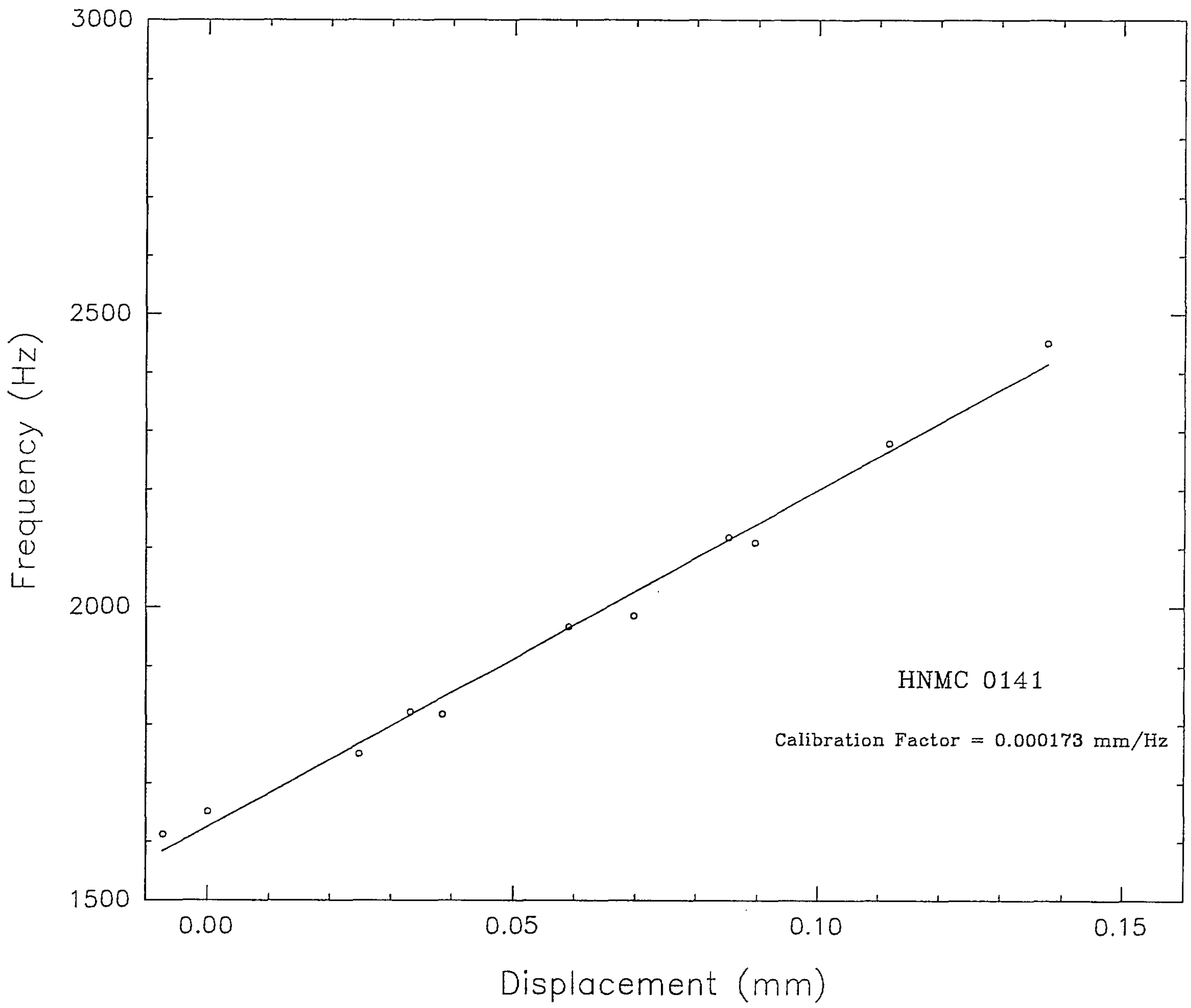
Please specify:

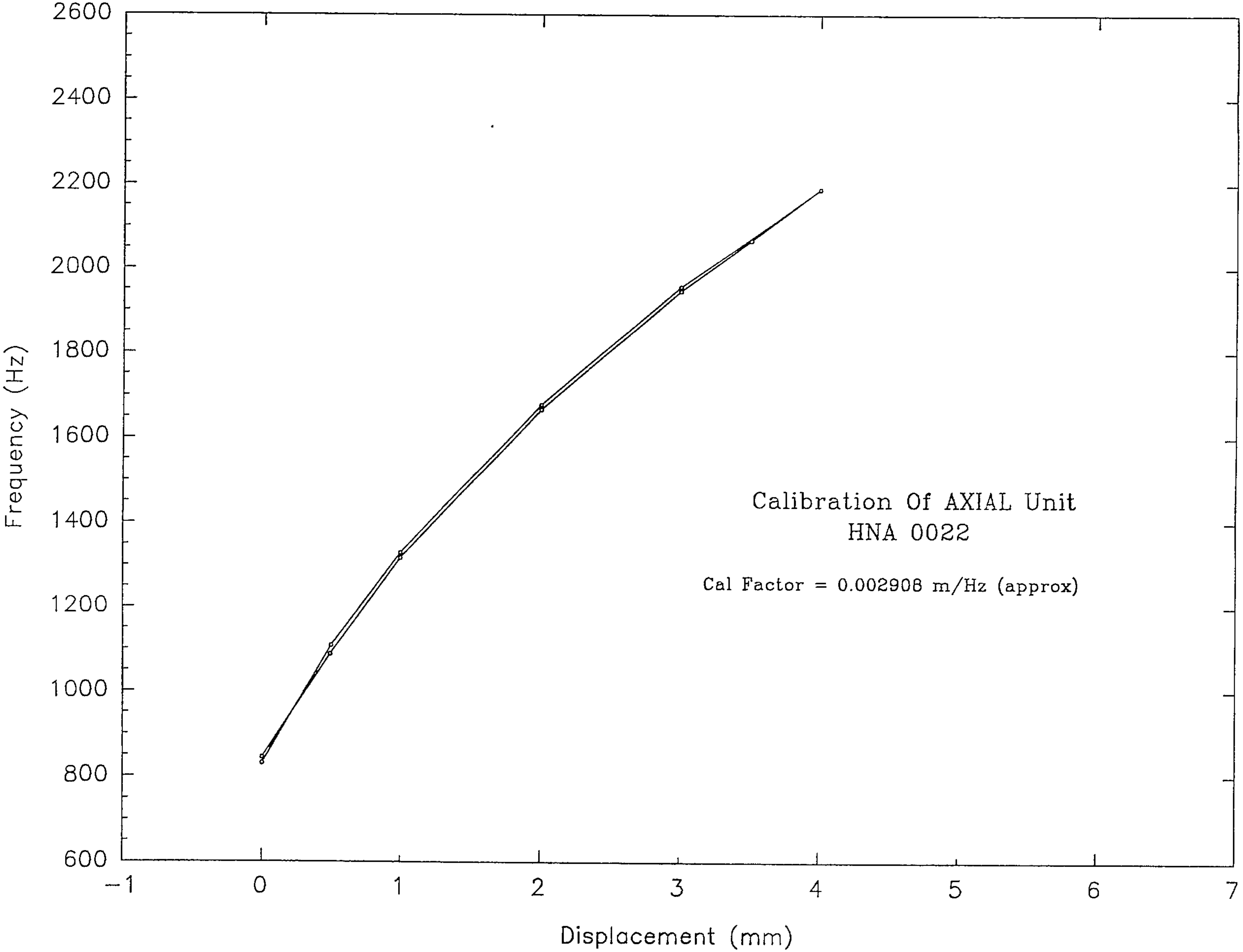
- Borehole diameter for sensor
- Type of sensor
- Distance to receiver
- Obstacles, line of sight
- Length of monitoring period
- Delivery and time schedule

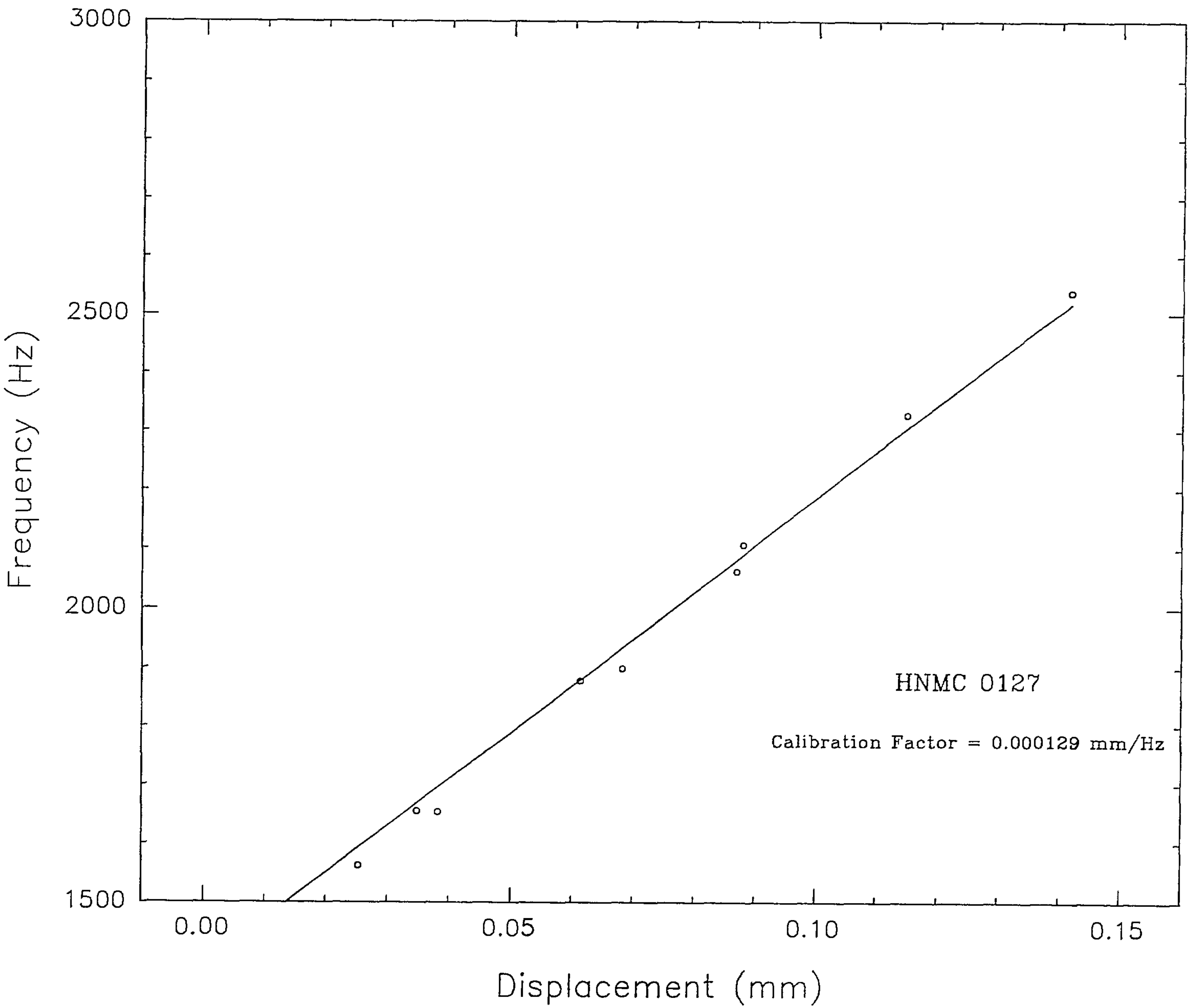
APPENDIX B

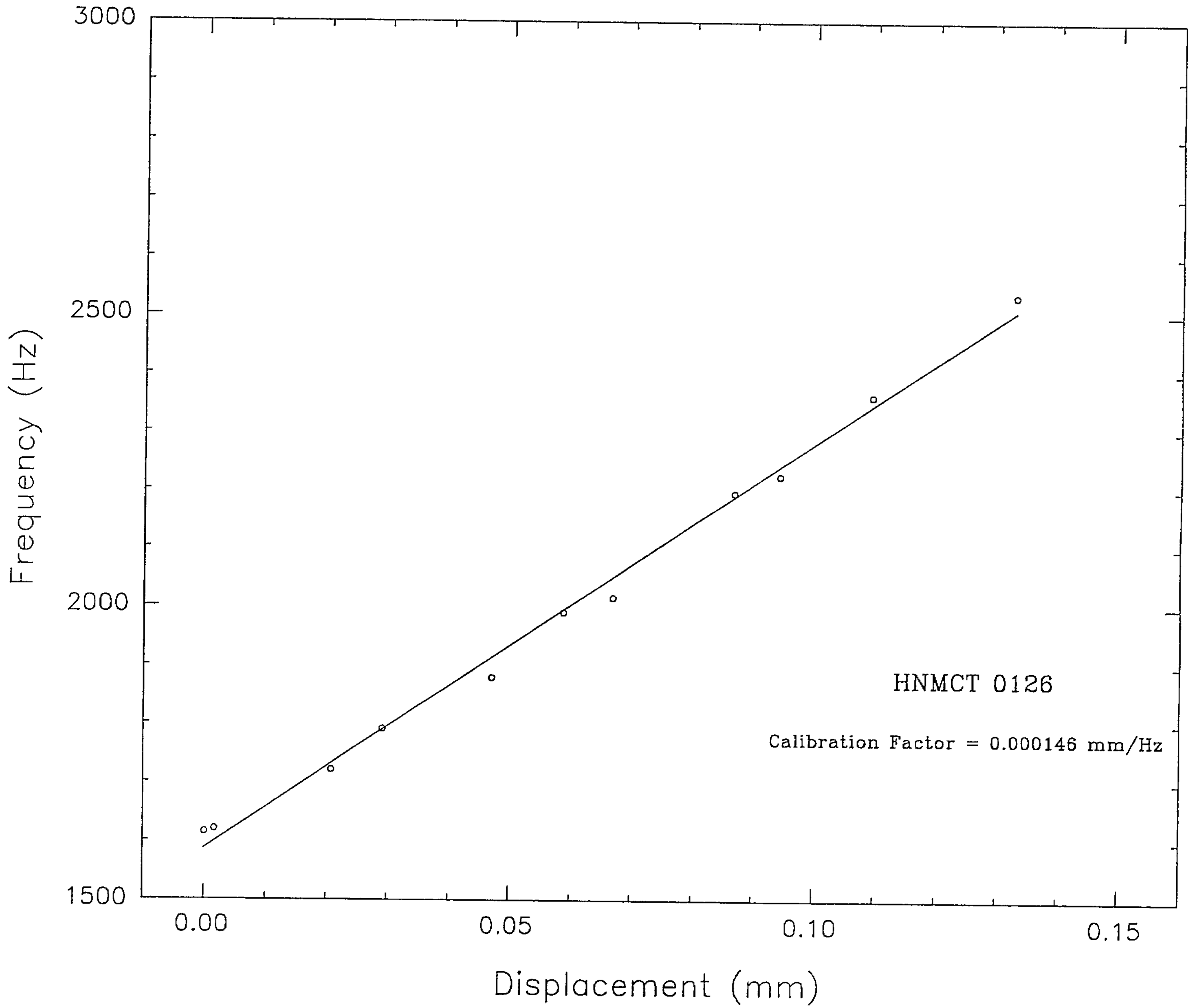
Calibration Charts of
Installed Borehole Monitoring Equipment
for Holes 1 to 5

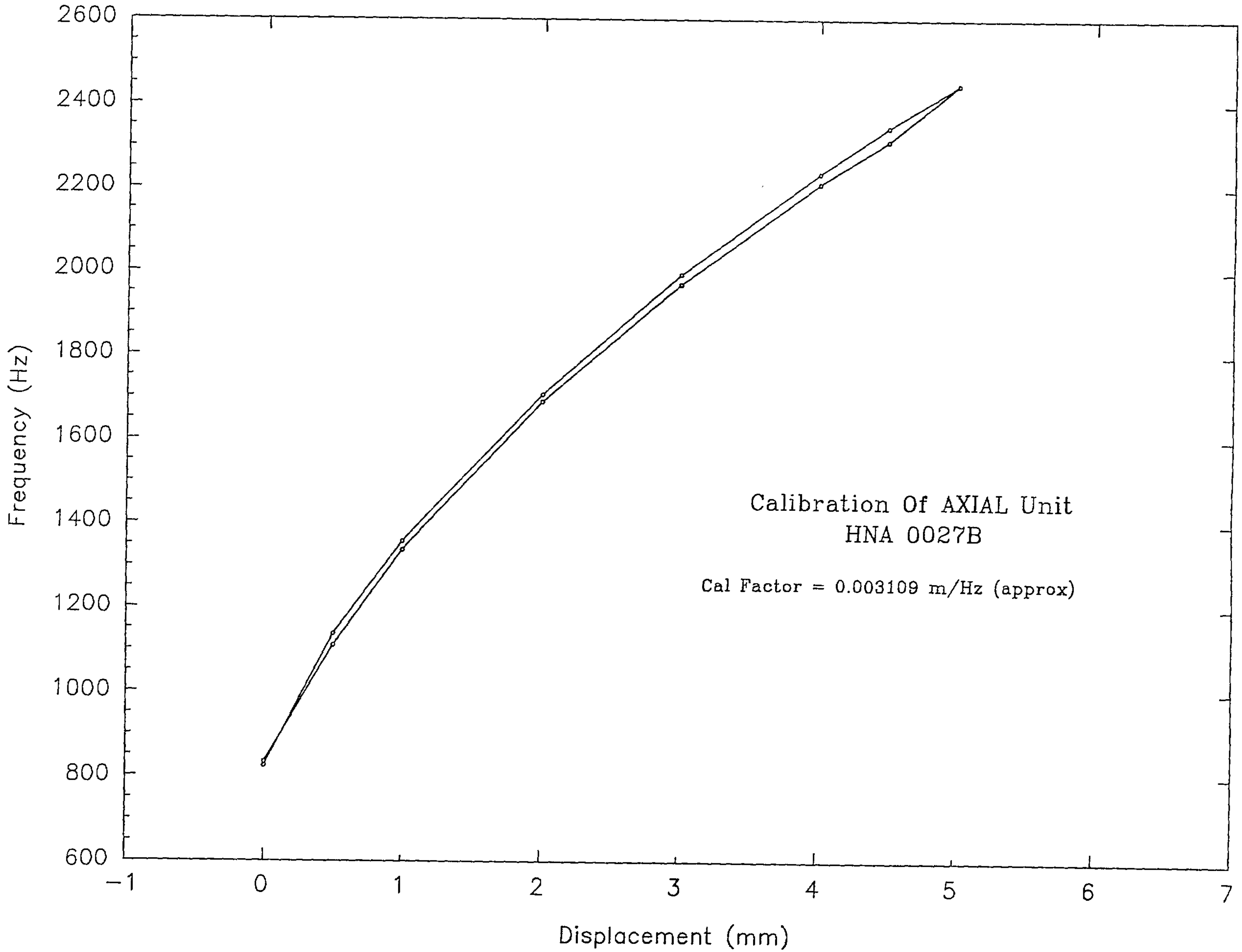
Calibration Charts for Hole 1.

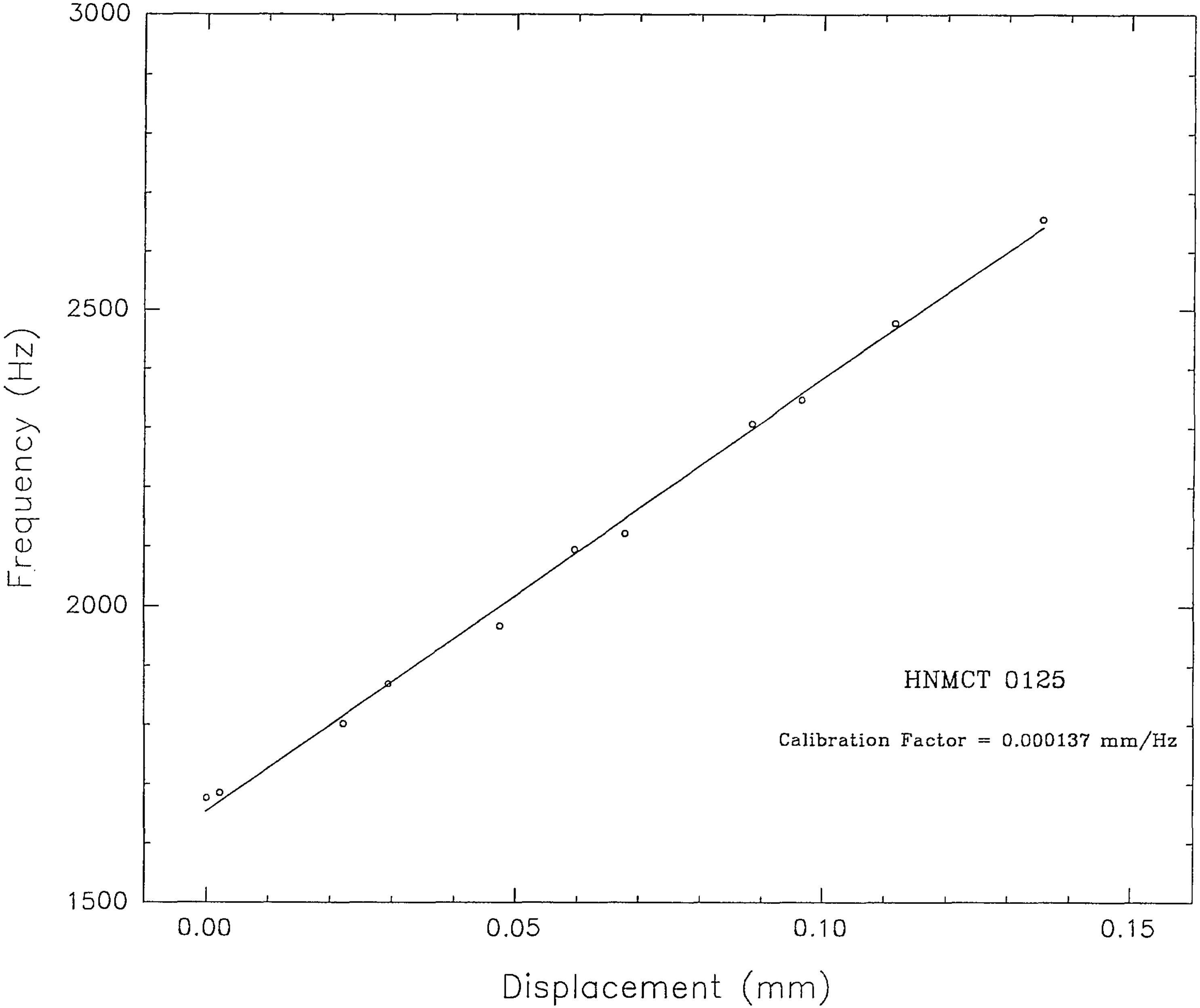

3000
2500
2000
1500
Frequency (Hz)
0.00
0.05
0.10
0.15
Displacement (mm)
HNMC 0141
Calibration Factor = 0.000173 mm/Hz

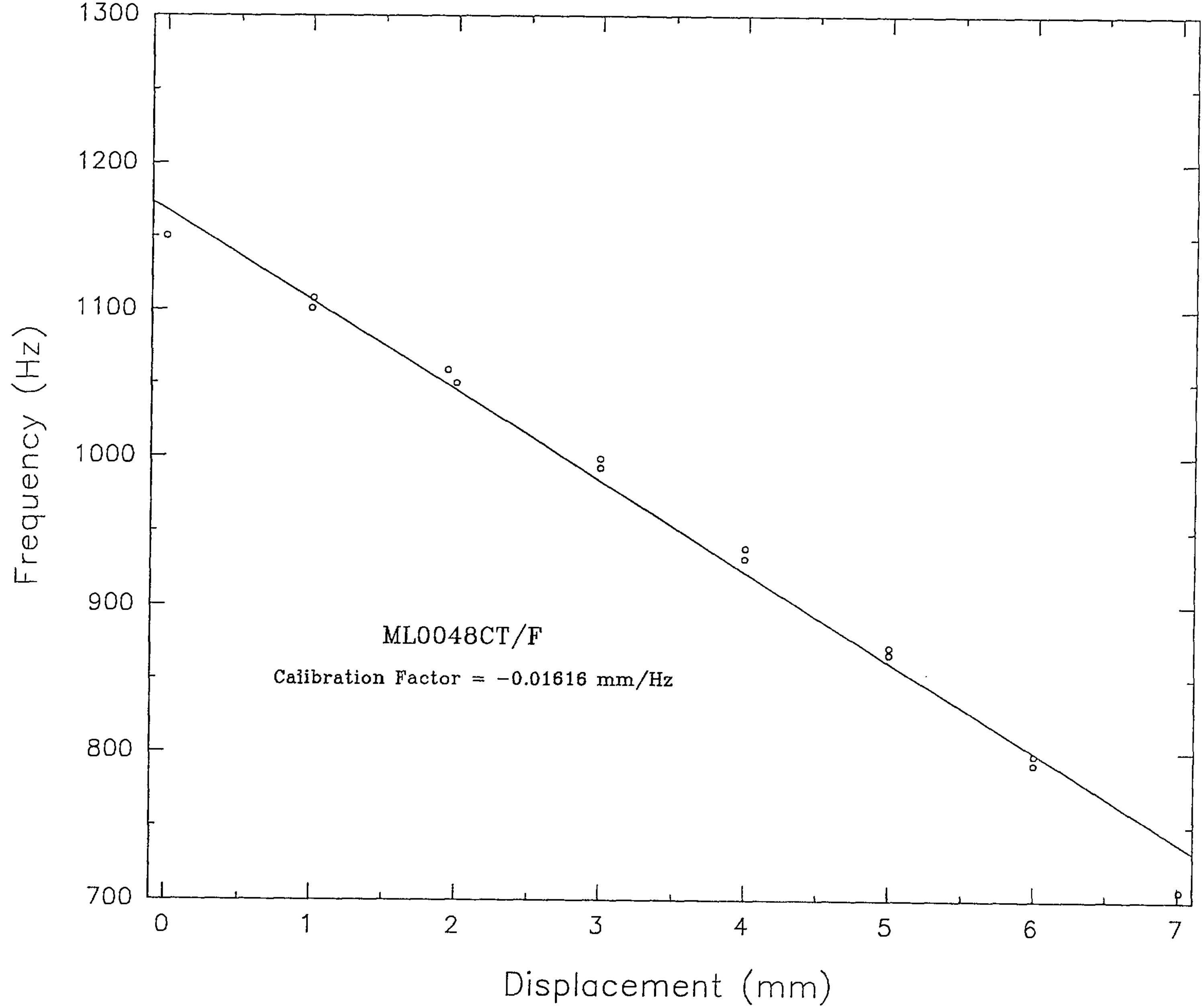

Calibration Of AXIAL Unit
HNA 0022
Cal Factor = 0.002908 m/Hz (approx)
Frequency (Hz)
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
Displacement (mm)
−1
0
1
2
3
4
5
6
7

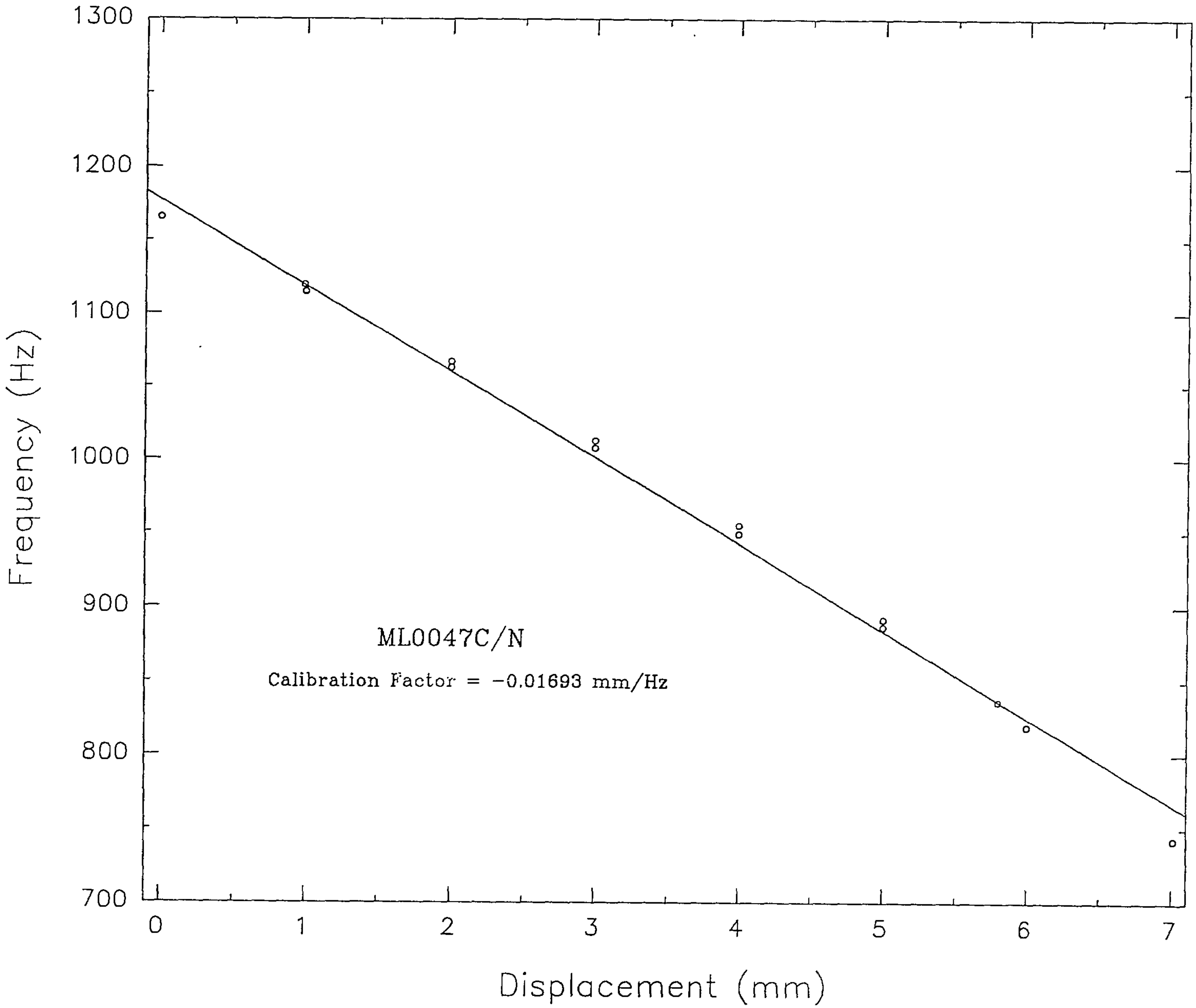

3000
2500
2000
1500
Frequency (Hz)
0.00
0.05
0.10
0.15
Displacement (mm)
HNMC 0127
Calibration Factor = 0.000129 mm/Hz

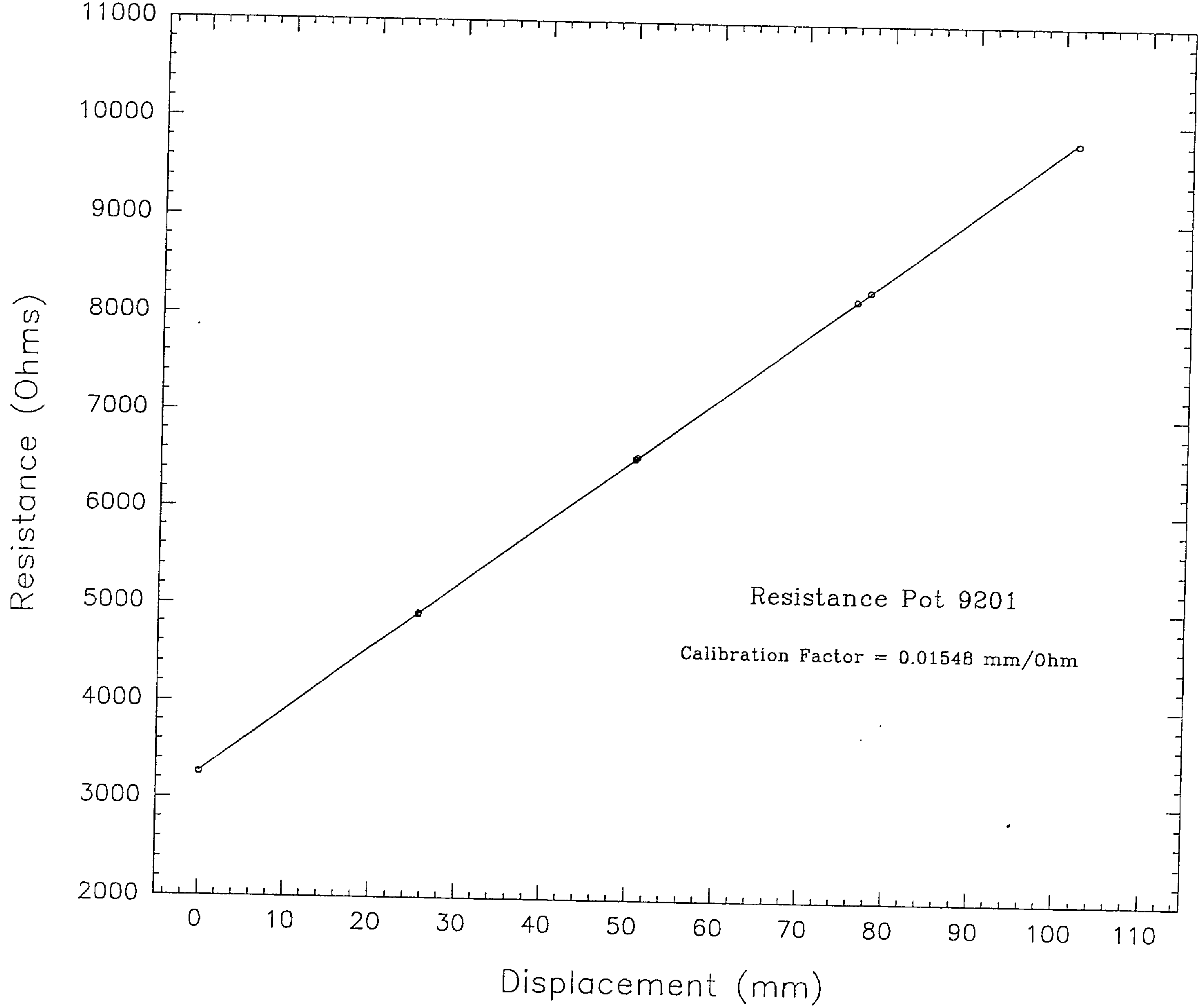

3000
2500
2000
1500
Frequency (Hz)
0.00
0.05
0.10
0.15
Displacement (mm)
HNMCT 0126
Calibration Factor = 0.000146 mm/Hz


Calibration Of AXIAL Unit
HNA 0027B
Cal Factor = 0.003109 m/Hz (approx)
Frequency (Hz)
Displacement (mm)
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
−1
0
1
2
3
4
5
6
7


3000
2500
2000
1500
Frequency (Hz)
0.00
0.05
0.10
0.15
Displacement (mm)
HNMCT 0125
Calibration Factor = 0.000137 mm/Hz

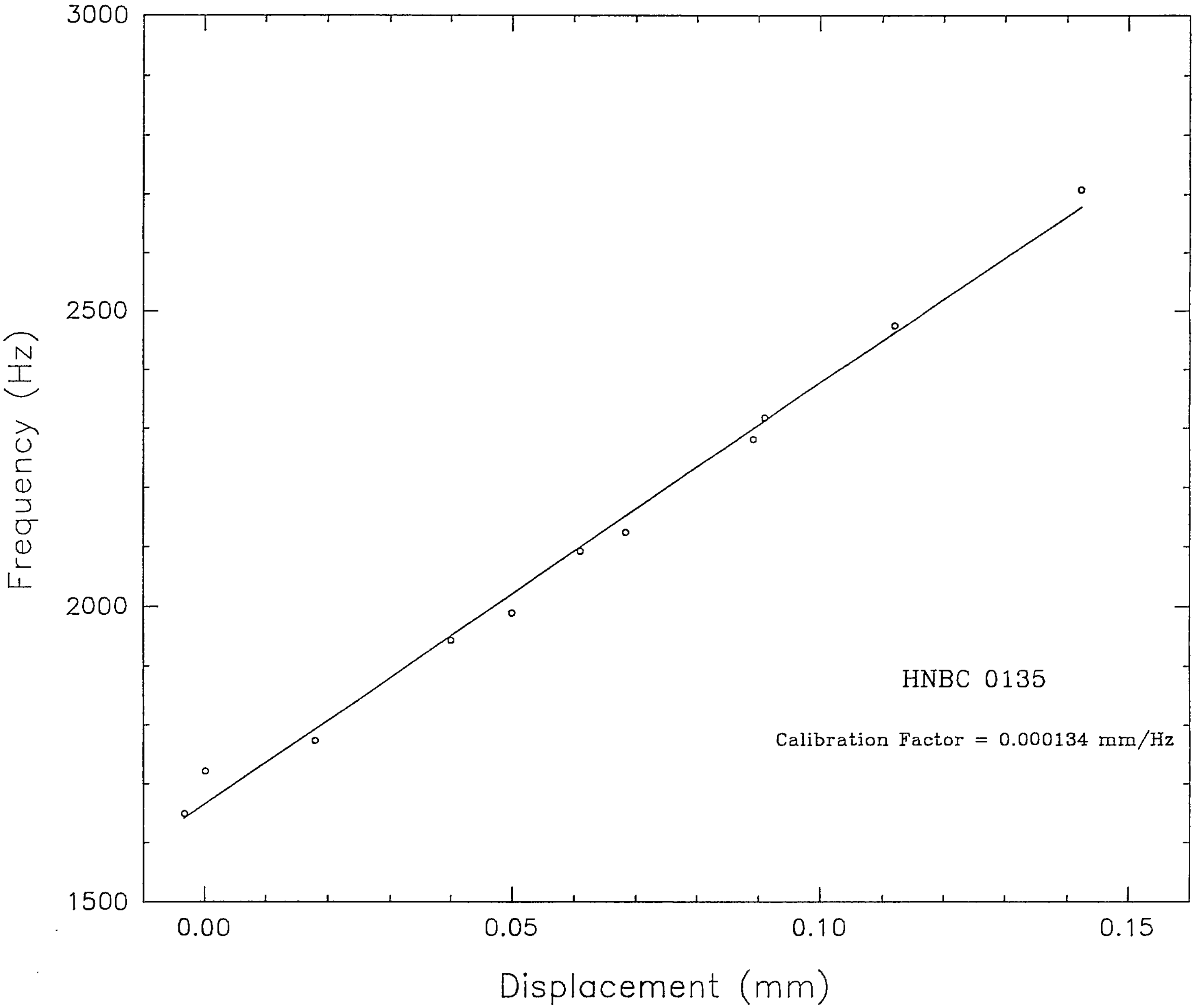

1300
1200
1100
1000
900
800
700
Frequency (Hz)
ML0048CT/F
Calibration Factor = −0.01616 mm/Hz
0
1
2
3
4
5
6
7
Displacement (mm)

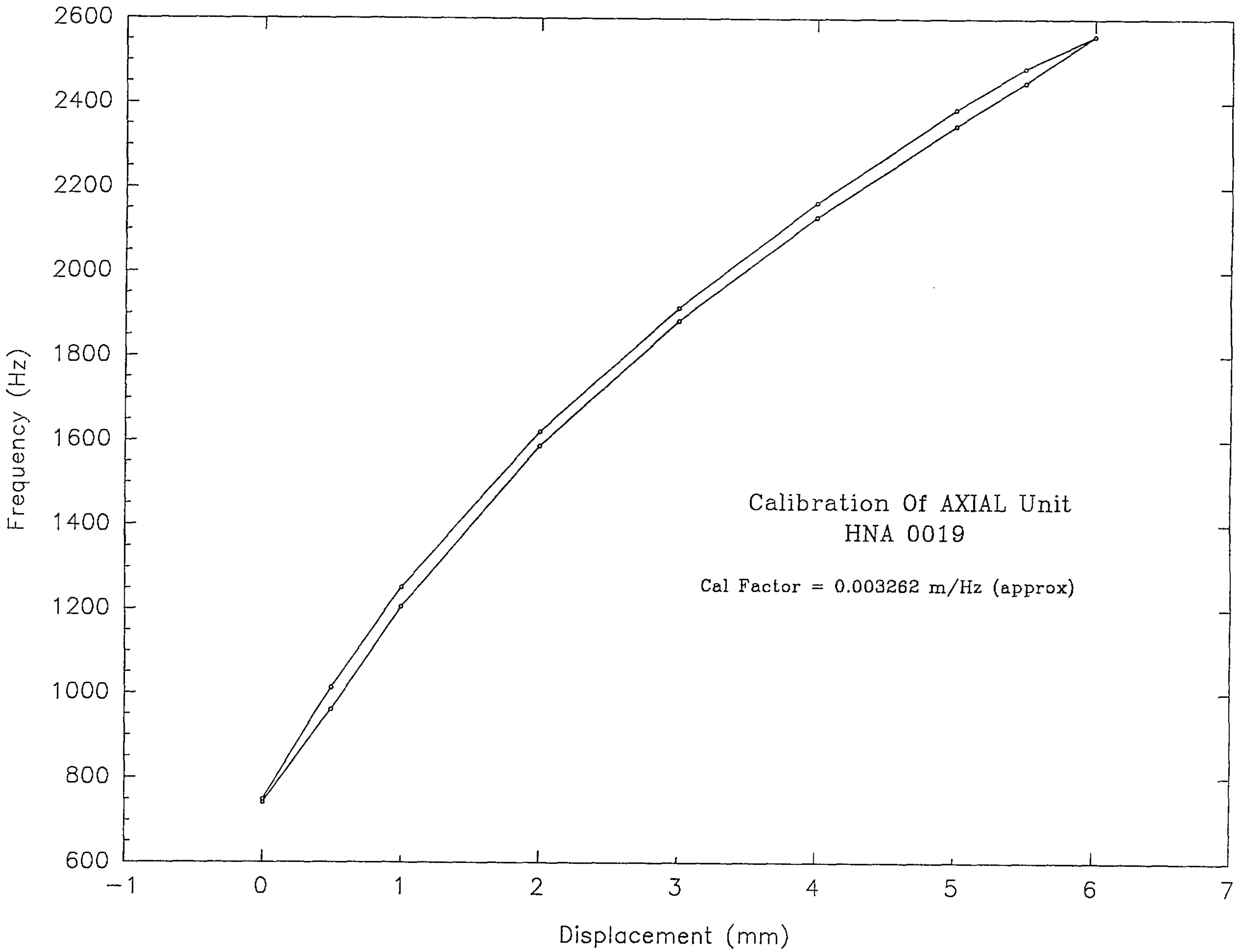

ML0047C/N
Calibration Factor = −0.01693 mm/Hz
Frequency (Hz)
Displacement (mm)
1300
1200
1100
1000
900
800
700
0
1
2
3
4
5
6
7

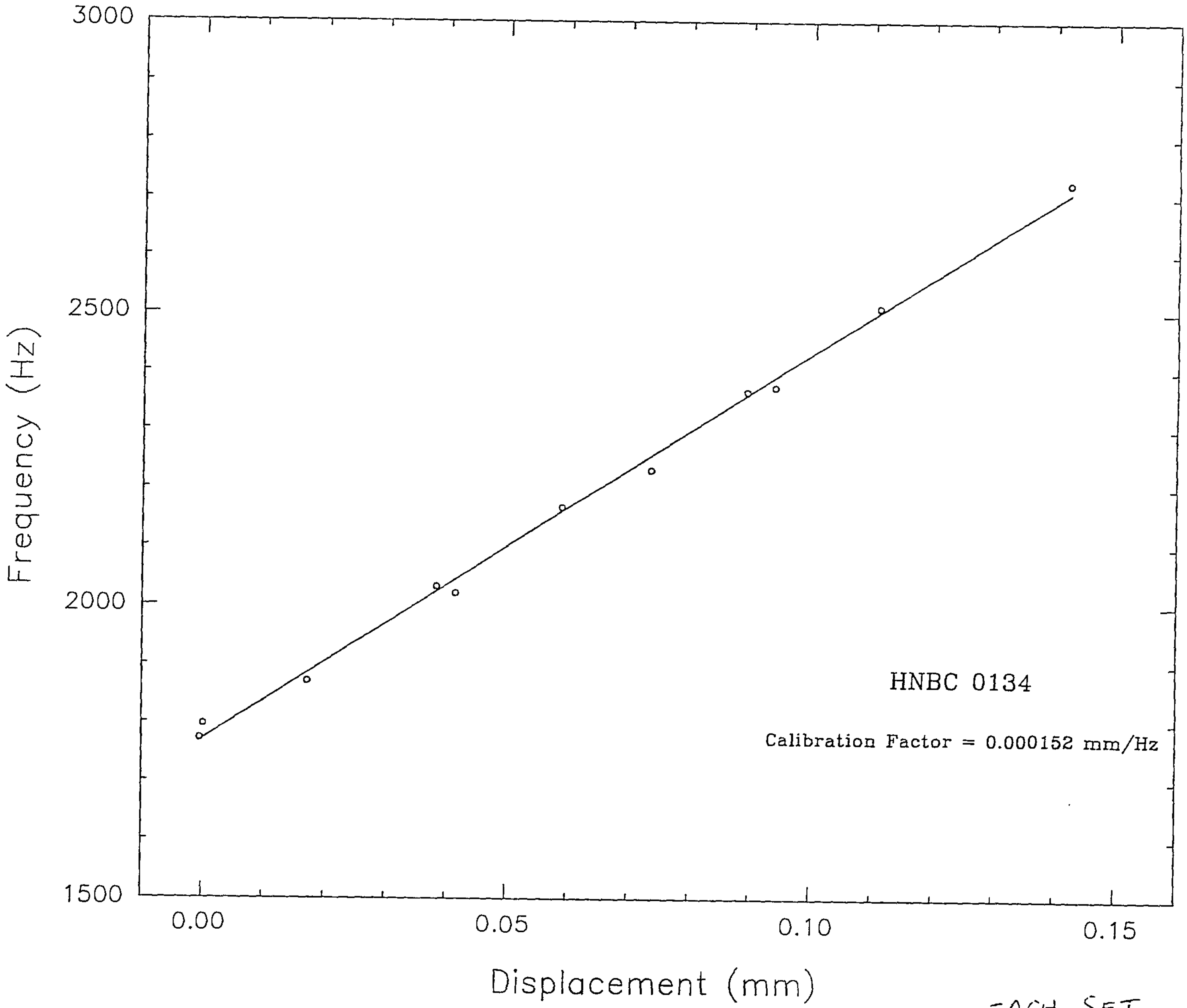


11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
Resistance (Ohms)
0
10
20
30
40
50
60
70
80
90
100
110
Displacement (mm)
Resistance Pot 9201
Calibration Factor = 0.01548 mm/Ohm

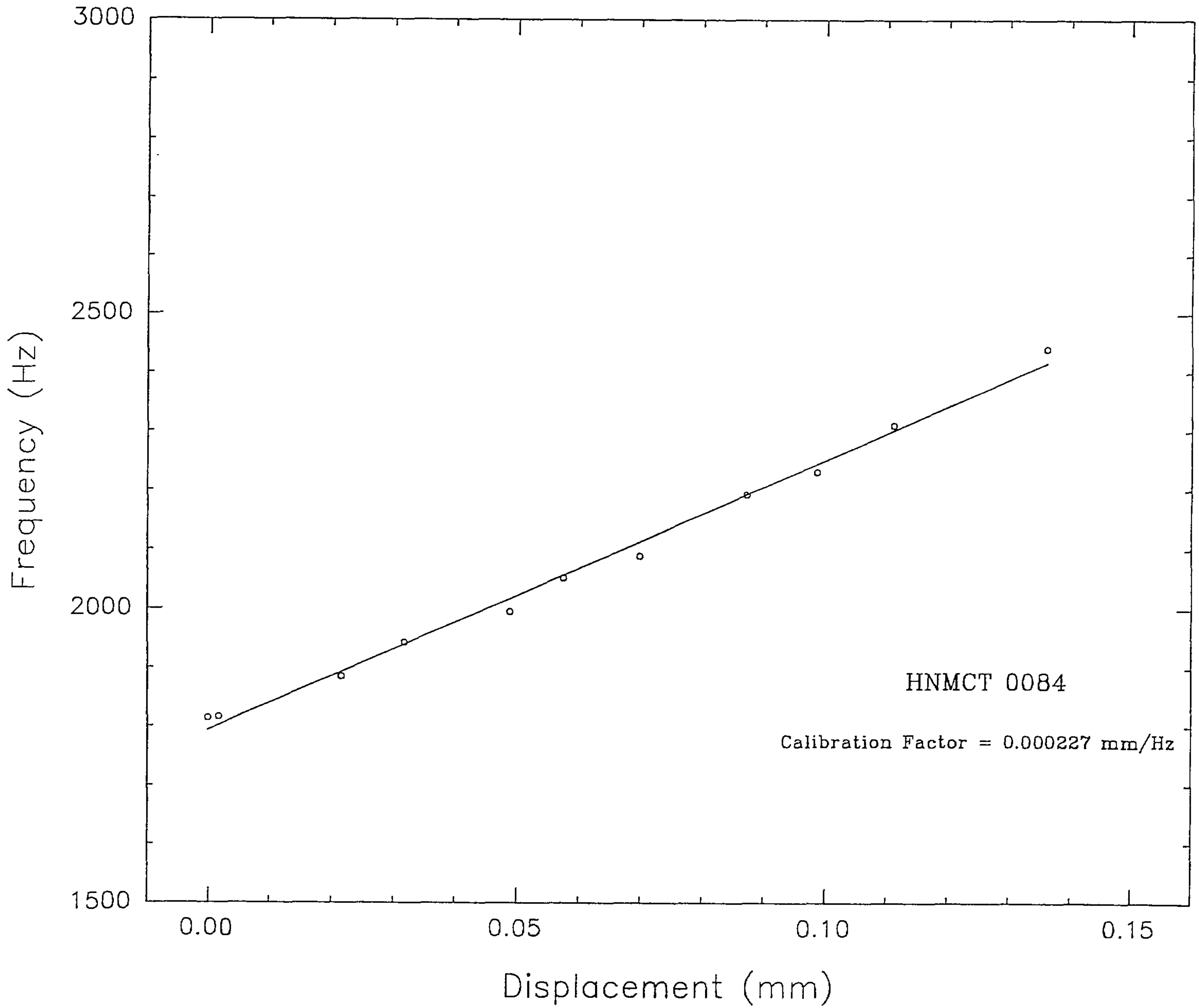
Calibration charts for hole 2.

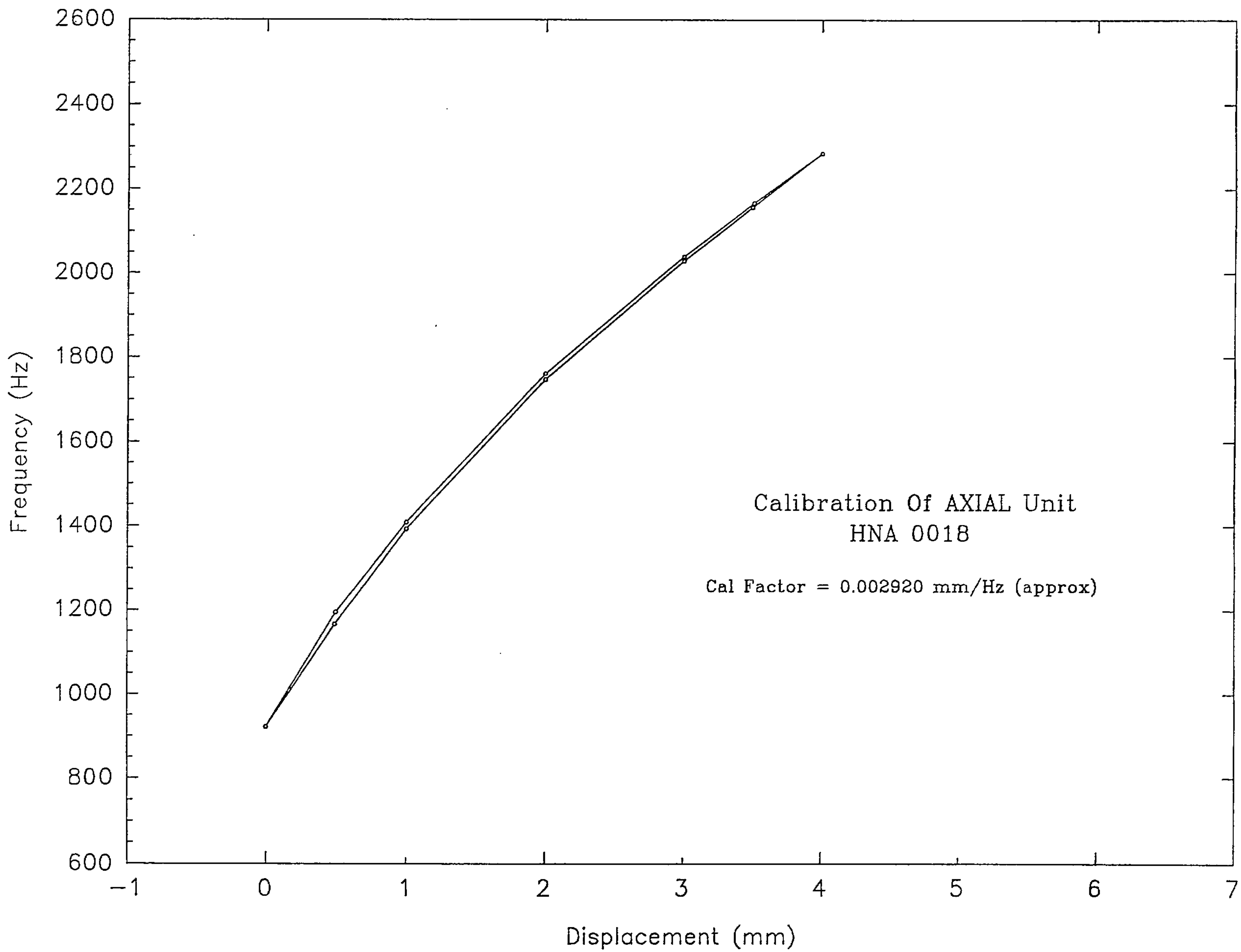

3000
2500
2000
1500
Frequency (Hz)
0.00
0.05
0.10
0.15
Displacement (mm)
HNBC 0135
Calibration Factor = 0.000134 mm/Hz

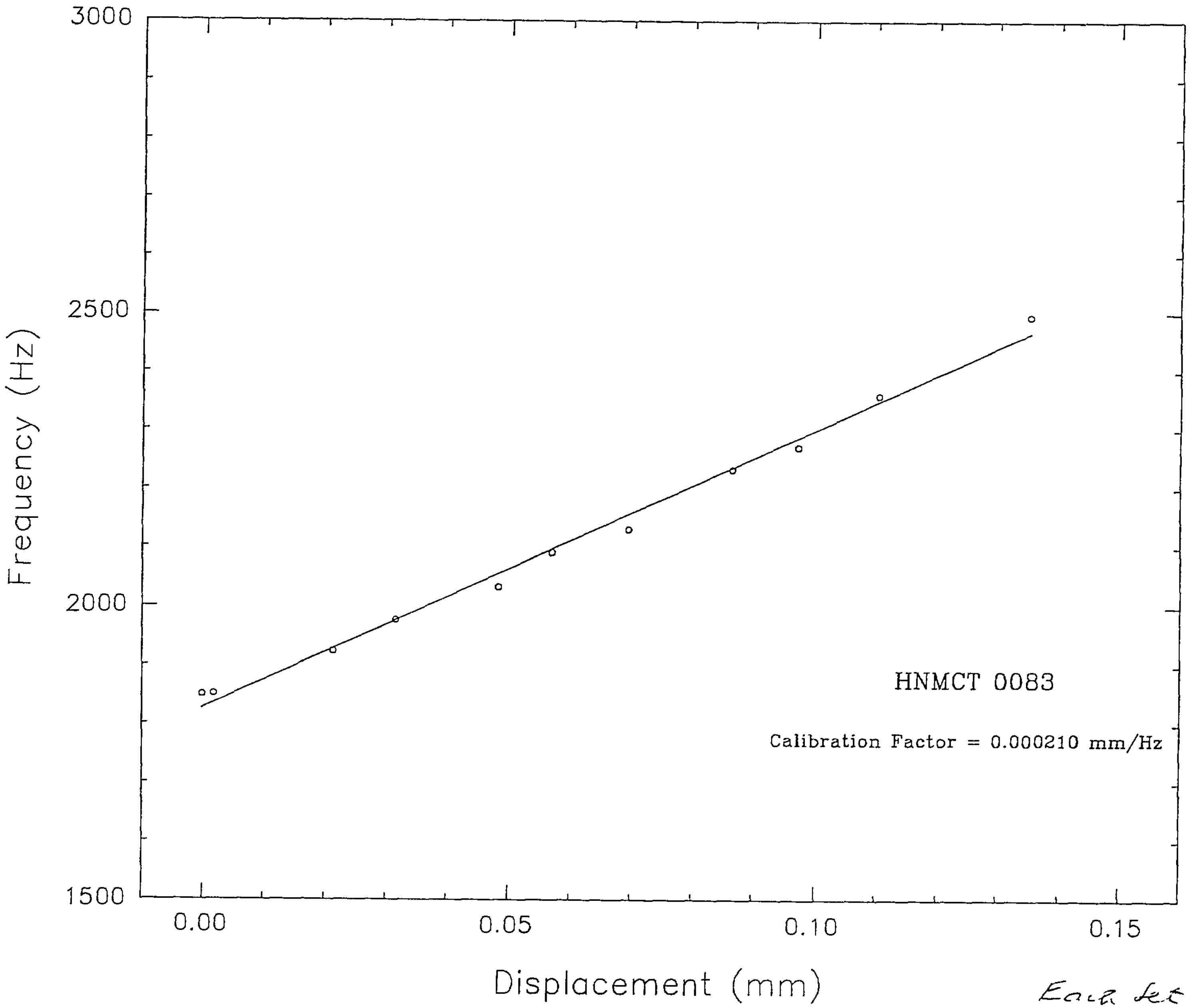

Calibration Of AXIAL Unit
HNA 0019
Cal Factor = 0.003262 m/Hz (approx)
Frequency (Hz)
Displacement (mm)
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
−1
0
1
2
3
4
5
6
7



EACH SET
NEAR/AXIAL/FAR

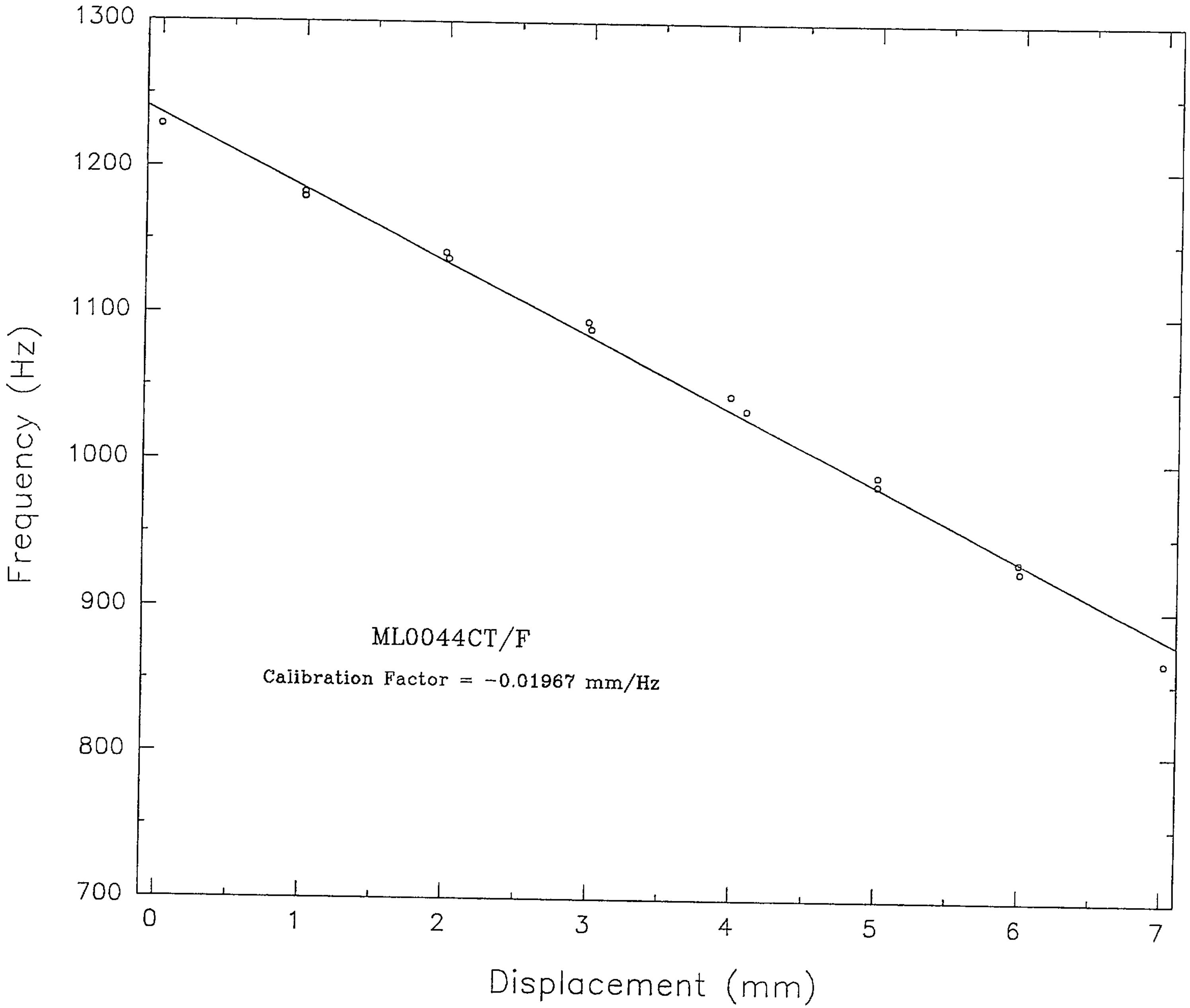

3000
2500
2000
1500
Frequency (Hz)
0.00
0.05
0.10
0.15
Displacement (mm)
HNMCT 0084
Calibration Factor = 0.000227 mm/Hz

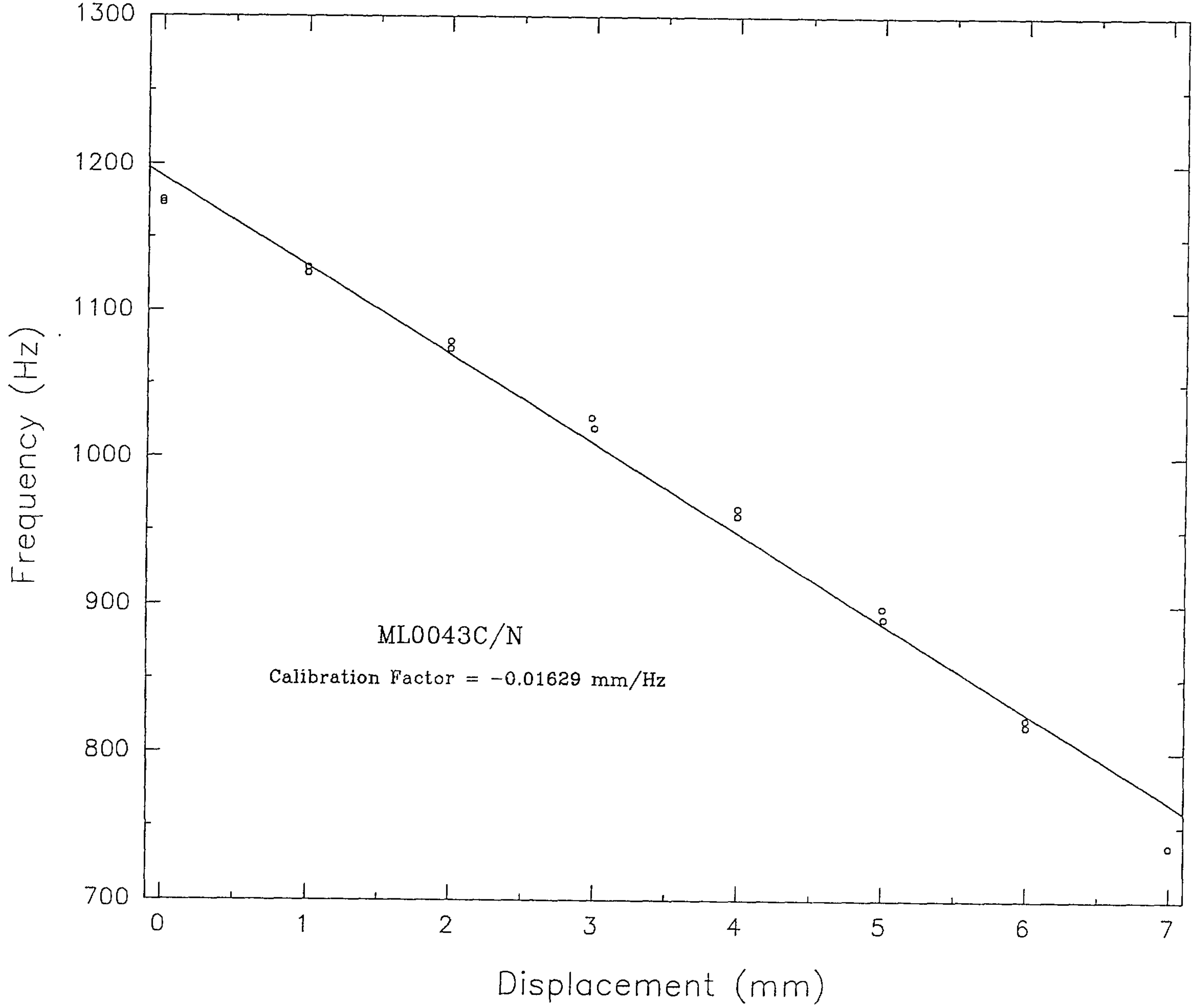

Calibration Of AXIAL Unit
HNA 0018
Cal Factor = 0.002920 mm/Hz (approx)
Frequency (Hz)
Displacement (mm)
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
−1
0
1
2
3
4
5
6
7

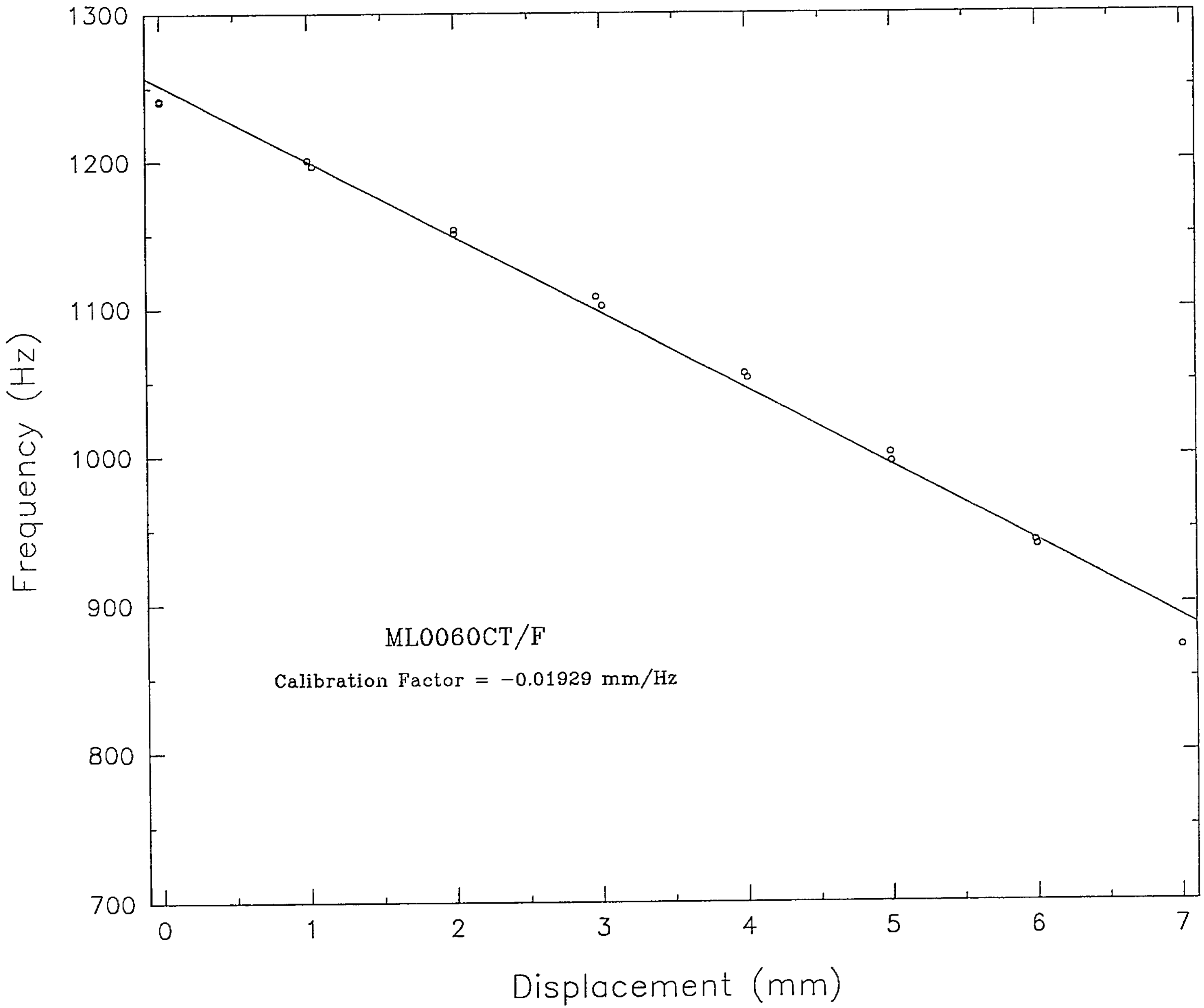


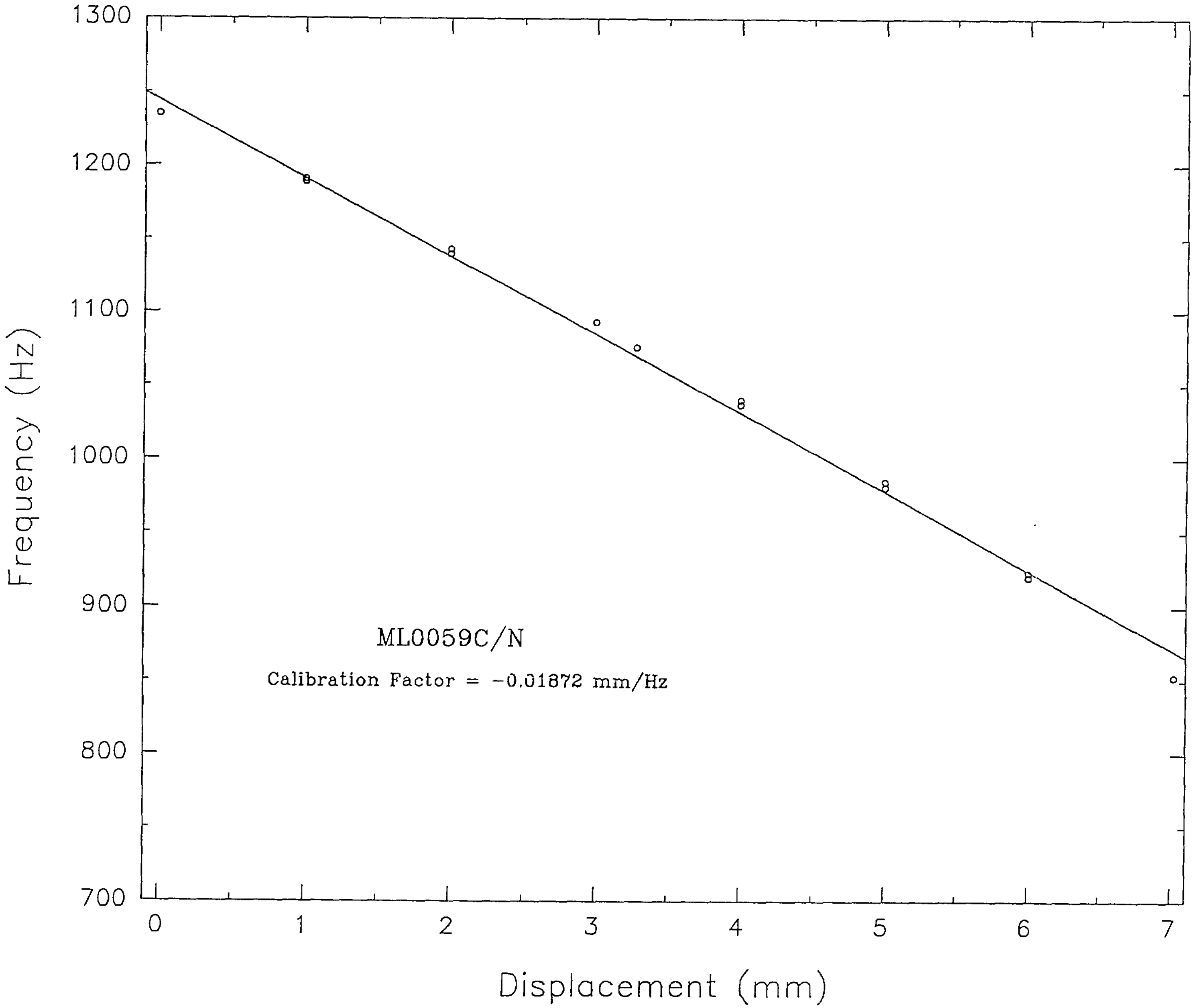
Each Set

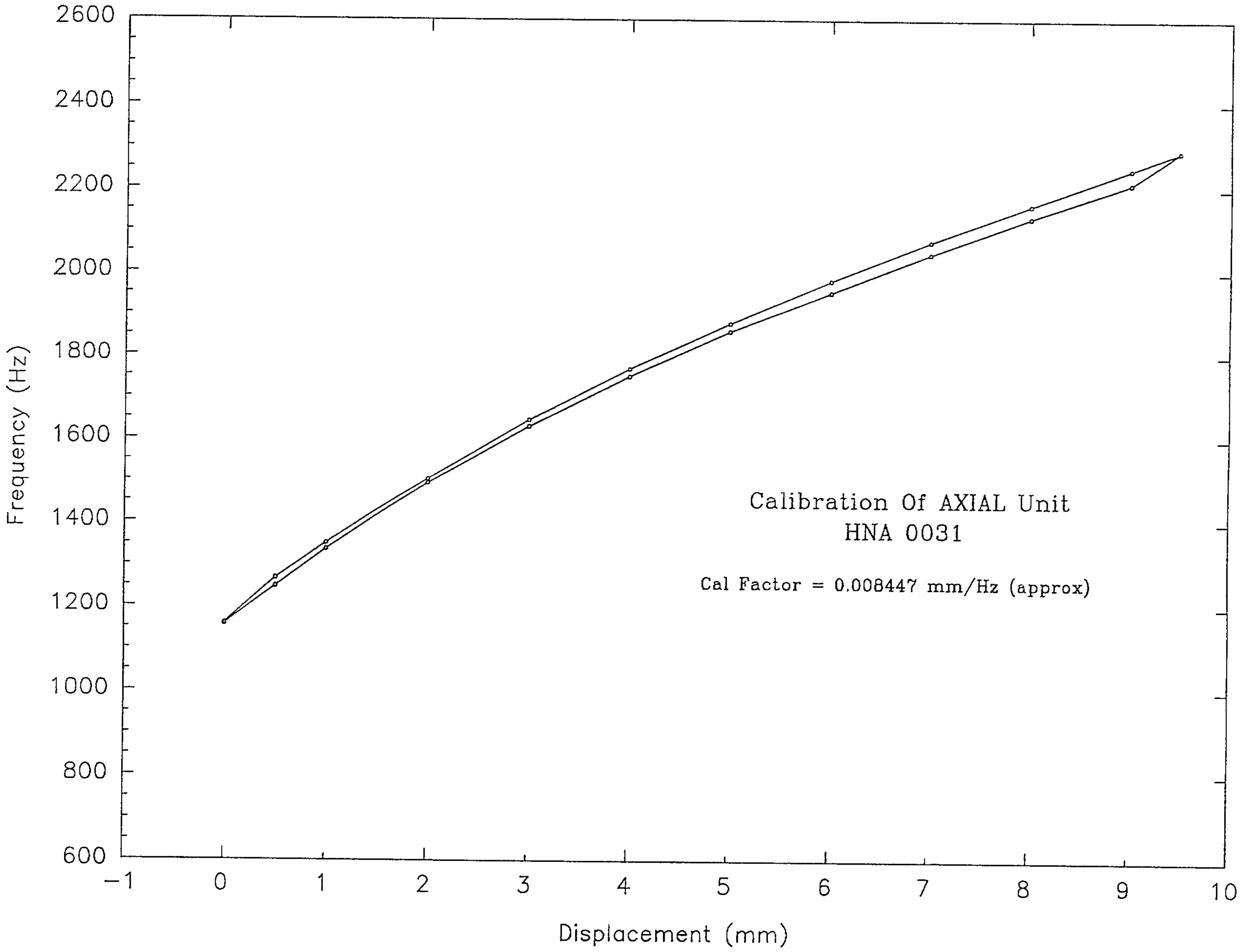
Near / Axial / FAR


1300
1200
1100
1000
900
800
700
Frequency (Hz)
0
1
2
3
4
5
6
7
Displacement (mm)
ML0044CT/F
Calibration Factor = -0.01967 mm/Hz

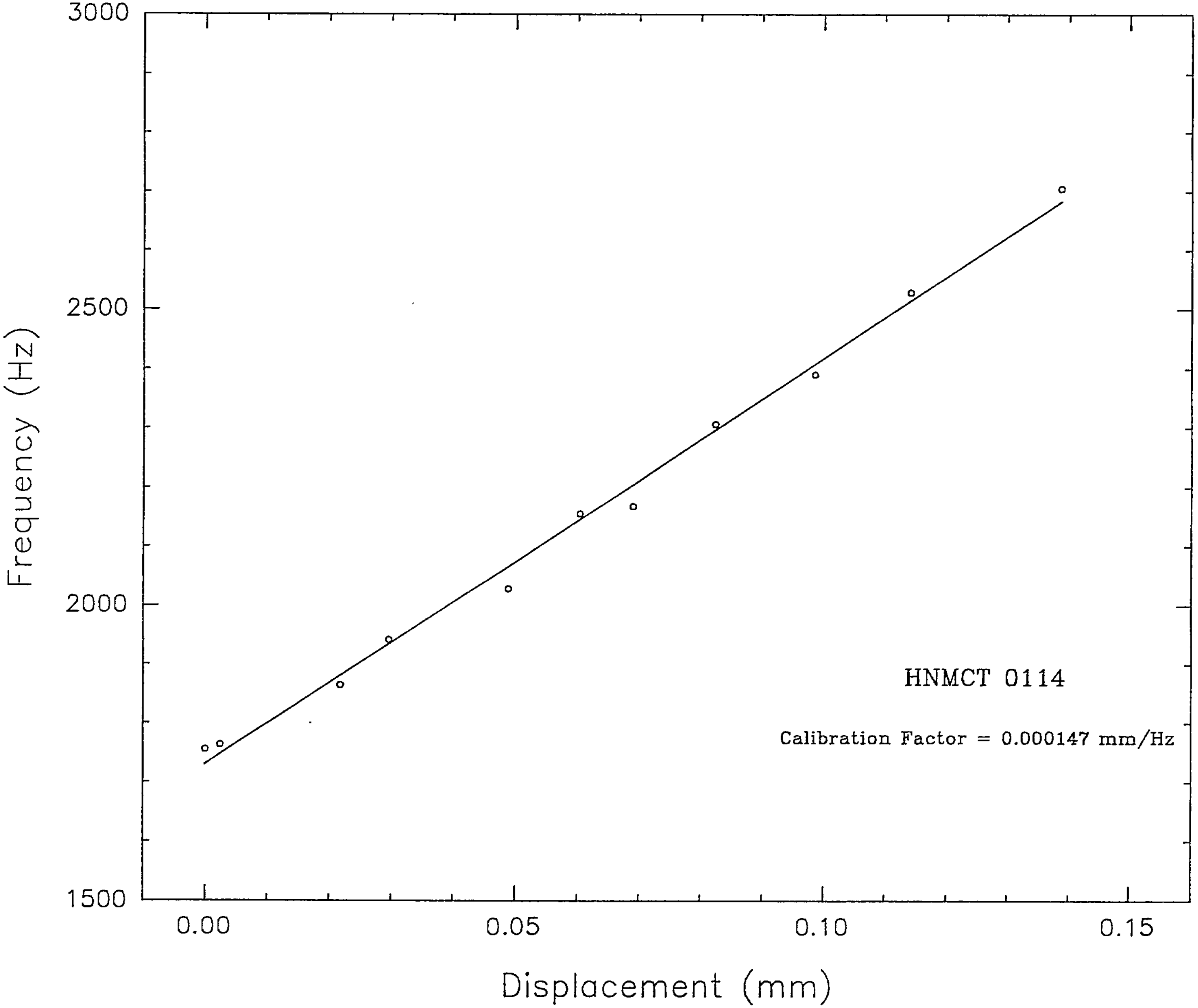

ML0043C/N
Calibration Factor = -0.01629 mm/Hz
Frequency (Hz)
Displacement (mm)
1300
1200
1100
1000
900
800
700
0
1
2
3
4
5
6
7

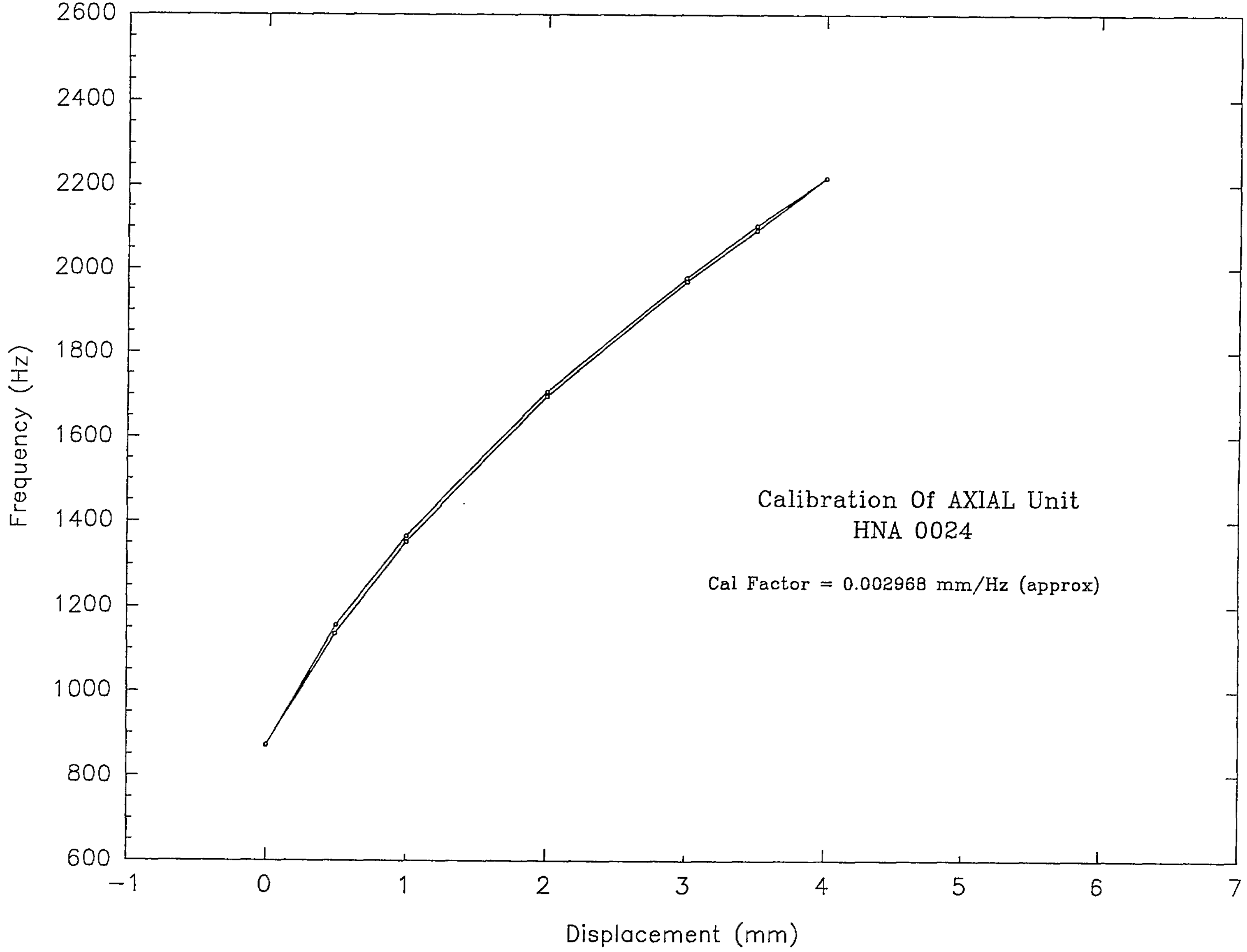

1300
1200
1100
1000
900
800
700
Frequency (Hz)
0
1
2
3
4
5
6
7
Displacement (mm)
ML0060CT/F
Calibration Factor = −0.01929 mm/Hz

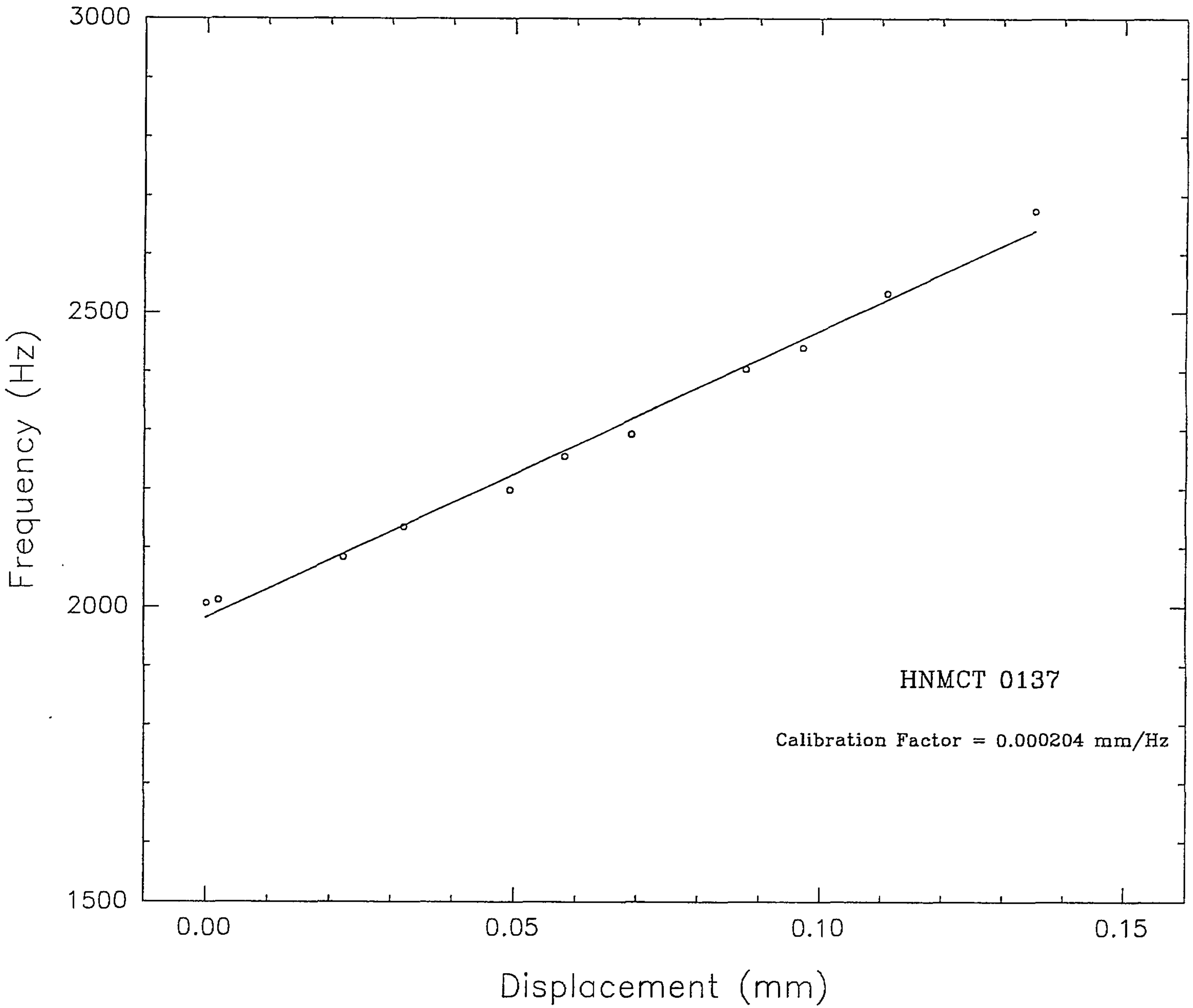

1300
1200
1100
1000
900
800
700
Frequency (Hz)
0
1
2
3
4
5
6
7
Displacement (mm)
ML0059C/N
Calibration Factor = -0.01872 mm/Hz

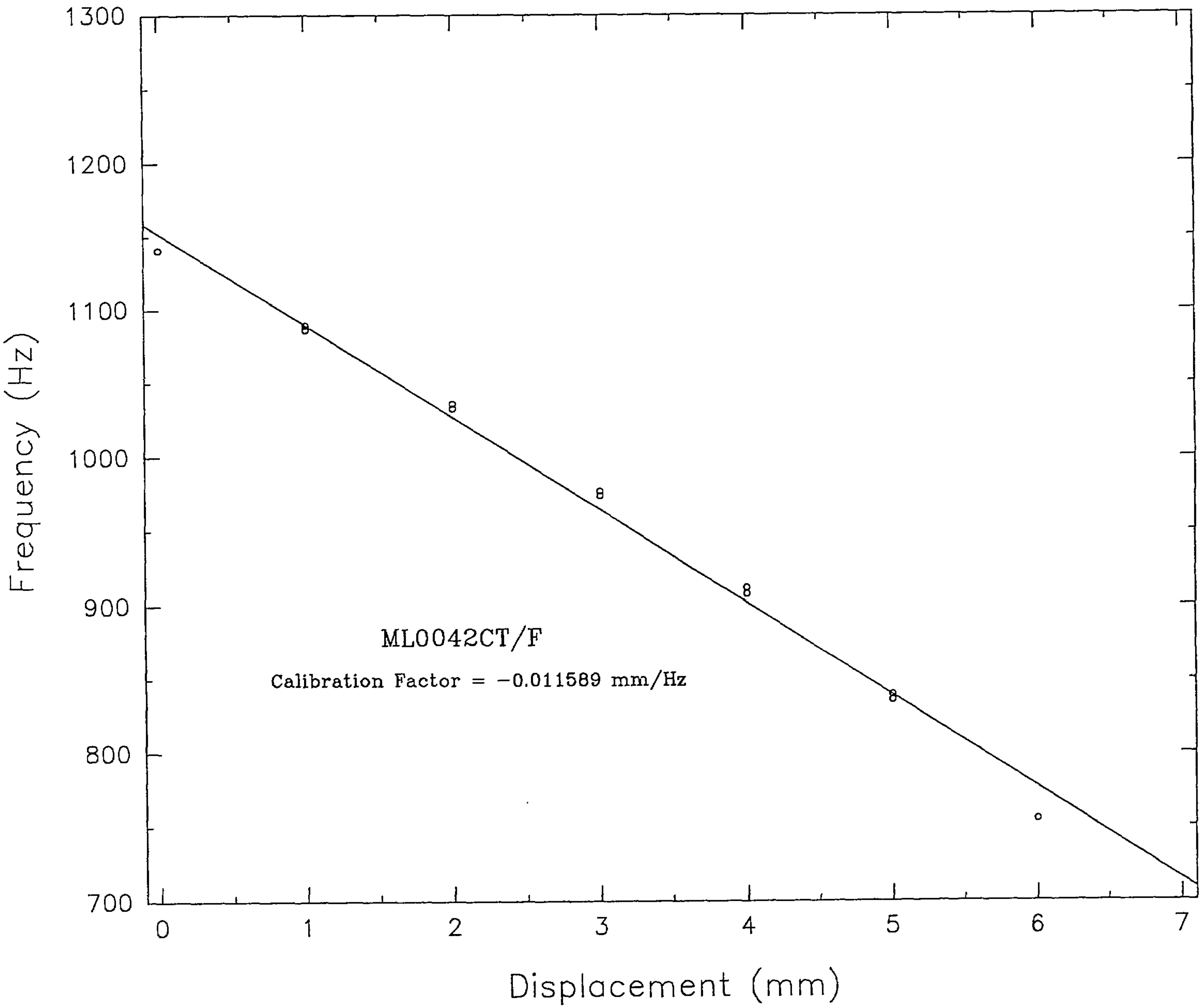

Calibration Of AXIAL Unit
HNA 0031
Cal Factor = 0.008447 mm/Hz (approx)
Frequency (Hz)
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
Displacement (mm)
−1
0
1
2
3
4
5
6
7
8
9
10

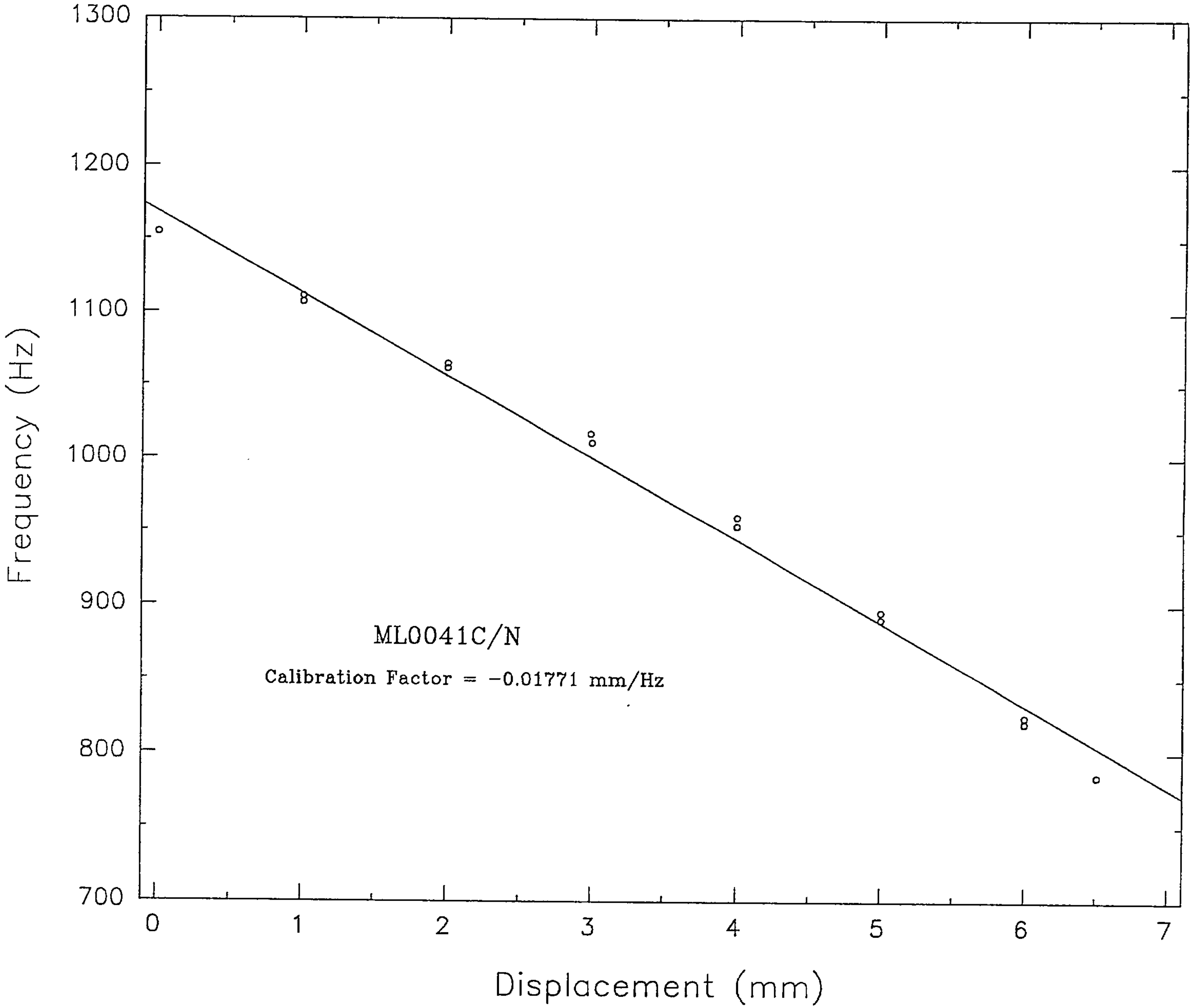
Calibration Charts for Hole 3.

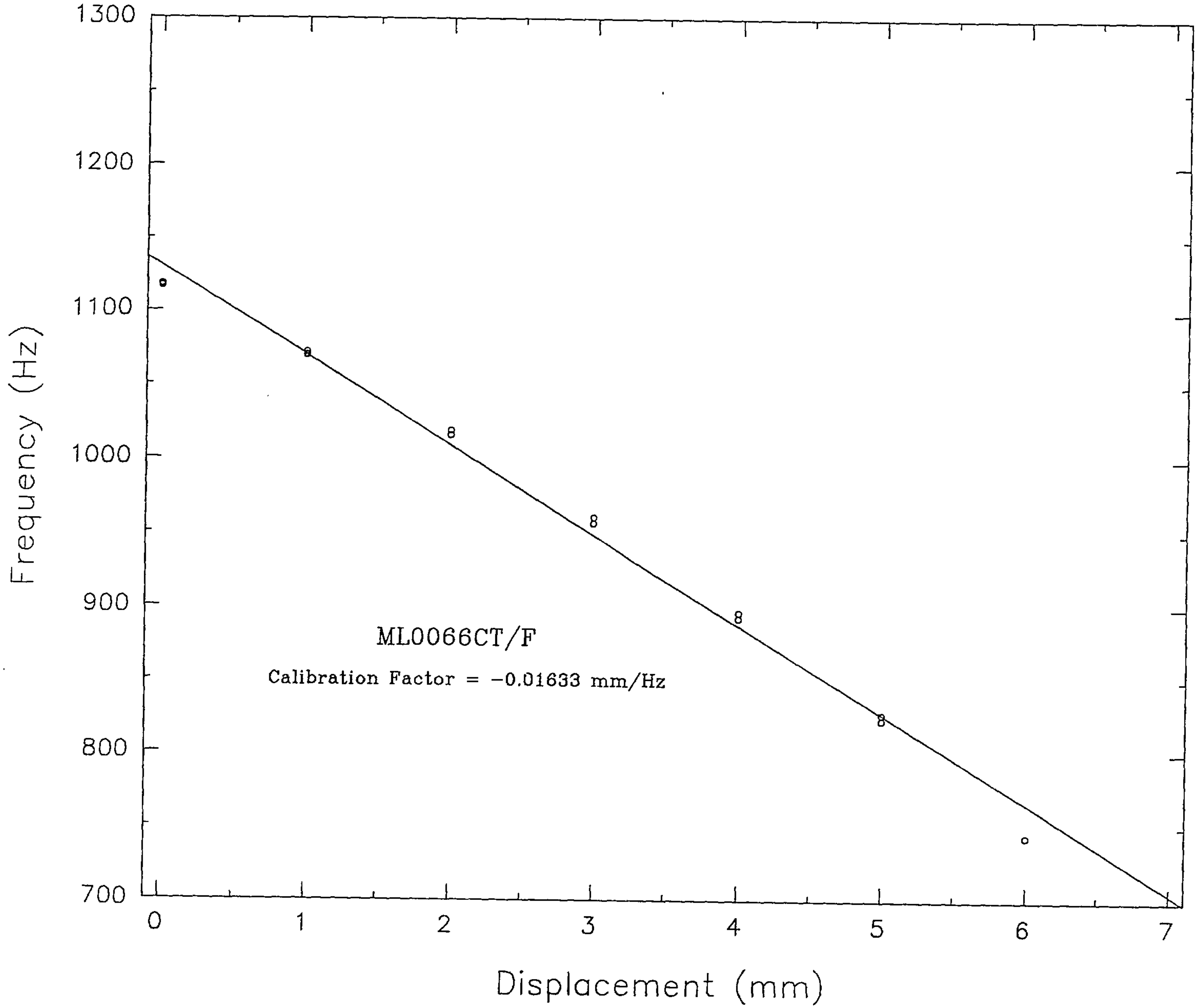

3000
2500
2000
1500
Frequency (Hz)
0.00
0.05
0.10
0.15
Displacement (mm)
HNMCT 0114
Calibration Factor = 0.000147 mm/Hz

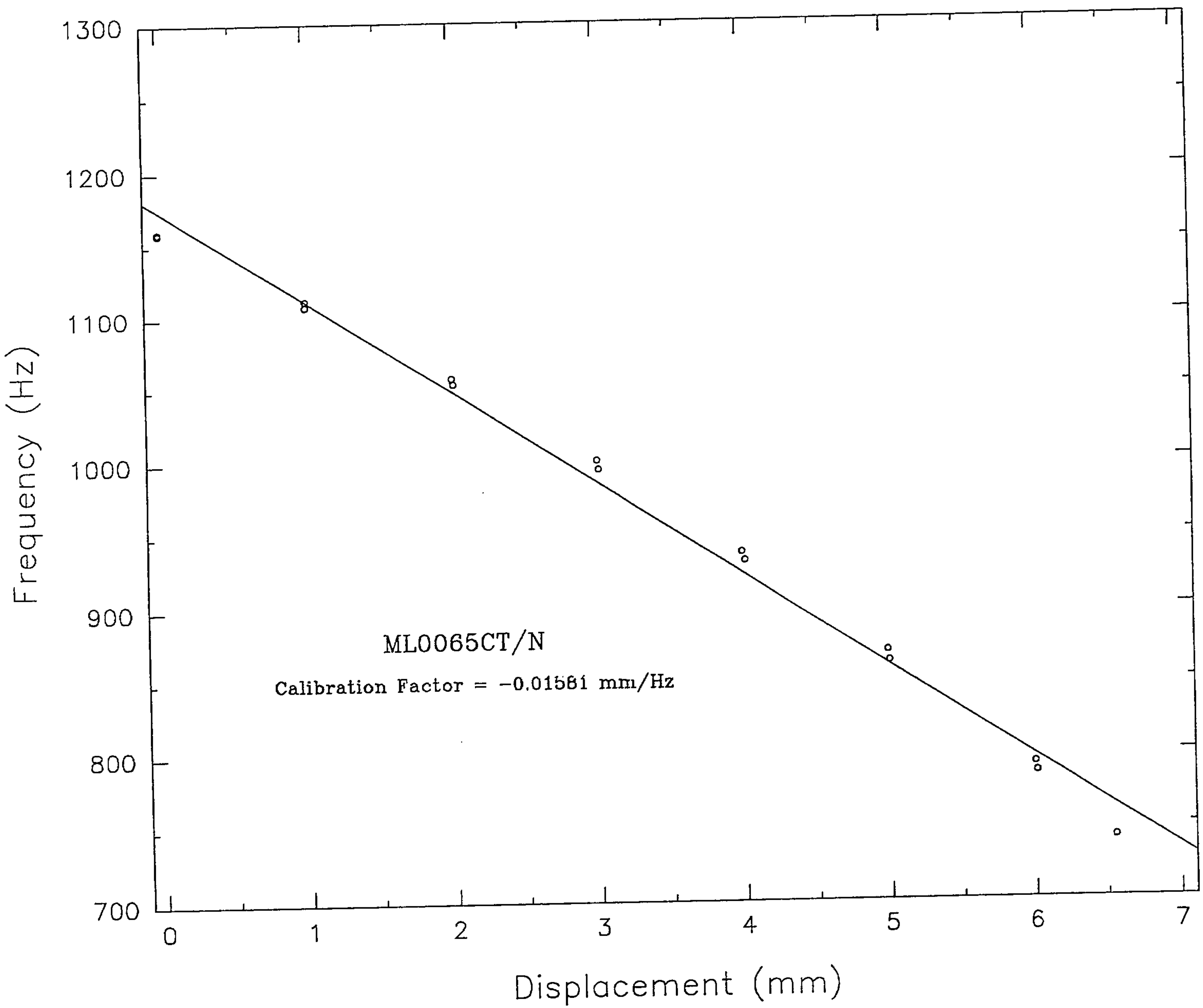

Calibration Of AXIAL Unit
HNA 0024
Cal Factor = 0.002968 mm/Hz (approx)
Frequency (Hz)
Displacement (mm)
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
−1
0
1
2
3
4
5
6
7


HNMCT 0137
Calibration Factor = 0.000204 mm/Hz
Frequency (Hz)
Displacement (mm)
3000
2500
2000
1500
0.00
0.05
0.10
0.15


1300
1200
1100
1000
900
800
700
Frequency (Hz)
0
1
2
3
4
5
6
7
Displacement (mm)
ML0042CT/F
Calibration Factor = −0.011589 mm/Hz

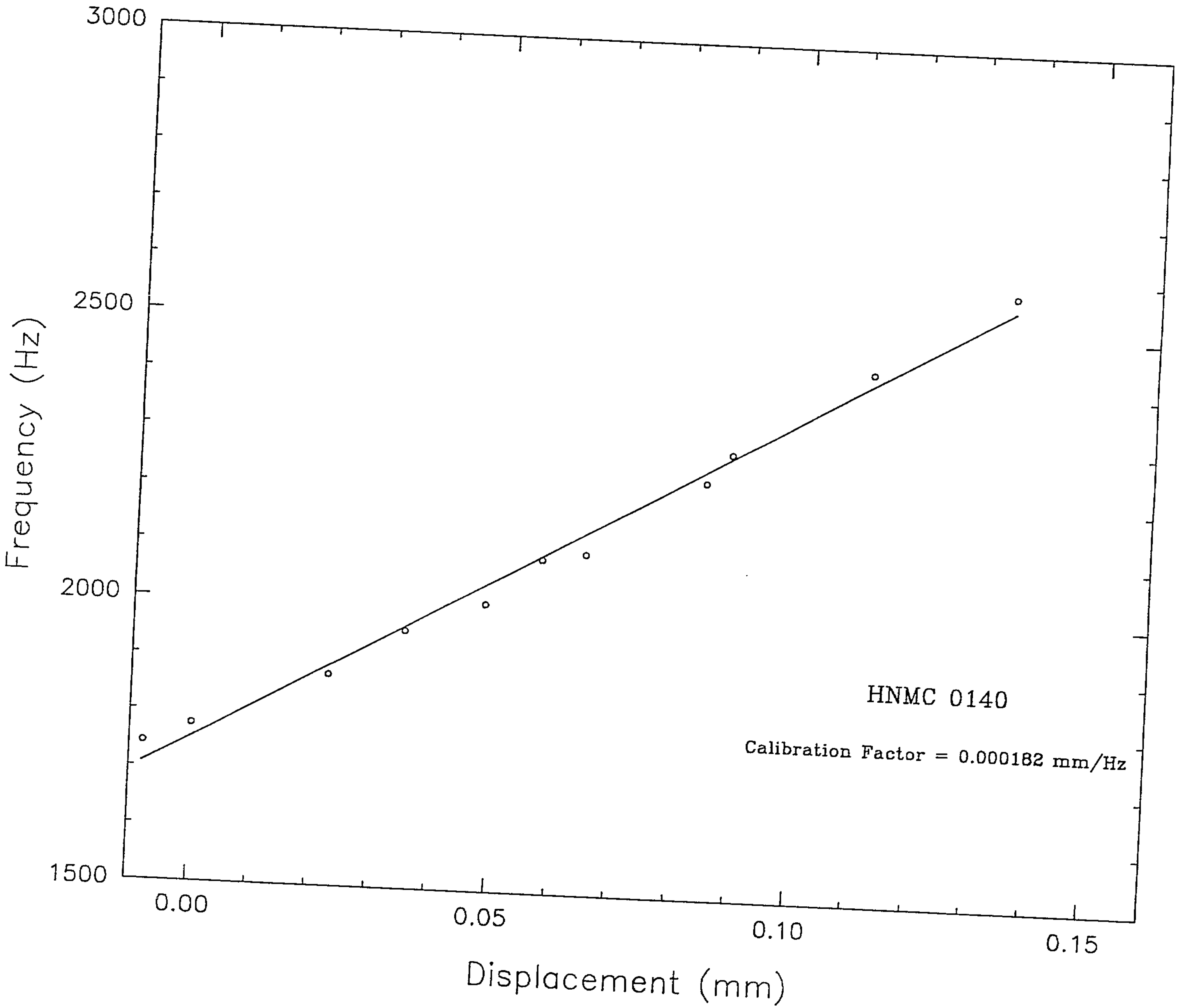

1300
1200
1100
1000
900
800
700
Frequency (Hz)
0
1
2
3
4
5
6
7
Displacement (mm)
ML0041C/N
Calibration Factor = -0.01771 mm/Hz

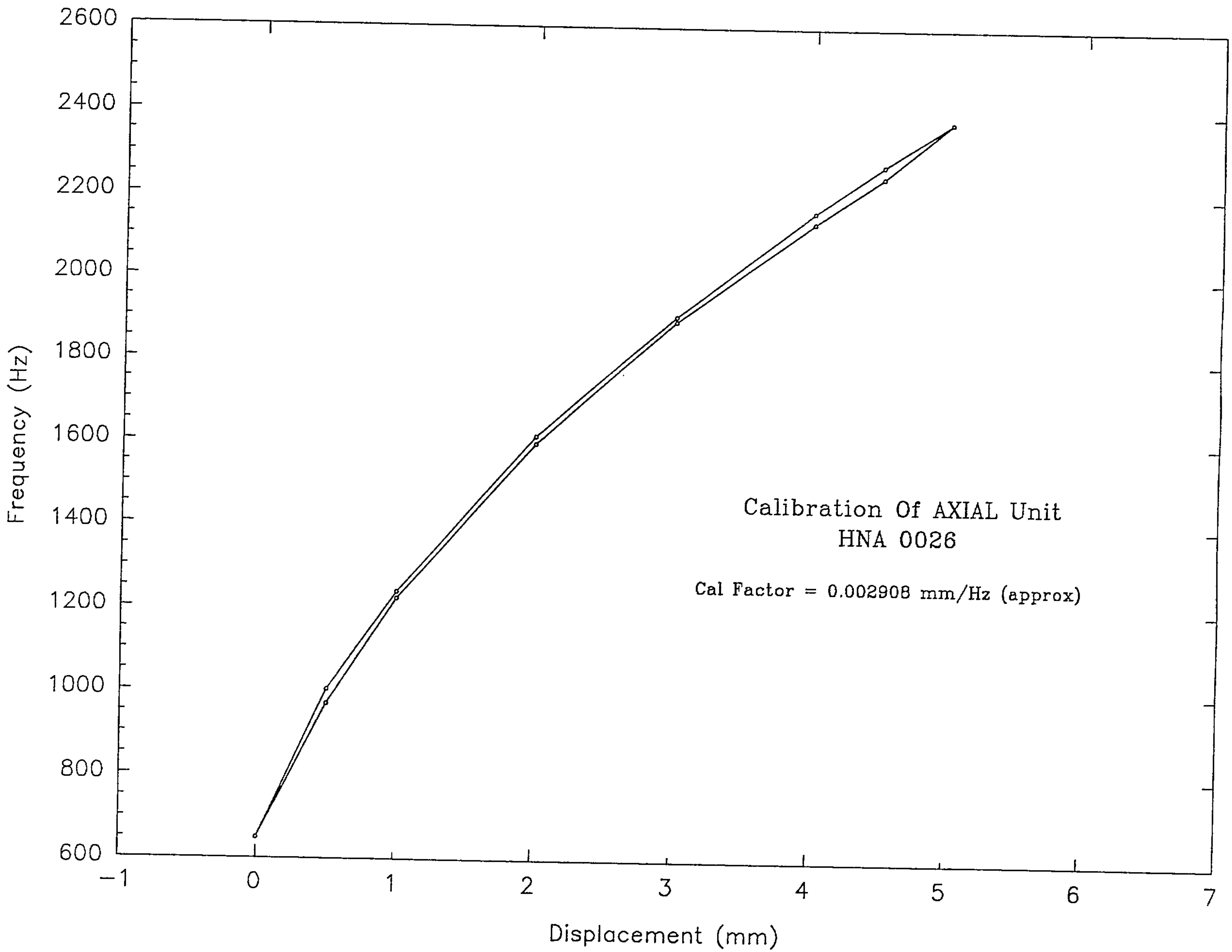

ML0066CT/F
Calibration Factor = -0.01633 mm/Hz
Frequency (Hz)
Displacement (mm)
1300
1200
1100
1000
900
800
700
0
1
2
3
4
5
6
7

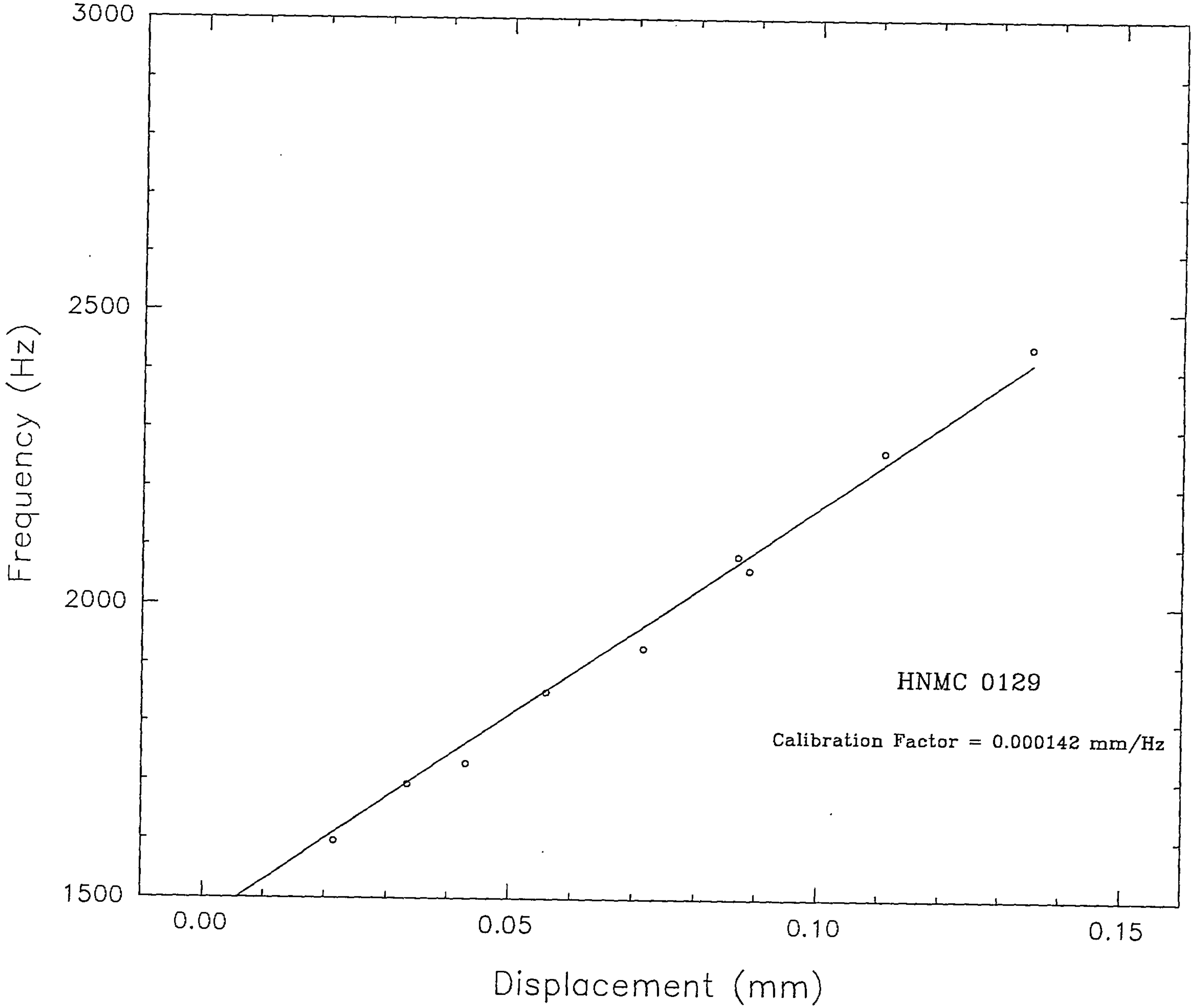


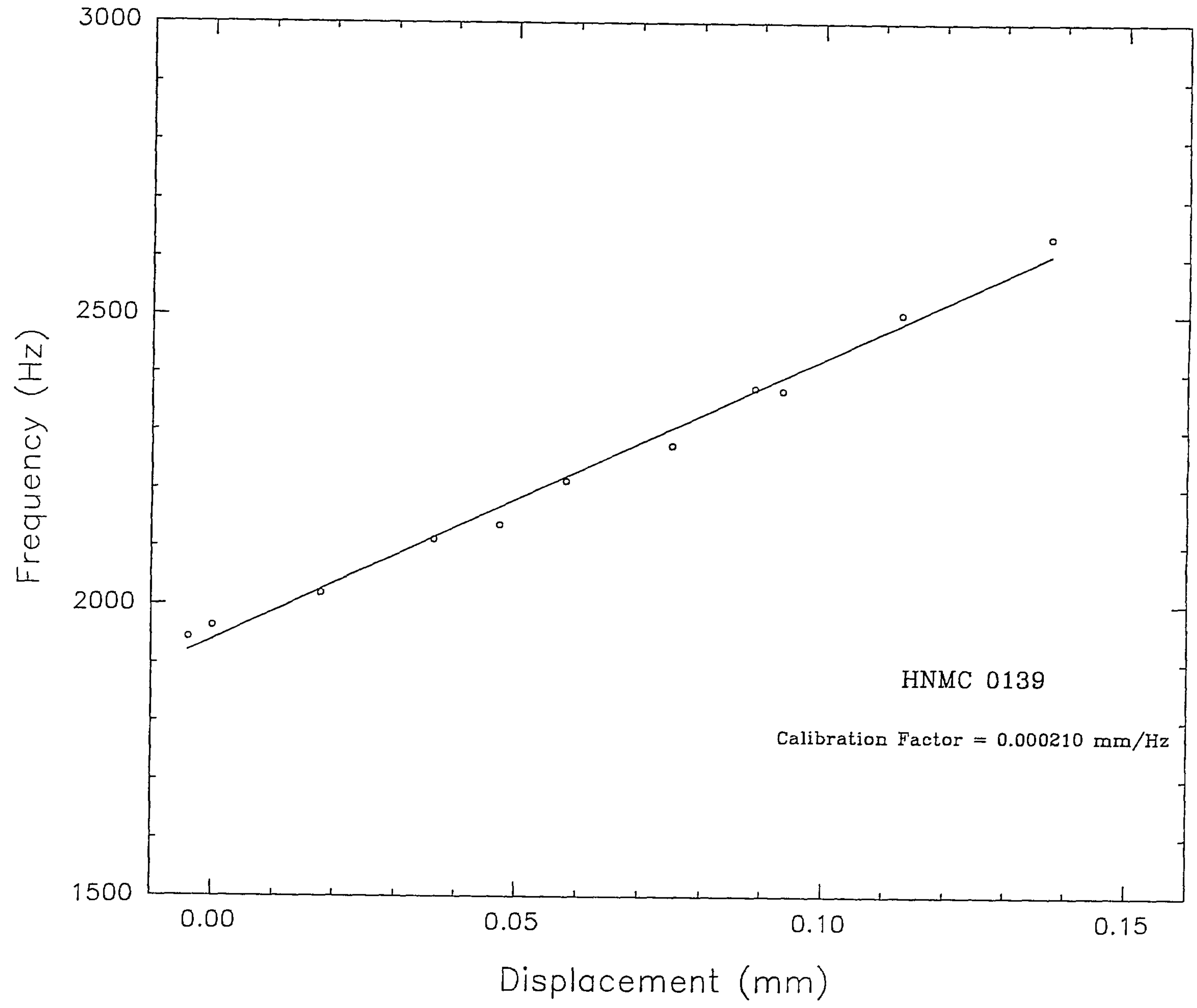
ML0065CT/N
Calibration Factor = -0.01581 mm/Hz
Frequency (Hz)
1300
1200
1100
1000
900
800
700
Displacement (mm)
0
1
2
3
4
5
6
7

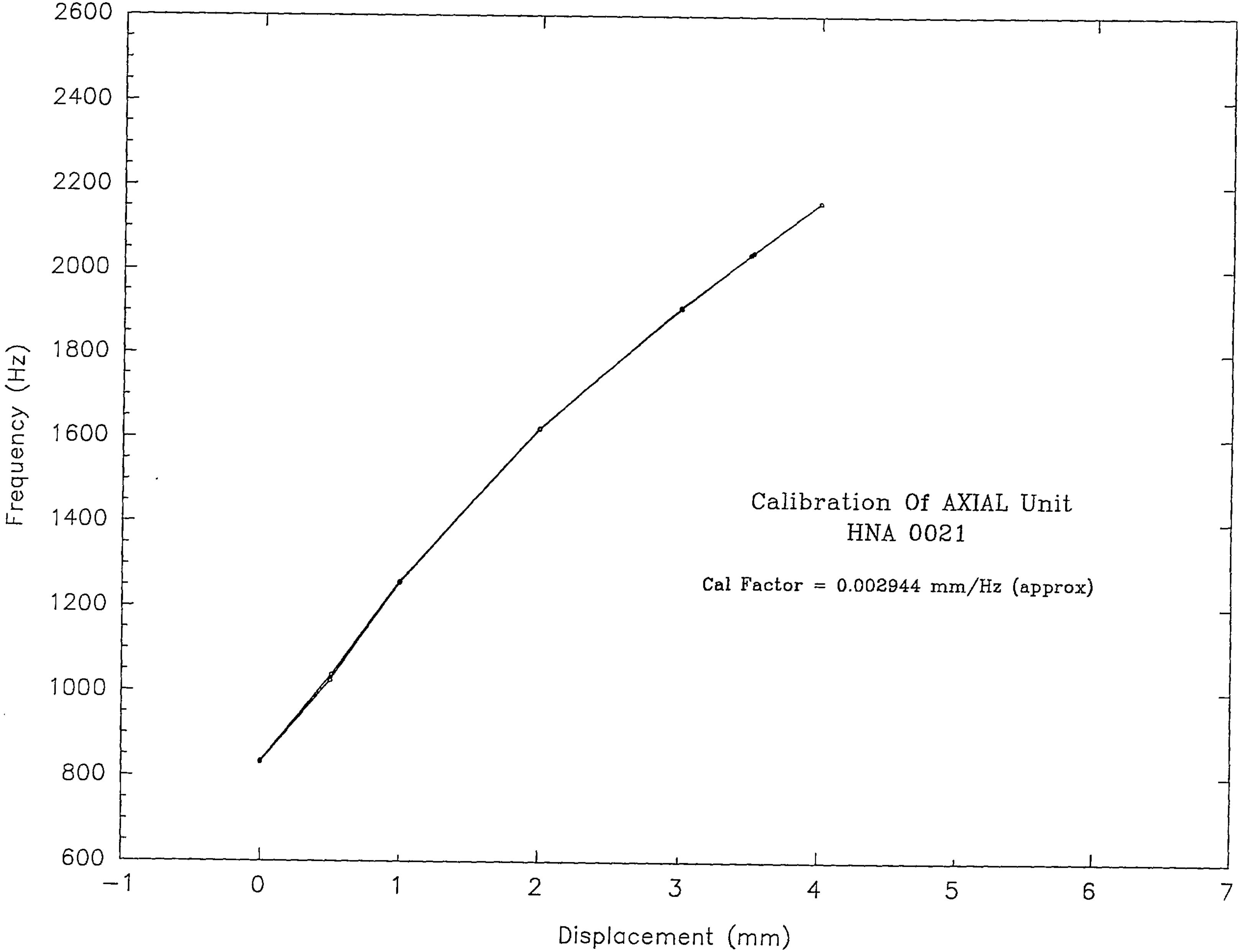
Calibration Charts for Hole 4.

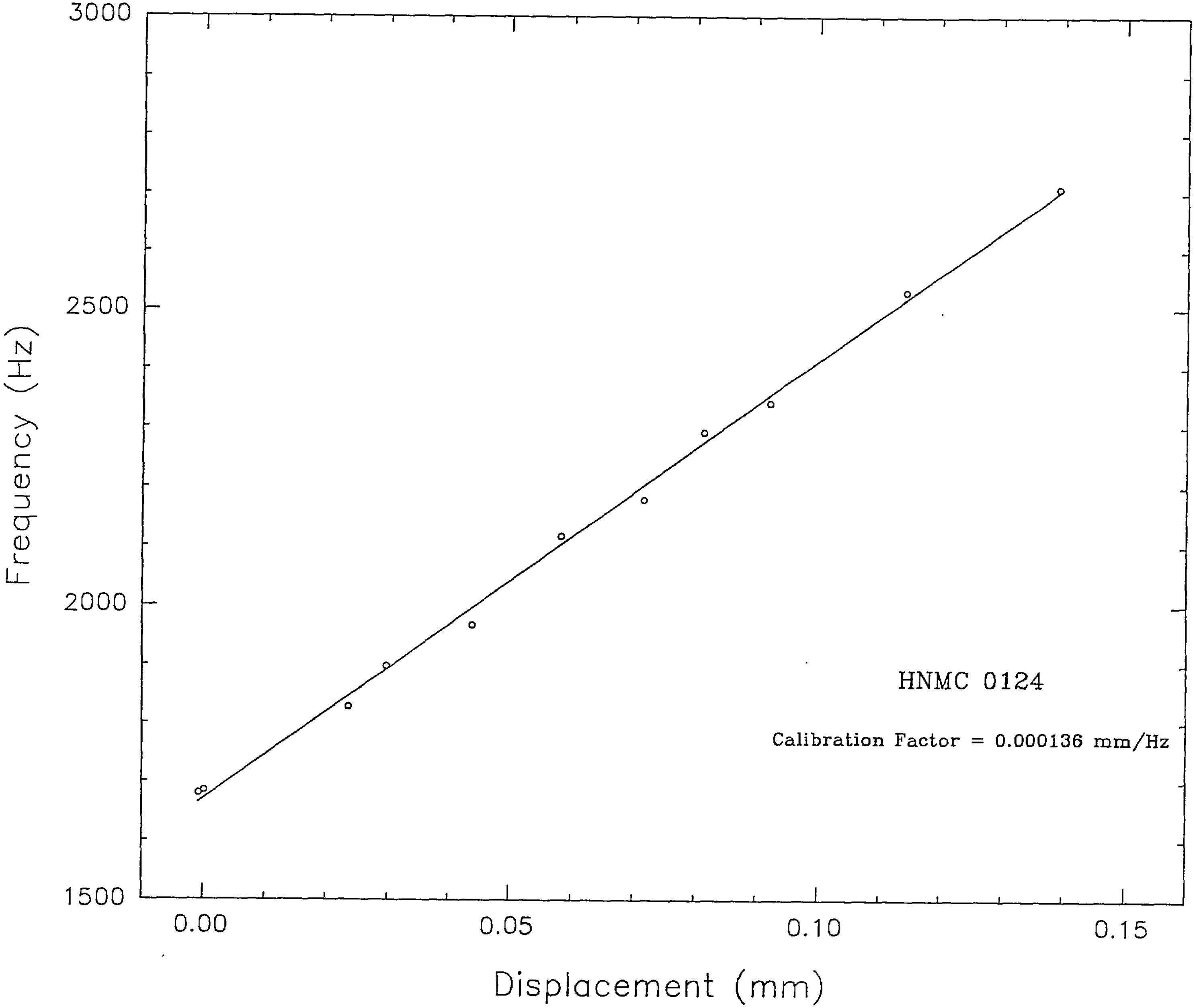

3000
2500
2000
1500
Frequency (Hz)
0.00
0.05
0.10
0.15
Displacement (mm)
HNMC 0140
Calibration Factor = 0.000182 mm/Hz

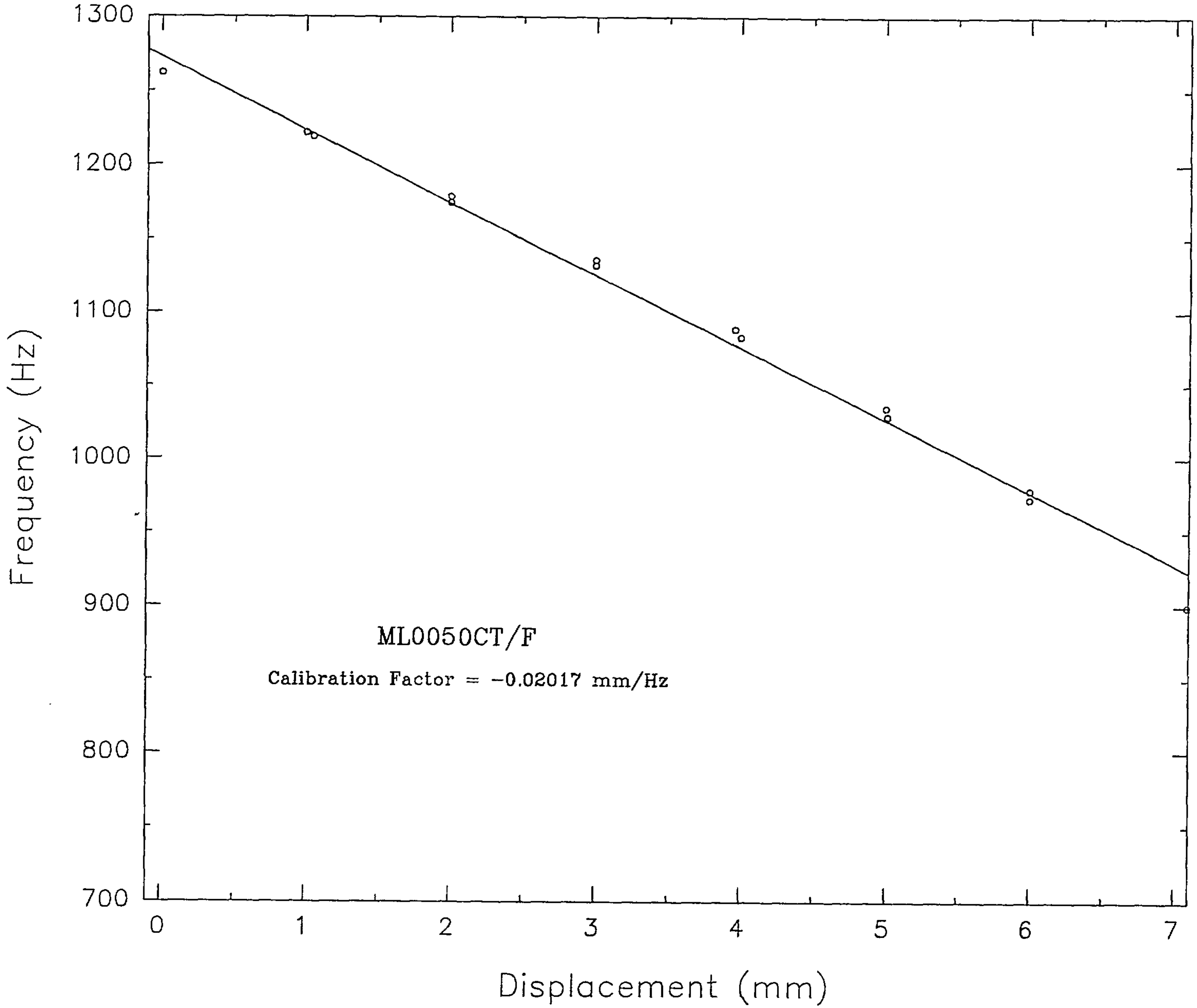

Calibration Of AXIAL Unit
HNA 0026
Cal Factor = 0.002908 mm/Hz (approx)
Frequency (Hz)
Displacement (mm)
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
−1
0
1
2
3
4
5
6
7

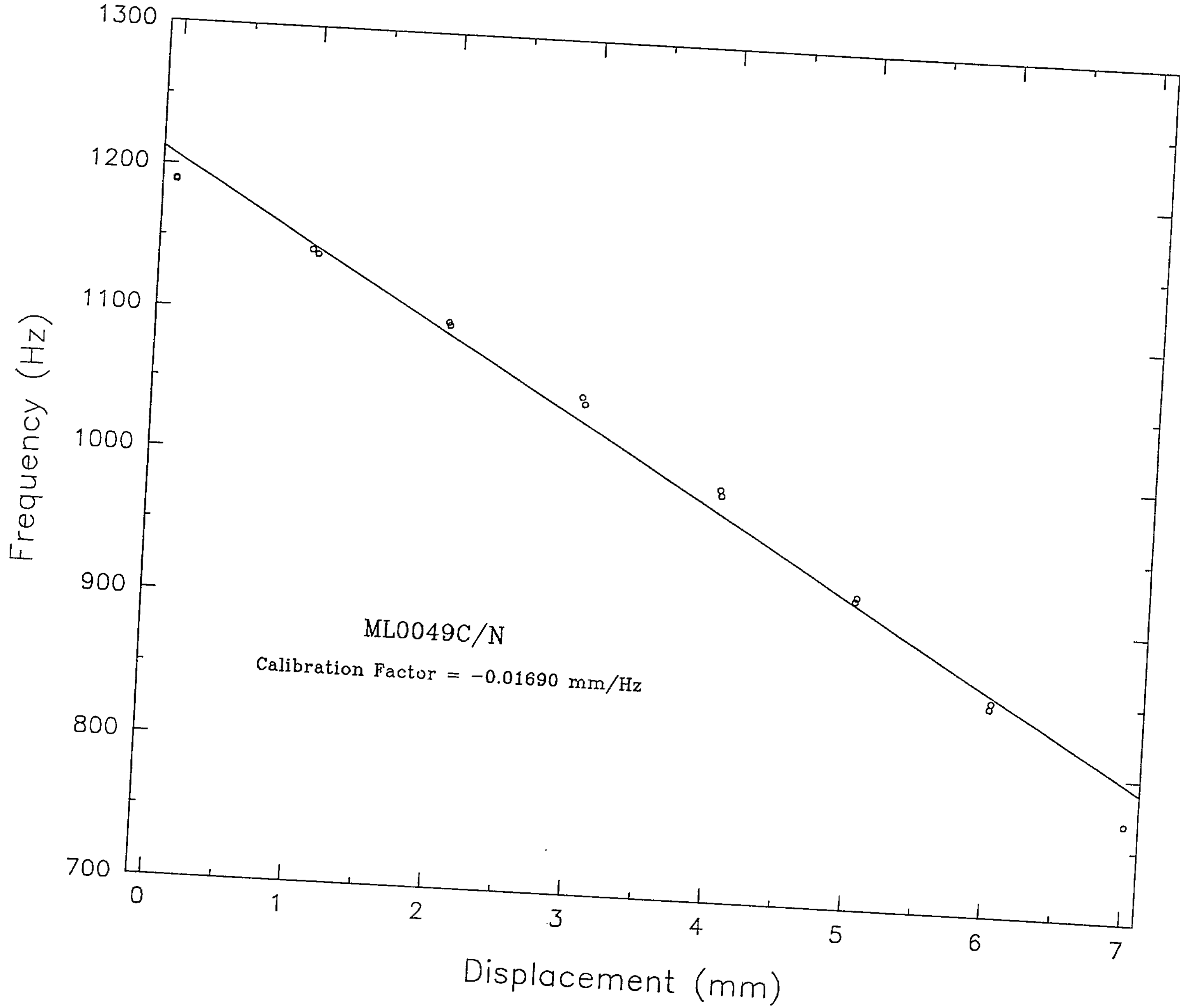

3000
2500
2000
1500
0.00
0.05
0.10
0.15
Frequency (Hz)
Displacement (mm)
HNMC 0129
Calibration Factor = 0.000142 mm/Hz

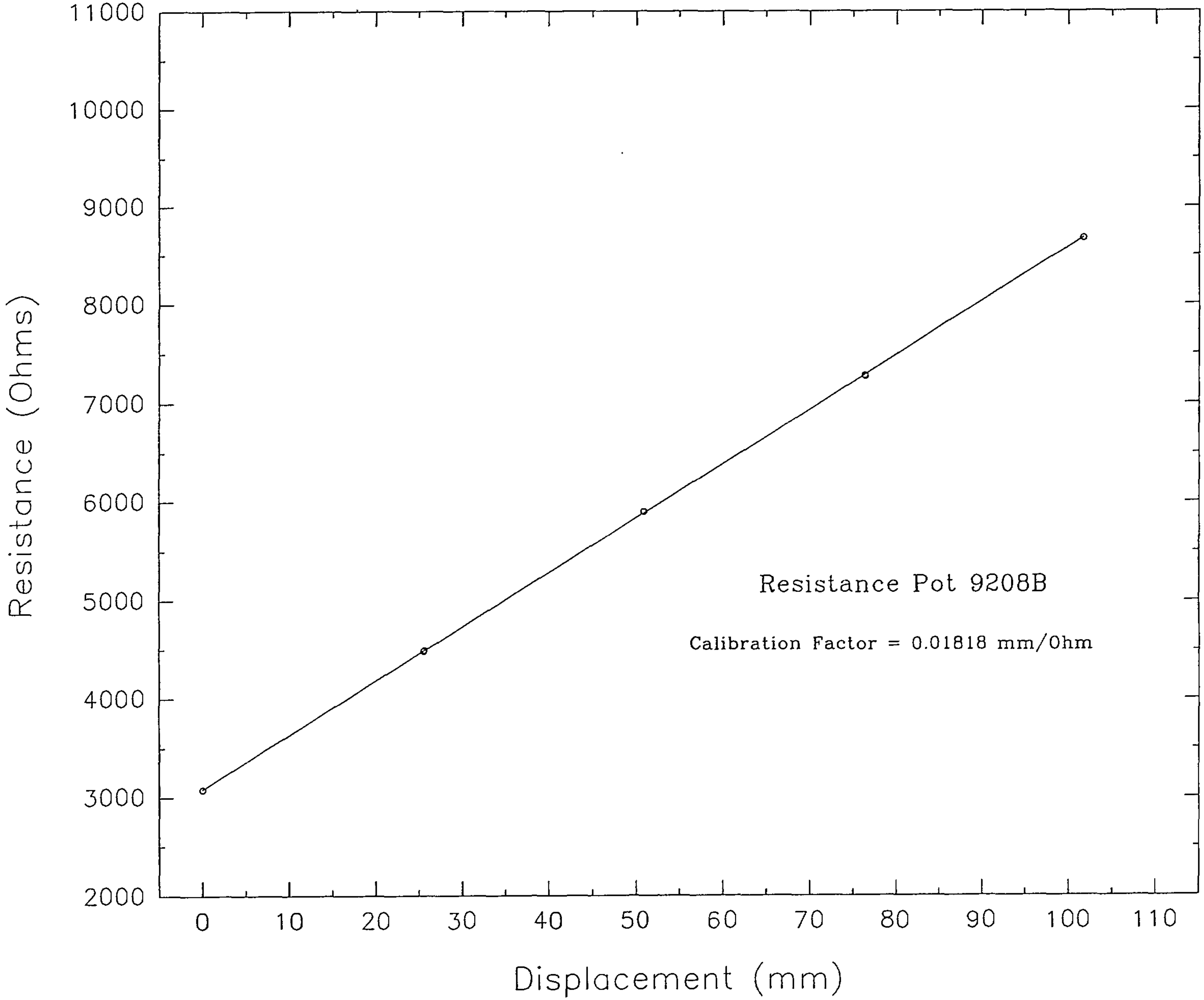

3000
2500
2000
1500
Frequency (Hz)
0.00
0.05
0.10
0.15
Displacement (mm)
HNMC 0139
Calibration Factor = 0.000210 mm/Hz


Calibration Of AXIAL Unit
HNA 0021
Cal Factor = 0.002944 mm/Hz (approx)
Frequency (Hz)
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
−1
0
1
2
3
4
5
6
7
Displacement (mm)

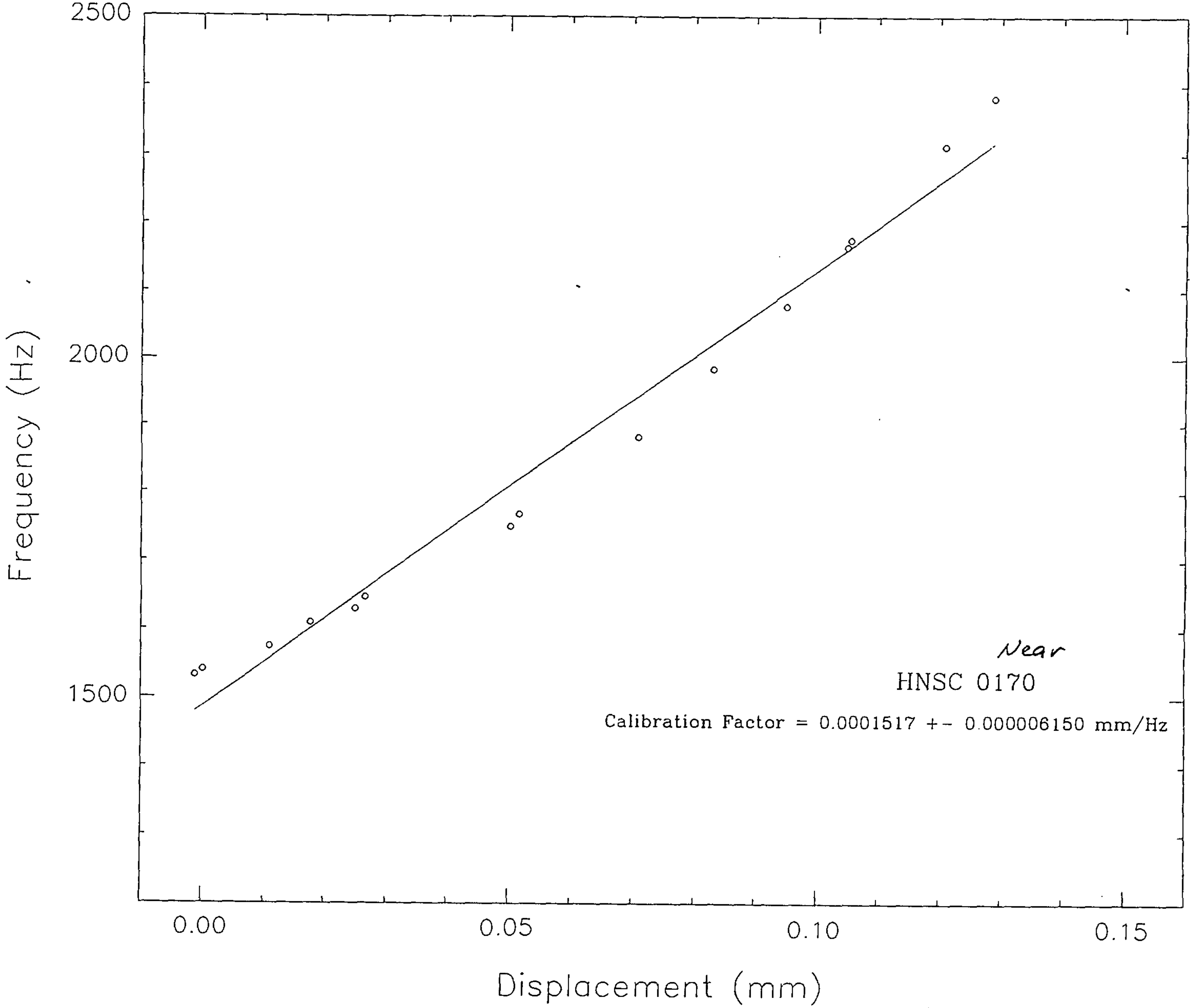

3000
2500
2000
1500
Frequency (Hz)
0.00
0.05
0.10
0.15
Displacement (mm)
HNMC 0124
Calibration Factor = 0.000136 mm/Hz

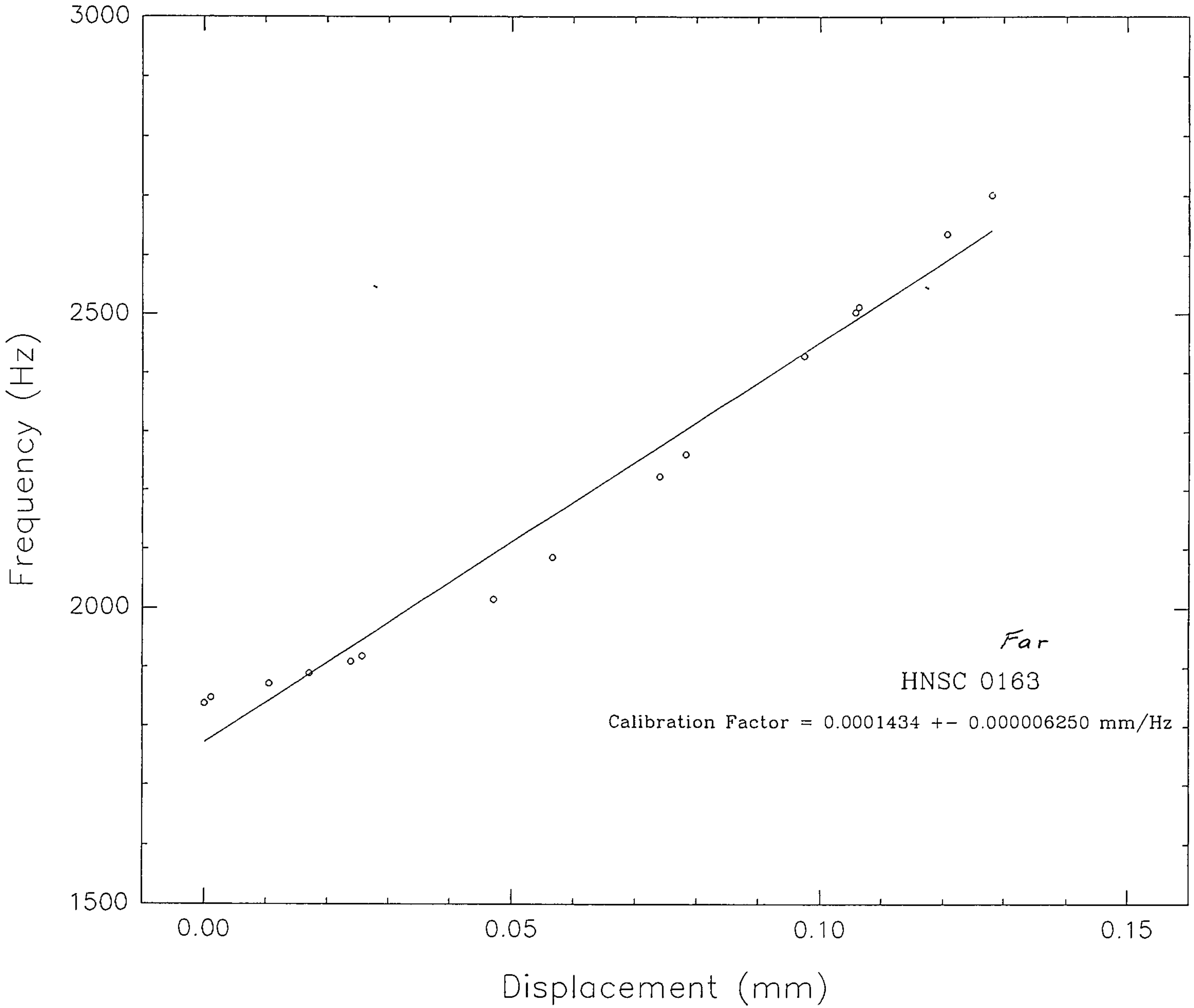

ML0050CT/F
Calibration Factor = -0.02017 mm/Hz
Frequency (Hz)
Displacement (mm)
1300
1200
1100
1000
900
800
700
0
1
2
3
4
5
6
7


ML0049C/N
Calibration Factor = -0.01690 mm/Hz
Frequency (Hz)
Displacement (mm)
1300
1200
1100
1000
900
800
700
0
1
2
3
4
5
6
7


Resistance (Ohms)
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
0
10
20
30
40
50
60
70
80
90
100
110
Displacement (mm)
Resistance Pot 9208B
Calibration Factor = 0.01818 mm/Ohm

Calibration Charts for Hole 5.


Frequency (Hz)
2500
2000
1500
Displacement (mm)
0.00
0.05
0.10
0.15
Near
HNSC 0170
Calibration Factor = 0.0001517 +- 0.000006150 mm/Hz


3000
2500
2000
1500
Frequency (Hz)
0.00
0.05
0.10
0.15
Displacement (mm)
Far
HNSC 0163
Calibration Factor = 0.0001434 +- 0.000006250 mm/Hz

APPENDIX C

Program SPLIT to separate CL800 logger data when multiplexers are used

Instrumentation For Ground Control

Split Utility Version 1.0, 1993

The Split Utility will manipulate an input file, which contains data collected on a logger, receiving from a ML-800 multiplexer. The input file contains data from 8 channels but is received as 4. The program will split the input file with 8 channels into two files containing data for 4 channels each.

Output file .ONE will contain data for channels 1 to 4 and output file .TWO will contain data for channels 5 to 8. Once the data has been split into the two files it can be better analyzed.

The program is called by typing SPLIT [datafile name] at the DOS prompt where [datafile name] is the name of the input file to be split (eg. SPLIT 3055.dat). The program will then do the proper file manipulates and store the two output files in the current directory (eg 3055.ONE and 3055.TWO).

The program will also do command line error checking to look for invalid input file names, invalid command lines (too many arguements), as well as checking if the user simply type SPLIT without a datafile name.

This information package contains the source code for the utility which was written in C language, as well as example input and output files for the program.

Split Utility Version 1.0
Source Code
Written In C Language

```
/* FUNCTION
/*              Split              This Program will split a file which
/*                                 contains data collected on a datalogger
/*                                 receiving from a ML-800 multiplexer.
/*                                 The Data will be split into two separate
/*                                 datafiles, each covering 4 separate channel
/*                                 from the multiplexor.
/* DESCRIPTION
/* main()
/*      IF command line has two arguements
/*              Open input file described in argv[1]
/*              IF input file is empty
/*                      Output error message "incorrect file"
/*                      Terminate program
/*              ENDIF
/*      ELSEIF command line has only one arguement
/*              Output error message "no data file input"
/*              Terminate program
/*      ENDIF
/*      Parse argv[1] 'xxxx.dat' into 'xxxx.one'
/*      Open output file 'xxxx.one' as outone
/*      Parse argv[1] 'xxxx.dat' into 'xxxx.two'
/*      Open output file 'xxxx.two' as outtwo
/*      FOR loop 19 times
/*              Get a line of text from input file
/*              Print line to outone
/*              Print line to outtwo
/*      ENDLOOP
/*      Set lineno to ODD
/*      WHILE not end of input file
/*              IF length of line is less than 20 (this is date line)
/*                      Print line to outone
/*                      Print line to outtwo
/*              ELSEIF lineno is ODD
/*                      Print line to outone
/*                      Set lineno to EVEN
/*              ELSEIF lineno is EVEN
/*                      Print line to outtwo
/*                      Set lineno to ODD
/*              ENDIF
/*              Get a line from input file
/*      ENDWHILE
/*      Close input file
/*      Close outone
/*      Close outtwo
/* ENDmain
/* PROTOTYPE
/*      main(int argc,char *argv[])
/* INPUTS
/*      argc and argv
/* OUTPU TS
/*      Two data files which are split of input file
/* HISTORY
/*      February 4, 1993           Instrumentation For Ground Control
/*                                 EMR/CANMET/MRL/CMTL
/*********************************************************************:
#include <stdio.h>
#include <ctype.h>

#define ODD  1
```

```
#define EVEN 2

main(argc, argv)
int argc;                   /* Number Of Arguments In Command Line */
char *argv[];               /* Command Line Arguments */
{
        int count,lineno;
        char line[80],*ptr1,*ptr2,temp1[80],temp2[80];
        FILE *infile,*outone,*outtwo;        /* File Descriptors */

        /**********************************************/
        /* Checking command line for proper arguements */
        /**********************************************/
        if (argc == 2)     /* If One Arguement In Command Line */
        {
                infile = fopen(argv[1],"r");
                if (infile == NULL)
                {
                        printf("ERROR : Illegal Filename %s\n",argv[1]);
                        exit(1);
                } /* ENDIF */
        }
        else if (argc == 1)     /* If No Arguements In Command Line */
        {
                printf("ERROR : No Data File In Command Line\n");
                exit(1);
        }
        else                    /* Improper number of arguements */
        {
                printf("ERROR : Illegal Number Of Arguements\n");
                exit(1);
        }

        /******************************************/
        /* Parser input file name for output files */
        /******************************************/
        strcpy(temp1,argv[1]);
        ptr1 = strchr(temp1,'.');
        strcpy(ptr1,".one");
        outone = fopen(temp1,"w");
        strcpy(temp2,argv[1]);
        ptr2 = strchr(temp2,'.');
        strcpy(ptr2,".two");
        outtwo = fopen(temp2,"w");

        /************************************************/
        /* Output program and file information to screen */
        /************************************************/
        printf("\n");
        printf("Split Utility, Version 1.0, 1993\n");
        printf("By Instrumentation For Ground Control\n");
        printf("Input File    : %s\n",argv[1]);
        printf("Output File 1 : %s\n",temp1);
        printf("Output File 2 : %s\n",temp2);

        /******************************************************/
        /* Get header from input file and write to output files */
        /******************************************************/
        for (count = 1; count <= 19; count++)
        {
```

```
                fgets(line,80,infile);
                fprintf(outone,"%s",line);
                fprintf(outtwo,"%s",line);
        } /* ENDFOR */

        /*************************************************************/
        /* Split up the input file data between the two output files */
        /*************************************************************/
        lineno = ODD;
        fgets(line,80,infile);
        while (!feof(infile))
        {
                if (strlen(line) < 20)
                {
                        fprintf(outone,"%s",line);
                        fprintf(outtwo,"%s",line);
                }
                else if (lineno == ODD)
                {
                        fprintf(outone,"%s",line);
                        lineno = EVEN;
                }
                else if (lineno == EVEN)
                {
                        fprintf(outtwo,"%s",line);
                        lineno = ODD;
                }
                fgets(line,80,infile);
        } /* ENDWHILE */

        /**********************************/
        /* Close up input and output files */
        /**********************************/
        fclose(infile);
        fclose(outone);
        fclose(outtwo);

} /* ENDmain */
```

Sample Input File
3055.DAT

```
RBR PL-800 1.0 003055
Host time       1993/01/01 10:11:19
Logger time       93/01/01 10:11:19
Logging start     93/01/01 14:00:00
Logging end       93/01/02 10:00:00
Sample period              00:30:00
Number of channels = 8, number of samples = 40, mode : 4
Calibration data from file 003055.cal :
Drawing 1328-801, created 12mar91 for logger PL-800.
D01%8.2f%8.2f%8.2f%8.2f%8.0f%8.0f%8.0f%8.0f
 1  2 7422.21 3851.21 7500 2 0 0 0 Degrees_C
 2  2 7422.21 3851.21 7500 2 0 0 0 Degrees_C
 3  2 7422.21 3851.21 7500 2 0 0 0 Degrees_C
 4  2 7422.21 3851.21 7500 2 0 0 0 Degrees_C
 5  1 0 1 0 0 0 0 0 Hz
 6  1 0 1 0 0 0 0 0 Hz
 7  1 0 1 0 0 0 0 0 Hz
 8  1 0 1 0 0 0 0 0 Hz
```

93/01/01 14:00:00

25.53	25.92	26.71	-95.98	1076	1118	1087	154
25.41	25.69	26.54	10.91	1079	1119	1125	700
25.34	25.53	26.44	26.61	1067	1122	1123	103
25.28	25.41	26.31	10.25	1087	1119	1123	706
25.25	25.34	26.28	26.15	1086	1119	1123	195
25.25	25.31	26.25	10.12	1083	1122	1126	698
25.37	25.34	26.28	26.15	1070	1119	1125	194
25.50	25.44	26.38	10.31	1088	1119	1123	701
25.66	25.66	26.61	26.64	1087	1122	1123	103
25.89	25.92	26.88	10.01	1075	1117	1123	699
26.05	26.15	27.08	27.11	1079	1117	1126	103
26.15	26.28	27.18	10.14	1069	1117	1123	702
26.25	26.35	27.25	27.11	1089	1117	1123	101
26.25	26.38	27.21	10.01	1084	1120	1127	702
26.21	26.31	27.14	26.88	1076	1117	1123	102
26.12	26.18	27.04	10.74	1076	1117	1123	703
25.95	26.05	26.91	26.54	1088	1118	1123	199
25.76	25.79	26.68	10.28	1084	1118	1123	705
25.53	25.57	26.41	26.05	1085	1119	1125	198
25.28	25.25	26.18	10.76	1067	1120	1122	698

93/01/02 00:00:00

24.99	24.93	25.89	25.47	1084	1123	1122	196
24.68	24.59	25.60	10.18	1067	1121	1122	697
24.34	24.24	25.28	24.87	1081	1122	1120	197
24.03	23.88	24.96	10.55	1068	1123	1123	694
23.69	23.54	24.62	24.24	1067	1123	1123	103
23.33	23.18	24.28	10.94	1073	1123	1120	696
23.00	22.85	23.97	23.63	1079	1127	1119	194
22.68	22.53	23.63	10.33	1081	1125	1119	696
22.35	22.21	23.33	23.03	1070	1126	1119	100
22.03	21.89	23.03	10.74	1081	1126	1122	689
21.75	21.57	22.74	22.44	1071	1127	1121	192
21.43	21.29	22.44	10.15	1074	1127	1118	696
21.18	21.01	22.18	21.92	1079	1127	1118	194
20.92	20.75	21.92	10.66	1075	1131	1121	692
20.70	20.50	21.66	21.43	1076	1131	1118	193
20.53	20.31	21.46	10.23	1072	1128	1118	692
20.39	20.14	21.29	21.06	1080	1129	1119	191
19.93	19.87	20.78	10.34	1082	1128	1117	687

19.71	19.73	20.61	20.09	1073	1129	1119	189
19.68	19.71	20.64	10.23	1077	1129	1119	690

Sample Output File One
3055.ONE

```
RBR PL-800 1.0 003055
Host time    1993/01/01 10:11:19
Logger time    93/01/01 10:11:19
Logging start 93/01/01 14:00:00
Logging end    93/01/02 10:00:00
Sample period           00:30:00
Number of channels = 8, number of samples = 40, mode : 4
Calibration data from file 003055.cal :
Drawing 1328-801, created 12mar91 for logger PL-800.
D01%8.2f%8.2f%8.2f%8.2f%8.0f%8.0f%8.0f%8.0f
 1  2 7422.21 3851.21 7500 2 0 0 0 Degrees_C
 2  2 7422.21 3851.21 7500 2 0 0 0 Degrees_C
 3  2 7422.21 3851.21 7500 2 0 0 0 Degrees_C
 4  2 7422.21 3851.21 7500 2 0 0 0 Degrees_C
 5  1 0 1 0 0 0 0 0 Hz
 6  1 0 1 0 0 0 0 0 Hz
 7  1 0 1 0 0 0 0 0 Hz
 8  1 0 1 0 0 0 0 0 Hz

93/01/01 14:00:00
   25.53   25.92   26.71  -95.98   1076   1118   1087   154
   25.34   25.53   26.44   26.61   1067   1122   1123   103
   25.25   25.34   26.28   26.15   1086   1119   1123   195
   25.37   25.34   26.28   26.15   1070   1119   1125   194
   25.66   25.66   26.61   26.64   1087   1122   1123   103
   26.05   26.15   27.08   27.11   1079   1117   1126   103
   26.25   26.35   27.25   27.11   1089   1117   1123   101
   26.21   26.31   27.14   26.88   1076   1117   1123   102
   25.95   26.05   26.91   26.54   1088   1118   1123   199
   25.53   25.57   26.41   26.05   1085   1119   1125   198

93/01/02 00:00:00
   24.99   24.93   25.89   25.47   1084   1123   1122   196
   24.34   24.24   25.28   24.87   1081   1122   1120   197
   23.69   23.54   24.62   24.24   1067   1123   1123   103
   23.00   22.85   23.97   23.63   1079   1127   1119   194
   22.35   22.21   23.33   23.03   1070   1126   1119   100
   21.75   21.57   22.74   22.44   1071   1127   1121   192
   21.18   21.01   22.18   21.92   1079   1127   1118   194
   20.70   20.50   21.66   21.43   1076   1131   1118   193
   20.39   20.14   21.29   21.06   1080   1129   1119   191
   19.71   19.73   20.61   20.09   1073   1129   1119   189
```

Sample Output File Two
3055.TWO

```
RBR PL-800 1.0 003055
Host time      1993/01/01 10:11:19
Logger time      93/01/01 10:11:19
Logging start  93/01/01 14:00:00
Logging end      93/01/02 10:00:00
Sample period             00:30:00
Number of channels = 8, number of samples = 40, mode : 4
Calibration data from file 003055.cal :
Drawing 1328-801, created 12mar91 for logger PL-800.
D01%8.2f%8.2f%8.2f%8.2f%8.0f%8.0f%8.0f%8.0f
 1  2 7422.21 3851.21 7500 2 0 0 0 Degrees_C
 2  2 7422.21 3851.21 7500 2 0 0 0 Degrees_C
 3  2 7422.21 3851.21 7500 2 0 0 0 Degrees_C
 4  2 7422.21 3851.21 7500 2 0 0 0 Degrees_C
 5  1 0 1 0 0 0 0 0 Hz
 6  1 0 1 0 0 0 0 0 Hz
 7  1 0 1 0 0 0 0 0 Hz
 8  1 0 1 0 0 0 0 0 Hz

93/01/01 14:00:00
   25.41   25.69   26.54   10.91    1079    1119    1125     700
   25.28   25.41   26.31   10.25    1087    1119    1123     706
   25.25   25.31   26.25   10.12    1083    1122    1126     698
   25.50   25.44   26.38   10.31    1088    1119    1123     701
   25.89   25.92   26.88   10.01    1075    1117    1123     699
   26.15   26.28   27.18   10.14    1069    1117    1123     702
   26.25   26.38   27.21   10.01    1084    1120    1127     702
   26.12   26.18   27.04   10.74    1076    1117    1123     703
   25.76   25.79   26.68   10.28    1084    1118    1123     705
   25.28   25.25   26.18   10.76    1067    1120    1122     698

93/01/02 00:00:00
   24.68   24.59   25.60   10.18    1067    1121    1122     697
   24.03   23.88   24.96   10.55    1068    1123    1123     694
   23.33   23.18   24.28   10.94    1073    1123    1120     696
   22.68   22.53   23.63   10.33    1081    1125    1119     696
   22.03   21.89   23.03   10.74    1081    1126    1122     689
   21.43   21.29   22.44   10.15    1074    1127    1118     696
   20.92   20.75   21.92   10.66    1075    1131    1121     692
   20.53   20.31   21.46   10.23    1072    1128    1118     692
   19.93   19.87   20.78   10.34    1082    1128    1117     687
   19.68   19.71   20.64   10.23    1077    1129    1119     690
```