Instrument design, manufacture and calibration for use in monitoring the field performance of jacked concrete pipes

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March 1992

Report No. OUEL 1919/92

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Summary

The design, manufacture and calibration phases of an extensive instrumentation system used to monitor the field performance of jacked concrete pipes are described. Principal design features including working drawings and supplier details are provided to enable replacement instruments to be purchased or manufactured. Calibration rigs and procedures are detailed and laboratory performance is assessed with the aid of quick reference tables of calibration coefficients, detailed individual plots and data regression analyses.

All of the instruments exhibit near linear and repeatable responses to excitation with no zero stability problems. The long term behaviour of the instruments is good with negligible changes in calibration coefficients and limited insitu damage substantiating the correct selection and design of the instruments for their intended purpose. The only instrument which performed poorly was the ground convergence indicator which was prone to jamming of the hinged fin. Redesign of the instrument is recommended prior to future use.

Recalibration of the instruments on a site by site basis is not strictly necessary, although routine calibrations are recommended for the pipe joint pressure cells which appear to be sensitive to damage sustained during removal.

The data acquisition system performed well throughout the field work. There is now sufficient information on jacking procedures to enable an automatic data acquisition strategy to be developed based on time interval, jacking load and pipe string movement. It is emphasised however that the presence of a dedicated research assistant remains a pre-requisite to successful fieldwork.

1. Introduction

1.1 Concrete Jacking Pipes - Stage II of the Oxford Research Project.

Pipe jacking is a technique for forming small diameter tunnels by progressively jacking a string of pipes through the ground from a thrust pit to a receiving pit. The method has advantages in many circumstances over other methods of tunnelling or the laying of pipes in trenches. However its wider use has been held back by a lack of understanding of many factors affecting the installation of such tunnels, and loss of confidence by some specifying authorities resulting from unexpected failures.

The need for research was recognised in the CIRIA report on the state of the art in pipejacking (Technical Note 112, 1983). Industry, represented by the Pipe Jacking Association, has been promoting research since then, and has had support from SERC and 5 water supply companies, Northumbrian, North West, Severn Trent and Yorkshire. Two three year programmes of research have been pursued at Oxford, stage 1 being laboratory based, while Stage 2 involves monitoring the performance of pipe jacks in the field. The overall purpose of the research programme is to improve understanding of the interaction between pipes and ground, and of the loading carried by the pipes, during the jacking phase when the pipes are most heavily loaded and liable to failure. The aim is to allow jacking loads in different ground conditions to be accurately assessed in advance, and pipes to be designed correctly to withstand the loading on them.

The current field work programme of research has involved instrumenting and monitoring, real pipe jack construction on five sites in various ground conditions. The intention has been to investigate interactions between pipes and the ground, the magnitude and distribution of loading across joints and through pipes, overall jacking loads, ground closure rates, and joint behaviour in relation to ground conditions and tunnel line and level.

The field instrumentation consists of three instrument clusters or monitoring stations as shown in Figure 1.1 Two stations are incorporated into specially prepared standard concrete pipes which can be inserted at any position in a pipe string while the third is positioned in the jacking pit. The lead instrumented pipe is only used in drives through cohesive material and is fitted with a ground convergence indicator which measures the rate of ground closure above the front end of the pipe string.

The main instrumented pipe is located further back in the pipe string and contains the following instruments:-

(i) Four contact stress cells, to measure both radial and shear total stresses on the surface of the pipe, with their active face flush with the surface of the pipe and provided with a similar surface finish;

(ii) Four pore pressure probes adjacent to the contact stress cells, measuring the local pore pressure and hence allowing determination of the effective radial stress;

(iii) Three joint movement indicators at each end of the pipe to measure the movements across the joint gaps;

(iv) Twelve pressure cells built into the packer in the joint at either end of the pipe to measure the magnitude and distribution of the loads transferred across the joints;

(v) Six tube extensometers equi-spaced around the pipe circumference to measure the overall longitudinal pipe compression.

(vi) A modular data acquisition system and purpose built "stable" power supply.

In the jacking pit the total jacking load is monitored continuously using two or four load cells positioned between the jack rams and the thrust ring, and the overall movement of the pipe string by a displacement transducer mounted above the tunnel entrance.

1.2 Scope of the Report

Full details of the design, construction and calibration of the instruments are presented. All instruments have been designed to operate successfully in the aggressive tunnel environment, have minimal effect on the property to be measured, be sufficiently accurate and simple to calibrate and disrupt normal site operations as little as possible.

The report has been split into two related parts.

<u>Part 1 Instrument Design, Manufacture and Calibration Procedures</u>

<u>Part 2 Instrument Calibrations and Performance Assessment.</u>

1.3 Acknowledgements

The instruments described in this report were developed as part of the Oxford Pipe Jacking Research project which is sponsored jointly by SERC, the PJA and five UK Water Service Companies, Northumbrian, North West, Severn Trent, Thames and Yorkshire. The author would particularly like to thank Dr George Milligan for his helpful support and advice during the instrument design phase; Mr Roy Smurthwaite and his technicians for their unstinting enthusiasm throughout the 2 year design, manufacture and refurbishment period; Mr Ron Morton for manufacturing the data acquisition hardware and his subsequent assistance in troubleshooting; Mr Chris Eggleton for assistance with the various calibrations undertaken and finally the large number of commercial organisations who have supplied equipment and instrumentation to the project and provided excellent after sales support.

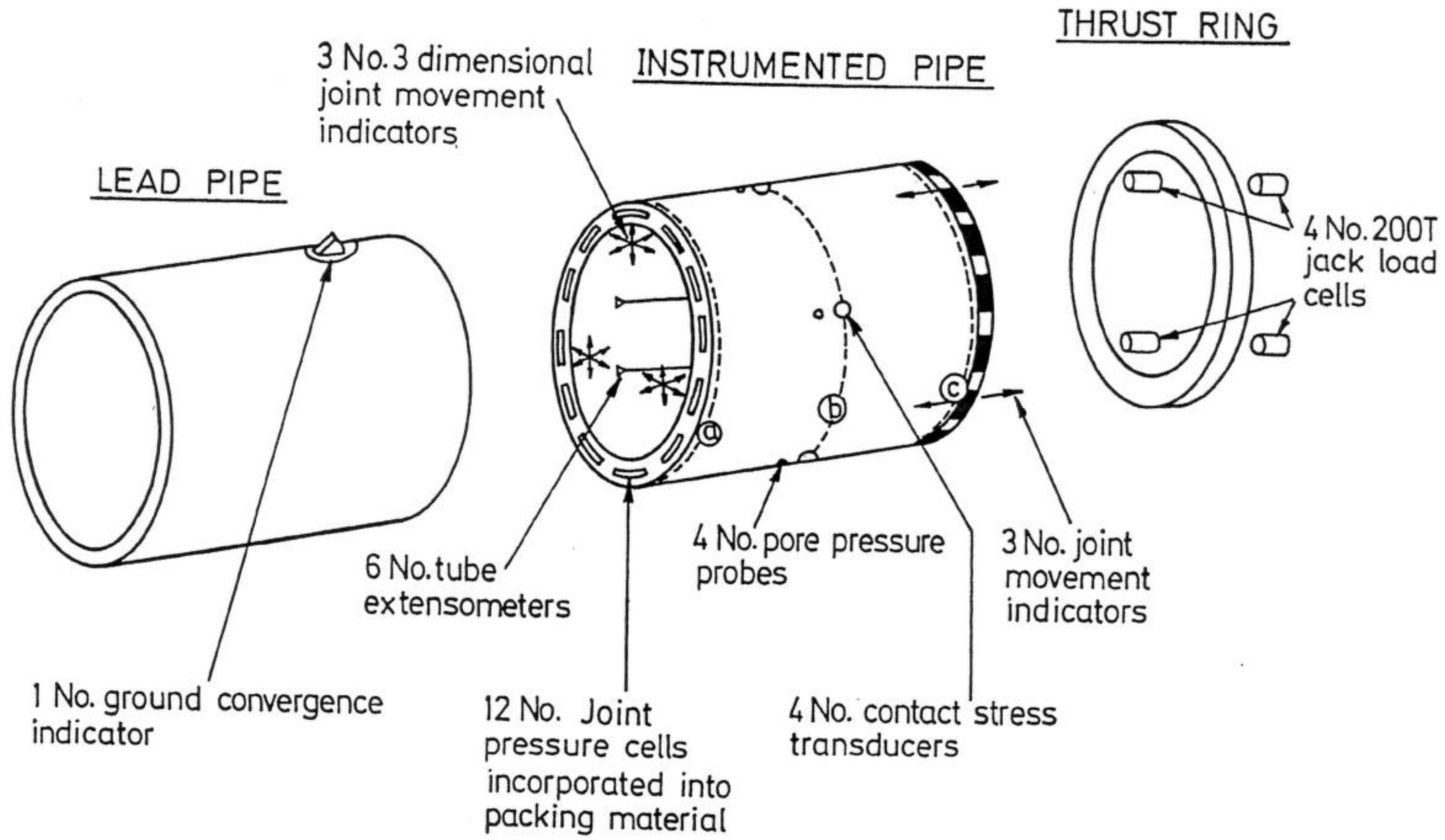


Figure 1.1 Schematic of Instrumentation System

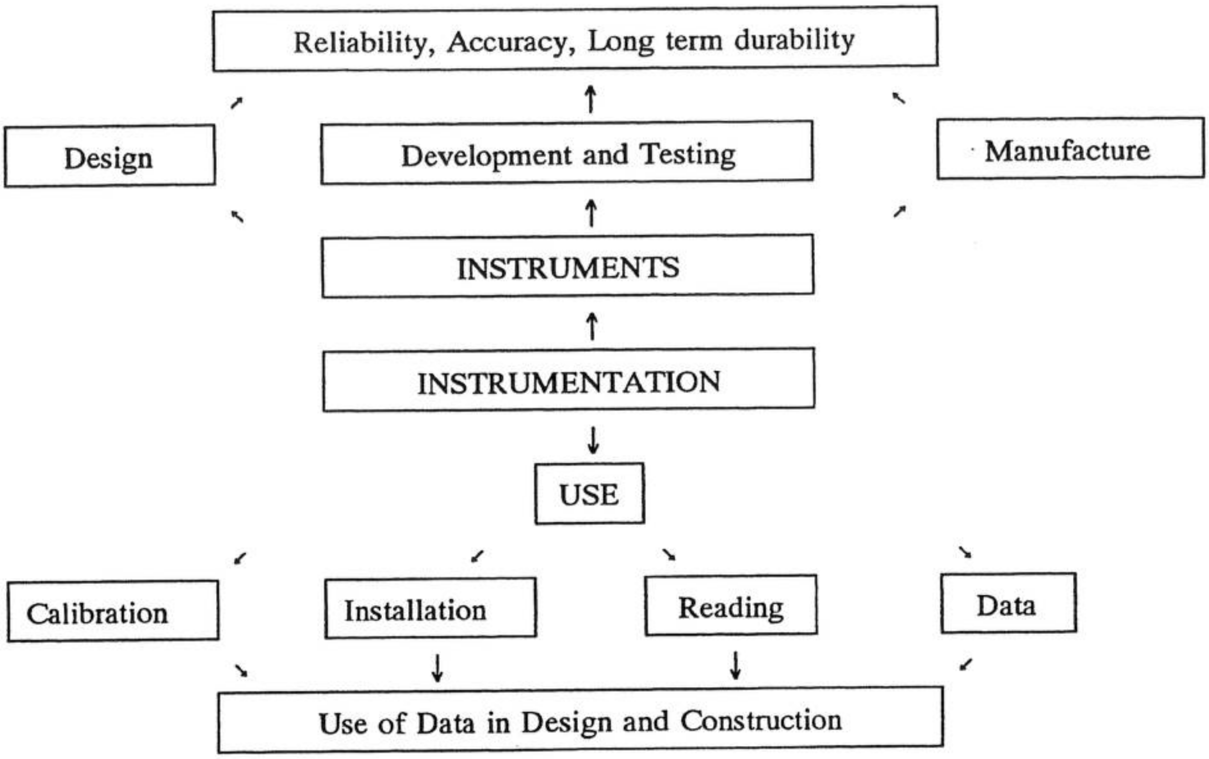
PART 1

INSTRUMENT DESIGN, MANUFACTURE AND CALIBRATION PROCEDURES

2 Instrument Design and Manufacture

2.1 General

There are many interrelated aspects of instrument design and use and these are shown in schematic form below.



It will be noted that instrumentation comprises two main aspects: the design, development testing and production of instruments, and the use of those instruments in the procurement of field data. Thus aspects such as quality, accuracy and overall reliability have to be considered in detail if the data produced is to provide the end user with confidence in its use. The main instrument characteristics required for the pipejacking research include:

* Easy installation into the pipes prior to incorporation into the permanent works, and subsequent removal, thus minimising delays to the tunnelling programme.

* Reliability and robustness in the tunnel environment.

* Designed for required accuracy and simple to calibrate.

* Minimal modification to the structural performance of the pipe and the soil-pipe interaction.

* Readings taken remotely from the location of the instruments.

All of the above characteristics have featured prominently in the evolution of the instrumentation scheme. An inventory of the equipment and costs at 1991 prices are presented below.

Item Description	Number	Replacement cost at 1991 prices (£) (excluding VAT)	Total Cost at 1991 prices (£) (excluding VAT)
1. Contact Stress Cells a) Housing b) Cambridge transducer	 5 8	 1500 900	 7500 7200
2. Pore Pressure Probe (including Druck PDCR81)	5	750	3750
3. Pipe Joint Pressure Cells	34	550	18,700
4. Tube Extensometers (including LVDT's)	6	850	5100
5. Pipe Joint Movement Indicators (including LVDTs) a) single dimension model b) three dimensional model	 3 3	 400 850	 1200 2550
6. Jack Load Cells (including caps)	4	1700	6800
7. Celesco Units a) 0-100" b) 0-150"	1 1	300 400	300 400
8. Ground Convergence Indicator	1	1500	1500
9. Data logger equipment including purpose built stable power supply steel enclosures and female connectors.	9	1200 (av)	10,800
10. P.C's a) 386 OPUS model b) 286 NESS model	1 1	1400 850	1400 850
11. Cabling a) flexible power b) rigid power c) signal	300 m 50 m 400 m	200 25 80	200 25 80
12. Male connectors/power supply plugs & sockets	ITEM	1500	1500
13. Instrument container	1	3200	3200
		TOTAL	£73,055

EQUIPMENT INVENTORY

2.2 Design and Manufacture

2.2.1 Contact stress cells

Full details of the contact stress cells are given in design drawings PN/PJR/01 and PN/PJR/02 and Plates 2.1 and 2.2.

The principal design features are noted below:

1. All of the main components are made from stainless steel, grade 316 save for the earth pressure cells (made from aluminium alloy 2014A)

2. The surface of the contact stress cell housing and inner surface of the cap is a good quality surface free of machining marks. The absence of machining marks is important if the pressure cell is to bed down properly.

3. The window pane and the window frame are joined together in a hot bonding process that injects pressurised rubber between their adjoining edges. The two components are held in the correct position relative to one another by an aluminium moulding jig, which is detailed in design drawing PN/PJR/03.

4. The Cambridge earth pressure cells are made on a CNC milling machine. Each cell is wired-up with three independent strain-gauge circuits, two to sense the radial stress and the other to sense the shear stress. A major advantage of the chosen wiring arrangement is that , should one of the compression circuits be lost, the value of the radial stress can still be estimated from the readings of the other circuit. This work was subcontracted to Cambridge Insitu. Further information and helpful advice on the design of Cambridge earth pressure cells is given by Bransby (1972).

5. The frictional characteristics of the active face of the cell should be similar to the outer surface of the concrete pipe. A series of interface shear box tests using Leighton Buzzard 14/25 sand and various construction materials indicated that a ground polymodified mortar finish was the most suitable, Figure 2.1. The mortar discs are cast using the mould detailed in design drawing PN/PJR/04. The discs are cured for 3 days under a polythene tent before being released from the mould and stored for later use.

6. Profiling of the caps to suit pipe external diameters is carried out using a CNC machine. To prevent movement of the active face during profiling a dummy earth pressure cell is used in the assembled cell, design drawing PN/PJR/05. Care has to be taken to ensure that coolant used during the cutting process does not contaminate the mortar disk. This can be overcome by adopting a 2 stage cutting process. The rubber bonded cap is "rough cut" using coolant, to remove the bulk of the material. The mortar disk is then glued into place using Araldite two part adhesive. The adhesive is heated using a hot air gun so that it can flow around the disk when inserted into the recess thus providing uniform contact. The final cut is carried out after 24 hours, avoiding the use of coolant.

7. Each cell is packed with a bag of silica gel to absorb moisture trapped at the time of assembly and any subsequent small leakage. The strain gauges are coated with M-Coat D as supplied by Welwyn Strain Measurement.

8. The Cambridge earth pressure cell and cap are bolted to each other and the main housing using M5 stainless steel cap screws. All screws are tightened using a torque wrench to a maximum torque of 9 Nm.

9. Water is kept from entering the cell by four main seals. The cap frame is sealed against the main housing by a rubber "O" ring which fits into the groove in the frame. The gap between the active face and frame is filled with hot-bonded rubber, as mentioned above. The cable entry point in the base of the housing is sealed using a cable gland, while finally the bolts which connect the active face to the pressure cell are sealed by annealed copper washers. A small plug of silicant sealant and a threaded cap with screw driver slot completed the sealing of the threaded holes U-U in design drawing PN/PJR/01.

2.2.2. Pore pressure probe

Full details of the pore pressure probes are given in design drawings PN/PJR/07,08 and 09. The design has been adapted from work by Bond (1989) who reported its successful operation over a one week period during field trials in London Clay.

The probe is illustrated in an exploded view in Plate 2.3.

At the heart of the pore pressure probe is a Druck PDCR81 pressure transducer. It is a very sensitive instrument, giving a full-scale output of $\sim$ 15mV/V. The transducer is supplied with its ceramic filter removed and is glued into the titanium holder using araldite two part epoxy resin, care being taken to ensure that it does not protrude from its recess in the holder.

The mounting block and thrust ring are made from acetal copolymer, a stable engineering plastic. The mounting block carries a sintered stainless steel porous filter in its front face which is fixed in place by expanding the block in an oven to 80°C, pressing the filter into place and allowing the block to cool.

On assembling the probe, the holder is clamped into position by the thrust ring which screws into the back of the mounting block. An O-ring seals the holder against the mounting block. Because the pressure sensing diaphragm of the transducer is set back from the front edge of its casing (to accommodate the optional ceramic filter) there is a small cavity ($\sim$ 180mm^3) between the diaphragm and the back of the probes porous filter.

2.2.3 Pipe joint pressure cell

The pressure cell used in the pipejack joint is a commercially available instrument. Generally it is connected to a hydraulic or pneumatic transducer to form a closed system. To take a reading air, nitrogen or a liquid is supplied from the readout unit to one side of a flexible diaphragm in the transducer. When this supply balances the pressure of the fluid in the cell, the valve opens and allows flow along a return line to a detector in a readout unit. This arrangement is somewhat cumbersome and slow for the intended application, and so a UK supplier was sought who could connect the pressure pad directly to a strain gauged diagram pressure transducer. At the time of enquiry no UK suppliers stocked such a unit. It was therefore necessary to purchase a suitable pressure transducer with a bleed nipple to assist in the de-airing and oil injection process and supply it to the pressure pad manufacturer. The resulting cell is detailed in drawing PN/PJR/11 and illustrated in Plate 2.4. Unusual features for the purpose of the research include a 5 mm diameter handle to assist in extracting the cell from the pipe joint once the monitoring period is finished and a limited number of cells fitted with a 45 x 8 x 6mm metal strip containing a central 4mm diameter through hole to accommodate a platinum resistance temperature probe.

2.2.4 Tube extensometers

Full details of the tube extensometer design are given in design drawing PN/PJR/12. An assembled instrument is shown in Plates 2.5 and 2.6.

2.2.5 Joint movement indicators

Two versions of the joint movement indicator are detailed in design drawings PN/PJR/13 and 14 and Plates 2.7 and 2.8. They essentially comprise of machined aluminium blocks geometrically shaped to hold either single or sets of three displacement transducers in orthogonal directions. The single transducer assembly is used across the leading joint of the instrument pipe and the three dimensional arrangement used across the trailing joint. The transducer holding part of the assembly is bolted to the surface of the instrumented pipe using two M8 bolts. The target components are glued to the leading and trailing pipe surfaces using Loctite multi-bond 330 structural adhesive. The transducers are locked into position by M3 grub screws.

2.2.6 Jack load cells

The load cells are a commercially available heavy duty 200 tonne compression type. The standard cable and its connection to the cell have been modified so that it can operate under submersed conditions. A cell is illustrated in Plate 2.9 with overall dimensions presented in design drawing PN/PJR/15.

2.2.7 Celesco unit

The celesco position displacement unit provides an electrical signal proportional to the linear extension of a stainless steel cable through the use of a precision rotary potentiometer. It is a commercially available instrument and is illustrated in Plate 2.10.

2.2.8 Ground convergence indicator

The ground convergence indicator is illustrated in Plate 2.11. No design drawing exists for the final version of the instrument. This is because the device has evolved from outline drawings in a form that requires extensive modification to simplify fabrication. If future instruments are required then redesign will be necessary. The device consists of a duraluminium circular main housing which facilitates installation into a steel lined hole in the concrete pipe wall. The principle of operation involves monitoring the movement of a spring loaded fin attached to a shaft using a rotary potentiometer. The fin is provided with a maximum vertical movement of 30mm relative to the top of the housing which is slightly greater than the overcut on most pipejacking contracts. The housing has been designed to enable access to the internal components. Particular care has been taken in sealing the compartment housing the potentiometer from moisture ingress, while allowing the void in the recess chamber accommodating the fin to stabilise with the surrounding ground water when present. Jamming of the fin in the housing is prevented by PTFE wipers.

2.2.9 Data acquisition & power supply

2.2.9.1 Data acquisition

The data acquisition system is shown diagrammatically in Figure 2.2. For simplicity a serial information communication technique is employed which allows a 286AT personal computer to be used as the basis of control. The system enables a family of commercially available standard "Datascan" measurement and analogue input modules (capable of accepting information from different types of transducer) to be located close to the measurement station. Short lengths of analogue signal cables and communication in digital form between the measurement modules (7010/7220) and the host computer minimises the risk of signal corruption. The system is readily expanded to 80 channels which is the maximum required during the research. The measurement system is capable of 16 bit measurement performance and contains a non-volatile memory, which retains the set-up information even after a system power down.

At the heart of the Datascan system is the measurement and processing unit types 7010 and 7220. These provide the measurement facilities and control the operation of the Datascan system. On board is a programmable ADC, a serial RS232 interface for connection to the host computer, a RS485 network interface permitting up to 32 measurement modules to be connected together and an expansion bus allowing the connection of up to 256 channels of analogue input. The units are powered by 24 Volt dc supply. Auto range is standard allowing ranges of 20mV, 150mV, 1.3V and 10V.

The 7020 and 7021 are input scanner and signal conditioning units which are connected to the measurement modules via a 20 way ribbon cable which must be located within a distance of 10 metres. The 7020 provides the facility to connect 16 d.c. voltage signal inputs. The 7021 provides eight channels of inputs for strain gauges and platinum resistance thermometers with on board energisation of 1.8V. Measurement accuracy using 16 bit resolution for the 20mV range, the most commonly used range in the research is:

$$\pm\ 0.02\%\ \text{rdg} + 0.01\%\ \text{range} + 5\mu V.$$

which is equivalent to 0.006% of the full range value.

The network system is completed by the 7011 network interface module which allows connection to a remote host computer. The link from the 7011 to the PC is through an isolated RS232 port with a baud rate setting of 9.6 k baud.

Measurement speed is dependent upon the number, type and measurement resolution of channels connected to each measurement module, the network distribution of the measurement modules and the communications link with the PC. For the arrangement shown in Figure 2.2 a single measurement on every channel can be made in 2.5 seconds. This is acceptable because the instrument logging strategy during the pipejacking research requires measurements every 5 seconds during pushes and 1 minute at all other times. Configuration of the system is carried out using a commercially available software package called Unigen.

It will be apparent from Plate 2.13 that the modules have not been designed or packaged for rough field conditions and that it has been necessary to house them in individual steel boxes to protect them against the tunnel environment, mechanical damage and the possibility of total immersion. Each box is designed to be din rail mounted and internally arranged to accommodate a single input module and a dedicated power supply

2.2.9.2 Power supply

Each transducer requires an energising supply of electric current which cannot be provided by the datascan units. A purpose built "stable" power supply has therefore been designed and incorporated into the system. The supply provides a 5V or 10V dc voltage which is maintained at ± 0.025% of the nominal value.

For the pipejacking research the power source is generally the national grid although a 20 kVa portable generator has been used on one site. The incoming 230 V, 50Hz ac supply is first converted to 110 V with a centre tapped earth, portable isolation stepdown transformer. This is to satisfy the current safety regulations for site use. The 110 V ac is fed to a "rectifier unit", figure 2.3 and Plate 2.12, housed in a steel box where it is converted via transformers, bridge rectifiers and a smoothing circuit to low voltage dc supply. The low voltage supply is then fed via screened cables to the steel boxes housing the high stability voltage regulators for each transducer and the datascan analogue input modules, Figure 2.3 and Plate 2.13. This arrangement ensures that the magnetic fields associated with the transformers are physically separated from the sensitive parts of the system (i.e.) the datascan input modules. The low voltage supplies are isolated from earth so that earth currents cannot produce a "noise" signal. Care has also been taken to ensure that variations in the mains supply and spikes do not effect the energising supply to the transducers. Spikes do not easily transfer through transformers and even if they do they are conducted to ground via small value ceramic capacitors in the rectifier unit.

Wherever practical, lamps have been installed to indicate the presence of supply voltage. This helps greatly in fault finding. Each transducer has its own separate supply to enable the system to continue operating in the event of a short circuit in one of the transducer energising outputs. In addition transducer connectors have been standardised so that 4 way connectors are used for signal cables and 5 way and 6 way used for 5V and 10V transducer energisation respectively. Lemo environmentally sealed connectors have been used to interface the transducers to the steel boxes. Wherever possible, cables are screened and twisted pair to reduce the possibility of electro magnetic interference from other equipment.

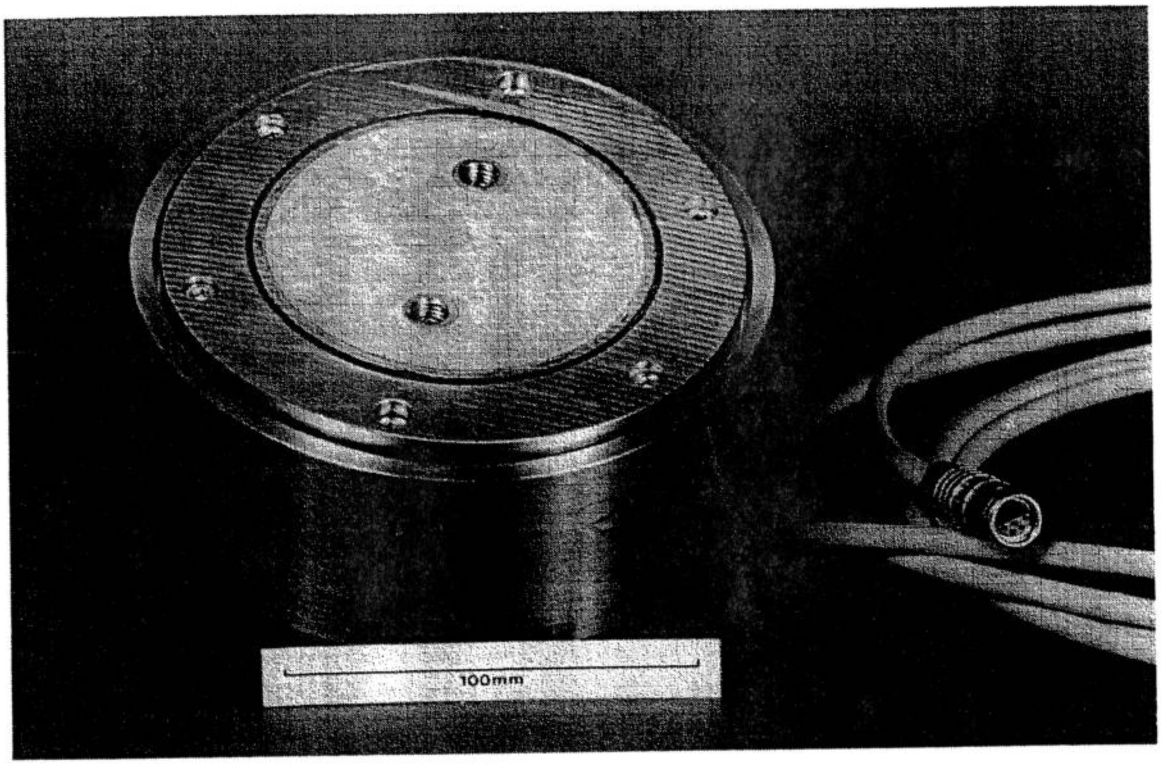


Plate 2.1 Contact stress cell

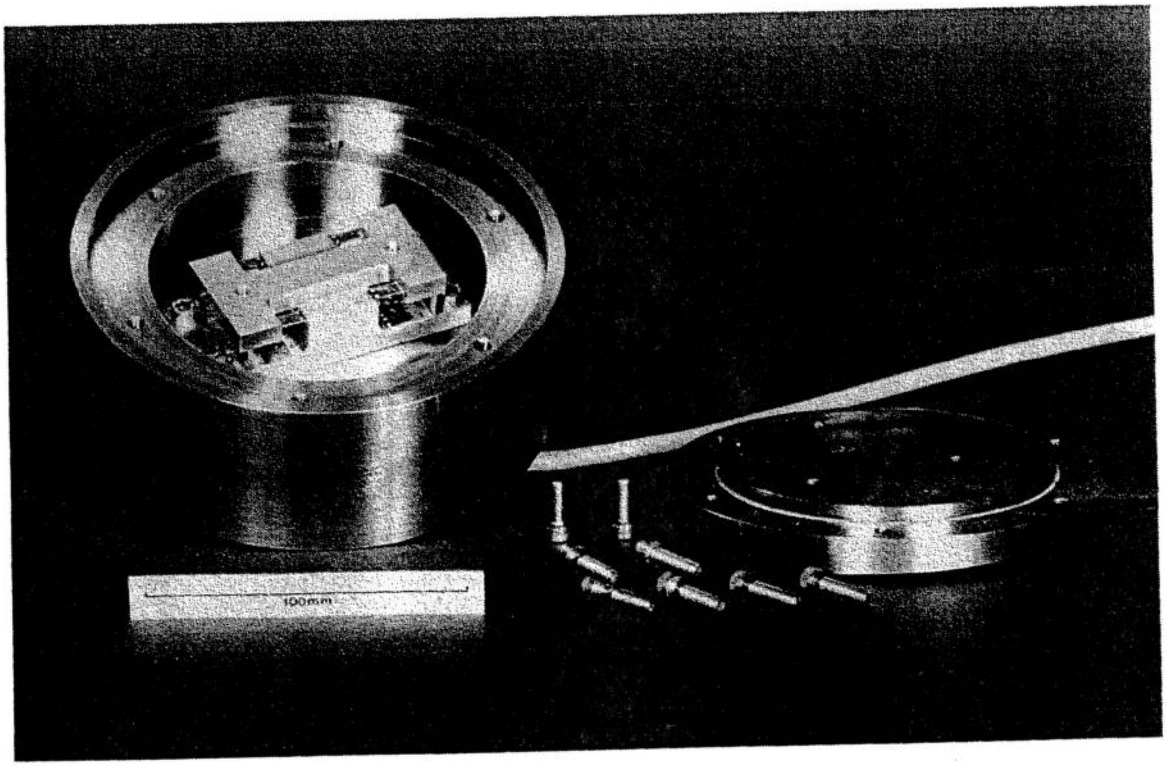


Plate 2.2 Exploded view of contact stress cell

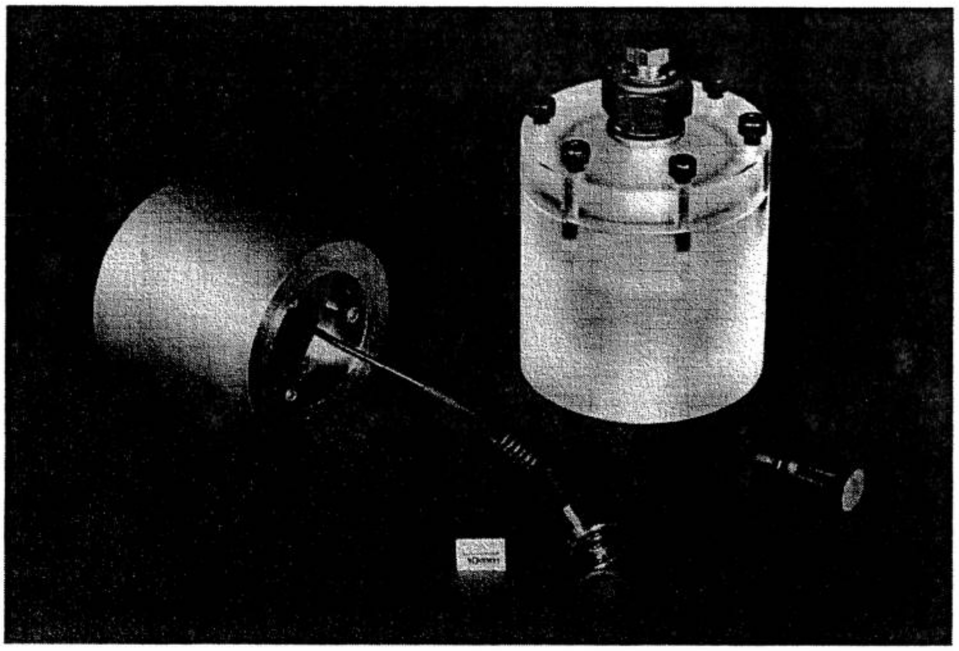


Plate 2.3 Pore pressure probe and transportation container

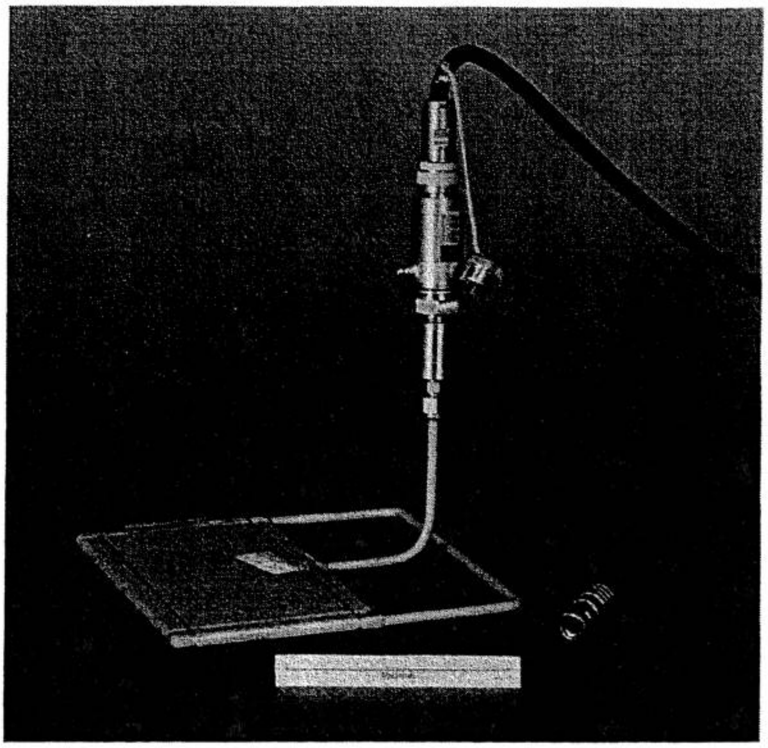


Plate 2.4 Pipe joint pressure cell

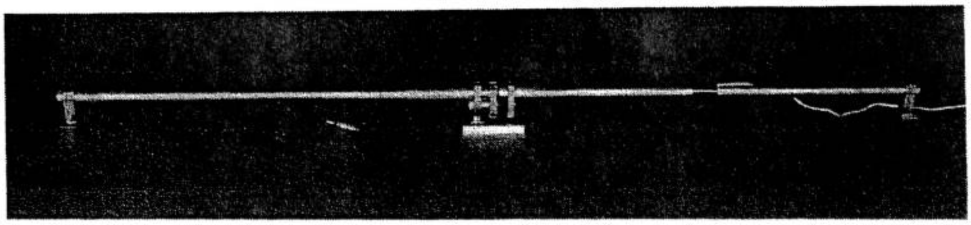


Plate 2.5 Tube extensometer

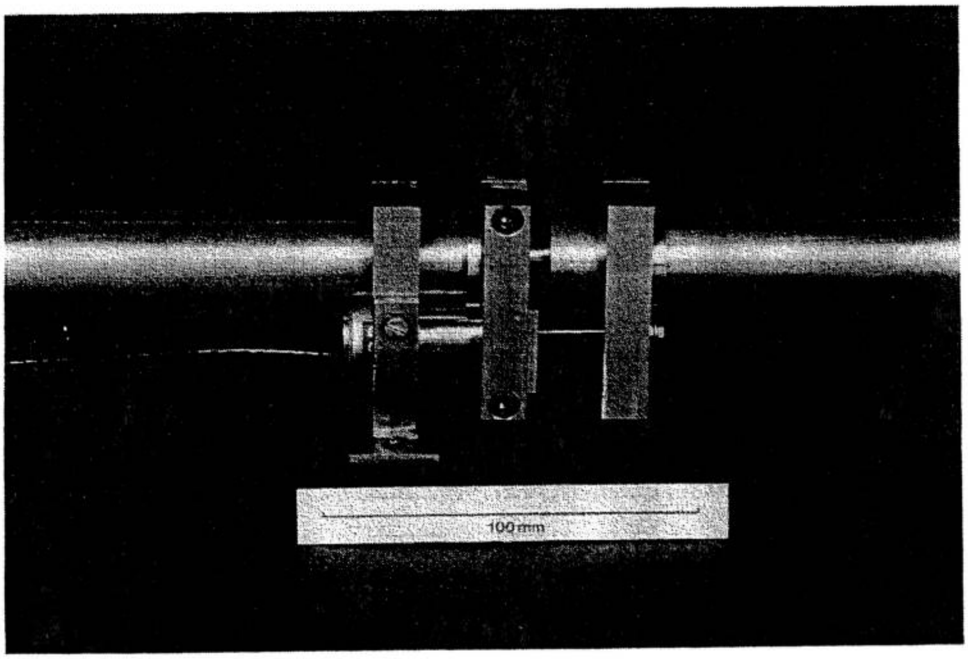


Plate 2.6 Tube extensometer

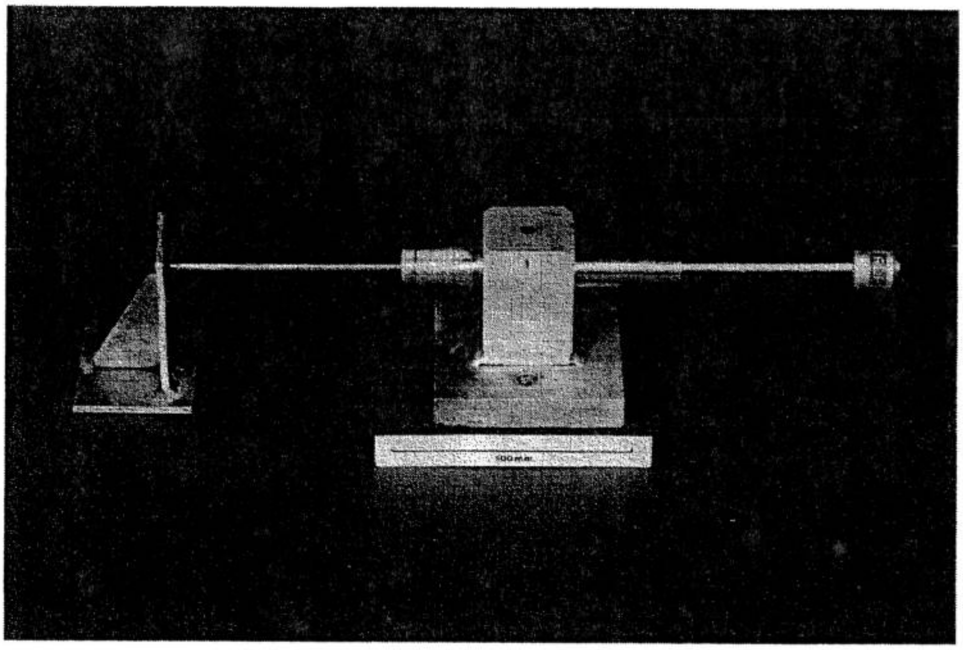


Plate 2.7 Single direction joint movement indicator

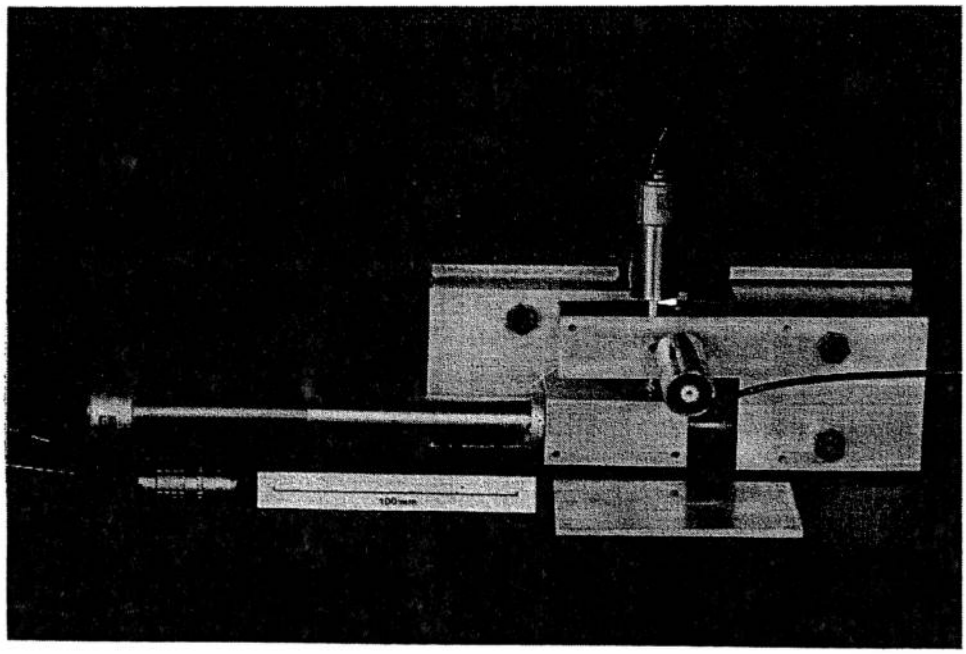


Plate 2.8 Three directional joint movement indicator

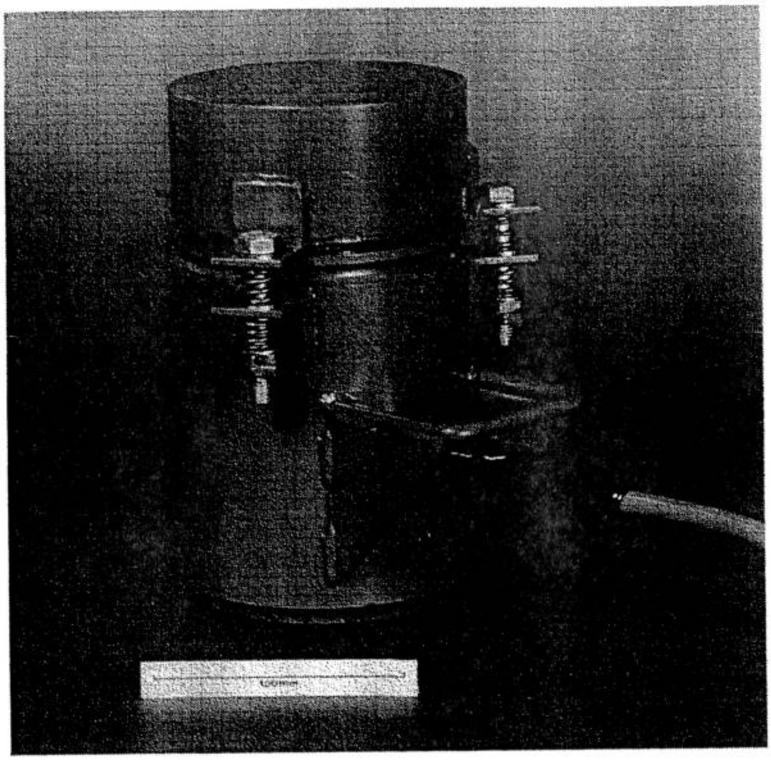


Plate 2.9 Jack load cell

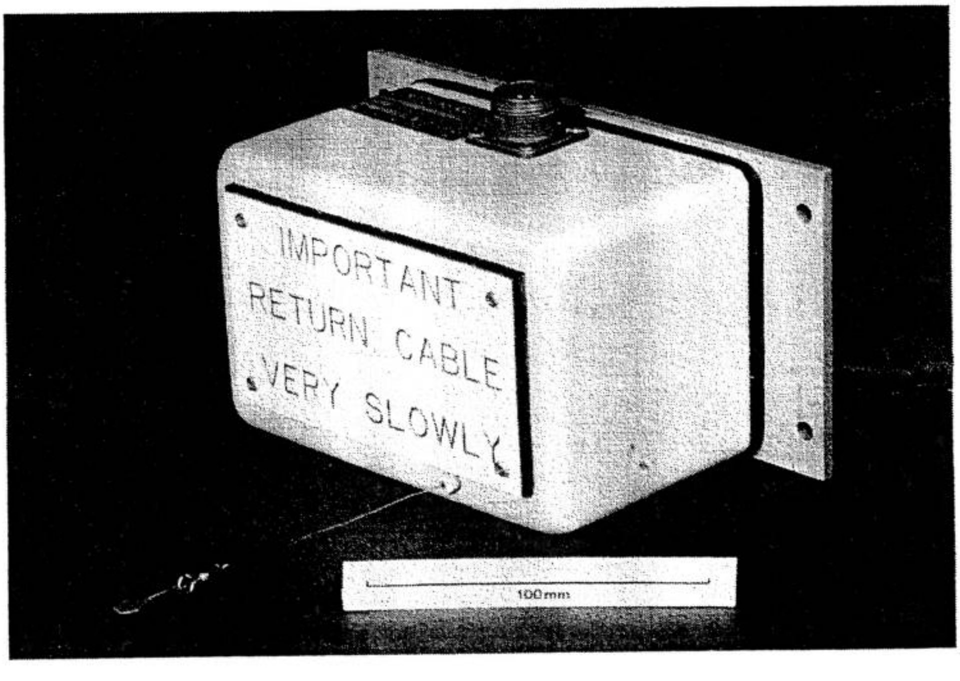


Plate 2.10 Celesco displacement transducer

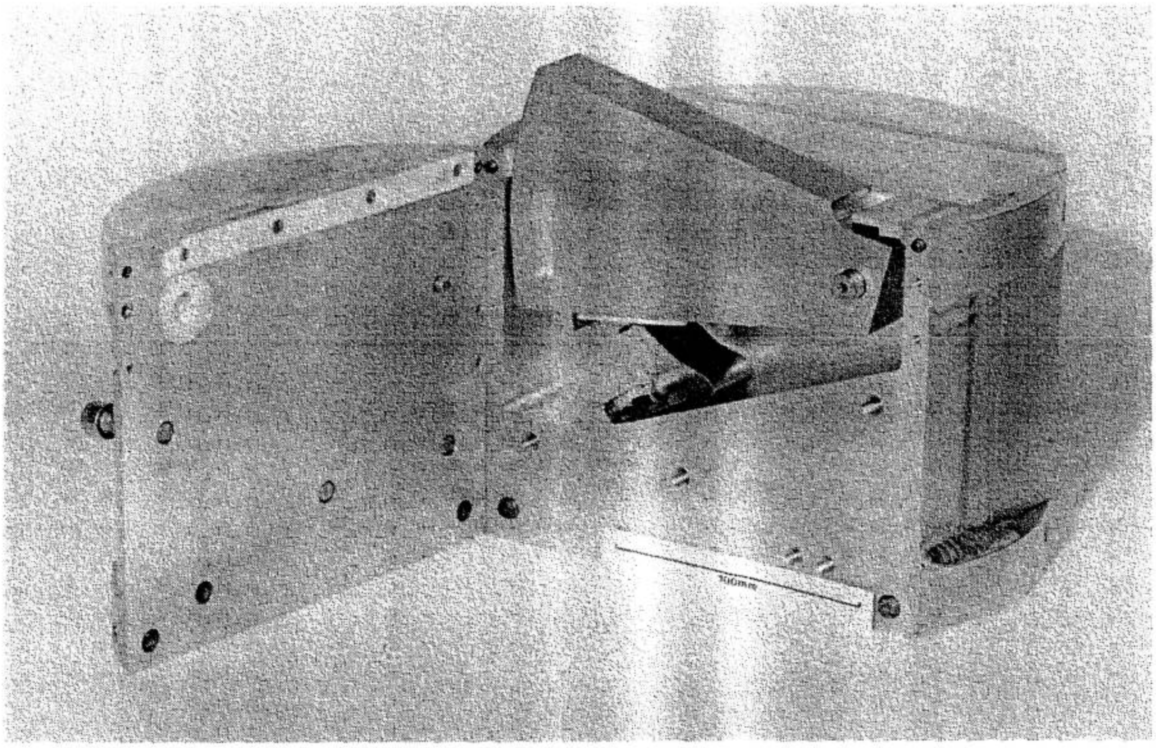


Plate 2.11 Ground convergence indicator

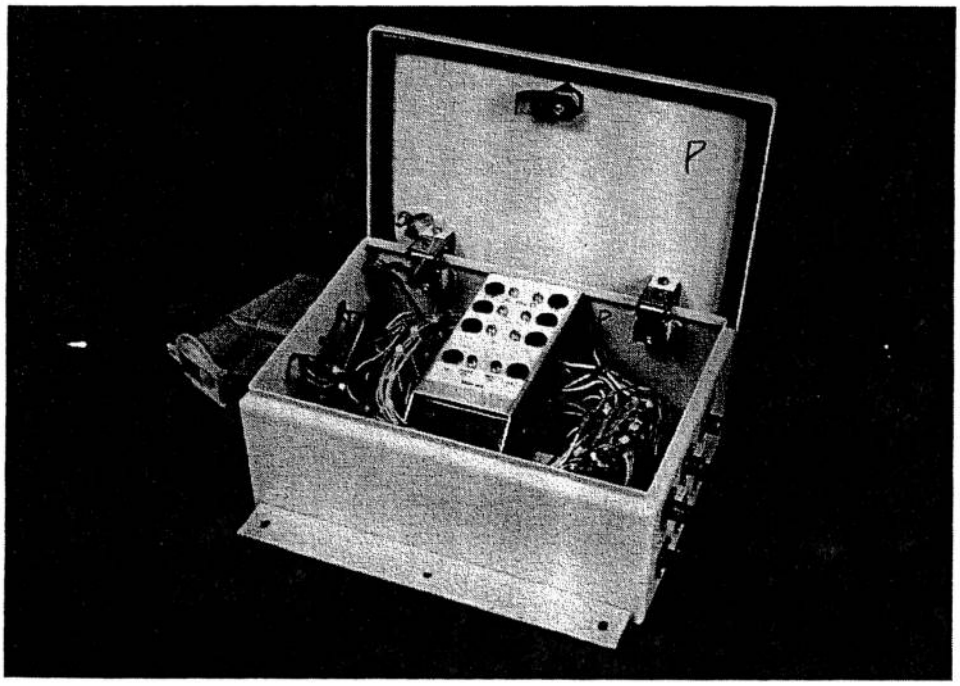


Plate 2.12 Transformer and rectifier unit

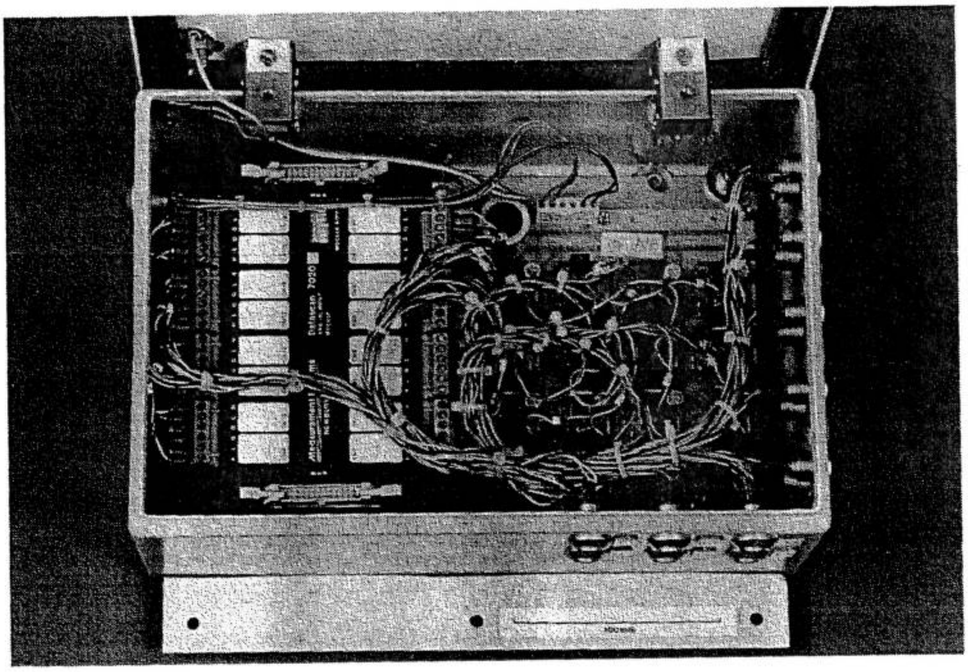


Plate 2.13 Regulator and datascan unit

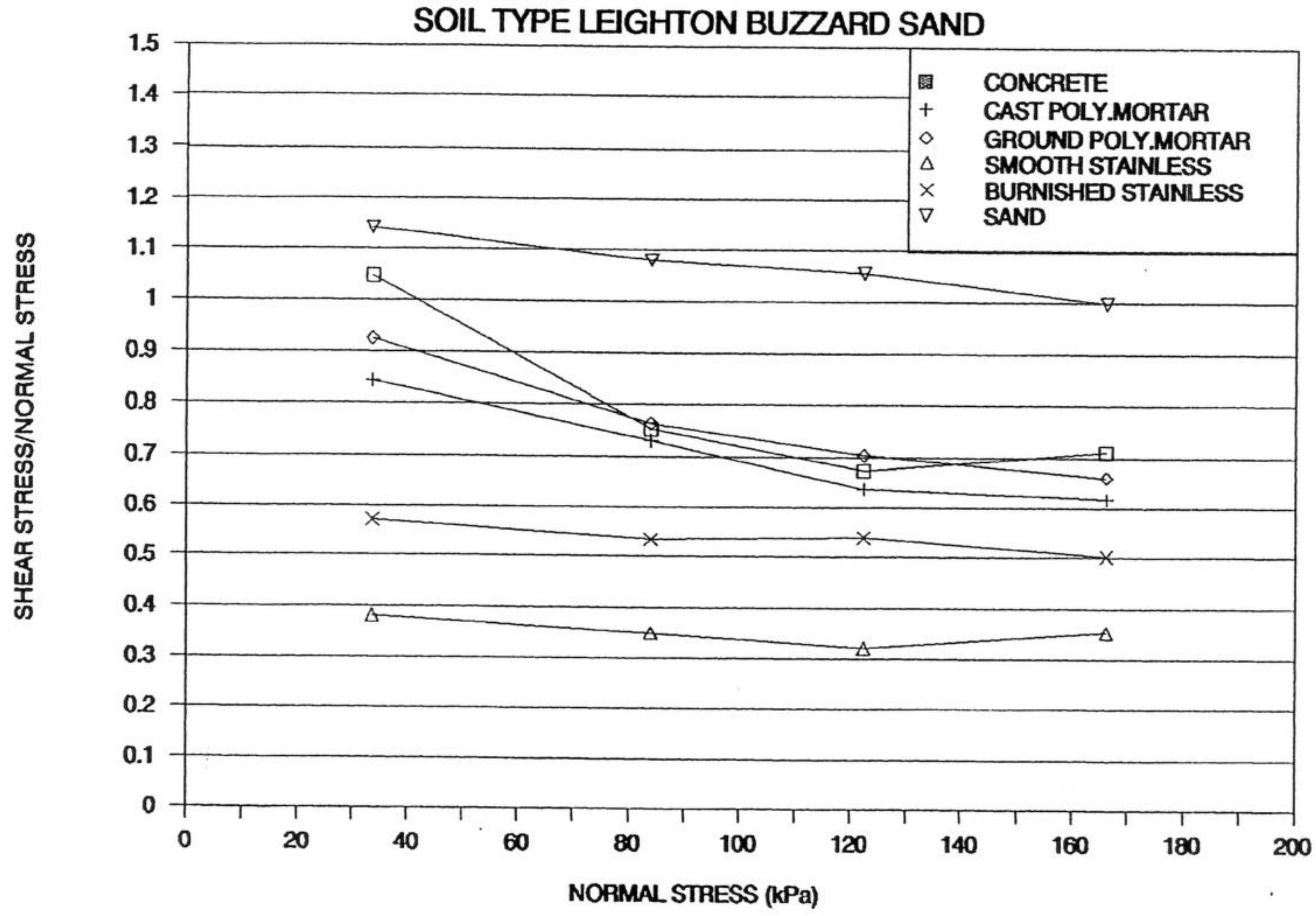
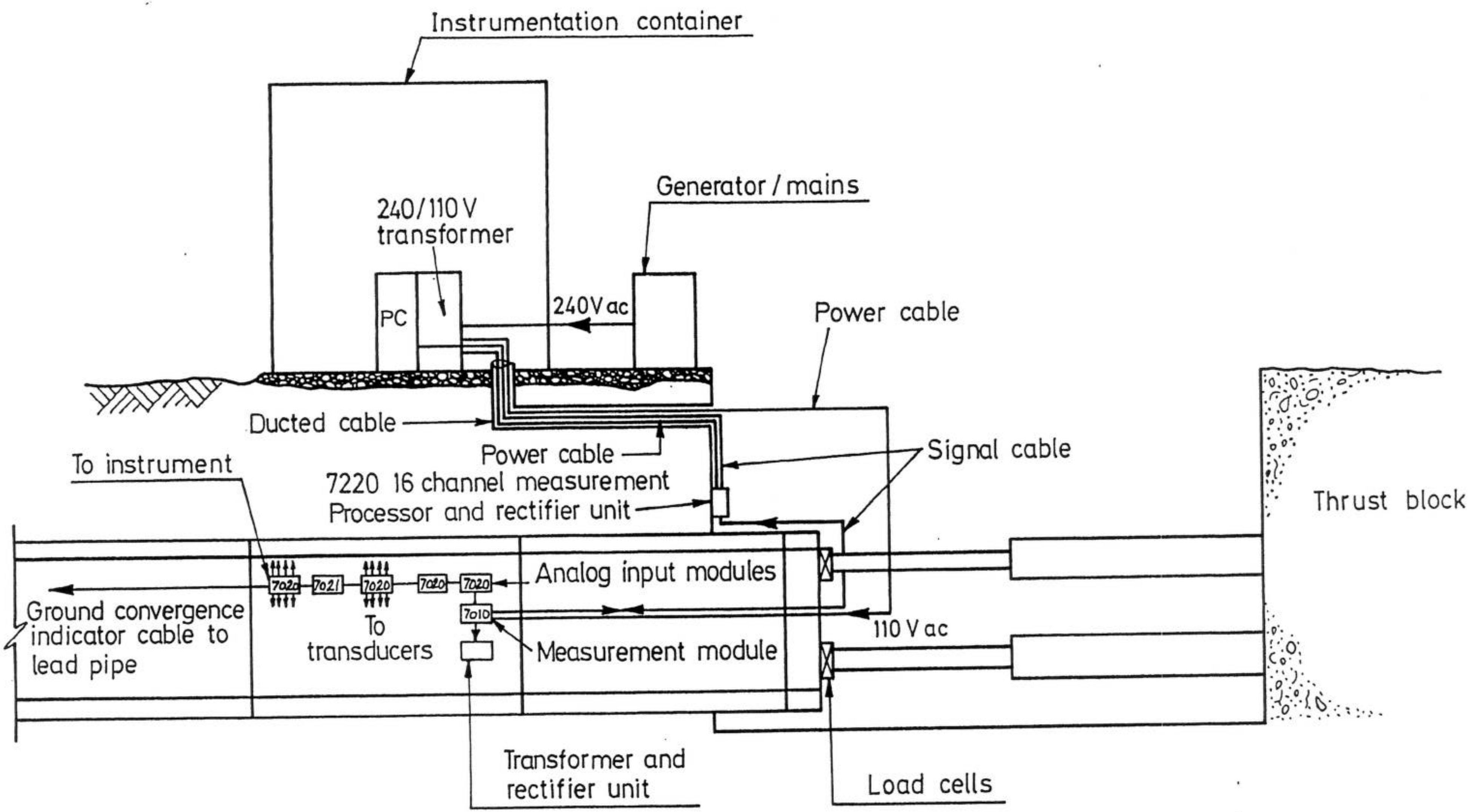
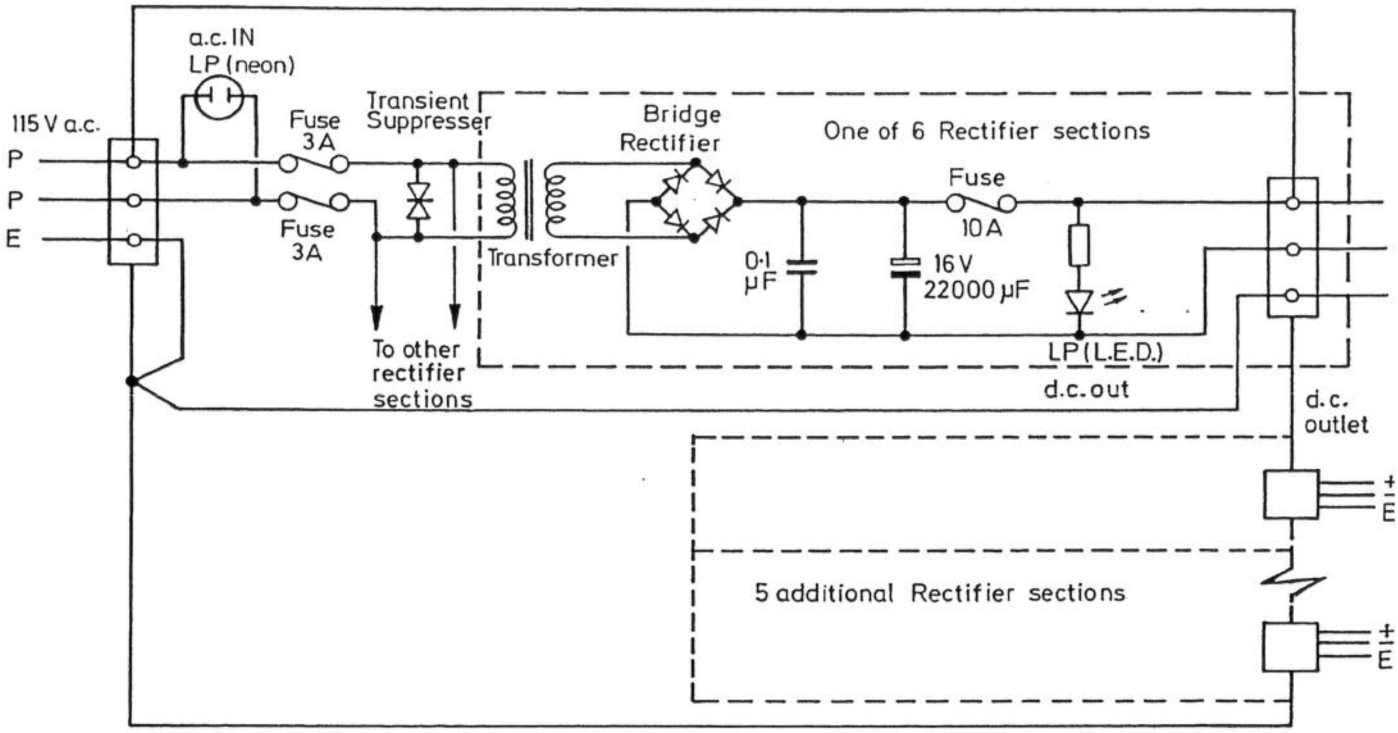


Figure 2.1 Shear box interface tests

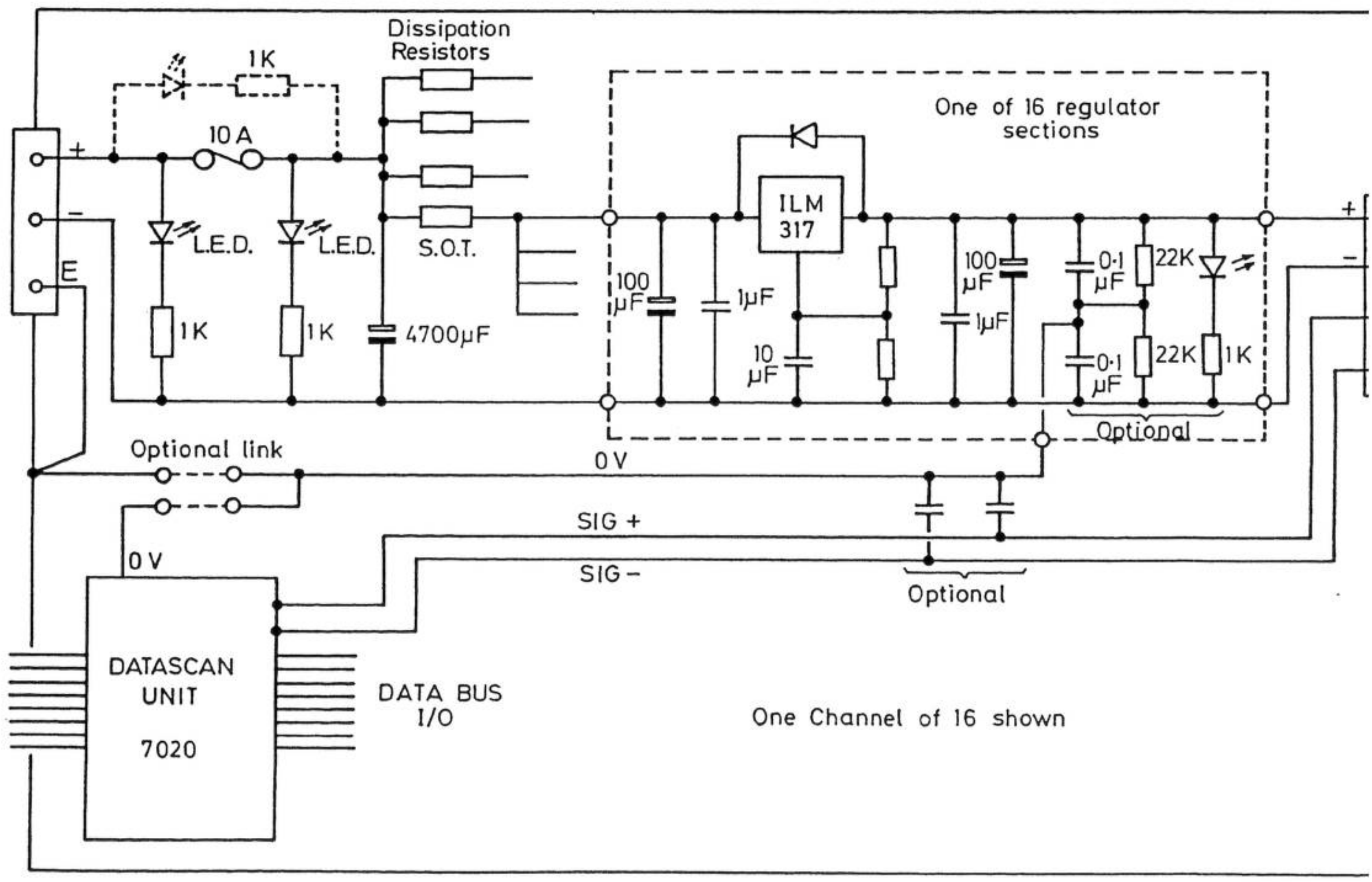


DIAGRAMMATIC REPRESENTATION OF DATA ACQUISITION SYSTEM

Figure 2·2

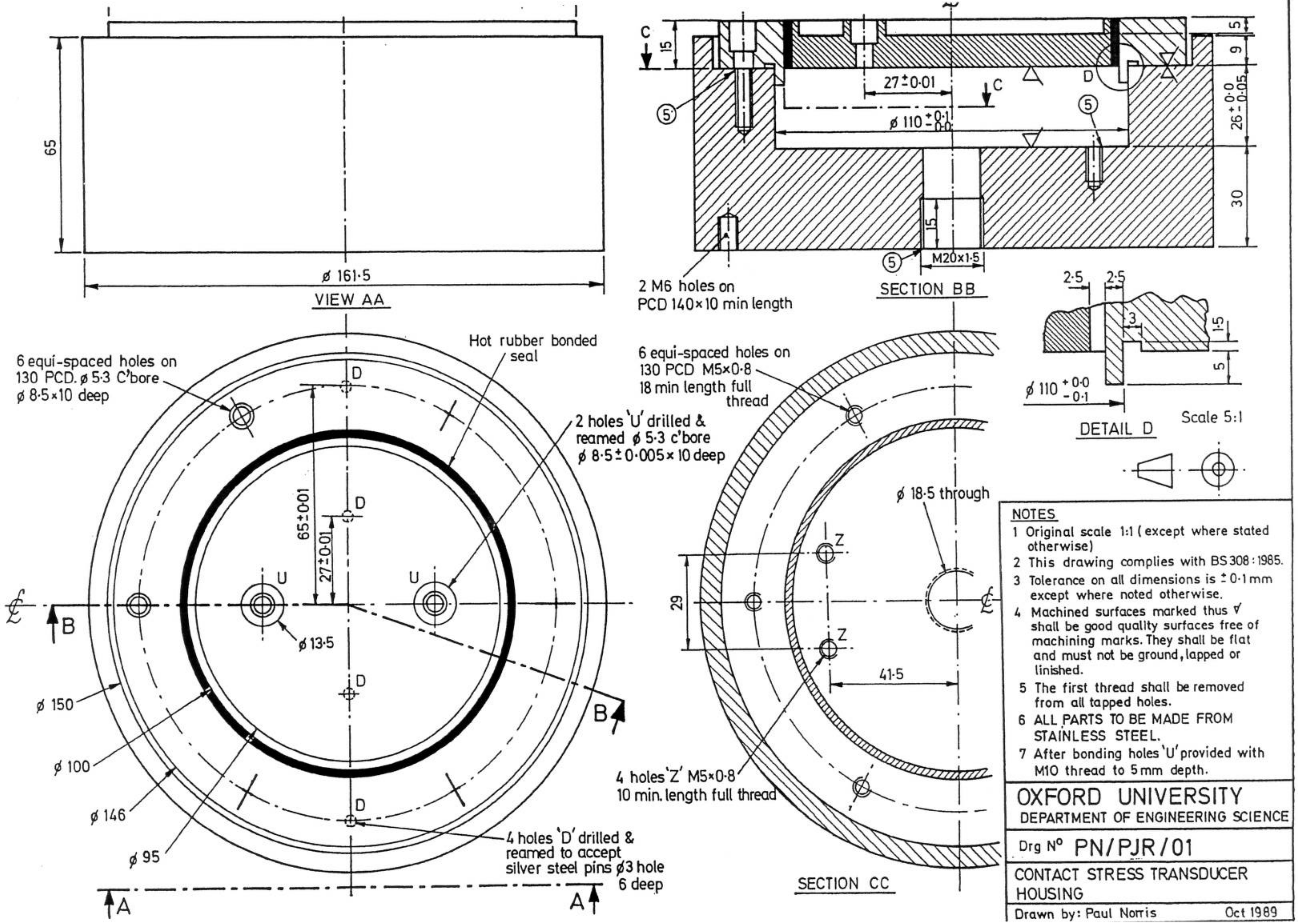


TRANSFORMER AND RECTIFIER UNIT



REGULATOR AND DATASCAN UNIT

Fig 2·3



NOTES

1. Original scale 1:1 (except where stated otherwise)
2. This drawing complies with BS 308 : 1985.
3. Tolerance on all dimensions is ± 0·1 mm except where noted otherwise.
4. Machined surfaces marked thus ∀ shall be good quality surfaces free of machining marks. They shall be flat and must not be ground, lapped or linished.
5. The first thread shall be removed from all tapped holes.
6. ALL PARTS TO BE MADE FROM STAINLESS STEEL.
7. After bonding holes 'U' provided with M10 thread to 5 mm depth.

OXFORD UNIVERSITY
DEPARTMENT OF ENGINEERING SCIENCE

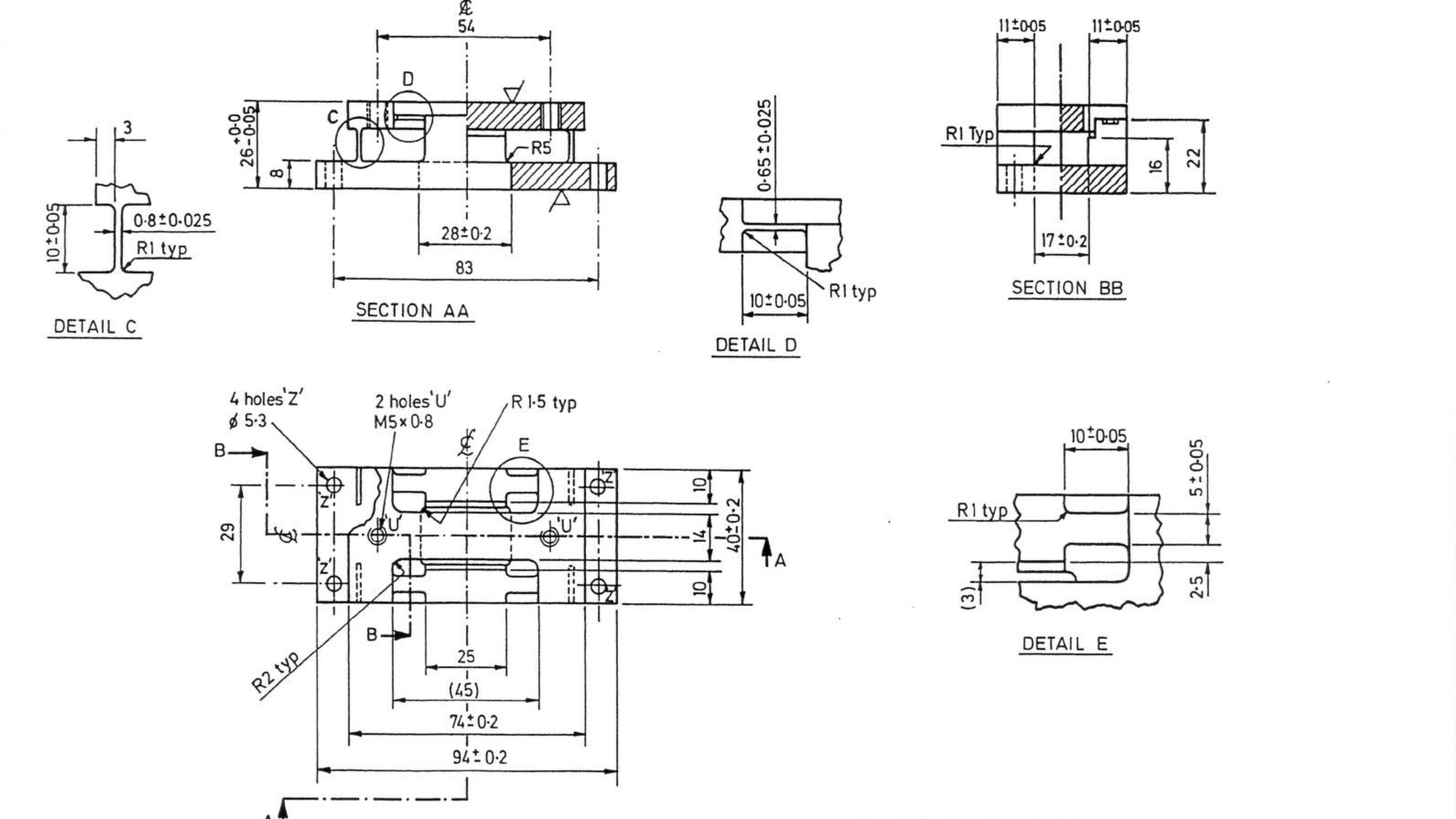
Drg N° PN/PJR/01

CONTACT STRESS TRANSDUCER HOUSING

Drawn by: Paul Norris   Oct 1989

USED ON DRG. No......................

THIRD ANGLE PROJECTION



Note: The first thread shall be removed from all tapped holes

ISSUE	DATE	MODIFICATION
1	Aug 1986	

MATERIALS Aluminium Alloy 2014 A (see BS1474:1972)

TOLERANCES ± 0·1 mm except where noted otherwise

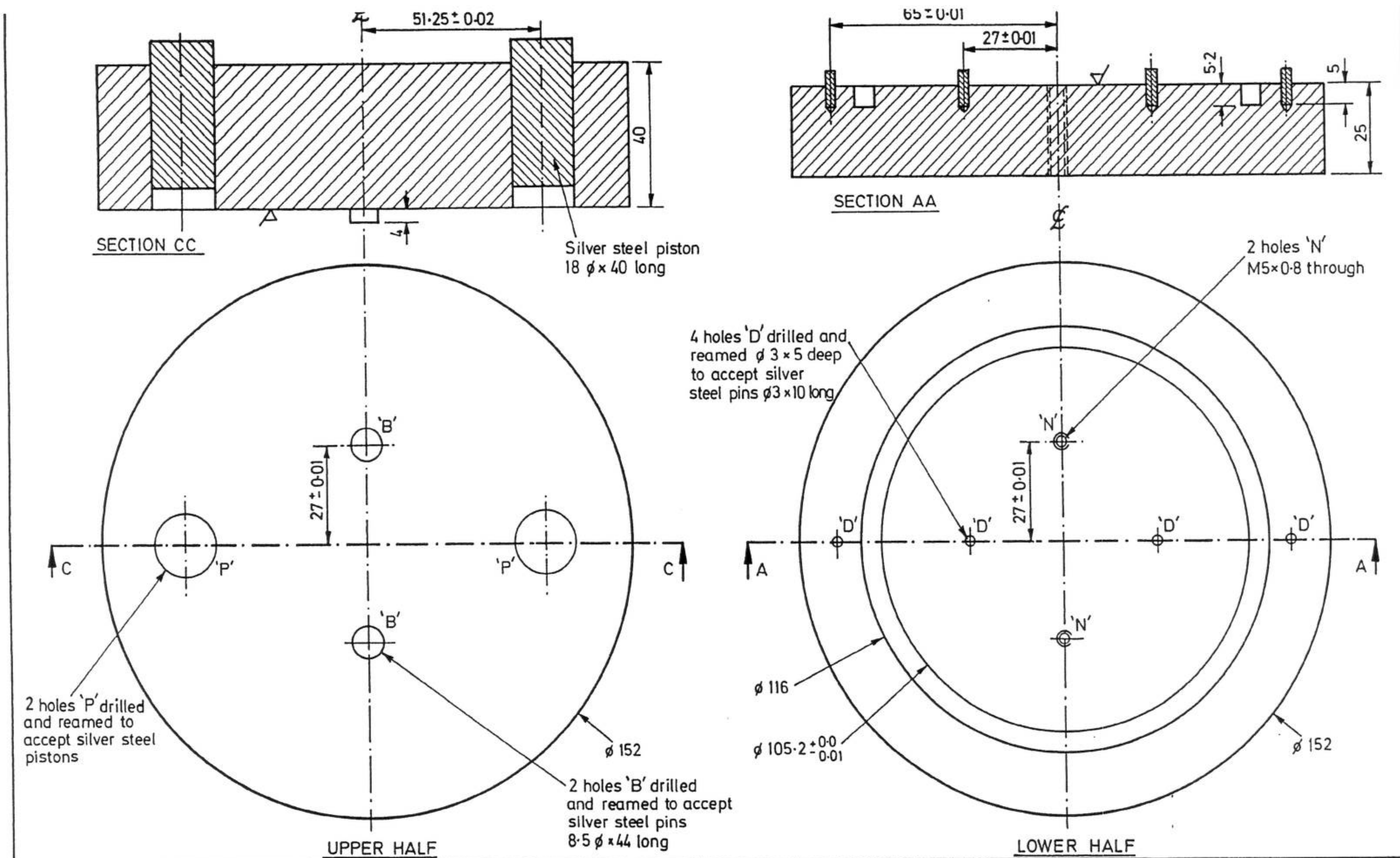
FINISH Machined surfaces marked thus ∇ shall be good quality surfaces free of machining marks. They shall be flat and must not be ground, lapped or linished.

SCALE	DRN.	TRD.	CHK'D.
Not to scale			

DEPARTMENT OF ENGINEERING SCIENCE
OXFORD UNIVERSITY

TITLE Cambridge Earth Pressure Cell

DRAWING No. A PN/PJR/02

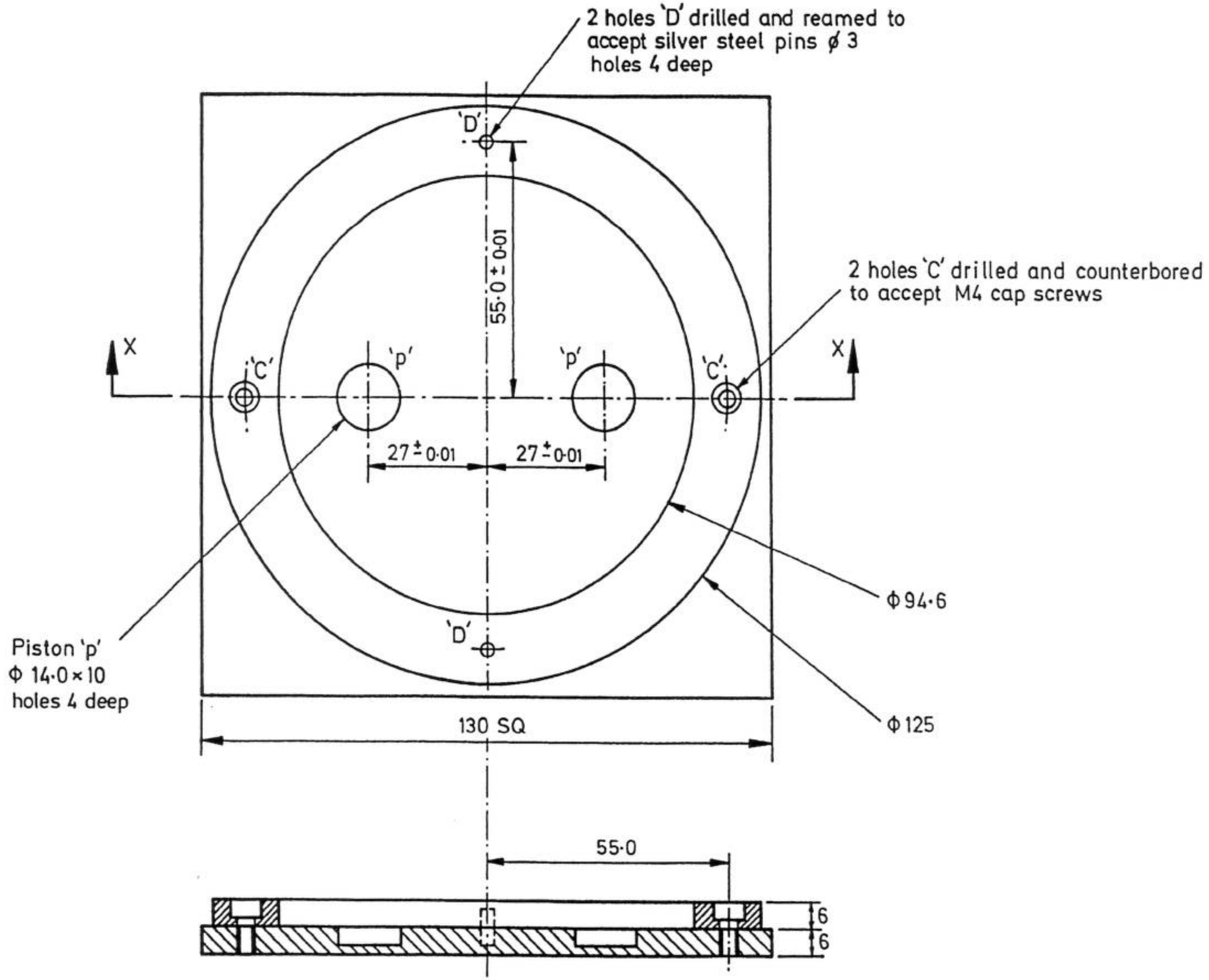


ISSUE	DATE	MODIFICATION	MATERIALS Aluminium Alloy		TOLERANCES ±0·1mm unless otherwise stated		DEPARTMENT OF ENGINEERING SCIENCE OXFORD UNIVERSITY	
1	Nov 1989		FINISH ∀ Machined surfaces marked shall be good quality surfaces free of machining marks				TITLE RUBBER BONDING MOULD	DRAWING No. A PN/PJR/03
			SCALE 1:1	DRN. P. Norris	TRD.	CHK'D.		

MY 310900 R

USED ON DRG. No............................

THIRD ANGLE PROJECTION



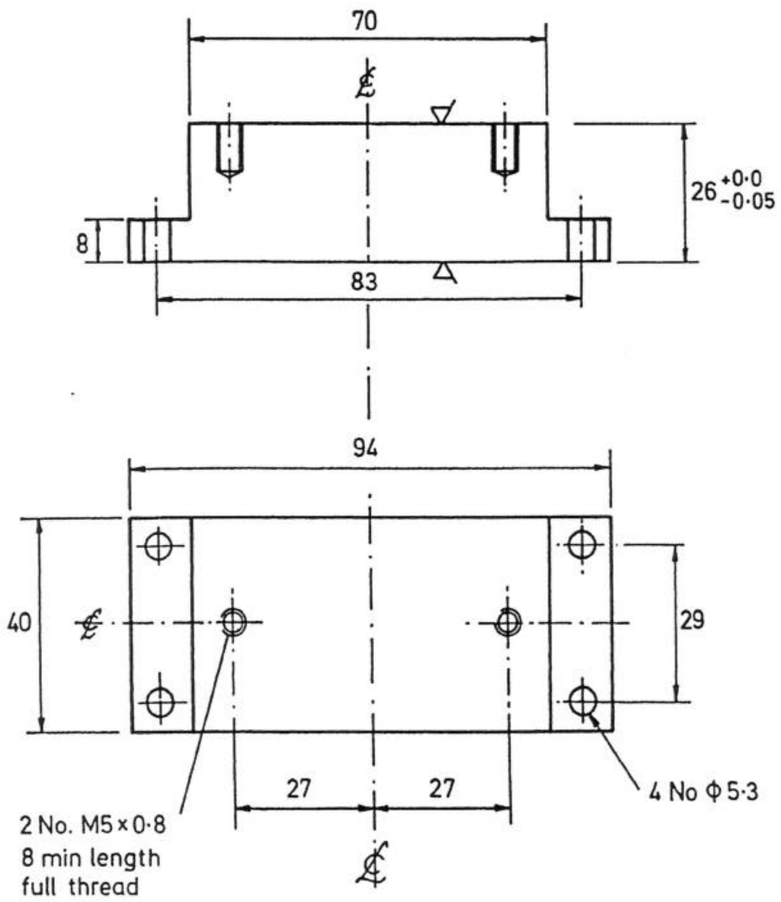
Section XX

ISSUE	DATE	MODIFICATION	MATERIALS Pistons to be made from stainless steel. Mould from mild steel FINISH		TOLERANCES ± 0·1 except where noted otherwise		DEPARTMENT OF ENGINEERING SCIENCE OXFORD UNIVERSITY	
1	March 1990		SCALE 1:1	DRN. P. Norris	TRD.	CHK'D.	TITLE MOULD FORMER FOR MORTAR DISCS	DRAWING No. **A** PN/PJR/04

DEC186

USED ON DRG. No.

THIRD ANGLE PROJECTION



Notes

The first thread shall be removed from all tapped holes.

ISSUE	DATE	MODIFICATION
1	March 1990	

MATERIALS Aluminium alloy 2014 A

FINISH Machine surfaces marked √ shall be good quality free of machine marks

SCALE 1:1

DRN. P. Norris

TOLERANCES
All tolerances ±0·1 mm except where noted otherwise

TRD.

CHK'D.

DEPARTMENT OF ENGINEERING SCIENCE
OXFORD UNIVERSITY

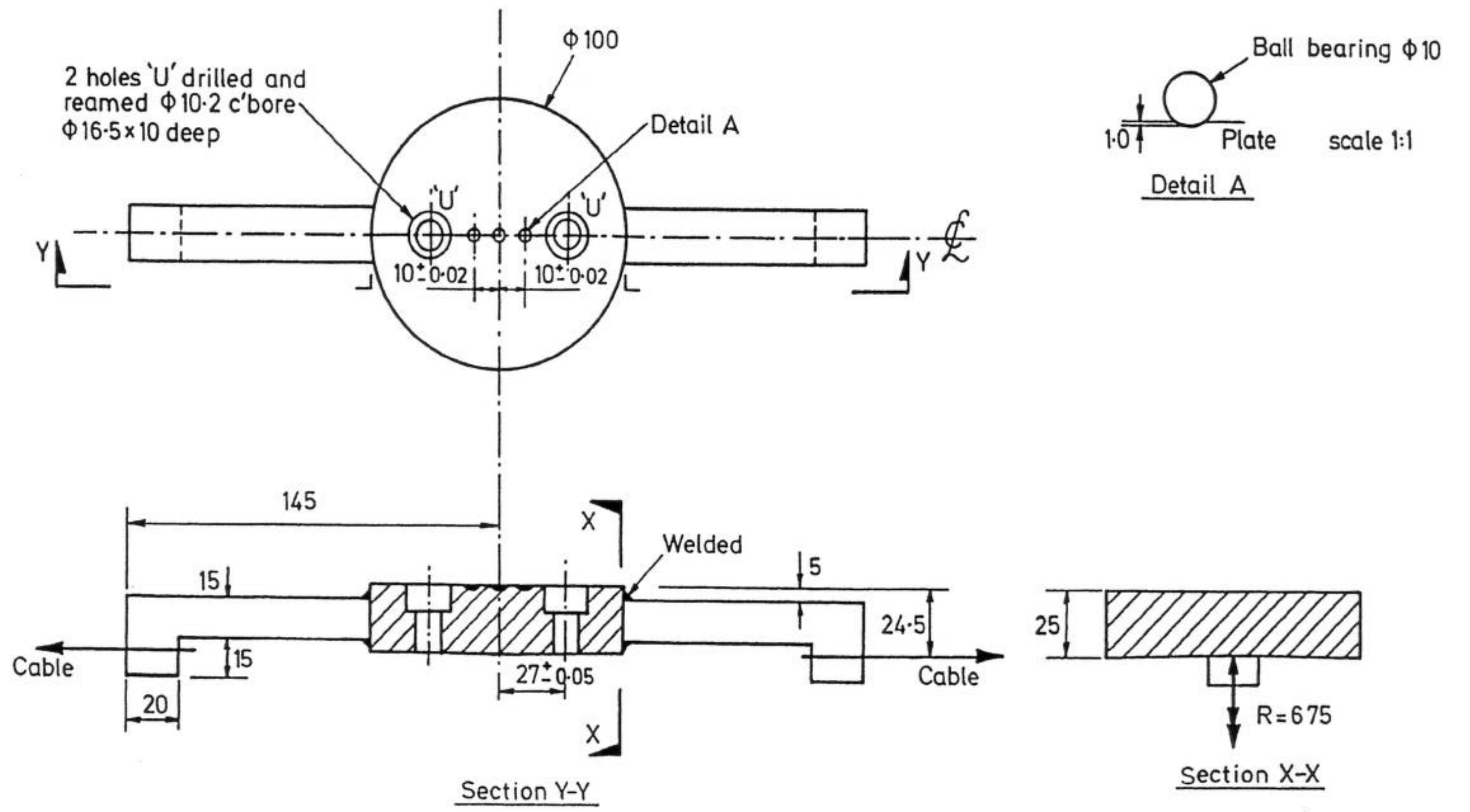
TITLE DUMMY CONTACT STRESS CELL

DRAWING No. A PN/PJR/05

MY 184903 R

USED ON DRG. No.

THIRD ANGLE PROJECTION

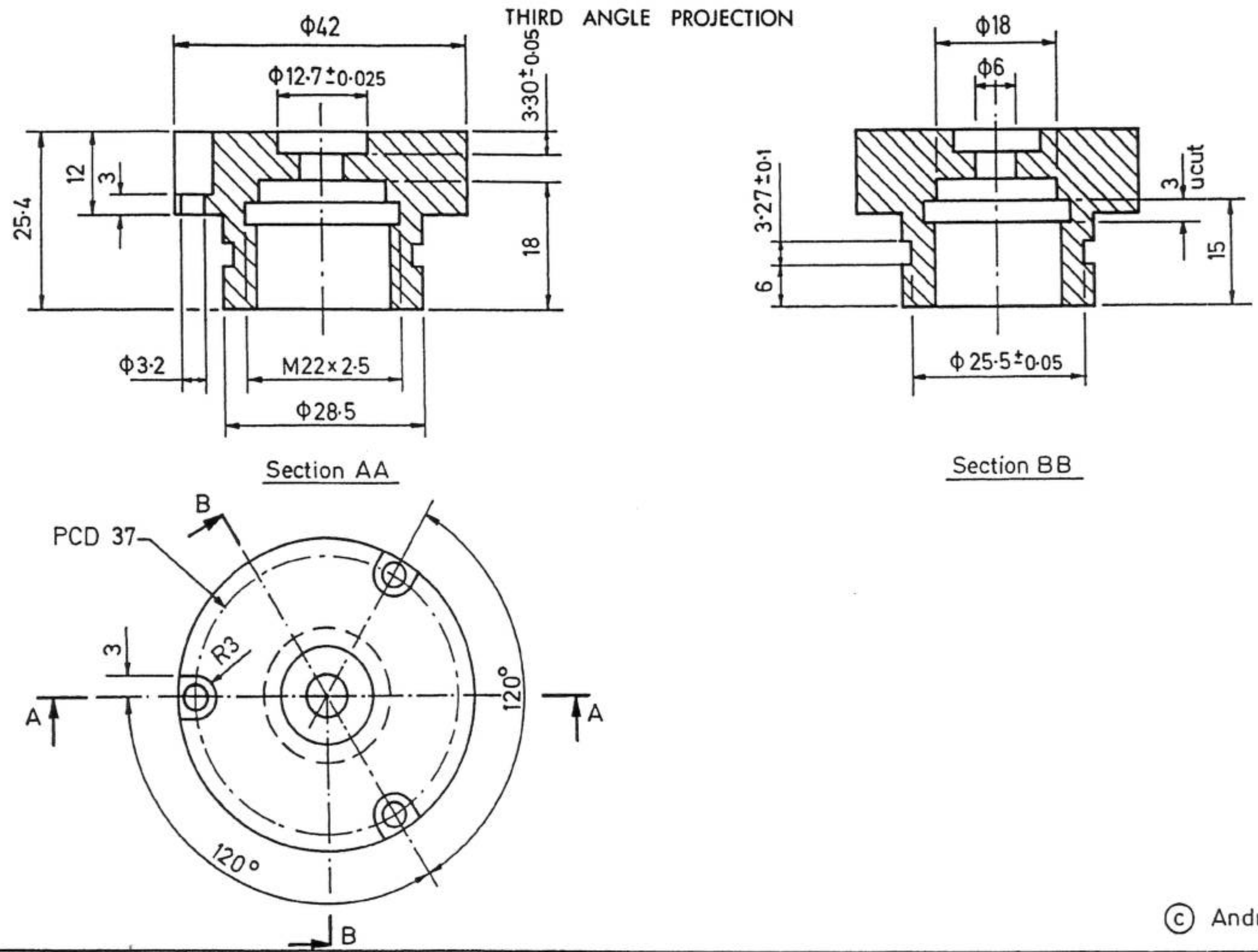


ISSUE	DATE	MODIFICATION	MATERIALS Mild steel Cable 3mm dia Bowden cable FINISH		TOLERANCES ±0·1 except where noted otherwise		DEPARTMENT OF ENGINEERING SCIENCE OXFORD UNIVERSITY	
1	Feb 1990		SCALE 2:1	DRN. P. Norris	TRD.	CHK'D.	TITLE CONTACT STRESS CELL CALIBRATION BLOCK	DRAWING No. **A** PN/PJR/06

MY 184903 R

USED ON DRG. No.

THIRD ANGLE PROJECTION

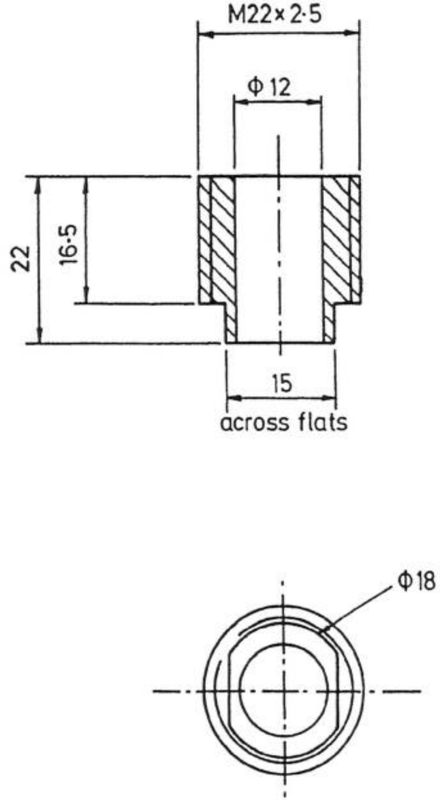


ISSUE	DATE	MODIFICATION	MATERIALS / FINISH		TOLERANCES		DEPARTMENT OF ENGINEERING SCIENCE OXFORD UNIVERSITY	
1	Feb.87		MATERIALS Acetal copolymer				TITLE	DRAWING No.
			FINISH				PORE PRESSURE BLOCK	A PN/PJR/07
			SCALE	DRN.	TRD.	CHK'D.		
			Not to scale					

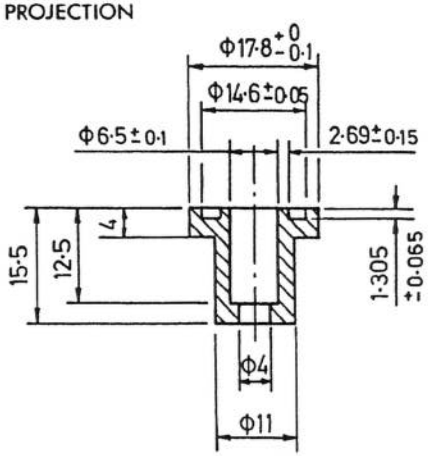
MY 184903 R

USED ON DRG. No.

THIRD ANGLE PROJECTION



THRUST RING
(acetal copolymer)



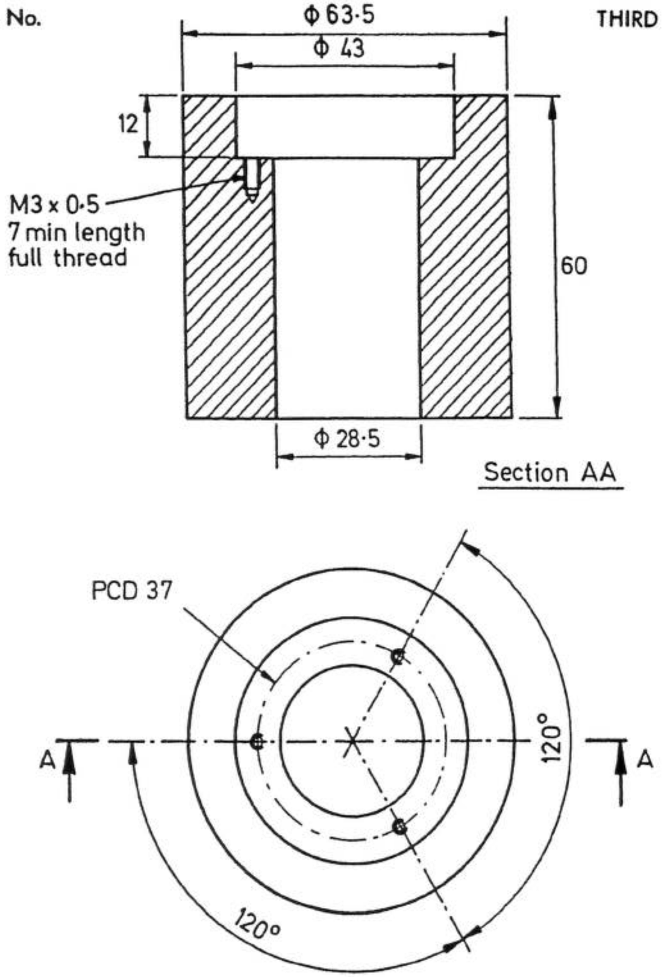
TRANSDUCER HOLDER
(titanium)

ISSUE	DATE	MODIFICATION	MATERIALS		TOLERANCES		DEPARTMENT OF ENGINEERING SCIENCE OXFORD UNIVERSITY	
1	Feb 87		FINISH				TITLE	DRAWING No.
			SCALE Not to scale	DRN.	TRD.	CHK'D.	THRUST RING & TRANSDUCER HOLDER	A PN/PJR/08

MY 184903 R

USED ON DRG. No.

THIRD ANGLE PROJECTION

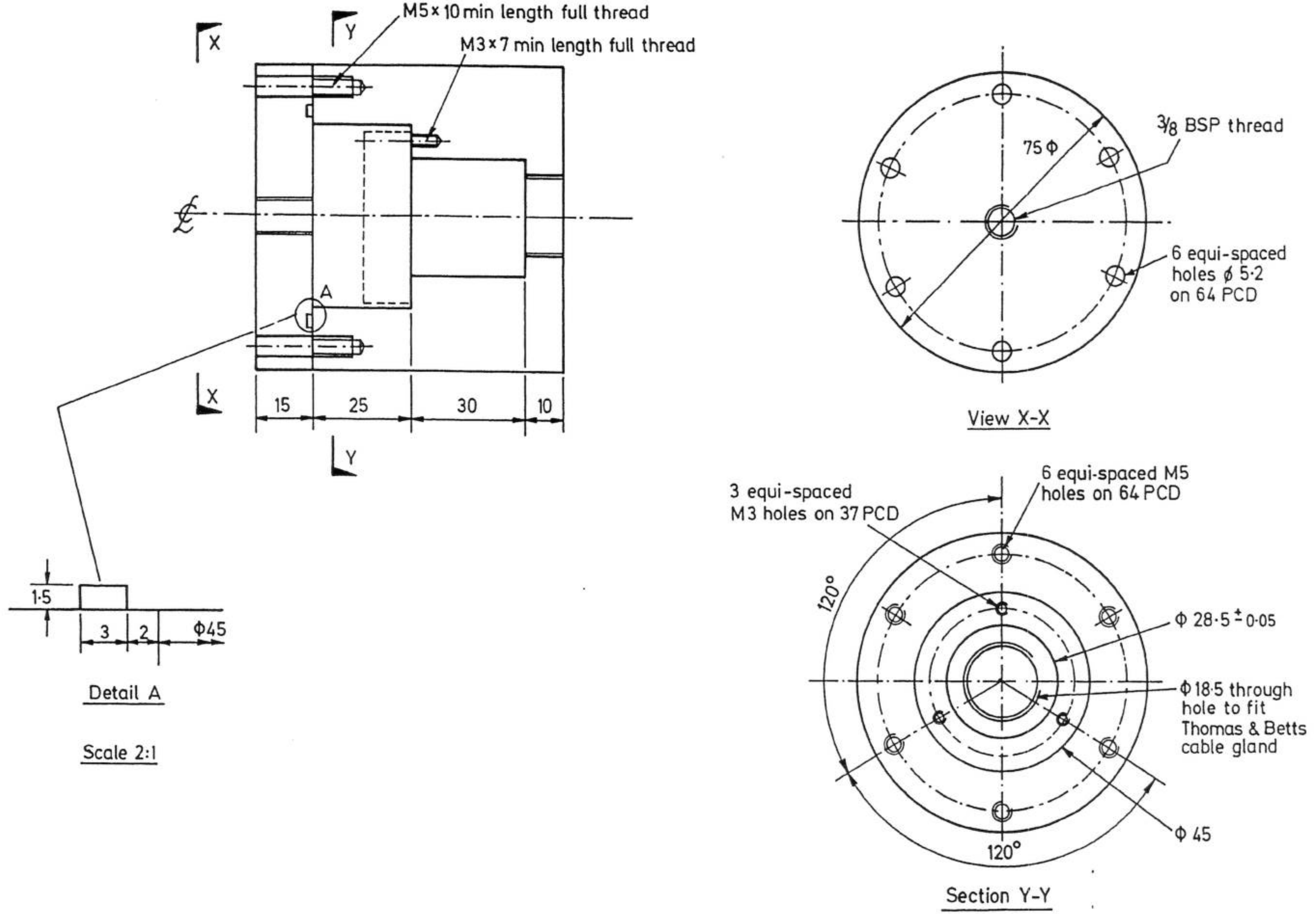


ISSUE	DATE	MODIFICATION	MATERIALS Stainless steel 316		TOLERANCES		DEPARTMENT OF ENGINEERING SCIENCE OXFORD UNIVERSITY	
1	Oct.1989		FINISH				TITLE	DRAWING No.
			SCALE	DRN.	TRD.	CHK'D.	PORE PRESSURE BLOCK HOUSING	
			Not to scale	P. Norris				A PN/PJR/09

MY 184903 R

USED ON DRG. No............................

THIRD ANGLE PROJECTION

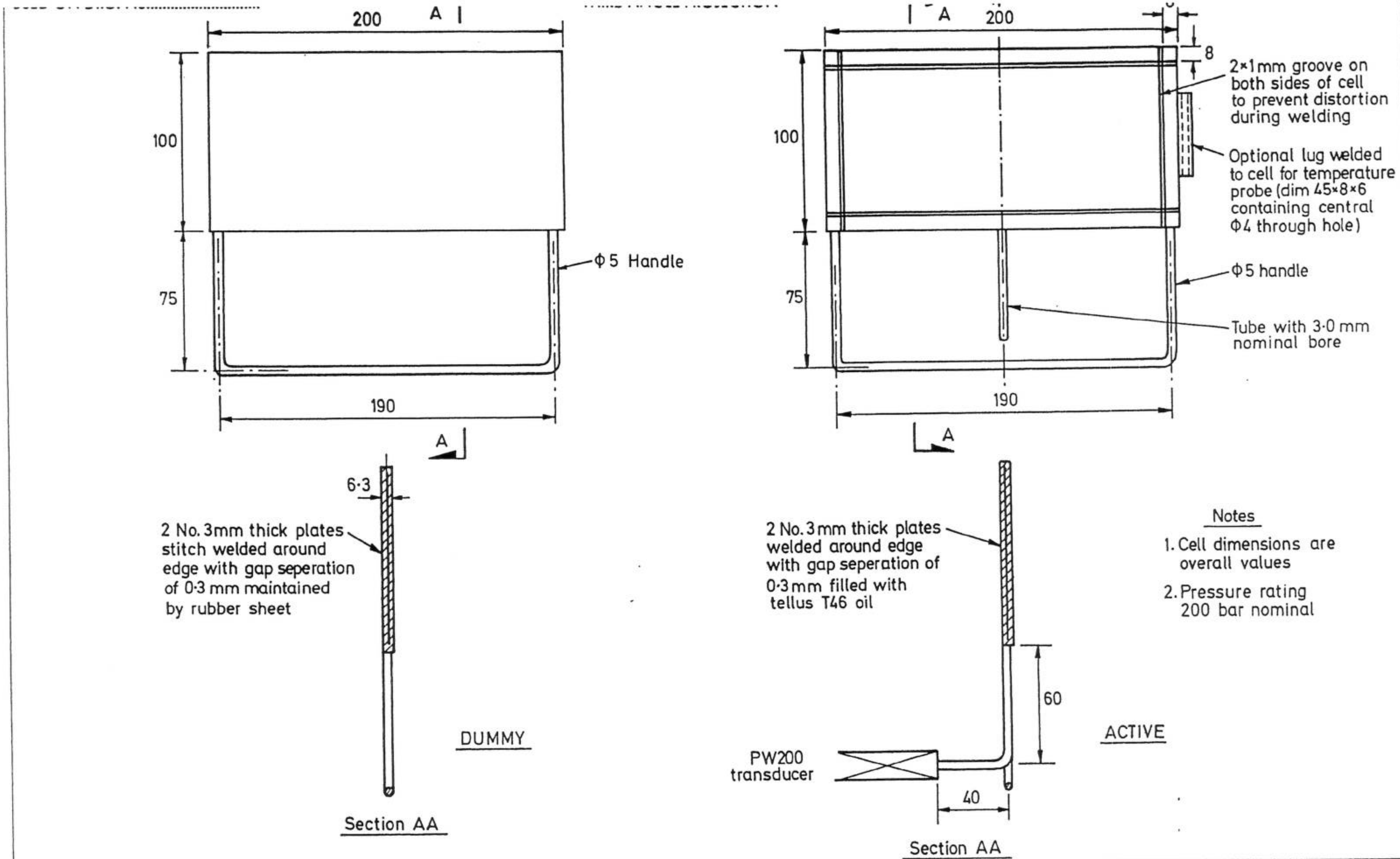


ISSUE	DATE	MODIFICATION
1	3. 1990	

MATERIALS PERSPEX		TOLERANCES ±0·1 mm except where noted otherwise	
FINISH			
SCALE 1:1	DRN. P. Norris	TRD.	CHK'D.

DEPARTMENT OF ENGINEERING SCIENCE
OXFORD UNIVERSITY

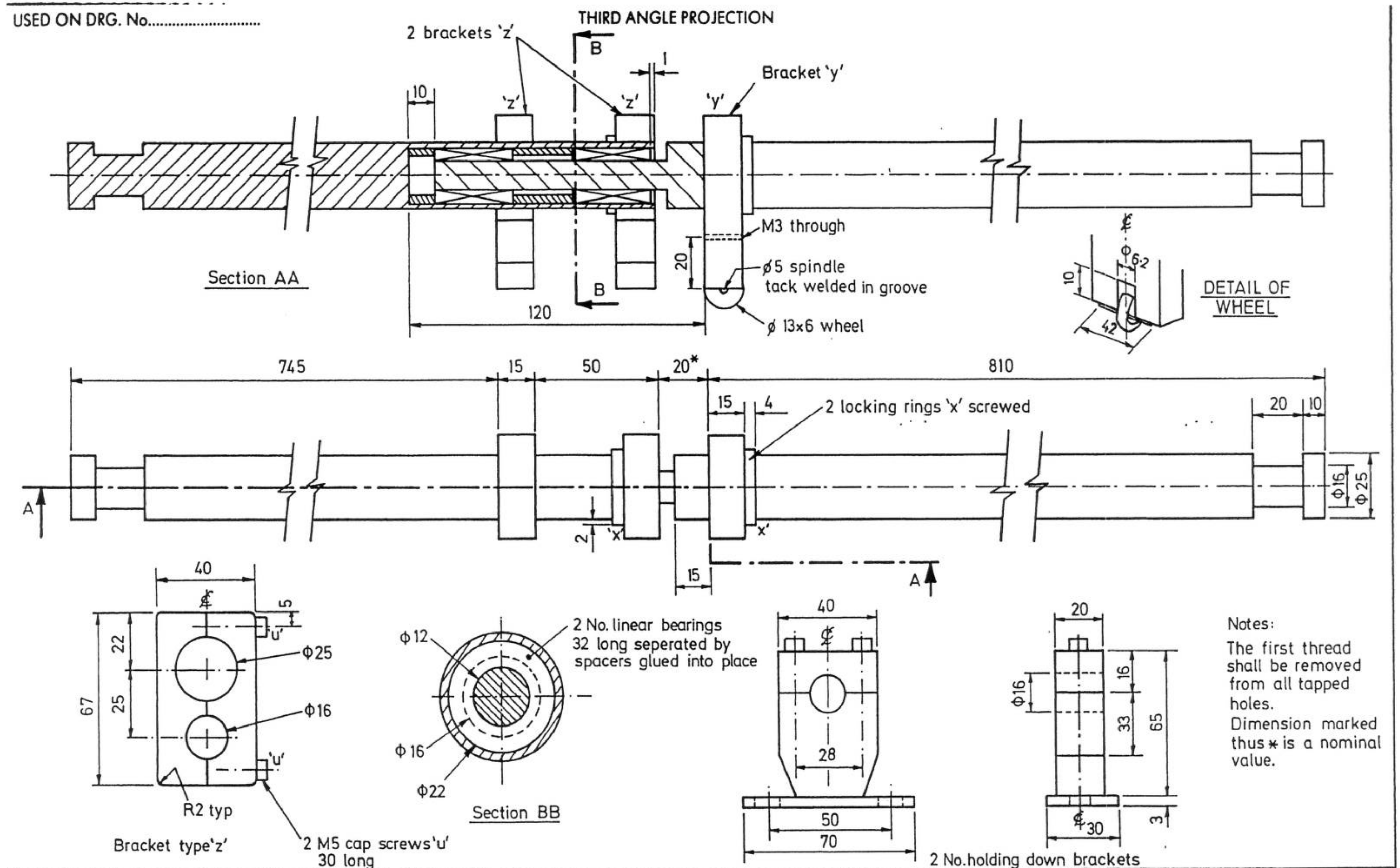
TITLE	DRAWING No.
PORE PRESSURE PROBE CALIBRATION / TRANSPORTATION CHAMBER	A PN/PJR/10



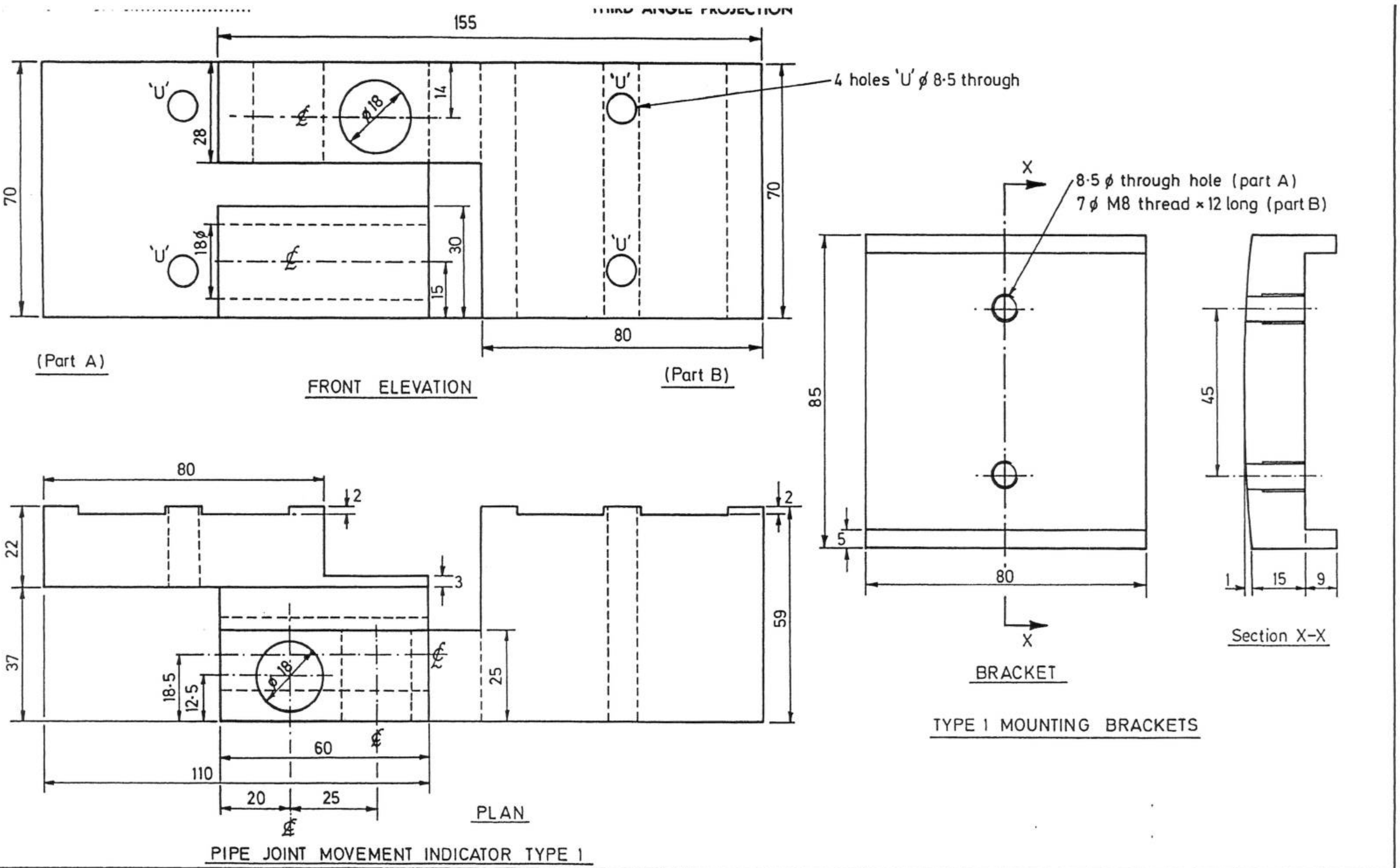
ISSUE	DATE	MODIFICATION	MATERIALS Stainless steel		TOLERANCES		DEPARTMENT OF ENGINEERING SCIENCE OXFORD UNIVERSITY	
1	June 91		FINISH				TITLE 200×100 DUMMY AND ACTIVE PRESSURE CELLS	DRAWING No. A PN/PJR/11
			SCALE 2:1	DRN. P. Norris	TRD.	CHK'D.		

DDEC186

USED ON DRG. No.............................



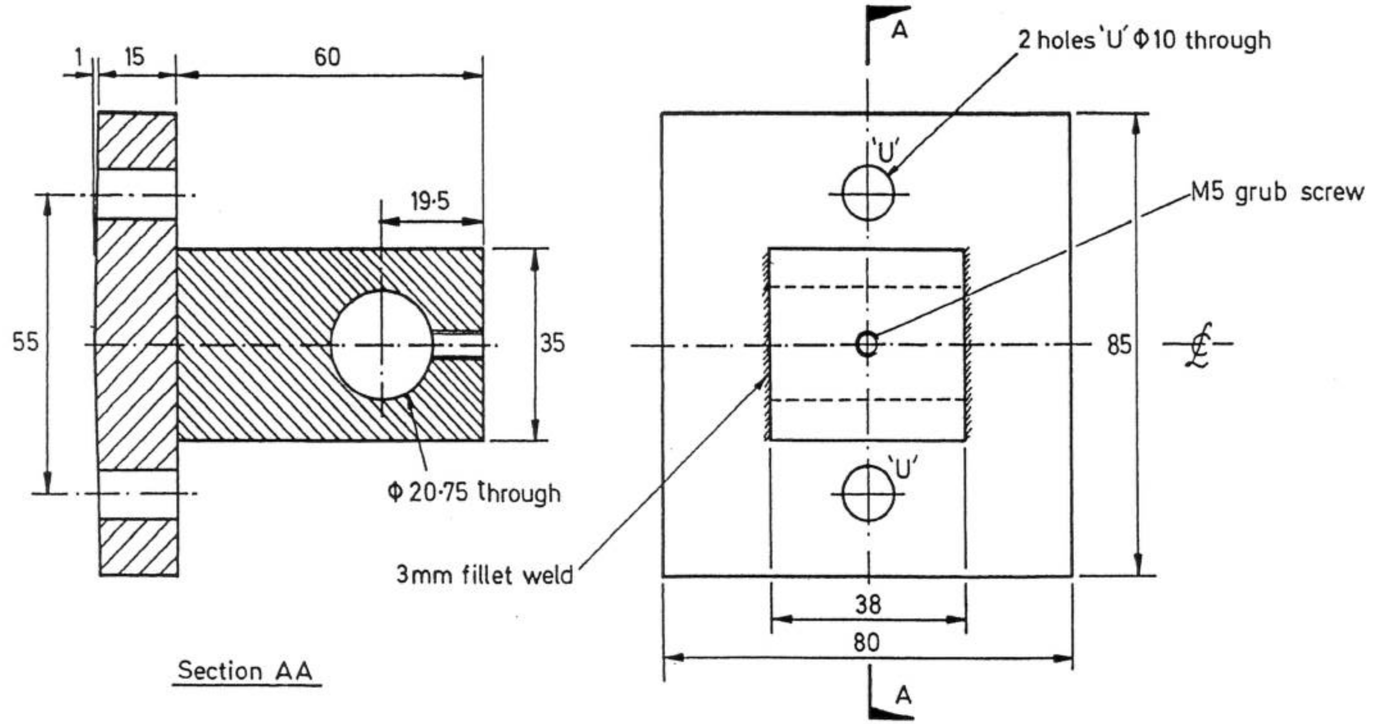
ISSUE	DATE	MODIFICATION	MATERIALS Round sections are silver steel other parts are mild steel	TOLERANCES ±0·1 mm except where noted otherwise	DEPARTMENT OF ENGINEERING SCIENCE OXFORD UNIVERSITY
1	Aug 89		FINISH		TITLE TUBE EXTENSOMETER
			SCALE Not to scale / DRN. P. Norris	TRD. / CHK'D.	DRAWING No. A PN/PJR12



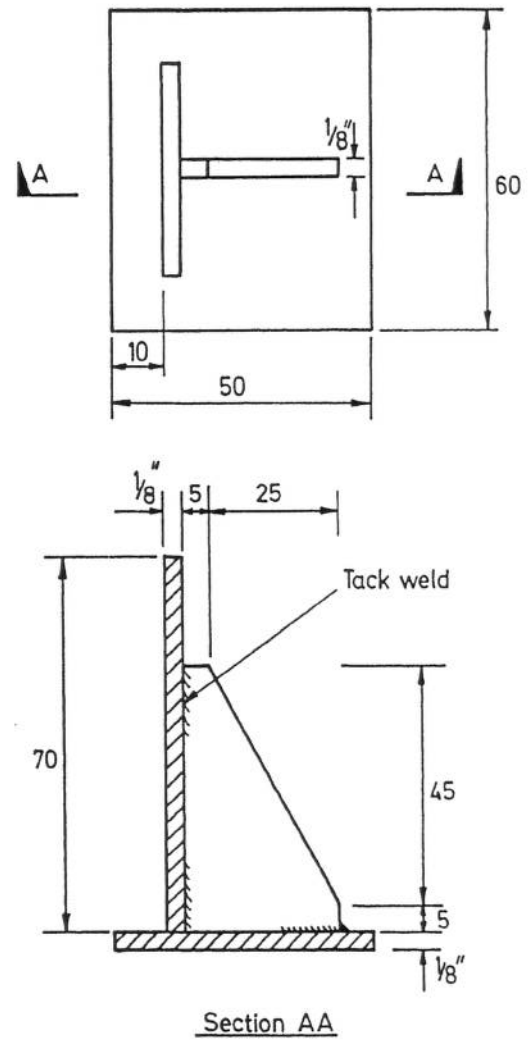
ISSUE	DATE	MODIFICATION	MATERIALS Aluminium		TOLERANCES ±0·1 mm		DEPARTMENT OF ENGINEERING SCIENCE OXFORD UNIVERSITY	
1	June 89		FINISH				TITLE	DRAWING No.
			SCALE 1:1	DRN. P. Norris	TRD.	CHK'D.	THREE DIMENSIONAL PIPE JOINT MOVEMENT INDICATOR	A PN/PJR 13

USED ON DRG. No............................

THIRD ANGLE PROJECTION



PIPE JOINT MOVEMENT INDICATOR
TYPE 2

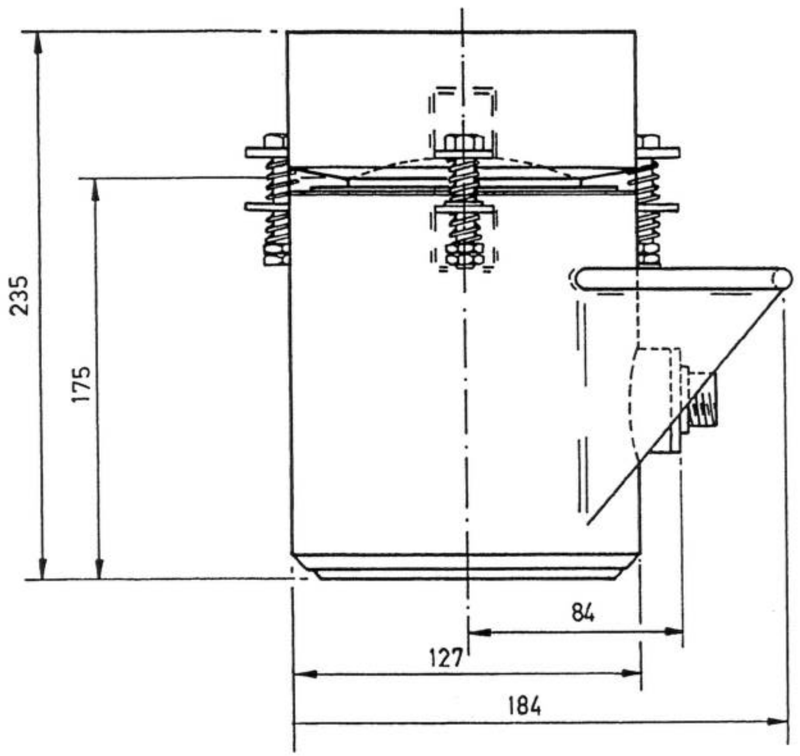


TYPE 2 TARGET

ISSUE	DATE	MODIFICATION	MATERIALS Aluminium		TOLERANCES ± 0·1		DEPARTMENT OF ENGINEERING SCIENCE OXFORD UNIVERSITY	
1	Sept 90		FINISH				TITLE ONE DIMENSIONAL PIPE JOINT MOVEMENT INDICATOR	DRAWING No. **A** PN/PJR/14
			SCALE 1:1	DRN. P. Norris	TRD.	CHK'D.		

USED ON DRG. No.

THIRD ANGLE PROJECTION



ISSUE	DATE	MODIFICATION	MATERIALS		TOLERANCES		DEPARTMENT OF ENGINEERING SCIENCE OXFORD UNIVERSITY	
			FINISH				TITLE JACK LOAD CELL DIMENSIONS	DRAWING No. A PN/PJR/15
			SCALE Not to scale	DRN.	TRD.	CHK'D.		

MY 184903 R

3. Calibration Rigs and Procedures

3.1 General

Reliable, safe calibration routines are a pre-requisite for field measurements. This is highlighted by the increasing application of modern electronic transducers which in most cases are interpreted as an indirect measurement of a physical quantity. Calibration procedures are therefore an integral part of the instrument quality assurance and should provide reliable information on the response of a single instrument subjected to various kinds of insitu excitation. In some cases however calibration routines may be inadequate because the well defined laboratory excitation does not model the insitu excitation conditions. Where possible the more precise methods restricted to the laboratory should be supplemented with simple check procedures in the field.

It is essential that instruments can be tested and calibrated on a regular basis. Calibrations procedures should therefore be as simple as possible. It is also important that calibration normals are incorporated into the procedures. These normals should be traceable and calibrated to national or international standards to ensure the expected accuracy. This requirement has been satisfied for the principal pipe jacking research instruments as follows:

(i) Contact stress cells: Calibrated using metal weights. The accuracy of properly manufactured weights is high in comparison to the field measurement requirements. Values of 10 kg weights when checked on a regularly calibrated set of scales showed errors less than ± 3g.

(ii) Pore pressure probes: Calibrated against a Druck digital pressure indicator checked by the manufacturer at the end of the monitoring programme and found to be in specification.

(iii) Joint pressure cells and jack load cells: Calibrated against a 50 Ton Denison Compression machine which is checked by the manufacturer on an annual basis. Calibrations of the machine over the 2 year monitoring period indicated that the machine remained within specification.

(iv) LVDT's: Calibrated by means of a micrometer screw bench. The precision of the micrometer screw bench itself being controlled by slip gauges which are manufactured and polished by high precision tools.

(v) Tube Extensometers: Calibrated against, optical gratings; accuracy ± 0.01mm.

3.2 Rigs and Procedures

3.2.1 <u>Contact stress cells</u>

The contact stress cells were calibrated using a special calibration rig which applies simultaneously shearing and compression forces to the active face. The calibration rig is illustrated in Plate 3.1. Assembly of the rig involves the following steps.

1. Fasten the bottom of the cell to the cross beam using two M6 cap screws.

2. Clamp the calibration block, design drawing PN/PJR/06, to the active face of the cell using two M10 cap screws which enter the threaded holes in the active face U-U of design drawing PN/PJR/01.

3. Hang the vertical weight hanger on the calibration block. A domed loading point is provided on the hanger cross arm and a series of dimples provided on the calibration block for concentric and eccentric load application. A lever arm arrangement is used to provide a mechanical advantage of 1.25 : 1. A small spirit level is used to check the verticality of the loading hanger.

4. The bowden cables attached to the calibration block are placed over each of the pulleys and a hanger attached to their ends. The assembly is ready for load application.

It is important to monitor the cell assembly and its incorporation into the calibration rig, using the three full bridge outputs, to avoid the possibility of overloading a cell. Load application is in accordance with the procedure summarised in Table 3.1

Step	Stage	Calibration	Radial kPa	Shear Kpa
1	Assembly	-	-	-
2	Exercise	Sustained loads	450 450	+202 -202
3	Exercise	Rapid cycling Rapid cycling	450	0→+202 0→-202
4 5 6	Shear Calibration	Vary shear stress whilst keeping radial stress constant	450 348 243	±202 ±202 ±202
7 8	Radial stress calibration	Vary radial stress whilst keeping shear stress constant	0-450 0-450	0 25
9 10	Eccentric loading	Apply radial load at +10mm Apply radial load at -10mm	0-450 0-450	0 0
11	Creep testing	Sustained loads	450	+202

Table 3.1. CALIBRATION PROCEDURE FOR CONTACT STRESS CELLS.

During the exercise period, sustained loading is in place for 24 hours. Rapid cycling involves applying 50 cycles of zero to maximum load using a quick release hydraulic hoist. The creep tests were carried out at the end of the calibration and involved maximum radial and shear loading being left in place for one week.

3.2.2 Pore pressure probes

Saturation of the pore pressure probe, using a general purpose grade glycerine, is achieved using the steps shown in the flowchart of Figure 3.1. The saturation and assembly procedure takes approximately 12 hours for each instrument.

Transducer calibration and transportation to site is carried out using the perspex cylindrical container detailed in design drawing PN/PJR/10. Transfer of the saturated probe to the stainless steel main housing which is glued into the pipe wall is left until the instrumented pipe is in position for jacking, thus minimising problems with desaturation.

The pore pressure probes are calibrated against a Druck digital pressure indicator (DPI). The calibration arrangement is shown diagrammatically in Figure 3.2.

3.2.3 Pipe joint pressure cells

The pipe joint pressure cells were calibrated against a 50 ton Denison loading machine. The test arrangement is illustrated in Plate 3.2 and consists of two 250 x 160 x 250mm grade 40 concrete blocks, a mild steel base plate, a 250 x 160 x25mm mild steel spreader plate machined to accept a 25mm diameter steel ball and 200 x 100 x 12mm medium density fibreboard (MDF) packer in a dry state. Note the packer material was pre conditioned by applying ten cycles of 0-34 tons of load before being used in any calibrations. This was necessary because tests had indicated that the material exhibited large permanent strain over the initial five load cycles (Figure 3.3) which can provide alternative load paths through the stiff cell edge during initial bedding down. A single packer was used to calibrate a total of twelve cells and was then changed.

The routine calibration procedure involves:

1. Set one of the concrete blocks level on the base plate using a thin layer of plaster of paris.

2. Glue the packer to the centre of the top face of the concrete block using araldite rapid two part epoxy resin.

3. Position the cell over the packer area ensuring that its edges are flush with the packer edge.

4. Set the spreader plate on the top of the second concrete block using plaster of paris.

5. Position the block and spreader cap centrally over the cell. A series of reference marks on the blocks and packer assist greatly during this operation.

6. Slide the total assembly into the compression machine ensuring that the centre of the ball bearing corresponds to the domed centre of the machine loading cap.

7. Set the oil delivery rate to a value of 3.5 and use the fine adjustment control to apply load.

Two levels of applied stress (2 cycles per stress level) were used during the routine calibration procedure; uniform stresses of 0-8.5N/mm^2 (0-17Tons) and 0-17N/mm^2 (0-34Tons) were used to simulate the anticipated average working stresses in a pipejack joint. Stress increments of 0.5N/mm^2 were adopted in the low stress range and 1N/mm^2 in the higher stress range. The delay time between load cycles was standardised at 5 minutes.

A principal assumption in the performance of the cell is that its high ratio of area to thickness approaches the ideal of an infinitely thin element minimising the influence of stress distortion due to variations in modulus between the sensor pad and the surrounding material.

Initial tests to determine the stress strain responses of a typical joint using 18mm nominal thickness MDF and the instrumented joint using a composite 12mm thick MDF and the 6mm thick cell are shown in Figures 3.3. The principal observations include:-

(i) The dry MDF suffers from irrecoverable deformation (compaction) on the first application of stress due to closure of voids in the material. Little additional compaction occurs under load cycling indicated by the relatively linear stress strain responses, although an increase in the applied stress produces further compaction. Irrecoverable strain immediately after the release of the final 17N/mm^2 stress cycle is approximately 60% of the maximum recorded strain.

(ii) Insertion of the cell into the dry MDF packer stiffens the joint response by an amount equivalent to the ratio of the original joint packer thickness to the modified joint packer thickness (i.e.) a 50% increase. The properties of the cell fluid appear to have little effect on the stiffness of the composite. In all other respects the behaviour of the composite is similar to the packer only case.

The stiffer response of the composite in the instrumented joint will lead to redistribution of normal stresses over the cell and an over prediction of the free field value.

The principal variables to be considered in evaluating the over - registration factor include:

a) The properties of the packer material under dry and saturated conditions.
b) The ratio of the cell area to loaded area.
c) The effect of load cycling and stress intensity.
d) The effect of shear forces.

e) The effect of eccentric loading over the cell area.
f) Temperature effects.
g) Duration of loading

A subsidiary set of calibration tests investigating these affects is in progress. Three stress levels; uniform 0-8.5N/mm^2 and 0-17N/mm^2; and an eccentric stress distribution with a maximum stress of 30N/mm^2 to simulate misalignment stresses are being used. The work will be presented separately in Barton (1992) It should be noted that the effect can be minimised by inserting dummy cells to provide a complete ring of cells and this has been done on schemes 4 and 5. Details of the dummy cells are given in drawing PN/PJR/11.

3.2.4 Tube extensometers

The LVDT's used in the tube extensometers were calibrated against a micrometer screw bench prior to assembly in the tube extensometers.

The tube extensometers were calibrated against an optical grating connected to a digital display unit on a milling machine. The calibration arrangement is illustrated in Plate 3.3 and described below:

1. Clamp one end of the tube extensometer to either a work bench or a pedestal. It is important that there is no movement at this support position.

2. Clamp the other end to the moving bed of the milling machine.

3. The central bracket should be supported to avoid sagging in the instrument.

4. The orientation and level of the instrument is checked to ensure that the linear movement of the machine bed is along the axis of the instrument. A spirit level is used to check the inclination.

5. During the calibration the machine bed is driven by hand with the displacement readout given on a digital display. The accuracy of the bed movement is ± 0.01mm.

6. The tube extensometers were subjected to two cycles within the following displacement ranges; ± 5mm in 1mm increments, ±5mm in 0.2mm increments, ± 0.5mm in 0.02mm increments.

3.2.5 Joint movement indicators

The LVDT's used in the joint movement indicators were calibrated against a micrometer screw bench. No calibrations were carried out with the LVDT's mounted in the aluminium assembly.

3.2.6 Jack load cells

Jack load cells were calibrated against a 50 ton Dension loading machine. The cells were subjected to concentric compression using a spreader cap and ball bearing arrangement. Each calibration consisted of applying 5 cycles of 45 ton in 5 ton increments with output being recorded on both the load and unload parts of the test.

3.2.7 Celesco unit

The unit was calibrated against a series of one metre rules laid end to end. The arrangement is illustrated in Plate 3.4. It is particularly important to clamp the free end of the cable against a small square block and slide this along the rulers. This reduces the likelihood of the spring controlled cable snapping back and damaging the unit.

3.2.8 Ground convergence indicator

The ground convergence indicator was calibrated against a 300mm steel rule held perpendicular to the top surface of the main housing and parallel to the spring loaded fin. Displacement increments of 5mm at the top edge of the fin were monitored on both the closing and opening cycles.

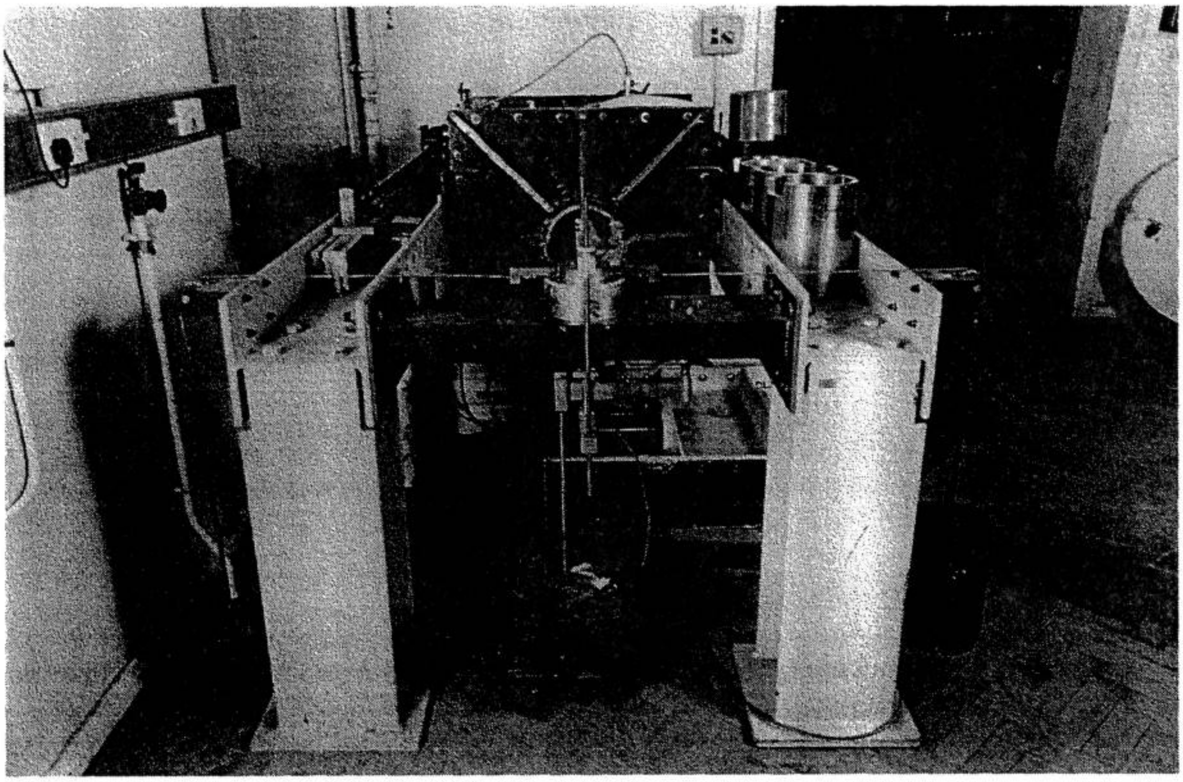


Plate 3.1 Calibration rig for contact stress cells

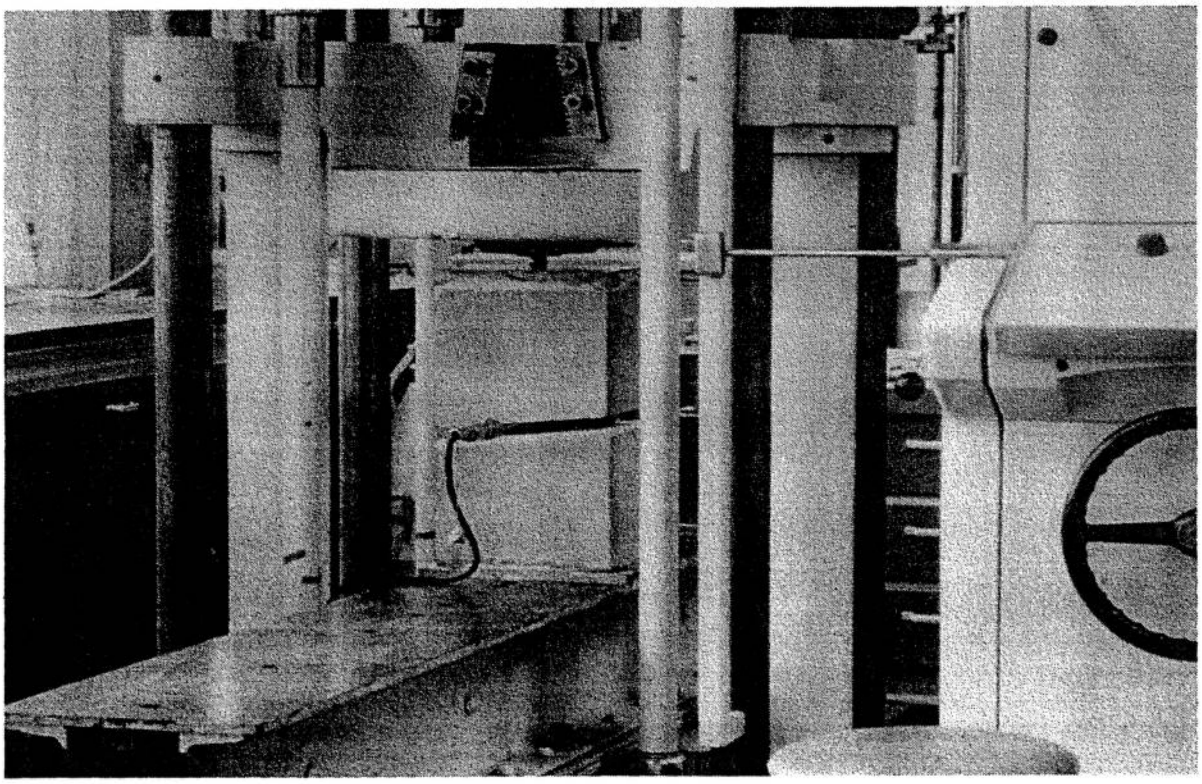


Plate 3.2 Calibration rig for pipe joint pressure cells

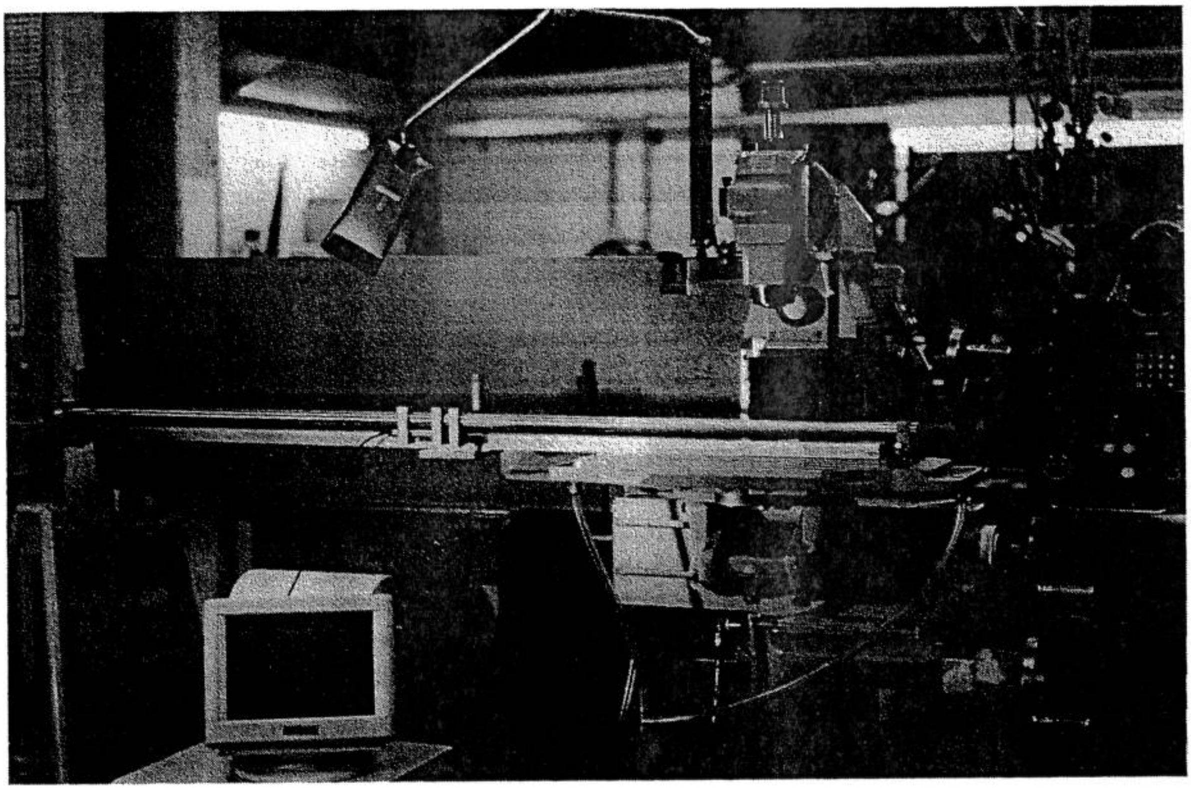


Plate 3.3 Calibration arrangement for tube extensometers

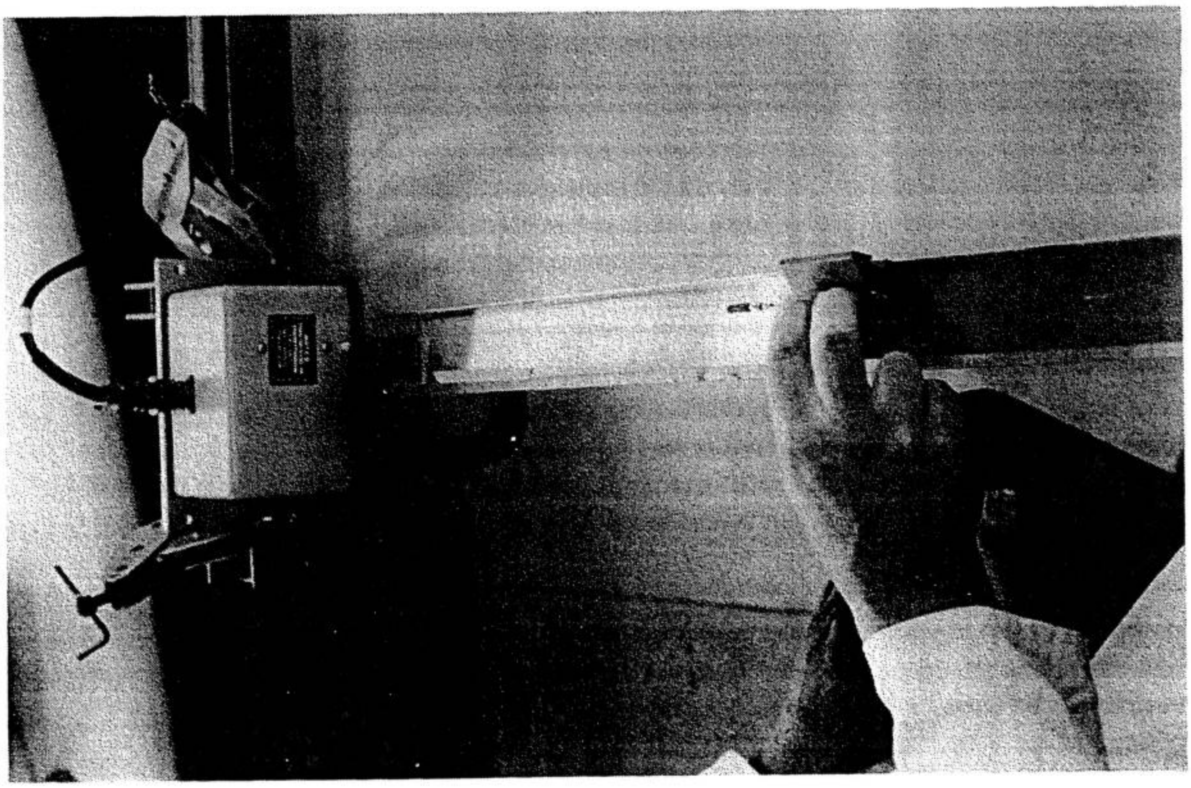


Plate 3.4 Calibration arrangement for celesco displacement transducer

Suspend the mounting block above a reservoir of glycerine in the vacuum/saturating chamber.

↓

Apply vacuum to chamber to remove air from the porous disc and to de-air the glycerine.

↓

Leave vacuum on for a minimum period of 6 hours. Immerse the mounting block into the glycerine and remove the vacuum, thereby saturating the disc.

↓

Immerse the transducer and thrust ring into the bath of glycerine dispelling any trapped air bubbles from the face of the transducer.

↓

Screw transducer into the back of the pore pressure mounting block.

↓

Remove from the bath of fluid and assemble it in the calibration/transportation container.

↓

Immerse the container in the bath and apply a vacuum for 30 minutes. Fix the top cap while the container is immersed.

↓

The unit may be stored prior to laboratory calibration and transportation to site.

Figure 3.1 PROCEDURE FOR SATURATION PORE PRESSURE SYSTEM WITH GLYCERINE FLUID

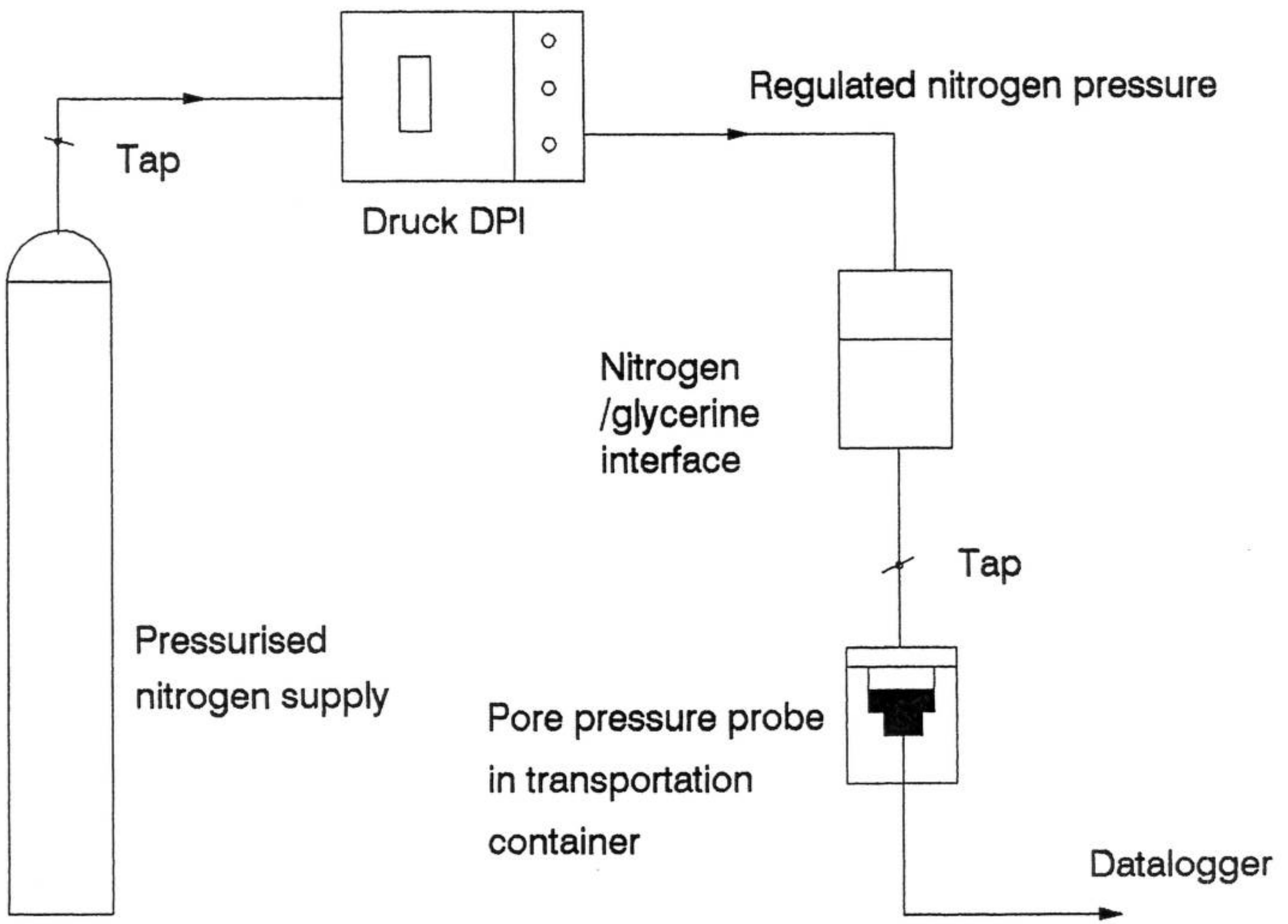
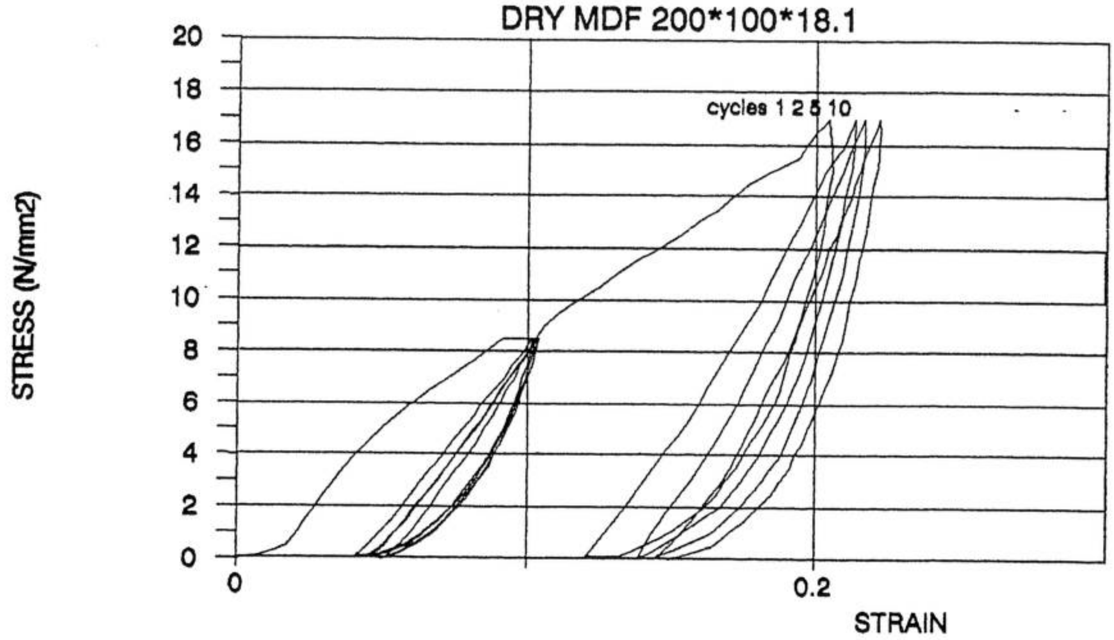


Figure 3.2 Pore pressure probe calibration arrangement



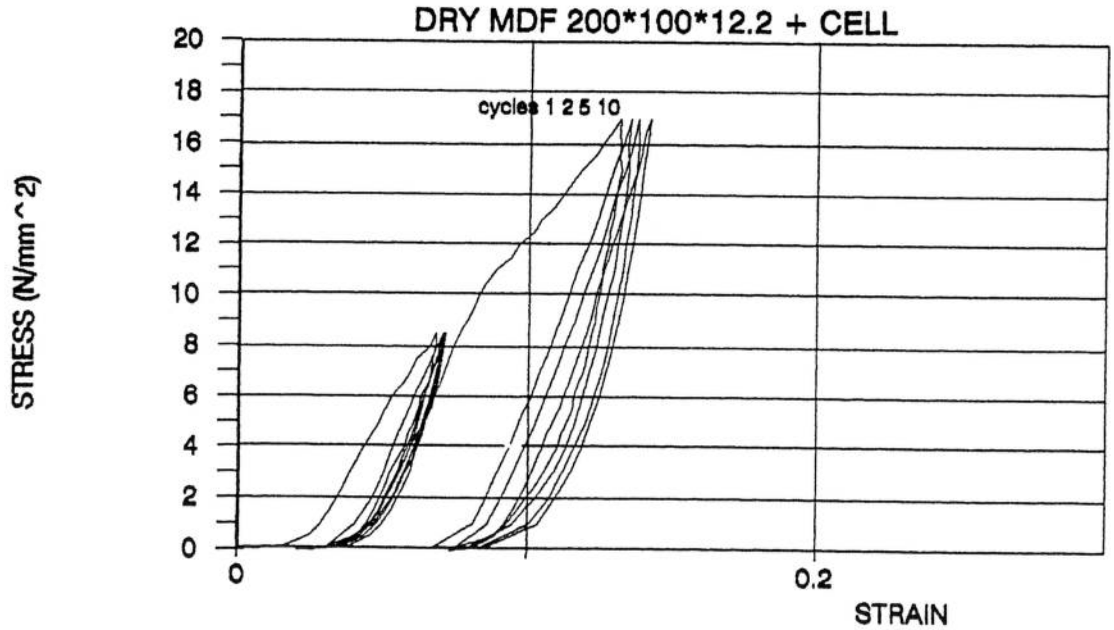


Figure 3.3 Stress strain response of packer material

PART 2

INSTRUMENT CALIBRATIONS AND PERFORMANCE ASSESSMENT

4. Instrument calibrations and interpretation

4.1 General

Before the results of the calibrations can be meaningfully discussed they need to be considered in the context of geotechnical field tests. The demand for accuracy of field measurements is often moderate because soil, by its nature, is inhòmógeneous. Measuring systems often trimmed to errors of a fraction of a percent of the full scale output under laboratory conditions do not need to illustrate this kind of accuracy in field usage - total errors of a few percent being tolerated in most cases.

There is little common ground for comparison of different transducer types using manufacturers' specifications because essential descriptive and performance specifications are generally quoted in widely different ways. The following notes are intended to clarify interpretation of instrument performance for this project:

Nominal working range

The range of the physical quantity within which the accuracy specification is maintained.

Accuracy

A term which consists of the composite errors due to hysteresis, nonlinearity, resolution and repeatability observed under constant environmental conditions.

Hysteresis

The difference between the output at a particular value measured on the upward and downward loop; it is expressed as a percentage of the full scale output.

Nonlinearity

On a plot of the measured output of a device versus the actual physical quantity, nonlinearity is a measure of the maximum deviation of the actual output from a least squares fit or "best" straight line. The coordinates of this line are established by normal statistical techniques supplied with Lotus 123 software. Non linearity is expressed as a percentage of full scale output.

Resolution.

The smallest change in the physical quantity that can be observed using the instrument and peripheral equipment.

Sensitivity

Sensitivity is the instrument output divided by the physical quantity.

Calibration coefficient

The reciprocal of sensitivity. This term is applied to the field output to convert it into engineering units.

Repeatability

The ability of a device to reproduce the same output for repeated identical physical quantities input under reference conditions.

Long term repeatability

The ability of an instrument, after each site use, to reproduce the same output for repeated identical physical quantities under laboratory reference conditions. Expressed as the percentage change in the calibration coefficient since the initial site 1 calibration.

Environmental sensitivity.

Most transducers are sensitive to temperature. At the extreme there is a survival temperature range, and in particular a maximum survival temperature, beyond which the transducer is likely to suffer permanent distortion or damage. Within this, there is an operating temperature range where the performance of the transducer should be within the specified accuracy limits unless particular temperature corrections are indicated. These are divided into zero shift and span shift, the latter being a change of sensitivity with temperature.

4.2 Presentation of the calibration data

In order to provide a rapid comparison of the individual calibrations, a series of tables listing the calibration coefficients and long term repeatability values for each instrument type have been produced. Interpretation of the instrument performance on a group basis is also presented. Individual calibration plots and data regression outputs can be found in Appendix III.

4.3 Discussion of the calibration data.

4.3.1 Contact stress cells

The contact stress cells are one of the most vulnerable instruments. They contain at their heart a Cambridge earth pressure transducer with relatively slender strain-gauged webs which are liable to damage by overloading and to strain gauge failure if moisture gets in. Table 4.1 presents the calibration history of the various contact stress cells that have been used on site. It will be noted that gauge readings have been lost on site 1 due to moisture ingress and site 3 where one complete transducer was crushed.

Each stress cell can measure the force applied normal to its active face, the component of the shear force in the direction parallel to the cell's longer edge and the moment applied to the active face about the axis parallel to the short edge. The relationship between output voltage and applied stress is given in equation 4.1.

$$\begin{vmatrix} Vn \\ Vs \\ Vm \end{vmatrix} = \begin{vmatrix} Vno \\ Vso \\ Vmo \end{vmatrix} + \begin{vmatrix} ann & ans & anm \\ asn & ass & asm \\ amn & ams & amm \end{vmatrix} \begin{vmatrix} N \\ S \\ M \end{vmatrix} \qquad (4:1)$$

where Vn, Vs, Vm are output voltage (mV),
N, S, M are radial stress (kPa), shear stress (kPa) and moment (Nm) respectively,
Vno, Vso, Vmo are constant and occur when N=S=M=O,
ann, ans ... amm are calibration coefficients.

During field use it is necessary to determine the stresses acting on the load cell from observed output voltages. The equations relating the stresses to the output voltages are obtained by inverting the matrix of calibration coefficients.

$$\text{If } A = \begin{vmatrix} ann & ans & anm \\ asn & ass & asm \\ amn & ams & amm \end{vmatrix} \qquad (4.2)$$

$$\text{Then} \quad \begin{vmatrix} N \\ S \\ M \end{vmatrix} = A^{-1} \begin{vmatrix} Vn - Vno \\ Vs - Vso \\ Vm - Vmo \end{vmatrix} \qquad (4.3)$$

The experimental procedure for determining the calibration coefficients is presented in section 3.2.1. A typical example determining the calibration coefficients is included in Appendix II. The calibration data for the contact stress cells are presented in Tables 4.2 and 4.3 and Figures III1 to III57. The principal observations include:

(a) Nominal working ranges: radial ≥ 450 kPa, shear ≥ 200 kPa, moment ≥ 35 Nm.

(b) A near linear response is illustrated between the signal and the applied load for the radial and shear calibrations although the relationship between the moment circuit and the applied moment tends to exhibit very small curvature. Repeatability of readings on loading and unloading was excellent . Combined non-linearity and hysteresis is typically better than 0.3% FS for the radial stress calibration coefficient, 0.6 % FS for the shear stress calibration coefficient and 1.9 % FS for the moment calibration coefficient.

(c) When comparing long term zero stability and long term repeatability of calibration coefficients (Tables 4.2 and 4.3) it is necessary to consider the contact stress cell history of Table 4.1. The initial calibrations prior to site 1 were rechecked after site use by recalibrating cells 2 and 4. Both cells showed large zero shifts as a result of moisture ingress. The ingress in cell 3 was sufficient to cause debonding of gauges. The problem was due to an ill-fitting "O" ring design, uncoated strain gauges and non-annealed copper washers under the cap screws securing the cell cap to the transducer. All of these design faults were rectified before site 2. The response of the re-assembled cells 1 and 2 prior to use on site 2 illustrated maximum changes in the principal coefficients of 0.9% radial, 1.6% shear and 4.1% moment. The change in sign of the shear and moment coefficients in cell 1 is due to inserting the Cambridge transducer at 180° to its original position. Use of the cells on site 2 resulted in further changes in the zero values. The cells were taken apart, inspected and all the seals replaced prior to site 3. The zero stability problems appear to have been overcome by site 3. The zero shift over the last 3 sets of calibrations is less than 2.5%FS. The problems with moisture do not appear to have adversely affected the calibration coefficients. The changes to the principal values over the five calibrations are typically less than 1.7% on the radial circuit, 1.8% on the shear circuit and 10.2% on the moment circuit. The larger variation in the moment calibration coefficient is felt to be a function of the bedding error of the hanger each time a calibration is carried out resulting in difficulties in obtaining consistent readings.

(d) Calibration of cell 5 prior to site 3, indicated that the cell response was faulty. Unfortunately the cell was used on site 3 because the short lead in time between site 2 and 3 prevented detailed interpretation of the calibrations and thus detection of the fault. The cell was subsequently crushed in service and could therefore not be recalibrated or inspected to establish possible reasons for the abnormal response.

4.3.2 Pore pressure probes:

The calibration data for the pore pressure probes are presented in Table 4.4 and Figures III58 to III62. The principal observations include:

a) Nominal working ranges 3 bar, 5 bar and 7 bar. Overpressure typically 3 times the working range.

b) Typical calibration coefficients of:

3.7 kPa/mV/5V for 3 bar instrument
6.8 kPa/mV/5V for 5 bar instrument
8.8 kPa/mv/5V for 7 bar instrument

c) Combined non-linearity and hysteresis is better than ± 1.1% FS.

d) Insufficient calibrations have been carried out over the 5 site monitoring period to make long term changes to the calibration coefficients meaningful. Comparison of the calibrations made for site 4 with the manufacturers indicate a difference of up to

3.8%. It is not certain whether this change is due to differences in the calibration procedures, changes in temperature or changes in the transducer with usage.

e) Manufacturers stated environmental sensitivity for the Druck PDCR81 unit include:

Thermal sensitivity shift	± 0.2 % of reading per °C.
Thermal zero shift	± 0.05 % FS per °C.

Laboratory verification of these transducer factors has not been carried out since the installed pore pressure probe response and ambient site temperatures are monitored prior to installation into the tunnel.

4.3.3 Pipe joint pressure cells

The response of the pressure cells to concentric loads of 0-17 Tons and 0-34 Tons are presented in Tables 4.5 to 4.6 and Figures III63 to III161.

The principal observations include:

a) Nominal working range 40 Ton. Typical ultimate load 300% of working load.

b) The calibration coefficients illustrate small differences between the two calibration load ranges. In general, the coefficients from the higher load range are up to 5% greater. This is a result of the non-linear response of the cells over the initial 4 Ton loading range and is probably related to bedding in effects. The initial non-linearity and the relatively small difference between the "high" and "low" load coefficients has led to the 0-34 Ton coefficient being used throughout the field data reduction.

c) The typical cell response is linear and repeatable. The combined non-linearity and hysteresis for the 0-34 Ton load range includes:

76% of calibrations	≤	± 1.0% FS
89% of calibrations	≤	± 1.6% FS
Worst calibrations	≤	± 2.6% FS

d) Typical calibration coefficients are in the range 1.708 Tons/mV/10V to 2.024 Tons/mV/10V.

e) Long term zero stability is good with maximum changes of 1.0% FS over the 15 month site monitoring period.

f) Long term repeatability of the calibration coefficients is poor. 41.5% of cells illustrate changes of up to 2.5% from their initial calibration, 29% up to 5.0%, 17% up to 7.5% and 12.5% up to 10.0%. The changes are not wholly consistent with some coefficients showing increases followed by decreases. The largest changes occur after sites 2 and 3. The extracted cells from these sites where deformed and in the case of site 3 badly scored. Calibration factors therefore appear to be highly dependent upon damage sustained during site use and substantiate the importance of carrying out calibrations for each cell after each site visit. Future calibrations need however only be carried out in the 0-34 Tons load range only.

g) Manufacturers thermal effects were not supplied. Thermal effects are unlikely to be critical since temperature variations in the tunnel are typically between ± 1°C.

4.3.4 Tube extensometers

The calibration data for the LVDTs used in the tube extensometers and the tube extensometers are presented in Table 4.7 and Figures III162 to III195. The principal observations include:

a) Nominal working ranges ± 5mm for RDP transducer and 0 to 25mm for LSC transducer.

b) LVDT calibration coefficients are in the range 3.81 μm/mV/10V (≡2.38 $\mu\varepsilon$/mV/10V) to 4.19 μm/mV/10V (≡2.62 $\mu\varepsilon$/mV/10V) for the RDP transducers and 377 μm/mV/10V (≡235 $\mu\varepsilon$/mV/10V) for the LSC transducer.

c) Typical combined non-linearity and hysteresis of the LVDTs is better than ± 0.3% FS.

d) Long term changes to the calibration coefficients is generally less than 2.0% over the 5 site monitoring period.

e) Parasitic effects from the tube extensometer operation are negligible (typically 0.24% change in calibration coefficient compared to the LVDT value) during calibration. The calibration factor for each LVDT is therefore applicable to the tube extensometer into which they are installed. Typical combined linearity and hysteresis for the tube extensometer is ± 0.58% FS.

f) LVDT manufacturers stated thermal effects include:

Temperature coefficient of sensitivity	± 0.02% FS per °C.
Thermal zero shift	± 0.05% FS per °C.

No specific temperature calibrations have been carried out for the tube extensometer assembly.

4.3.5 Joint movement indicators

The calibration data for the joint movement indicator LVDTs are presented in Table 4.8 and Figures III196 to III239. The principal observations include:

a) Nominal working ranges ± 25mm and ± 5mm.

b) The LVDT calibration coefficients are in the range 11.26 to 11.35 μm/mV/10V for the ± 25mm instruments and -3.63 to -3.71 μm/mV/10V for the ± 5mm instruments.

c) Combined non-linearity and hysteresis is better than ± 0.35% FS.

d) Long term changes to the calibration coefficients is less then ± 0.55% over the 5 site monitoring period.

e) LVDT manufacturers stated thermal effects include:

Temperature coefficients sensitivity	± 0.03% FS per °C.
Thermal zero shift	± 0.01% FS per °C.

4.3.6 Jack load cells

The calibration data for the jack load cells are presented in Table 4.9 and Figures III240 to III255. The principal observations include:

a) Nominal working range 200 Tons. Ultimate load 300% of working range.

b) The load cell calibration coefficients are in the range 13.065 to 13.163 Tons/mV/10V.

c) Combined non-linearity and hysteresis is better than ± 0.7% FS.

d) Long term changes to the calibration coefficients are less than 0.6% during the 5 site monitoring period. This also takes into account damage sustained by load cell 50915 during sites 3 and 4 in which the load cell cap was sheared off and required rewelding.

e) The load cells are well designed for their intended purpose. Although the repeatability of calibrations indicate that recalibration of each cell is not necessary for every site, all of the other instrument responses are related to the total jacking load and it is therefore important that they continue to be calibrated for each site.

f) Long term zero stability in the cells is good. Two of the cells show changes less than 0.4% FS, one cell 0.63% FS and the cell subject to most abuse on site 1.28% FS.

g) The thermal effects for the jack load cell include:

Temperature coefficient of sensitivity	± 0.005% rated load per °C.
Thermal zero shift	±0.005% rated load per °C.

Checks on thermal zero shift during site use are readily available from the field data.

4.3.7 Celesco

The calibration data for the two different celesco units are presented in Table 4.10 and Figures III256 to III260. The principal observations include:

a) Two nominal working ranges were used 0-100 inch and 0-150 inch.

b) Instrument calibration coefficients for unit 1 (range 0 - 100 inch) was 257 μm/mV/10V and unit 2 (range 0 - 150 inch) 411 μm/mV/10V.

c) Combined non-linearity and hysteresis better than ± 0.15% FS.

d) No apparent long term change in calibration.

e) No manufacturers thermal information is provided. No attempt has been made to evaluate thermal effects on the instrument since the device is principally used as a means of monitoring pipe string movement and not an accurate record of distance pushed.

4.3.8 Ground convergence indicator.

The ground convergence indicator has only been used on site 1. The calibration data is presented in Figure III261.

	CONTACT STRESS CELL				
DESCRIPTION	1	2	3	4	5
(i) Calibration May 1990 for use on site 1	✓ CEC 1	✓ CEC 2	✓ CEC 3 (Moisture ingress damaged cell)	✓ CEC 4	
(ii) Recalibration Oct. 1990 to check effect of site use. All 4 contact stress cells taken apart and 0- rings replaced		✓		✓	
(iii) Recalibration Dec 1990 after cells taken apart and "O" rings replaced	✓ CEC 1	✓ CEC 2	✓ CEC 5	✓ CEC 4	
(iv) Site 2	✓ CEC 1 (large zero shift)	✓ CEC 2			
(v) Calibration Feb 1991	(✓) CEC 1	(✓) CEC 2			✓ CEC 6
(vi) Site 3		✓ CEC 2	✓ CEC 5	✓ CEC 4	✓ CEC 6 (crushed)
(vii) Calibration May 1991 for use on site 4	✓ CEC 1	✓ CEC 2	✓ CEC 5	✓ CEC 4	
(viii) Calibration Sept 1991 for use on site 5	✓ CEC 7*	✓ CEC 2	✓ CEC 5	✓ CEC 4	✓ CEC 8*

Notes
1. CEC - Cambridge earth pressure cell
2. ( ) - Partial calibration
3. * - Cells with vertical web thickness increased from 0.8 to 1.2mm and horizontal webs increased from 0.65 to 0.9mm

Table 4.1 CONTACT STRESS CELL HISTORY

	SITE 1			SITE 2			SITE 3			SITE 4			SITE 5		
CONTACT	29.330	0.031	0.062	29.463	-0.183	-0.071	29.643	-0.089	0.357	29.828	-0.253	-0.662	50.058	0.726	0.174
STRESS	0.156	16.758	-0.734	-0.043	-16.583	2.130	-0.008	-16.529	2.223	-0.081	-16.831	2.711	-0.052	22.275	-2.430
CELL 1	-0.012	-2.054	-7.854	0.010	1.980	8.062	0.167	1.745	7.051	0.209	1.855	7.482	0.027	-2.452	-13.357
CONTACT	30.308	0.046	-0.158	30.038	0.019	-0.160	30.014	0.046	-0.260	30.095	0.331	-0.112	30.196	0.325	-0.208
STRESS	0.022	-14.927	1.445	0.165	-14.691	1.381	0.022	-14.952	1.503	0.135	-15.021	1.724	0.039	-14.893	1.949
CELL 2	0.231	1.744	8.949	-0.111	1.936	8.579	-0.119	2.275	8.990	-0.064	1.825	8.415	-0.106	1.763	8.126
CONTACT	30.449	0.457	-0.132				-31.276	-1.416	-0.398	-31.236	-1.356	-0.178	-31.123	-1.459	-0.482
STRESS	-0.287	-17.248	-2.203				-0.385	16.317	-1.428	0.034	16.456	-2.189	0.035	16.412	-2.152
CELL 3	-0.016	1.824	8.668				-0.118	-1.946	-8.374	-0.060	-1.952	-8.355	0.040	-2.005	-8.661
CONTACT	-30.943	0.765	-0.153				-30.881	0.308	-0.094	-31.035	0.315	-0.215	-31.309	0.358	-0.229
STRESS	0.344	16.272	-2.389				0.155	15.990	-2.325	0.117	16.150	-3.226	0.035	16.572	-1.535
CELL 4	0.096	-1.919	-8.696				-0.048	-1.996	-8.298	-0.056	-2.017	-8.502	-0.033	-1.975	-8.416
CONTACT							-34.163	10.601	38.488				50.794	-0.025	0.812
STRESS							-25.387	-5.775	-75.524				-0.052	21.121	-2.841
CELL 5							-9.092	6.085	-18.944				-0.154	-2.386	-13.389

Table 4.2 CONTACT STRESS CELL CALIBRATION COEFFICIENTS [A^{-1}]

		SITE 1		SITE 2		SITE 3		SITE 4		SITE 5	
		(mV)	% change	(mV)	% change	(mV)	% change	(mV)	% change	(mV)	% change
CONTACT STRESS CELL 1	Vno	6.469	-	-4.158	-	82.072	-	82.352	1.8	9.357	-
	Vso	1.880	-	9.372	-	8.170	-	8.419	2.2	-3.959	-
	Vmo	-0.169	-	0.809	-	22.629	-	22.497	-3.4	3.543	-
CONTACT STRESS CELL 2	Vno	8.981	-	15.407	-	15.236	-	15.397	1.1	15.313	0.5
	Vso	1.459	-	9.699	-	7.948	-	8.124	-1.4	8.162	-1.6
	Vmo	-2.657	-	-3.822	-	-3.698	-	-3.760	1.5	-3.727	0.7
CONTACT STRESS CELL 3	Vno	5.410	-			14.025	-	14.322	-2.1	14.361	-2.3
	Vso	-1.594	-			14.585	-	14.812	1.9	14.853	2.2
	Vmo	5.276	-			0.930	-	0.970	-1.0	0.982	-1.3
CONTACT STRESS CELL 4	Vno	1.760	-			3.668	-	4.033	-2.5	4.027	-2.5
	Vso	4.936	-			5.729	-	5.674	-0.5	5.697	-0.3
	Vmo	-2.958	-			-6.711	-	-6.725	-0.4	-6.703	0.2
CONTACT STRESS CELL 5	Vno					3.881	-			0.263	-
	Vso					-5.332	-			-11.951	-
	Vmo					4.962	-			3.620	-

Notes:- 1. % change = change in zero from site 3* 100/full scale output for circuit.

Table 4.3 CONTACT STRESS CELL ZERO SHIFT

	SITE 1	SITE 2	SITE 3	SITE 4		SITE 5
Serial Number	Calibration factor (kPa/mV/5V)	Calibration factor (kPa/mV/5V)		Calibration factor (kPa/mV/5V)	% change	
5292 (3 Bar)■	3.383 (3.482*)	-	-	3.363	-0.59	-
5293 (3 Bar)■	3.861*	-	-	3.713	-3.8	-
5361 (7 Bar)■	-	8.894*	-	8.774	-1.35	-
5369 (7 Bar)■	-	8.909*	-	8.936	0.30	-
4922 (5 Bar)■	-	-	-	-		-

Notes: 1. * Instrument manufacturers calibration
2. ■ Manufacturers stated working range
3. % change = change in coefficient * 100/initial coefficient

Table 4.4 CALIBRATION COEFFICIENTS FOR PORE PRESSURE PROBES

	SITE 1		SITE 2		SITE 3		SITE 4		SITE 5	
CELL	Calibration Coeffiicent (Tons/mV/10V)	% Change	Calibration Coefficient (Tons/mV/10V)	% Change	Calibration Coefficient (Tons/mV/10V)	% Change	Calibration Coefficient (Tons/mV/10V)	% Change	Calibration Coefficient (Tons/mV/10V)	% Change
9527	1.835	-	1.891	3.1	1.939	5.7	1.974	7.6	-	-
9528	1.798	-	1.816	1.0	1.881	4.6	1.966	9.3	-	-
9529	1.790	-	1.762	-1.6	1.844	3.0	1.775	-0.8	1.873	4.6
9530	1.865	-	1.857	0.4	1.920	2.9	2.022	8.4	-	-
9531	1.864	-	1.882	1.0	1.937	3.9	1.939	4.0	2.024	8.6
9532	1.825	-	1.859	1.9	1.918	5.1	1.908	4.5	1.874	2.7
9533	1.839	-	1.873	1.8	1.978	7.6	-	-	-	-
9534	1.815	-	1.825	0.6	1.939	6.8	1.895	4.4	-	-
9535	-1.805	-	-1.801	-0.2	-1.916	6.1	-1.792	-0.7	-1.887	4.5
9536	1.824	-	1.832	0.4	1.917	5.1	1.817	-0.4	1.970	8.0
9537	1.708	-	1.722	0.8	1.819	6.5	1.725	1.0	1.776	4.0
9538	1.871	-	1.886	0.8	1.960	4.8	1.907	1.9	1.967	5.1
0558	-	-	-	-	-	-	-	-	1.801	-
0559	-	-	-	-	-	-	-	-	1.816	-
0560	-	-	-	-	-	-	-	-	1.801	-
0561	-	-	-	-	-	-	-	-	1.855	-
0562	-	-	-	-	-	-	-	-	1.779	-
0563	-	-	-	-	-	-	1.817	-	1.856	2.1
0564	-	-	-	-	-	-	-	-	1.859	-
0565	-	-	-	-	-	-	-	-	1.825	-
0566	-	-	-	-	-	-	1.708	-	1.882	5.7
0567	-	-	-	-	-	-	1.814	-	1.882	3.7
0568	-	-	-	-	1.770	-	1.731	-2.2	1.880	6.2
0569	-	-	-	-	1.809	-	-	-	-	-
0570	-	-	-	-	1.853	-	1.858	0.3	1.886	1.8
0571	-	-	-	-	1.764	-	1.831	3.8	-	-
0572	-	-	-	-	1.756	-	1.804	2.7	1.827	4.0
0573	-	-	-	-	1.769	-	-	-	-	-
0574	-	-	-	-	1.726	-	1.821	5.5	1.940	10.5
0575	-	-	1.729	-	1.828	5.7	1.780	2.9	1.846	6.8
0576	-	-	1.876	-	1.895	1.0	2.020	7.7	-	-
0577	-	-	1.771	-	1.787	0.9	1.798	1.5	1.842	4.0
0578	-	-	1.851	-	1.821	-1.6	1.896	2.4	-	-
0579	-	-	-	-	1.841	-	1.870	1.6	1.845	0.2

Notes: 1. Values are quoted for the 0-34 Ton load range only
2. % change = (site "n" coefficient - initial coefficient)*100/initial coefficient

Table 4.5 PIPE JOINT PRESSURE CELL CALIBRATION COEFFICIENTS

	SITE 1		SITE 2		SITE 3		SITE 4		SITE 5	
CELL	Zero (mV)	%	Zero (mV)	%	Zero (mV)	%	Zero (mV)	%	Zero (mV)	%
9527	0.217	-	0.269	0.26	0.270	0.26	0.338	0.61	-	-
9528	-0.219	-	-0.193	0.13	-0.186	0.17	-0.089	0.65	-	-
9529	-0.009	-	0.067	0.38	0.072	0.41	0.146	0.78	0.205	1.1
9560	-0.105	-	-0.061	0.22	-0.069	0.18	-0.105	0	-	-
9531	0.268	-	0.294	0.13	0.298	0.15	0.363	0.48	0.381	0.57
9532	-0.020	-	0.009	0.15	0.029	0.25	0.153	0.87	0.132	0.76
9533	-0.113	-	-0.101	0.06	-0.094	0.10	-	-	-	-
9534	0.201	-	0.247	0.23	0.249	0.24	0.245	0.22	-	-
9535	0.134	-	0.091	-0.22	0.082	-0.26	0.053	-0.41	0.027	-0.54
9536	-0.217	-	-0.171	0.23	-0.134	0.42	-0.061	0.78	-0.012	1.0
9537	0.001	-	0.120	0.60	0.128	0.64	0.201	1.0	0.190	0.95
9538	-0.006	-	0.013	0.10	0.032	0.19	0.081	0.44	0.110	0.58
0558	-	-	-	-	-	-	-	-	0.030	-
0559	-	-	-	-	-	-	-	-	-0.137	-
0560	-	-	-	-	-	-	-	-	0.096	-
0561	-	-	-	-	-	-	-	-	0.196	-
0562	-	-	-	-	-	-	-	-	-0.269	-
0563	-	-	-	-	-	-	-0.129	-	-0.112	0.09
0564	-	-	-	-	-	-	-	-	-0.276	-
0565	-	-	-	-	-	-	-	-	-0.229	-
0566	-	-	-	-	-	-	0.208	-	0.216	0.04
0567	-	-	-	-	-	-	-0.157	-	-0.145	0.06
0568	-	-	-	-	-0.163	-	-0.095	0.34	-0.097	0.33
0569	-	-	-	-	-0.150	-	-0.163	-0.07	-	-
0570	-	-	-	-	0.048	-	0.098	0.25	0.120	-0.36
0571	-	-	-	-	0.091	-	0.234	0.72	-	-
0572	-	-	-	-	0.093	-	0.109	0.08	0.079	-0.07
0573	-	-	-	-	0.101	-	0.042	-0.30	-	-
0574	-	-	-	-	-0.161	-	0.008*	0.85	0.064	0.49
0575	-	-	0.272	-	0.215	-0.29	0.189*	-0.42	0.168	-0.52
0576	-	-	-0.093	-	-0.075	0.09	-0.058	0.18	-	-
0577	-	-	-0.302	-	-0.304	-0.01	-0.326	-0.12	-0.361	-0.30
0578	-	-	0.137	-	0.135	-0.01	0.272	0.68	-	-
0579	-	-	-	-	0.165	-	0.169	0.02	0.149	-0.08

Notes: 1. % change = change in zero from initial calib. *100/Rated Output

Table 4.6 PIPE JOINT PRESSURE CELL ZERO SHIFT

LVDT's	SITE 1		SITE 2		SITE 3		SITE 4		SITE 5	
Serial Number	mm/mV/10V	% change	mm/mV/10V	% change	mm/mV/10V	% change	mm/mV/10V	% change	mm/mV/10V	% change
953	-0.00382	-	-0.00380	-0.52			-0.00381	-0.06	-0.00381	-0.26
954	-0.00403	-	-0.00401	-0.50			-0.00398	-1.24	-0.00397	-1.50
955					-0.00402	-	-0.00410	2.00	-0.00410	2.00
956					-0.00388	-	-0.00386	-0.52	-0.00384	-1.0
977					-0.00418	-	-0.00419	0.24	-0.00418	0
LSC	0.377190	-			0.377323	0.04	-0.377120	-0.02	0.376952	-0.06
EXTENSOMETERS		% diff						% diff		
TE 953	-0.00383	0.26								
TE 954	-0.00404	0.25					-0.00398	0		
TE 955							-0.00411	0.24		
TE 977							-0.00420	0.24		
TE LSC	0.377395	0.05					-			
NO CHECK KEPT ON ZERO SHIFT										

Notes: 1. % change = (site "n" coefficient - initial coefficient) * 100/initial coefficient
2. % diff = (LVDT coefficient - T.E coefficient) * 100/LVDT coefficient

Table 4.7 CALIBRATION COEFFICIENTS FOR TUBE EXTENSOMETER LVDT'S & EXTENSOMETERS

LVDT's	SITE 1		SITE 2		SITE 3		SITE 4		SITE 5	
Serial Number	mm/mV/10V	% change	mm/mV/10V	% change	mm/mV/10V	% change	mm/mV/10V	% change	mm/mV/10V	% change
653	-0.01128	-	-0.01134	0.53	-0.01132	0.35	-0.01134	0.53	-0.01132	0.35
654	-0.01130	-	-0.01135	0.44	-0.01132	0.18	-0.01133	0.26	-0.01131	0.09
655	-0.01132	-	-0.01133	0.09	-0.01133	0.09	-0.01132	0	-0.01133	0.09
753	-	-	-0.01130	-	-0.01128	-0.17	-0.01129	-0.09	-0.01128	-0.17
754	-	-	-0.01129	-	-0.01126	-0.27	-0.01127	-0.18	-0.01125	-0.35
755	-	-	-0.01135	-	-0.01130	-0.44	-0.01130	-0.44	-0.01131	-0.35
3926	-	-	-	-	-0.00366	-	-	-	-0.00368	0.55
3927	-	-	-	-	-0.00363	-	-	-	-0.00364	0.28
3928	-	-	-	-	-0.00366	-	-	-	-0.00367	0.27
3929	-	-	-	-	-0.00374	-	-	-	-0.00376	0.53
3930		-	-	-	-0.00370	-	-	-	-0.00371	0.27
3931	-	-	-	-	-0.00367	-	-	-	-	-

Notes: 1. No check kept on zero shift
2. % change = (site "n" coefficient - initial coefficient) * 100/initial coefficient

Table 4.8 CALIBRATION COEFFICIENTS FOR JOINT MOVEMENT INDICATOR LVDT'S

LOAD CELL	SITE 1		SITE 2		SITE 3		SITE 4		SITE 5	
Serial Number	(Tons/mV/10V)	% change	(Tons/mV/10V)	% change	(Tons/mV/10V)	% change	(Tons/mV/10V)	% change	(Tons/mV/10V)	% change
50912	-	-	-	-	13.119	-	13.137	0.1	13.157	0.3
50913	-	-	-	-	13.105	-	13.099	-0.1	13.107	0
50914	13.133	-	13.173	0.3	13.154	0.2	13.109	-0.2	13.065	-0.5
50915	13.083	-	13.142	0.4	13.166	0.6	13.163	0.6	13.125	0.5
					(Zero shift)					
LOAD CELL	Zero (mv)	%	Zero (mv)	%	Zero (mv)	%	Zero (mv)	%	Zero (mv)	%
50912	0.051	-	-	-	0.053	0.01	0.054	0.02	0.056	0.03
50913	-0.015	-	-	-	-0.022	-0.05	0.064	0.53	0.079	0.63
50914	0.020	-	0.011	-0.06	-0.011	-0.21	0.079	0.39	0.079	0.39
50915	-0.056	-	-0.062	-0.04	0.055*	0.74	0.068*	0.83	0.136	1.28

1. * Load cell damaged on site: cap sheared off
2. % change in calibration coefficient = (site "n" coeff initial coeff) * 100/initial coeff)
3. % change in zero = change in zero from initial calib. * 100/F.S. output

Table 4.9 CALIBRATION COEFFICIENTS FOR JACK LOAD CELLS

	SITE 2		SITE 3		SITE 4		SITE 5	
	m/mV/10V	% change	m/mV/10V	% change	m/mV/10V	% change	m/mV/10V	% change
UNIT 1	0.000257	-	0.000257	0	-	-	-	-
UNIT 2	-	-	-	-	0.000411	-	0.000411	0

Table 4.10 **CALIBRATION COEFFICIENTS FOR CELESCO UNITS**

5. Conclusions and comments

Design phase

All the instruments have been selected or designed to operate successfully in an aggressive tunnel environment, have minimal effect on the property to be measured, be sufficiently accurate and reasonably simple to calibrate and to minimise disruption to normal site operations. Where possible advantage has been taken of the reduced development and testing costs of using commercially available instruments. The pipe joint pressure cells, jack load cells and celesco unit fall into this category and have performed well. The remaining instruments were specifically designed and manufactured for the pipe jacking research and performed within specification, with the exception of the ground convergence indicator which had a poor field performance record. The cost of the project hardware is currently £73,000. All of the equipment has been designed for easy retrieval from the permanent works and subsequent reuse. Insurance of the equipment (while in Oxford and on the various sites) has been arranged through Burlington Insurance Services Ltd.

Calibration phase

Extensive laboratory calibration of the instruments has been carried out prior to the start of each contract. The calibration procedures have been designed to simulate as closely as practical the insitu excitation of the various instruments, be simple to perform and minimise the amount of time spent carrying them out. A full set of calibrations typically takes 135 hours to complete. Typical instrument performance under laboratory conditions are presented in Table 5.1. All the instrument types produce near linear and repeatable responses under laboratory calibrations. Moisture ingress, the main cause of zero drift in strain gauged transducers has been eliminated in the designs resulting in very small zero changes. Long term changes in the calibration coefficients of the instruments are negligible (< 2%) with the exception of the pipe joint pressure cells. Routine recalibrations may therefore be carried out on a less frequent basis, perhaps every third site. The pipe joint pressure cells appear to be sensitive to minor damage sustained during extraction from the joints and it is therefore recommended that each cell is recalibrated prior to site use. Where possible simple site check procedures have been adopted to verify correct performance.

Temperature coefficients are not shown in Table 5.1. Field monitoring of pipejack tunnel temperatures indicate that a stable environment (± 1 °C) exists when the instrumented pipe is insitu. Temperature changes are therefore not a major variable. It is sufficient to monitor the various instrument responses when the pipe is on the surface (subjected to ambient temperature changes) and use the resulting trends to adjust the zero values of the instruments to the values expected at ambient tunnel temperatures.

Fieldwork phase

The careful selection and design of the instruments has led to few in service failures (Table 5.2). The pipe joint pressure cells, jack load cells, pipe joint movement indicators, tube extensometers and data acquisition system demonstrated their fitness for purpose during the pilot test. The contact stress cells initially highlighted problems due to ground water ingress but this was overcome by redesign of the primary seals. The pore pressure probes were found to be susceptible to cable damage during extraction and future use of the current design will need to be supplemented with an armoured cable.

Only the celesco displacement unit and ground convergence indicator performed poorly in the field. The celesco unit was very prone to damage and required frequent repair, although it did provide useful data. The ground convergence indicator quickly became non operational because of fine particles jamming between the PTFE wipers and the spring loaded fin preventing further movement. A complete redesign of the instrument is necessary if convergence data is required on future contracts.

Greater automation of the monitoring process is now possible and can be achieved by updating the data acquisition software. The present system operates on a time basis with full manual intervention required because the jacking process was not well defined at the start of the research. By linking the acquisition interval to threshold values based on time, jacking load level and pipe string movement an automatic system can be obtained.

Instrument type	Working range	Excitation voltage	Calibration coefficients	Combined non linearity & hysteresis (% FS)	Long term zero stability (% FS)	Long term calibration coefficient changes (%)
Contact stress	Radial > 450 kPa Shear > 200 kPa	5V	30 kPa/mV/5V *	± 0.3 ± 0.6	2.5 2.2	1.7 1.8
Pore pressure	3 bar 5 bar 7 bar	5V	3.7 kPa/mV/5V 6.8 kPa/mV/5V 8.8 kPa/mV/5V	± 1.1	0.2	3.8
Pipe joint pressure	40 Ton (20 MPa)	5V	1.7 to 2.0 Tons/mV/10V	± 1.6	1.0	10.0
Tube extensometer	RDP ± 2.5 mm LSC ± 2.5 mm (± 1562 $\mu\varepsilon$)	10V	2.5 $\mu\varepsilon$/mV/10V 236 $\mu\varepsilon$/mV/10V	± 0.6	-	2.0
Pipe joint movement	(i) ± 25 mm (ii) ± 5 mm	10V	11.3 $\mu\varepsilon$/mV/10V 3.7 $\mu\varepsilon$/mV/10V	± 0.35	-	0.5
Jack load cells	200 Tons	10V	13.1 Tons/mV/10V	± 0.7	0.6	0.6
Celesco displacement	(i) 0-100 inch (ii) 0-150 inch	10V	257 μm/mV/10V 411 μm/mV/10V	± 0.15	0	0

Notes:
1. * denotes coupled term unable to state as a single direct calibration coefficient.
2. Values of combined non-linearity etc for the shear term are based on the shear circuit output under the shear calibration loading.

Table 5.1 LABORATORY CALIBRATION PERFORMANCE

Schemes	Bolton (Scheme 1)		Newcastle (Scheme 2)		Honor Oak (Scheme 3)		Abbey Village (Scheme 4)		Cheltenham (Scheme 5)	
Instrument type	Number	Failures/Cause	Number	Failures/Cause	Number	Failures/Cause	Number	Failures/Cause	Number	Failures/Cause
Contact stress	4	2/Moisture ingress	2	1 Moisture	4	1/Overload	4	-	5	Cables cut by coring contractor
Pore pressure	2	-	2	-	4	4/Cables severed	4	1/Faulty repair cable	5	3/Faulty cable repairs
Pipe joint pressure	12	-	16	-	24	3/Cells crushed	24	-	16	-
Joint movements	3	-	6	-	6	-	6	1/LVDT cable cut	6	1 LVDT faulty
Tube extensometers	3	-	2	-	5	-	6	-	5	-
ERS gauges	3	3/Moisture	N/A	N/A	2	2/Moisture	N/A	N/A	N/A	N/A
Jack load cells	2	-	2	-	4	-	4	-	4	1/Cable cut
Temperature probes	4	-	5	1 Moisture	4	-	4	-	5	-
Ground convergence	1	1/Fine particles caused jamming	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pipeline displacement transducer	N/A	N/A	1	1/Draw wire snapped	1	1/Draw wire snapped	1	-	1	1/Draw wire snapped
Data acquisition	Complete	-	Complete	-	Complete	1/Cabin network interface failure	Complete	1/Pit bottom box failure	Complete	-
Total No. channels	42		40		68		67		57	

Table 5.2 FIELD RELIABILITY

6. Bibliography

Barton, C.A. (1992) "Performance of Glotzl Type Pressure Cells in Pipe Jack Joints". 4th Year Project Report, Department of Engineering Science, University of Oxford.

Bond, A.J. (1989) "Behaviour of Displacement Piles in Overconsolidated Clays". PhD Thesis, Imperial College of Science, Technology and Medicine, University of London.

Bransby, P.L. (1972) "Cambridge Contact Stress Transducers" Lecture notes for the course "Research techniques and equipment in soil mechanics" Cambridge University Engineering Department, Report N°. CUED/C-SOILS/LN2

APPENDICES

I 2 **Pore pressure probes**

Pressure transducer PDCR 81 with ceramic tips extracted and supplied loose. (Pressure ranges used 3,5, & 7 bar.)	**Druck Ltd** Fir Tree Lane Groby Leicester LE6 0FH Tel. 0533 314314
"O" Rings. Vitron rubber Refs. 022 and 806	**Mecro Ltd** Unit 14A Botley Works North Hinksey Lane Botley Oxford OX2 0LL Tel. 0865 250060
Glycerol GPR (Product Nº 28454-6F)	**BDH Chemicals** Fourways Atherston Warwickshire CU9 1JQ Tel. 0202 745520
Sintered stainless steel. Grade PH PSS ((i.e.) 13 μm pore size 0.125 inch sheet thickness)	**PALL** Europa House Havant Street Portsmouth PO1 3RD Tel. 0705 753545
Acetal copolymer. (Black) Extruded rod 45mm diameter.	**VT Plastics** Unit 3 Block B Electra Park Ind. Estate Electric Avenue Witton Birmingham B6 7EB Tel. 021 328 5880
Aradlite two part epoxy adhesive	**Ciba - Geigy Plastics** Duxford Cambridge CB2 4QA Tel. 0223 832121

I 3 **Pipe joint pressure cells**

Manufacture and supply
100 x 200mm x 6mm Tellus T46 oil filled 300 bar pressure cell fitted with transducer supplied by others

Soil Instruments Ltd
Bell Lane
Uckfield
East Sussex
TN22 1QL
Tel. 0825 5044

Pressure transducer type "PW-200"
(Fitted to above cell)

Techni Measure
Alexandra Buildings
Studley
Warwickshire
B8 7NJ
Tel. 0527 854103

I 4 **Tube extensometers**

D2/200 DC-DC LVDT's.
(Working Range ± 5mm)

RDP Electronics Ltd
Grove Street
Heath Town
Wolverhampton
WV10 0PY

Linear bearings
Ref. 0600/012 (12mm internal diameter by 32mm long)

Mecro Ltd
Unit 14A
Botley Works
North Hinksey Lane
Botley
Oxford OX2 0LL
Tel. 0865 250060

I 5 **Joint movement indicators**

LDC/1000/ A DC-LVDT's
(working range ± 25mm)

D2/200/ A DC-DC LVDT's
(working range ± 5mm)

RDP Electronics Ltd
Grove Street
Heath Town
Wolverhampton
WV10 0PY
Tel. 0902 57512

Multi Bond 330 structural adhesive	**Loctite UK** Watchmead Welwyn Garden City Herts AL7 1JB Tel. 0707 331277

I 6 Jack load cells

Basic 2385-2 type load cell with four M10 tapped holes in the base, top cap, single carrying handle and an integral 8m of non standard type P5 underwater cable	**Strainstall Ltd** Denmark Road Cowes Isle of Wight PO31 7TB Tel. 0983 295111

I 7 Celesco unit

Model PT 101 (Range 0-150 inches)	**Calvin Instruments** Smugglers Wood Road Christchurch Dorset BH23 4PL Tel. 04252 76808

I 8 Ground convergence indicator

Rotary potentiometer Ref FCPS - 22AC - 10K	**Techni Measure** Alexandra Buildings Studley Warwickshire Tel. 0527 854103
Cable gland: (Order Code 9521)	**Farnell Electronics** Canal Road Leeds West Yorkshire LS12 2TU Tel. 0532 636311

I 9 Data acquisition and power supply

1 Nº 7010 measurement module including processor, battery backed RAM, 14/16 bit ADC, local expansion bus, isolated RS232 host communications port and isolated RS485 network interface.	**Measurement Systems Ltd** Units 4B/7B Faraday Road Newbury Berkshire RG13 2AD Tel. 0635 42677
4 Nº 7020 16 channel analogue input module for current, voltage and thermocouples	"
1 Nº 7220 16 channel measurement processor including processor, battery backed RAM, 14/16 bit ADC, isolated RS232 host communication port, isolated RS485 network interface and 16 input channels for current, voltage and thermocouples.	"
1 Nº 7011 Network interface module including processor, battery backed RAM, isolated RS232 host communications port and isolated RS485 network interface.	"
1 Nº 7021 8 channel analogue input module for voltage, thermocouple, strain and platinum resistance temperature probes.	"
UNIGEN - IBM PC compatible data logging software	"
Transformer box fitted with three dual output transformrs six rectifiers, six smoothing circuits, six low voltage output connectors, one 110 V inlet connector and the internal wiring of the various components. (Steel enclosure supplied by PJR Group).	**Oxford Scientific Products Ltd** 74 Shakespeare Road Eynsham Oxford OX8 1PY Tel. 0865 883211
Regulator and transducer interface boxes filled with one regulator card with capacity to supply sixteen transducers, sixteen Lemo connectors, one low voltage inlet connector, internal wiring to interconnect the sixteen transducer connectors, the regulator board, the low voltage input and the Datascan unit. (Datascan and steel enclosures supplied by PJR Group).	"
Steel enclosure. Environmental protection IP55. Stock Number 508-958 and 509-248.	**R S Components** P.O. Box 99 Corby Northants NN129RS Tel. 0536 201201

Chassis plate. Stock number 508-144 and 508-138. "

110V plugs, sockets and surface mounted inlets for power supply cables. Stock numbers 488-719, 488-854 and 487-457 respectively. "

Lemo Connectors.

Size 1	Environmentally	sealed		4 way
"	"	"	"	5 way
"	"	"	"	6 way
size 2		"	"	5 way
size 2	"	"	"	6 way
size 3		"	"	5 way

Lemo UK Ltd
12 North Street
Worthing
West Sussex BN11
Tel. 0903 34543

Low voltage power sockets and plugs, miniature sealed baynet coupling pattern 105 AB connectors Ref Nº 10-06 plug and socket (Military specification MIL-C26482)

AB Connectors Ltd
Abercynon
Mountain Ash
Mid Glamorgan
CF45 4SF
Tel. 0443 740331

I 10 Cables

Power cable.
Flexible armoured cable
(order code 379-126)

RS Components
P.O. Box 99
Corby
Northants
NN17 9RS
Tel. 0536 201201

Signal Cable
multipair O/A Screen
(order code GB150)
1 twisted pair / PVC insulation

Unitel Ltd
Unitel House
Fishers Green Rd
Stevenage
Hertfordshire
SC1 2PT
Tel. 0438 312393

240/110V Portable isolation stepdown transformer. Rating 1200 kVA.	**Farnell Electronics** Canal Road Leeds West Yorkshire LS12 2YU Tel. 0532 636311
Din rails and mounting adaptors. Stock numbers 614-687 and 423-936	**R S Components** P.O. Box 99 Corby Northants NN17 9RS Tel. 0536 201201
Self amalgamating tape PIB (Polyisobuylene) grade	"
Ribbon cable and connectors 20 way plain grey. 3M Part No. 3365/20 20 way IDC socket Fujitsu Part No. FCN 707-B020 -AU/0-HN	**Vero Speed** Boyatt Wood Eastleigh Hampshire SO7 4ZY Tel. 0703 644555

II Example contact stress cell calibration coefficient calculation.

Consider the calibration of CSC2 prior to scheme 5.

Normal stress calibration: M = 0, S = 0, N = Variable

Using Figure III 46

(i) Vn = Vno + annN = 15.31287 + 0.033118N ⇒ Vno = 15.31287, ann = 0.033118

constant from normal circuit output — gradient

(ii) Vs = Vso + asnN = 8.162350 + 0.00014N ⇒ Vso = 8.16235, asn = 0.00014

constant from shear circuit output — gradient

(iii) Vm = Vmo + amnM = -3.72718 + 0.0004N ⇒ Vmo = -3.72718, amn = 0.0004

constant from moment circuit output — gradient

Shear stress calibration: M = 0, N = 450 kPa, S = variable

Using Figure III 47

(iv) Vn = Vno + ann N +ansS = 30.27929 + 0.000801S ⇒ ans = 0.000801, ann = 0.033236

$V_{no} + 450\,a_{nn}$

(v) Vs = Vso + asnN +assS = 8.222794 - 0.06529S ⇒ ass = -0.06529, amn = 0.00134

$V_{so} + 450\,a_{sn}$

(vi) Vm = Vmo + amnN + amsS = -3.582 + 0.014179S ⇒ ams = 0.014179, amn = 0.00032

$V_{mo} + 450\,a_{mn}$

Moment calibration: S = 0 N & M variable

Using Figure III 48

(vii) Vn = Vno + annN + anmM = Vno + $\left(\frac{ann}{1000Ae} + anm\right)$M

Where A is the area (m^2) of the active face = 0.00785398; e is eccentricity of load = +0.01m

constant from normal circuit output — gradient

= 15.29511 + 0.422331M

If ann = 0.033118
anm = 0.000655

(viii) $Vs = Vso + asnN + asmM \quad = \; Vso + \left(\frac{asn}{1000Ae} + asm\right)M$

$$= \; 8.13669 + 0.017448M$$

If $asn = 0.00014$
$asm = 0.015665$

(ix) $Vm = Vmo + amnN + ammM \quad = \; Vmo + \left(\frac{amn}{1000Ae} + amm\right)M$

$$= \; -3.78571 + 0.124768M$$

If $amn = 0.0004$
$amn = 0.119674$

Hence:

$$A = \begin{vmatrix} 0.03312 & 0.00080 & 0.00066 \\ 0.00014 & -0.06529 & 0.01567 \\ 0.00040 & 0.01418 & 0.11967 \end{vmatrix}$$

III Calibration plots and data regression analyses.

Erratum:

The plots of pipe joint pressure cell response reported herein refer to the name "Glotzl". It is not intended to infer that the cells were supplied by Glotzl Baumeßtechnik or their UK distributor Geotechnical Instruments.

CONTACT STRESS CELL 1 (SITE 1)

NORMAL LOAD VARIABLE M=0 S=0

NORMAL CIRCUIT

Regression Output:	
Constant	6.468523
Std Err of Y Est	0.004318
R Squared	0.999998
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	0.034084
Std Err of Coef.	0.000009

MOMENT CIRCUIT

Regression Output:	
Constant	-0.16855
Std Err of Y Est	0.009262
R Squared	0.063632
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	0.000025
Std Err of Coef.	0.000019

SHEAR CIRCUIT

Regression Output:	
Constant	1.880419
Std Err of Y Est	0.003201
R Squared	0.989078
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	-0.00032
Std Err of Coef.	0.000006

CONTACT STRESS CELL 1 (SITE 1)

NORMAL LOAD VARIABLE M=0 S=24.93kPa

NORMAL CIRCUIT

Regression Output:	
Constant	6.462129
Std Err of Y Est	0.002747
R Squared	0.999999
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	0.034072
Std Err of Coef.	0.000005

SHEAR CIRCUIT

Regression Output:	
Constant	3.351286
Std Err of Y Est	0.004999
R Squared	0.948426
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	-0.00022
Std Err of Coef.	0.000010

MOMENT CIRCUIT

Regression Output:	
Constant	-0.55310
Std Err of Y Est	0.016509
R Squared	0.346273
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	0.000127
Std Err of Coef.	0.000035

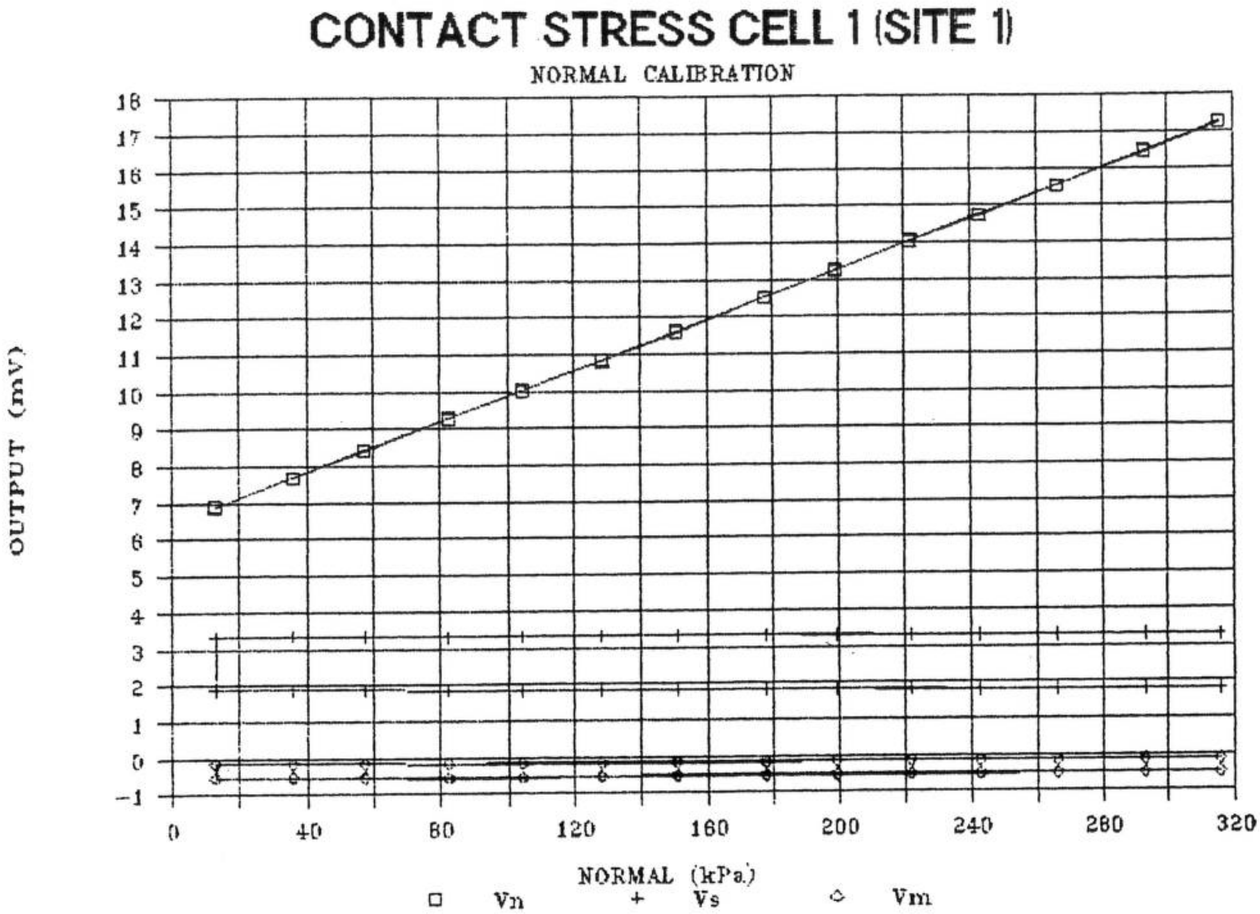

CONTACT STRESS CELL 1 (SITE 1)
NORMAL CALIBRATION
OUTPUT (mV)
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
0
40
80
120
160
200
240
280
320
NORMAL (kPa)
Vn
Vs
Vm

FIGURE III 1

CONTACT STRESS CELL 1 (SITE 1)

SHEAR LOAD VARIABLE M=0 N =316kPa

SHEAR CIRCUIT

Regression Output:	
Constant	1.7855
Std Err of Y Est	0.031576
R Squared	0.999963
No. of Observations	26
Degrees of Freedom	24
X Coefficient(s)	0.060446
Std Err of Coef.	0.000074

MOMENT CIRCUIT

Regression Output:	
Constant	-0.15007
Std Err of Y Est	0.007244
R Squared	0.999970
No. of Observations	26
Degrees of Freedom	24
X Coefficient(s)	-0.01537
Std Err of Coef.	0.000017

NORMAL CIRCUIT

Regression Output:	
Constant	17.21661
Std Err of Y Est	0.013814
R Squared	0.108297
No. of Observations	26
Degrees of Freedom	24
X Coefficient(s)	-0.00005
Std Err of Coef.	0.000032

CONTACT STRESS CELL 1 (SITE 1)

SHEAR LOAD VARIABLE M=0 N =221kPa

SHEAR CIRCUIT

Regression Output:	
Constant	1.806825
Std Err of Y Est	0.051341
R Squared	0.999902
No. of Observations	26
Degrees of Freedom	24
X Coefficient(s)	0.059864
Std Err of Coef.	0.000120

MOMENT CIRCUIT

Regression Output:	
Constant	-0.20532
Std Err of Y Est	0.012712
R Squared	0.999906
No. of Observations	26
Degrees of Freedom	24
X Coefficient(s)	-0.01509
Std Err of Coef.	0.000029

NORMAL CIRCUIT

Regression Output:	
Constant	13.97890
Std Err of Y Est	0.013041
R Squared	0.334789
No. of Observations	26
Degrees of Freedom	24
X Coefficient(s)	-0.00010
Std Err of Coef.	0.000030

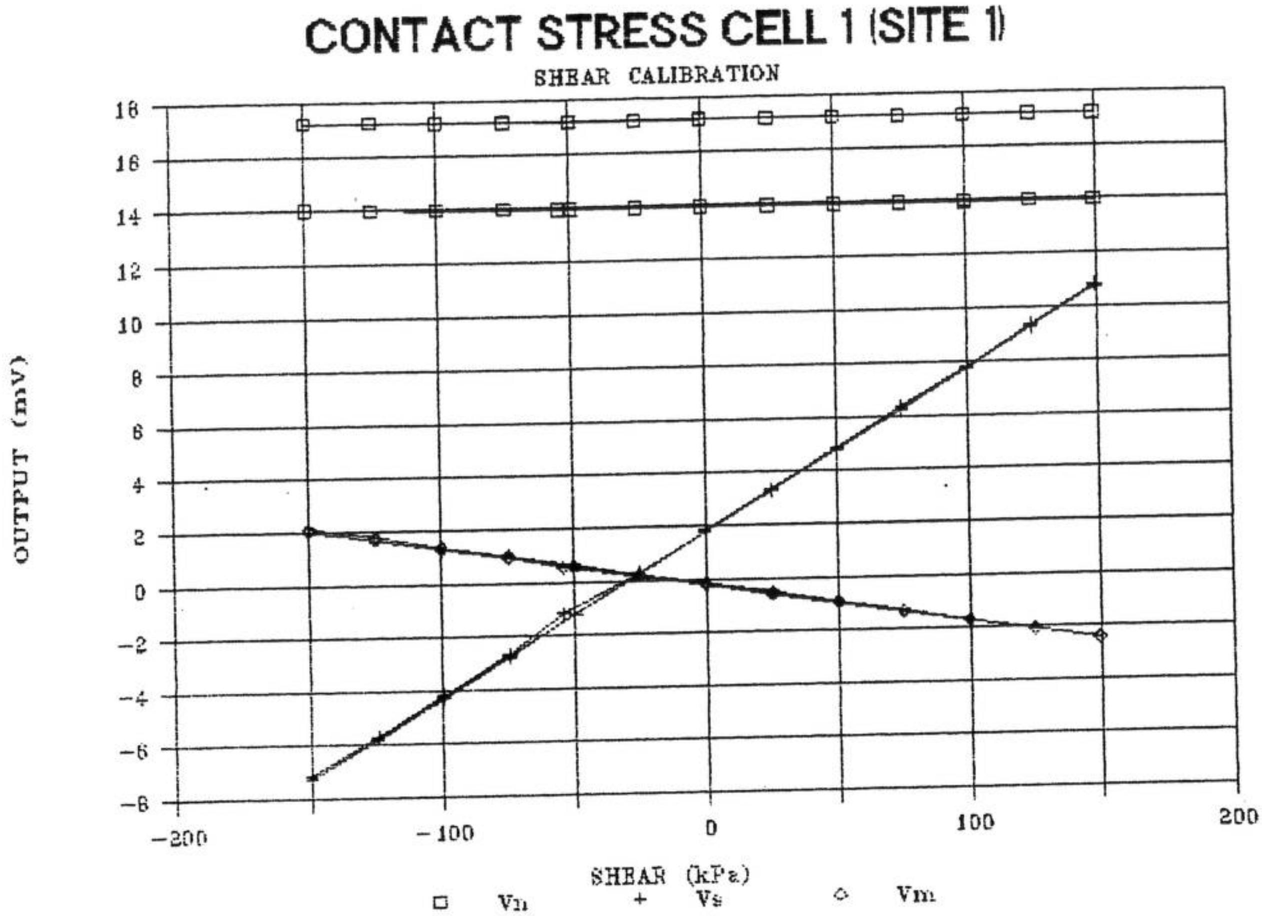

CONTACT STRESS CELL 1 (SITE 1)
SHEAR CALIBRATION
OUTPUT (mV)
SHEAR (kPa)
Vn
Vs
Vm

FIGURE III 2

CONTACT STRESS CELL 1 (SITE 1)

MOMENT & NORMAL LOAD VARIABLE S=0

MOMENT CIRCUIT -ve		MOMENT CIRCUIT +ve	
Regression Output:		Regression Output:	
Constant	-0.16945	Constant	-0.13640
Std Err of Y Est	0.002029	Std Err of Y Est	0.003732
R Squared	0.999995	R Squared	0.999984
No. of Observations	27	No. of Observations	27
Degrees of Freedom	25	Degrees of Freedom	25
X Coefficient(s)	-0.12400	X Coefficient(s)	-0.12779
Std Err of Coef.	0.000054	Std Err of Coef.	0.000100

NORMAL CIRCUIT -ve		NORMAL CIRCUIT +ve	
Regression Output:		Regression Output:	
Constant	6.446459	Constant	6.445033
Std Err of Y Est	0.005089	Std Err of Y Est	0.003849
R Squared	0.999997	R Squared	0.999998
No. of Observations	27	No. of Observations	27
Degrees of Freedom	25	Degrees of Freedom	25
X Coefficient(s)	-0.43376	X Coefficient(s)	0.434312
Std Err of Coef.	0.000137	Std Err of Coef.	0.000103

SHEAR CIRCUIT	
Regression Output:	
Constant	1.884517
Std Err of Y Est	0.003966
R Squared	0.999194
No. of Observations	54
Degrees of Freedom	52
X Coefficient(s)	-0.00958
Std Err of Coef.	0.000037

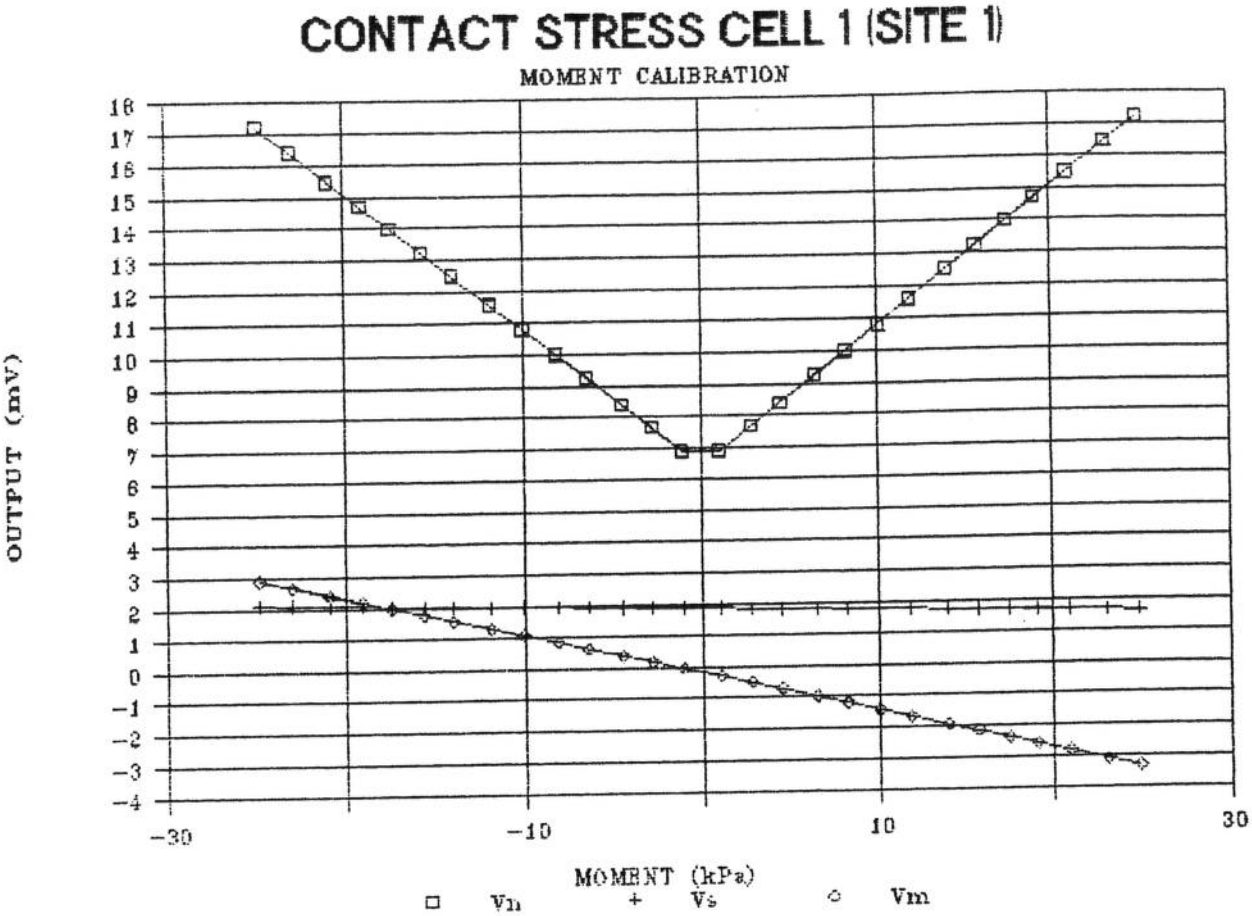

CONTACT STRESS CELL 1 (SITE 1)
MOMENT CALIBRATION
OUTPUT (mV)
MOMENT (kPa)
Vn
Vs
Vm

FIGURE III3

CONTACT STRESS CELL 2 (SITE 1)

NORMAL LOAD VARIABLE M=0 S=0

NORMAL CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	8.980633	Constant	-2.65701
Std Err of Y Est	0.007163	Std Err of Y Est	0.011420
R Squared	0.999994	R Squared	0.979052
No. of Observations	27	No. of Observations	27
Degrees of Freedom	25	Degrees of Freedom	25
X Coefficient(s)	0.033031	X Coefficient(s)	0.000827
Std Err of Coef.	0.000015	Std Err of Coef.	0.000024

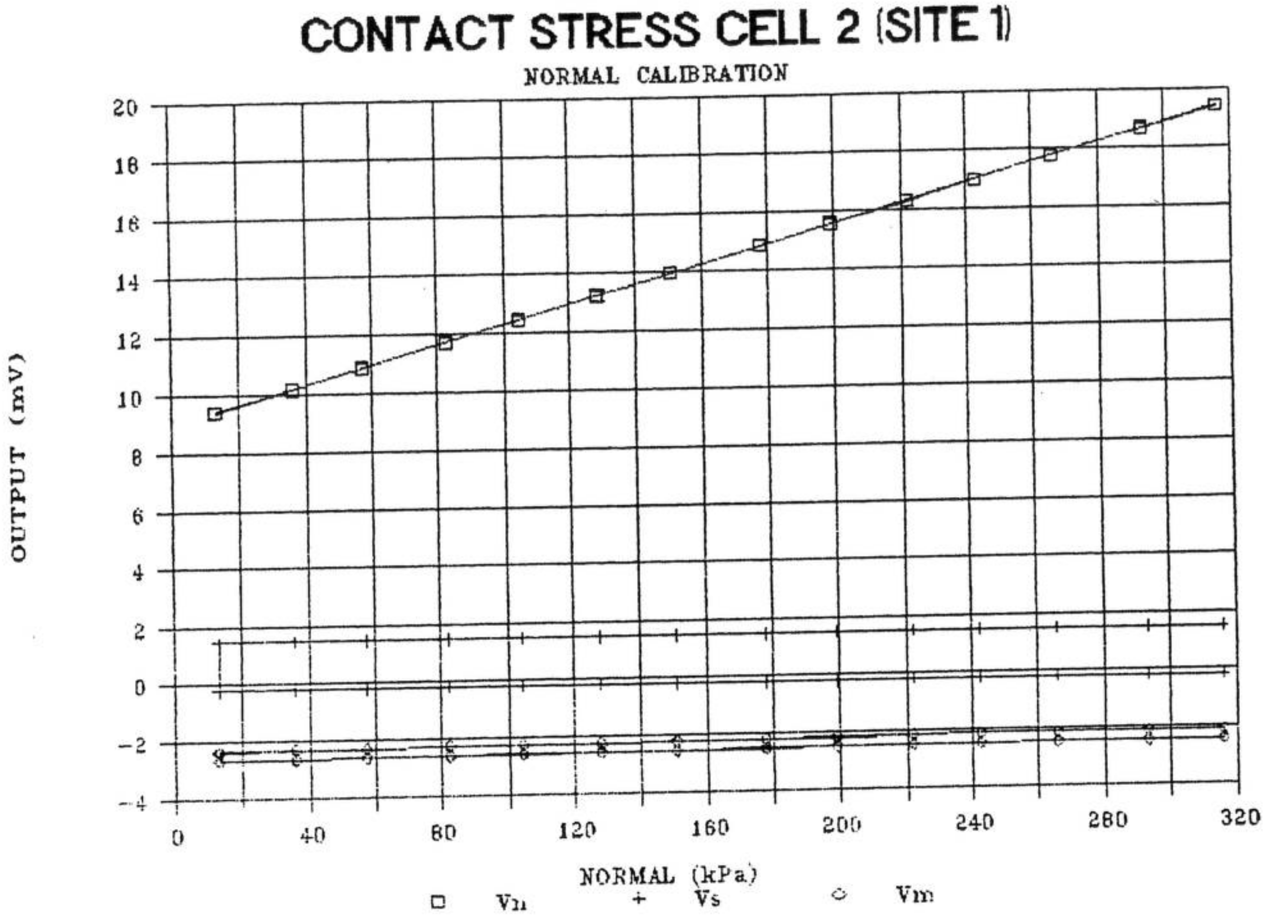
SHEAR CIRCUIT	
Regression Output:	
Constant	1.458720
Std Err of Y Est	0.003880
R Squared	0.906722
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	0.000128
Std Err of Coef.	0.000008

CONTACT STRESS CELL 2 (SITE 1)

NORMAL LOAD VARIABLE M=0 S= 24.93 kPa

NORMAL CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	8.980367	Constant	-2.33673
Std Err of Y Est	0.005474	Std Err of Y Est	0.013924
R Squared	0.999996	R Squared	0.970745
No. of Observations	27	No. of Observations	27
Degrees of Freedom	25	Degrees of Freedom	25
X Coefficient(s)	0.033069	X Coefficient(s)	0.000850
Std Err of Coef.	0.000011	Std Err of Coef.	0.000029

SHEAR CIRCUIT	
Regression Output:	
Constant	-0.18202
Std Err of Y Est	0.009024
R Squared	0.003236
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	-0.00000
Std Err of Coef.	0.000019



CONTACT STRESS CELL 2 (SITE 1)
NORMAL CALIBRATION
OUTPUT (mV)
20
18
16
14
12
10
8
6
4
2
0
-2
-4
0
40
80
120
160
200
240
280
320
NORMAL (kPa)
Vn
Vs
Vm

FIGURE III 4

CONTACT STRESS CELL 2 (SITE 1)

SHEAR VARIABLE M=0 N=316 kPa

SHEAR CIRCUIT

Regression Output:	
Constant	1.447692
Std Err of Y Est	0.050336
R Squared	0.999926
No. of Observations	26
Degrees of Freedom	24

X Coefficient(s)	-0.06730
Std Err of Coef.	0.000118

MOMENT CIRCUIT

Regression Output:	
Constant	-2.38857
Std Err of Y Est	0.015585
R Squared	0.999841
No. of Observations	26
Degrees of Freedom	24

X Coefficient(s)	0.014238
Std Err of Coef.	0.000036

NORMAL CIRCUIT

Regression Output:	
Constant	19.41303
Std Err of Y Est	0.019797
R Squared	0.896171
No. of Observations	26
Degrees of Freedom	24

X Coefficient(s)	0.000668
Std Err of Coef.	0.000046

CONTACT STRESS CELL 2 (SITE 1)

SHEAR VARIABLE M=0 N=222kPa

SHEAR CIRCUIT

Regression Output:	
Constant	1.419630
Std Err of Y Est	0.077163
R Squared	0.999824
No. of Observations	26
Degrees of Freedom	24

X Coefficient(s)	-0.06690
Std Err of Coef.	0.000180

MOMENT CIRCUIT

Regression Output:	
Constant	-2.47769
Std Err of Y Est	0.021273
R Squared	0.999694
No. of Observations	26
Degrees of Freedom	24

X Coefficient(s)	0.013971
Std Err of Coef.	0.000049

NORMAL CIRCUIT

Regression Output:	
Constant	16.26656
Std Err of Y Est	0.017680
R Squared	0.911351
No. of Observations	26
Degrees of Freedom	24

X Coefficient(s)	0.000631
Std Err of Coef.	0.000041

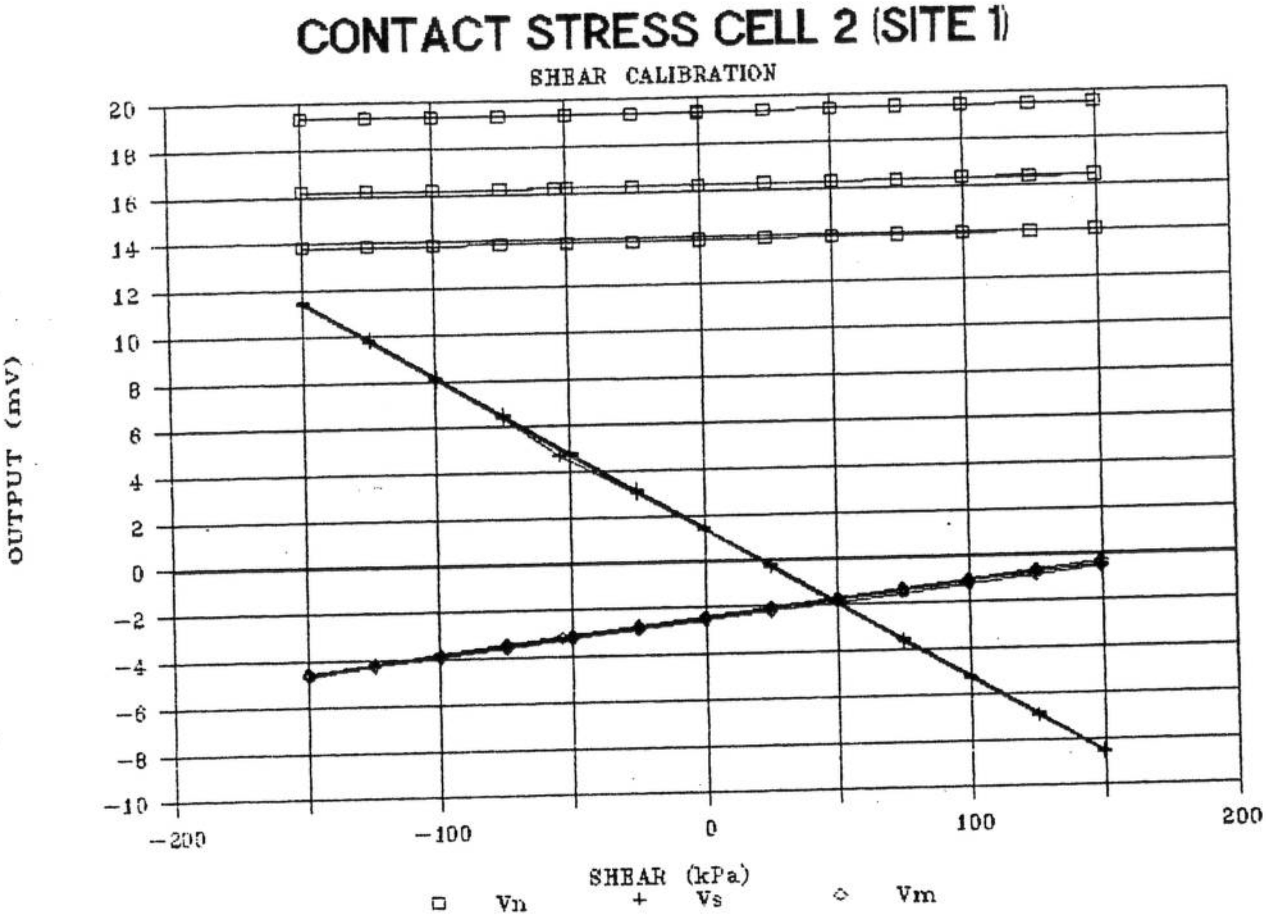

CONTACT STRESS CELL 2 (SITE 1)
SHEAR CALIBRATION
20
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
OUTPUT (mV)
-200
-100
0
100
200
SHEAR (kPa)
Vn
Vs
Vm

FIGURE III 5

CONTACT STRESS CELL 2 (SITE 1)

MOMENT & NORMAL LOADS VARIABLE S=0

MOMENT CIRCUIT

Regression Output:	
Constant	-2.53267
Std Err of Y Est	0.078189
R Squared	0.998015
No. of Observations	54
Degrees of Freedom	52

X Coefficient(s) 0.120333
Std Err of Coef. 0.000744

NORMAL CIRCUIT -ve

Regression Output:	
Constant	8.952261
Std Err of Y Est	0.003879
R Squared	0.999998
No. of Observations	27
Degrees of Freedom	25

X Coefficient(s) -0.42050
Std Err of Coef. 0.000104

SHEAR CIRCUIT

Regression Output:	
Constant	1.442297
Std Err of Y Est	0.006980
R Squared	0.998473
No. of Observations	54
Degrees of Freedom	52

X Coefficient(s) 0.012260
Std Err of Coef. 0.000066

NORMAL CIRCUIT +ve

Regression Output:	
Constant	8.953907
Std Err of Y Est	0.004148
R Squared	0.999998
No. of Observations	27
Degrees of Freedom	25

X Coefficient(s) 0.421455
Std Err of Coef. 0.000112

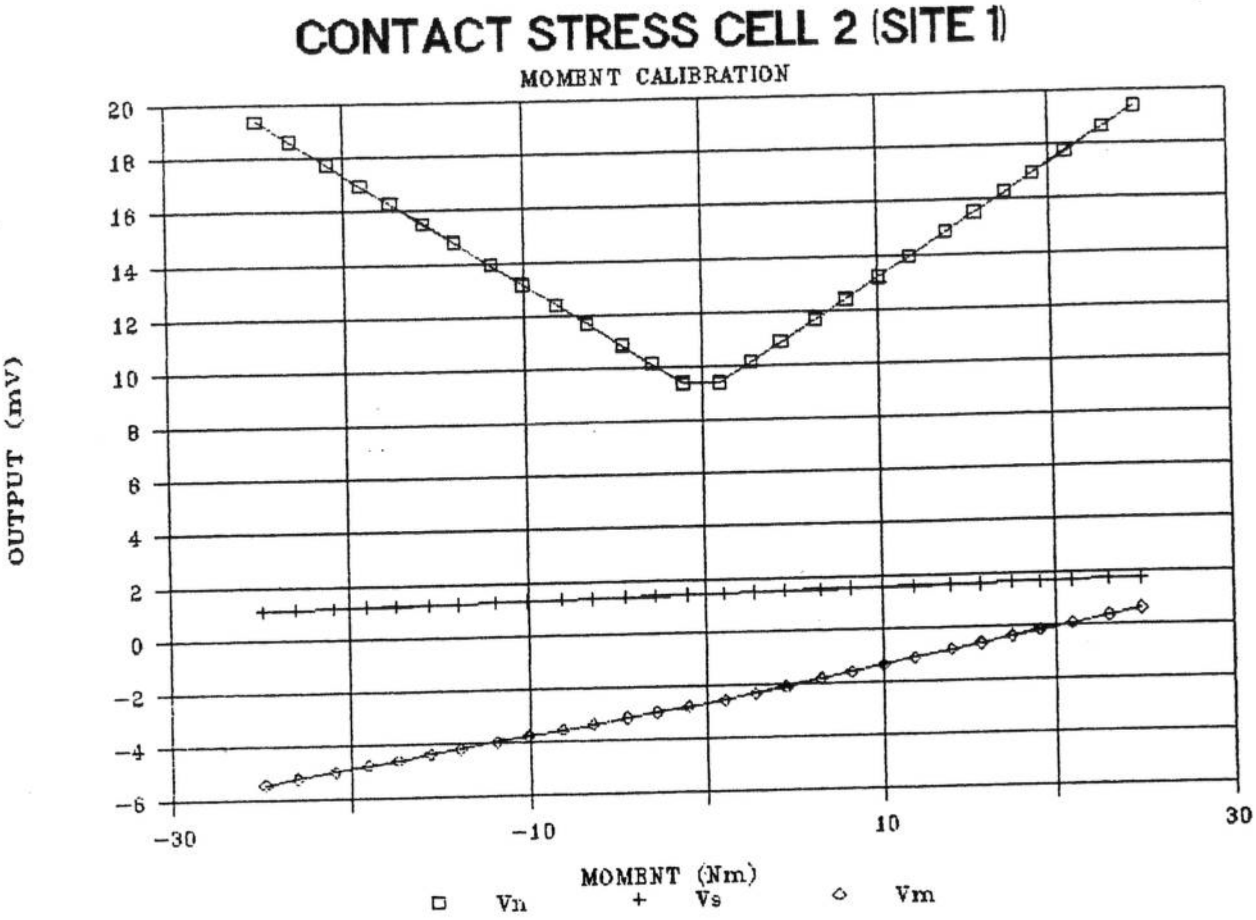

CONTACT STRESS CELL 2 (SITE 1)
MOMENT CALIBRATION
OUTPUT (mV)
20
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
-30
-10
10
30
MOMENT (Nm)
Vn
Vs
Vm

FIGURE III6

CONTACT STRESS CELL 3 (SITE 1)

NORMAL LOAD VARIABLE M=0 S=0

NORMAL CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	5.409673	Constant	5.276045
Std Err of Y Est	0.002309	Std Err of Y Est	0.016583
R Squared	0.999999	R Squared	0.514820
No. of Observations	27	No. of Observations	27
Degrees of Freedom	25	Degrees of Freedom	25
X Coefficient(s)	0.032853	X Coefficient(s)	0.000181
Std Err of Coef.	0.000004	Std Err of Coef.	0.000035

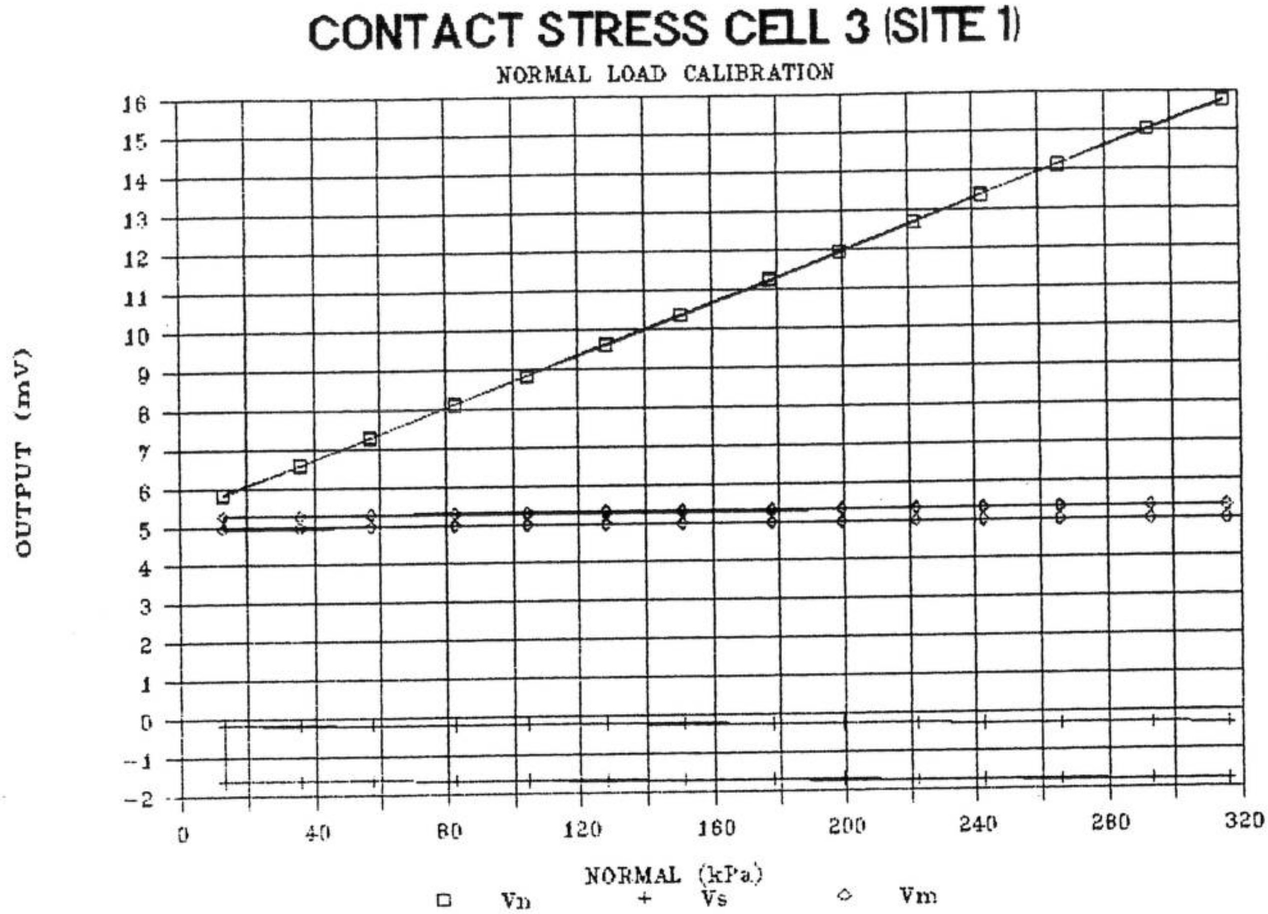
SHEAR CIRCUIT	
Regression Output:	
Constant	-1.59410
Std Err of Y Est	0.005883
R Squared	0.988384
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	-0.00057
Std Err of Coef.	0.000012

CONTACT STRESS CELL 3 (SITE 1)

NORMAL LOAD VARIABLE M=0 S= 24.93kPa

NORMAL CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	5.391998	Constant	4.971911
Std Err of Y Est	0.002841	Std Err of Y Est	0.014927
R Squared	0.999999	R Squared	0.220212
No. of Observations	27	No. of Observations	27
Degrees of Freedom	25	Degrees of Freedom	25
X Coefficient(s)	0.032845	X Coefficient(s)	0.000084
Std Err of Coef.	0.000006	Std Err of Coef.	0.000031

SHEAR CIRCUIT	
Regression Output:	
Constant	-0.14231
Std Err of Y Est	0.007798
R Squared	0.973372
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	-0.00049
Std Err of Coef.	0.000016



CONTACT STRESS CELL 3 (SITE 1)
NORMAL LOAD CALIBRATION
OUTPUT (mV)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
0
40
80
120
160
200
240
280
320
NORMAL (kPa)
Vn
Vs
Vm

FIGURE III 7

CONTACT STRESS CELL 3 (SITE 1)

SHEAR LOAD VARIABLE M=0 N= 316 kPa

SHEAR CIRCUIT

Regression Output:

Constant	-1.75784
Std Err of Y Est	0.030788
R Squared	0.999965
No. of Observations	26
Degrees of Freedom	24

X Coefficient(s)	-0.06004
Std Err of Coef.	0.000072

MOMENT CIRCUIT

Regression Output:

Constant	5.213730
Std Err of Y Est	0.015040
R Squared	0.999816
No. of Observations	26
Degrees of Freedom	24

X Coefficient(s)	0.012775
Std Err of Coef.	0.000035

NORMAL CIRCUIT

Regression Output:

Constant	15.70434
Std Err of Y Est	0.017283
R Squared	0.959605
No. of Observations	26
Degrees of Freedom	24

X Coefficient(s)	0.000968
Std Err of Coef.	0.000040

CONTACT STRESS CELL 3 (SITE 1)

SHEAR LOAD VARIABLE M=0 N= 222kPa

SHEAR CIRCUIT

Regression Output:

Constant	-1.71274
Std Err of Y Est	0.057290
R Squared	0.999878
No. of Observations	26
Degrees of Freedom	24

X Coefficient(s)	-0.05960
Std Err of Coef.	0.000134

MOMENT CIRCUIT

Regression Output:

Constant	5.229161
Std Err of Y Est	0.019278
R Squared	0.999688
No. of Observations	26
Degrees of Freedom	24

X Coefficient(s)	0.012547
Std Err of Coef.	0.000045

NORMAL CIRCUIT

Regression Output:

Constant	12.60491
Std Err of Y Est	0.015871
R Squared	0.964477
No. of Observations	26
Degrees of Freedom	24

X Coefficient(s)	0.000949
Std Err of Coef.	0.000037

CONTACT STRESS CELL 3 (SITE 1)

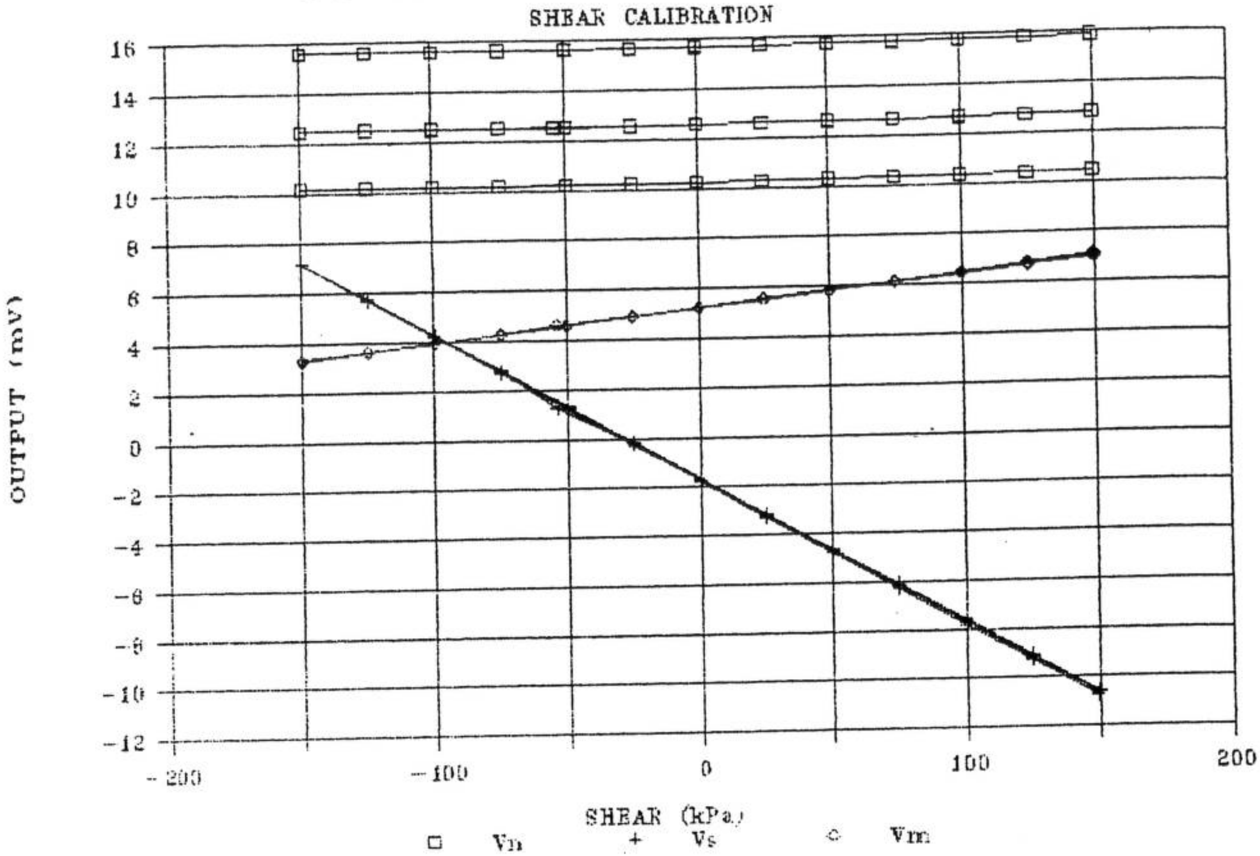


FIGURE III8

CONTACT STRESS CELL 3 (SITE 1)

MOMENT & NORMAL LOAD VARIABLE S=0

MOMENT CIRCUIT

Regression Output:

Constant	5.300971
Std Err of Y Est	0.022717
R Squared	0.999833
No. of Observations	54
Degrees of Freedom	52

X Coefficient(s)	0.120875
Std Err of Coef.	0.000216

NORMAL CIRCUIT -ve

Regression Output:

Constant	5.414107
Std Err of Y Est	0.003436
R Squared	0.999998
No. of Observations	27
Degrees of Freedom	25

X Coefficient(s)	-0.41915
Std Err of Coef.	0.000092

SHEAR CIRCUIT

Regression Output:

Constant	-1.69068
Std Err of Y Est	0.062612
R Squared	0.771852
No. of Observations	54
Degrees of Freedom	52

X Coefficient(s)	0.007902
Std Err of Coef.	0.000595

NORMAL CIRCUIT +ve

Regression Output:

Constant	5.418610
Std Err of Y Est	0.002935
R Squared	0.999999
No. of Observations	27
Degrees of Freedom	25

X Coefficient(s)	0.417664
Std Err of Coef.	0.000079

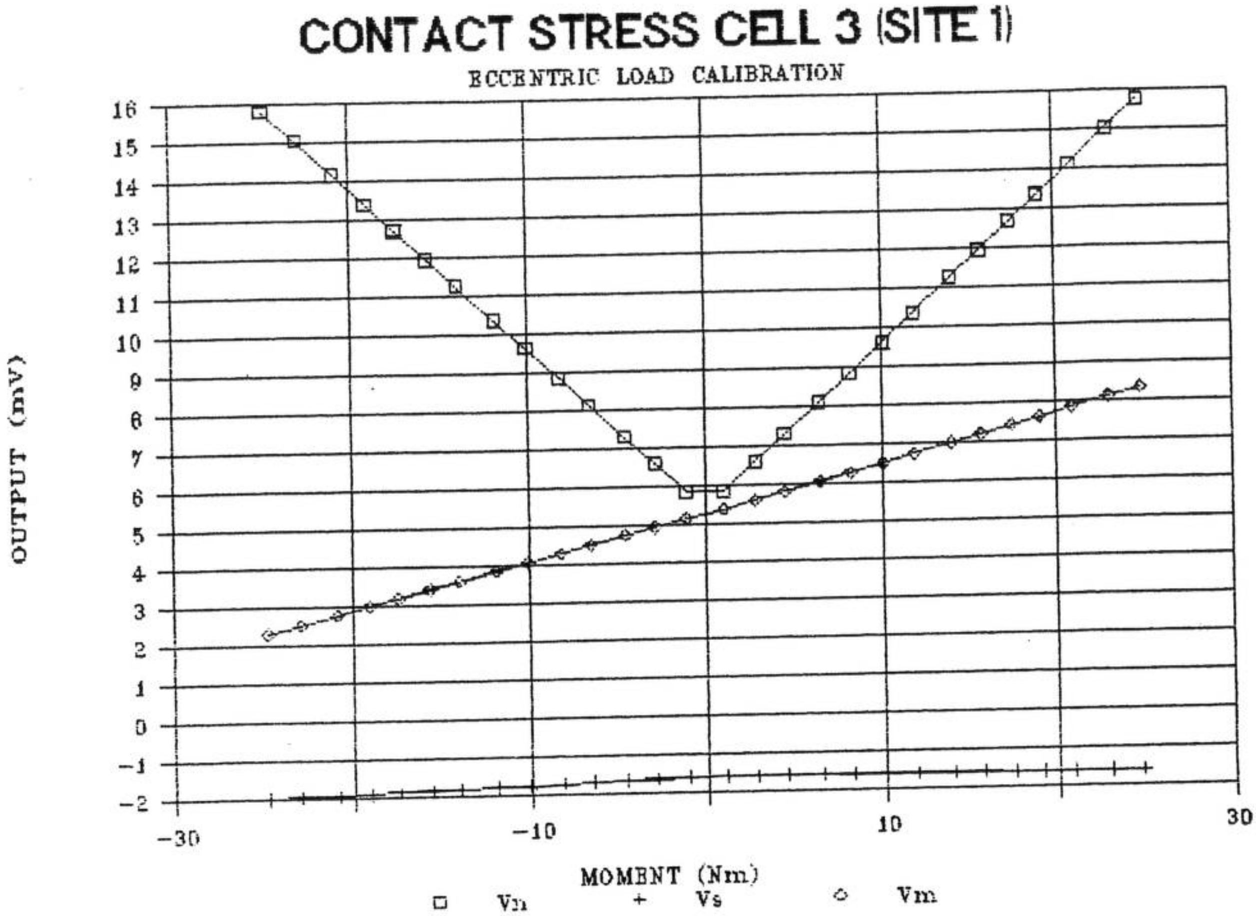

CONTACT STRESS CELL 3 (SITE 1)
ECCENTRIC LOAD CALIBRATION
OUTPUT (mV)
MOMENT (Nm)
Vn
Vs
Vm

FIGURE III9

CONTACT STRESS CELL 4 (SITE 1)

NORMAL LOAD VARIABLE M=0 S=0

NORMAL CIRCUIT

Regression Output:	
Constant	1.760052
Std Err of Y Est	0.003230
R Squared	0.999998
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	-0.03230
Std Err of Coef.	0.000006

MOMENT CIRCUIT

Regression Output:	
Constant	-2.95822
Std Err of Y Est	0.019697
R Squared	0.847008
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	-0.00049
Std Err of Coef.	0.000041

SHEAR CIRCUIT

Regression Output:	
Constant	4.936278
Std Err of Y Est	0.006691
R Squared	0.986715
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	0.000611
Std Err of Coef.	0.000014

CONTACT STRESS CELL 4 (SITE 1)

NORMAL LOAD VARIABLE M=0 S= 24.93 kPa

NORMAL CIRCUIT

Regression Output:	
Constant	1.798577
Std Err of Y Est	0.002333
R Squared	0.999999
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	-0.03233
Std Err of Coef.	0.000004

MOMENT CIRCUIT

Regression Output:	
Constant	-3.28515
Std Err of Y Est	0.017253
R Squared	0.885868
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	-0.00050
Std Err of Coef.	0.000036

SHEAR CIRCUIT

Regression Output:	
Constant	6.419570
Std Err of Y Est	0.005736
R Squared	0.992671
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	0.000707
Std Err of Coef.	0.000012

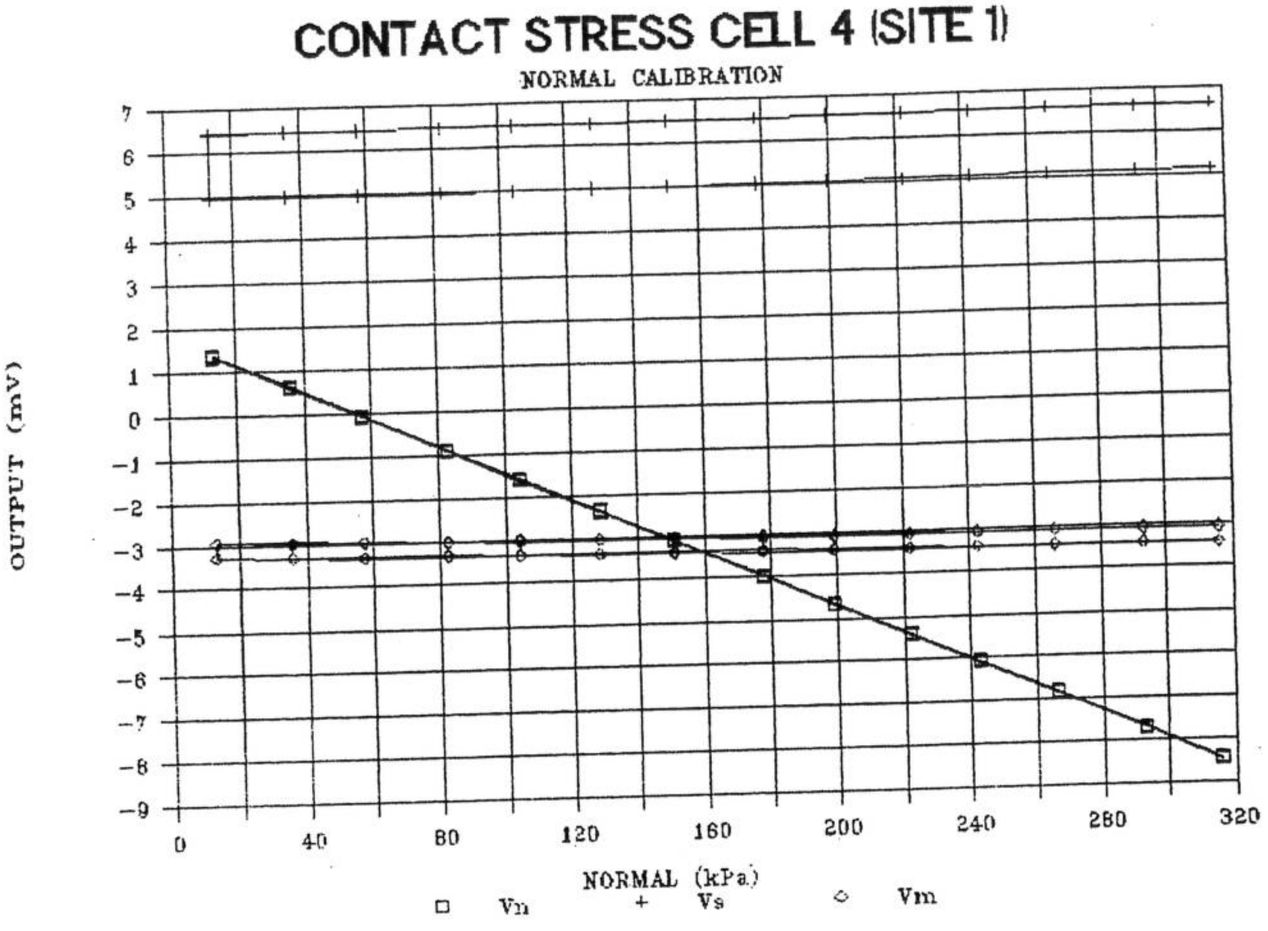


FIGURE III 10

CONTACT STRESS CELL 4 (SITE 1)

SHEAR LOAD VARIABLE M=0 N= 316 kPa

SHEAR CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	5.1355	Constant	-3.09646
Std Err of Y Est	0.035883	Std Err of Y Est	0.008395
R Squared	0.999953	R Squared	0.999950
No. of Observations	26	No. of Observations	26
Degrees of Freedom	24	Degrees of Freedom	24
X Coefficient(s)	0.060679	X Coefficient(s)	-0.01376
Std Err of Coef.	0.000084	Std Err of Coef.	0.000019

NORMAL CIRCUIT	
Regression Output:	
Constant	-8.44038
Std Err of Y Est	0.022555
R Squared	0.918693
No. of Observations	26
Degrees of Freedom	24
X Coefficient(s)	0.000871
Std Err of Coef.	0.000052

CONTACT STRESS CELL 4 (SITE 1)

SHEAR LOAD VARIABLE M=0 N=222 kPa

SHEAR CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	5.081202	Constant	-3.09119
Std Err of Y Est	0.057520	Std Err of Y Est	0.011223
R Squared	0.999880	R Squared	0.999909
No. of Observations	26	No. of Observations	26
Degrees of Freedom	24	Degrees of Freedom	24
X Coefficient(s)	0.060313	X Coefficient(s)	-0.01352
Std Err of Coef.	0.000134	Std Err of Coef.	0.000026

NORMAL CIRCUIT	
Regression Output:	
Constant	-5.39497
Std Err of Y Est	0.022289
R Squared	0.926116
No. of Observations	26
Degrees of Freedom	24
X Coefficient(s)	0.000906
Std Err of Coef.	0.000052

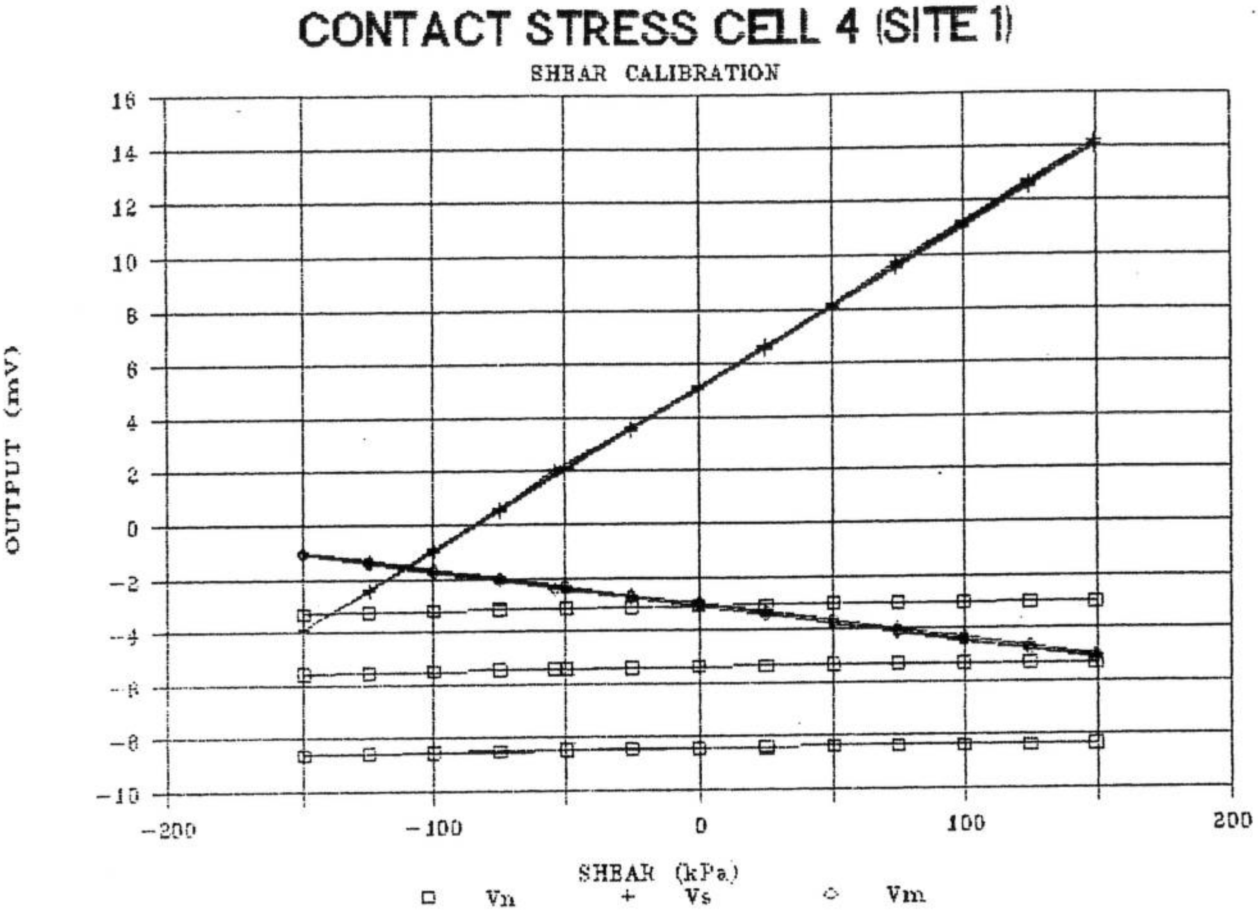


FIGURE III 11

CONTACT STRESS CELL 4 (SITE 1)

MOMENT & NORMAL LOAD VARIABLE S=0

MOMENT CIRCUIT

Regression Output:

Constant	-2.99369
Std Err of Y Est	0.036183
R Squared	0.999554
No. of Observations	54
Degrees of Freedom	52
X Coefficient(s)	-0.11762
Std Err of Coef.	0.000344

NORMAL CIRCUIT -ve

Regression Output:

Constant	1.789743
Std Err of Y Est	0.003253
R Squared	0.999998
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	0.410954
Std Err of Coef.	0.000087

SHEAR CIRCUIT

Regression Output:

Constant	5.031832
Std Err of Y Est	0.048413
R Squared	0.869854
No. of Observations	54
Degrees of Freedom	52
X Coefficient(s)	-0.00858
Std Err of Coef.	0.000460

NORMAL CIRCUIT +ve

Regression Output:

Constant	1.794713
Std Err of Y Est	0.002322
R Squared	0.999999
No. of Observations	27
Degrees of Freedom	25
X Coefficient(s)	-0.41141
Std Err of Coef.	0.000062

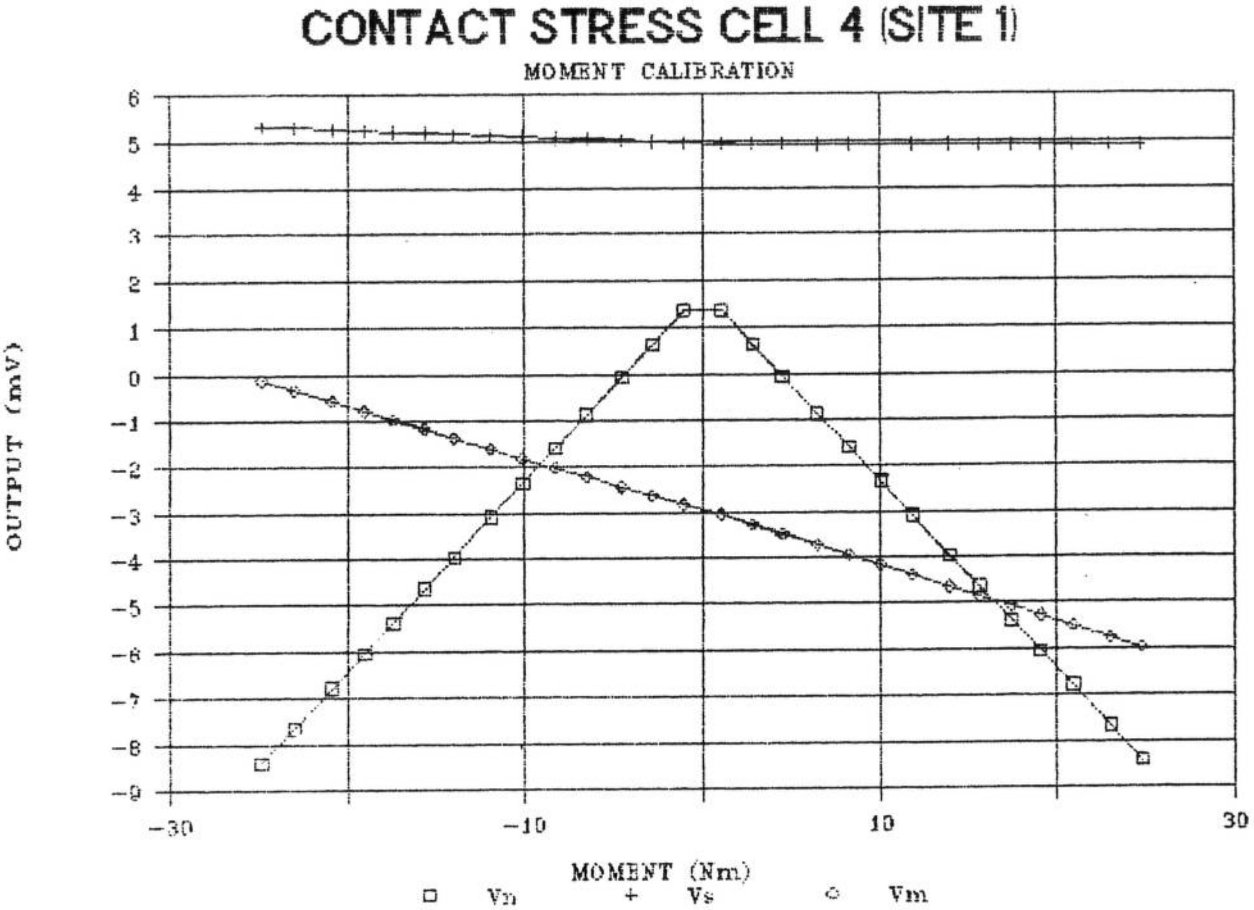


FIGURE III 12

CONTACT STRESS CELL 1 (SITE 2)

SHEAR LOAD VARIABLE M=0   N=450kPa

SHEAR CIRCUIT Regression Output:		MOMENT CIRCUIT Regression Output:	
Constant	9.360852	Constant	0.844235
Std Err of Y Est	0.040750	Std Err of Y Est	0.032857
R Squared	0.999965	R Squared	0.999634
No. of Observations	34	No. of Observations	34
Degrees of Freedom	32	Degrees of Freedom	32
X Coefficient(s)	-0.05896	X Coefficient(s)	0.014614
Std Err of Coef.	0.000061	Std Err of Coef.	0.000049

NORMAL CIRCUIT

Regression Output:

Constant	11.02188
Std Err of Y Est	0.004241
R Squared	0.950654
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.000158
Std Err of Coef.	0.000006

CONTACT STRESS CELL 1 (SITE 2)

SHEAR LOAD VARIABLE M=0   N=243kPa

SHEAR CIRCUIT Regression Output:		MOMENT CIRCUIT Regression Output:	
Constant	9.357705	Constant	0.883382
Std Err of Y Est	0.030373	Std Err of Y Est	0.031545
R Squared	0.999980	R Squared	0.999650
No. of Observations	34	No. of Observations	34
Degrees of Freedom	32	Degrees of Freedom	32
X Coefficient(s)	-0.05822	X Coefficient(s)	0.014337
Std Err of Coef.	0.000045	Std Err of Coef.	0.000047

NORMAL CIRCUIT

Regression Output:

Constant	4.060852
Std Err of Y Est	0.005162
R Squared	0.816103
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.000092
Std Err of Coef.	0.000007

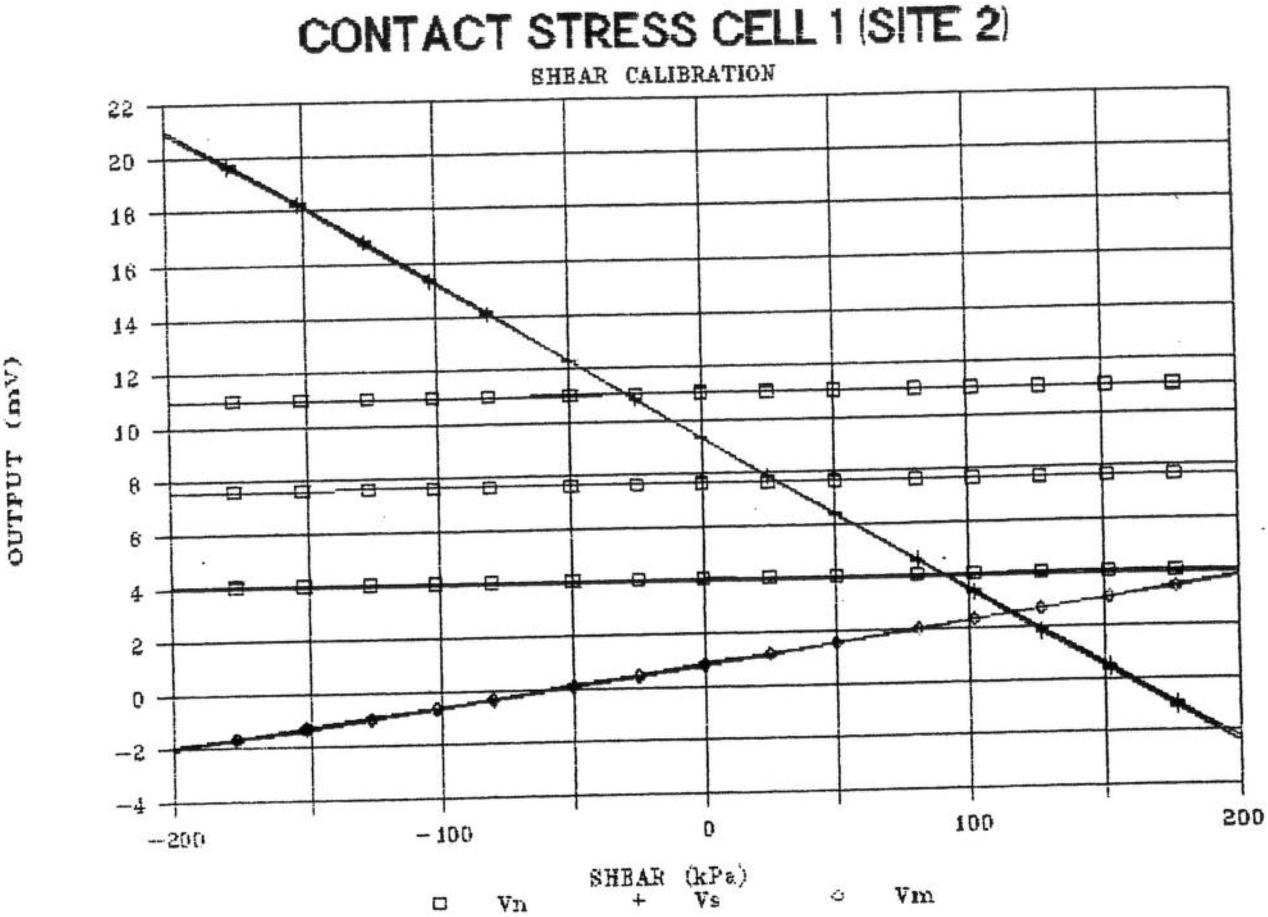


FIGURE III 14

CONTACT STRESS CELL 1 (SITE 2)

NORMAL LOAD AND MOMENT VARIABLE S=0

MOMENT CIRCUIT

Regression Output:

Constant	0.720974
Std Err of Y Est	0.044052
R Squared	0.999679
No. of Observations	78
Degrees of Freedom	76

X Coefficient(s)	0.119988
Std Err of Coef.	0.000246

SHEAR CIRCUIT

Regression Output:

Constant	9.286269
Std Err of Y Est	0.034011
R Squared	0.986699
No. of Observations	78
Degrees of Freedom	76

X Coefficient(s)	0.014297
Std Err of Coef.	0.000190

NORMAL CIRCUIT -ve regression

Regression Output:

Constant	-4.17160
Std Err of Y Est	0.015535
R Squared	0.999987
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.43053
Std Err of Coef.	0.000249

NORMAL CIRCUIT +ve regression

Regression Output:

Constant	-4.18650
Std Err of Y Est	0.015402
R Squared	0.999987
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.431300
Std Err of Coef.	0.000247

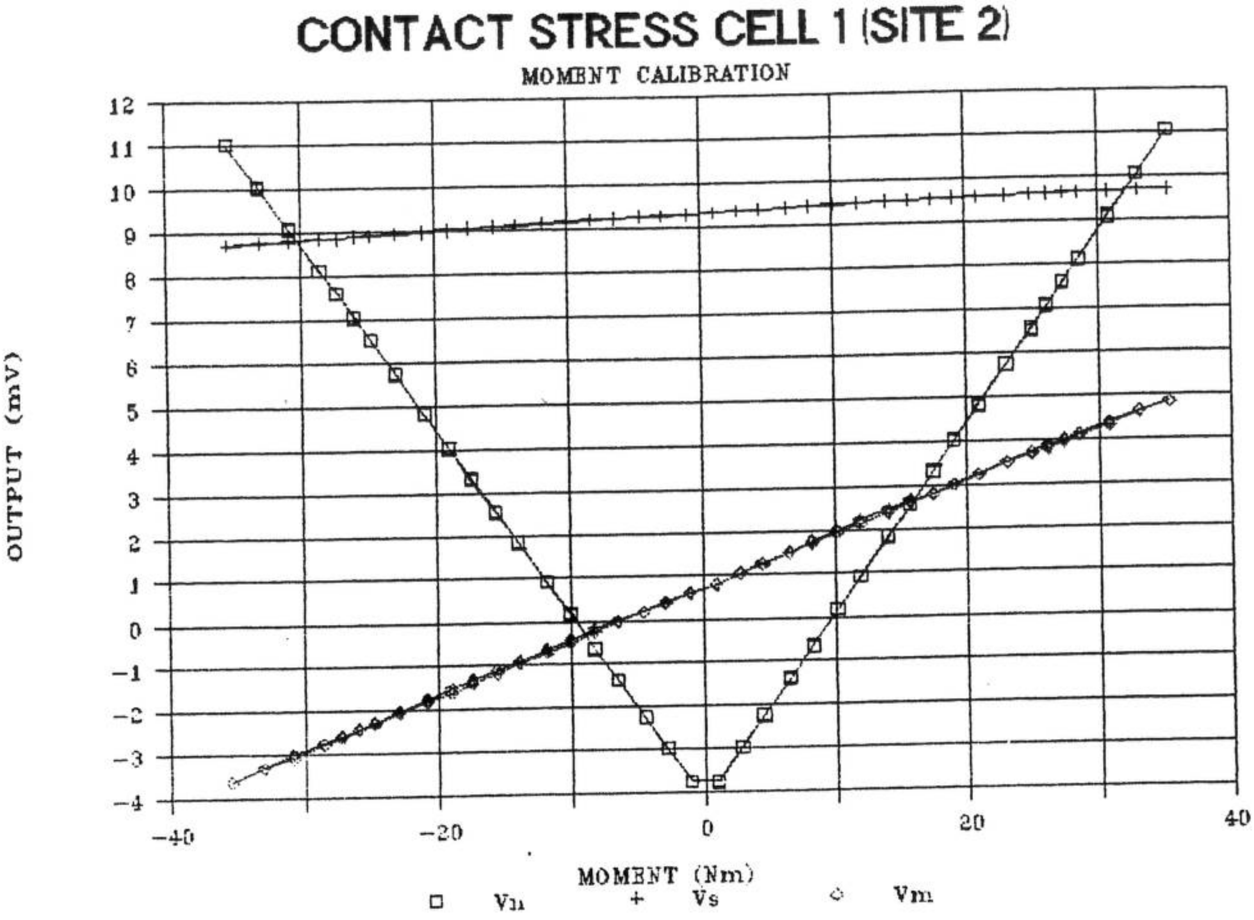


FIGURE III 15

CONTACT STRESS CELL 2 (SITE 2)

NORMAL LOAD VARIABLE M=0 S=0

SHEAR CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	9.698800	Constant	-3.82173
Std Err of Y Est	0.017992	Std Err of Y Est	0.058447
R Squared	0.895741	R Squared	0.361813
No. of Observations	39	No. of Observations	39
Degrees of Freedom	37	Degrees of Freedom	37
X Coefficient(s)	0.000405	X Coefficient(s)	0.000338
Std Err of Coef.	0.000022	Std Err of Coef.	0.000073

NORMAL CIRCUIT	
Regression Output:	
Constant	15.40658
Std Err of Y Est	0.013800
R Squared	0.999989
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.033291
Std Err of Coef.	0.000017

CONTACT STRESS CELL 2 (SITE 2)

NORMAL LOAD VARIABLE M=0 S=24.93kPa

SHEAR CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	8.058231	Constant	-3.49721
Std Err of Y Est	0.016136	Std Err of Y Est	0.053071
R Squared	0.870827	R Squared	0.587961
No. of Observations	39	No. of Observations	39
Degrees of Freedom	37	Degrees of Freedom	37
X Coefficient(s)	0.000321	X Coefficient(s)	0.000486
Std Err of Coef.	0.000020	Std Err of Coef.	0.000067

NORMAL CIRCUIT	
Regression Output:	
Constant	15.41230
Std Err of Y Est	0.019031
R Squared	0.999980
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.033335
Std Err of Coef.	0.000024

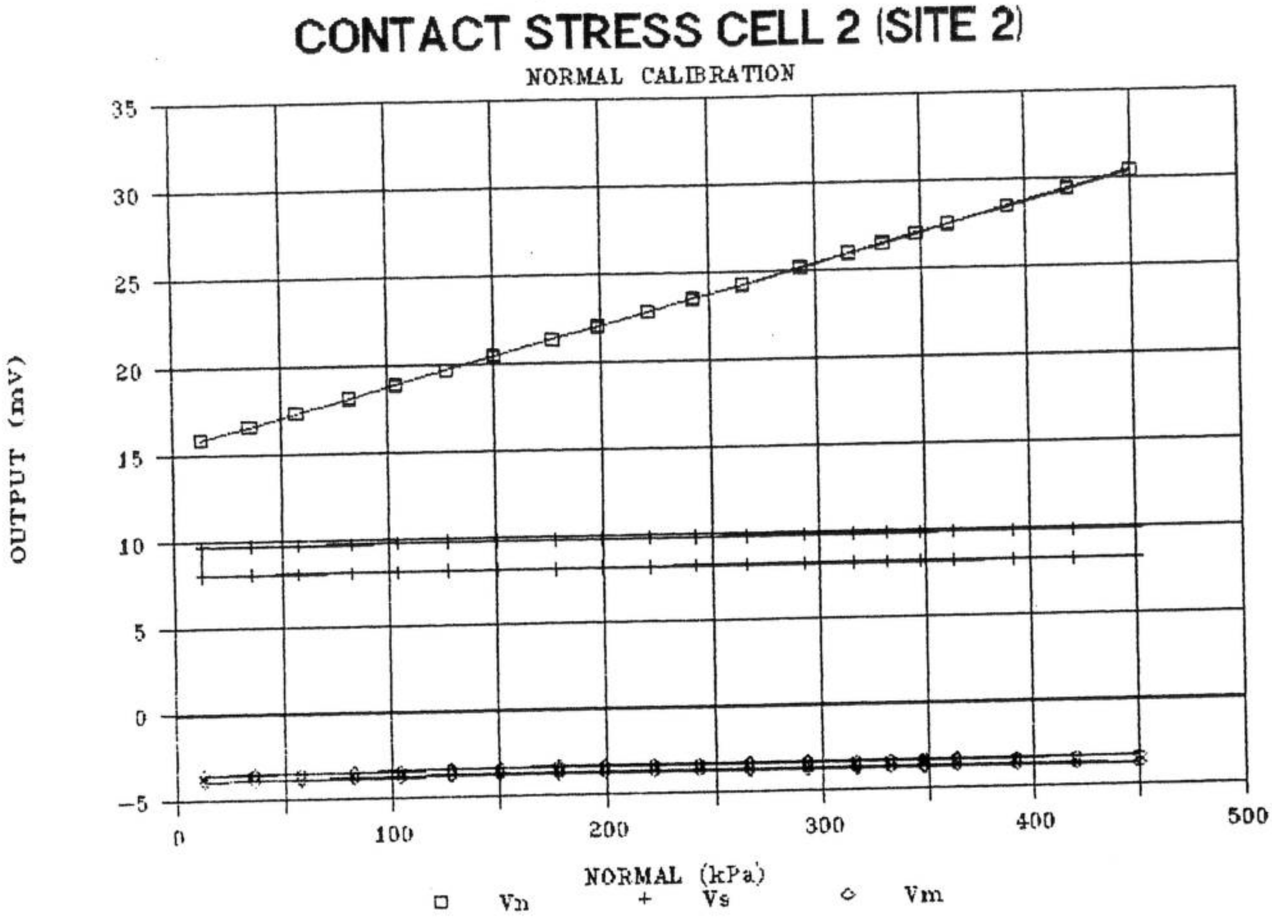


FIGURE III 16

CONTACT STRESS CELL 2 (SITE 2)

SHEAR LOAD VARIABLE M=0 N=450kPa

SHEAR CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	9.881470	Constant	-3.77302
Std Err of Y Est	0.069787	Std Err of Y Est	0.054885
R Squared	0.999920	R Squared	0.999038
No. of Observations	34	No. of Observations	34
Degrees of Freedom	32	Degrees of Freedom	32
X Coefficient(s)	-0.06665	X Coefficient(s)	0.015044
Std Err of Coef.	0.000104	Std Err of Coef.	0.000082

NORMAL CIRCUIT	
Regression Output:	
Constant	30.49361
Std Err of Y Est	0.044666
R Squared	0.095519
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.000123
Std Err of Coef.	0.000067

CONTACT STRESS CELL 2 (SITE 2)

SHEAR LOAD VARIABLE M=0 N=243kPa

SHEAR CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	9.821411	Constant	-3.74088
Std Err of Y Est	0.069409	Std Err of Y Est	0.011685
R Squared	0.999920	R Squared	0.999949
No. of Observations	34	No. of Observations	34
Degrees of Freedom	32	Degrees of Freedom	32
X Coefficient(s)	-0.06599	X Coefficient(s)	0.014017
Std Err of Coef.	0.000104	Std Err of Coef.	0.000017

NORMAL CIRCUIT	
Regression Output:	
Constant	23.522
Std Err of Y Est	0.023734
R Squared	0.933736
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.000757
Std Err of Coef.	0.000035

CONTACT STRESS CELL 2 (SITE 2)

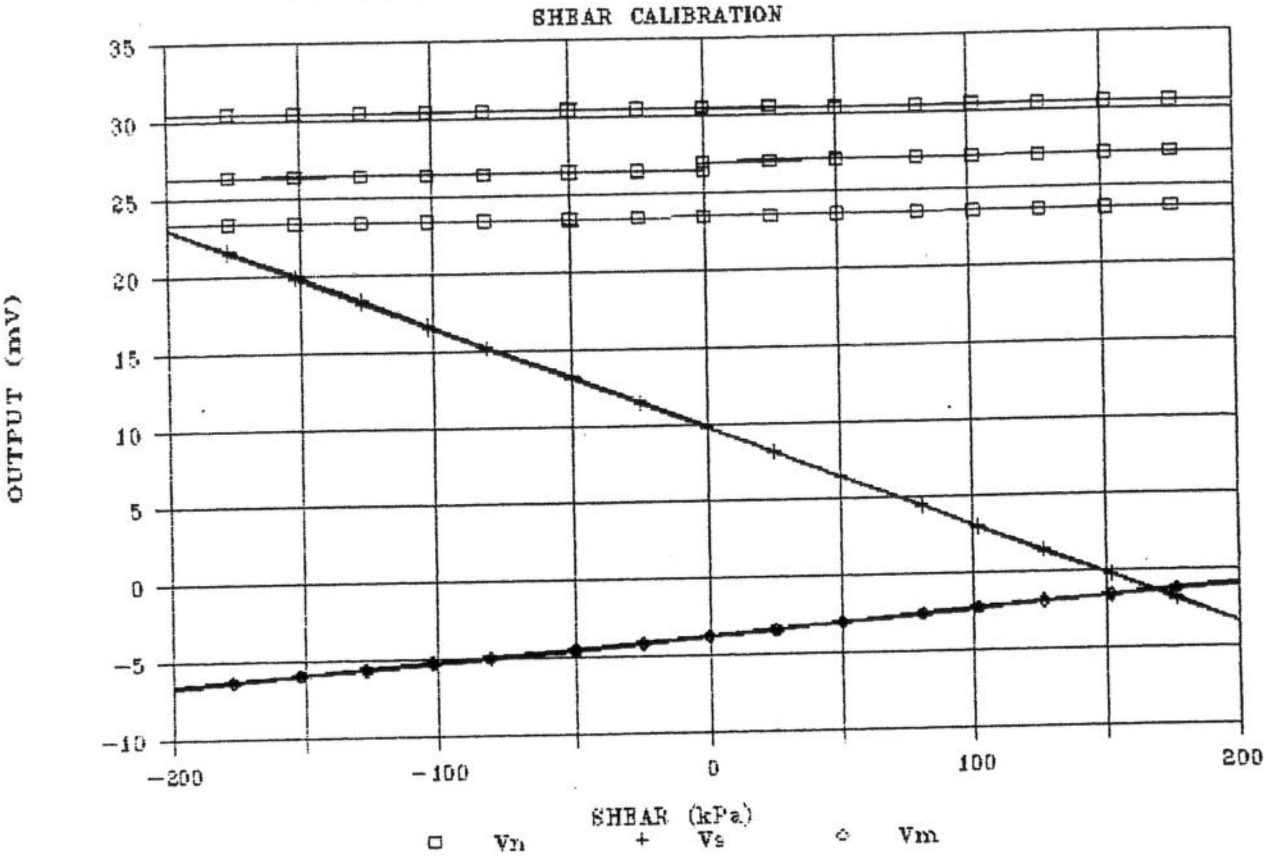


FIGURE III 17

CONTACT STRESS CELL 2 (SITE 2)

NORMAL LOAD AND MOMENT VARIABLE S=0

MOMENT CIRCUIT

Regression Output:

Constant	-3.78519
Std Err of Y Est	0.076221
R Squared	0.999014
No. of Observations	78
Degrees of Freedom	76

X Coefficient(s)	0.118439
Std Err of Coef.	0.000426

NORMAL CIRCUIT -ve regression

Regression Output:

Constant	15.38731
Std Err of Y Est	0.013355
R Squared	0.999990
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.42318
Std Err of Coef.	0.000214

SHEAR CIRCUIT

Regression Output:

Constant	9.711897
Std Err of Y Est	0.037561
R Squared	0.986863
No. of Observations	78
Degrees of Freedom	76

X Coefficient(s)	0.015889
Std Err of Coef.	0.000210

NORMAL CIRCUIT +ve regression

Regression Output:

Constant	15.37577
Std Err of Y Est	0.014876
R Squared	0.999988
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.423363
Std Err of Coef.	0.000239

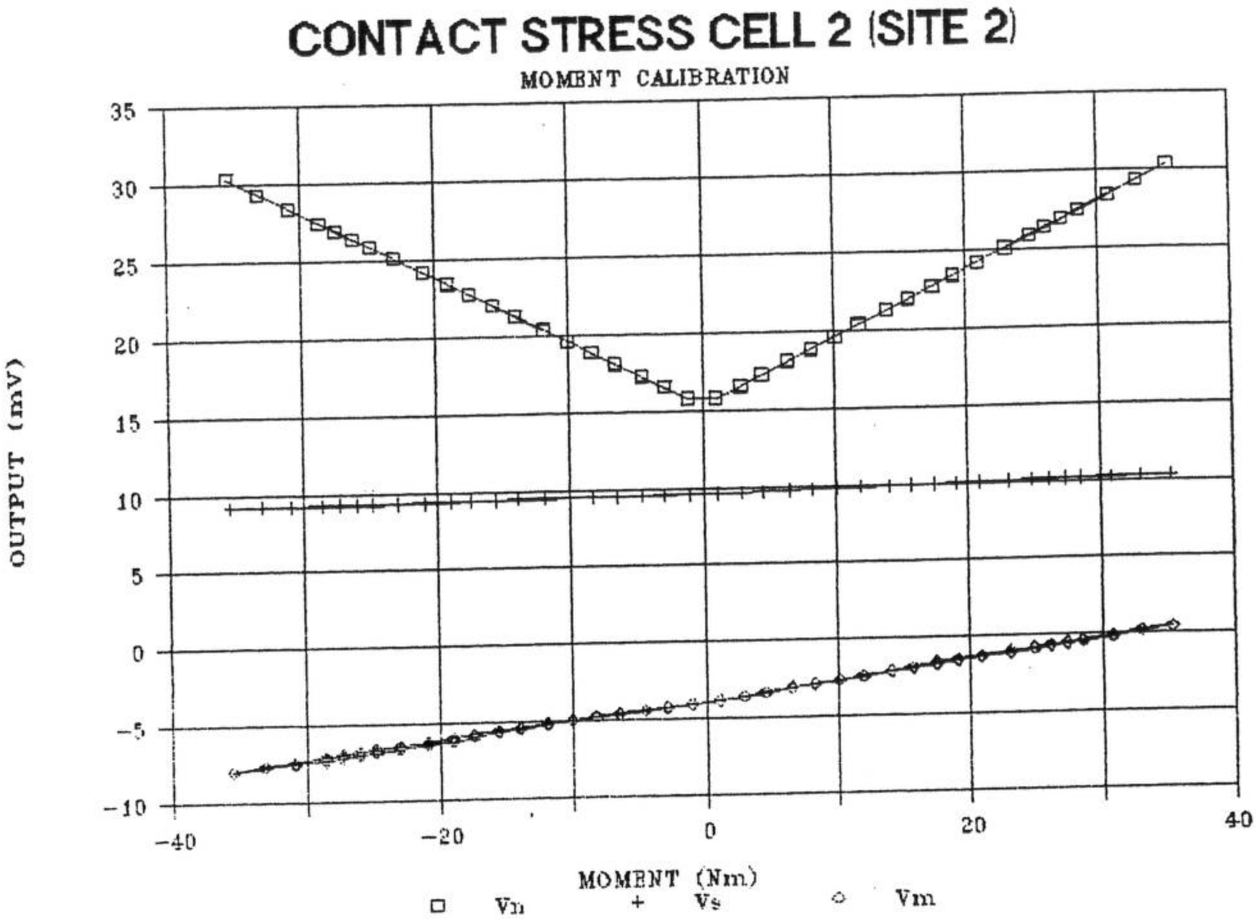


FIGURE III 18

CONTACT STRESS CELL 2 (SITE 3)

NORMAL LOAD VARIABLE M=0 S=0

SHEAR CIRCUIT

Regression Output:	
Constant	7.947586
Std Err of Y Est	0.010613
R Squared	0.560778
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.000092
Std Err of Coef.	0.000013

MOMENT CIRCUIT

Regression Output:	
Constant	-3.69755
Std Err of Y Est	0.032771
R Squared	0.734313
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.000418
Std Err of Coef.	0.000041

NORMAL CIRCUIT

Regression Output:	
Constant	15.23560
Std Err of Y Est	0.016626
R Squared	0.999985
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.033324
Std Err of Coef.	0.000020

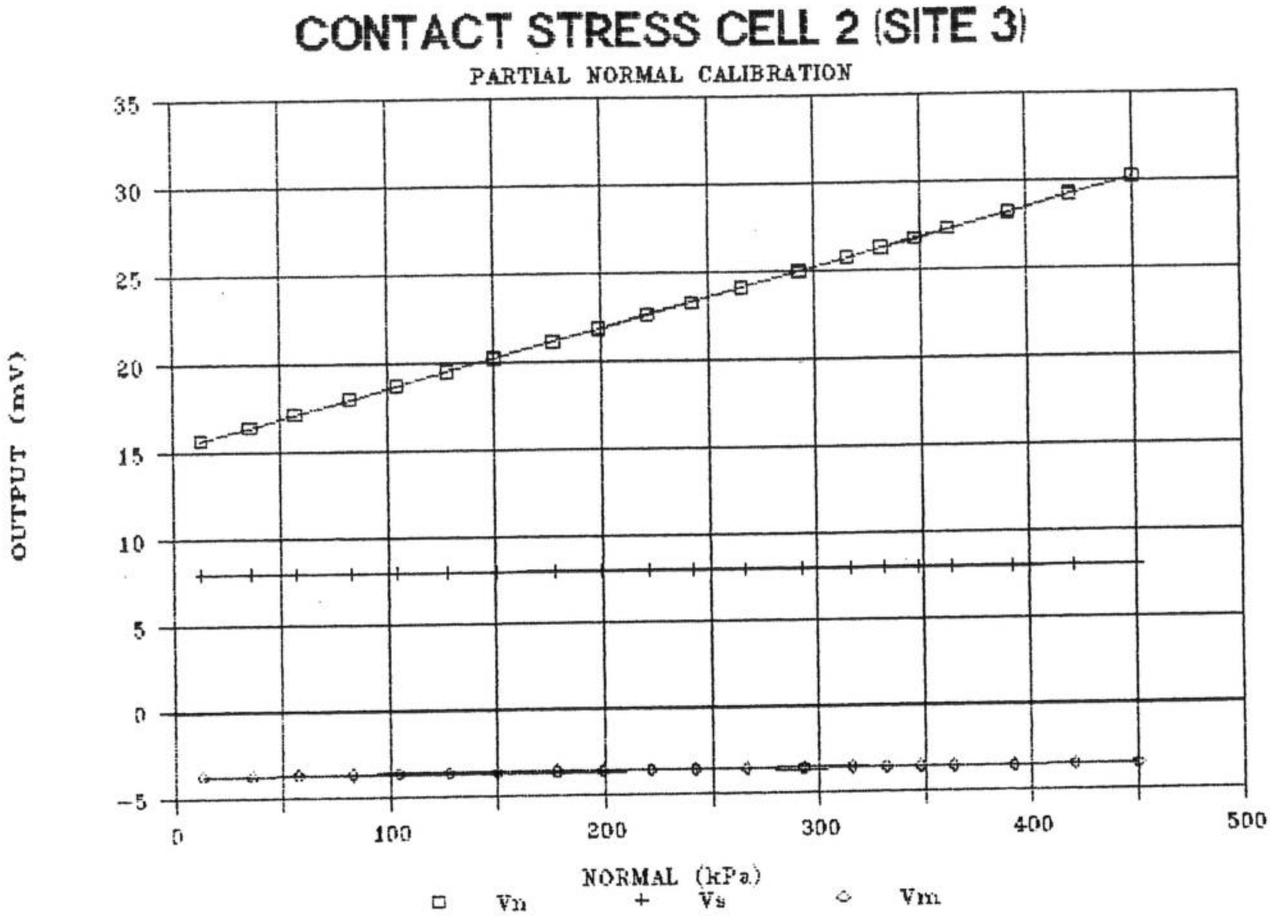


FIGURE III 19

CONTACT STRESS CELL 2 (SITE 3)

SHEAR LOAD VARIABLE M=0 N=450kPa

SHEAR CIRCUIT

Regression Output:	
Constant	7.785176
Std Err of Y Est	0.078306
R Squared	0.999895
No. of Observations	34
Degrees of Freedom	32

X Coefficient(s)	-0.06522
Std Err of Coef.	0.000117

MOMENT CIRCUIT

Regression Output:	
Constant	-3.86908
Std Err of Y Est	0.189018
R Squared	0.990611
No. of Observations	34
Degrees of Freedom	32

X Coefficient(s)	0.016508
Std Err of Coef.	0.000284

NORMAL CIRCUIT

Regression Output:	
Constant	30.17679
Std Err of Y Est	0.047430
R Squared	0.267041
No. of Observations	34
Degrees of Freedom	32

X Coefficient(s)	0.000243
Std Err of Coef.	0.000071

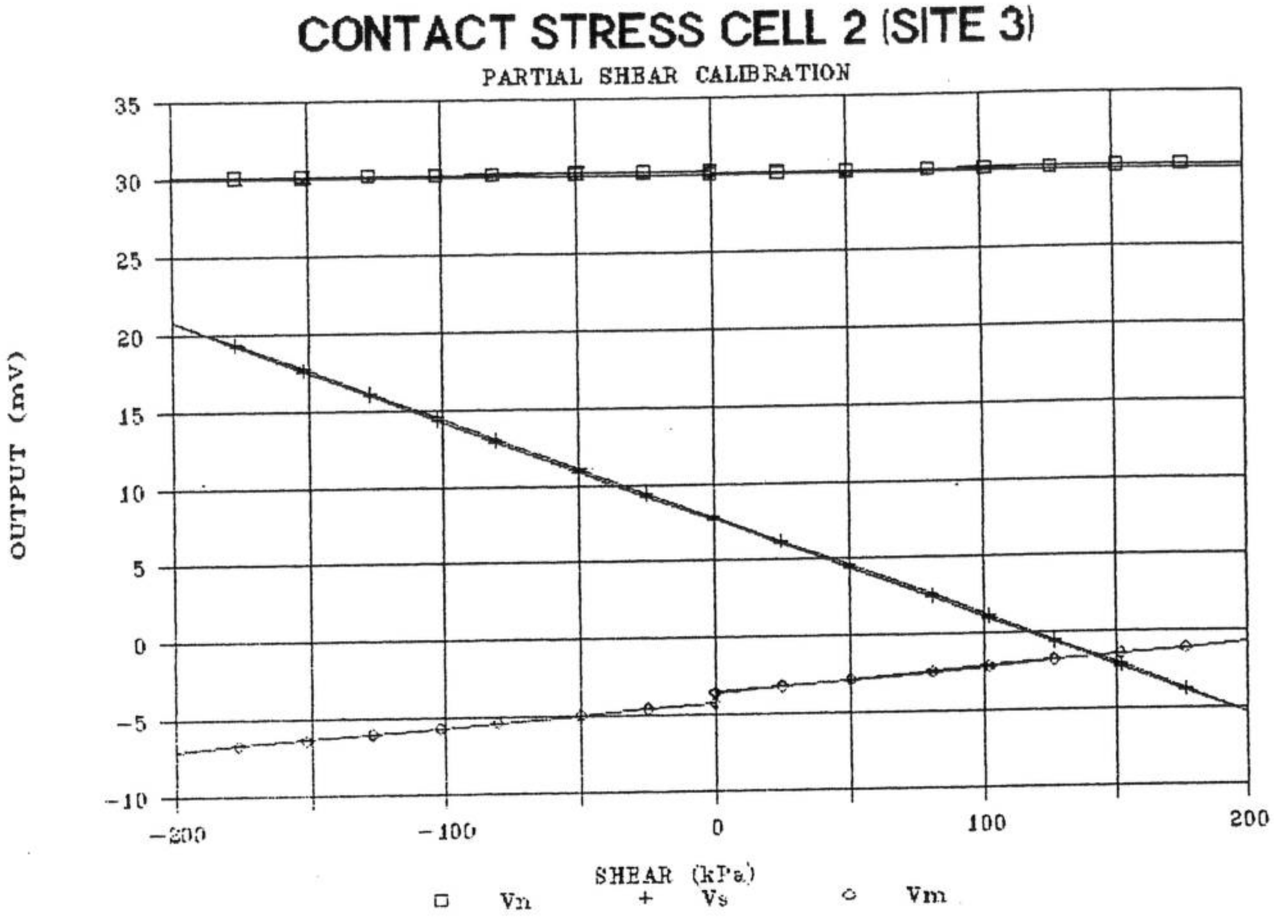


FIGURE III 20

CONTACT STRESS CELL 2 (SITE 3)

NORMAL LOAD AND MOMENT VARIABLE S=0

MOMENT CIRCUIT

Regression Output:	
Constant	-3.71179
Std Err of Y Est	0.035076
R Squared	0.999092
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.113822
Std Err of Coef.	0.000563

NORMAL CIRCUIT -ve regression

Regression Output:	
Constant	15.23460
Std Err of Y Est	0.015198
R Squared	0.999987
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.42337
Std Err of Coef.	0.000244

SHEAR CIRCUIT

Regression Output:	
Constant	7.931593
Std Err of Y Est	0.013464
R Squared	0.988263
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.012083
Std Err of Coef.	0.000216

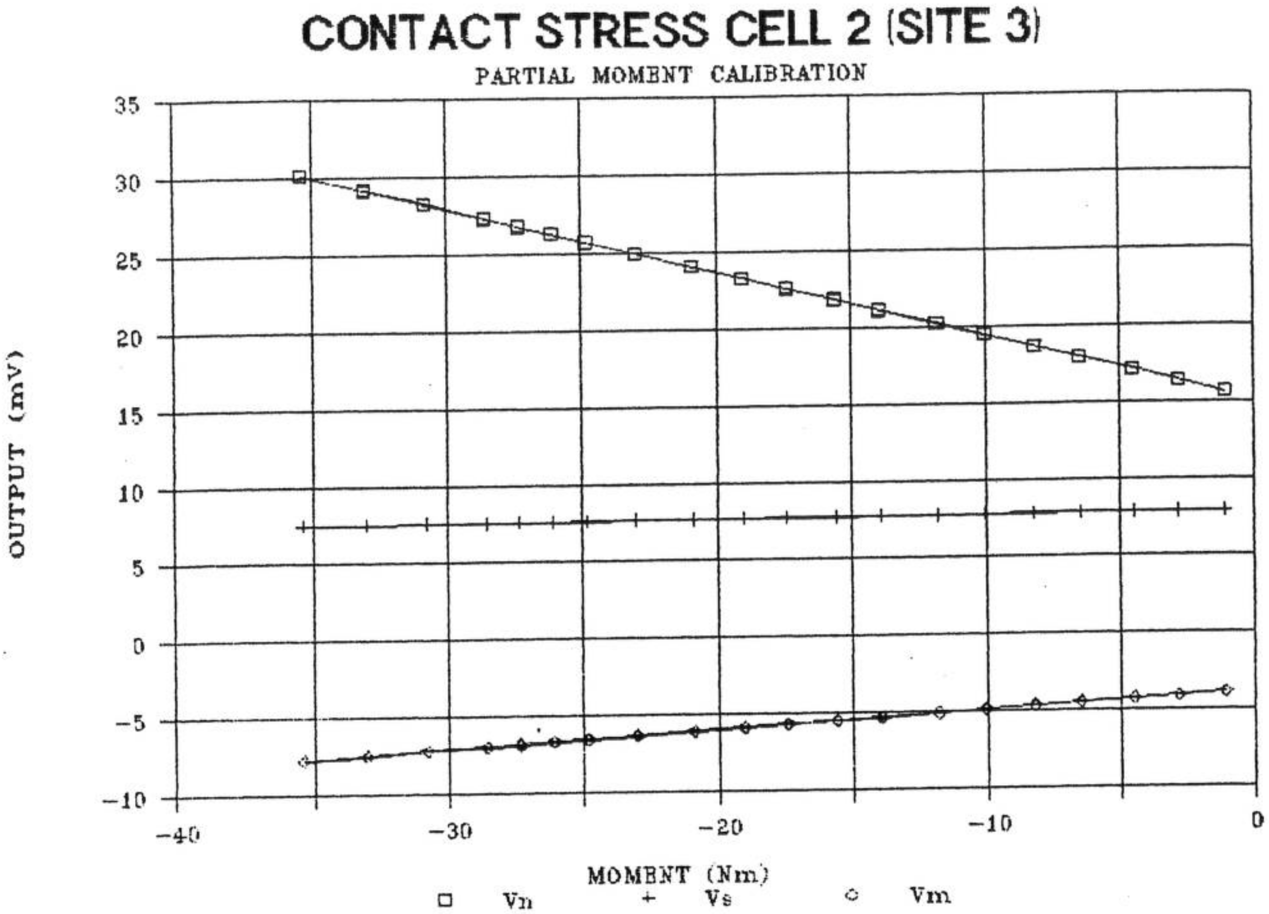


FIGURE III 21

CONTACT STRESS CELL 3 (SITE 3)

NORMAL LOAD VARIABLE M=0 S=0

SHEAR CIRCUIT

Regression Output:

Constant	14.58544
Std Err of Y Est	0.014334
R Squared	0.975932
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.00070
Std Err of Coef. 0.000018

MOMENT CIRCUIT

Regression Output:

Constant	0.929767
Std Err of Y Est	0.046225
R Squared	0.748510
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) 0.000612
Std Err of Coef. 0.000058

NORMAL CIRCUIT

Regression Output:

Constant	14.02483
Std Err of Y Est	0.012247
R Squared	0.999991
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.03195
Std Err of Coef. 0.000015

CONTACT STRESS CELL 3 (SITE 3)

NORMAL LOAD VARIABLE M=0 S=24.93kPa

SHEAR CIRCUIT

Regression Output:

Constant	16.06466
Std Err of Y Est	0.014568
R Squared	0.971248
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.00065
Std Err of Coef. 0.000018

MOMENT CIRCUIT

Regression Output:

Constant	0.605526
Std Err of Y Est	0.056687
R Squared	0.522534
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) 0.000455
Std Err of Coef. 0.000071

NORMAL CIRCUIT

Regression Output:

Constant	13.96911
Std Err of Y Est	0.016448
R Squared	0.999984
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.03198
Std Err of Coef. 0.000020

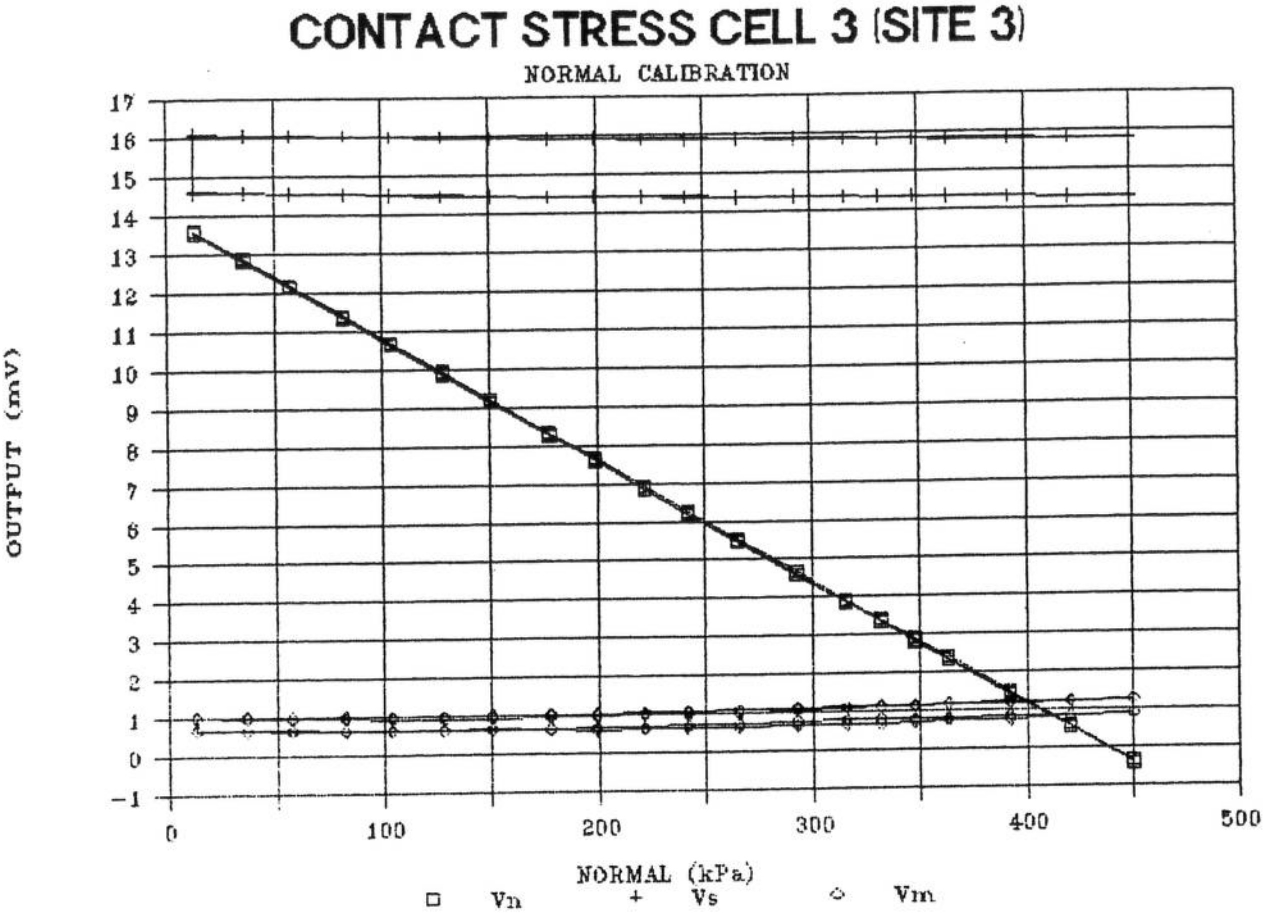


FIGURE III 22

CONTACT STRESS CELL 3 (SITE 3)

SHEAR LOAD VARIABLE M=0   N=450kPa

SHEAR CIRCUIT

Regression Output:	
Constant	14.23229
Std Err of Y Est	0.044853
R Squared	0.999960
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.060384
Std Err of Coef.	0.000067

MOMENT CIRCUIT

Regression Output:	
Constant	1.268911
Std Err of Y Est	0.032324
R Squared	0.999616
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.01403
Std Err of Coef.	0.000048

NORMAL CIRCUIT

Regression Output:	
Constant	-0.3965
Std Err of Y Est	0.018956
R Squared	0.996043
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.00255
Std Err of Coef.	0.000028

CONTACT STRESS CELL 3 (SITE 3)

SHEAR LOAD VARIABLE M=0   N=243kPa

SHEAR CIRCUIT

Regression Output:	
Constant	14.41932
Std Err of Y Est	0.038875
R Squared	0.999969
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.059489
Std Err of Coef.	0.000058

MOMENT CIRCUIT

Regression Output:	
Constant	1.093735
Std Err of Y Est	0.033224
R Squared	0.999575
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.01371
Std Err of Coef.	0.000049

NORMAL CIRCUIT

Regression Output:	
Constant	6.252794
Std Err of Y Est	0.021380
R Squared	0.994937
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.00254
Std Err of Coef.	0.000032

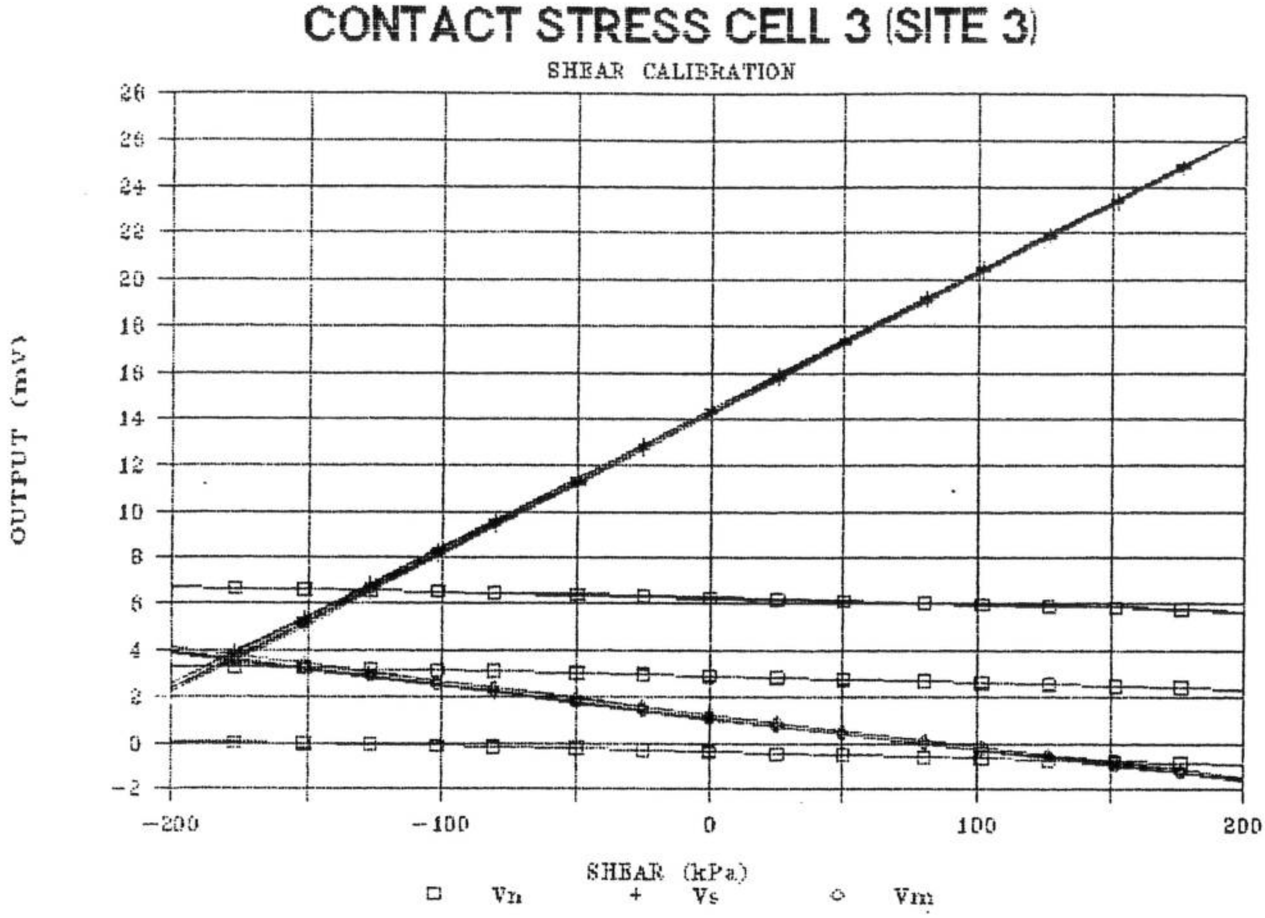


FIGURE III 23

CONTACT STRESS CELL 4 (SITE 3)

NORMAL LOAD VARIABLE M=0 S=0

SHEAR CIRCUIT

Regression Output:	
Constant	5.728749
Std Err of Y Est	0.013046
R Squared	0.915375
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.000329
Std Err of Coef.	0.000016

MOMENT CIRCUIT

Regression Output:	
Constant	-6.71088
Std Err of Y Est	0.046713
R Squared	0.085588
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.000109
Std Err of Coef.	0.000058

NORMAL CIRCUIT

Regression Output:	
Constant	3.667998
Std Err of Y Est	0.019983
R Squared	0.999977
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	-0.03238
Std Err of Coef.	0.000025

CONTACT STRESS CELL 4 (SITE 3)

NORMAL LOAD VARIABLE M=0 S=24.98kPa

SHEAR CIRCUIT

Regression Output:	
Constant	7.235364
Std Err of Y Est	0.013105
R Squared	0.932595
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.000374
Std Err of Coef.	0.000016

MOMENT CIRCUIT

Regression Output:	
Constant	-7.06756
Std Err of Y Est	0.041395
R Squared	0.122224
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.000118
Std Err of Coef.	0.000052

NORMAL CIRCUIT

Regression Output:	
Constant	3.693565
Std Err of Y Est	0.021064
R Squared	0.999975
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	-0.03240
Std Err of Coef.	0.000026

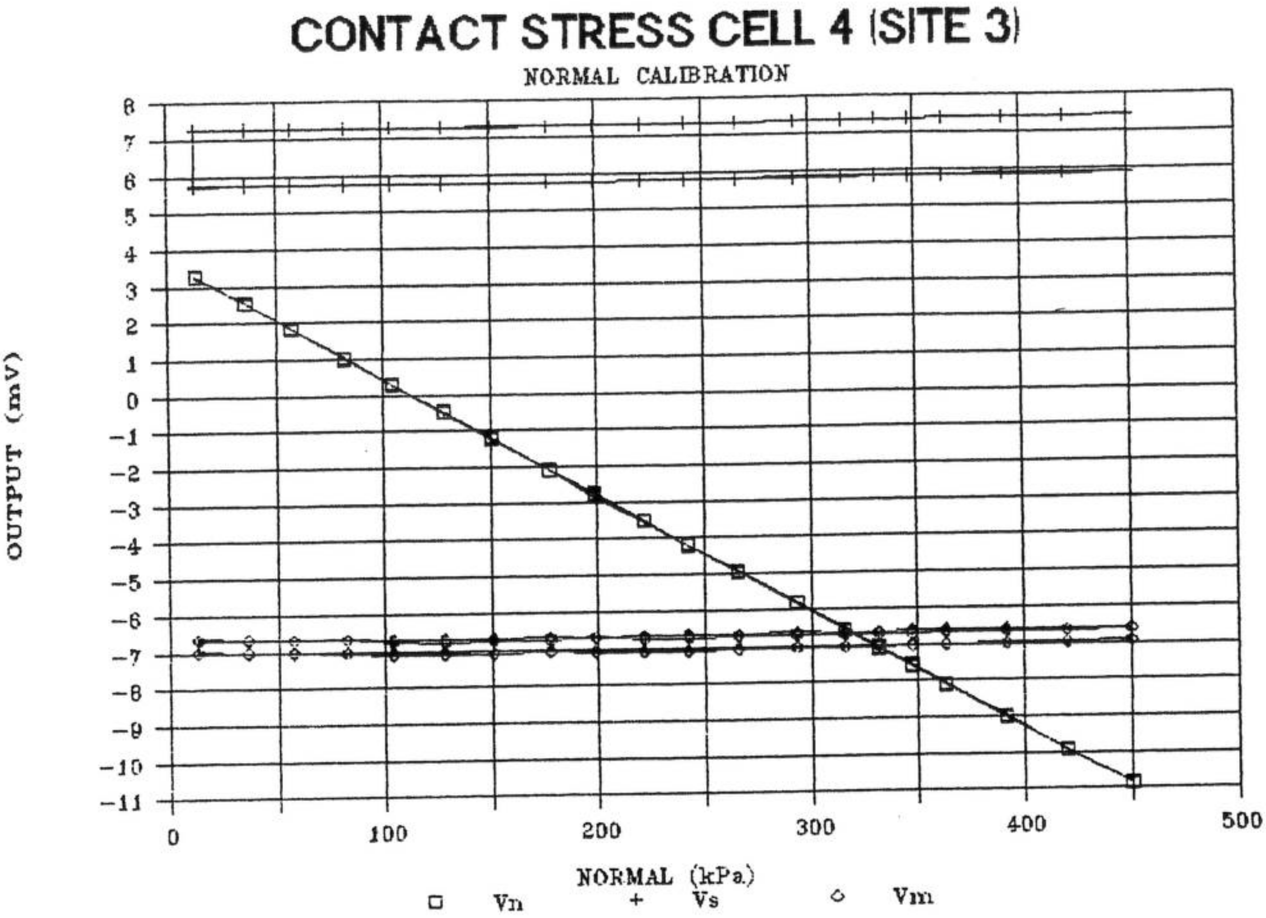


FIGURE III 25

CONTACT STRESS CELL 4 (SITE 3)

SHEAR LOAD VARIABLE M=0 N=450kPa

SHEAR CIRCUIT

Regression Output:	
Constant	5.856176
Std Err of Y Est	0.051358
R Squared	0.999948
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.060960
Std Err of Coef.	0.000077

MOMENT CIRCUIT

Regression Output:	
Constant	-6.74535
Std Err of Y Est	0.015586
R Squared	0.999917
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.01457
Std Err of Coef.	0.000023

NORMAL CIRCUIT

Regression Output:	
Constant	-10.9258
Std Err of Y Est	0.010432
R Squared	0.978210
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.000594
Std Err of Coef.	0.000015

CONTACT STRESS CELL 4 (SITE 3)

SHEAR LOAD VARIABLE M=0 N=243kPa

SHEAR CIRCUIT

Regression Output:	
Constant	5.834117
Std Err of Y Est	0.042342
R Squared	0.999964
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.060082
Std Err of Coef.	0.000063

MOMENT CIRCUIT

Regression Output:	
Constant	-6.71570
Std Err of Y Est	0.027730
R Squared	0.999736
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.01451
Std Err of Coef.	0.000041

NORMAL CIRCUIT

Regression Output:	
Constant	-4.21341
Std Err of Y Est	0.014138
R Squared	0.965377
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.000634
Std Err of Coef.	0.000021

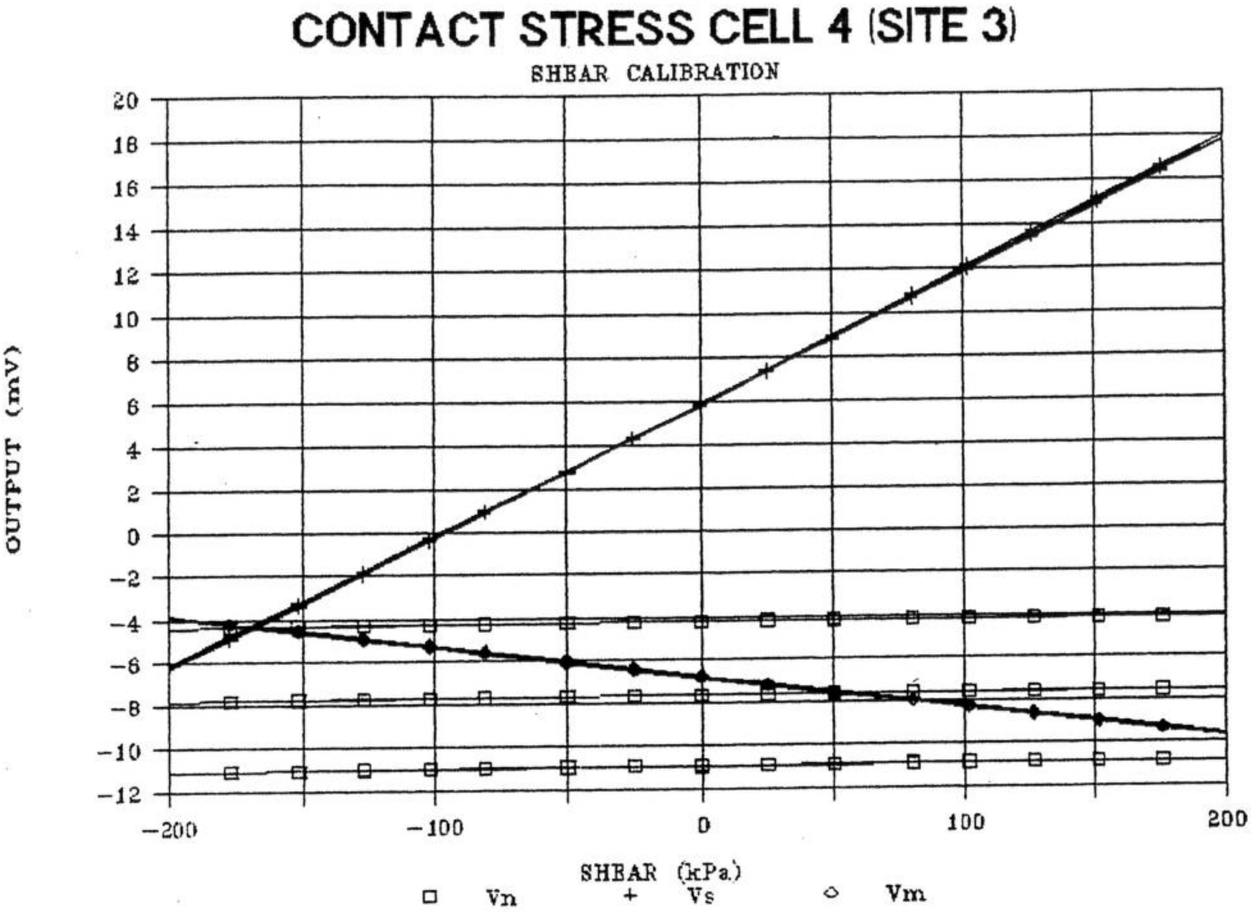


FIGURE III 26

CONTACT STRESS CELL 4 (SITE 3)

MOMENT AND NORMAL LOAD VARIABLE S=0

MOMENT CIRCUIT

Regression Output:

Constant	-6.65708
Std Err of Y Est	0.029231
R Squared	0.999846
No. of Observations	78
Degrees of Freedom	76

X Coefficient(s) -0.11505
Std Err of Coef. 0.000163

NORMAL CIRCUIT -ve REGRESSION

Regression Output:

Constant	3.695624
Std Err of Y Est	0.010847
R Squared	0.999993
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) 0.412035
Std Err of Coef. 0.000174

SHEAR CIRCUIT

Regression Output:

Constant	5.861910
Std Err of Y Est	0.048404
R Squared	0.966796
No. of Observations	78
Degrees of Freedom	76

X Coefficient(s) -0.01274
Std Err of Coef. 0.000271

NORMAL CIRCUIT +ve REGRESSION

Regression Output:

Constant	3.692521
Std Err of Y Est	0.020977
R Squared	0.999975
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.41241
Std Err of Coef. 0.000337

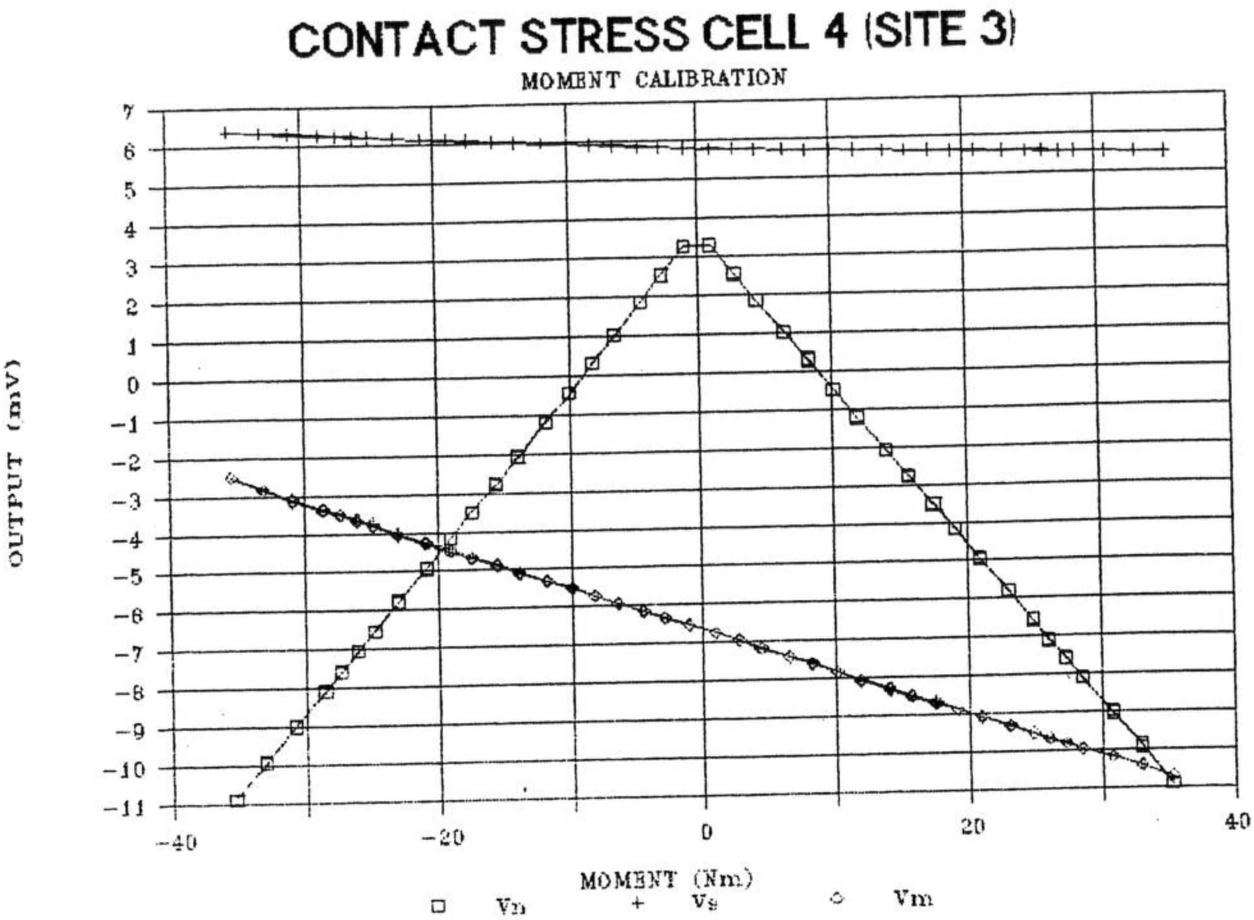


FIGURE III 27

CONTACT STRESS CELL 5 (SITE 3)

NORMAL LOAD VARIABLE M=0 S=0

SHEAR CIRCUIT

Regression Output:

Constant	-5.33220
Std Err of Y Est	0.025411
R Squared	0.999429
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.00816
Std Err of Coef.	0.000032

MOMENT CIRCUIT

Regression Output:

Constant	4.961975
Std Err of Y Est	0.037531
R Squared	0.998767
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.008207
Std Err of Coef.	0.000047

NORMAL CIRCUIT

Regression Output:

Constant	3.880918
Std Err of Y Est	0.023422
R Squared	0.999936
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.02256
Std Err of Coef.	0.000029

CONTACT STRESS CELL 5 (SITE 3)

NORMAL LOAD VARIABLE M=0 S=24.93kPa

SHEAR CIRCUIT

Regression Output:

Constant	-6.32737
Std Err of Y Est	0.048241
R Squared	0.998025
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.00833
Std Err of Coef.	0.000060

MOMENT CIRCUIT

Regression Output:

Constant	4.859827
Std Err of Y Est	0.074924
R Squared	0.995423
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.008487
Std Err of Coef.	0.000094

NORMAL CIRCUIT

Regression Output:

Constant	3.476185
Std Err of Y Est	0.039825
R Squared	0.999815
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.02248
Std Err of Coef.	0.000050

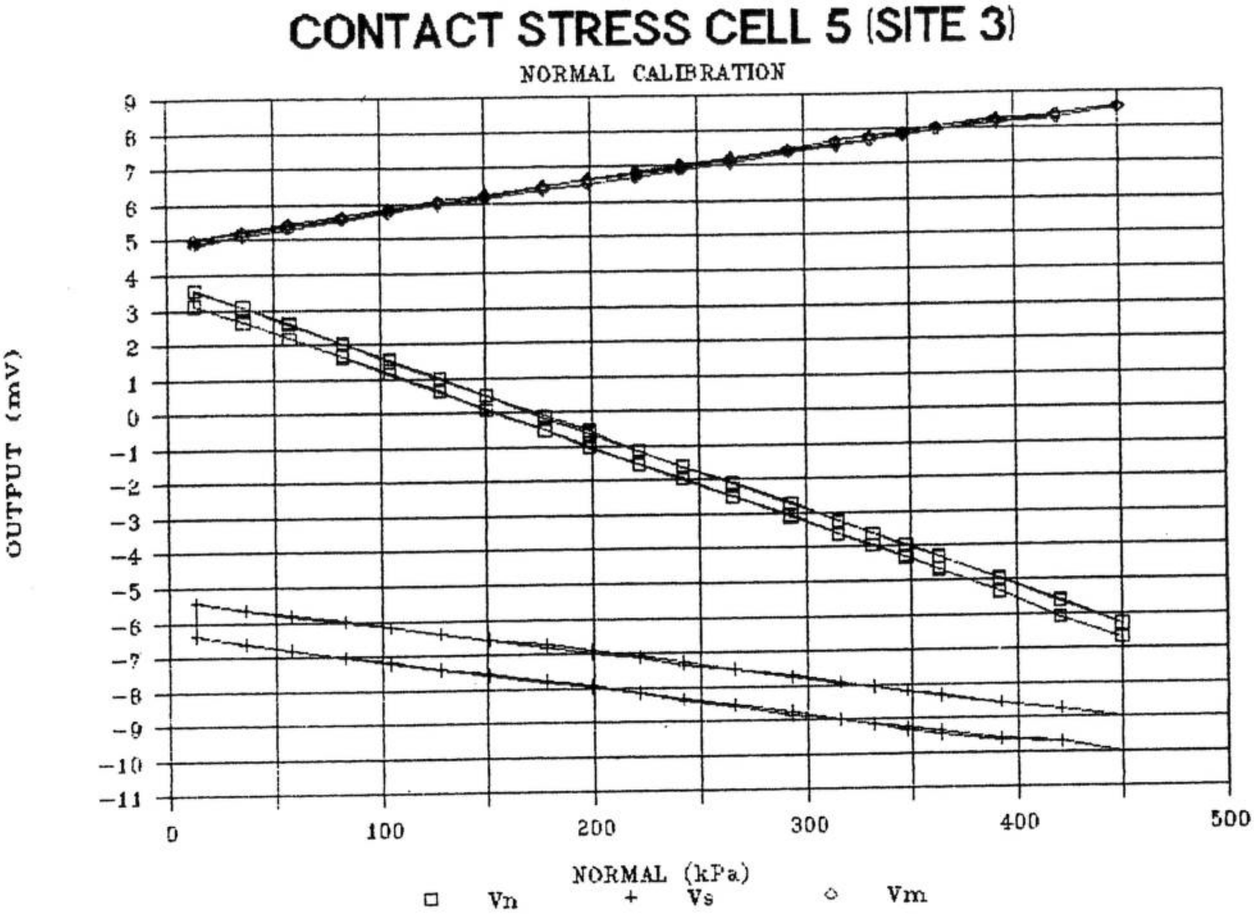


FIGURE III 28

CONTACT STRESS CELL 5 (SITE 3)

SHEAR LOAD VARIABLE M=0 N=450kPa

SHEAR CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	-8.87729	Constant	8.429735
Std Err of Y Est	0.029838	Std Err of Y Est	0.020750
R Squared	0.999959	R Squared	0.998399
No. of Observations	34	No. of Observations	34
Degrees of Freedom	32	Degrees of Freedom	32
X Coefficient(s)	-0.03975	X Coefficient(s)	-0.00440
Std Err of Coef.	0.000044	Std Err of Coef.	0.000031

NORMAL CIRCUIT	
Regression Output:	
Constant	-6.83120
Std Err of Y Est	0.024115
R Squared	0.999862
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.01745
Std Err of Coef.	0.000036

CONTACT STRESS CELL 5 (SITE 3)

SHEAR LOAD VARIABLE M=0 N=243kPa

SHEAR CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	-7.40485	Constant	7.029558
Std Err of Y Est	0.026032	Std Err of Y Est	0.027922
R Squared	0.999968	R Squared	0.997302
No. of Observations	34	No. of Observations	34
Degrees of Freedom	32	Degrees of Freedom	32
X Coefficient(s)	-0.03920	X Coefficient(s)	-0.00456
Std Err of Coef.	0.000039	Std Err of Coef.	0.000041

NORMAL CIRCUIT	
Regression Output:	
Constant	-1.78261
Std Err of Y Est	0.035045
R Squared	0.999695
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.01707
Std Err of Coef.	0.000052

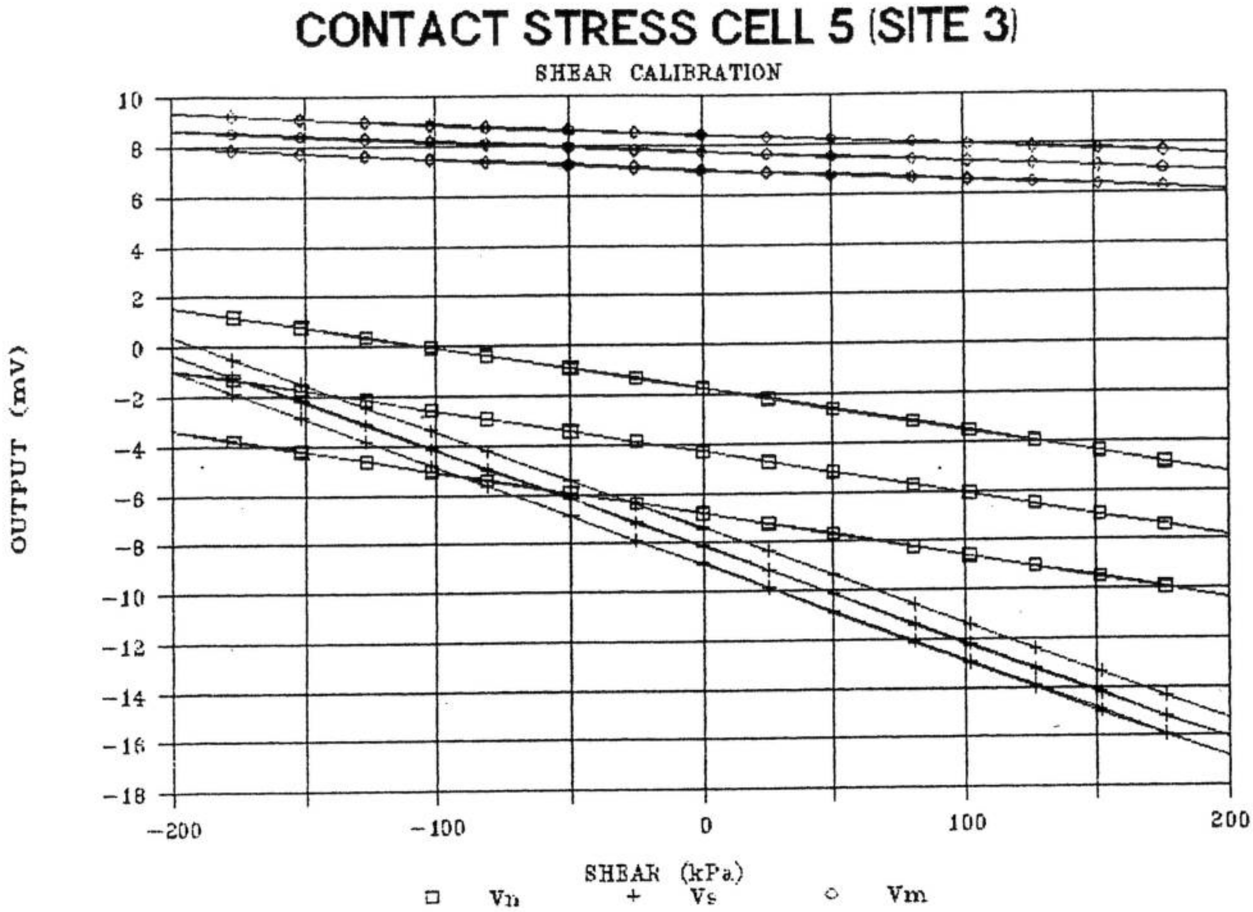


FIGURE III 29

CONTACT STRESS CELL 5 (SITE 3)

NORMAL LOAD AND MOMENT VARIABLE S=0

MOMENT CIRCUIT

Regression Output:

Constant	6.745833
Std Err of Y Est	1.046160
R Squared	0.739361
No. of Observations	78
Degrees of Freedom	76

X Coefficient(s) 0.086000
Std Err of Coef. 0.005857

NORMAL CIRCUIT -ve regression

Regression Output:

Constant	3.873780
Std Err of Y Est	0.030297
R Squared	0.999873
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) 0.262953
Std Err of Coef. 0.000487

SHEAR CIRCUIT

Regression Output:

Constant	-7.21573
Std Err of Y Est	1.060326
R Squared	0.340245
No. of Observations	78
Degrees of Freedom	76

X Coefficient(s) 0.037165
Std Err of Coef. 0.005936

NORMAL CIRCUIT +ve regression

Regression Output:

Constant	3.875062
Std Err of Y Est	0.027886
R Squared	0.999922
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.30883
Std Err of Coef. 0.000448

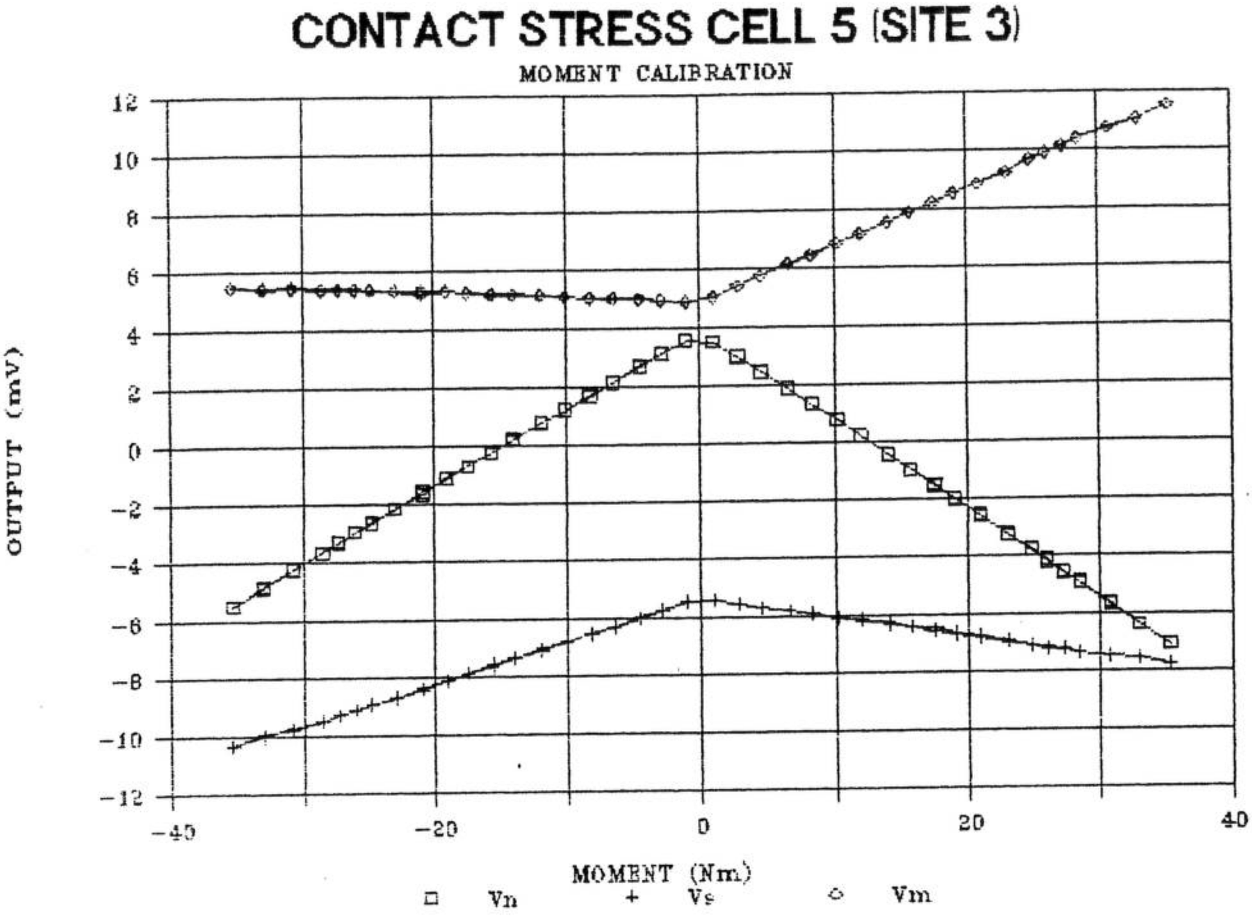


FIGURE III 30

CONTACT STRESS CELL 1 (SITE 4)

NORMAL LOAD VARIABLE M=0 S=0

SHEAR CIRCUIT

Regression Output:	
Constant	8.419384
Std Err of Y Est	0.009504
R Squared	0.945694
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.00030
Std Err of Coef.	0.000012

MOMENT CIRCUIT

Regression Output:	
Constant	22.49664
Std Err of Y Est	0.027545
R Squared	0.943959
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.00086
Std Err of Coef.	0.000034

NORMAL CIRCUIT

Regression Output:	
Constant	82.35167
Std Err of Y Est	0.013310
R Squared	0.999990
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.033504
Std Err of Coef.	0.000016

CONTACT STRESS CELL 1 (SITE 4)

NORMAL LOAD VARIABLE M=0 S=24.93kPa

SHEAR CIRCUIT

Regression Output:	
Constant	7.015566
Std Err of Y Est	0.008163
R Squared	0.973129
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.00037
Std Err of Coef.	0.000010

MOMENT CIRCUIT

Regression Output:	
Constant	22.83910
Std Err of Y Est	0.031730
R Squared	0.914792
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.00079
Std Err of Coef.	0.000040

NORMAL CIRCUIT

Regression Output:	
Constant	82.33893
Std Err of Y Est	0.015657
R Squared	0.999987
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.033514
Std Err of Coef.	0.000019

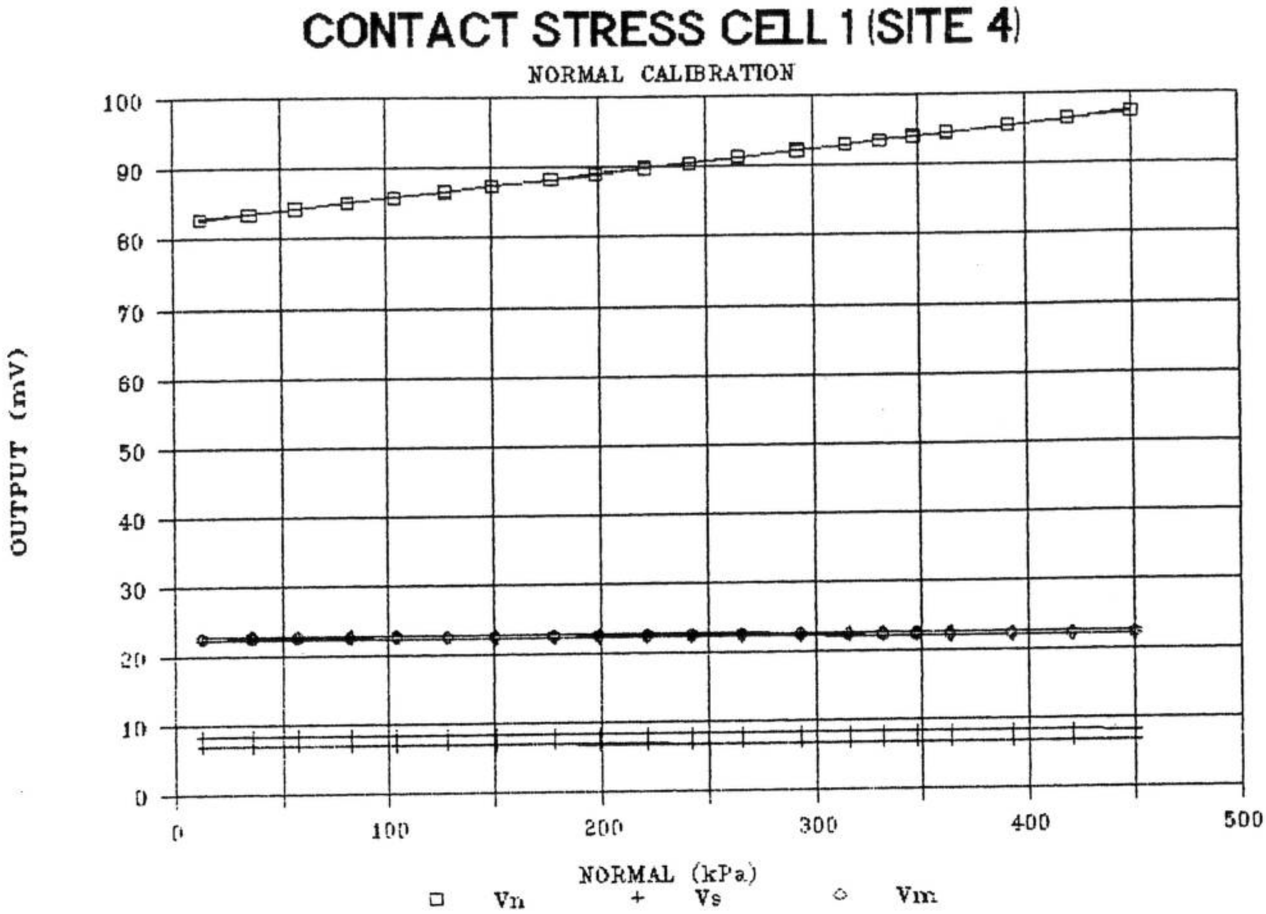


FIGURE III 31

CONTACT STRESS CELL 1 (SITE 4)

SHEAR LOAD VARIABLE M=0   N=450kPa

SHEAR CIRCUIT

Regression Output:

Constant	8.311294
Std Err of Y Est	0.046426
R Squared	0.999952
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.05730
Std Err of Coef.	0.000069

MOMENT CIRCUIT

Regression Output:

Constant	22.29126
Std Err of Y Est	0.044415
R Squared	0.999299
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.014260
Std Err of Coef.	0.000066

NORMAL CIRCUIT

Regression Output:

Constant	97.44502
Std Err of Y Est	0.015288
R Squared	0.795902
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.00025
Std Err of Coef.	0.000022

CONTACT STRESS CELL 1 (SITE 4)

SHEAR LOAD VARIABLE M=0   N=243kPa

SHEAR CIRCUIT

Regression Output:

Constant	8.339235
Std Err of Y Est	0.048526
R Squared	0.999947
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.05682
Std Err of Coef.	0.000072

MOMENT CIRCUIT

Regression Output:

Constant	22.38726
Std Err of Y Est	0.038690
R Squared	0.999450
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.014031
Std Err of Coef.	0.000058

NORMAL CIRCUIT

Regression Output:

Constant	90.52391
Std Err of Y Est	0.006550
R Squared	0.915475
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.00018
Std Err of Coef.	0.000009

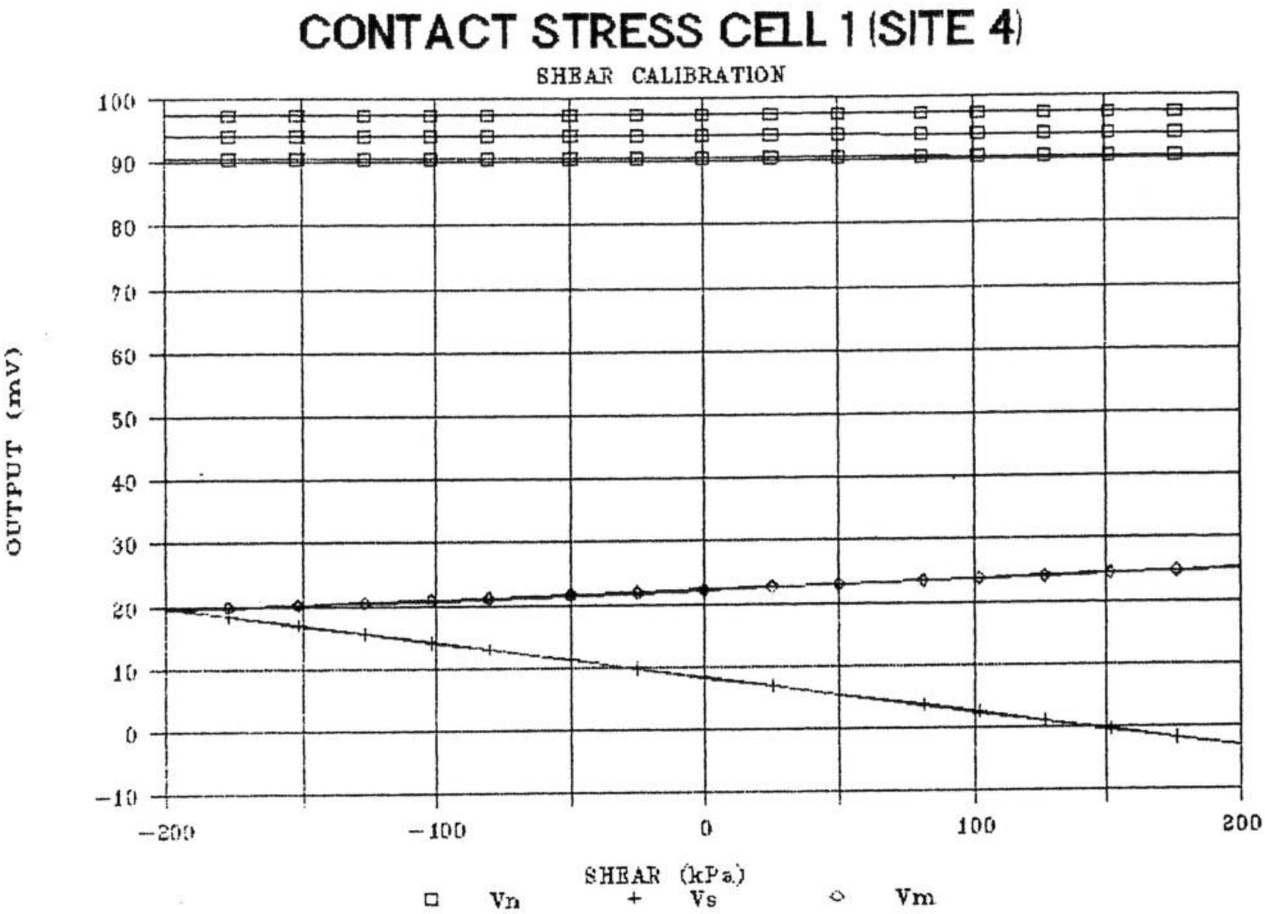


FIGURE III 32

CONTACT STRESS CELL 1 (SITE 4)

NORMAL LOAD AND MOMENT VARIABLE S=0

MOMENT CIRCUIT

Regression Output:

Constant	22.33834
Std Err of Y Est	0.118298
R Squared	0.997591
No. of Observations	78
Degrees of Freedom	76

X Coefficient(s) 0.117498
Std Err of Coef. 0.000662

NORMAL CIRCUIT -ve regression

Regression Output:

Constant	82.34046
Std Err of Y Est	0.125246
R Squared	0.999191
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.43050
Std Err of Coef. 0.002013

SHEAR CIRCUIT

Regression Output:

Constant	8.365538
Std Err of Y Est	0.027936
R Squared	0.993501
No. of Observations	78
Degrees of Freedom	76

X Coefficient(s) 0.016858
Std Err of Coef. 0.000156

NORMAL CIRCUIT +ve regression

Regression Output:

Constant	82.34623
Std Err of Y Est	0.015645
R Squared	0.999987
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) 0.424444
Std Err of Coef. 0.000251

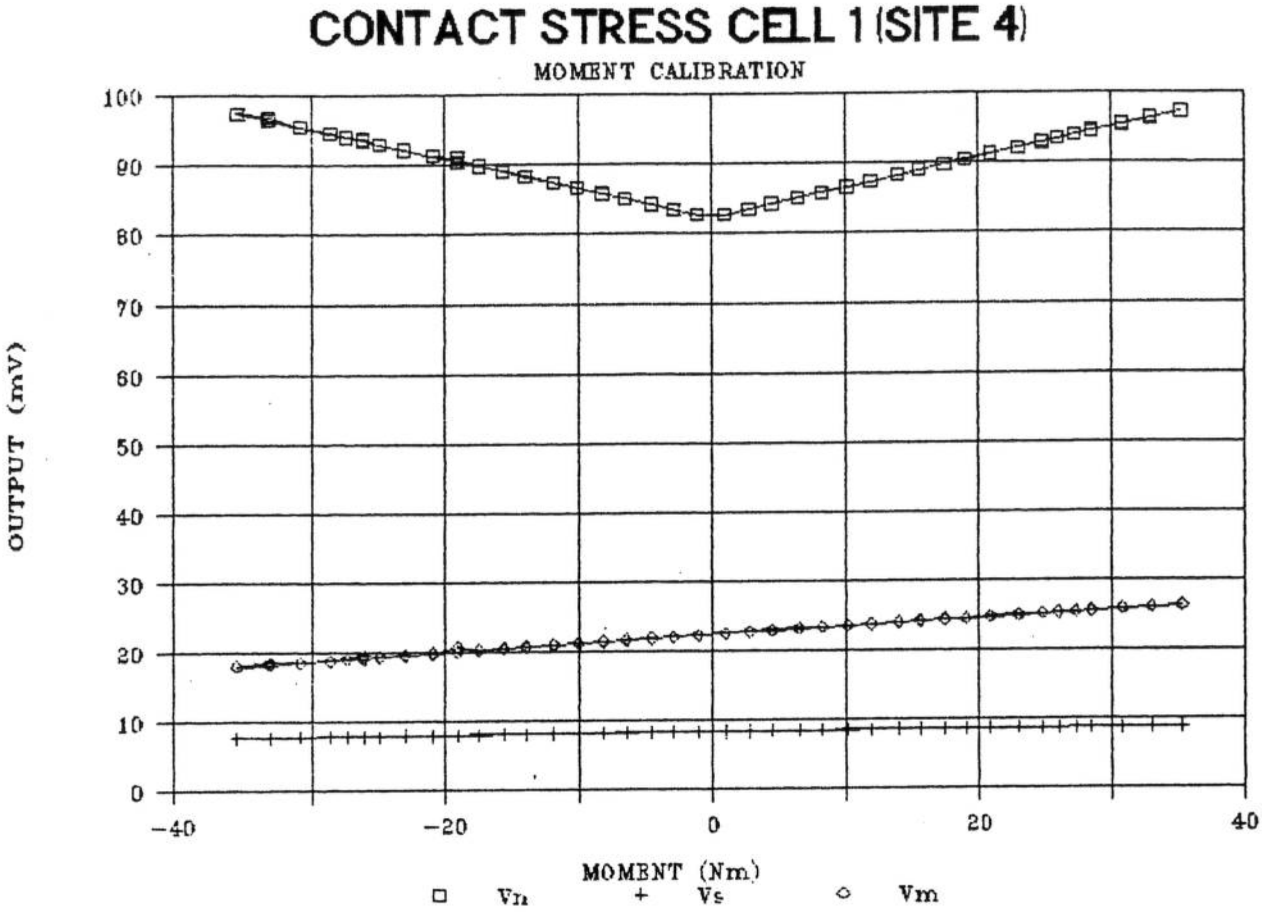


FIGURE III33

CONTACT STRESS CELL 2 (SITE 4)

NORMAL LOAD VARIABLE M=0 S=0

SHEAR CIRCUIT

Regression Output:	
Constant	8.124083
Std Err of Y Est	0.010676
R Squared	0.938567
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.000320
Std Err of Coef.	0.000013

MOMENT CIRCUIT

Regression Output:	
Constant	-3.76004
Std Err of Y Est	0.027418
R Squared	0.438178
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.000185
Std Err of Coef.	0.000034

NORMAL CIRCUIT

Regression Output:	
Constant	15.39715
Std Err of Y Est	0.023205
R Squared	0.999971
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.033225
Std Err of Coef.	0.000029

CONTACT STRESS CELL 2 (SITE 4)

NORMAL LOAD VARIABLE M=0 S=24.93kPa

SHEAR CIRCUIT

Regression Output:	
Constant	6.536933
Std Err of Y Est	0.007958
R Squared	0.917643
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.000204
Std Err of Coef.	0.000010

MOMENT CIRCUIT

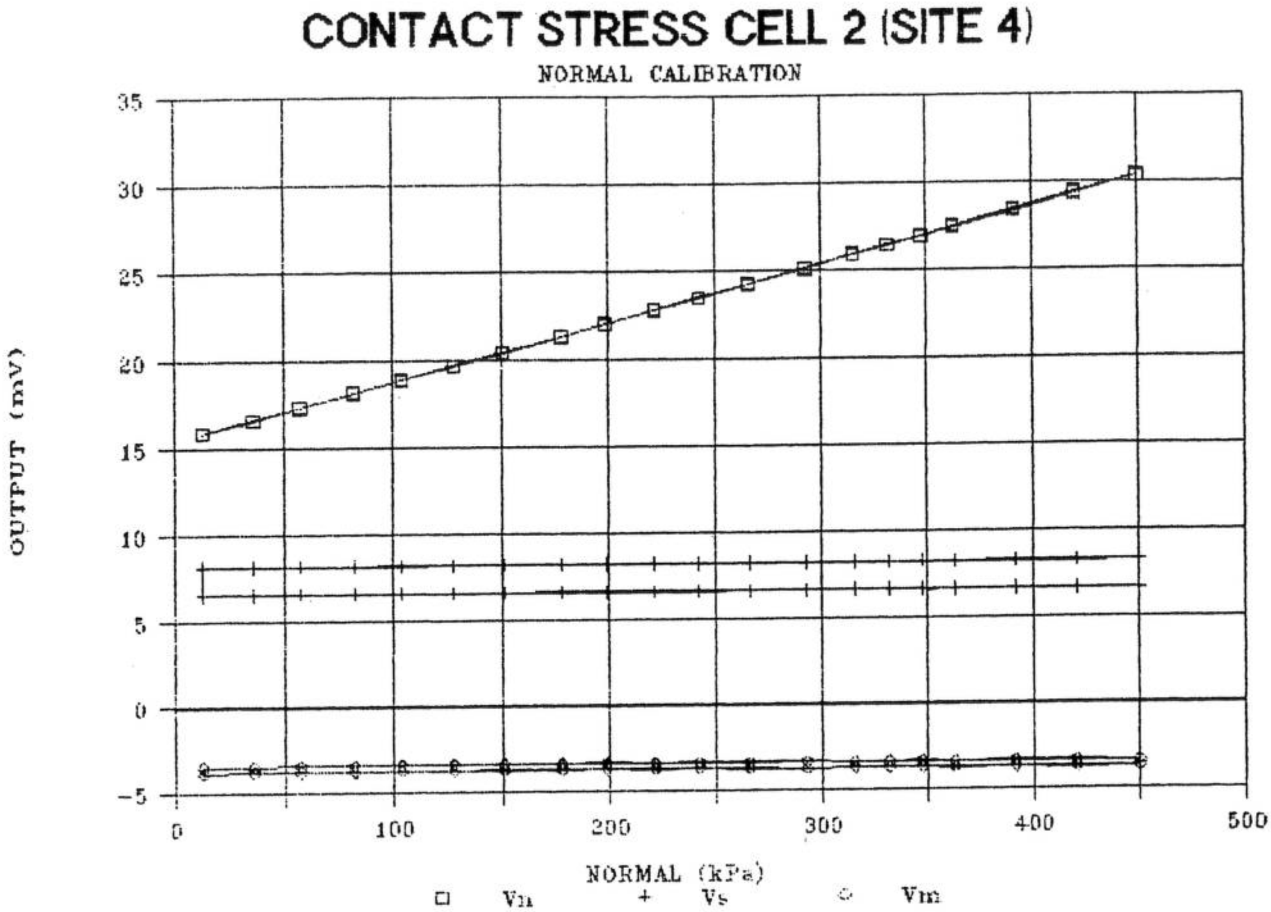
Regression Output:	
Constant	-3.42694
Std Err of Y Est	0.024284
R Squared	0.579416
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.000218
Std Err of Coef.	0.000030

NORMAL CIRCUIT

Regression Output:	
Constant	15.41269
Std Err of Y Est	0.017579
R Squared	0.999983
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.033247
Std Err of Coef.	0.000022


CONTACT STRESS CELL 2 (SITE 4)
NORMAL CALIBRATION
OUTPUT (mV)
35
30
25
20
15
10
5
0
-5
0
100
200
300
400
500
NORMAL (kPa)
Vn
Vs
Vm

CONTACT STRESS CELL 2 (SITE 4)

SHEAR LOAD VARIABLE M=0 N=450kPa

SHEAR CIRCUIT

Regression Output:

Constant	8.275823
Std Err of Y Est	0.070877
R Squared	0.999914
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.06528
Std Err of Coef.	0.000106

MOMENT CIRCUIT

Regression Output:

Constant	-3.73952
Std Err of Y Est	0.015827
R Squared	0.999911
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.014285
Std Err of Coef.	0.000023

NORMAL CIRCUIT

Regression Output:

Constant	30.37758
Std Err of Y Est	0.012919
R Squared	0.979914
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.000767
Std Err of Coef.	0.000019

CONTACT STRESS CELL 2 (SITE 4)

SHEAR LOAD VARIABLE M=0 N=243kPa

SHEAR CIRCUIT

Regression Output:

Constant	8.216264
Std Err of Y Est	0.061698
R Squared	0.999933
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.06455
Std Err of Coef.	0.000092

MOMENT CIRCUIT

Regression Output:

Constant	-3.70270
Std Err of Y Est	0.008830
R Squared	0.999970
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.013865
Std Err of Coef.	0.000013

NORMAL CIRCUIT

Regression Output:

Constant	23.47158
Std Err of Y Est	0.021977
R Squared	0.946595
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.000786
Std Err of Coef.	0.000033

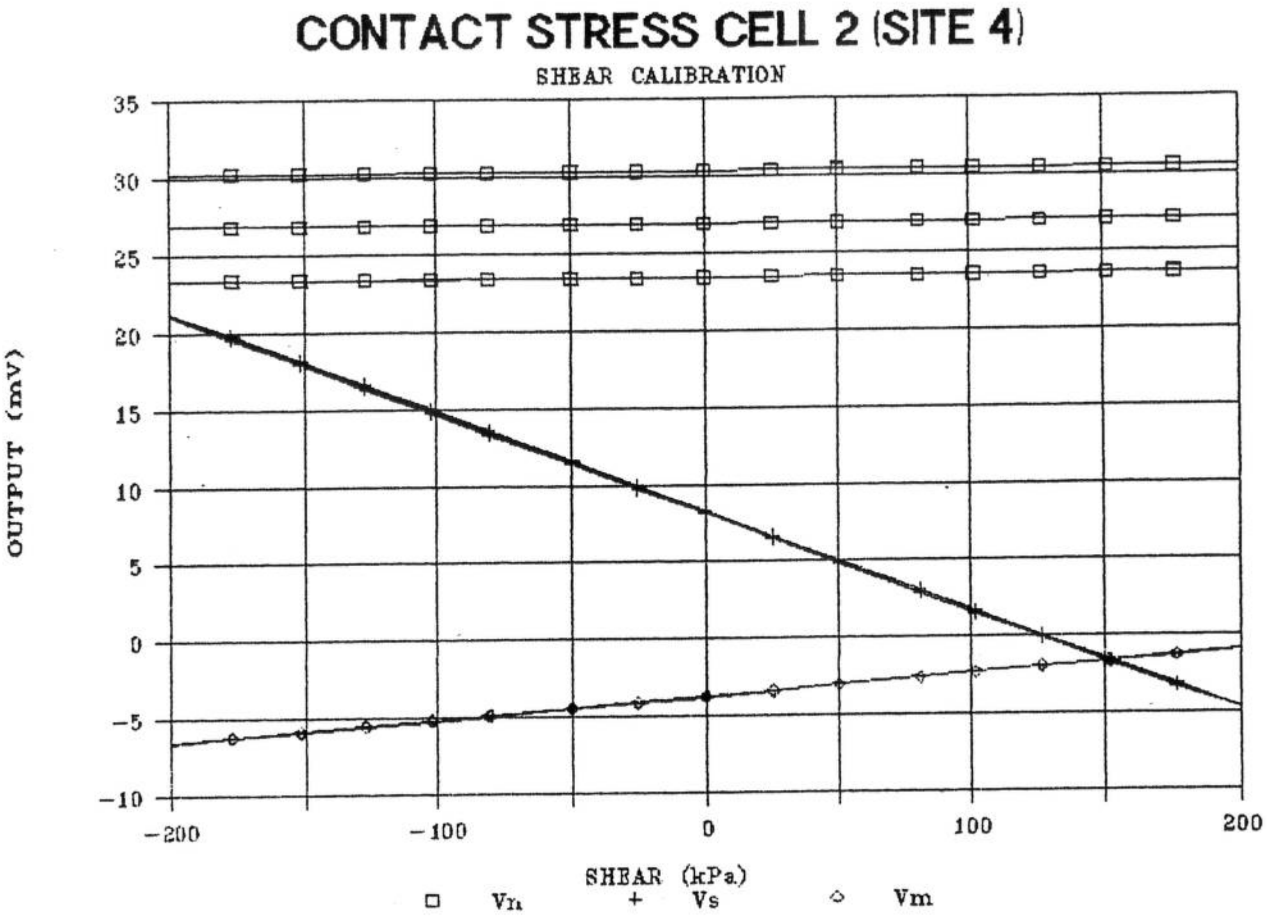


FIGURE III35

CONTACT STRESS CELL 2 (SITE 4)

NORMAL LOAD AND MOMENT VARIABLE S=0

MOMENT CIRCUIT

Regression Output:

Constant	-3.70141
Std Err of Y Est	0.052151
R Squared	0.999537
No. of Observations	78
Degrees of Freedom	76

X Coefficient(s)	0.118304
Std Err of Coef.	0.000291

NORMAL CIRCUIT -ve regression

Regression Output:

Constant	15.39773
Std Err of Y Est	0.017304
R Squared	0.999983
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.42266
Std Err of Coef.	0.000278

SHEAR CIRCUIT

Regression Output:

Constant	8.128948
Std Err of Y Est	0.019402
R Squared	0.997041
No. of Observations	78
Degrees of Freedom	76

X Coefficient(s)	0.017383
Std Err of Coef.	0.000108

NORMAL CIRCUIT +ve regression

Regression Output:

Constant	15.39030
Std Err of Y Est	0.024415
R Squared	0.999968
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.422835
Std Err of Coef.	0.000392

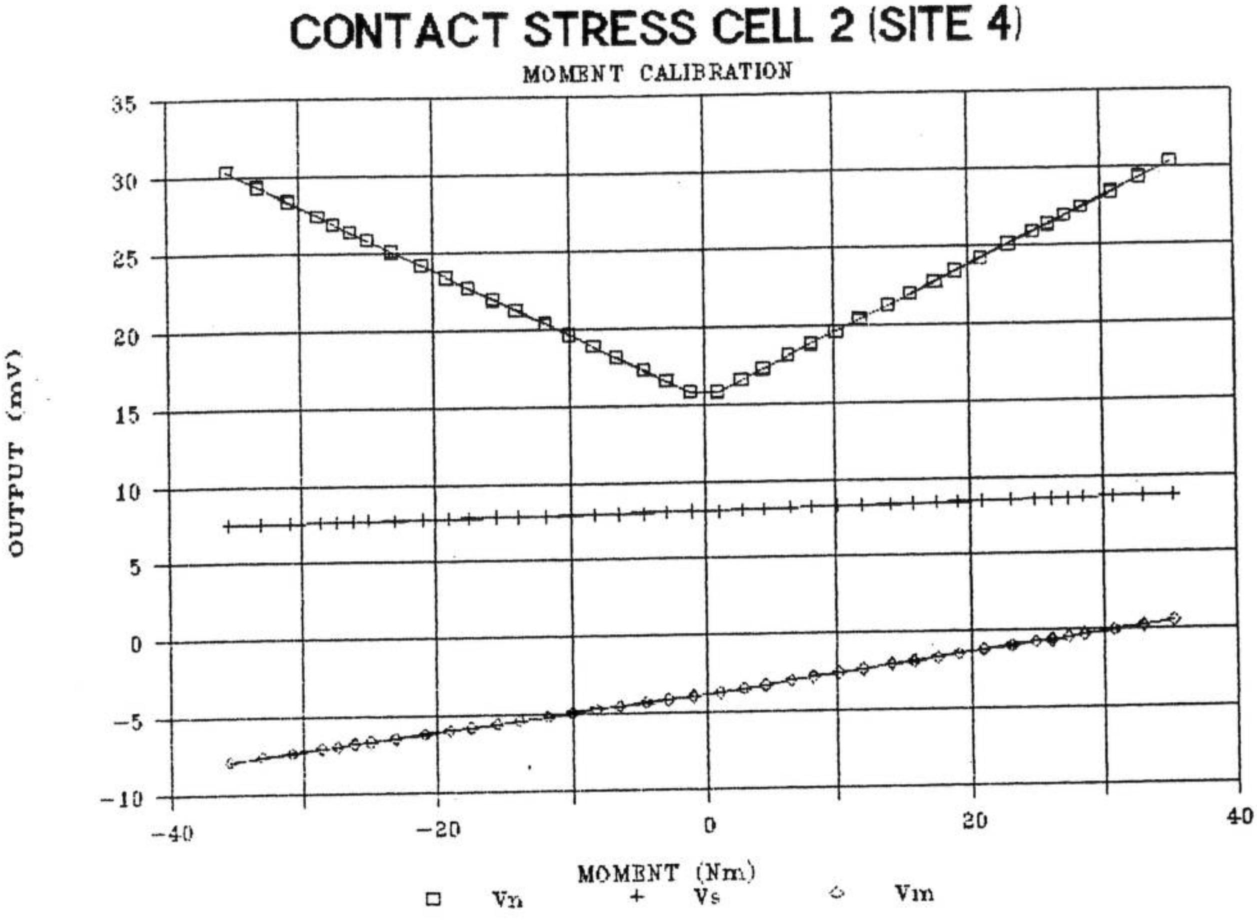


FIGURE III 36

CONTACT STRESS CELL 3 (SITE 4)

NORMAL LOAD VARIABLE M=0   S=0

SHEAR CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	14.81188	Constant	0.969500
Std Err of Y Est	0.004252	Std Err of Y Est	0.020104
R Squared	0.892947	R Squared	0.648511
No. of Observations	39	No. of Observations	39
Degrees of Freedom	37	Degrees of Freedom	37
X Coefficient(s)	0.000094	X Coefficient(s)	0.000209
Std Err of Coef.	0.000005	Std Err of Coef.	0.000025

NORMAL CIRCUIT	
Regression Output:	
Constant	14.32247
Std Err of Y Est	0.014999
R Squared	0.999987
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	-0.03202
Std Err of Coef.	0.000018

CONTACT STRESS CELL 3 (SITE 4)

NORMAL LOAD VARIABLE M=0   S=24.93kPa

SHEAR CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	16.24529	Constant	0.647709
Std Err of Y Est	0.004931	Std Err of Y Est	0.021656
R Squared	0.960307	R Squared	0.494590
No. of Observations	39	No. of Observations	39
Degrees of Freedom	37	Degrees of Freedom	37
X Coefficient(s)	0.000186	X Coefficient(s)	0.000164
Std Err of Coef.	0.000006	Std Err of Coef.	0.000027

NORMAL CIRCUIT	
Regression Output:	
Constant	14.26956
Std Err of Y Est	0.017940
R Squared	0.999981
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	-0.03205
Std Err of Coef.	0.000022

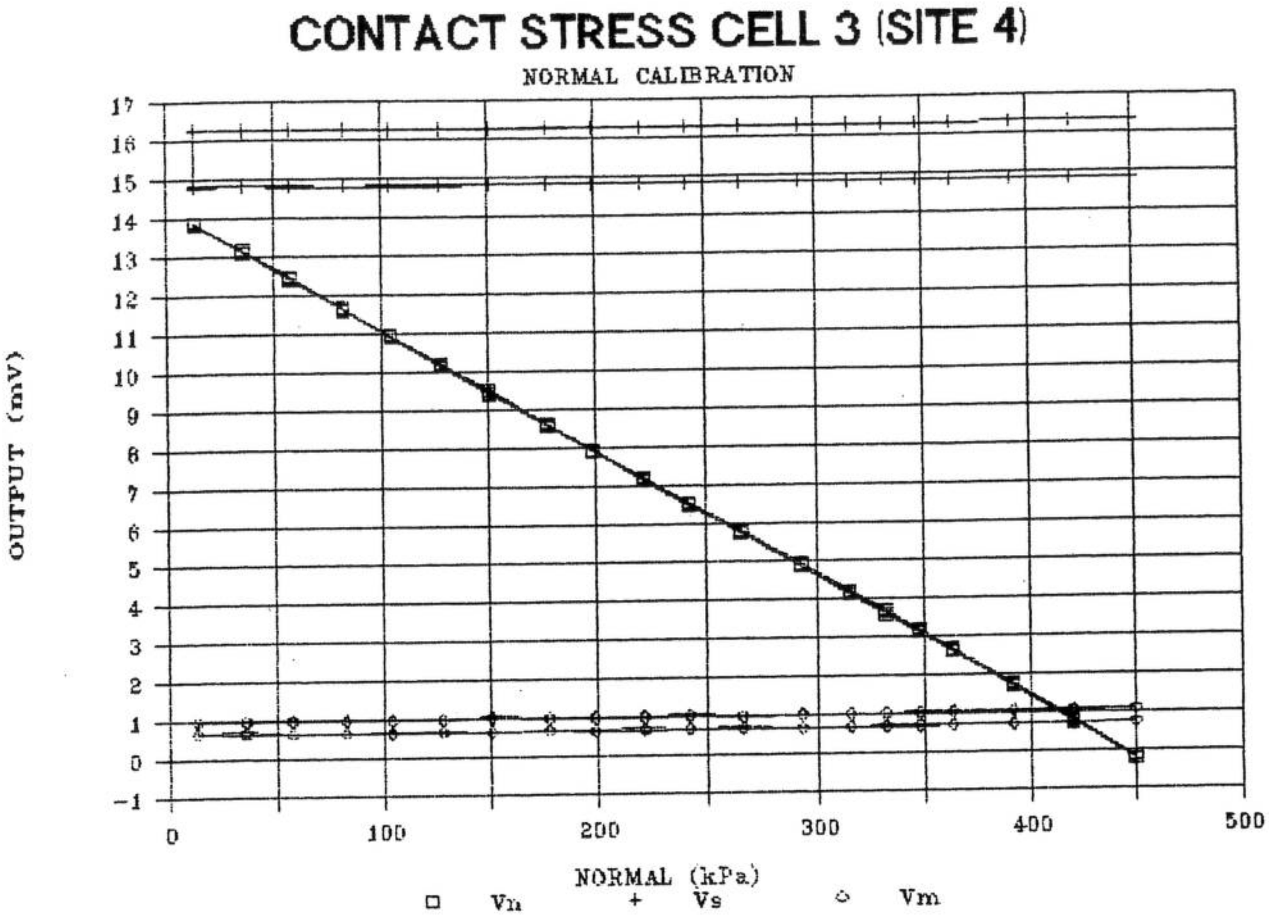


FIGURE III 37

CONTACT STRESS CELL 3 (SITE 4)

SHEAR LOAD VARIABLE M=0   N=450kPa

SHEAR CIRCUIT

Regression Output:	
Constant	14.87782
Std Err of Y Est	0.044017
R Squared	0.999959
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.059134
Std Err of Coef.	0.000066

MOMENT CIRCUIT

Regression Output:	
Constant	1.121205
Std Err of Y Est	0.041011
R Squared	0.999366
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.01384
Std Err of Coef.	0.000061

NORMAL CIRCUIT

Regression Output:	
Constant	-0.10238
Std Err of Y Est	0.016645
R Squared	0.996778
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.00248
Std Err of Coef.	0.000025

CONTACT STRESS CELL 3 (SITE 4)

SHEAR LOAD VARIABLE M=0   N=243kPa

SHEAR CIRCUIT

Regression Output:	
Constant	14.83514
Std Err of Y Est	0.036948
R Squared	0.999971
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.058422
Std Err of Coef.	0.000055

MOMENT CIRCUIT

Regression Output:	
Constant	1.060117
Std Err of Y Est	0.036436
R Squared	0.999475
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.01351
Std Err of Coef.	0.000054

NORMAL CIRCUIT

Regression Output:	
Constant	6.533352
Std Err of Y Est	0.019517
R Squared	0.995754
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.00254
Std Err of Coef.	0.000029

CONTACT STRESS CELL 3 (SITE 4)

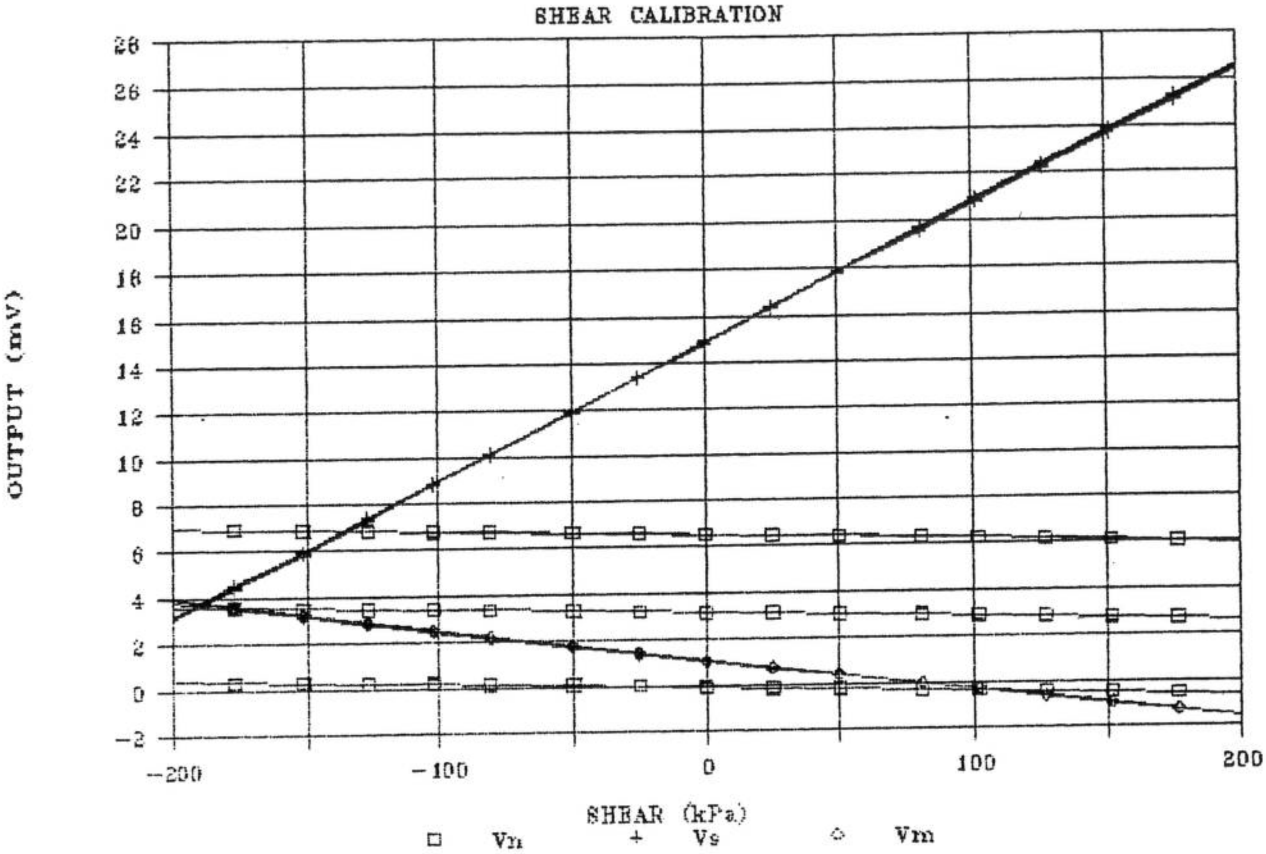


FIGURE III 38

CONTACT STRESS CELL 3 (SITE 4)

NORMAL LOAD AND MOMENT VARIABLE S=0

MOMENT CIRCUIT

Regression Output:	
Constant	0.995974
Std Err of Y Est	0.021999
R Squared	0.999910
No. of Observations	78
Degrees of Freedom	76

X Coefficient(s) -0.11343
Std Err of Coef. 0.000123

NORMAL CIRCUIT -ve regression

Regression Output:	
Constant	14.32310
Std Err of Y Est	0.011529
R Squared	0.999992
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) 0.408895
Std Err of Coef. 0.000185

SHEAR CIRCUIT

Regression Output:	
Constant	14.84158
Std Err of Y Est	0.007198
R Squared	0.999393
No. of Observations	78
Degrees of Freedom	76

X Coefficient(s) -0.01425
Std Err of Coef. 0.000040

NORMAL CIRCUIT +ve regression

Regression Output:	
Constant	14.34149
Std Err of Y Est	0.016827
R Squared	0.999983
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.40623
Std Err of Coef. 0.000270

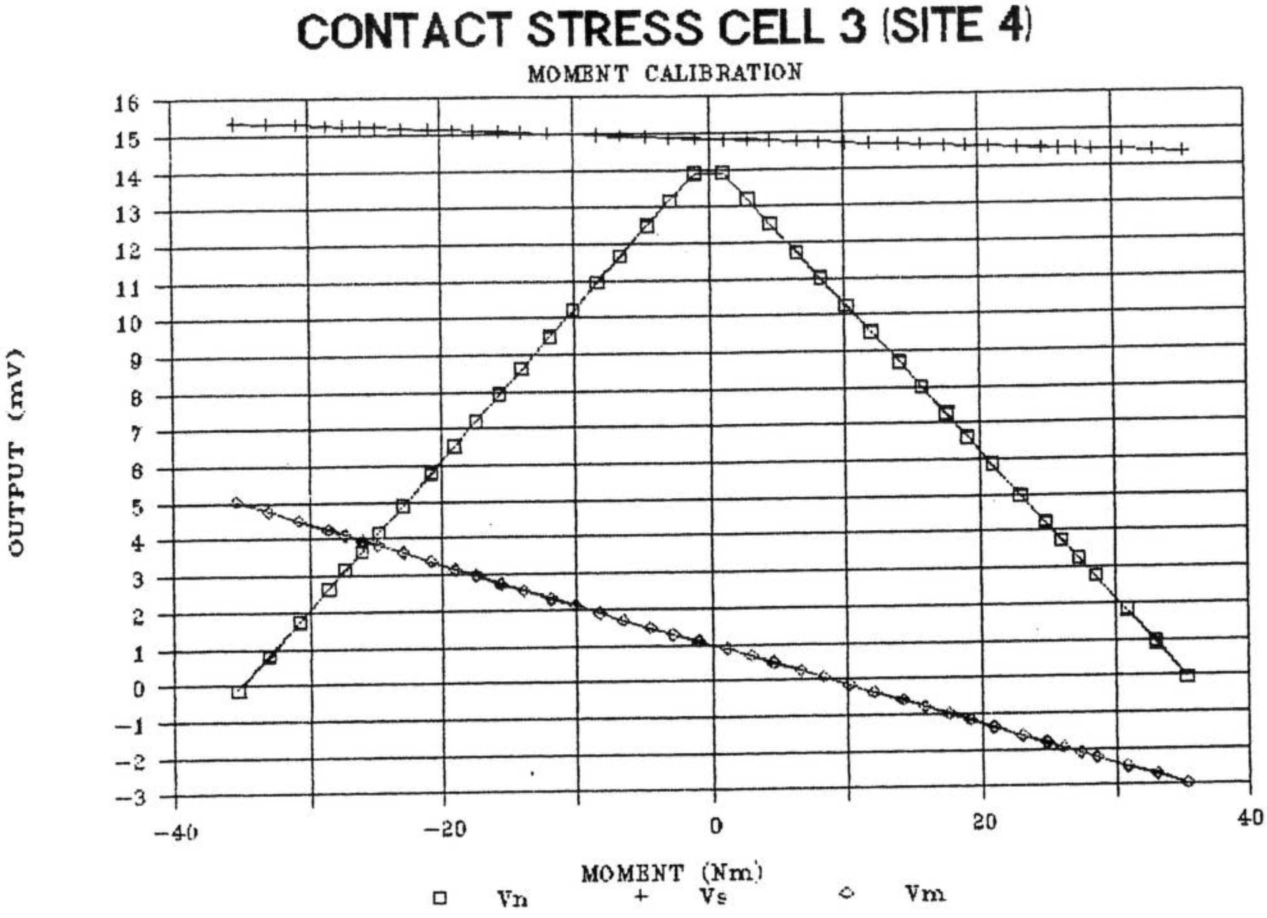


FIGURE III 39

CONTACT STRESS CELL 4 (SITE 4)

NORMAL LOAD VARIABLE M=0 S=0

SHEAR CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	5.673952	Constant	-6.72522
Std Err of Y Est	0.007316	Std Err of Y Est	0.022680
R Squared	0.956483	R Squared	0.428990
No. of Observations	39	No. of Observations	39
Degrees of Freedom	37	Degrees of Freedom	37
X Coefficient(s)	0.000263	X Coefficient(s)	0.000151
Std Err of Coef.	0.000009	Std Err of Coef.	0.000028

NORMAL CIRCUIT	
Regression Output:	
Constant	4.033044
Std Err of Y Est	0.011063
R Squared	0.999993
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	-0.03222
Std Err of Coef.	0.000013

CONTACT STRESS CELL 4 (SITE 4)

NORMAL LOAD VARIABLE M=0 S=24.93kPa

SHEAR CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	7.118911	Constant	-7.05821
Std Err of Y Est	0.004024	Std Err of Y Est	0.017337
R Squared	0.991962	R Squared	0.468657
No. of Observations	39	No. of Observations	39
Degrees of Freedom	37	Degrees of Freedom	37
X Coefficient(s)	0.000343	X Coefficient(s)	0.000125
Std Err of Coef.	0.000005	Std Err of Coef.	0.000021

NORMAL CIRCUIT	
Regression Output:	
Constant	4.049939
Std Err of Y Est	0.011309
R Squared	0.999992
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	-0.03225
Std Err of Coef.	0.000014

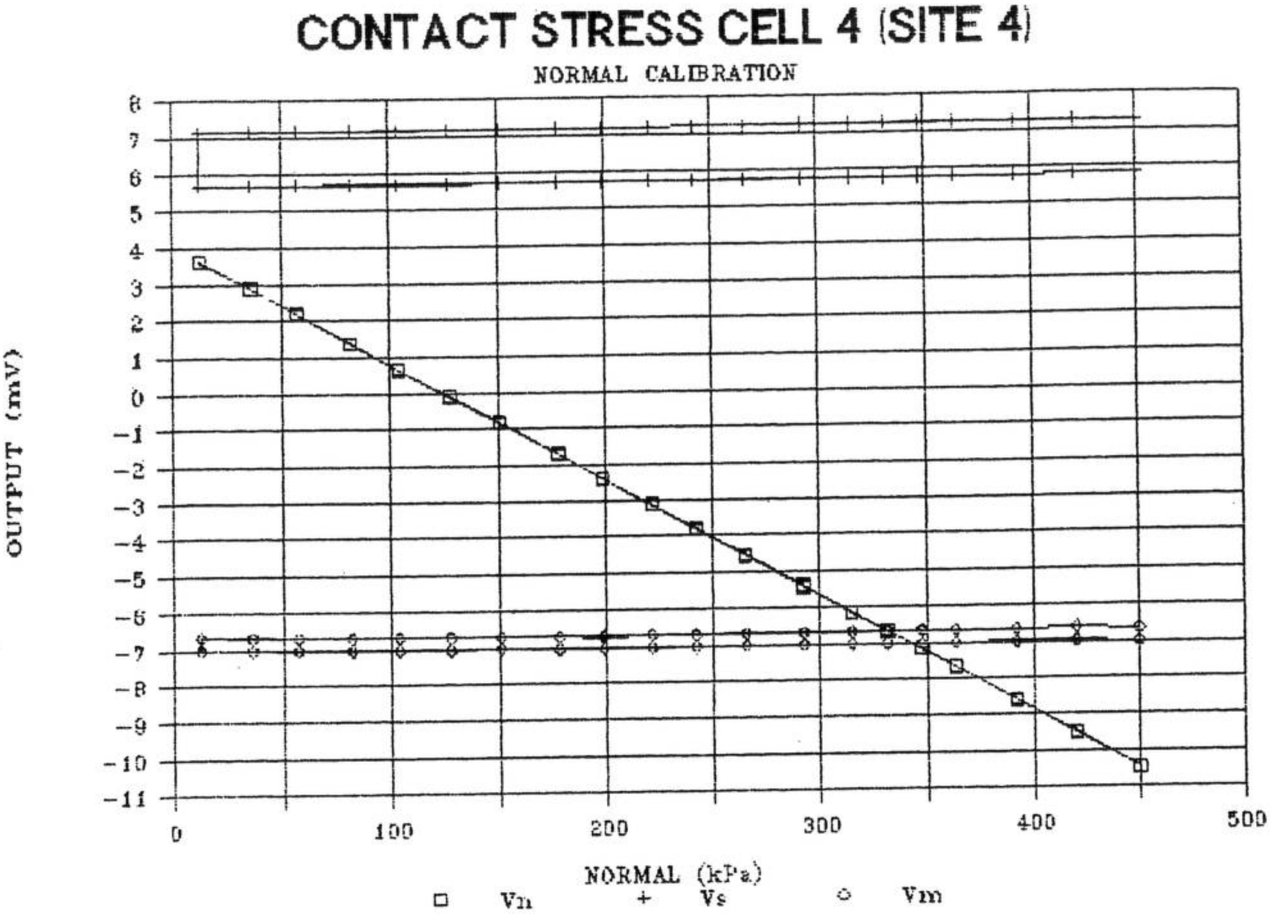


FIGURE III 40

CONTACT STRESS CELL 4 (SITE 4)

SHEAR LOAD VARIABLE M=0 N=450kPa

SHEAR CIRCUIT

Regression Output:	
Constant	5.771794
Std Err of Y Est	0.047279
R Squared	0.999953
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.059196
Std Err of Coef.	0.000071

MOMENT CIRCUIT

Regression Output:	
Constant	-6.62902
Std Err of Y Est	0.015901
R Squared	0.999907
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.01408
Std Err of Coef.	0.000023

NORMAL CIRCUIT

Regression Output:	
Constant	-10.4499
Std Err of Y Est	0.010040
R Squared	0.985875
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.000713
Std Err of Coef.	0.000015

CONTACT STRESS CELL 4 (SITE 4)

SHEAR LOAD VARIABLE M=0 N=243kPa

SHEAR CIRCUIT

Regression Output:	
Constant	5.740470
Std Err of Y Est	0.050214
R Squared	0.999947
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.058834
Std Err of Coef.	0.000075

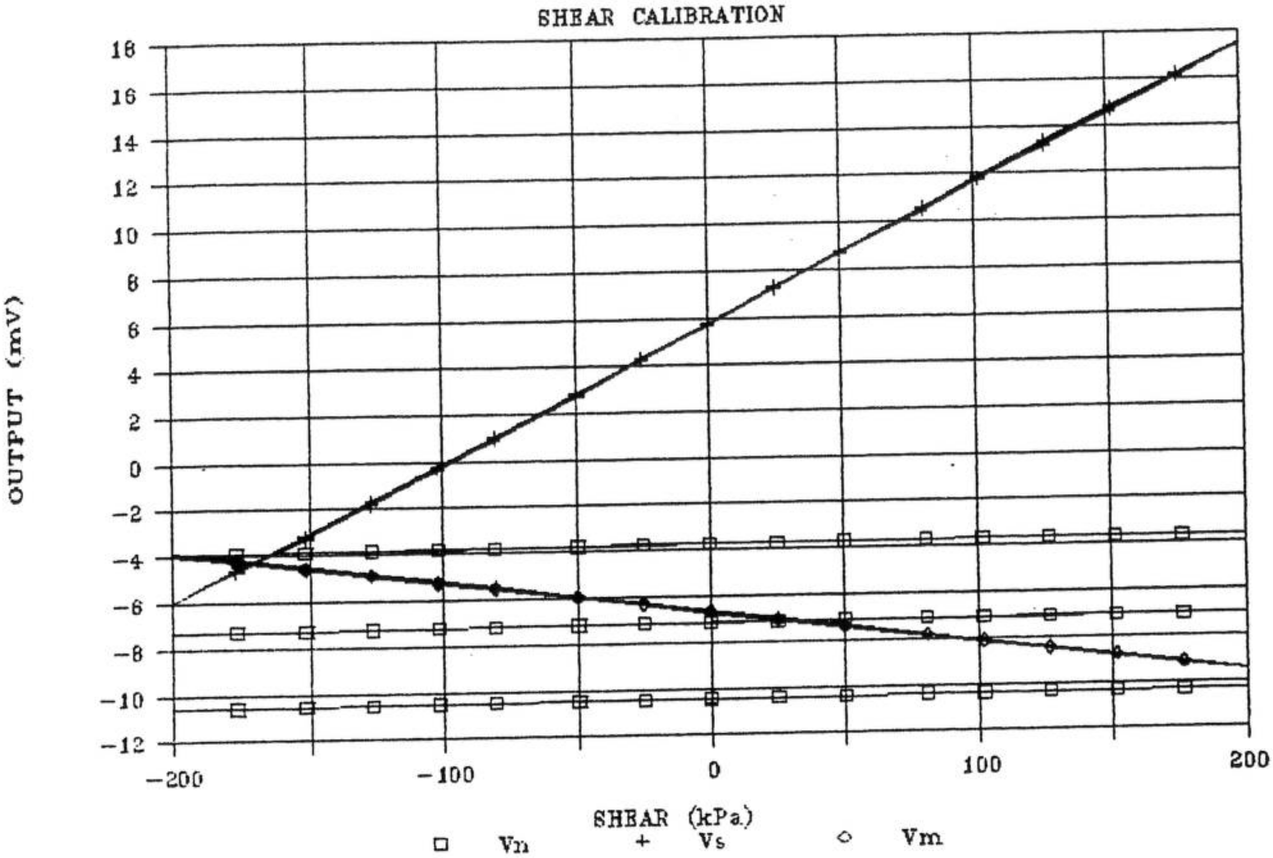
MOMENT CIRCUIT

Regression Output:	
Constant	-6.71964
Std Err of Y Est	0.013331
R Squared	0.999933
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.01390
Std Err of Coef.	0.000020

NORMAL CIRCUIT

Regression Output:	
Constant	-3.73611
Std Err of Y Est	0.018145
R Squared	0.952085
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.000687
Std Err of Coef.	0.000027

CONTACT STRESS CELL 4 (SITE 4)



CONTACT STRESS CELL 4 (SITE 4)

NORMAL LOAD AND MOMENT VARIABLE S=0

MOMENT CIRCUIT

Regression Output:	
Constant	-7.09307
Std Err of Y Est	0.042970
R Squared	0.999639
No. of Observations	78
Degrees of Freedom	76

X Coefficient(s)	-0.11037
Std Err of Coef.	0.000240

NORMAL CIRCUIT -ve regression

Regression Output:	
Constant	4.048511
Std Err of Y Est	0.011500
R Squared	0.999992
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.409518
Std Err of Coef.	0.000184

SHEAR CIRCUIT

Regression Output:	
Constant	7.309730
Std Err of Y Est	0.100172
R Squared	0.938502
No. of Observations	78
Degrees of Freedom	76

X Coefficient(s)	-0.01909
Std Err of Coef.	0.000560

NORMAL CIRCUIT +ve regression

Regression Output:	
Constant	4.047909
Std Err of Y Est	0.023760
R Squared	0.999967
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.40986
Std Err of Coef.	0.000382

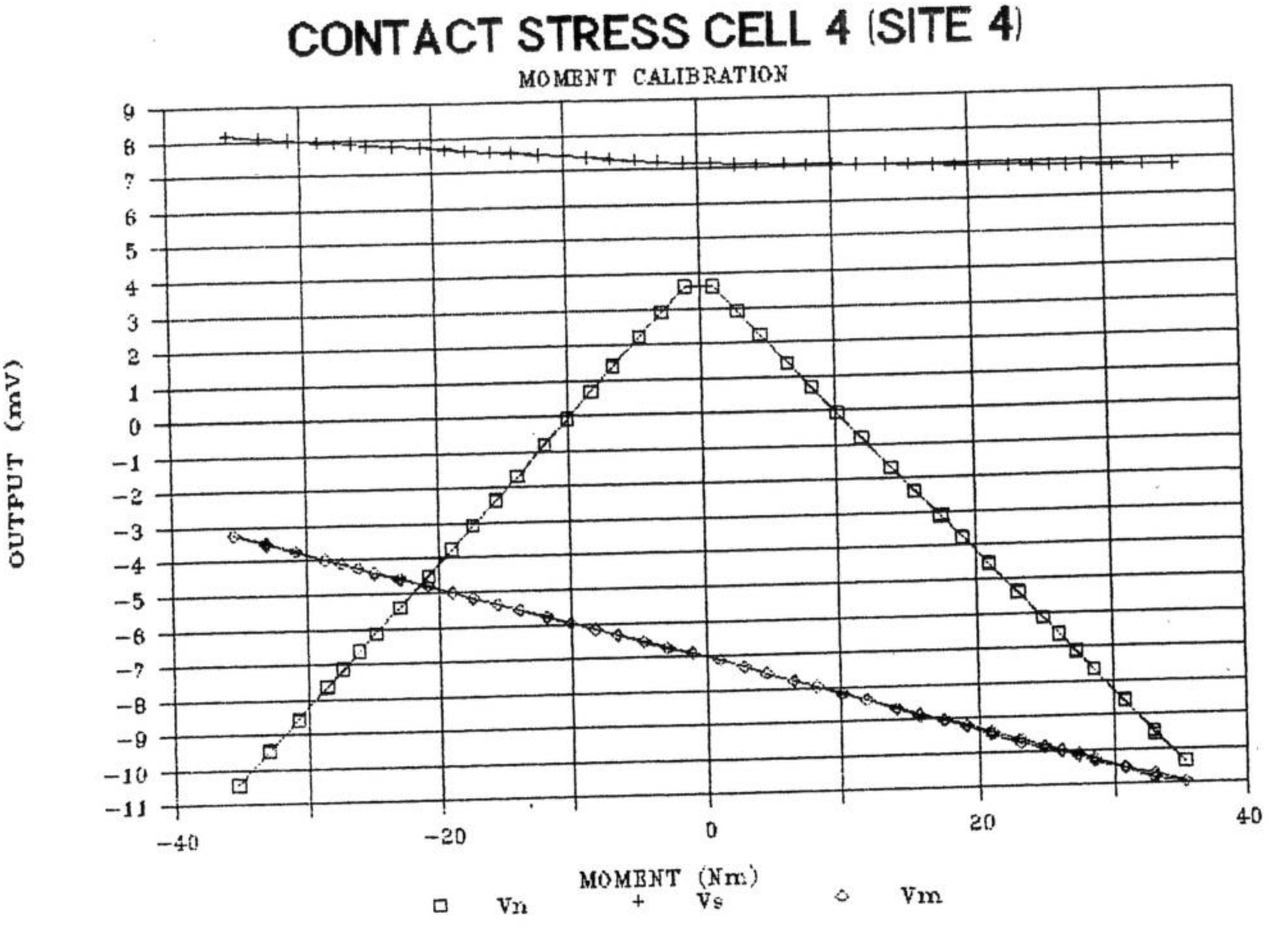


FIGURE III 42

CONTACT STRESS CELL 1 (SITE 5)

NORMAL LOAD VARIABLE M=0 S=0

SHEAR CIRCUIT

Regression Output:	
Constant	-3.95945
Std Err of Y Est	0.015840
R Squared	0.148271
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.000050
Std Err of Coef.	0.000020

MOMENT CIRCUIT

Regression Output:	
Constant	3.542814
Std Err of Y Est	0.043570
R Squared	0.008838
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.000031
Std Err of Coef.	0.000055

NORMAL CIRCUIT

Regression Output:	
Constant	9.357301
Std Err of Y Est	0.009668
R Squared	0.999986
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.019976
Std Err of Coef.	0.000012

CONTACT STRESS CELL 1 (SITE 5)

NORMAL LOAD VARIABLE M=0 S=24.93kPa

SHEAR CIRCUIT

Regression Output:	
Constant	-2.89871
Std Err of Y Est	0.014260
R Squared	0.473557
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.000103
Std Err of Coef.	0.000018

MOMENT CIRCUIT

Regression Output:	
Constant	3.382985
Std Err of Y Est	0.042225
R Squared	0.084889
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	-0.00009
Std Err of Coef.	0.000053

NORMAL CIRCUIT

Regression Output:	
Constant	9.344411
Std Err of Y Est	0.008477
R Squared	0.999989
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.019964
Std Err of Coef.	0.000010

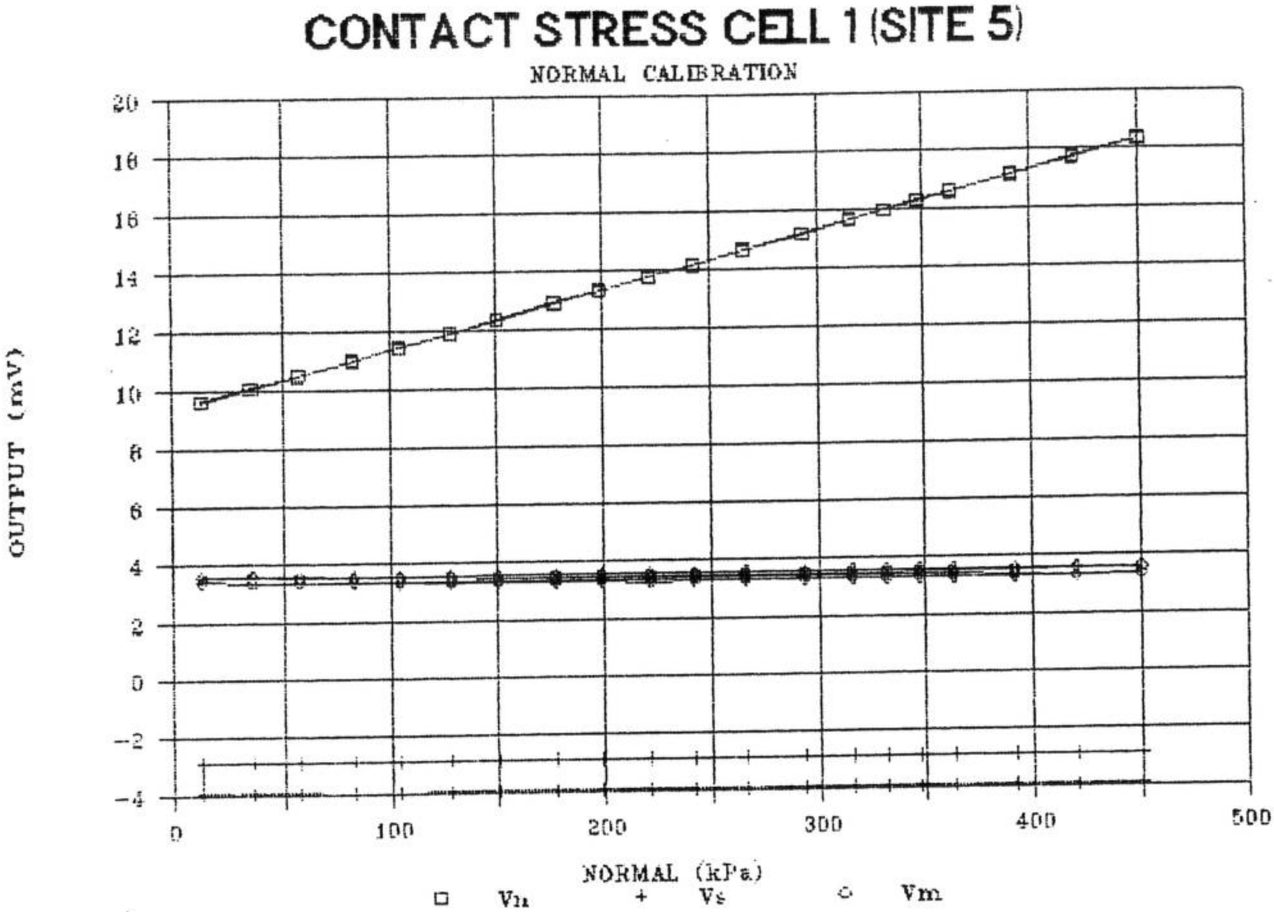


FIGURE III43

CONTACT STRESS CELL 1 (SITE 5)

SHEAR LOAD VARIABLE M=0   N=450kPa

SHEAR CIRCUIT

Regression Output:

Constant	-3.99285
Std Err of Y Est	0.025992
R Squared	0.999974
No. of Observations	34
Degrees of Freedom	32

X Coefficient(s)	0.044010
Std Err of Coef.	0.000039

MOMENT CIRCUIT

Regression Output:

Constant	3.506941
Std Err of Y Est	0.011067
R Squared	0.999864
No. of Observations	34
Degrees of Freedom	32

X Coefficient(s)	-0.00808
Std Err of Coef.	0.000016

NORMAL CIRCUIT

Regression Output:

Constant	18.41017
Std Err of Y Est	0.016131
R Squared	0.952158
No. of Observations	34
Degrees of Freedom	32

X Coefficient(s)	-0.00061
Std Err of Coef.	0.000024

CONTACT STRESS CELL 1 (SITE 5)

SHEAR LOAD VARIABLE M=0   N=243kPa

SHEAR CIRCUIT

Regression Output:

Constant	-3.97911
Std Err of Y Est	0.025158
R Squared	0.999975
No. of Observations	34
Degrees of Freedom	32

X Coefficient(s)	0.043235
Std Err of Coef.	0.000037

MOMENT CIRCUIT

Regression Output:

Constant	3.500705
Std Err of Y Est	0.009307
R Squared	0.999892
No. of Observations	34
Degrees of Freedom	32

X Coefficient(s)	-0.00762
Std Err of Coef.	0.000013

NORMAL CIRCUIT

Regression Output:

Constant	14.23129
Std Err of Y Est	0.018727
R Squared	0.927607
No. of Observations	34
Degrees of Freedom	32

X Coefficient(s)	-0.00056
Std Err of Coef.	0.000028

CONTACT STRESS CELL 1 (SITE 5)

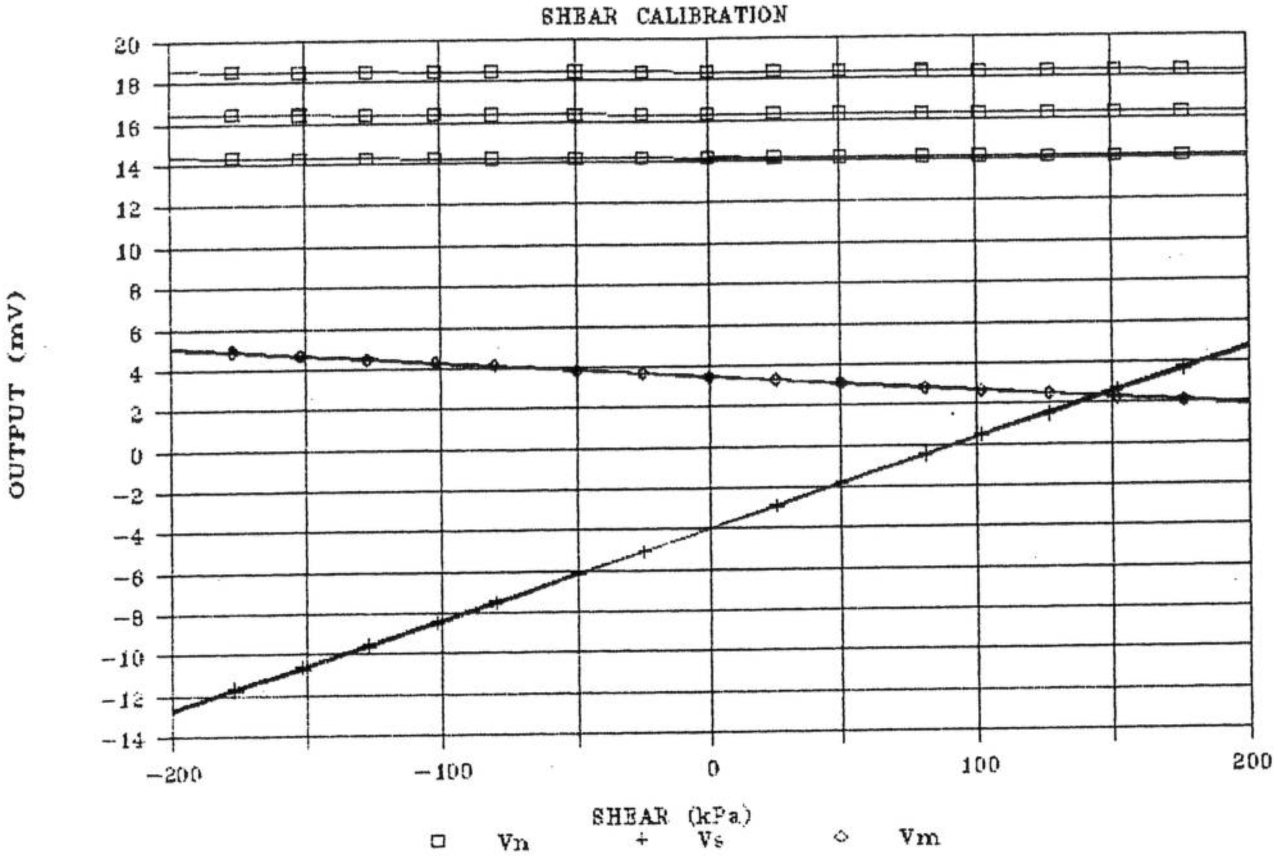


FIGURE III 44

CONTACT STRESS CELL 1 (SITE 5)

NORMAL LOAD & MOMENT VARIABLE S=0

MOMENT CIRCUIT -ve regression

Regression Output:

Constant	3.555501
Std Err of Y Est	0.024295
R Squared	0.998909
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.07191
Std Err of Coef. 0.000390

MOMENT CIRCUIT +ve regression

Regression Output:

Constant	3.580896
Std Err of Y Est	0.029405
R Squared	0.998450
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.07300
Std Err of Coef. 0.000472

SHEAR CIRCUIT -ve regression

Regression Output:

Constant	-3.93083
Std Err of Y Est	0.011534
R Squared	0.989927
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.01118
Std Err of Coef. 0.000185

SHEAR CIRCUIT +ve regression

Regression Output:

Constant	-3.96481
Std Err of Y Est	0.010537
R Squared	0.980858
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.00737
Std Err of Coef. 0.000169

NORMAL CIRCUIT -ve regression

Regression Output:

Constant	9.353126
Std Err of Y Est	0.008466
R Squared	0.999989
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.25365
Std Err of Coef. 0.000136

NORMAL CIRCUIT +ve regression

Regression Output:

Constant	9.349821
Std Err of Y Est	0.008499
R Squared	0.999989
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) 0.254716
Std Err of Coef. 0.000136

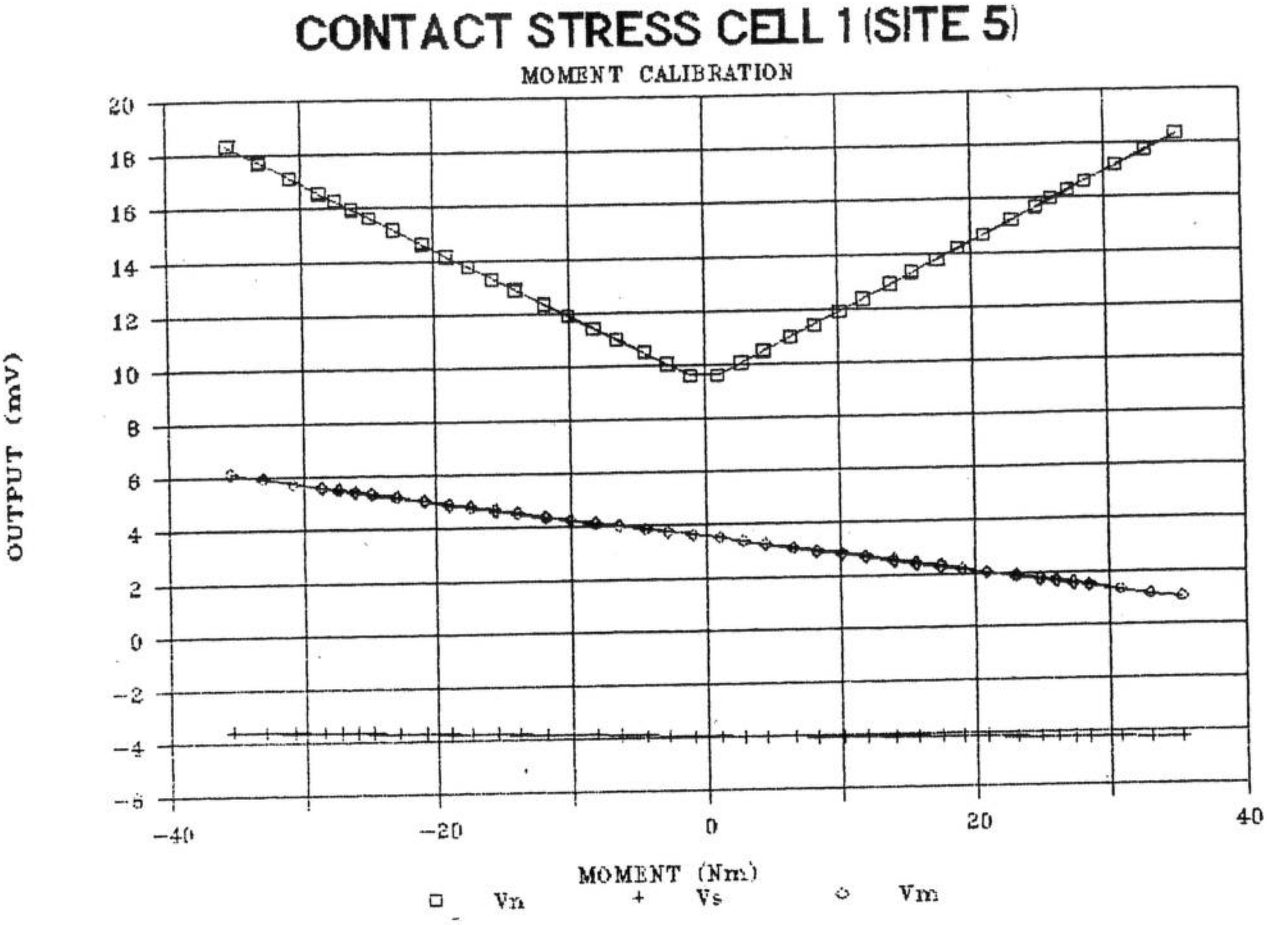


FIGURE III 45

CONTACT STRESS CELL 2 (SITE 5)

NORMAL LOAD VARIABLE M=0 S=0

SHEAR CIRCUIT

Regression Output:	
Constant	8.162350
Std Err of Y Est	0.020647
R Squared	0.440472
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.000140
Std Err of Coef.	0.000026

MOMENT CIRCUIT

Regression Output:	
Constant	-3.72718
Std Err of Y Est	0.053621
R Squared	0.485638
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.000400
Std Err of Coef.	0.000067

NORMAL CIRCUIT

Regression Output:	
Constant	15.31287
Std Err of Y Est	0.012661
R Squared	0.999991
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.033118
Std Err of Coef.	0.000015

CONTACT STRESS CELL 2 (SITE 5)

NORMAL LOAD VARIABLE M=0 S=24.93kPa

SHEAR CIRCUIT

Regression Output:	
Constant	6.568883
Std Err of Y Est	0.015715
R Squared	0.285854
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.000076
Std Err of Coef.	0.000019

MOMENT CIRCUIT

Regression Output:	
Constant	-3.39298
Std Err of Y Est	0.050533
R Squared	0.672850
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.000556
Std Err of Coef.	0.000063

NORMAL CIRCUIT

Regression Output:	
Constant	15.32786
Std Err of Y Est	0.013101
R Squared	0.999990
No. of Observations	39
Degrees of Freedom	37
X Coefficient(s)	0.033172
Std Err of Coef.	0.000016

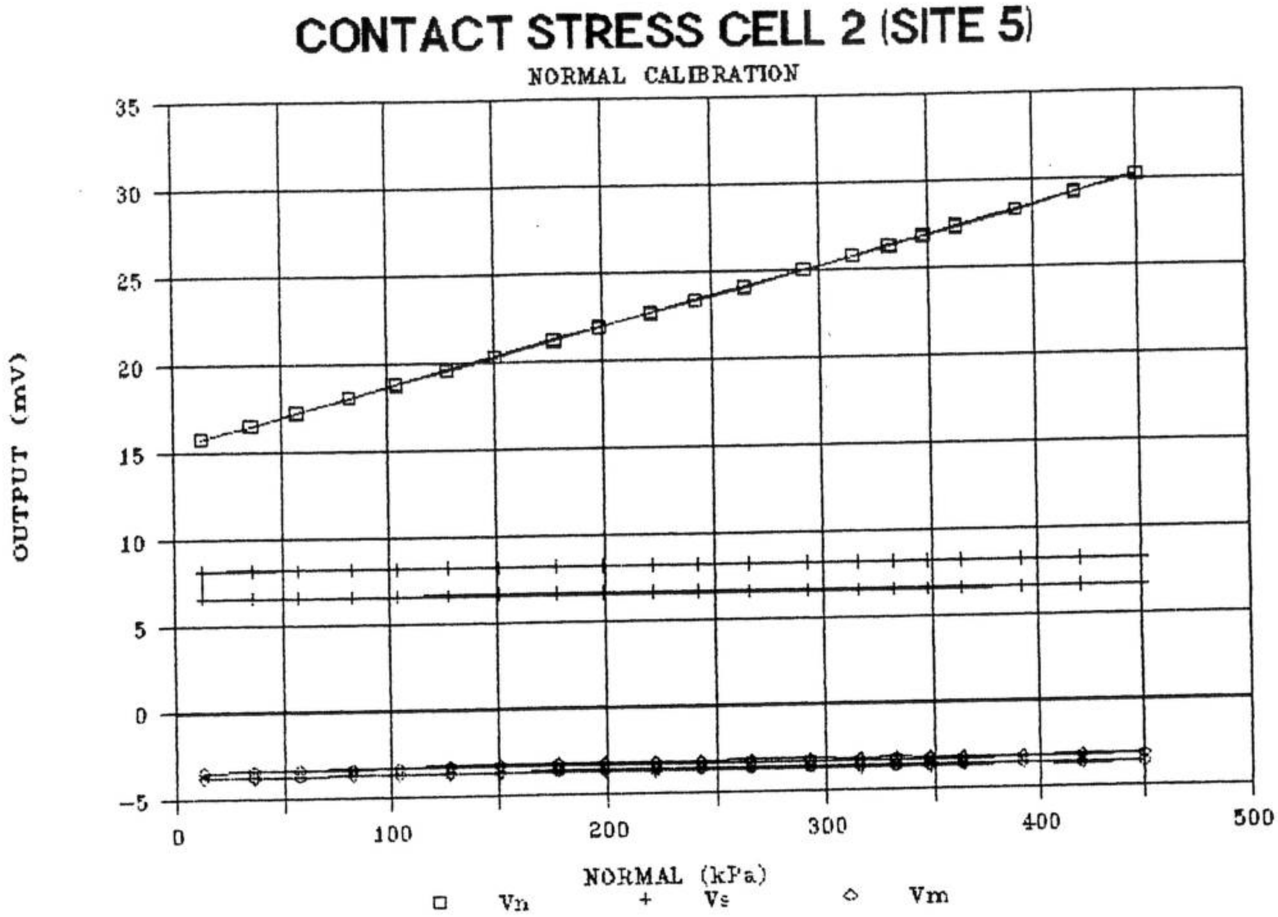


FIGURE III 46

CONTACT STRESS CELL 2 (SITE 5)

SHEAR LOAD VARIABLE M=0   N=450kPa

SHEAR CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	8.222794	Constant	-3.582
Std Err of Y Est	0.063548	Std Err of Y Est	0.016713
R Squared	0.999931	R Squared	0.999899
No. of Observations	34	No. of Observations	34
Degrees of Freedom	32	Degrees of Freedom	32
X Coefficient(s)	-0.06529	X Coefficient(s)	0.014179
Std Err of Coef.	0.000095	Std Err of Coef.	0.000025

NORMAL CIRCUIT	
Regression Output:	
Constant	30.27929
Std Err of Y Est	0.014782
R Squared	0.976016
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.000801
Std Err of Coef.	0.000022

CONTACT STRESS CELL 2 (SITE 5)

SHEAR LOAD VARIABLE M=0   N=243kPa

SHEAR CIRCUIT		MOMENT CIRCUIT	
Regression Output:		Regression Output:	
Constant	8.207264	Constant	-3.58429
Std Err of Y Est	0.057940	Std Err of Y Est	0.010109
R Squared	0.999942	R Squared	0.999961
No. of Observations	34	No. of Observations	34
Degrees of Freedom	32	Degrees of Freedom	32
X Coefficient(s)	-0.06470	X Coefficient(s)	0.013772
Std Err of Coef.	0.000087	Std Err of Coef.	0.000015

NORMAL CIRCUIT	
Regression Output:	
Constant	23.37952
Std Err of Y Est	0.021949
R Squared	0.950449
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.000817
Std Err of Coef.	0.000032

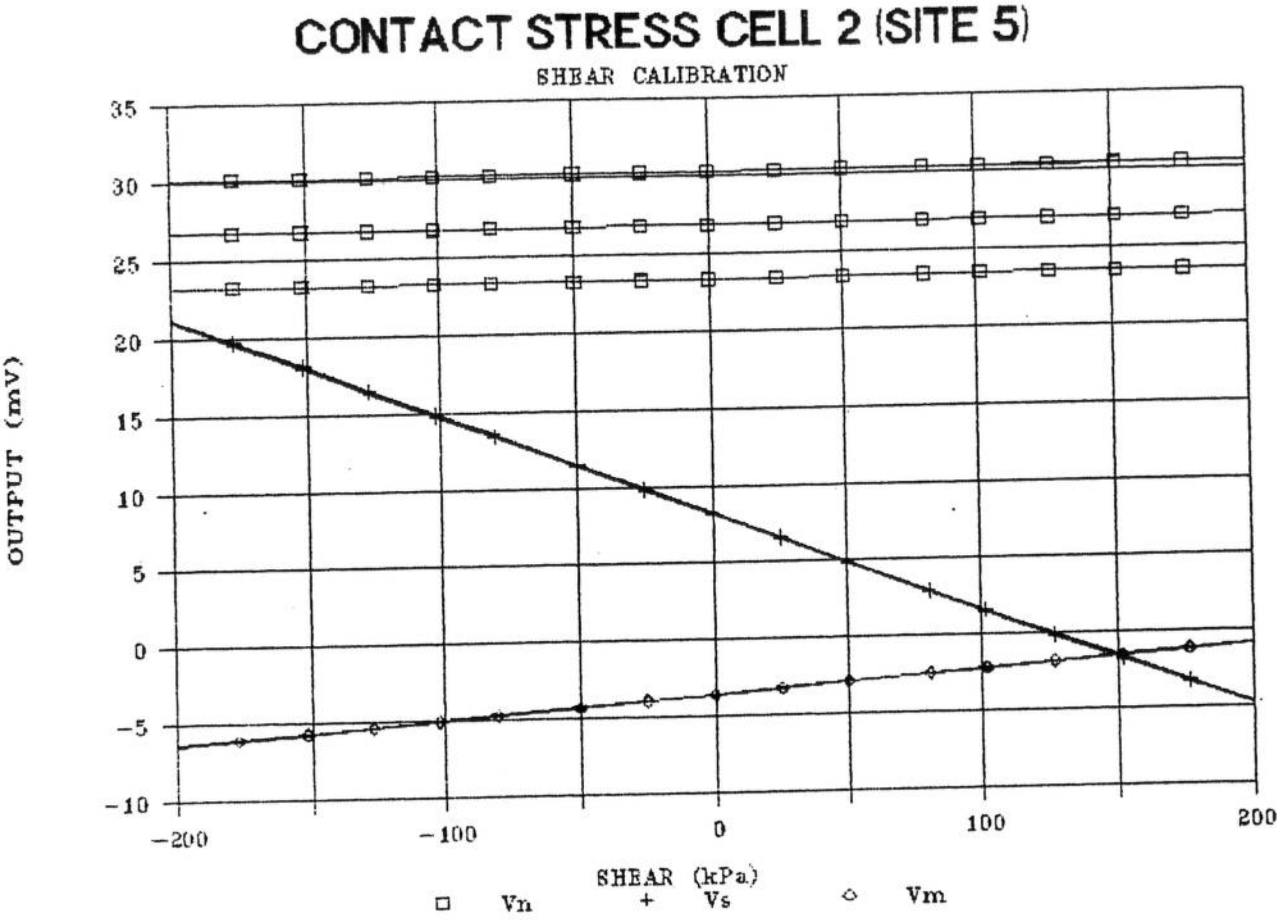


FIGURE III47

CONTACT STRESS CELL 2 (SITE 5)

NORMAL LOAD AND MOMENT VARIABLE S=0

MOMENT CIRCUIT -ve regression

Regression Output:

Constant	-3.77064
Std Err of Y Est	0.040142
R Squared	0.998793
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.112976
Std Err of Coef.	0.000645

MOMENT CIRCUIT +ve regression

Regression Output:

Constant	-3.78571
Std Err of Y Est	0.068158
R Squared	0.997153
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.124768
Std Err of Coef.	0.001095

SHEAR CIRCUIT -ve regression

Regression Output:

Constant	8.128058
Std Err of Y Est	0.019607
R Squared	0.980646
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.013649
Std Err of Coef.	0.000315

SHEAR CIRCUIT +ve regression

Regression Output:

Constant	8.136690
Std Err of Y Est	0.023479
R Squared	0.982974
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.017448
Std Err of Coef.	0.000377

NORMAL CIRCUIT -ve regression

Regression Output:

Constant	15.29914
Std Err of Y Est	0.016849
R Squared	0.999984
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.42223
Std Err of Coef.	0.000270

NORMAL CIRCUIT +ve regression

Regression Output:

Constant	15.29511
Std Err of Y Est	0.014321
R Squared	0.999989
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.422331
Std Err of Coef.	0.000230

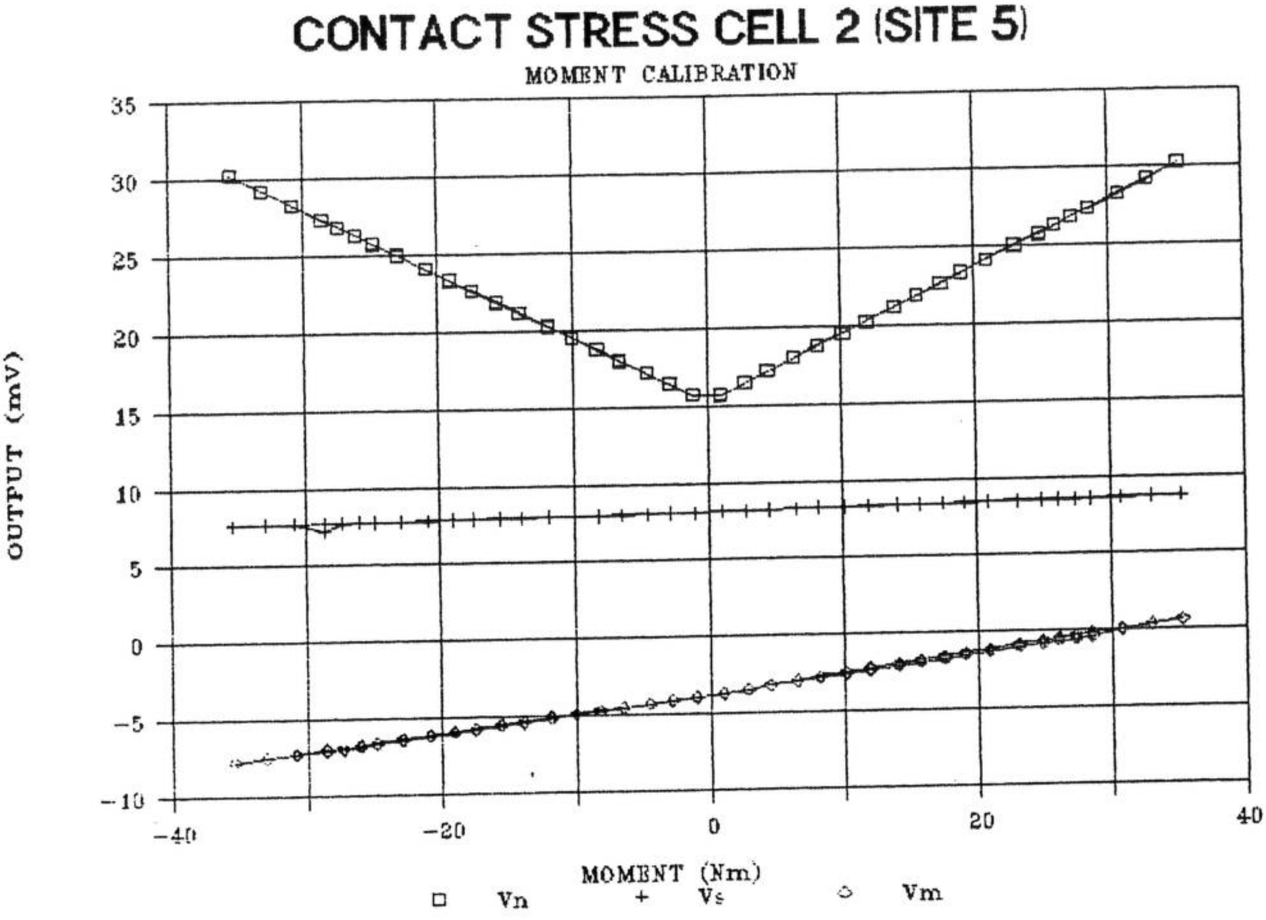


FIGURE III 48

CONTACT STRESS CELL 3 (SITE 5)

NORMAL LOAD VARIABLE M=0   S=0

SHEAR CIRCUIT

Regression Output:

Constant	14.85265
Std Err of Y Est	0.012535
R Squared	0.199817
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) 0.000048
Std Err of Coef. 0.000015

MOMENT CIRCUIT

Regression Output:

Constant	0.982300
Std Err of Y Est	0.059262
R Squared	0.117488
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.00016
Std Err of Coef. 0.000074

NORMAL CIRCUIT

Regression Output:

Constant	14.36061
Std Err of Y Est	0.021747
R Squared	0.999972
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.03213
Std Err of Coef. 0.000027

CONTACT STRESS CELL 3 (SITE 5)

NORMAL LOAD VARIABLE M=0   S=24.93kPa

SHEAR CIRCUIT

Regression Output:

Constant	16.30167
Std Err of Y Est	0.013801
R Squared	0.625934
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) 0.000137
Std Err of Coef. 0.000017

MOMENT CIRCUIT

Regression Output:

Constant	0.645836
Std Err of Y Est	0.058213
R Squared	0.105276
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.00015
Std Err of Coef. 0.000073

NORMAL CIRCUIT

Regression Output:

Constant	14.30261
Std Err of Y Est	0.021109
R Squared	0.999974
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.03212
Std Err of Coef. 0.000026

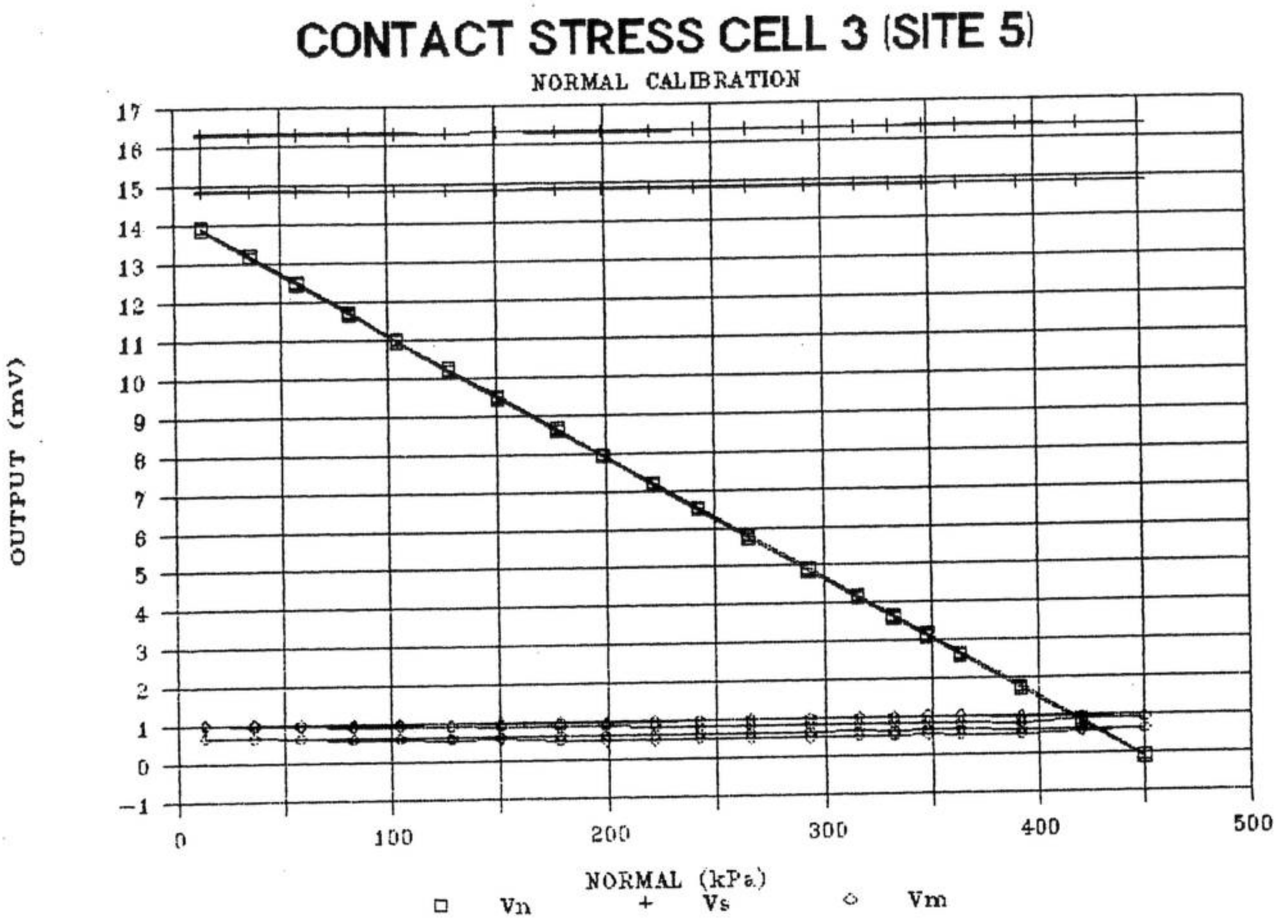


FIGURE III 49

CONTACT STRESS CELL 3 (SITE 5)

SHEAR LOAD VARIABLE M=0   N=450kPa

SHEAR CIRCUIT

Regression Output:

Constant	14.94152
Std Err of Y Est	0.056547
R Squared	0.999933
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.059139
Std Err of Coef.	0.000084

MOMENT CIRCUIT

Regression Output:

Constant	1.010882
Std Err of Y Est	0.031312
R Squared	0.999622
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.01370
Std Err of Coef.	0.000047

NORMAL CIRCUIT

Regression Output:

Constant	0.010647
Std Err of Y Est	0.019308
R Squared	0.995907
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.00256
Std Err of Coef.	0.000029

CONTACT STRESS CELL 3 (SITE 5)

SHEAR LOAD VARIABLE M=0   N=243kPa

SHEAR CIRCUIT

Regression Output:

Constant	14.89264
Std Err of Y Est	0.040074
R Squared	0.999966
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.058444
Std Err of Coef.	0.000060

MOMENT CIRCUIT

Regression Output:

Constant	0.941852
Std Err of Y Est	0.026861
R Squared	0.999710
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.01341
Std Err of Coef.	0.000040

NORMAL CIRCUIT

Regression Output:

Constant	6.537617
Std Err of Y Est	0.022719
R Squared	0.994294
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.00255
Std Err of Coef.	0.000034

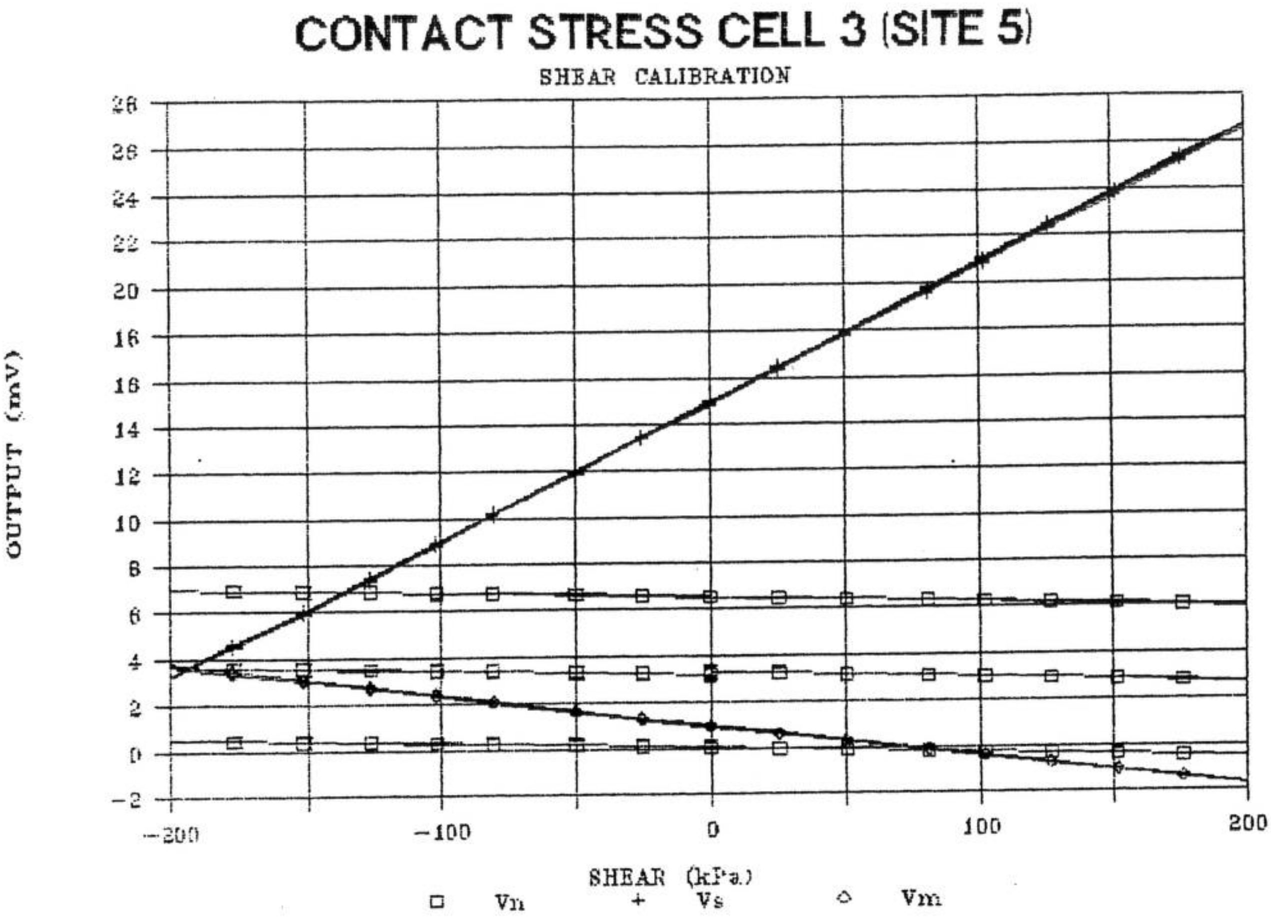

CONTACT STRESS CELL 3 (SITE 5)
SHEAR CALIBRATION
OUTPUT (mV)
SHEAR (kPa)
Vn
Vs
Vm

FIGURE II 50

CONTACT STRESS CELL 3 (SITE 5)

NORMAL LOAD AND MOMENT VARIABLE S=0

MOMENT CIRCUIT +ve regression

Regression Output:

Constant	0.959572
Std Err of Y Est	0.027806
R Squared	0.999444
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.11536
Std Err of Coef.	0.000447

MOMENT CIRCUIT +ve regression

Regression Output:

Constant	0.988132
Std Err of Y Est	0.043248
R Squared	0.998627
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.11409
Std Err of Coef.	0.000695

SHEAR CIRCUIT -ve regression

Regression Output:

Constant	14.88453
Std Err of Y Est	0.007178
R Squared	0.997420
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.01380
Std Err of Coef.	0.000115

SHEAR CIRCUIT +ve regression

Regression Output:

Constant	14.88631
Std Err of Y Est	0.010380
R Squared	0.994838
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.01409
Std Err of Coef.	0.000166

NORMAL CIRCUIT -ve regression

Regression Output:

Constant	14.36026
Std Err of Y Est	0.015540
R Squared	0.999986
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.409808
Std Err of Coef.	0.000249

NORMAL CIRCUIT +ve regression

Regression Output:

Constant	14.37094
Std Err of Y Est	0.013822
R Squared	0.999988
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.40667
Std Err of Coef.	0.000222

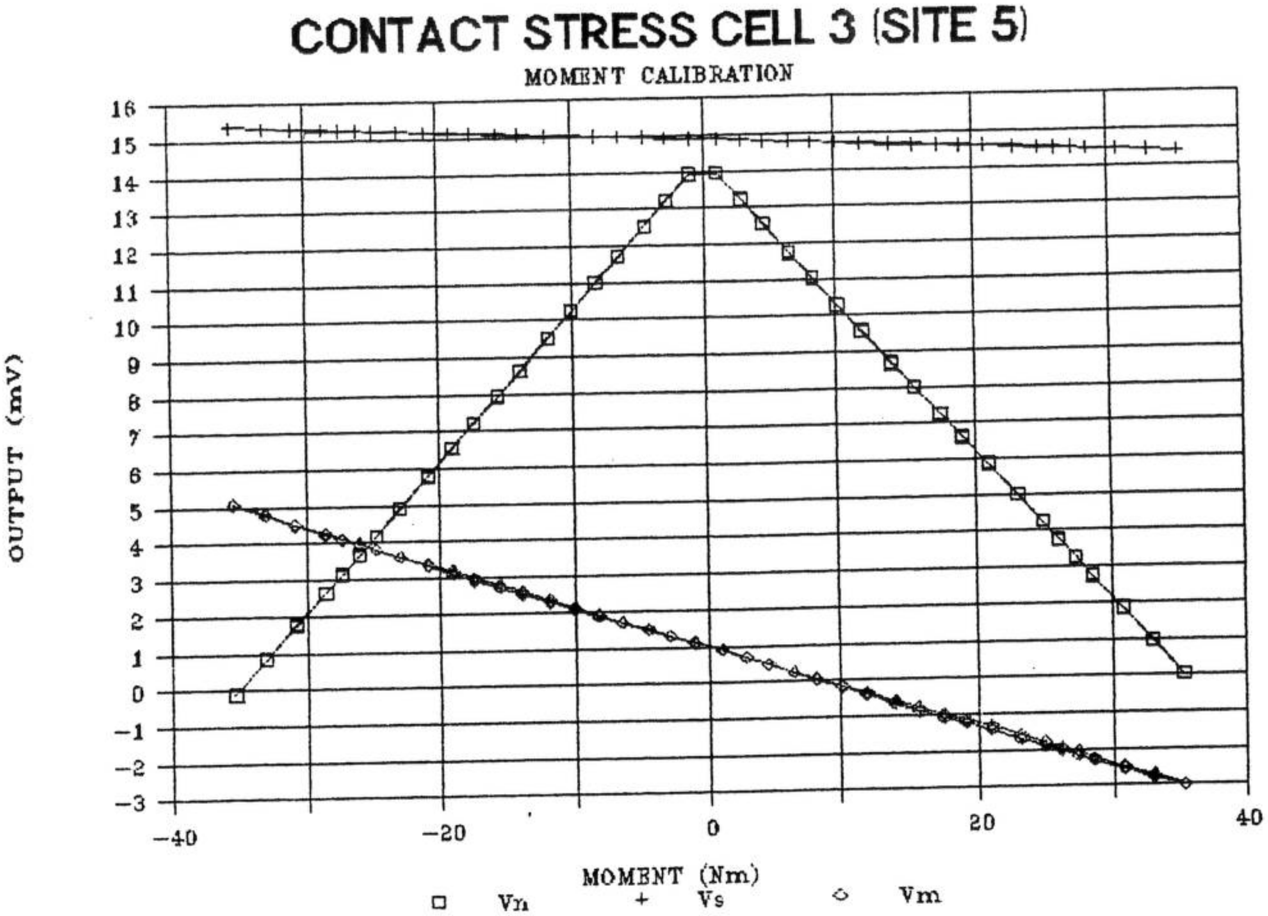


FIGURE III.51

CONTACT STRESS CELL 4 (SITE 5)

NORMAL LOAD VARIABLE M=0   S=0

SHEAR CIRCUIT

Regression Output:

Constant	5.697222
Std Err of Y Est	0.013695
R Squared	0.353773
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.000077
Std Err of Coef.	0.000017

MOMENT CIRCUIT

Regression Output:

Constant	-6.70271
Std Err of Y Est	0.046244
R Squared	0.082635
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.000106
Std Err of Coef.	0.000058

NORMAL CIRCUIT

Regression Output:

Constant	4.026690
Std Err of Y Est	0.017640
R Squared	0.999982
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.03194
Std Err of Coef.	0.000022

CONTACT STRESS CELL 4 (SITE 5)

NORMAL LOAD VARIABLE M=0   S=24.93kPa

SHEAR CIRCUIT

Regression Output:

Constant	7.172059
Std Err of Y Est	0.013839
R Squared	0.262756
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	0.000063
Std Err of Coef.	0.000017

MOMENT CIRCUIT

Regression Output:

Constant	-7.02505
Std Err of Y Est	0.048340
R Squared	0.149172
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.00015
Std Err of Coef.	0.000061

NORMAL CIRCUIT

Regression Output:

Constant	4.047980
Std Err of Y Est	0.012630
R Squared	0.999990
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s)	-0.03197
Std Err of Coef.	0.000015

CONTACT STRESS CELL 4 (SITE 5)

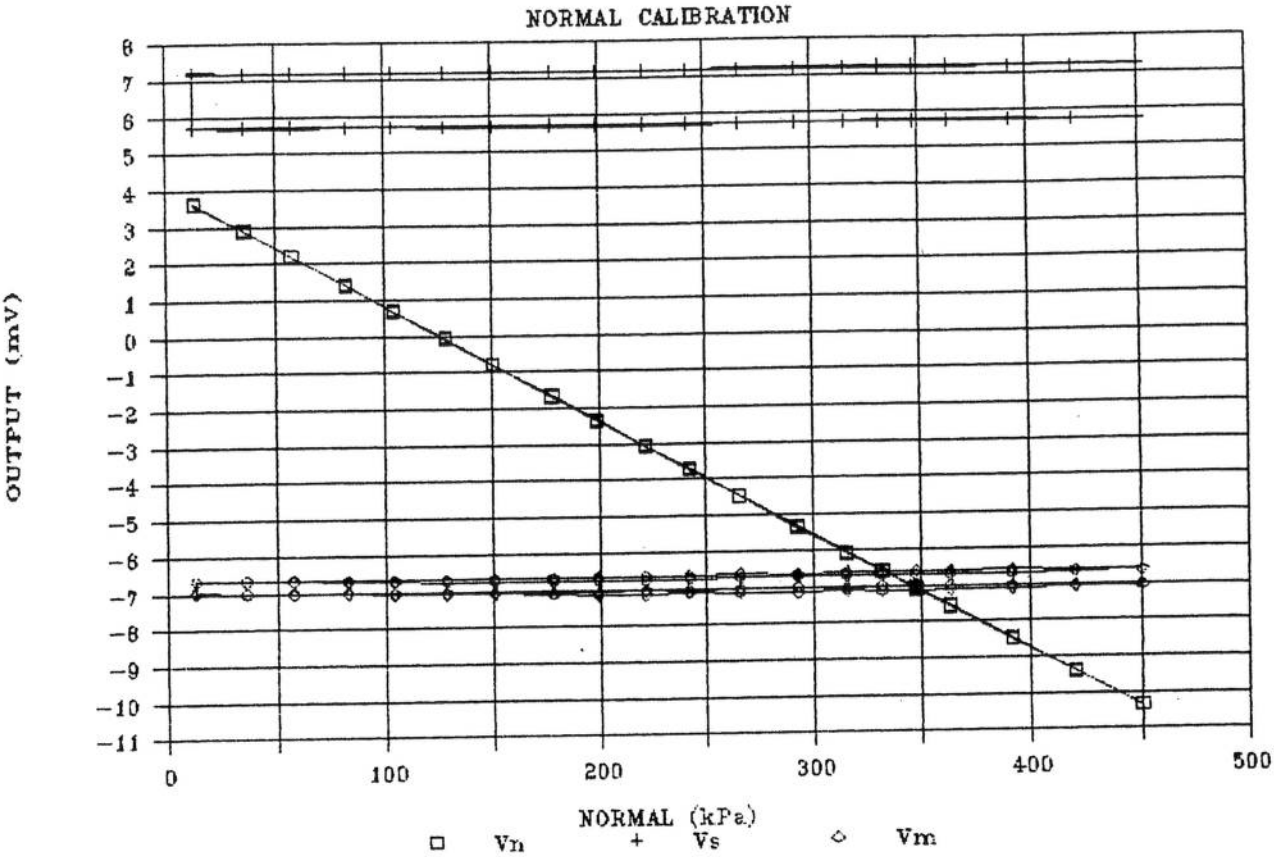


FIGURE III 52

CONTACT STRESS CELL 4 (SITE 5)

SHEAR LOAD VARIABLE M=0 N=450kPa

SHEAR CIRCUIT

Regression Output:

Constant	5.748470
Std Err of Y Est	0.042329
R Squared	0.999962
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.059057
Std Err of Coef.	0.000063

MOMENT CIRCUIT

Regression Output:

Constant	-6.50235
Std Err of Y Est	0.018398
R Squared	0.999872
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.01386
Std Err of Coef.	0.000027

NORMAL CIRCUIT

Regression Output:

Constant	-10.3612
Std Err of Y Est	0.015964
R Squared	0.970335
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.000776
Std Err of Coef.	0.000023

CONTACT STRESS CELL 4 (SITE 5)

SHEAR LOAD VARIABLE M=0 N=243kPa

SHEAR CIRCUIT

Regression Output:

Constant	5.736205
Std Err of Y Est	0.045444
R Squared	0.999956
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.058718
Std Err of Coef.	0.000068

MOMENT CIRCUIT

Regression Output:

Constant	-6.66888
Std Err of Y Est	0.014462
R Squared	0.999920
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	-0.01378
Std Err of Coef.	0.000021

NORMAL CIRCUIT

Regression Output:

Constant	-3.734
Std Err of Y Est	0.023342
R Squared	0.911990
No. of Observations	34
Degrees of Freedom	32
X Coefficient(s)	0.000638
Std Err of Coef.	0.000035

CONTACT STRESS CELL 4 (SITE 5)

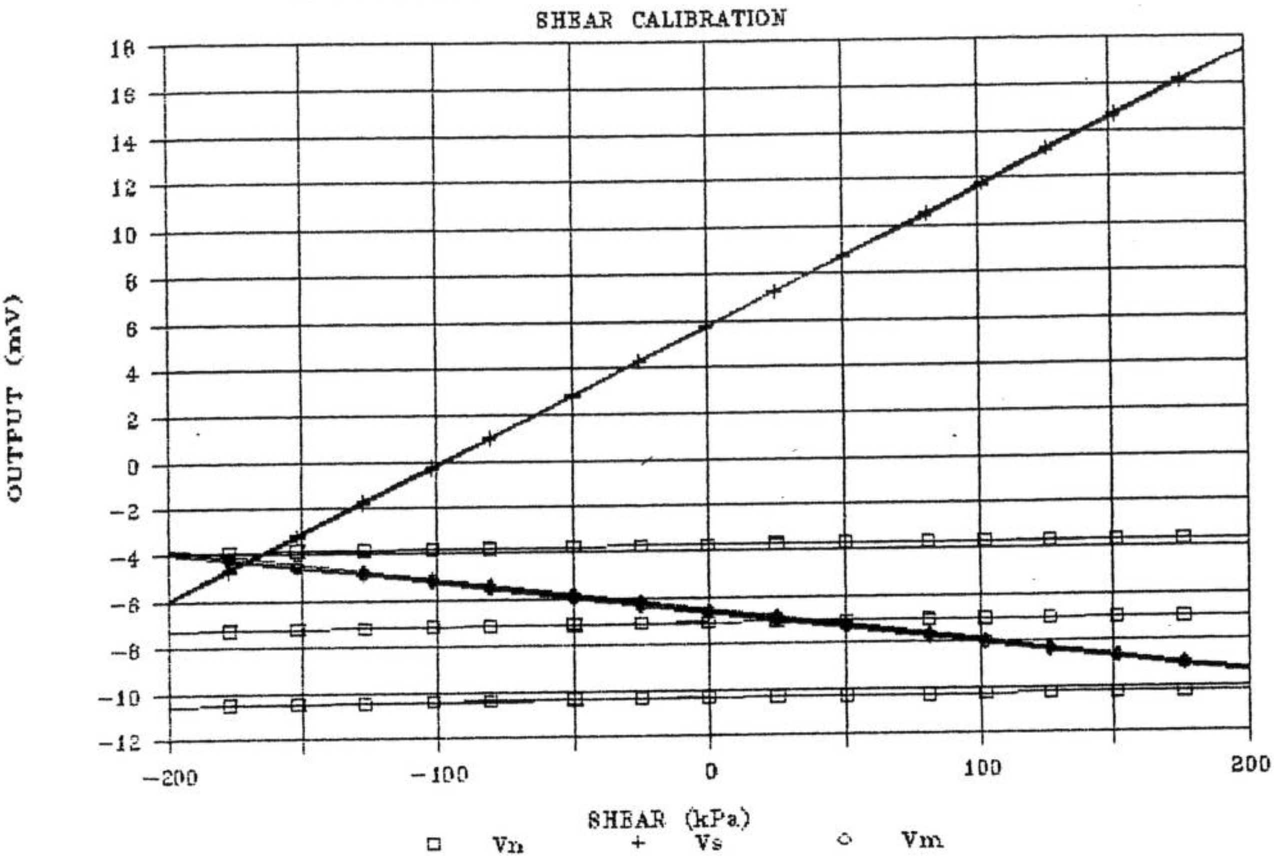


FIGURE III 53

CONTACT STRESS CELL 4 (SITE 5)

NORMAL LOAD AND MOMENT VARIABLE S=0

MOMENT CIRCUIT -ve regression		MOMENT CIRCUIT +ve regression	
Regression Output:		Regression Output:	
Constant	-6.67307	Constant	-6.65242
Std Err of Y Est	0.044486	Std Err of Y Est	0.056747
R Squared	0.998526	R Squared	0.997674
No. of Observations	39	No. of Observations	39
Degrees of Freedom	37	Degrees of Freedom	37
X Coefficient(s)	-0.11327	X Coefficient(s)	-0.11495
Std Err of Coef.	0.000715	Std Err of Coef.	0.000912

SHEAR CIRCUIT -ve regression		SHEAR CIRCUIT +ve regression	
Regression Output:		Regression Output:	
Constant	5.732033	Constant	5.733569
Std Err of Y Est	0.019227	Std Err of Y Est	0.012407
R Squared	0.987159	R Squared	0.984870
No. of Observations	39	No. of Observations	39
Degrees of Freedom	37	Degrees of Freedom	37
X Coefficient(s)	-0.01648	X Coefficient(s)	-0.00979
Std Err of Coef.	0.000309	Std Err of Coef.	0.000199

NORMAL CIRCUIT -ve regression		NORMAL CIRCUIT +ve regression	
Regression Output:		Regression Output:	
Constant	4.044002	Constant	4.031849
Std Err of Y Est	0.014484	Std Err of Y Est	0.023950
R Squared	0.999987	R Squared	0.999966
No. of Observations	39	No. of Observations	39
Degrees of Freedom	37	Degrees of Freedom	37
X Coefficient(s)	0.406701	X Coefficient(s)	-0.40595
Std Err of Coef.	0.000232	Std Err of Coef.	0.000385

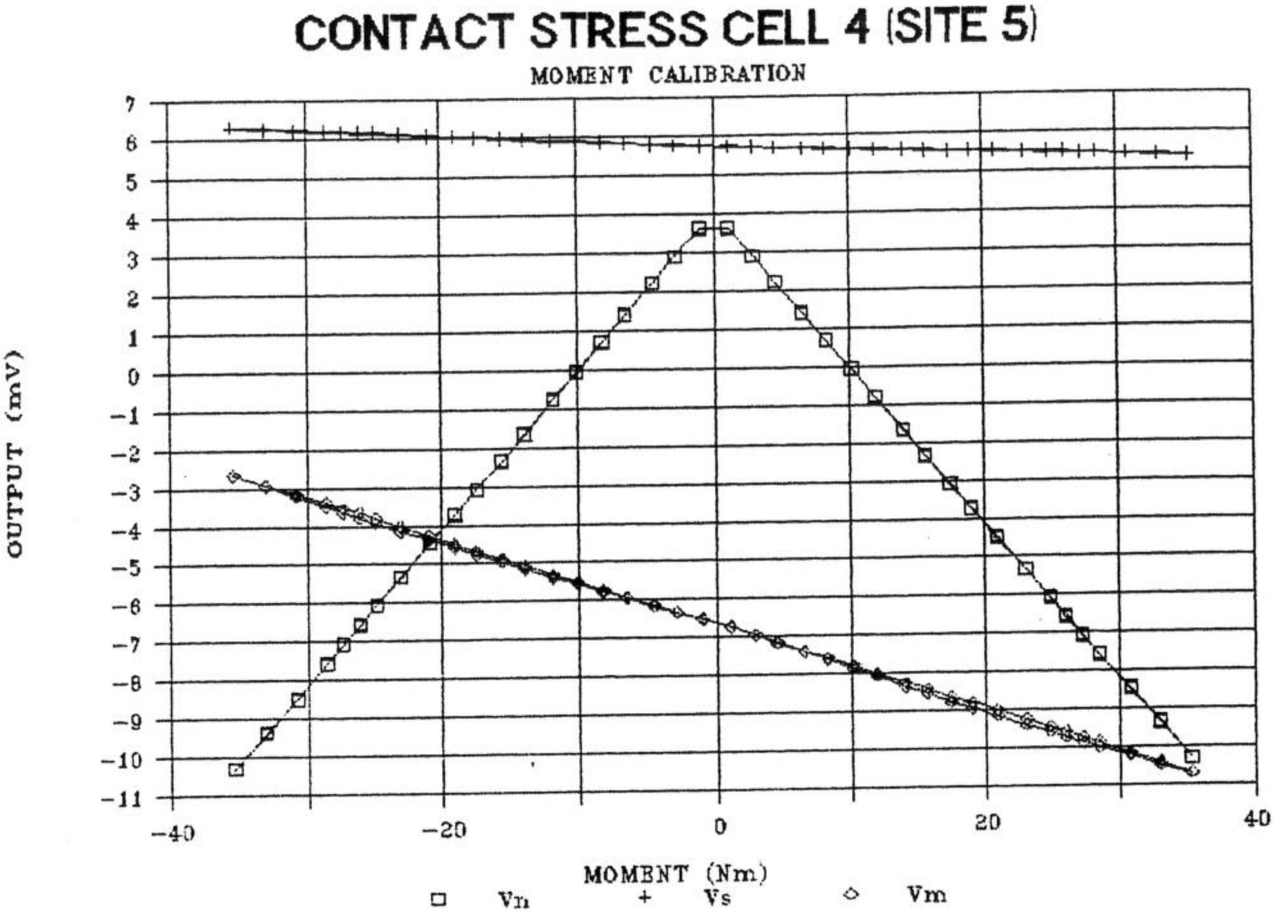


Figure III54

CONTACT STRESS CELL 5 (SITE 5)

NORMAL LOAD VARIABLE M=0 S=0

SHEAR CIRCUIT

Regression Output:	
Constant	-11.9512
Std Err of Y Est	0.013000
R Squared	0.031836
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) 0.000018
Std Err of Coef. 0.000016

MOMENT CIRCUIT

Regression Output:	
Constant	3.620085
Std Err of Y Est	0.034700
R Squared	0.438395
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.00023
Std Err of Coef. 0.000043

NORMAL CIRCUIT

Regression Output:	
Constant	0.263047
Std Err of Y Est	0.013458
R Squared	0.999972
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) 0.019691
Std Err of Coef. 0.000016

CONTACT STRESS CELL 5 (SITE 5)

NORMAL LOAD VARIABLE M=0 S=24.93kPa

SHEAR CIRCUIT

Regression Output:	
Constant	-10.8340
Std Err of Y Est	0.010768
R Squared	0.483852
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) 0.000080
Std Err of Coef. 0.000013

MOMENT CIRCUIT

Regression Output:	
Constant	3.445691
Std Err of Y Est	0.028310
R Squared	0.726398
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.00035
Std Err of Coef. 0.000035

NORMAL CIRCUIT

Regression Output:	
Constant	0.268870
Std Err of Y Est	0.009157
R Squared	0.999987
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) 0.019659
Std Err of Coef. 0.000011

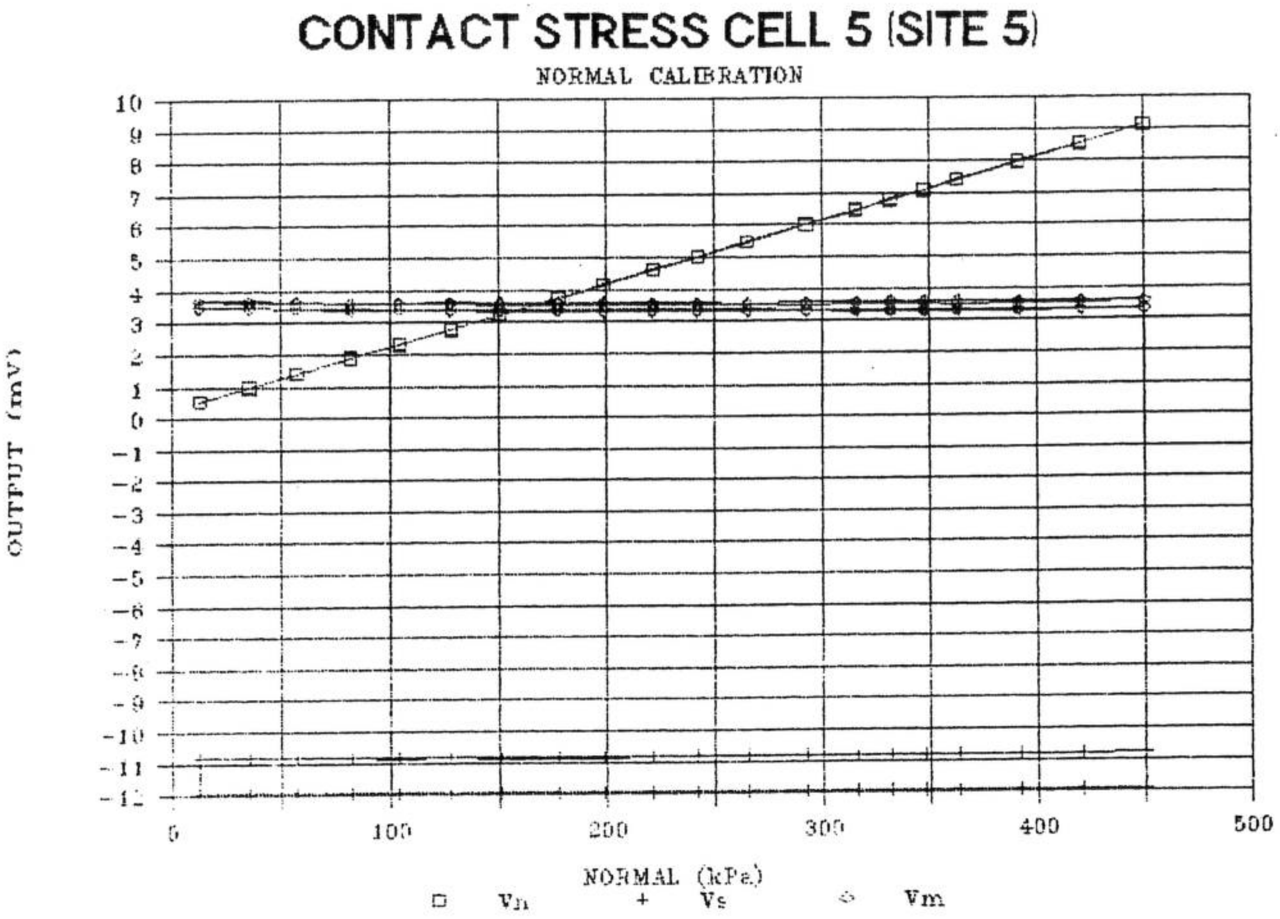


FIGURE III.55

CONTACT STRESS CELL 5 (SITE 5)

SHEAR LOAD VARIABLE M=0   N=450kPa

SHEAR CIRCUIT

Regression Output:

Constant	-12.0364
Std Err of Y Est	0.029477
R Squared	0.999970
No. of Observations	34
Degrees of Freedom	32

X Coefficient(s)	0.046238
Std Err of Coef.	0.000044

MOMENT CIRCUIT

Regression Output:

Constant	3.421205
Std Err of Y Est	0.011501
R Squared	0.999859
No. of Observations	34
Degrees of Freedom	32

X Coefficient(s)	-0.00824
Std Err of Coef.	0.000017

NORMAL CIRCUIT

Regression Output:

Constant	9.203382
Std Err of Y Est	0.028590
R Squared	0.288597
No. of Observations	34
Degrees of Freedom	32

X Coefficient(s)	0.000154
Std Err of Coef.	0.000042

CONTACT STRESS CELL 5 (SITE 5)

SHEAR LOAD VARIABLE M=0   N=243kPa

SHEAR CIRCUIT

Regression Output:

Constant	-12.0189
Std Err of Y Est	0.024717
R Squared	0.999978
No. of Observations	34
Degrees of Freedom	32

X Coefficient(s)	0.045552
Std Err of Coef.	0.000037

MOMENT CIRCUIT

Regression Output:

Constant	3.425205
Std Err of Y Est	0.010230
R Squared	0.999870
No. of Observations	34
Degrees of Freedom	32

X Coefficient(s)	-0.00763
Std Err of Coef.	0.000015

NORMAL CIRCUIT

Regression Output:

Constant	5.069852
Std Err of Y Est	0.027211
R Squared	0.423385
No. of Observations	34
Degrees of Freedom	32

X Coefficient(s)	0.000198
Std Err of Coef.	0.000040

CONTACT STRESS CELL 5 (SITE 5)

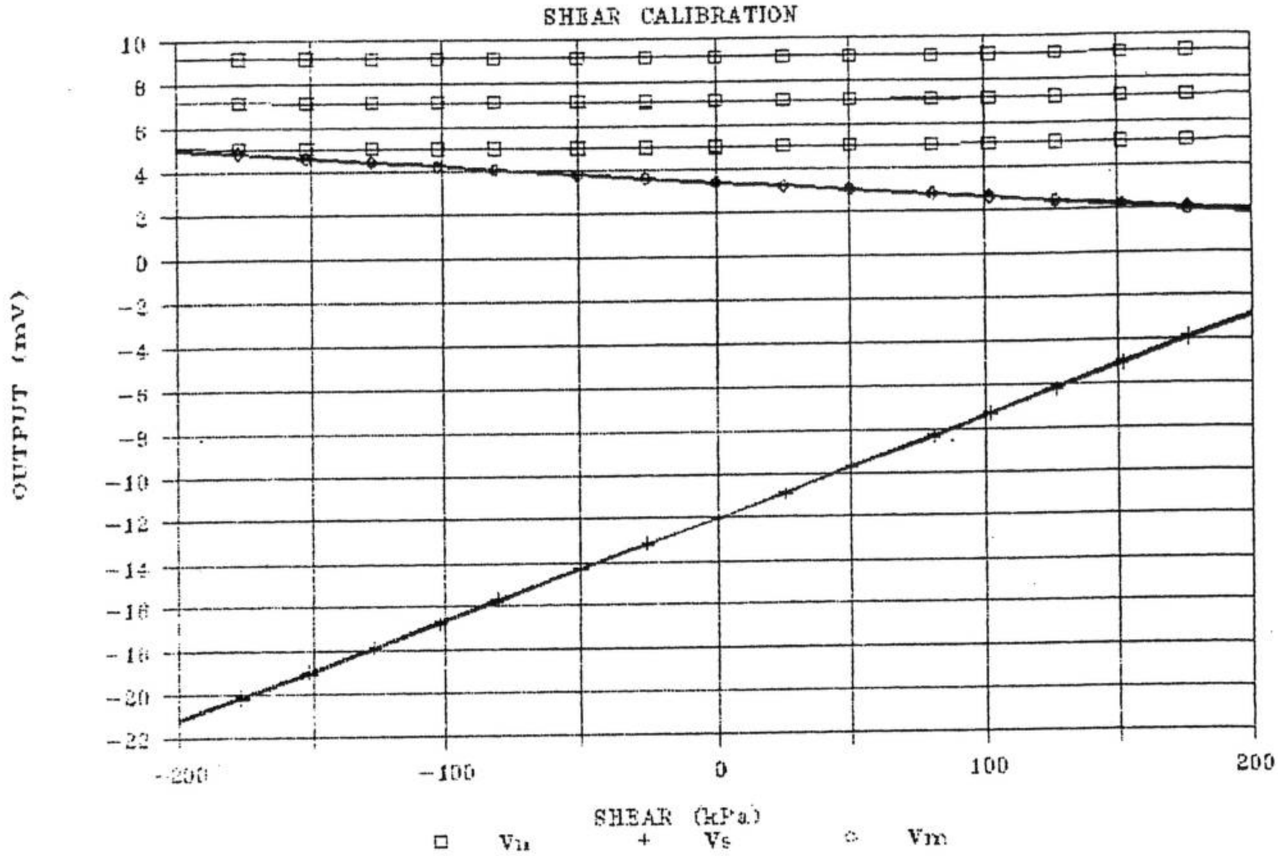


FIGURE III 56

CONTACT STRESS CELL 5 (SITE 5)

NORMAL LOAD AND MOMENT VARIABLE S=0

MOMENT CIRCUIT -ve regression

Regression Output:

Constant	3.624220
Std Err of Y Est	0.021686
R Squared	0.999046
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.06866
Std Err of Coef. 0.000348

MOMENT CIRCUIT +ve regression

Regression Output:

Constant	3.656646
Std Err of Y Est	0.027063
R Squared	0.998784
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.07588
Std Err of Coef. 0.000435

SHEAR CIRCUIT -ve regression

Regression Output:

Constant	-11.9238
Std Err of Y Est	0.007621
R Squared	0.990592
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.00764
Std Err of Coef. 0.000122

SHEAR CIRCUIT +ve regression

Regression Output:

Constant	-11.9443
Std Err of Y Est	0.012851
R Squared	0.983080
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.00958
Std Err of Coef. 0.000206

NORMAL CIRCUIT -ve regression

Regression Output:

Constant	0.250568
Std Err of Y Est	0.014811
R Squared	0.999966
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) -0.25018
Std Err of Coef. 0.000238

NORMAL CIRCUIT +ve regression

Regression Output:

Constant	0.253690
Std Err of Y Est	0.010892
R Squared	0.999982
No. of Observations	39
Degrees of Freedom	37

X Coefficient(s) 0.251877
Std Err of Coef. 0.000175

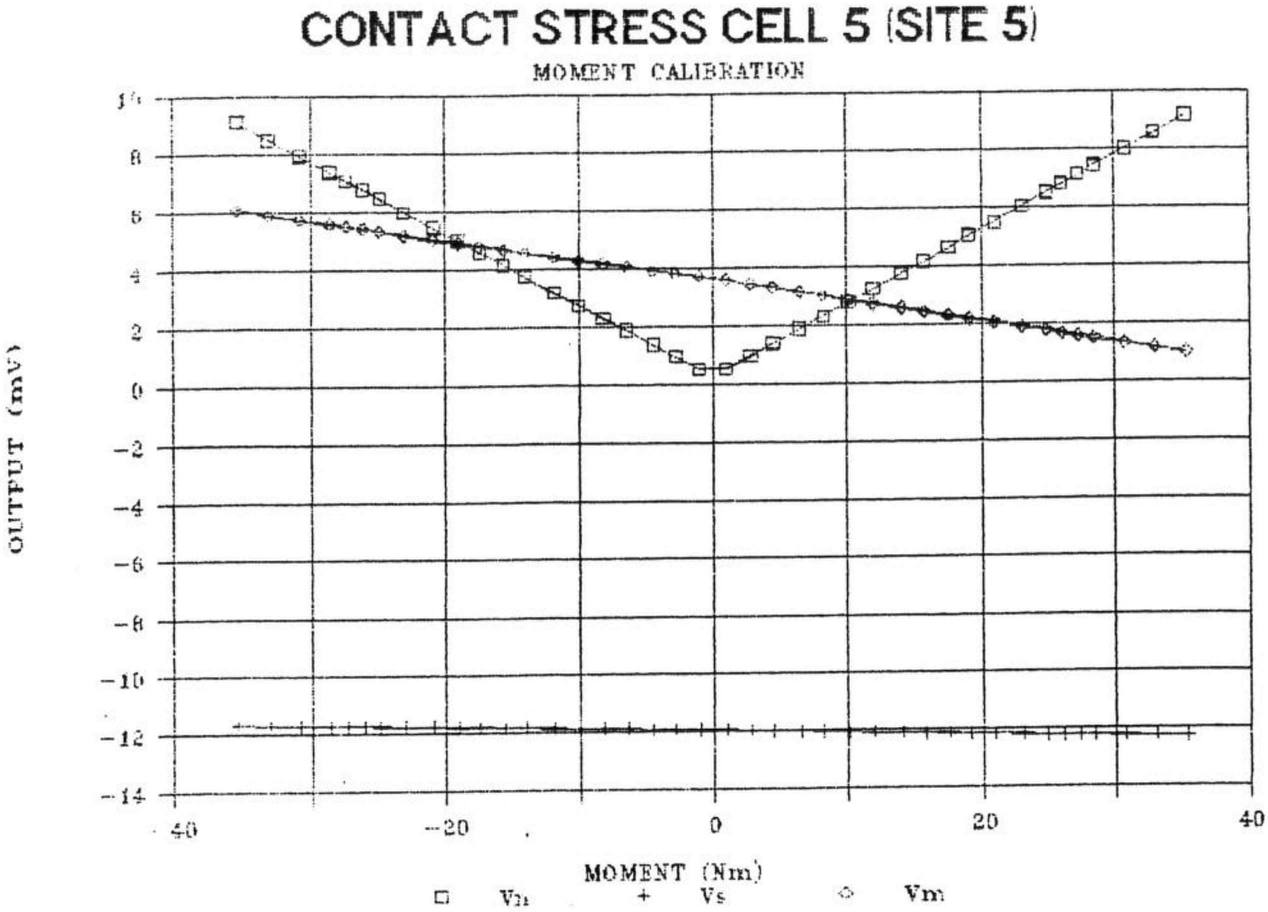
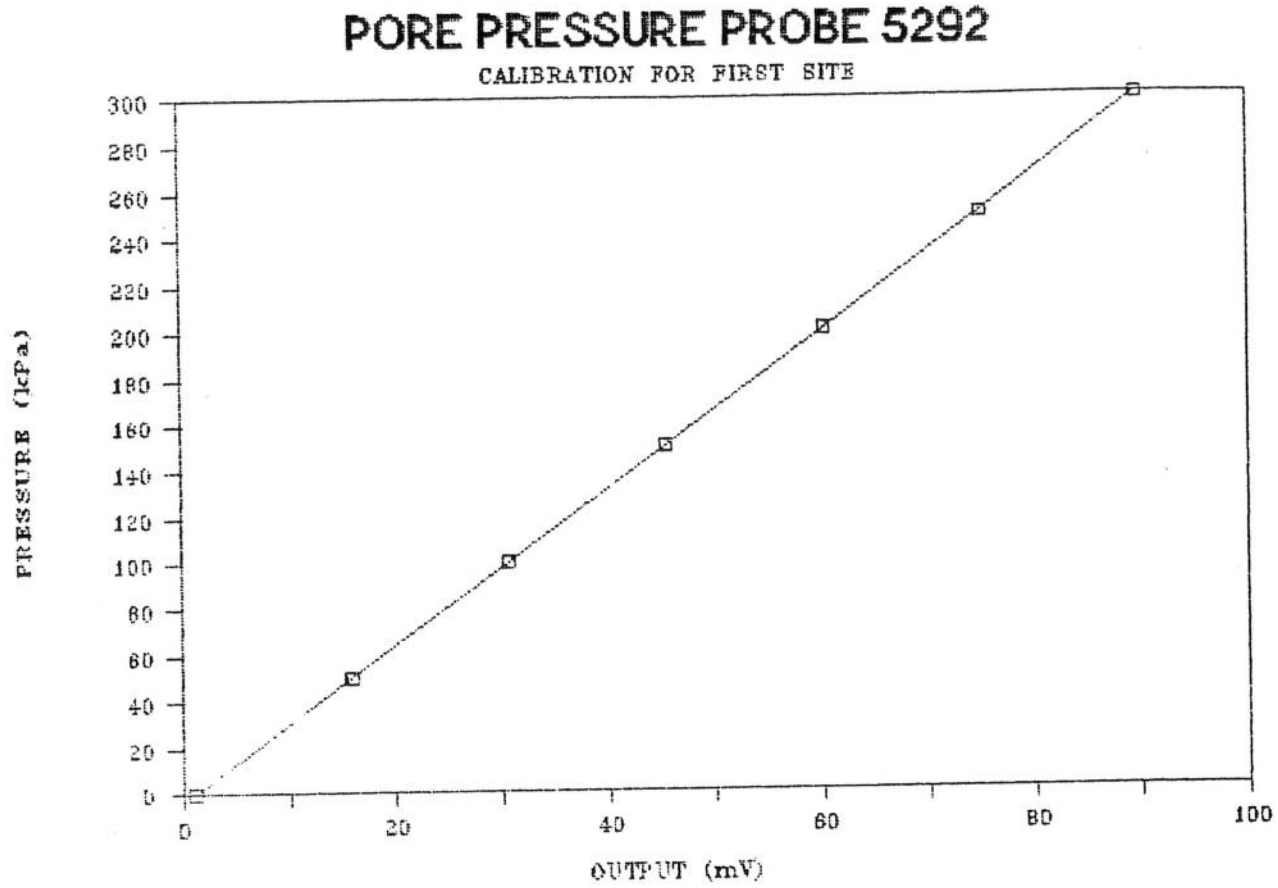


FIGURE III.57

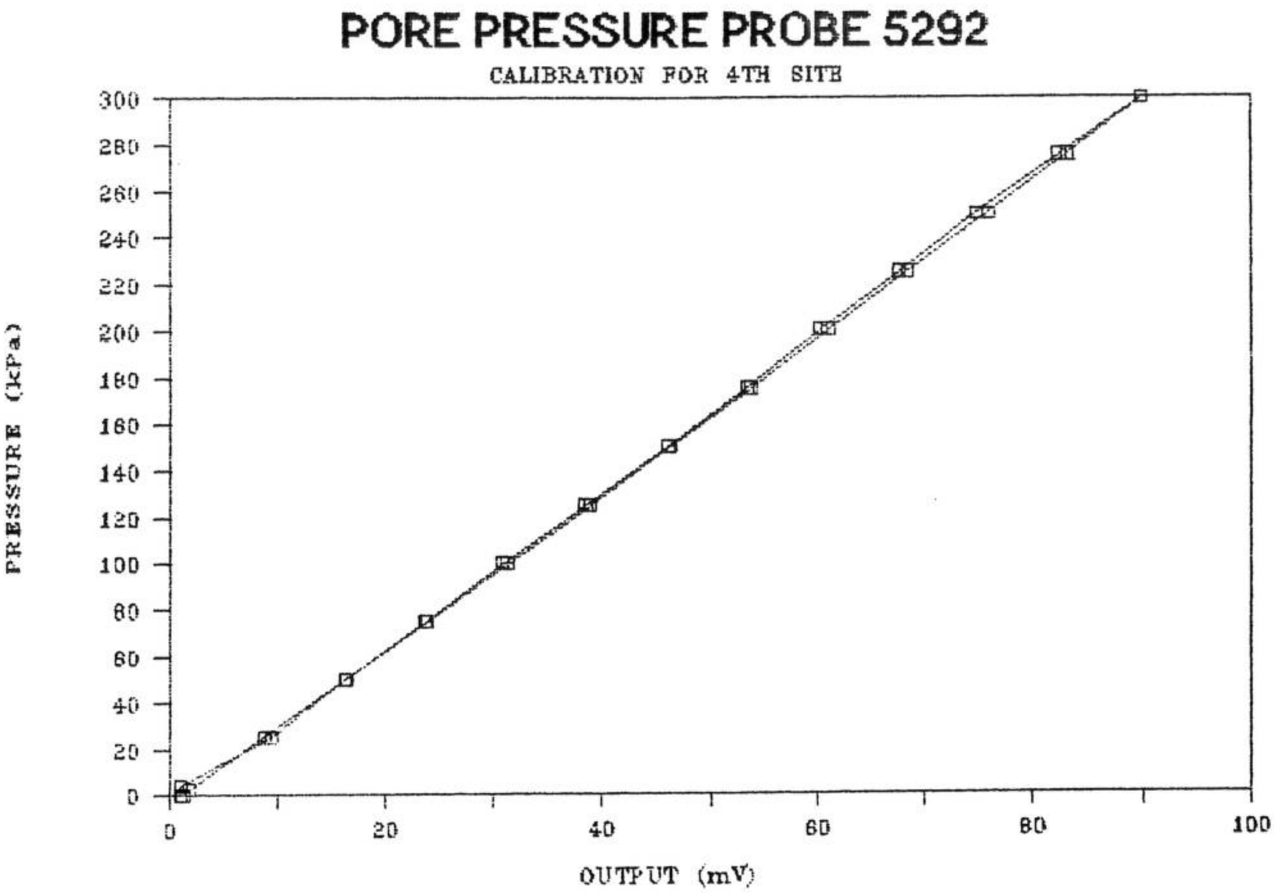


PORE PRESSURE PROBE 5292

Regression Output:	
Constant	-3.82150
Std Err of Y Est	0.072574
R Squared	0.999999
No. of Observations	13
Degrees of Freedom	11

X Coefficient(s)	3.382796
Std Err of Coef.	0.000721

FIGURE III 58



PORE PRESSURE PROBE 5292

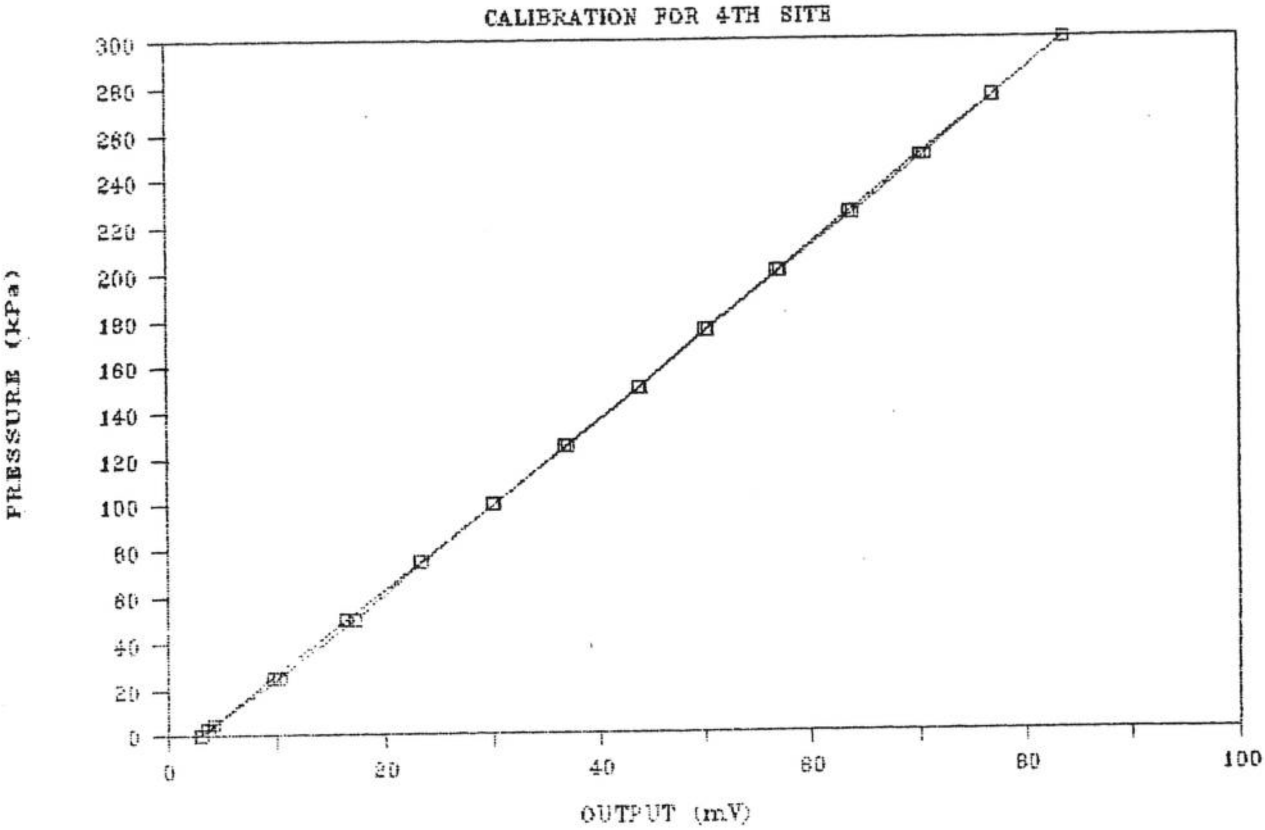
Regression Output:

Constant	-4.49619
Std Err of Y Est	1.573992
R Squared	0.999742
No. of Observations	27
Degrees of Freedom	25

X Coefficient(s)	3.362956
Std Err of Coef.	0.010787

FIGURE III59

PORE PRESSURE PROBE 5293



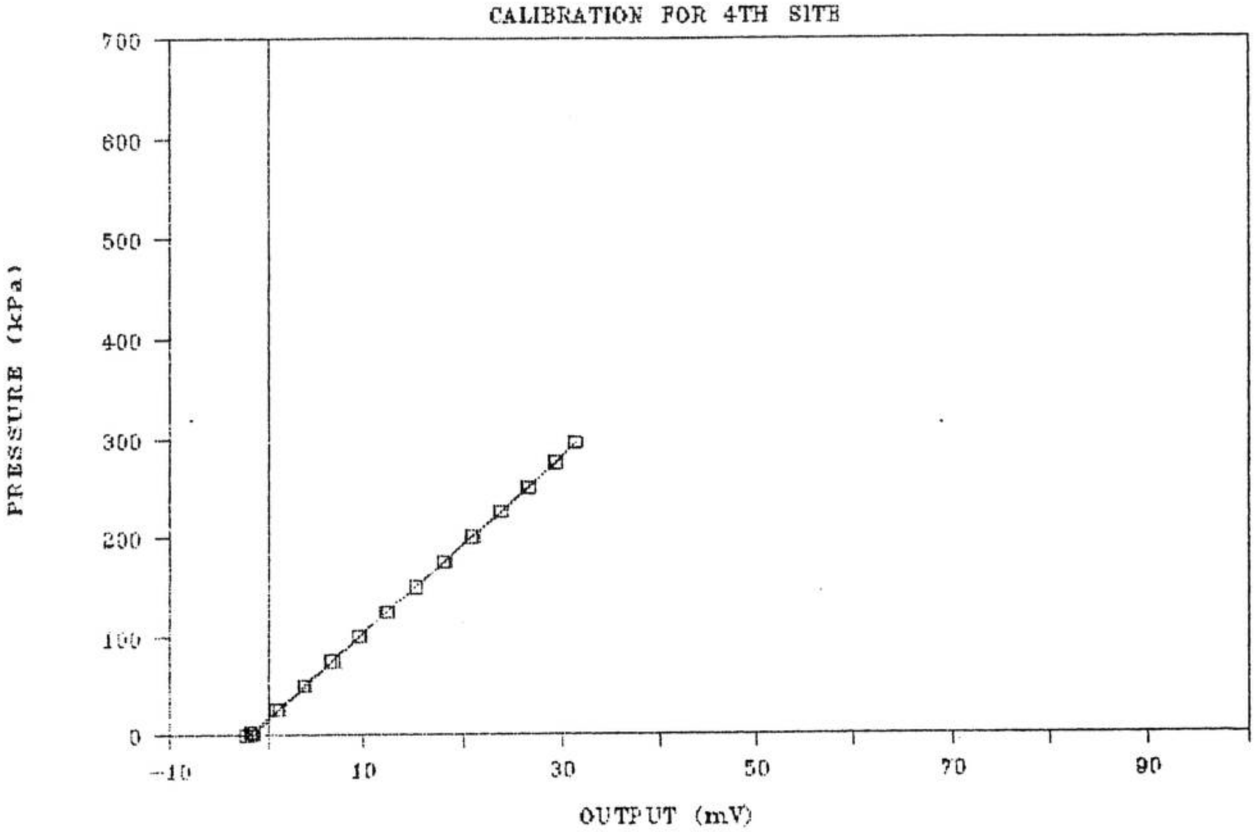
PORE PRESSURE PROBE 5293

Regression Output:	
Constant	-11.9618
Std Err of Y Est	0.833142
R Squared	0.999927
No. of Observations	27
Degrees of Freedom	25

X Coefficient(s)	3.712793
Std Err of Coef.	0.006306

FIGURE III 60

PORE PRESSURE PROBE 5361



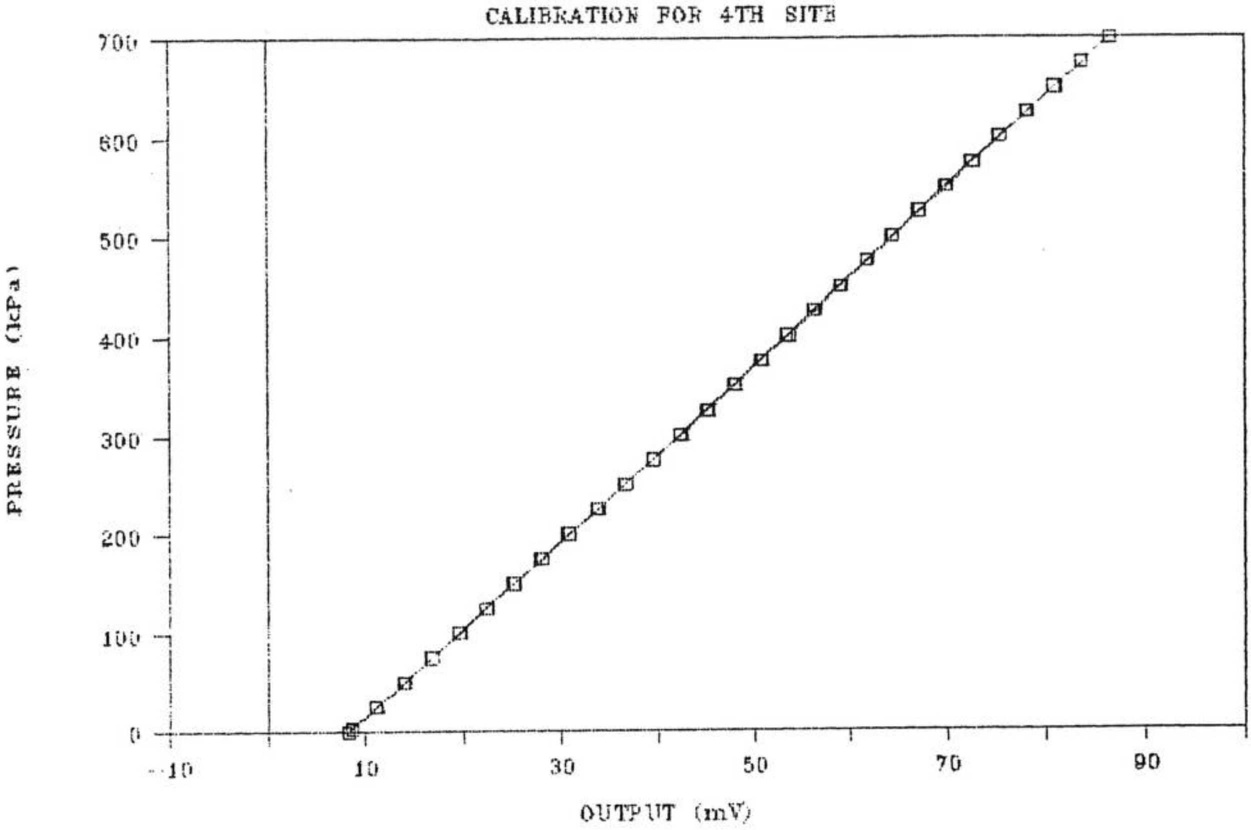
PORE PRESSURE PROBE 5361

Regression Output:	
Constant	16.78626
Std Err of Y Est	1.363480
R Squared	0.999805
No. of Observations	27
Degrees of Freedom	25

X Coefficient(s)	8.773662
Std Err of Coef.	0.024451

FIGURE III 61

PORE PRESSURE PROBE 5369



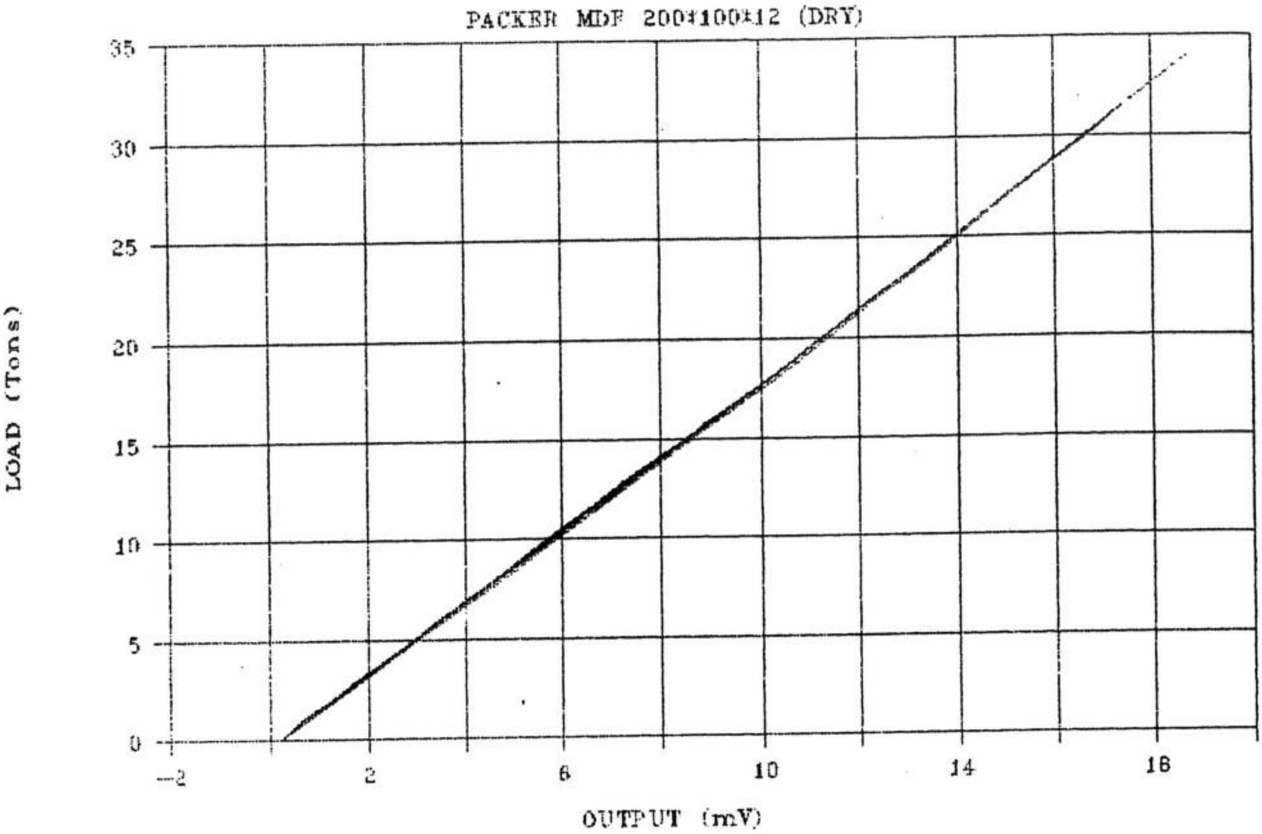
PORE PRESSURE PROBE 5369

Regression Output:	
Constant	-76.1595
Std Err of Y Est	1.837849
R Squared	0.999926
No. of Observations	59
Degrees of Freedom	57

X Coefficient(s)	8.935998
Std Err of Coef.	0.010115

FIGURE III 62

GLOTZL CELL 9527 (SITE 1)



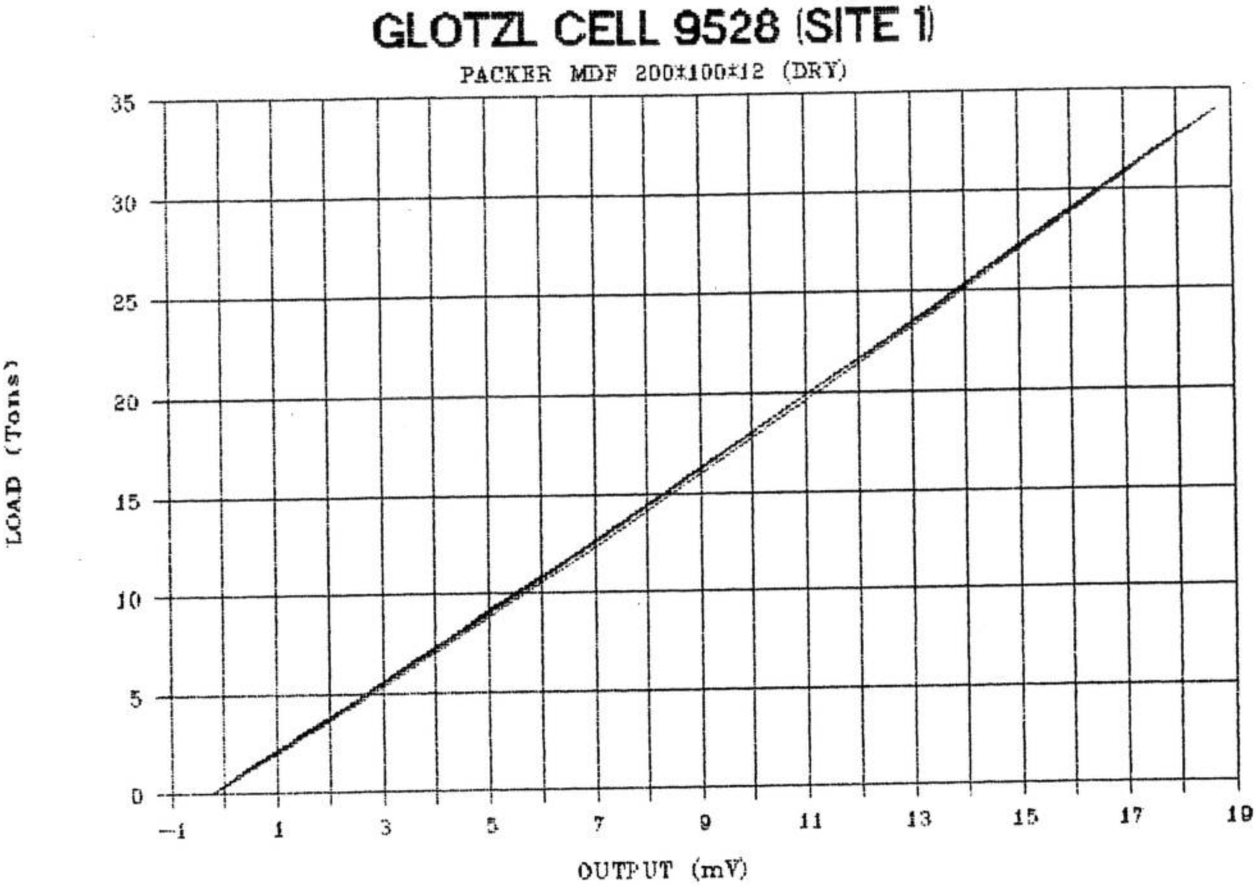
9527 LOW STRESS CYCLING

Regression Output:	
Constant	-0.27386
Std Err of Y Est	0.066072
R Squared	0.999834
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.793665
Std Err of Coef.	0.002801

9527 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.57963
Std Err of Y Est	0.140355
R Squared	0.999812
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.834575
Std Err of Coef.	0.003043

FIGURE III63



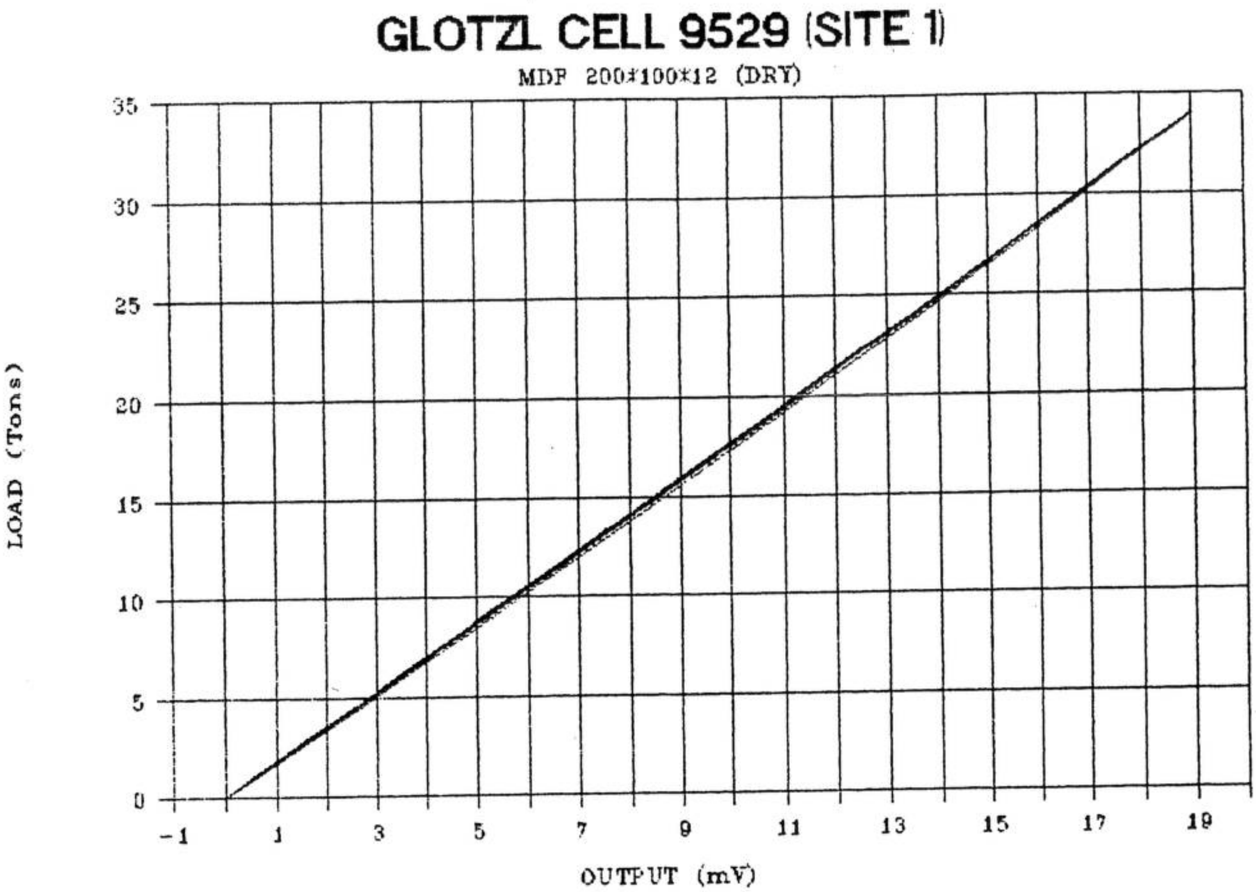
9528 LOW STRESS CYCLING

Regression Output:	
Constant	0.094910
Std Err of Y Est	0.166010
R Squared	0.999738
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.798195
Std Err of Coef.	0.003528

9528 HIGH STRESS CYCLING

Regression Output:	
Constant	0.109927
Std Err of Y Est	0.182794
R Squared	0.999682
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.797651
Std Err of Coef.	0.003884

FIGURE II64



9529 LOW STRESS CYCLING

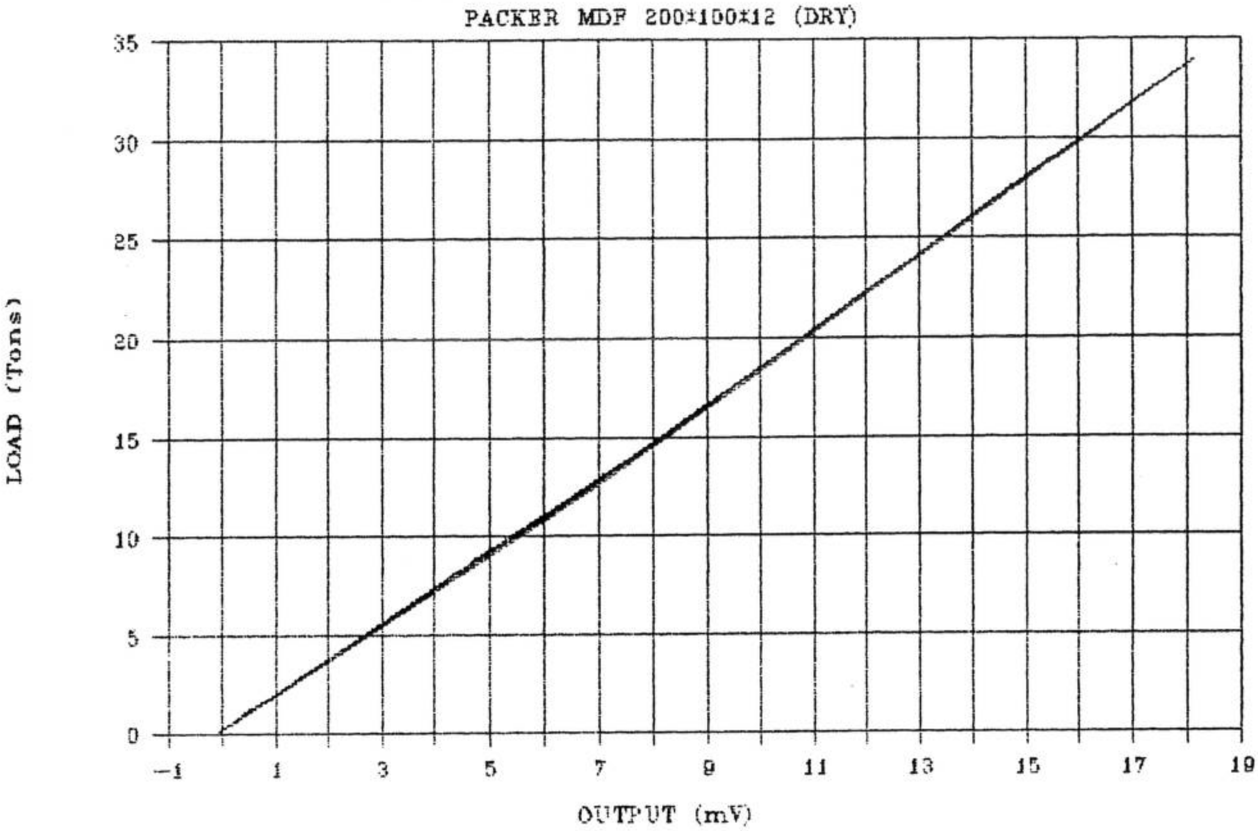
Regression Output:	
Constant	0.021203
Std Err of Y Est	0.062310
R Squared	0.999852
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.747393
Std Err of Coef.	0.002574

9529 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.21416
Std Err of Y Est	0.152953
R Squared	0.999777
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.790454
Std Err of Coef.	0.003237

FIGURE III65

GLOTZL CELL 9530 (SITE 1)



9530 LOW STRESS CYCLING

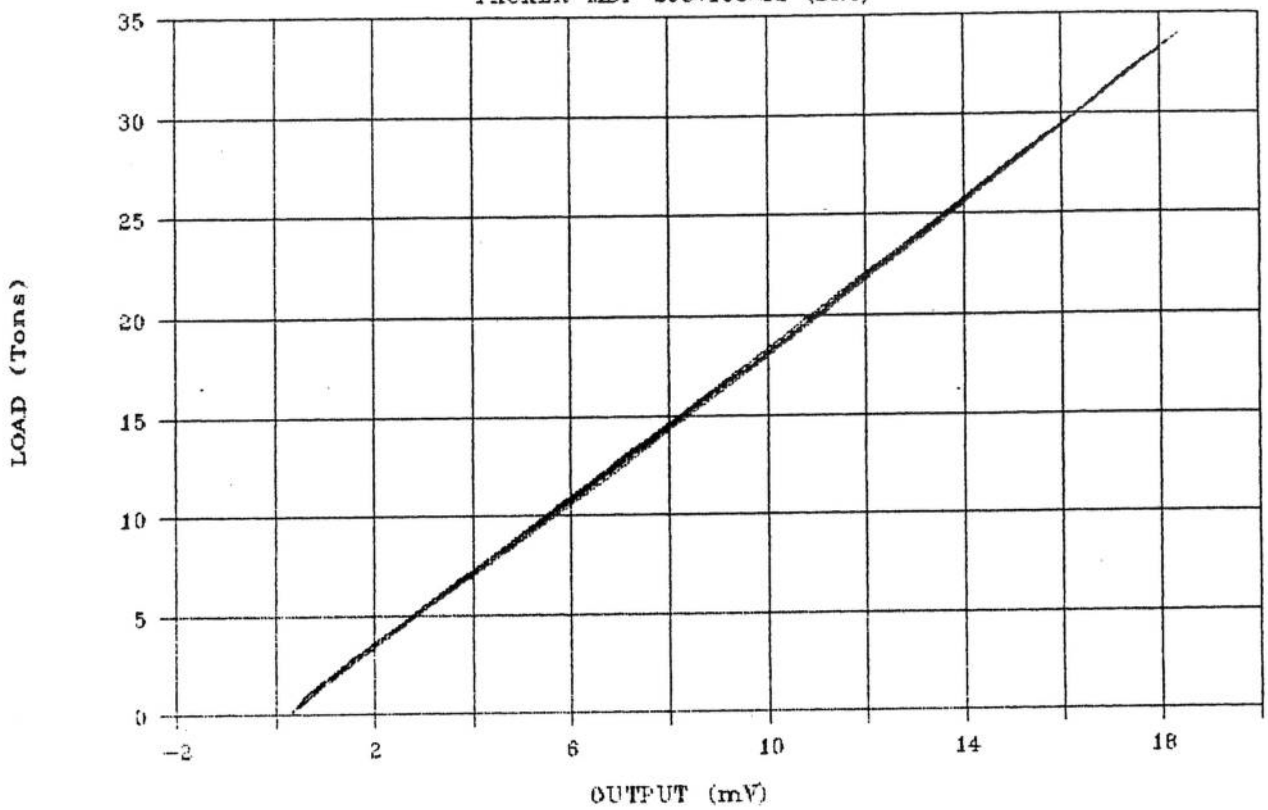
Regression Output:	
Constant	0.149190
Std Err of Y Est	0.078161
R Squared	0.999767
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.809216
Std Err of Coef.	0.003343

9530 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.08384
Std Err of Y Est	0.160732
R Squared	0.999754
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.864970
Std Err of Coef.	0.003543

GLOTZL CELL 9531 (SITE 1)

PACKER MDF 200*100*12 (DRY)



9531 LOW STRESS CYCLING

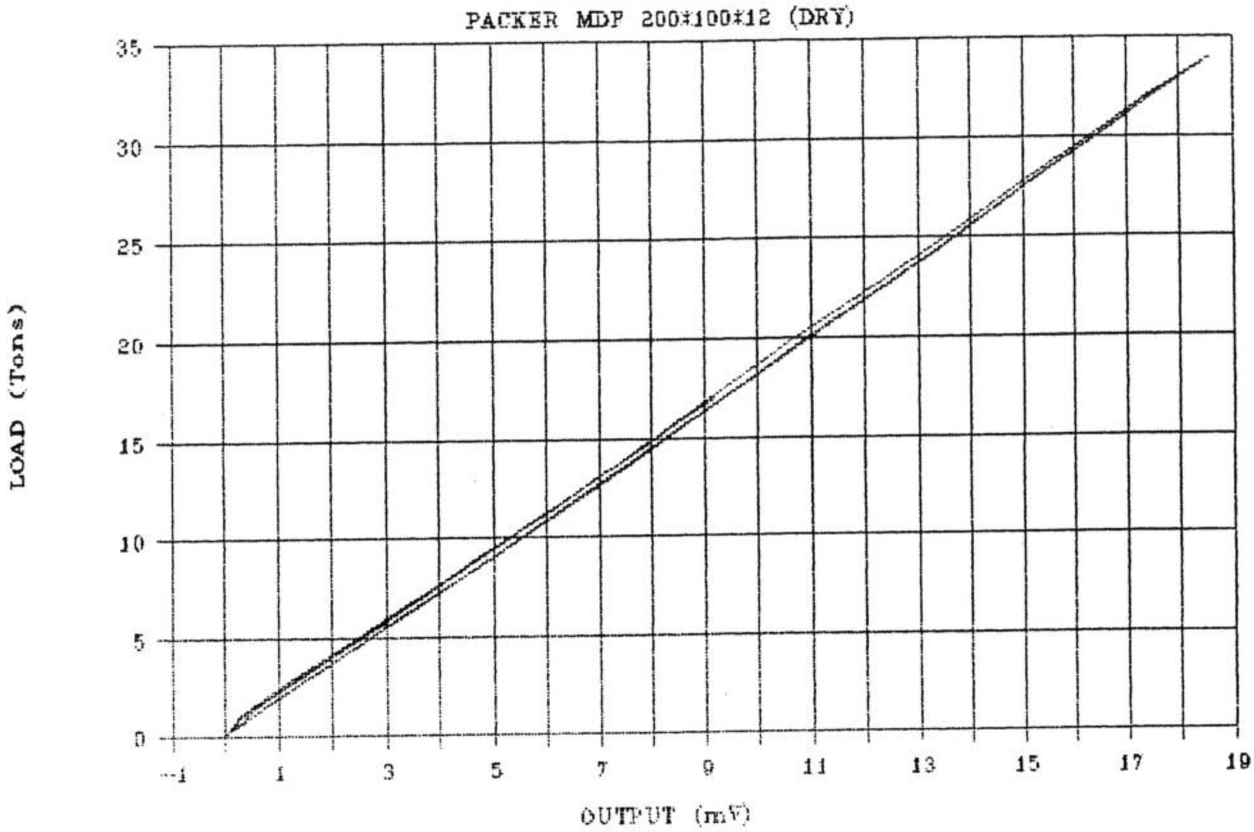
Regression Output:	
Constant	-0.16693
Std Err of Y Est	0.099070
R Squared	0.999627
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.845853
Std Err of Coef.	0.004323

9531 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.39863
Std Err of Y Est	0.128746
R Squared	0.999842
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.863588
Std Err of Coef.	0.002836

FIGURE III67

GLOTZL CELL 9532 (SITE 1)



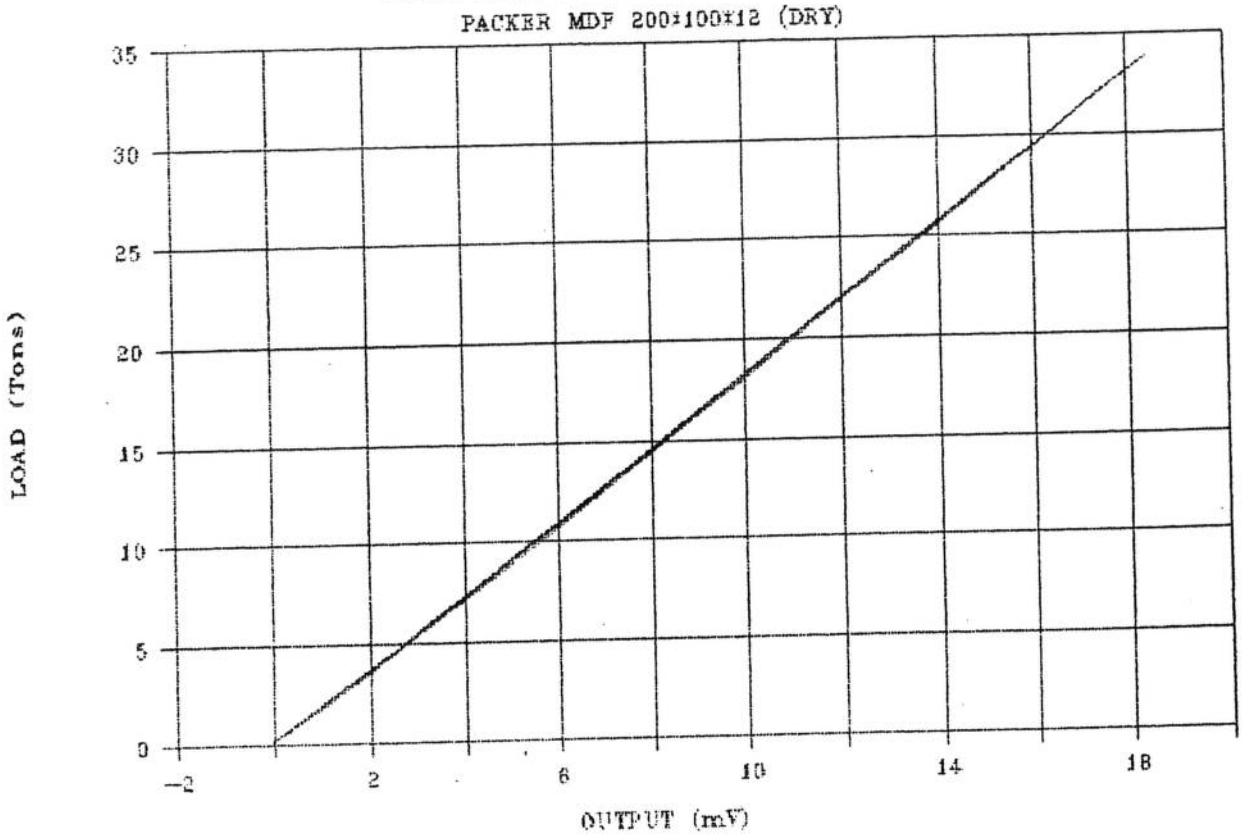
9532 LOW STRESS CYCLING

Regression Output:	
Constant	0.394218
Std Err of Y Est	0.111605
R Squared	0.999526
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.810809
Std Err of Coef.	0.004778

9532 HIGH STRESS CYCLING

Regression Output:	
Constant	0.073440
Std Err of Y Est	0.174565
R Squared	0.999710
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.825002
Std Err of Coef.	0.003766

GLOTZL CELL 9533 (SITE 1)



9533 LOW STRESS CYCLING

Regression Output:

Constant	0.164967
Std Err of Y Est	0.054898
R Squared	0.999885
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.793501
Std Err of Coef.	0.002327

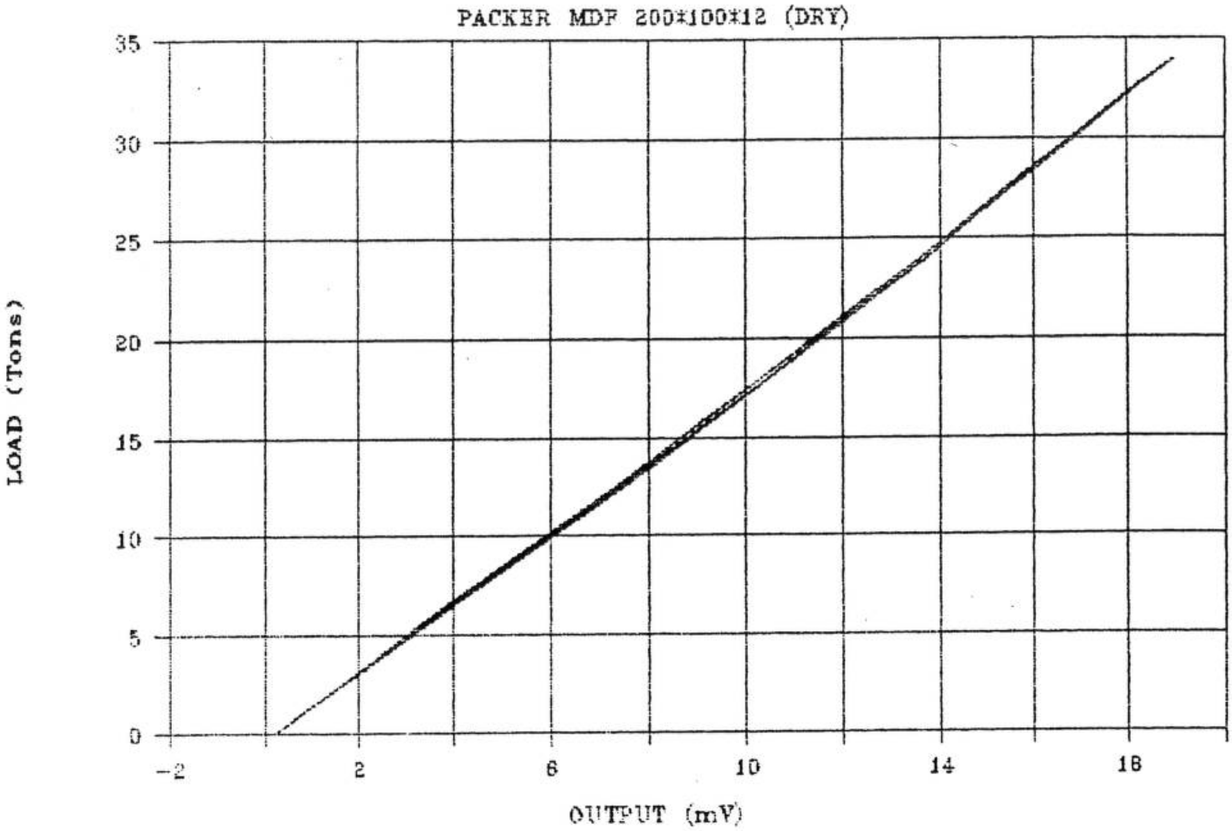
9533 HIGH STRESS CYCLING

Regression Output:

Constant	-0.06133
Std Err of Y Est	0.138540
R Squared	0.999817
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.838872
Std Err of Coef.	0.003011

FIGURE III69

GLOTZL CELL 9534 (SITE 1)



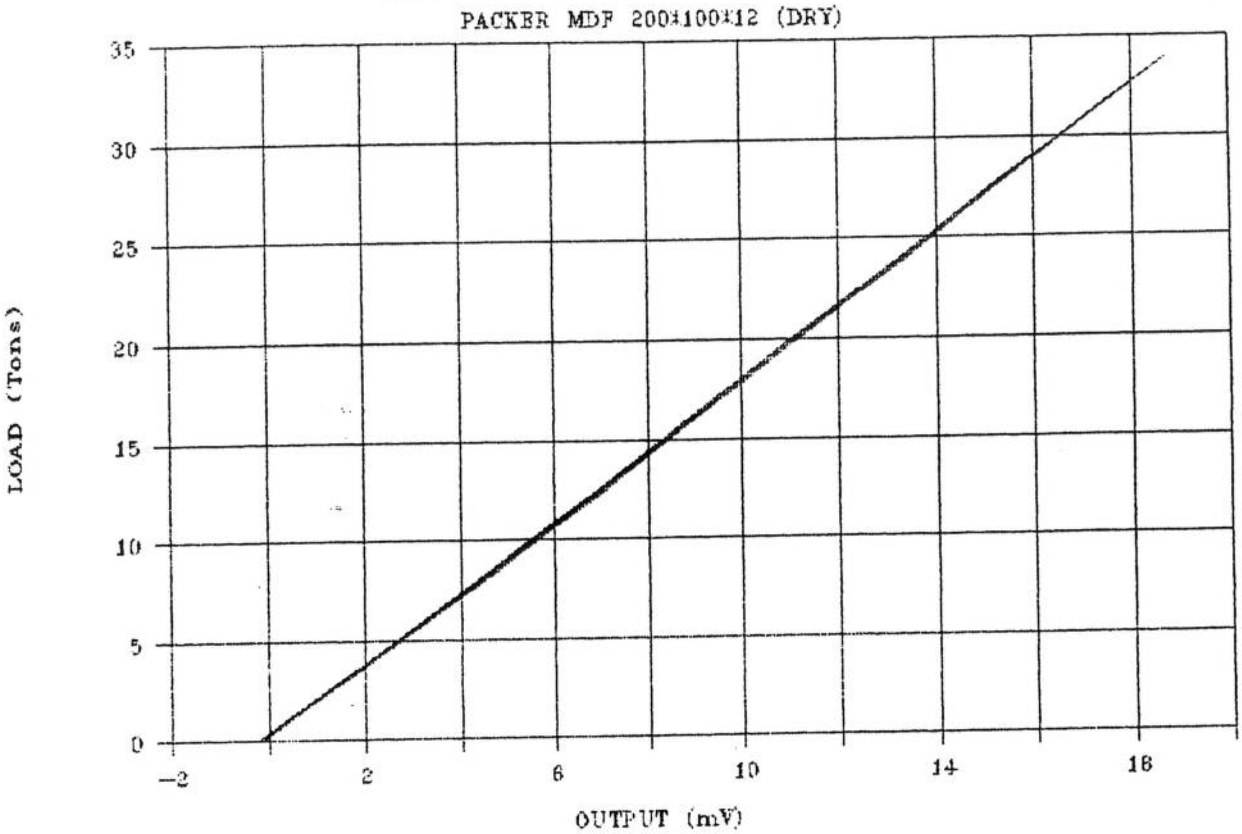
9534 LOW STRESS CYCLING

Regression Output:	
Constant	-0.37471
Std Err of Y Est	0.073500
R Squared	0.999794
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.738006
Std Err of Coef.	0.003020

9534 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.67821
Std Err of Y Est	0.211069
R Squared	0.999576
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.814706
Std Err of Coef.	0.004528

GLOTZL CELL 9535 (SITE 1)



9535 LOW STRESS CYCLING

Regression Output:

Constant	0.304547
Std Err of Y Est	0.062605
R Squared	0.999851
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.747729
Std Err of Coef.	0.002586

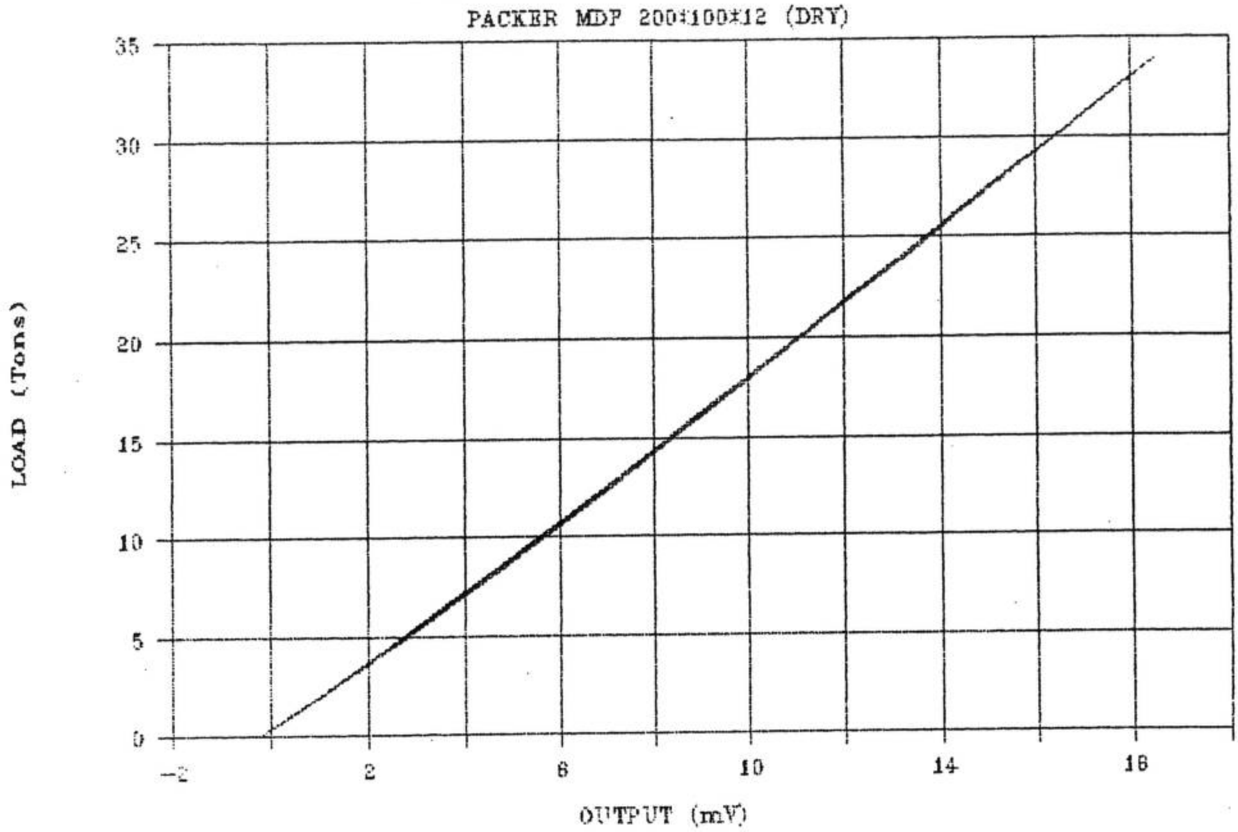
9535 HIGH STRESS CYCLING

Regression Output:

Constant	0.056143
Std Err of Y Est	0.150833
R Squared	0.999783
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.804550
Std Err of Coef.	0.003217

FIGURE III 71

GLOTZL CELL 9536 (SITE 1)



9536 LOW STRESS CYCLING

Regression Output:

Constant	0.221685
Std Err of Y Est	0.096407
R Squared	0.999646
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s) 1.748424
Std Err of Coef. 0.003985

9536 HIGH STRESS CYCLING

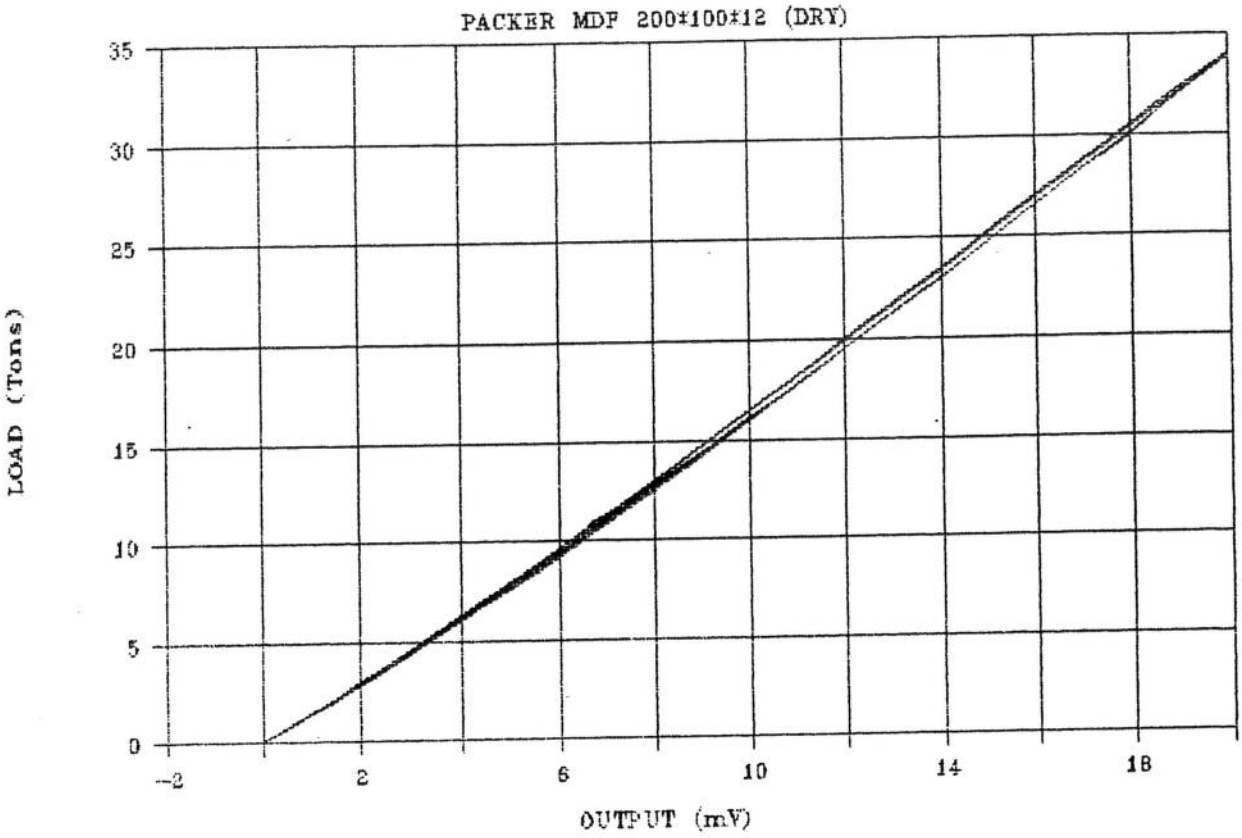
Regression Output:

Constant	-0.06557
Std Err of Y Est	0.209946
R Squared	0.999581
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s) 1.824465
Std Err of Coef. 0.004528

FIGURE III 72

GLOTZL CELL 9537 (SITE 1)



9537 LOW STRESS CYCLING

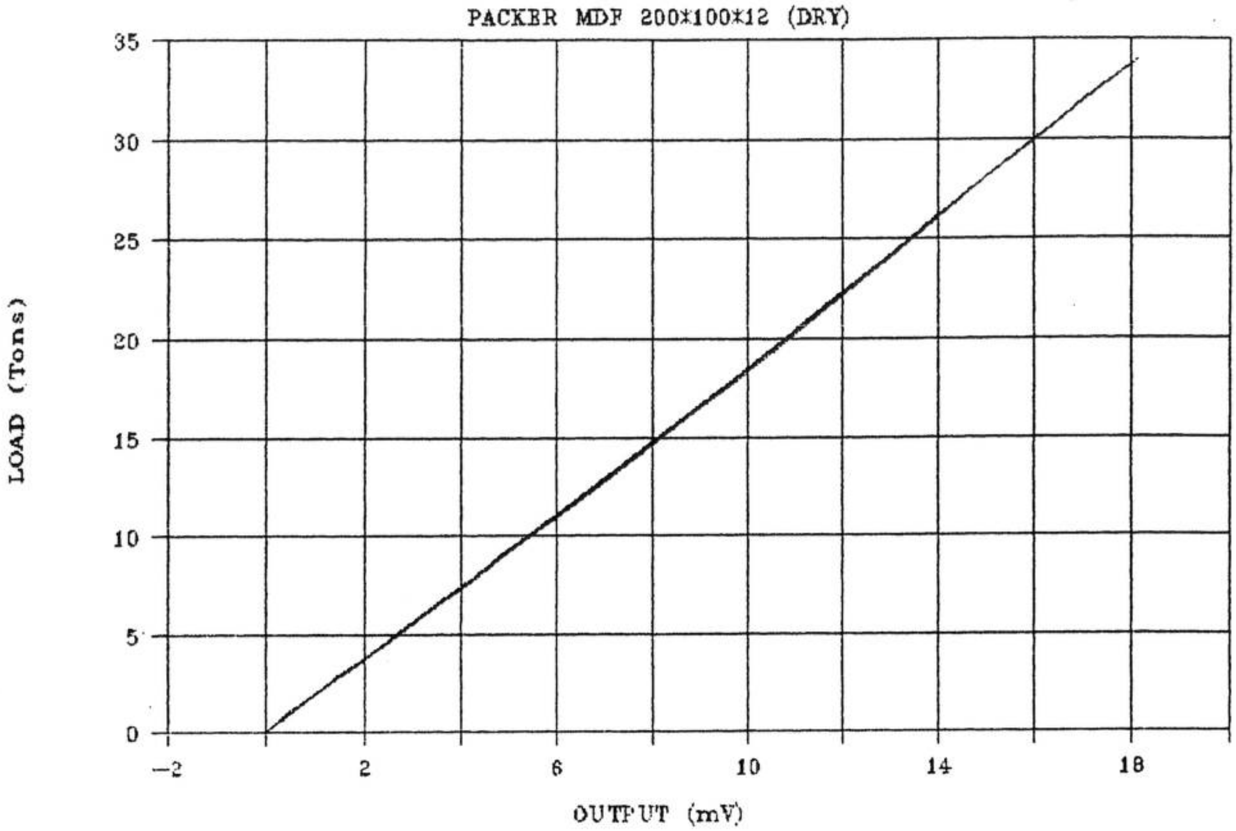
Regression Output:	
Constant	-0.24680
Std Err of Y Est	0.127245
R Squared	0.999384
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.622545
Std Err of Coef.	0.004882

9537 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.60638
Std Err of Y Est	0.303985
R Squared	0.999122
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.708006
Std Err of Coef.	0.006139

FIGURE III 73

GLOTZL CELL 9538 (SITE 1)



9538 LOW STRESS CYCLING

Regression Output:	
Constant	0.119904
Std Err of Y Est	0.063111
R Squared	0.999848
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s) 1.821744
Std Err of Coef. 0.002718

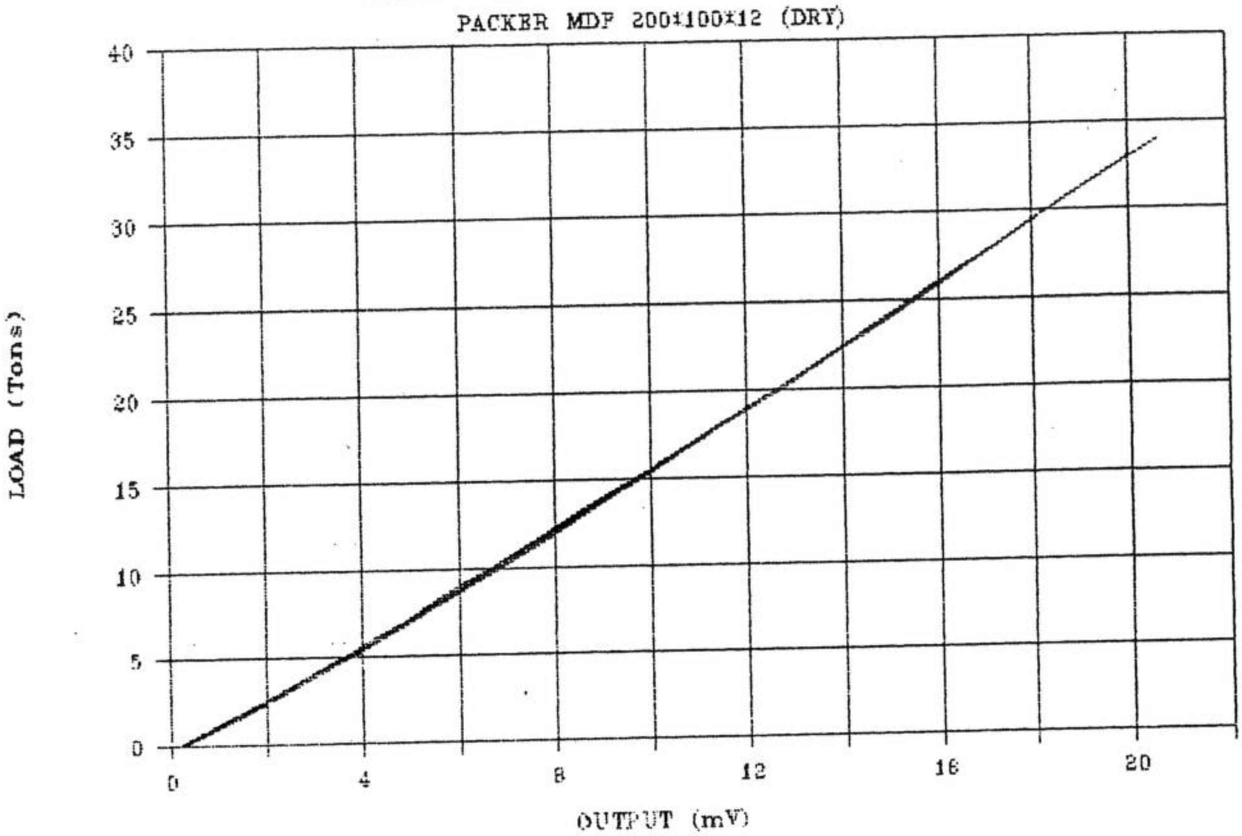
9538 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.09976
Std Err of Y Est	0.133539
R Squared	0.999830
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s) 1.870906
Std Err of Coef. 0.002953

GLOTZL CELL 0575 (SITE 2)

PACKER MDF 200*100*12 (DRY)



0575 LOW STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

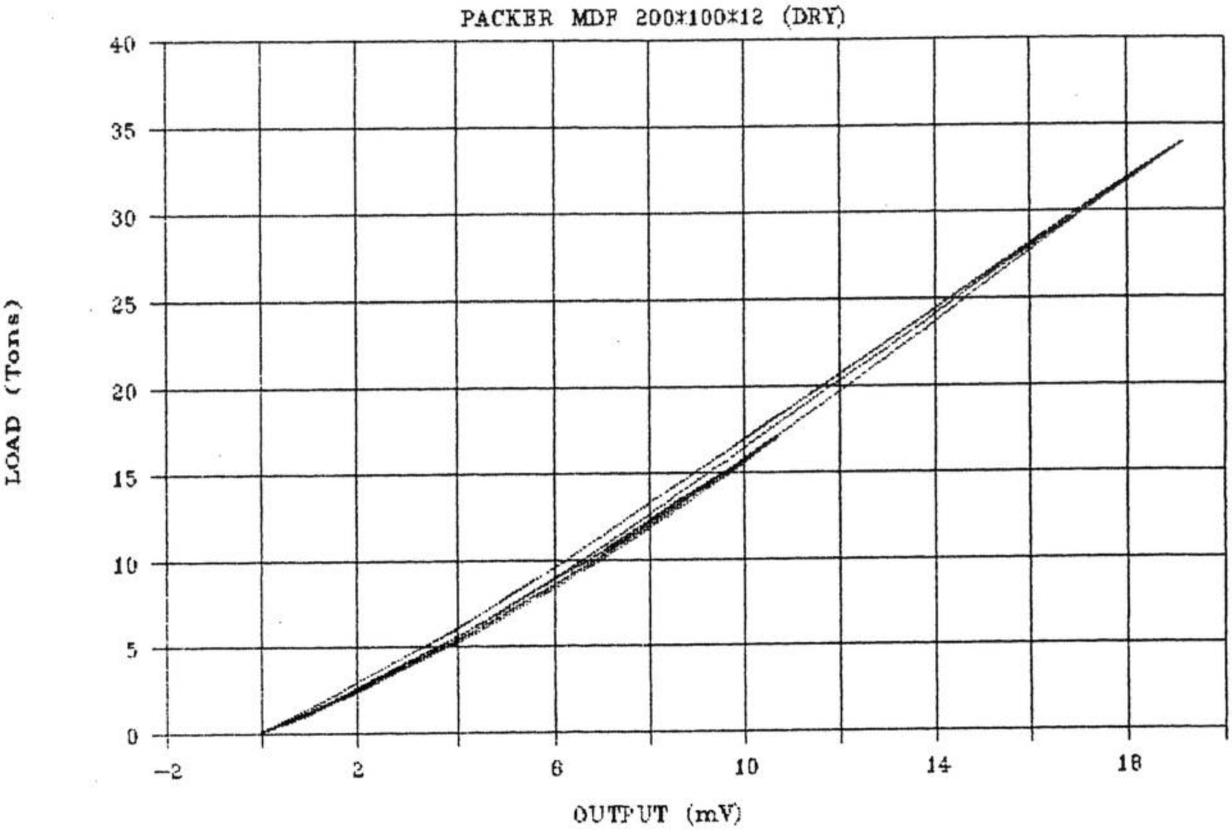
Constant	-1.16617
Std Err of Y Est	0.103864
R Squared	0.999207
No. of Observations	50
Degrees of Freedom	48
X Coefficient(s)	1.664025
Std Err of Coef.	0.006765

0575 HIGH STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-1.71835
Std Err of Y Est	0.119478
R Squared	0.999803
No. of Observations	58
Degrees of Freedom	56
X Coefficient(s)	1.728926
Std Err of Coef.	0.003236

FIGURE II75

GLOTZL CELL 0576 (SITE 2)

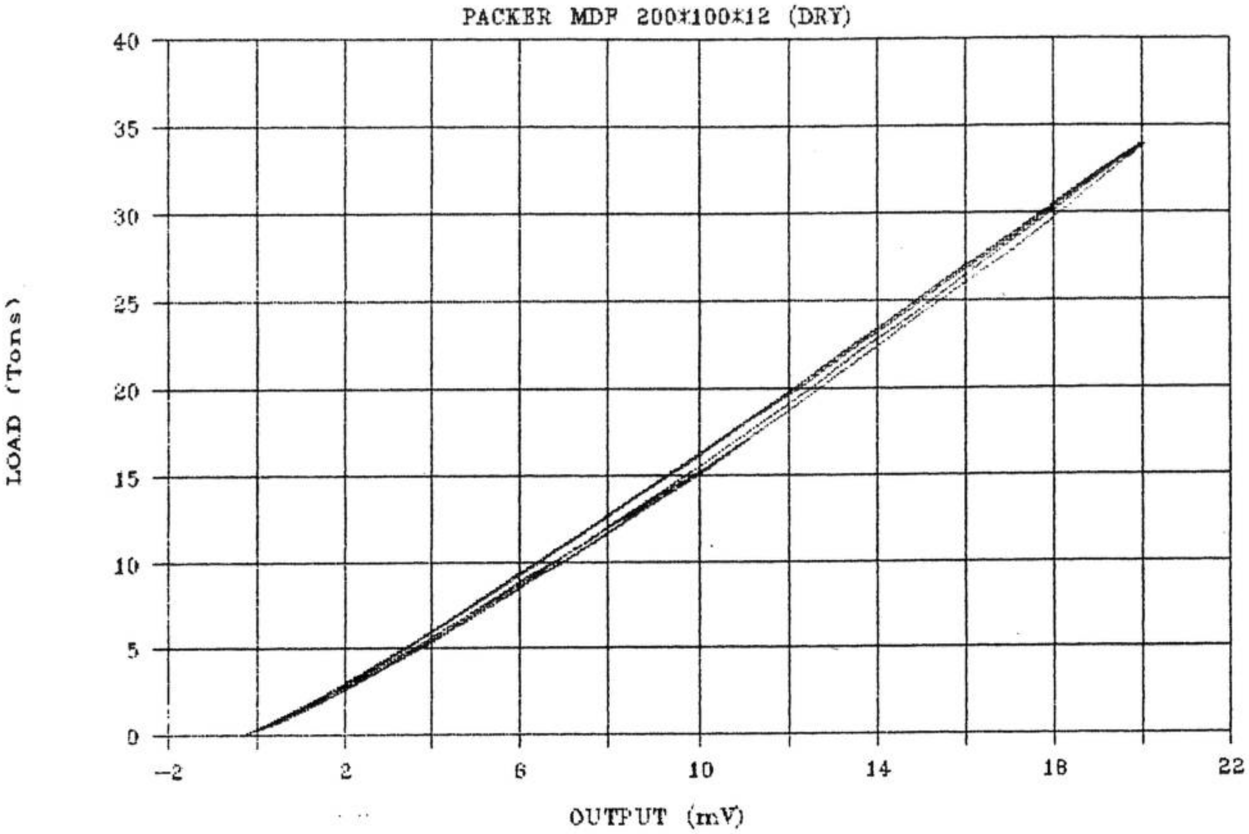



```
  0576   LOW STRESS CYCLING
(initial 4 Tons not included)
         Regression Output:
Constant                      -1.52580
Std Err of Y Est              0.209579
R Squared                     0.996771
No. of Observations                 50
Degrees of Freedom                  48

X Coefficient(s)  1.714041
Std Err of Coef.  0.014079
```

```
  0576   HIGH STRESS CYCLING
(initial 4 Tons not included)
         Regression Output:
Constant                      -2.06289
Std Err of Y Est              0.394316
R Squared                     0.997862
No. of Observations                 58
Degrees of Freedom                  56

X Coefficient(s)  1.875979
Std Err of Coef.  0.011601
```

FIGURE III 76

GLOTZL CELL 0577 (SITE 2)



0577 LOW STRESS CYCLING
(initial 4 Tons not included)
Regression Output:

Constant	-0.97158
Std Err of Y Est	0.157990
R Squared	0.998165
No. of Observations	50
Degrees of Freedom	48

X Coefficient(s) 1.607691
Std Err of Coef. 0.009947

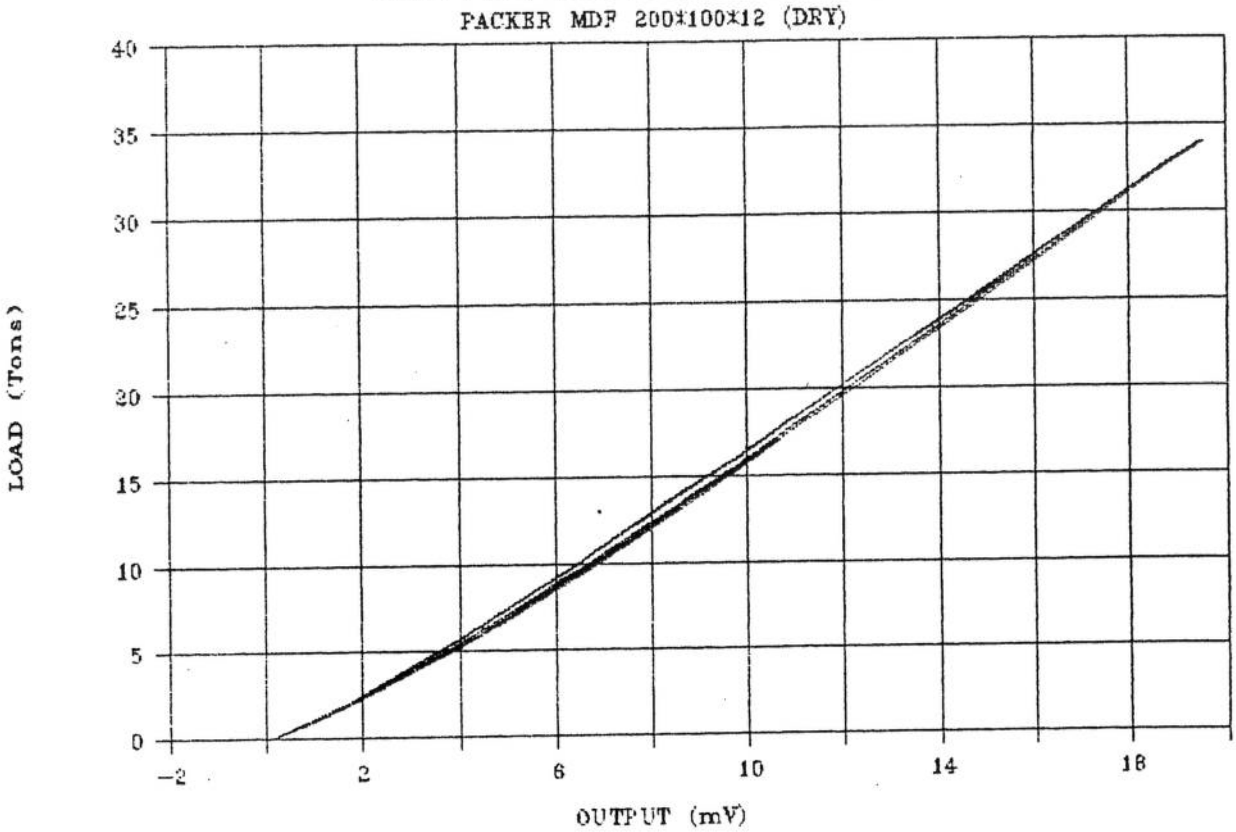
0577 HIGH STRESS CYCLING
(initial 4 Tons not included)
Regression Output:

Constant	-1.77383
Std Err of Y Est	0.424863
R Squared	0.997519
No. of Observations	58
Degrees of Freedom	56

X Coefficient(s) 1.770965
Std Err of Coef. 0.011802

FIGURE III77

GLOTZL CELL 0578 (SITE 2)



0578 LOW STRESS CYCLING
(initial 4 Tons not included)
Regression Output:

Constant	-1.74728
Std Err of Y Est	0.163495
R Squared	0.998035
No. of Observations	50
Degrees of Freedom	48

X Coefficient(s) 1.750274
Std Err of Coef. 0.011208

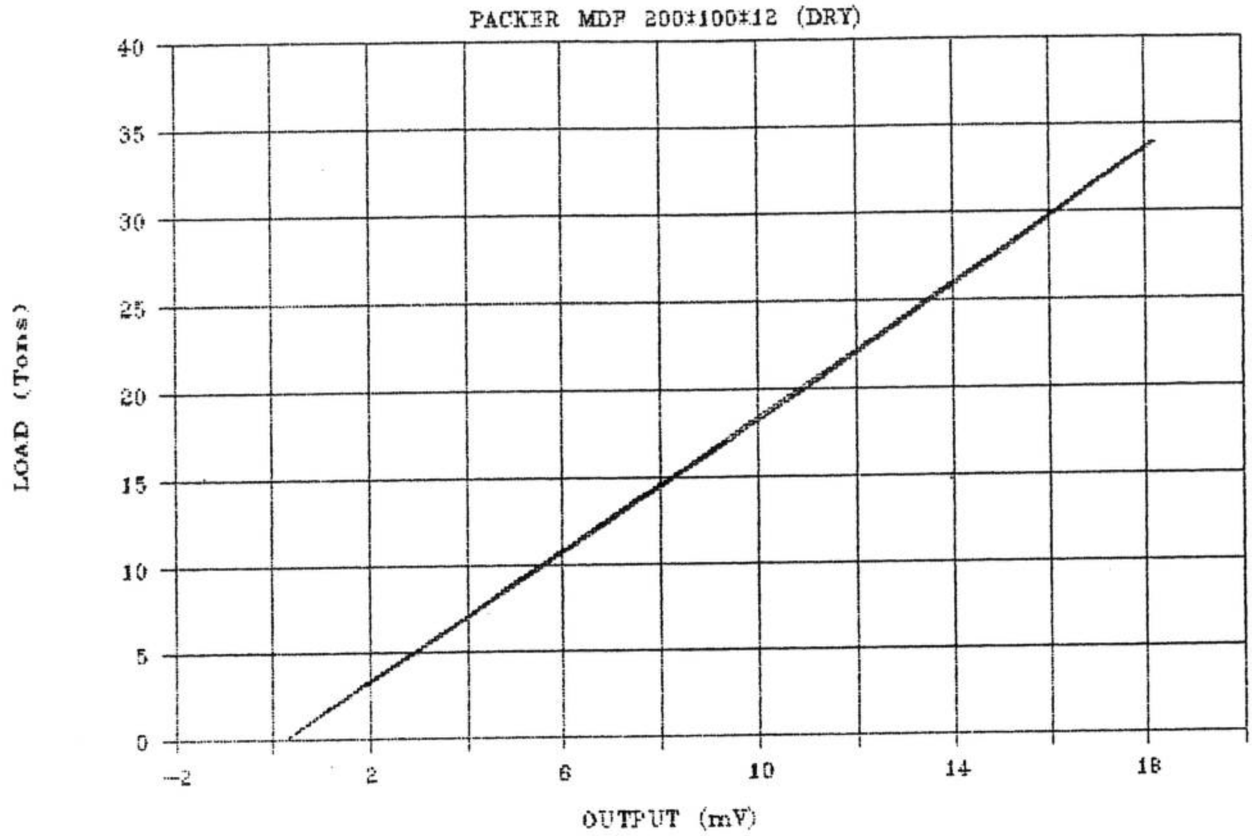
0578 HIGH STRESS CYCLING
(initial 4 Tons not included)
Regression Output:

Constant	-2.18578
Std Err of Y Est	0.263042
R Squared	0.999049
No. of Observations	58
Degrees of Freedom	56

X Coefficient(s) 1.850674
Std Err of Coef. 0.007630

FIGURE III 78

GLOTZL CELL 9527 (SITE 2)



9527 LOW STRESS CYCLING

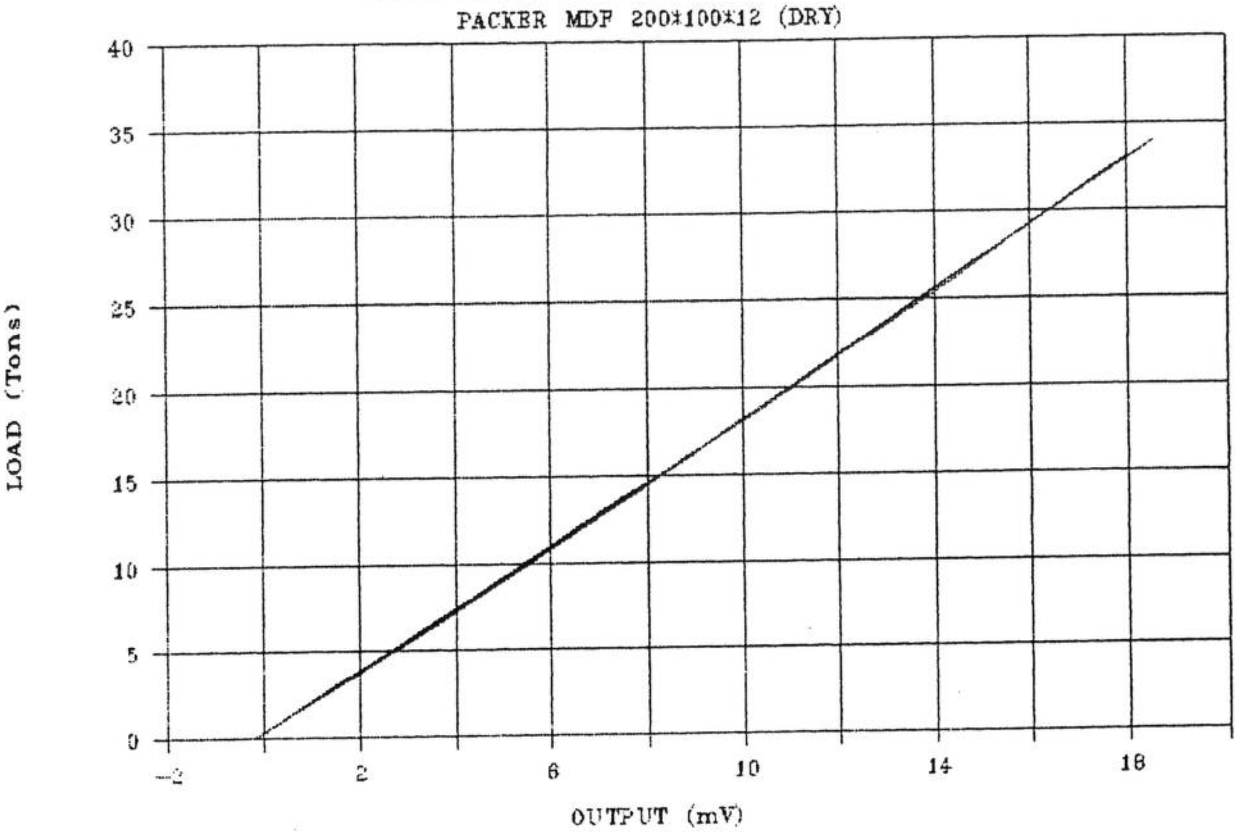
Regression Output:	
Constant	-0.36434
Std Err of Y Est	0.048791
R Squared	0.999909
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.869951
Std Err of Coef.	0.002156

9527 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.55952
Std Err of Y Est	0.109544
R Squared	0.999885
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.891166
Std Err of Coef.	0.002448

FIGURE III 79

GLOTZL CELL 9528 (SITE 2)



9528 LOW STRESS CYCLING

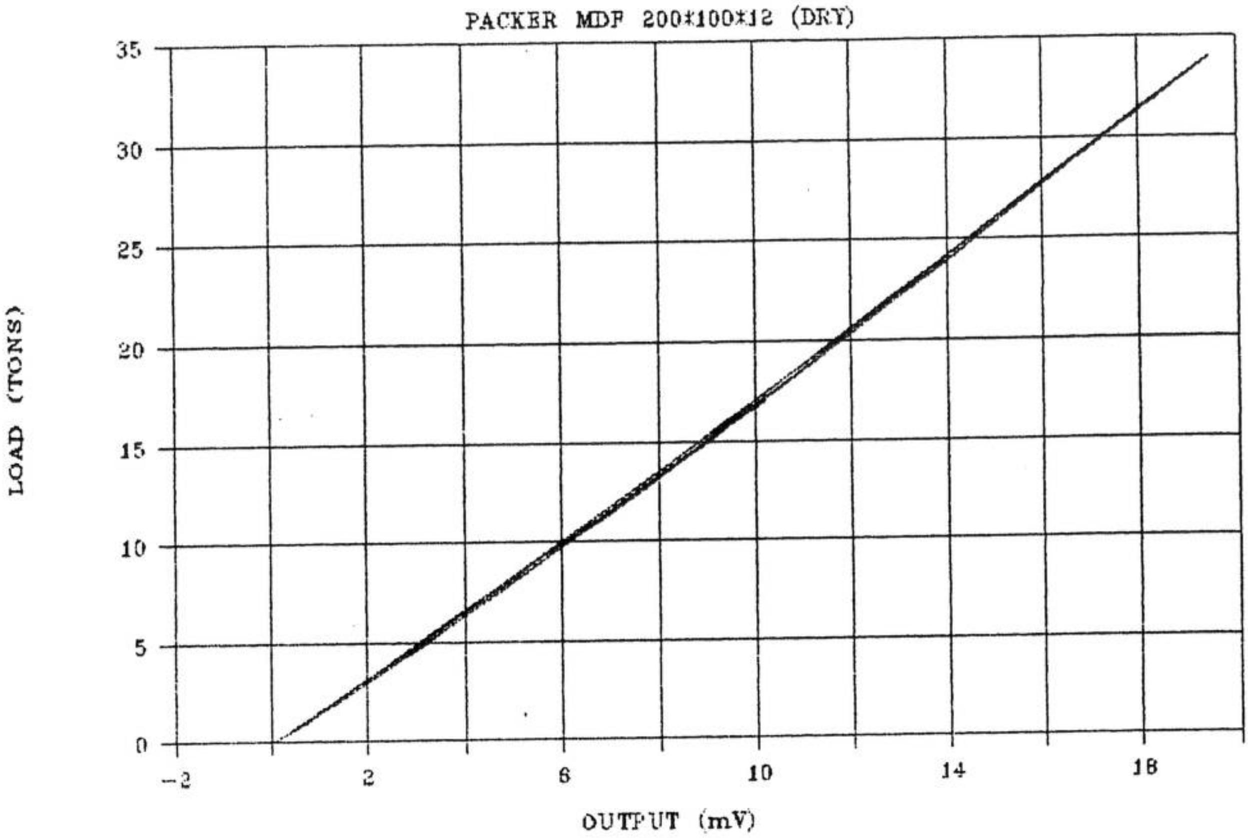
Regression Output:	
Constant	0.314433
Std Err of Y Est	0.066714
R Squared	0.999830
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.774618
Std Err of Coef.	0.002799

9528 HIGH STRESS CYCLING

Regression Output:	
Constant	0.112490
Std Err of Y Est	0.132825
R Squared	0.999832
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.816404
Std Err of Coef.	0.002852

FIGURE III80

GLOTZL CELL 9529 (SITE 2)



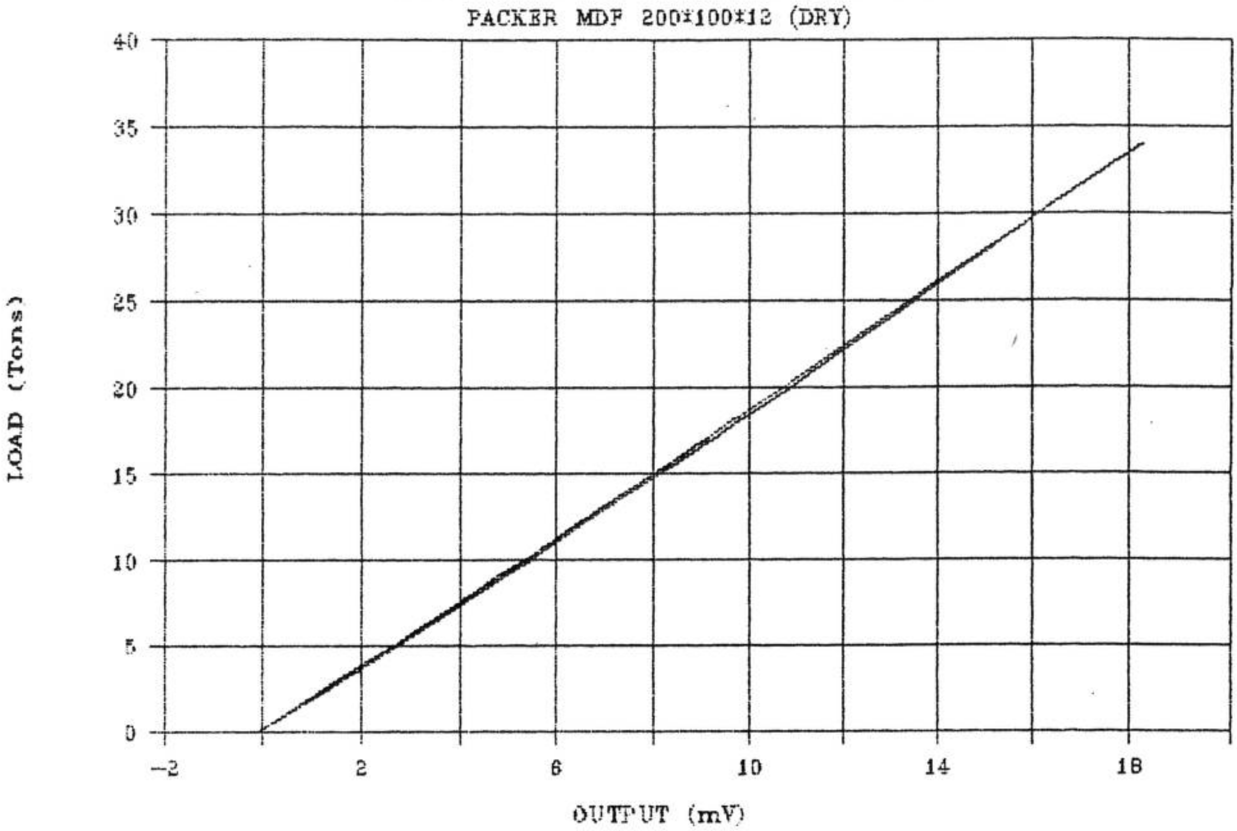
9529 LOW STRESS CYCLING

Regression Output:	
Constant	-0.33044
Std Err of Y Est	0.113710
R Squared	0.999508
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.694620
Std Err of Coef.	0.004556

9529 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.55283
Std Err of Y Est	0.197841
R Squared	0.999628
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.762284
Std Err of Coef.	0.004121

GLOTZL CELL 9530 (SITE 2)



9530 LOW STRESS CYCLING

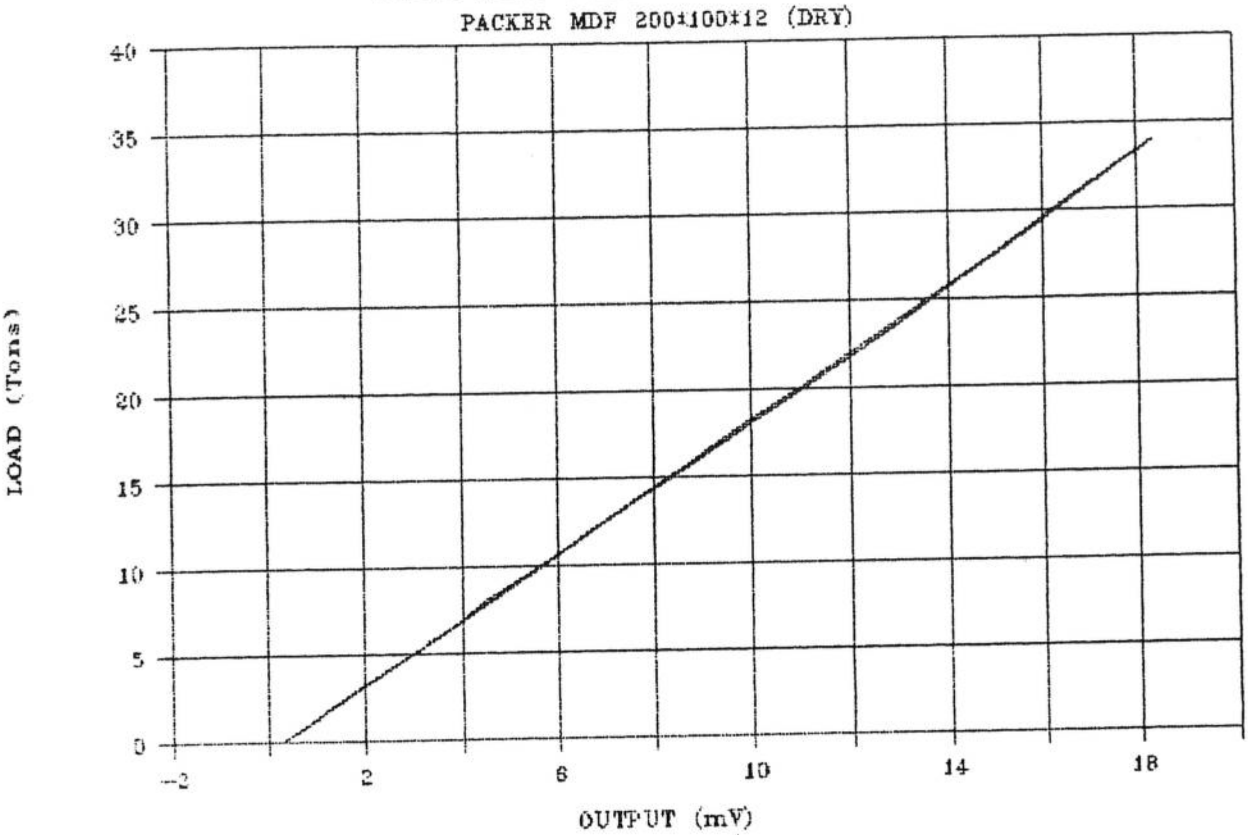
Regression Output:	
Constant	0.135376
Std Err of Y Est	0.041569
R Squared	0.999934
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.848328
Std Err of Coef.	0.001816

9530 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.00905
Std Err of Y Est	0.108842
R Squared	0.999887
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.856873
Std Err of Coef.	0.002389

FIGURE III82

GLOTZL CELL 9531 (SITE 2)



9531 LOW STRESS CYCLING

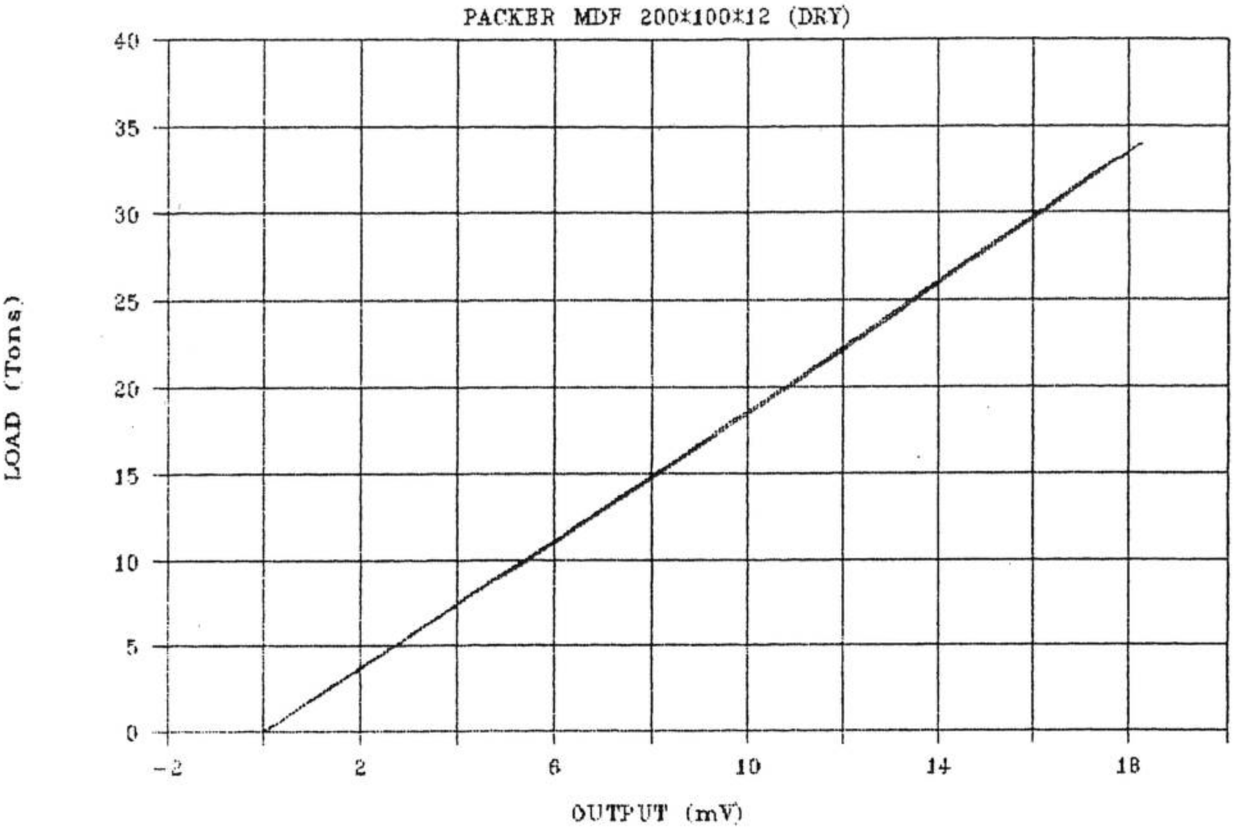
Regression Output:	
Constant	-0.50032
Std Err of Y Est	0.037078
R Squared	0.999947
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.858872
Std Err of Coef.	0.001629

9531 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.63750
Std Err of Y Est	0.098948
R Squared	0.999906
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.881975
Std Err of Coef.	0.002201

FIGURE III83

GLOTZL CELL 9532 (SITE 2)



9532 LOW STRESS CYCLING

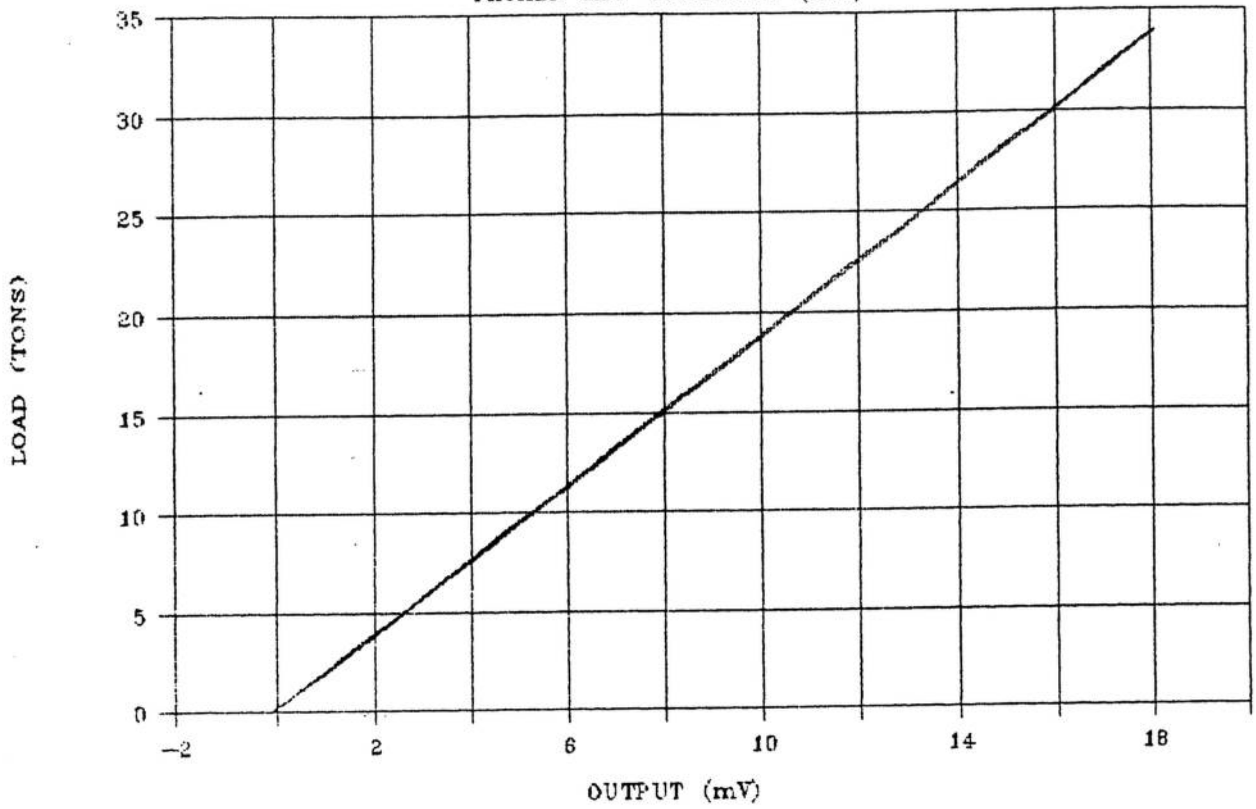
Regression Output:		
Constant		0.057843
Std Err of Y Est		0.031725
R Squared		0.999961
No. of Observations		70
Degrees of Freedom		68
X Coefficient(s)	1.844564	
Std Err of Coef.	0.001383	

9532 HIGH STRESS CYCLING

Regression Output:		
Constant		-0.08408
Std Err of Y Est		0.091916
R Squared		0.999919
No. of Observations		70
Degrees of Freedom		68
X Coefficient(s)	1.859347	
Std Err of Coef.	0.002020	

GLOTZL CELL 9533 (SITE 2)

PACKER MDF 200*100*12 (DRY)



9533 LOW STRESS CYCLING

Regression Output:

Constant	0.225667
Std Err of Y Est	0.039397
R Squared	0.999941
No. of Observations	70
Degrees of Freedom	68

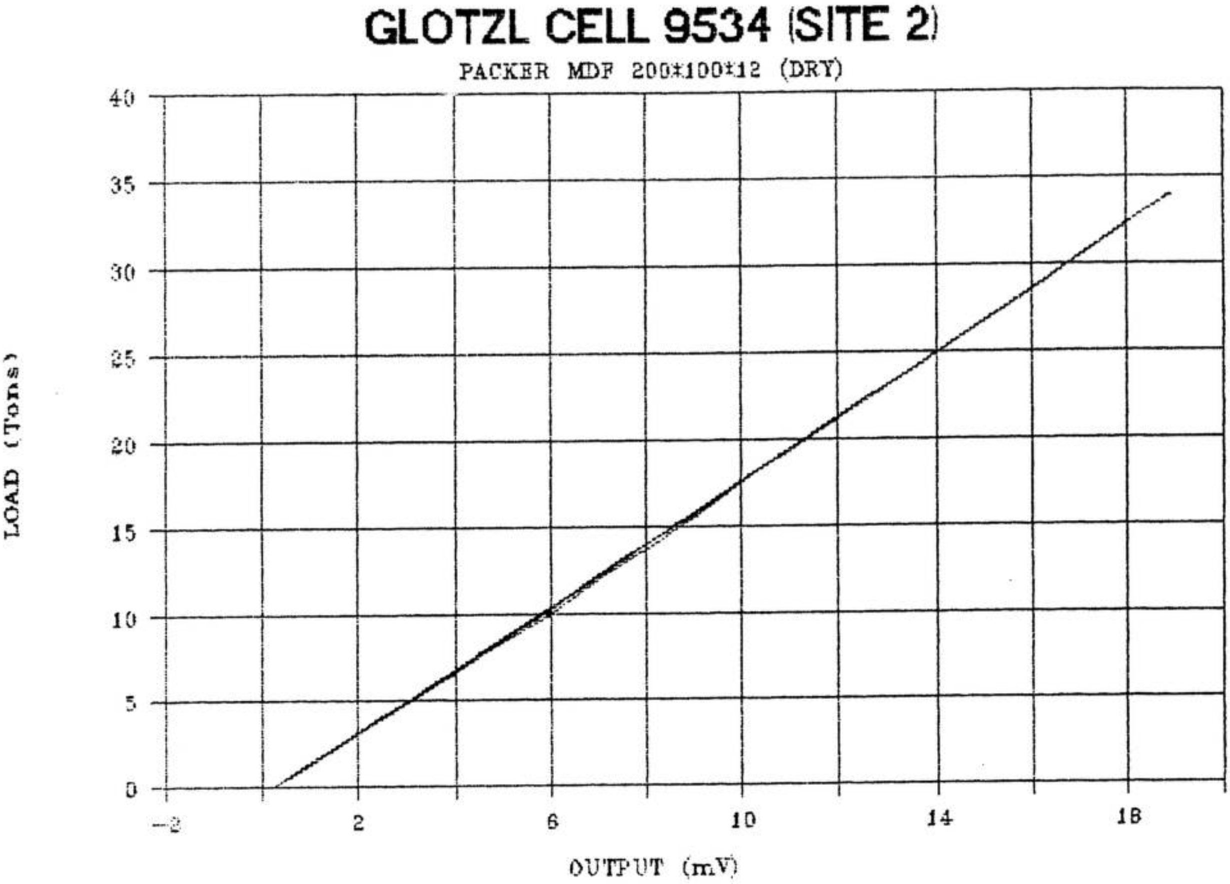
X Coefficient(s)	1.857602
Std Err of Coef.	0.001730

9533 HIGH STRESS CYCLING

Regression Output:

Constant	0.106264
Std Err of Y Est	0.073587
R Squared	0.999948
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.872722
Std Err of Coef.	0.001628



9534 LOW STRESS CYCLING

Regression Output:

Constant		-0.46356
Std Err of Y Est		0.050427
R Squared		0.999903
No. of Observations		70
Degrees of Freedom		68
X Coefficient(s)	1.799625	
Std Err of Coef.	0.002145	

9534 HIGH STRESS CYCLING

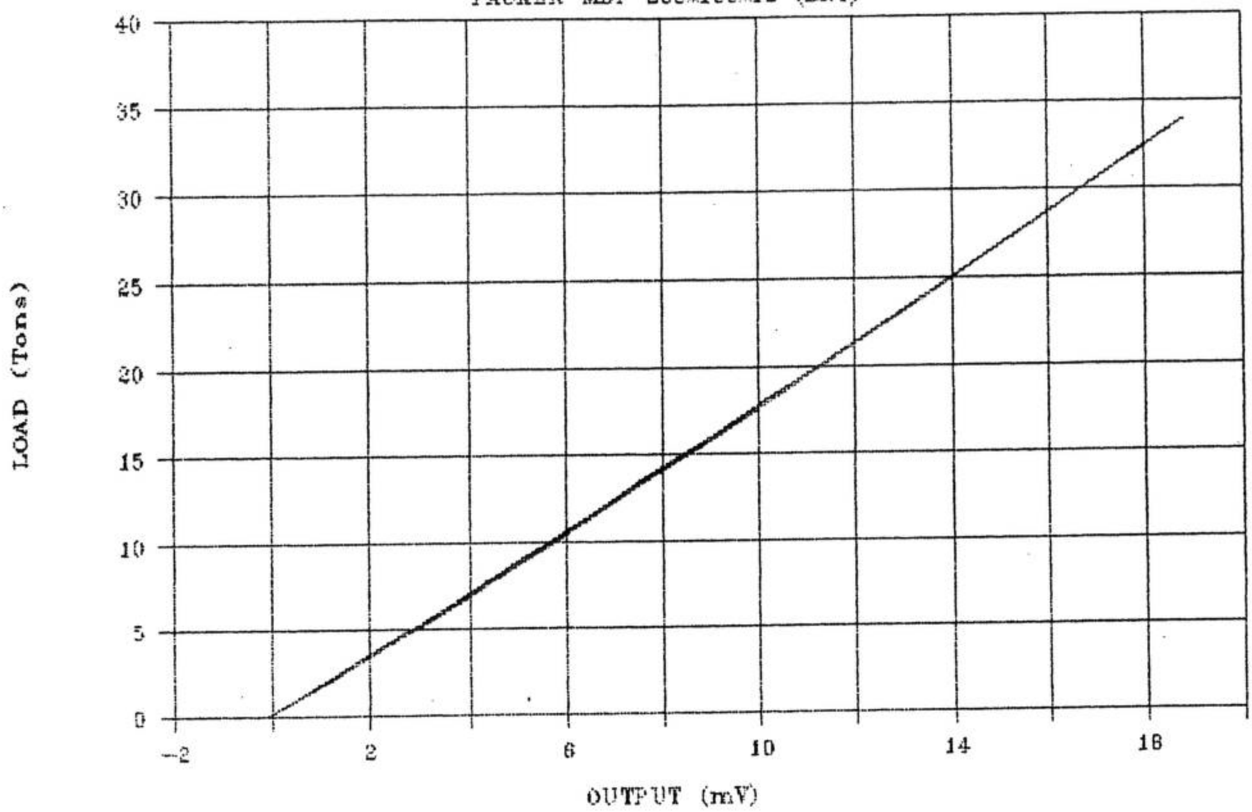
Regression Output:

Constant		-0.61630
Std Err of Y Est		0.102632
R Squared		0.999899
No. of Observations		70
Degrees of Freedom		68
X Coefficient(s)	1.824669	
Std Err of Coef.	0.002213	

FIGURE III86

GLOTZL CELL 9535 (SITE 2)

PACKER MDF 200*100*12 (DRY)



9535 LOW STRESS CYCLING

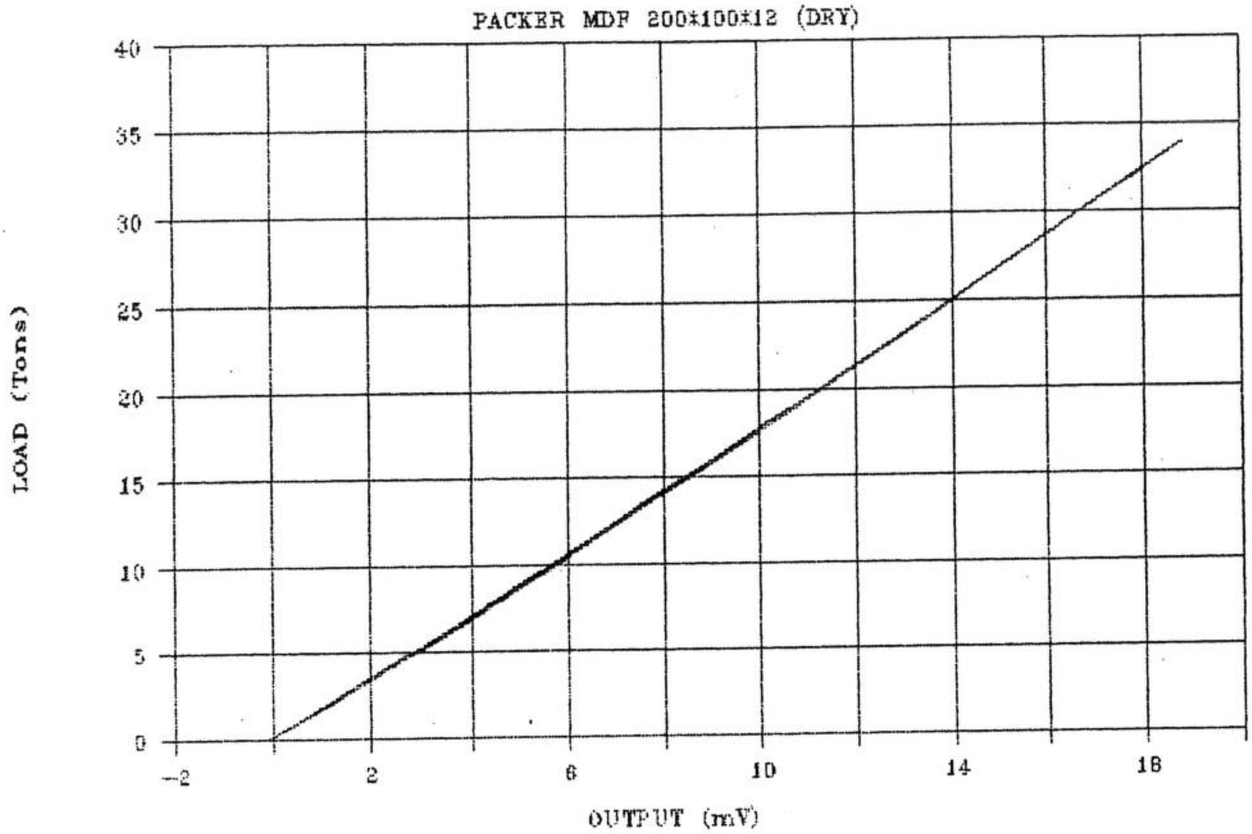
Regression Output:		
Constant		0.055654
Std Err of Y Est		0.073782
R Squared		0.999793
No. of Observations		70
Degrees of Freedom		68
X Coefficient(s)	1.751716	
Std Err of Coef.	0.003055	

9535 HIGH STRESS CYCLING

Regression Output:		
Constant		-0.15319
Std Err of Y Est		0.151572
R Squared		0.999781
No. of Observations		70
Degrees of Freedom		68
X Coefficient(s)	1.800985	
Std Err of Coef.	0.003226	

FIGURE III87

GLOTZL CELL 9535 (SITE 2)



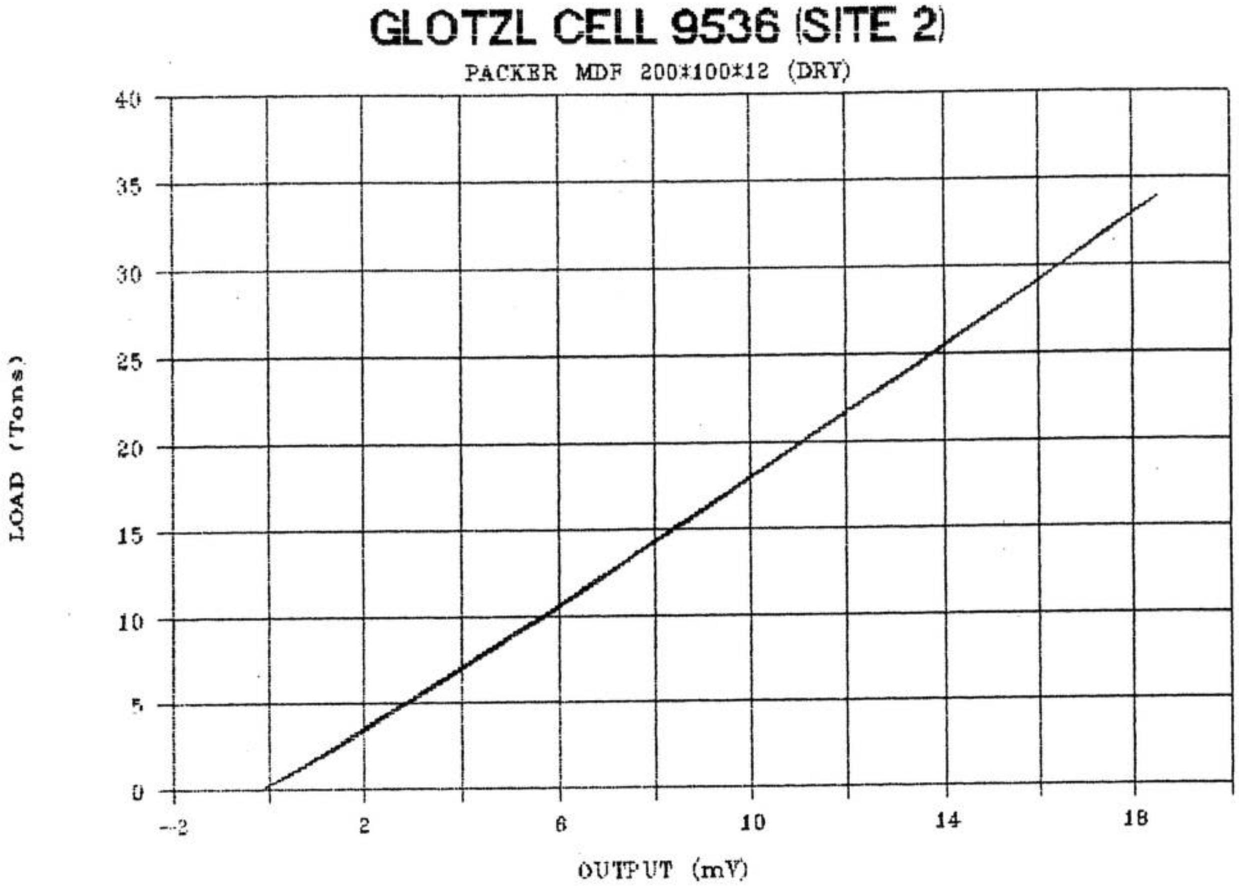
9535 LOW STRESS CYCLING

Regression Output:	
Constant	0.055654
Std Err of Y Est	0.073782
R Squared	0.999793
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.751716
Std Err of Coef.	0.003055

9535 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.15319
Std Err of Y Est	0.151572
R Squared	0.999781
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.800985
Std Err of Coef.	0.003226

FIGURE II87



9536 LOW STRESS CYCLING

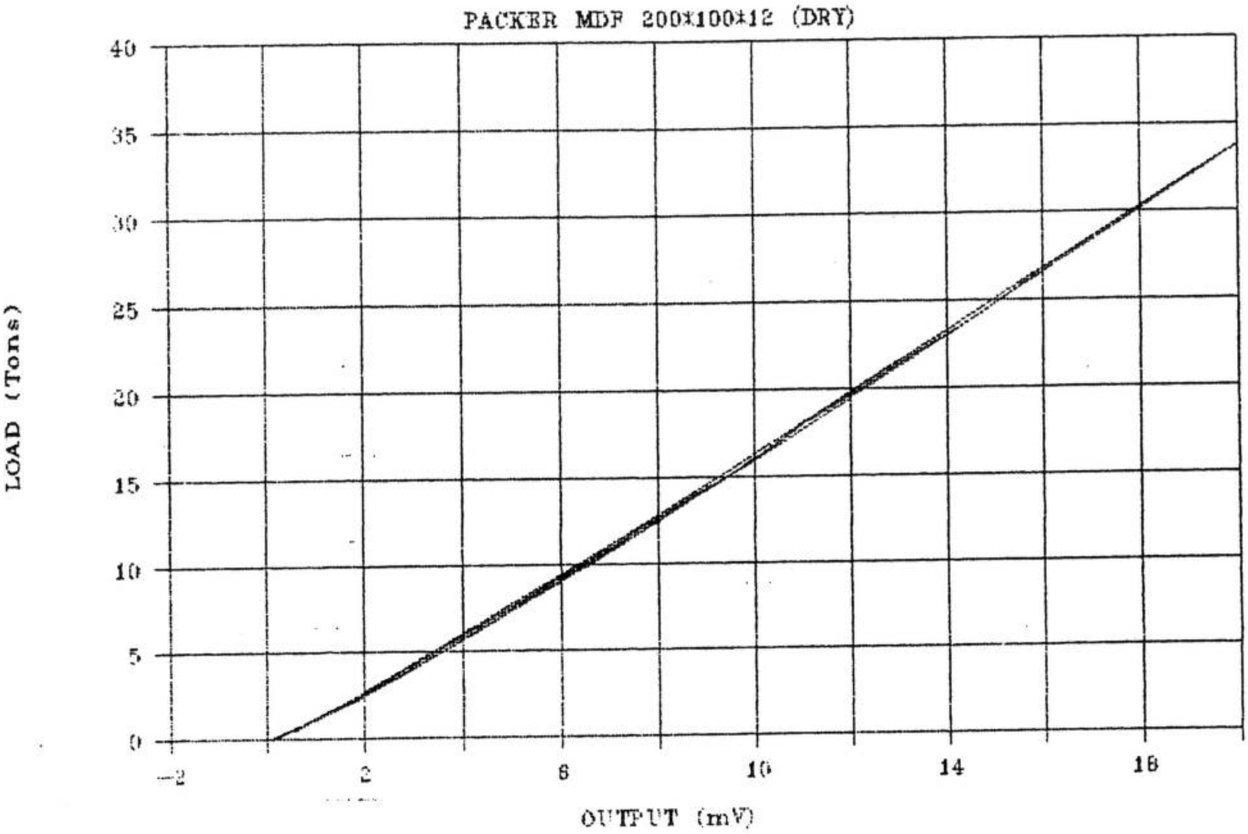
Regression Output:	
Constant	-0.00057
Std Err of Y Est	0.133435
R Squared	0.999323
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.772716
Std Err of Coef.	0.005593

9536 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.22817
Std Err of Y Est	0.194161
R Squared	0.999641
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.832242
Std Err of Coef.	0.004205

FIGURE III88

GLOTZL CELL 9537 (SITE 2)



9537 LOW STRESS CYCLING

Regression Output:

Constant	-0.62687
Std Err of Y Est	0.174176
R Squared	0.998847
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.647223
Std Err of Coef.	0.006786

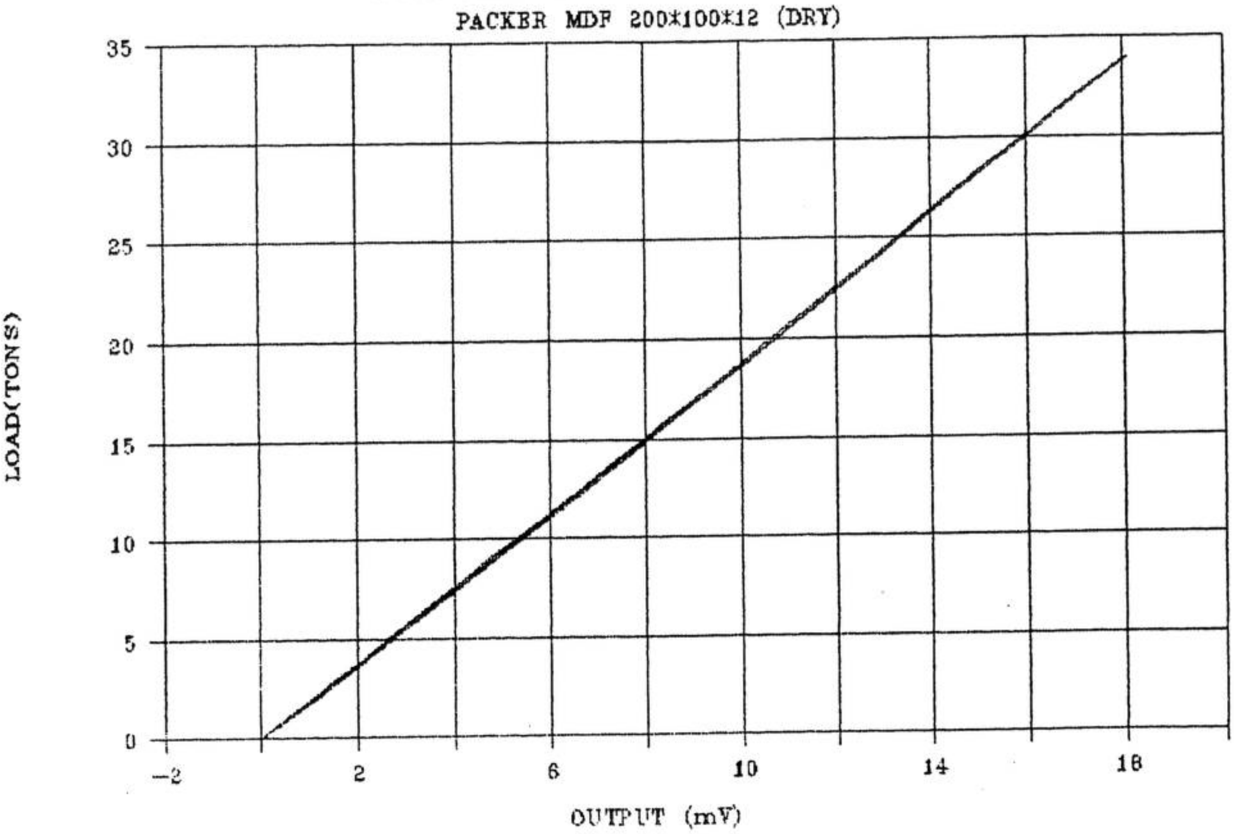
9537 HIGH STRESS CYCLING

Regression Output:

Constant	-0.90133
Std Err of Y Est	0.268404
R Squared	0.999315
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.721822
Std Err of Coef.	0.005464

FIGURE III 89

GLOTZL CELL 9538 (SITE 2)



9538 LOW STRESS CYCLING

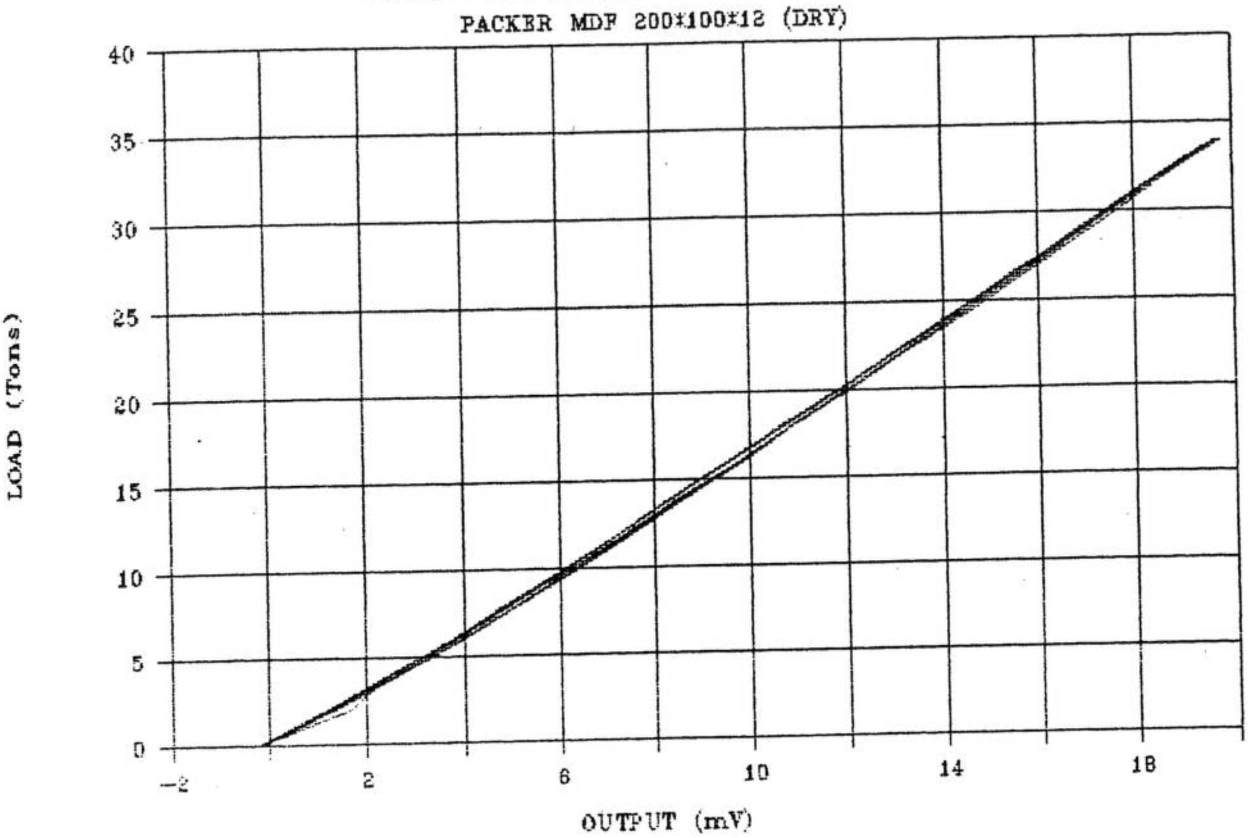
Regression Output:	
Constant	-0.01328
Std Err of Y Est	0.052992
R Squared	0.999893
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.878807
Std Err of Coef.	0.002353

9538 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.16029
Std Err of Y Est	0.081236
R Squared	0.999937
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.886130
Std Err of Coef.	0.001811

FIGURE III 90

GLOTZL CELL 0568 (SITE 3)



0568 LOW STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-0.57623
Std Err of Y Est	0.108294
R Squared	0.999138
No. of Observations	50
Degrees of Freedom	48

X Coefficient(s)	1.687115
Std Err of Coef.	0.007152

0568 HIGH STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

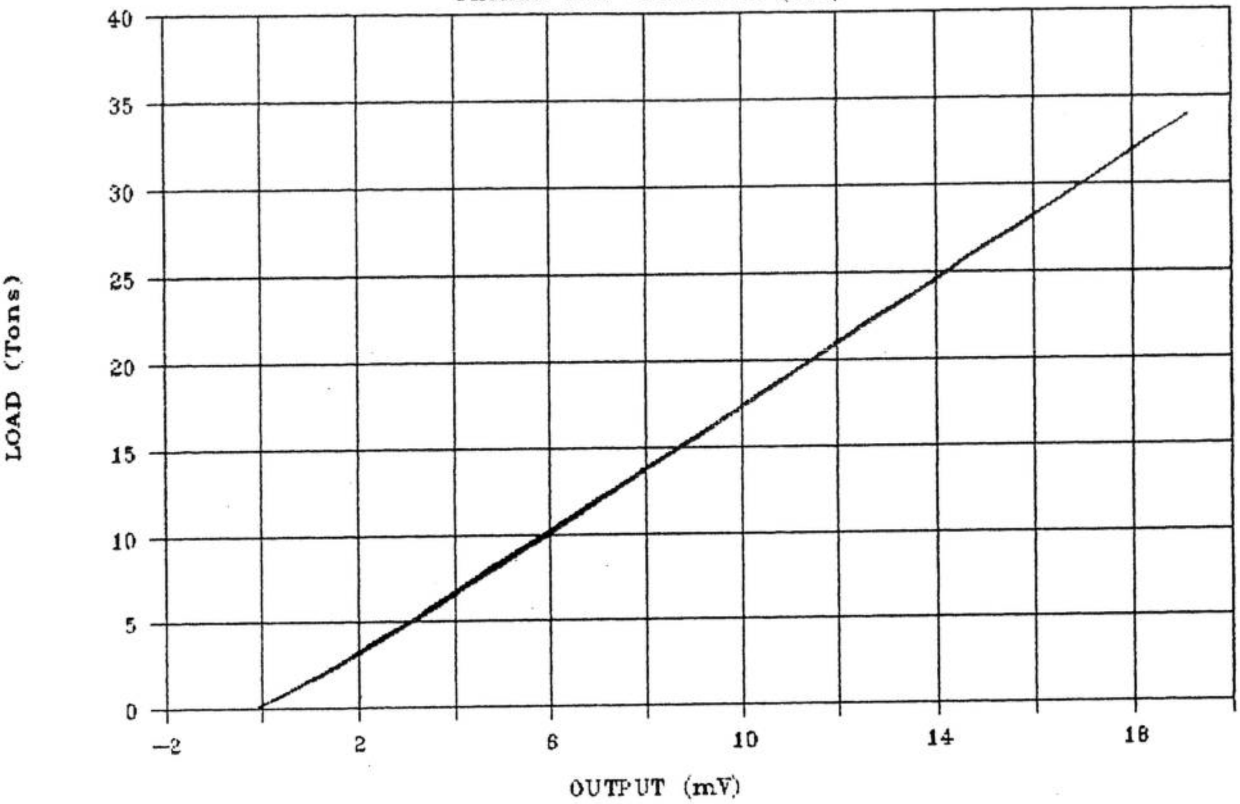
Constant	-1.04195
Std Err of Y Est	0.207975
R Squared	0.999405
No. of Observations	58
Degrees of Freedom	56

X Coefficient(s)	1.770328
Std Err of Coef.	0.005769

FIGURE III91

GLOTZL CELL 0569 (SITE 3)

PACKER MDF 200*100*12 (DRY)



0569 LOW STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-0.44973
Std Err of Y Est	0.077007
R Squared	0.999564
No. of Observations	50
Degrees of Freedom	48
X Coefficient(s)	1.780447
Std Err of Coef.	0.005366

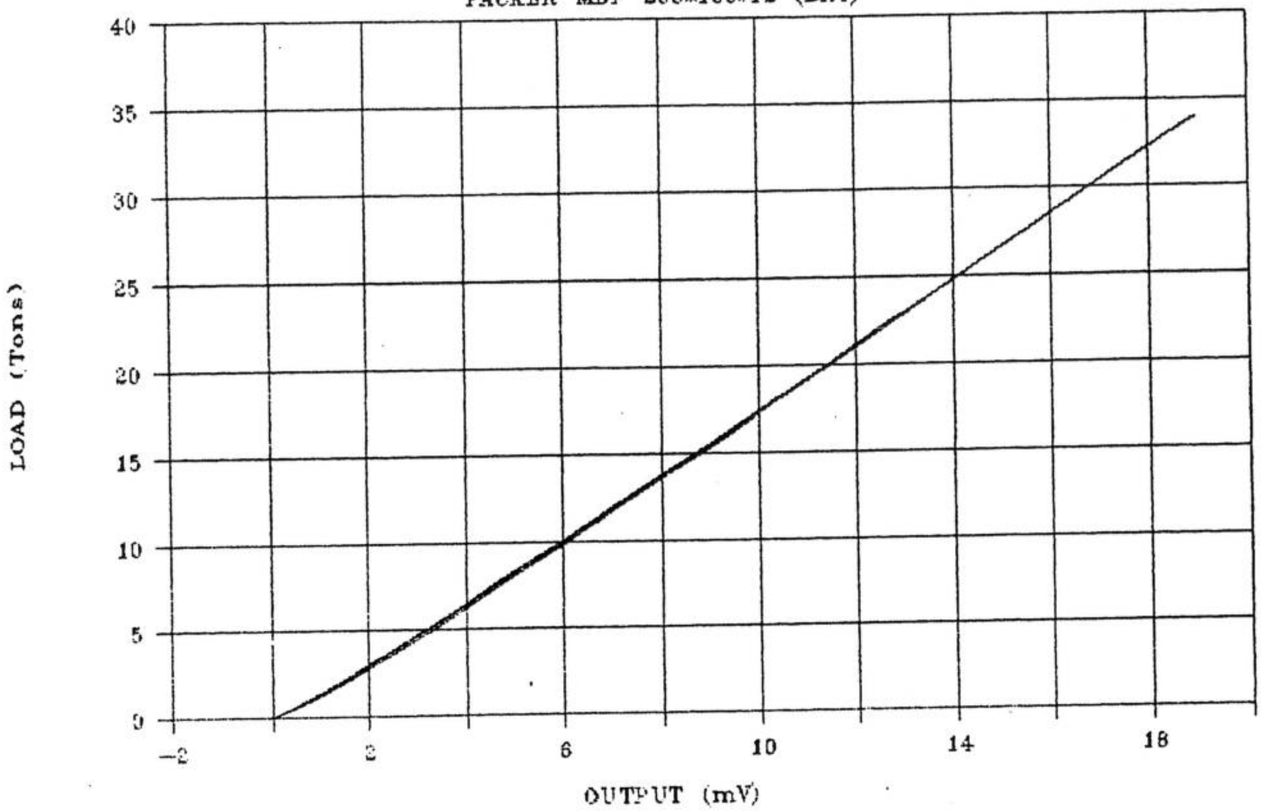
0569 HIGH STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-0.69389
Std Err of Y Est	0.087584
R Squared	0.999894
No. of Observations	58
Degrees of Freedom	56
X Coefficient(s)	1.809038
Std Err of Coef.	0.002482

FIGURE II192

GLOTZL CELL 0570 (SITE 3)

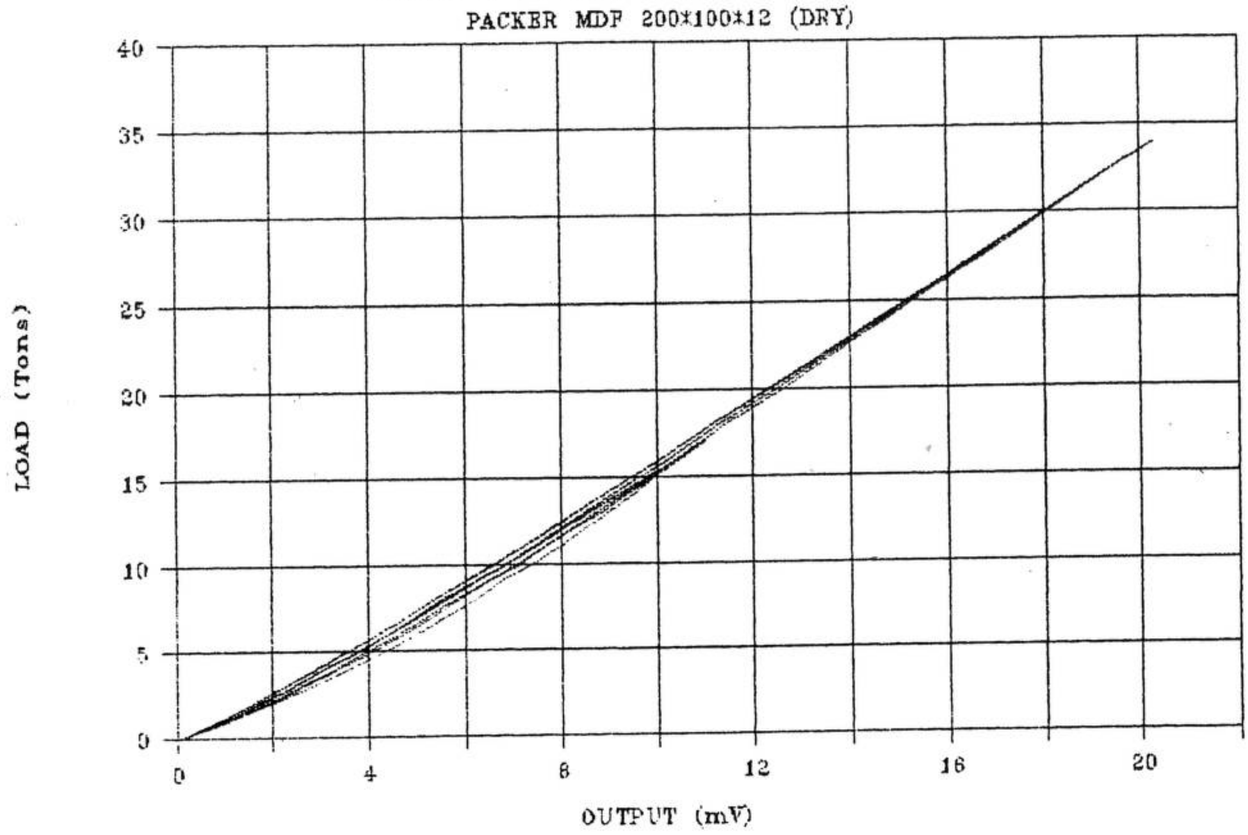
PACKER MDF 200*100*12 (DRY)




```
  0570   LOW STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                       -0.90505
Std Err of Y Est               0.082674
R Squared                      0.999497
No. of Observations                  50
Degrees of Freedom                   48

X Coefficient(s)  1.814991
Std Err of Coef.  0.005872
```

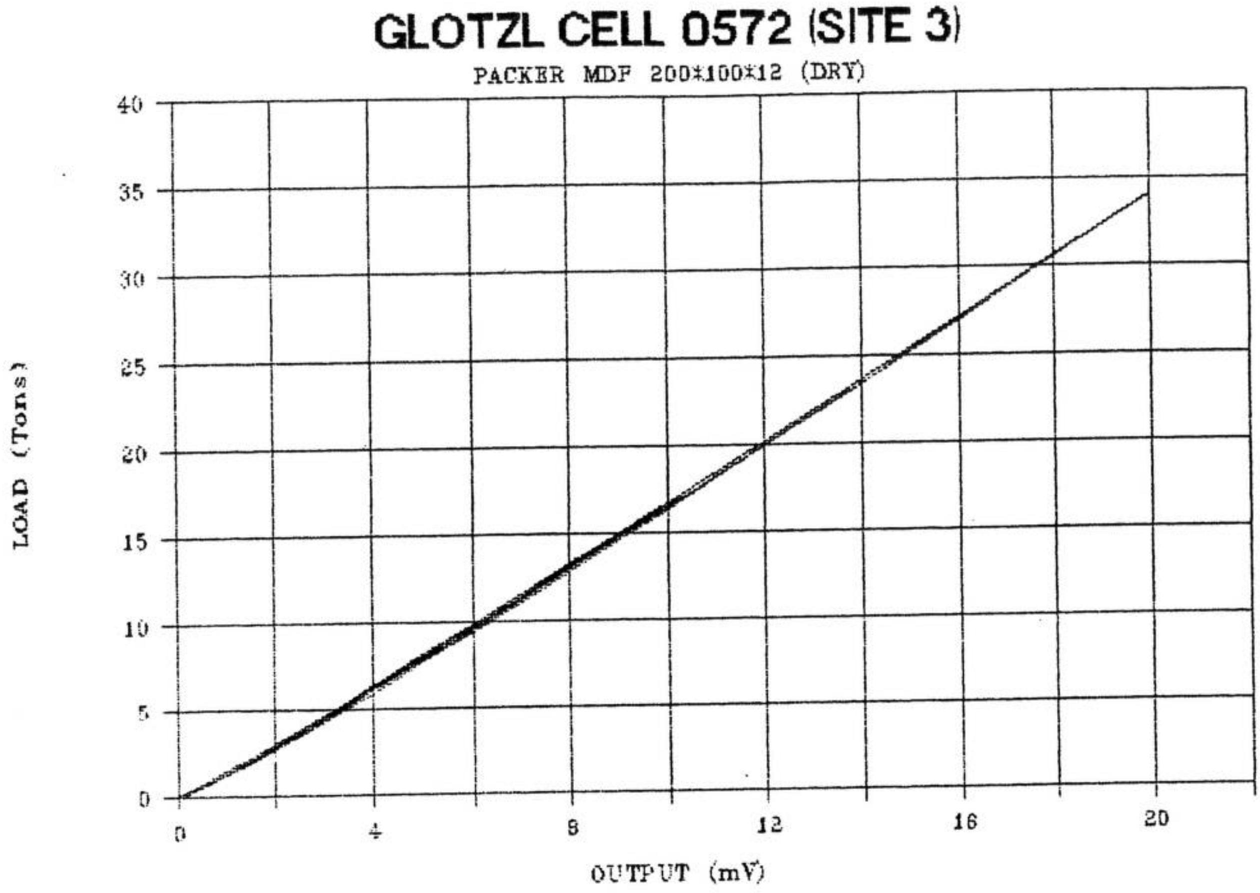
```
  0570   HIGH STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                       -1.12563
Std Err of Y Est               0.085831
R Squared                      0.999898
No. of Observations                  58
Degrees of Freedom                   56

X Coefficient(s)  1.852897
Std Err of Coef.  0.002491
```

GLOTZL CELL 0571 (SITE 3)




```
  0571   LOW STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                       -1.87054
Std Err of Y Est               0.346910
R Squared                      0.991155
No. of Observations                  50
Degrees of Freedom                   48

X Coefficient(s)  1.697795
Std Err of Coef.  0.023149
```

```
  0571   HIGH STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                       -1.87362
Std Err of Y Est               0.248757
R Squared                      0.999149
No. of Observations                  58
Degrees of Freedom                   56

X Coefficient(s)  1.763728
Std Err of Coef.  0.006876
```

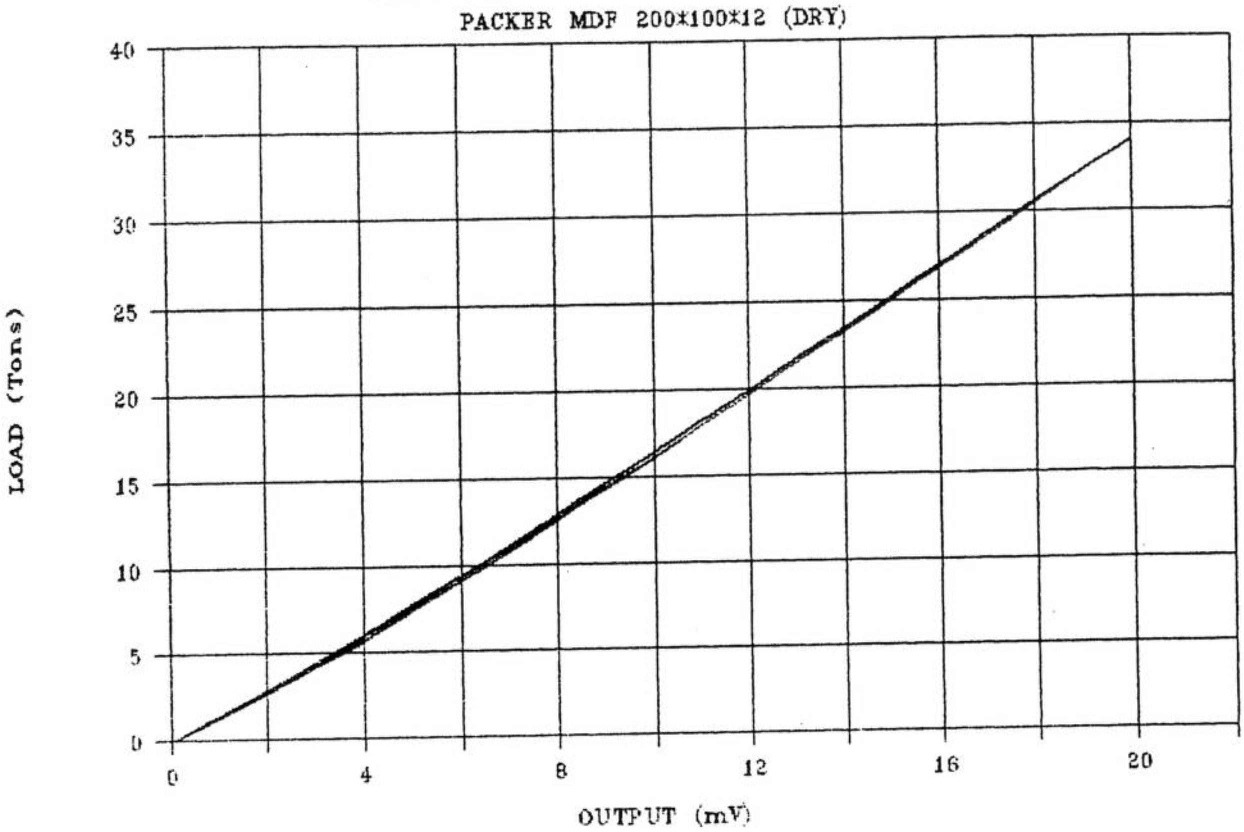



```
  0572    LOW STRESS CYCLING
(initial 4 Tons not considered)
          Regression Output:
Constant                         -0.62341
Std Err of Y Est                 0.099935
R Squared                        0.999266
No. of Observations                    50
Degrees of Freedom                     48

X Coefficient(s)   1.720734
Std Err of Coef.   0.006731
```

```
  0572    HIGH STRESS CYCLING
(initial 4 Tons not considered)
          Regression Output:
Constant                         -1.03061
Std Err of Y Est                 0.102933
R Squared                        0.999854
No. of Observations                    58
Degrees of Freedom                     56

X Coefficient(s)   1.756423
Std Err of Coef.   0.002832
```

FIGURE III 95

GLOTZL CELL 0573 (SITE 3)



0573 LOW STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-1.02801
Std Err of Y Est	0.123169
R Squared	0.998885
No. of Observations	50
Degrees of Freedom	48

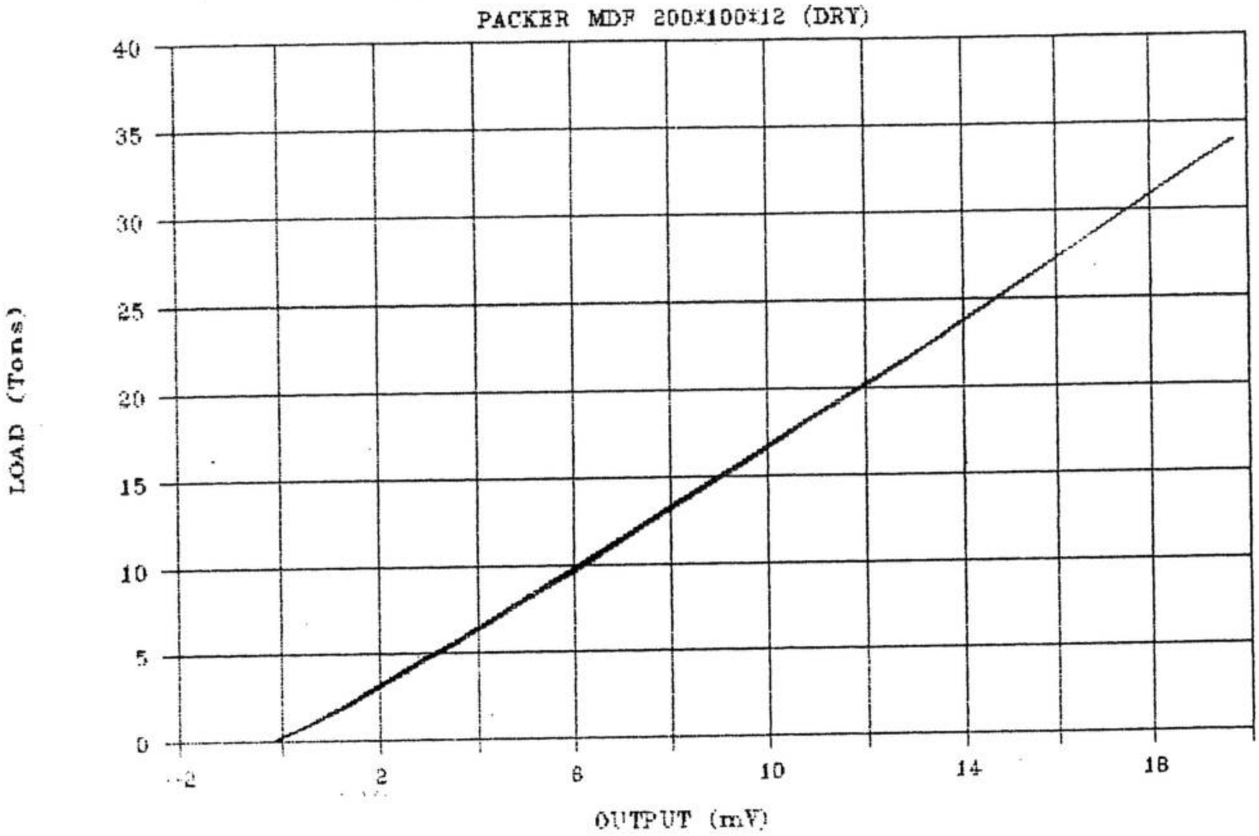
X Coefficient(s)	1.707358
Std Err of Coef.	0.008233

0573 HIGH STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-1.36197
Std Err of Y Est	0.148578
R Squared	0.999696
No. of Observations	58
Degrees of Freedom	56

X Coefficient(s)	1.769469
Std Err of Coef.	0.004119

GLOTZL CELL 0574 (SITE 3)



0574 LOW STRESS CYCLING

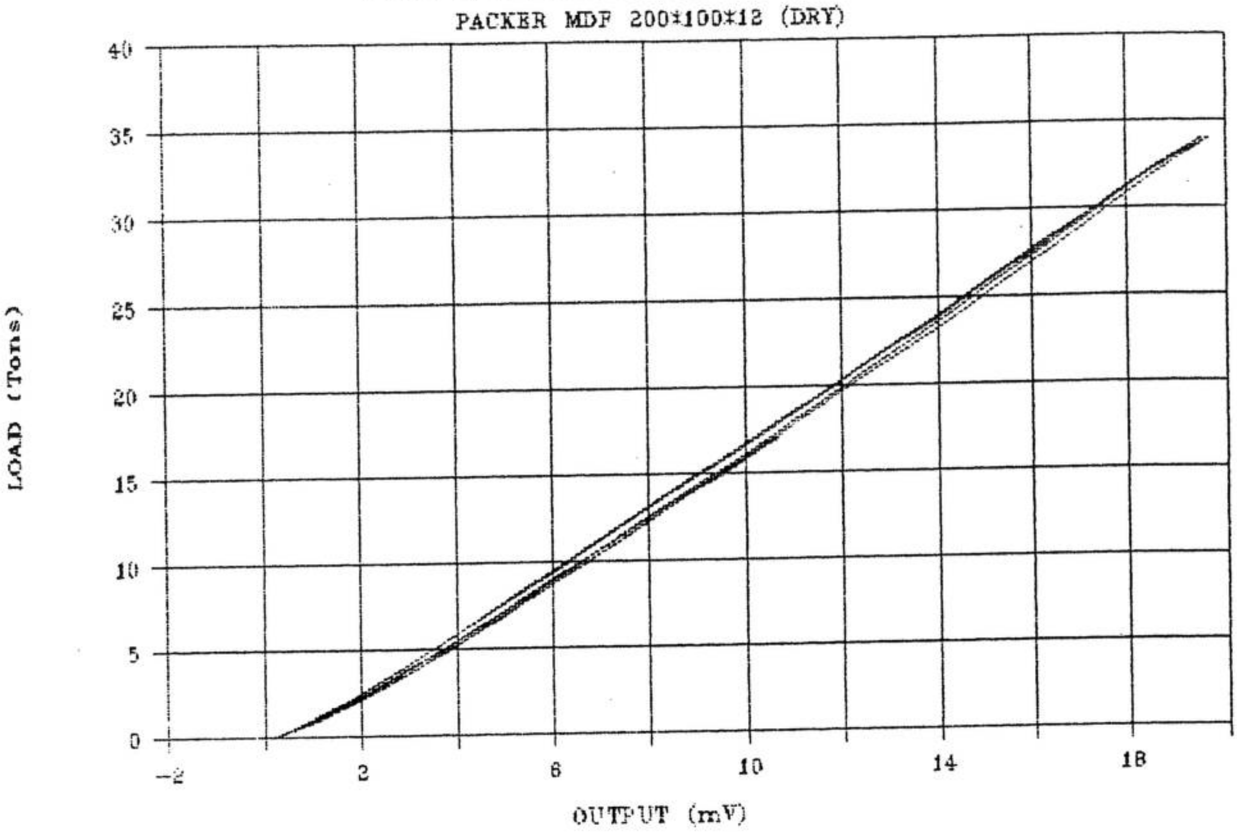
Regression Output:	
Constant	-0.06774
Std Err of Y Est	0.151351
R Squared	0.999129
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.651937
Std Err of Coef.	0.005913

0574 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.37634
Std Err of Y Est	0.237609
R Squared	0.999463
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.725508
Std Err of Coef.	0.004847

FIGURE III.97

GLOTZL CELL 0575 (SITE 3)



0575 LOW STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-1.69281
Std Err of Y Est	0.119075
R Squared	0.998957
No. of Observations	50
Degrees of Freedom	48

X Coefficient(s) 1.754515
Std Err of Coef. 0.008179

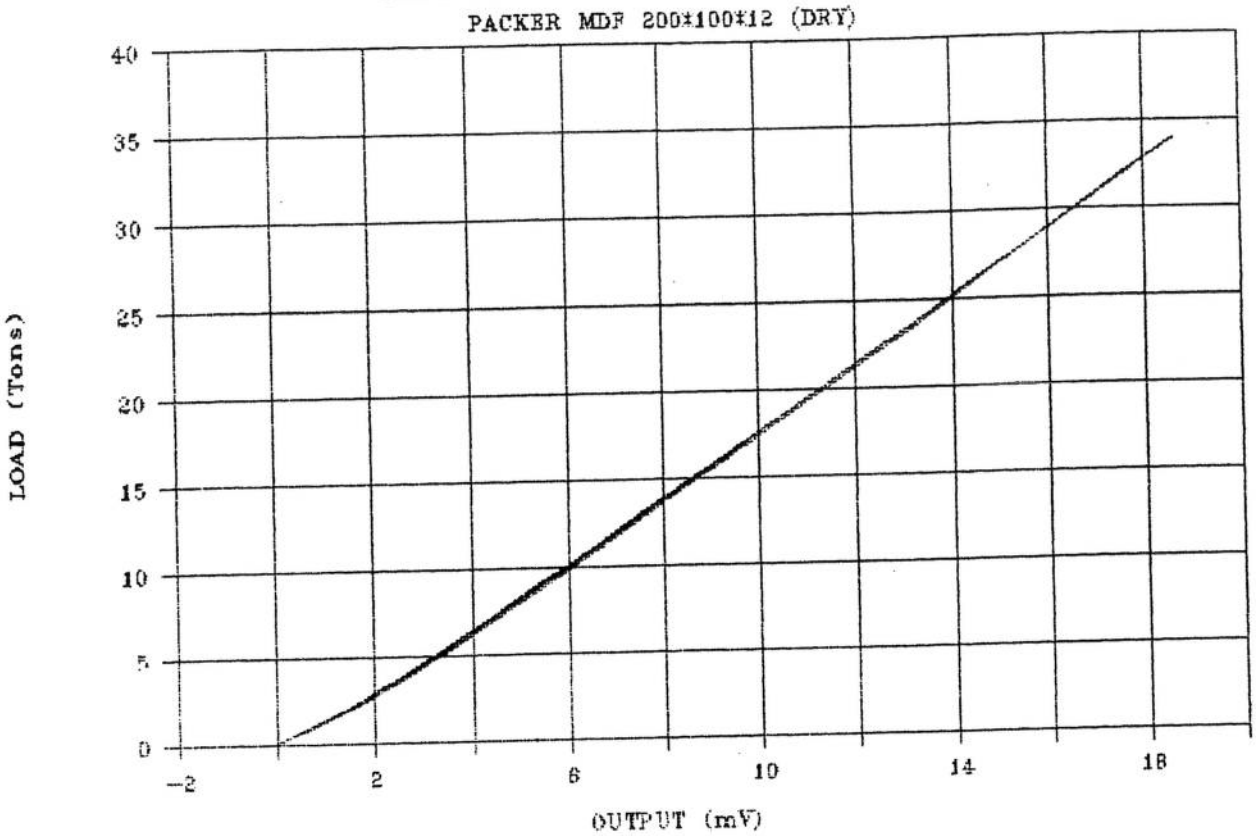
0575 HIGH STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-1.85427
Std Err of Y Est	0.301237
R Squared	0.998752
No. of Observations	58
Degrees of Freedom	56

X Coefficient(s) 1.827503
Std Err of Coef. 0.008629

FIGURE III98

GLOTZL CELL 0576 (SITE 3)



0576 LOW STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-0.98182
Std Err of Y Est	0.064871
R Squared	0.999690
No. of Observations	50
Degrees of Freedom	48

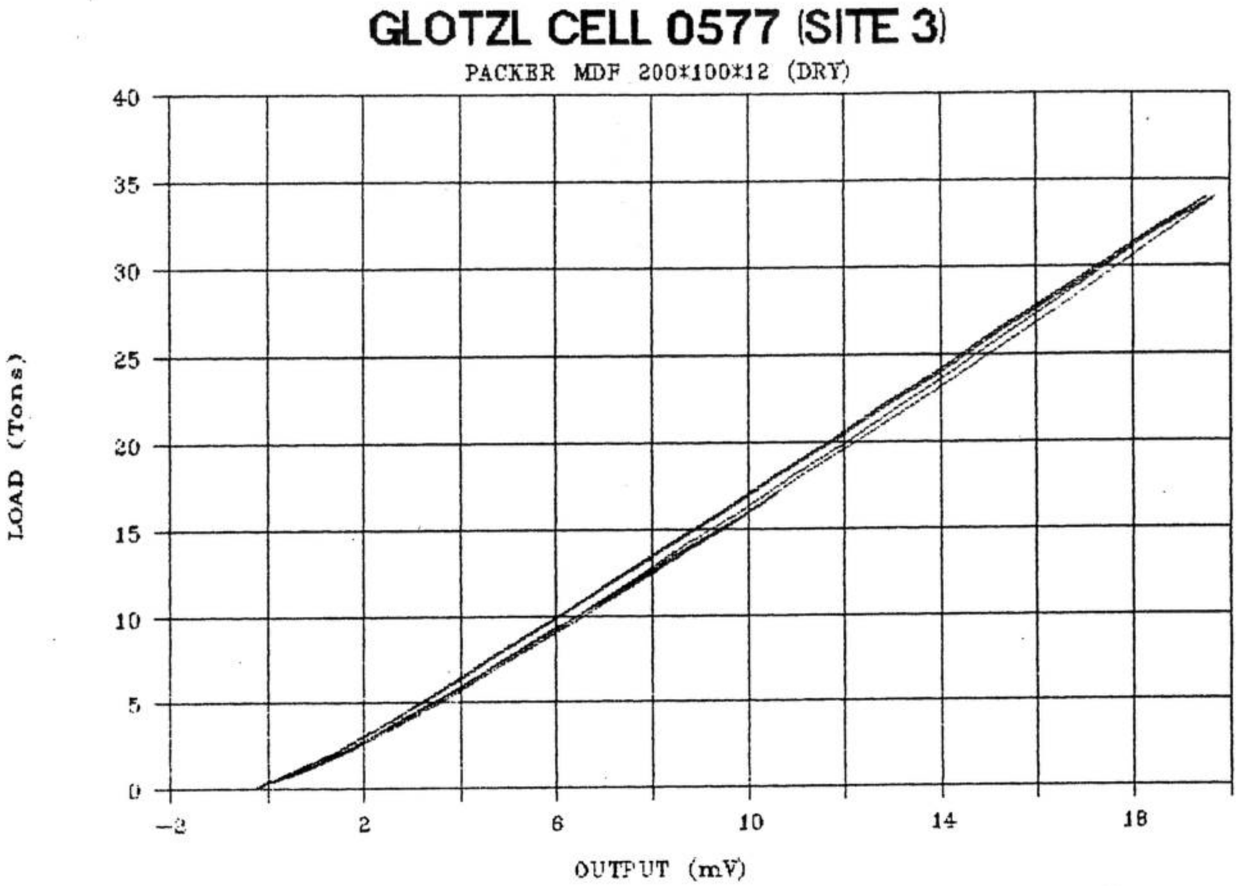
X Coefficient(s)	1.850511
Std Err of Coef.	0.004698

0576 HIGH STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-1.32778
Std Err of Y Est	0.102197
R Squared	0.999856
No. of Observations	58
Degrees of Freedom	56

X Coefficient(s)	1.895100
Std Err of Coef.	0.003034

FIGURE II99

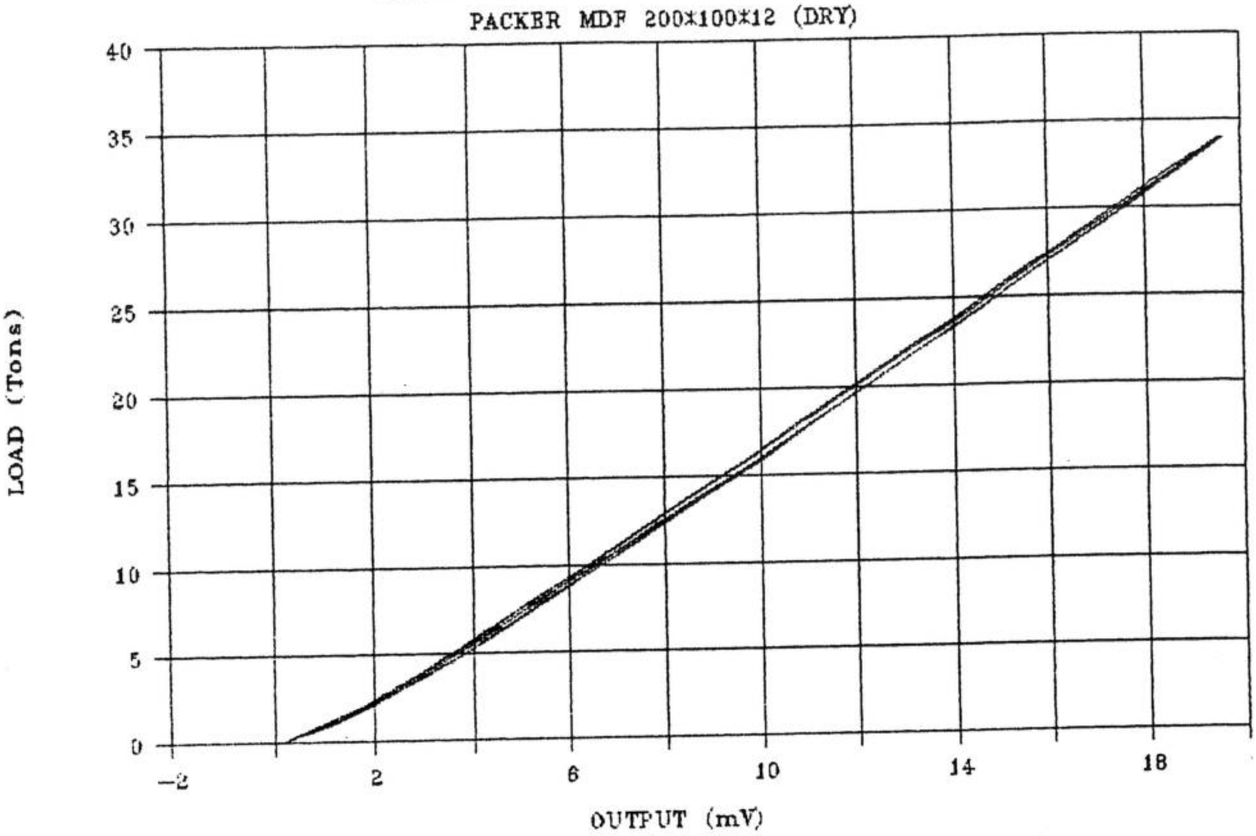



```
  0577   LOW STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                        -0.95191
Std Err of Y Est                0.111060
R Squared                       0.999093
No. of Observations                   50
Degrees of Freedom                    48

X Coefficient(s)  1.690640
Std Err of Coef.  0.007350
```

```
  0577   HIGH STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                        -1.20582
Std Err of Y Est                0.388667
R Squared                       0.997923
No. of Observations                   58
Degrees of Freedom                    56

X Coefficient(s)  1.786797
Std Err of Coef.  0.010891
```

FIGURE III 100

GLOTZL CELL 0578 (SITE 3)

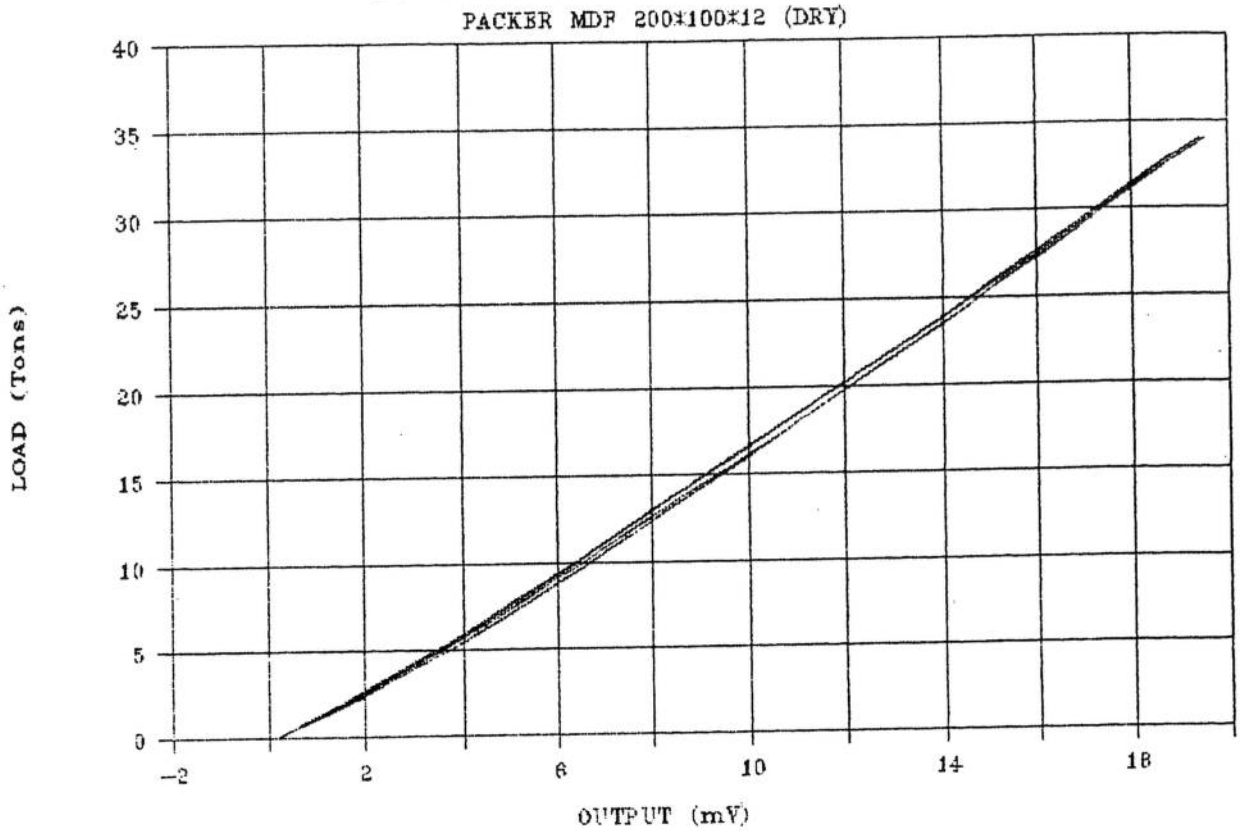



```
  0578    LOW STRESS CYCLING
(initial 4 Tons not considered)
          Regression Output:
Constant                          -1.54535
Std Err of Y Est                  0.107700
R Squared                         0.999147
No. of Observations                     50
Degrees of Freedom                      48

X Coefficient(s)  1.749749
Std Err of Coef.  0.007377
```

```
  0578    HIGH STRESS CYCLING
(initial 4 Tons not considered)
          Regression Output:
Constant                          -1.90346
Std Err of Y Est                  0.240902
R Squared                         0.999202
No. of Observations                     58
Degrees of Freedom                      56

X Coefficient(s)  1.820967
Std Err of Coef.  0.006875
```

FIGURE III 101

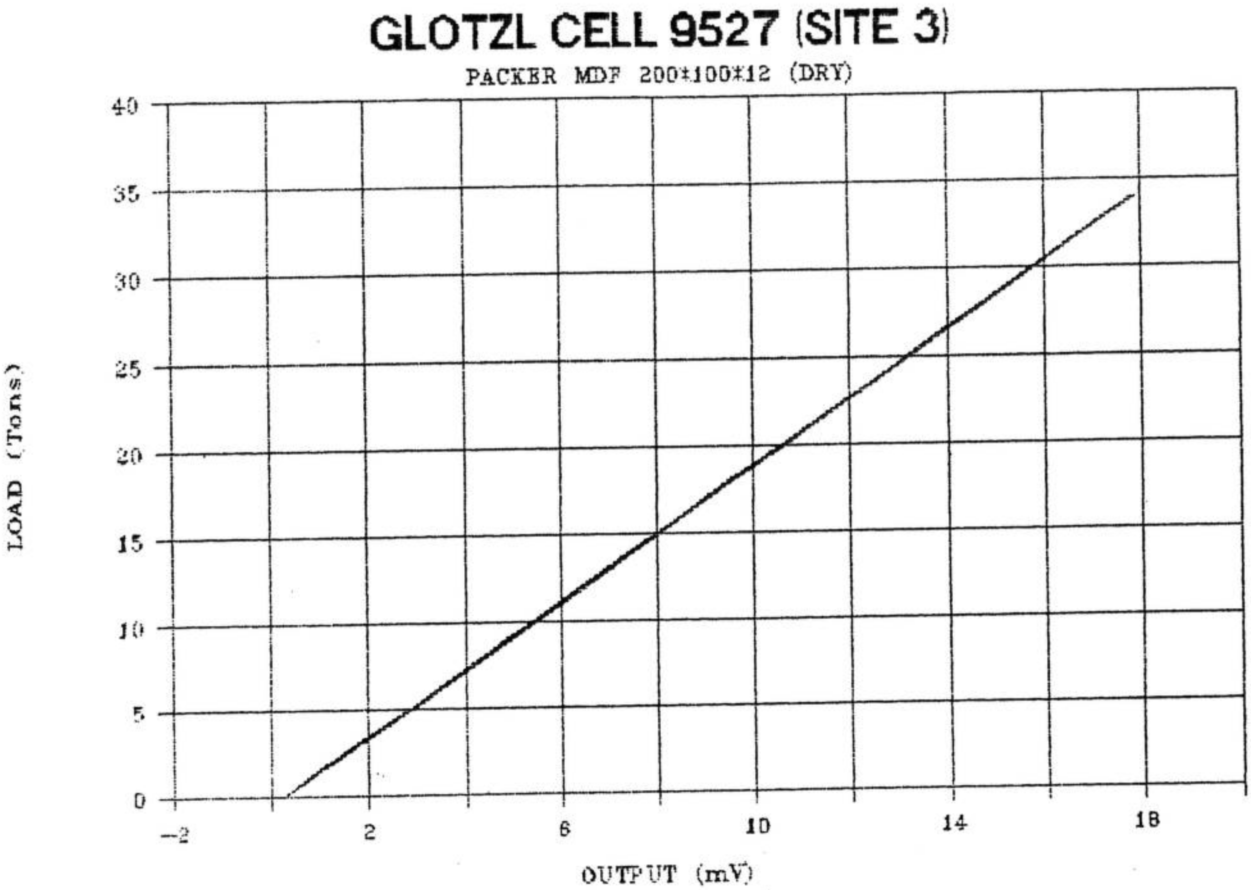
GLOTZL CELL 0579 (SITE 3)




```
  0579   LOW STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                        -1.42938
Std Err of Y Est                0.138428
R Squared                       0.998591
No. of Observations                   50
Degrees of Freedom                    48

X Coefficient(s)   1.741634
Std Err of Coef.   0.009440
```

```
  0579   HIGH STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                        -1.99733
Std Err of Y Est                0.259125
R Squared                       0.999077
No. of Observations                   58
Degrees of Freedom                    56

X Coefficient(s)   1.840577
Std Err of Coef.   0.007475
```

FIGURE III 102



9527 LOW STRESS CYCLING

Regression Output:

Constant	-0.43076
Std Err of Y Est	0.037921
R Squared	0.999945
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.929263
Std Err of Coef.	0.001729

9527 HIGH STRESS CYCLING

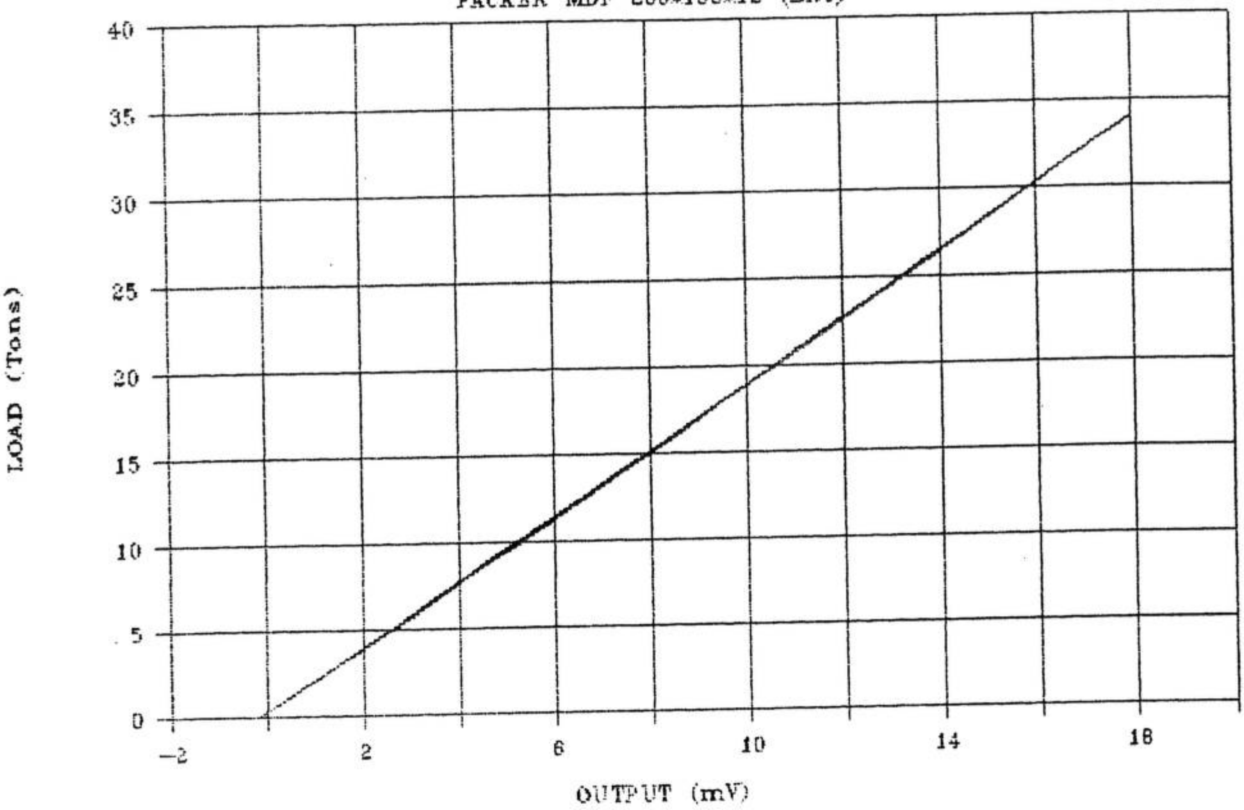
Regression Output:

Constant	-0.55323
Std Err of Y Est	0.065501
R Squared	0.999959
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.938512
Std Err of Coef.	0.001500

GLOTZL CELL 9528 (SITE 3)

PACKER MDF 200*100*12 (DRY)



9528 LOW STRESS CYCLING

Regression Output:

Constant	0.304780
Std Err of Y Est	0.053024
R Squared	0.999893
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.846772
Std Err of Coef.	0.002315

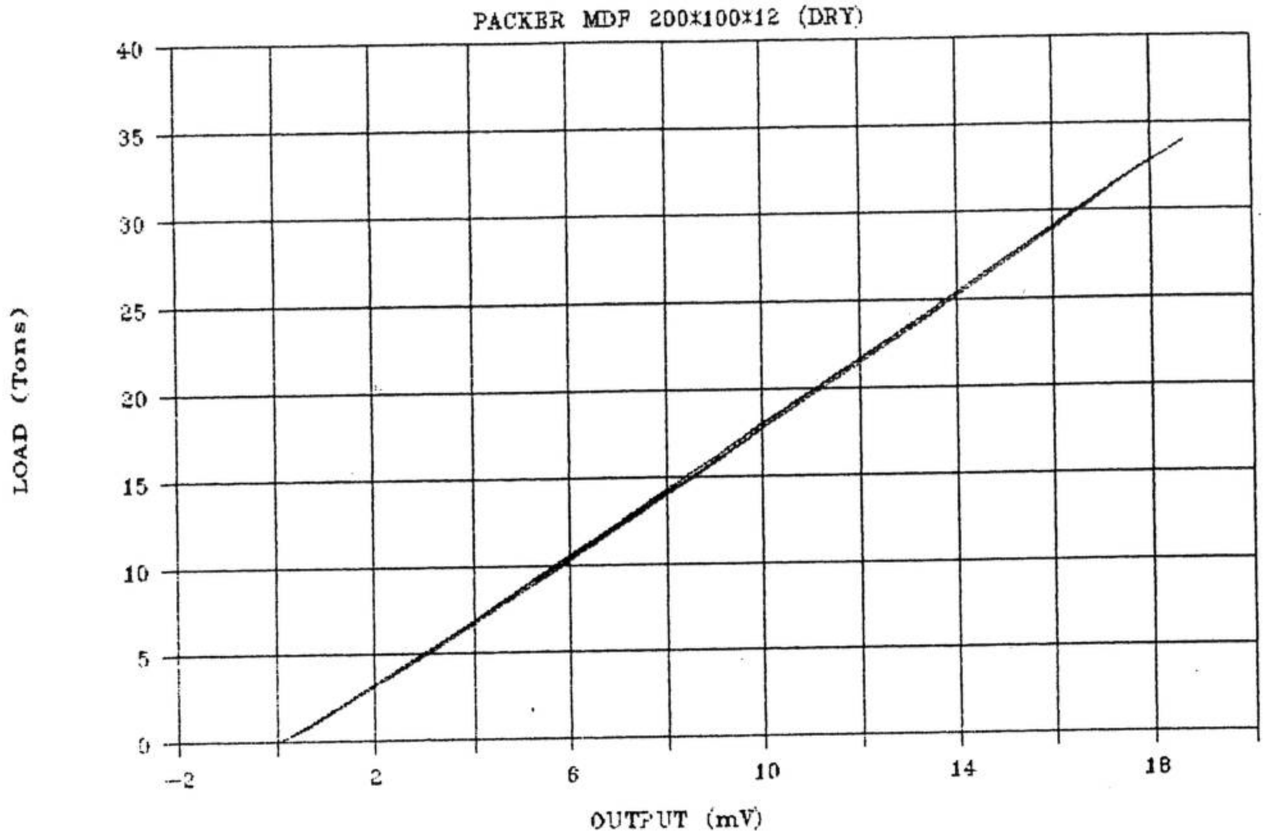
9528 HIGH STRESS CYCLING

Regression Output:

Constant	0.143007
Std Err of Y Est	0.100908
R Squared	0.999903
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.881366
Std Err of Coef.	0.002244

FIGURE III 104

GLOTZL CELL 9529 (SITE 3)



9529 LOW STRESS CYCLING

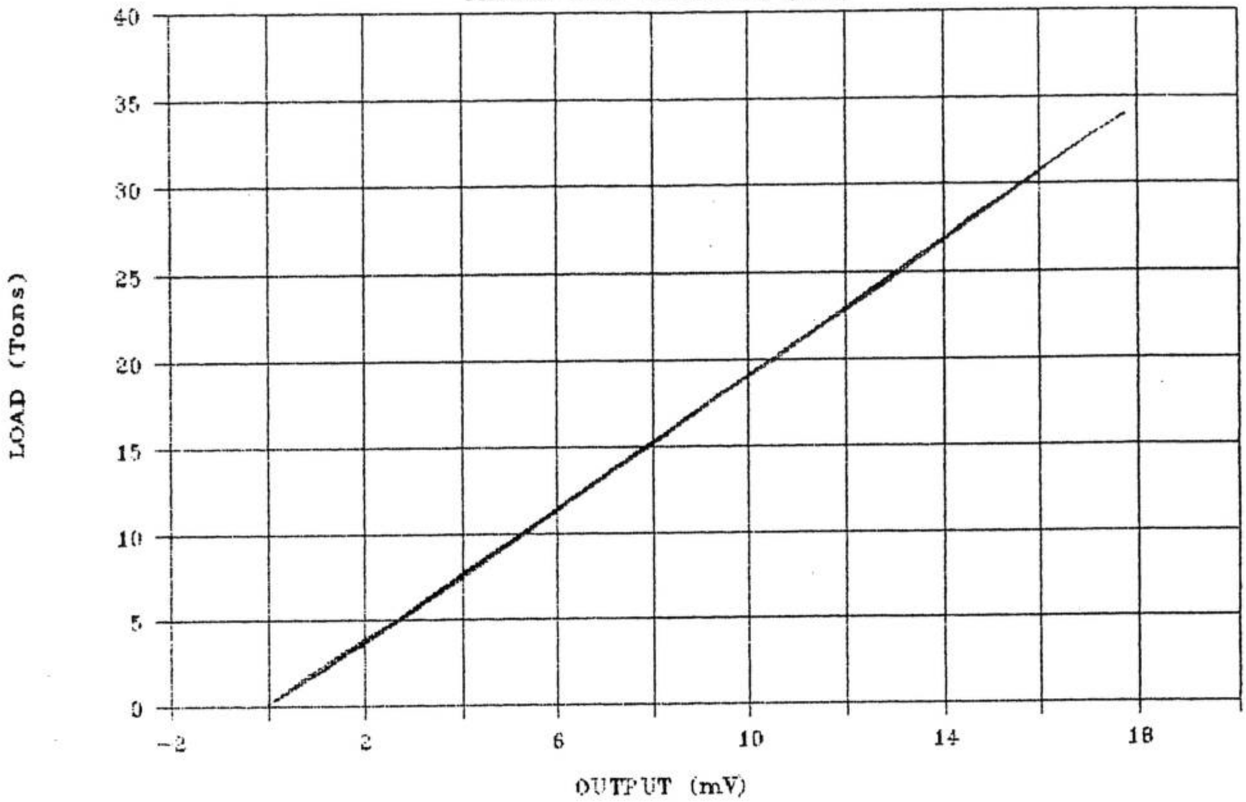
Regression Output:	
Constant	-0.33407
Std Err of Y Est	0.099741
R Squared	0.999621
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.789863
Std Err of Coef.	0.004221

9529 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.50930
Std Err of Y Est	0.172694
R Squared	0.999716
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.843862
Std Err of Coef.	0.003764

GLOTZL CELL 9530 (SITE 3)

PACKER MDF 200*100*12 (DRY)



9530 LOW STRESS CYCLING

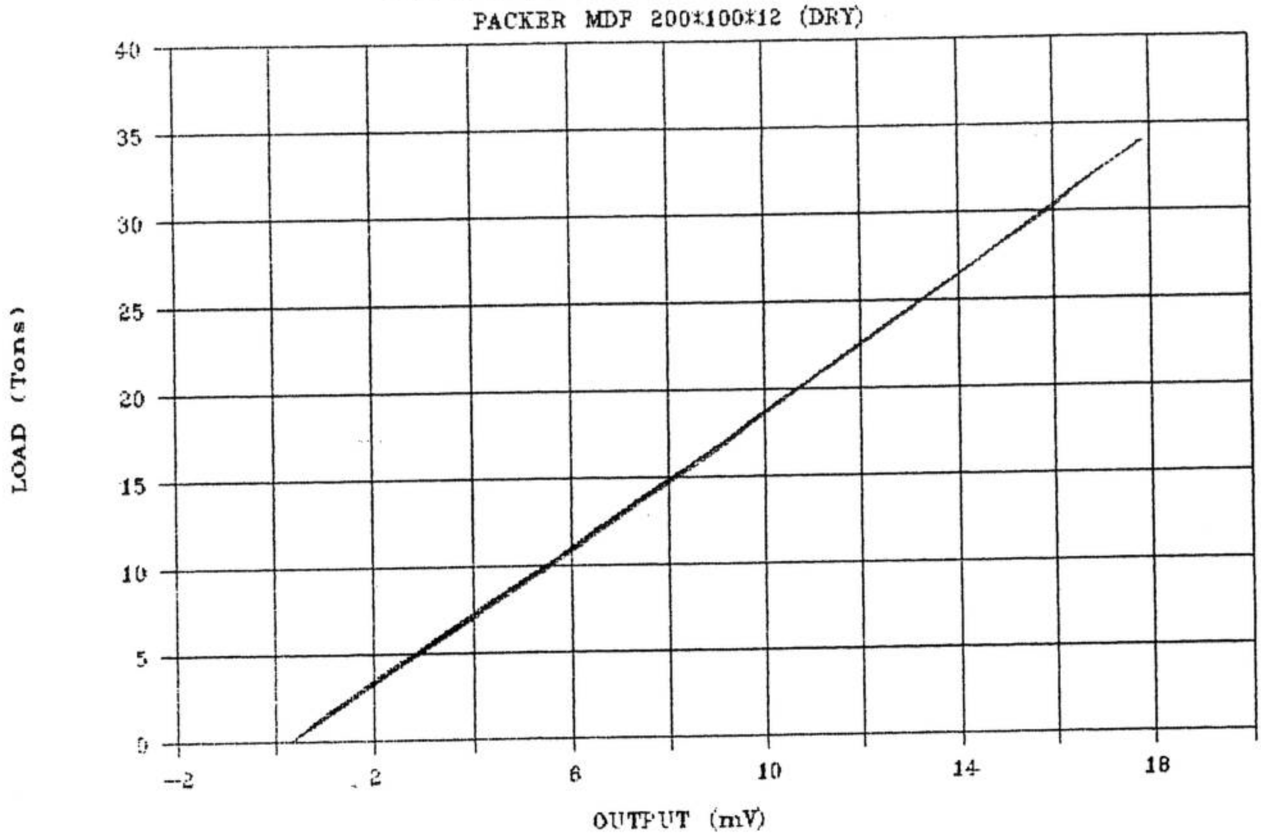
Regression Output:	
Constant	0.097971
Std Err of Y Est	0.068424
R Squared	0.999822
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.884328
Std Err of Coef.	0.003048

9530 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.07706
Std Err of Y Est	0.107559
R Squared	0.999890
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.920323
Std Err of Coef.	0.002441

FIGURE III 106

GLOTZL CELL 9531 (SITE 3)



9531 LOW STRESS CYCLING

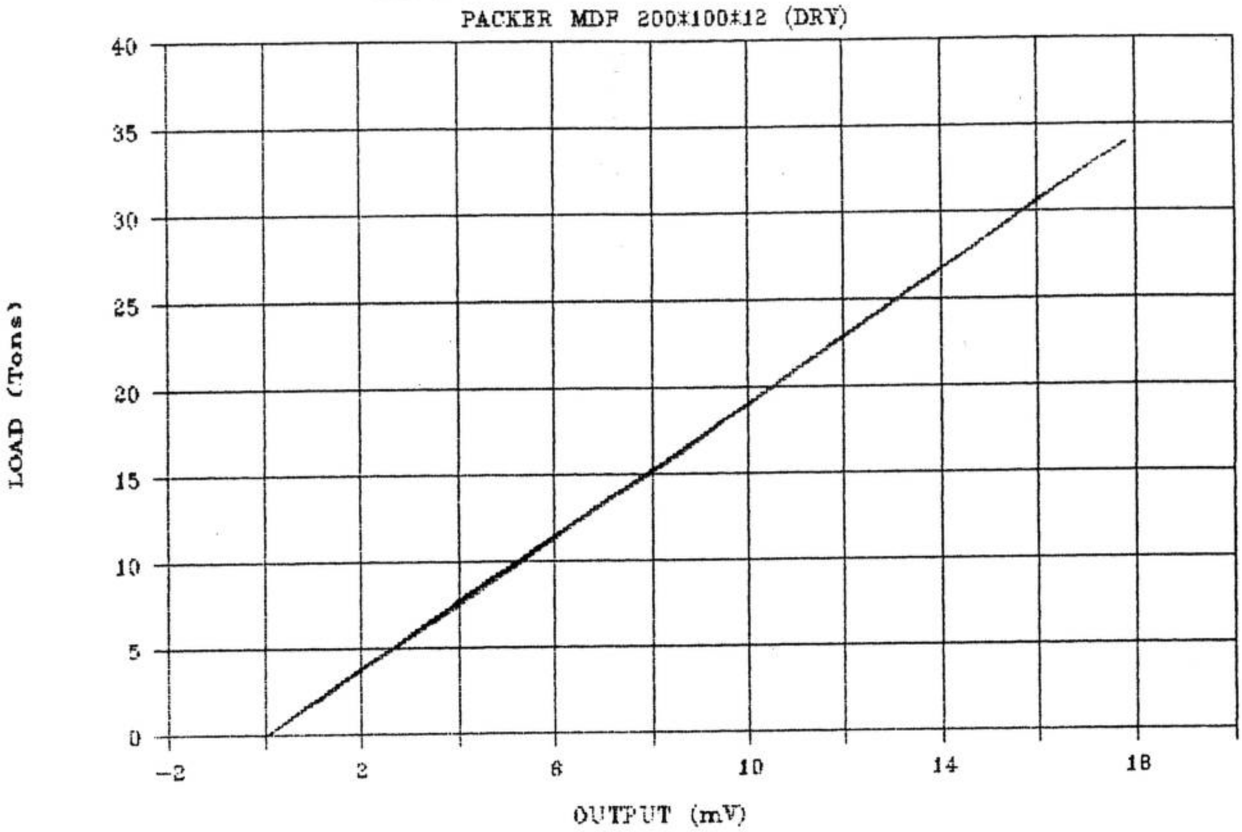
Regression Output:		
Constant		-0.43312
Std Err of Y Est		0.064574
R Squared		0.999841
No. of Observations		70
Degrees of Freedom		68
X Coefficient(s)	1.908486	
Std Err of Coef.	0.002913	

9531 HIGH STRESS CYCLING

Regression Output:		
Constant		-0.65315
Std Err of Y Est		0.096767
R Squared		0.999911
No. of Observations		70
Degrees of Freedom		68
X Coefficient(s)	1.936981	
Std Err of Coef.	0.002215	

FIGURE III 107

GLOTZL CELL 9532 (SITE 3)



9532 LOW STRESS CYCLING

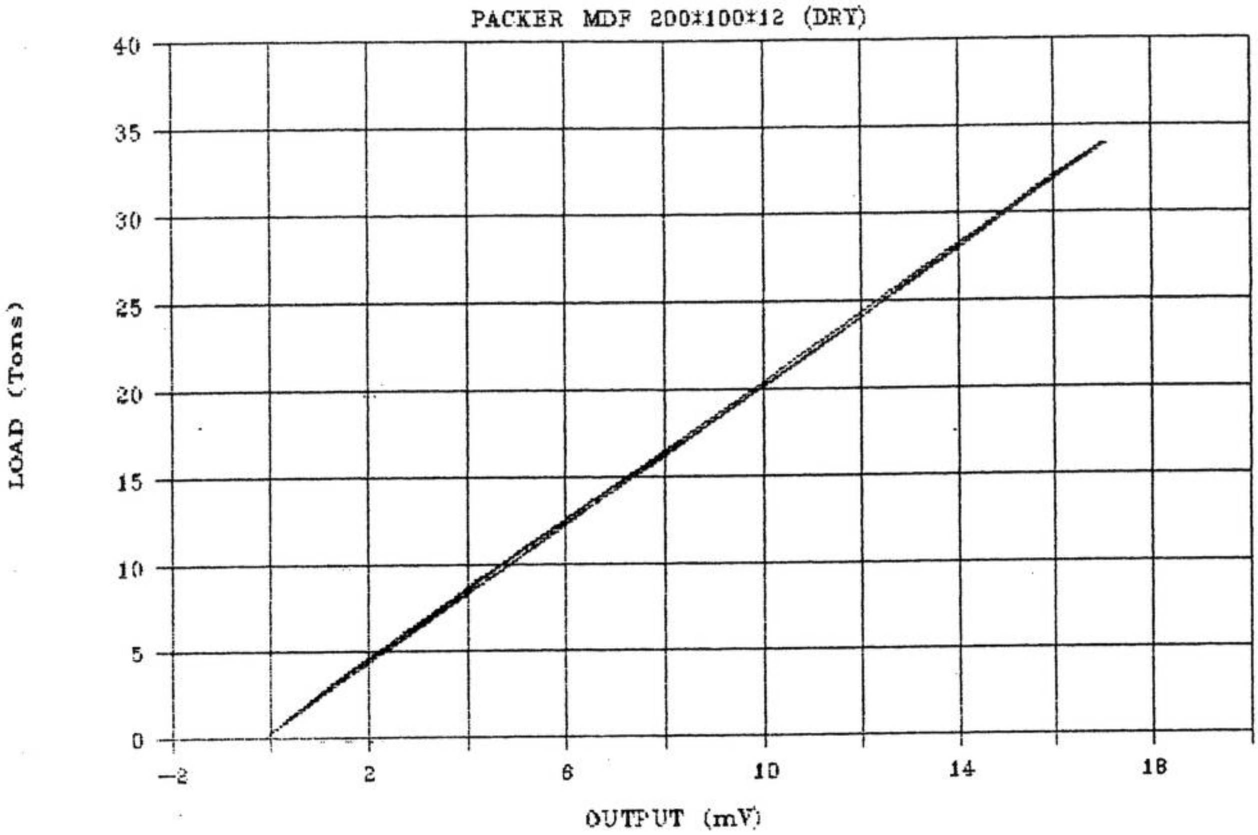
Regression Output:	
Constant	0.019368
Std Err of Y Est	0.043982
R Squared	0.999926
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.906148
Std Err of Coef.	0.001981

9532 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.12059
Std Err of Y Est	0.068661
R Squared	0.999955
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.917720
Std Err of Coef.	0.001556

FIGURE III 108

GLOTZL CELL 9533 (SITE 3)



9533 LOW STRESS CYCLING

Regression Output:	
Constant	0.465253
Std Err of Y Est	0.102327
R Squared	0.999602
No. of Observations	70
Degrees of Freedom	68

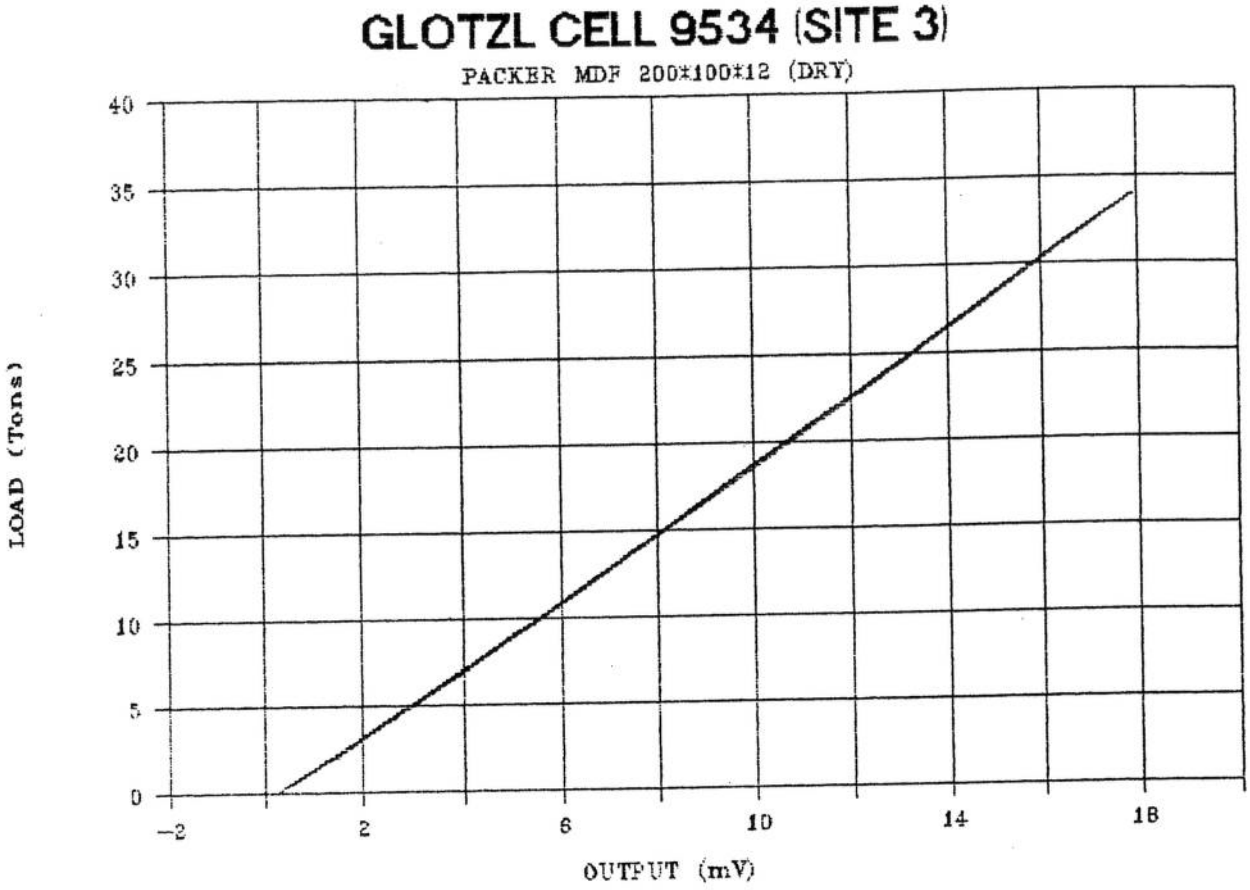
X Coefficient(s)	2.013616
Std Err of Coef.	0.004871

9533 HIGH STRESS CYCLING

Regression Output:	
Constant	0.426204
Std Err of Y Est	0.131491
R Squared	0.999835
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.978043
Std Err of Coef.	0.003074

FIGURE III 109



9534 LOW STRESS CYCLING

Regression Output:

Constant	-0.61161
Std Err of Y Est	0.062018
R Squared	0.999853
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.918500
Std Err of Coef.	0.002812

9534 HIGH STRESS CYCLING

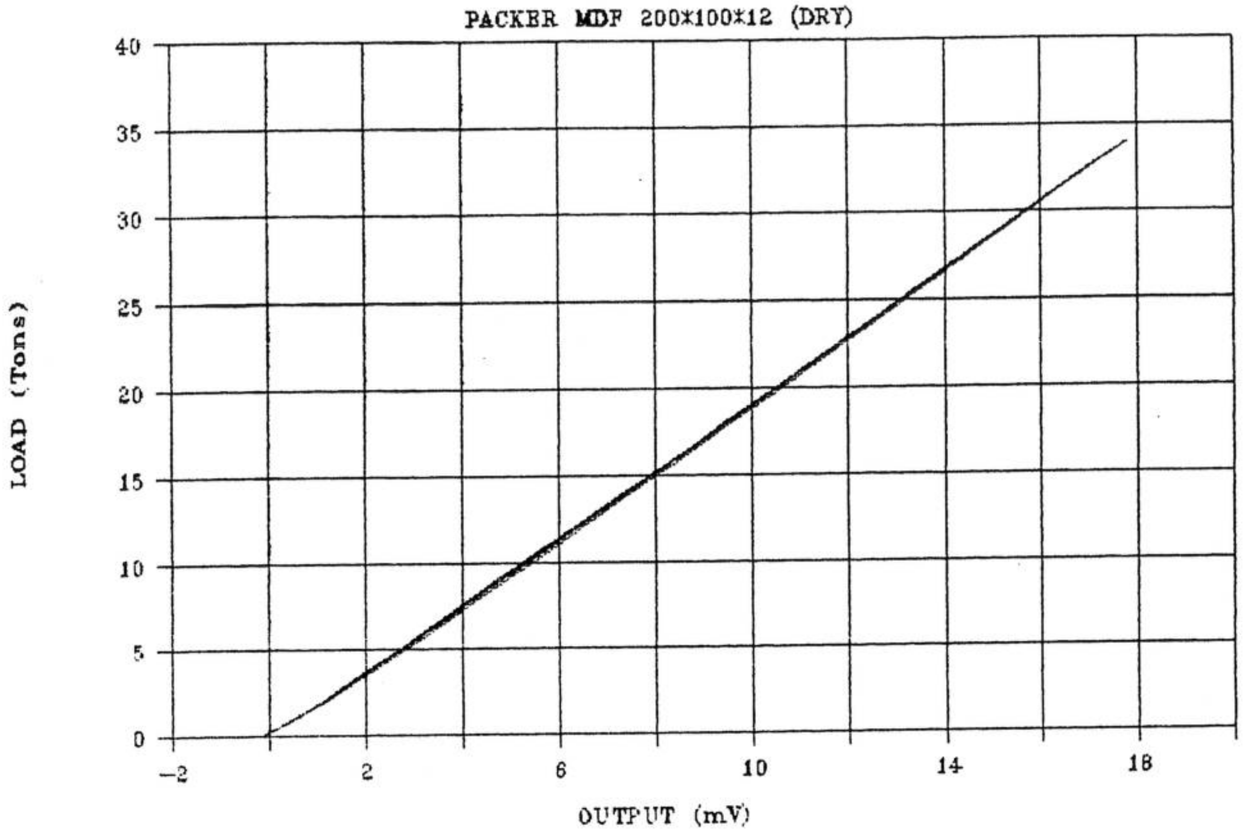
Regression Output:

Constant	-0.71295
Std Err of Y Est	0.098306
R Squared	0.999908
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.938522
Std Err of Coef.	0.002252

FIGURE III11

LOAD (Tons)

GLOTZL CELL 9536 (SITE 3)



9536 LOW STRESS CYCLING

Regression Output:	
Constant	0.010708
Std Err of Y Est	0.093826
R Squared	0.999665
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.887129
Std Err of Coef.	0.004186

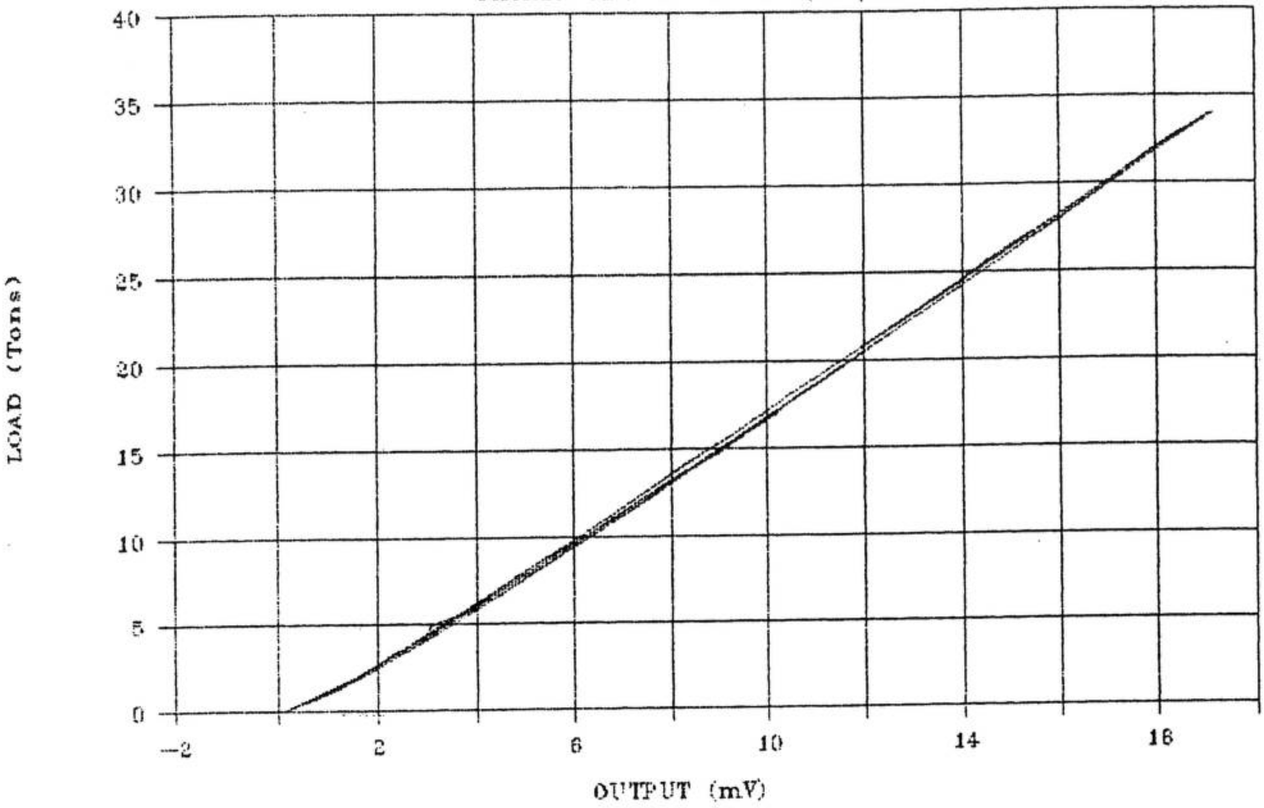
9536 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.14792
Std Err of Y Est	0.144874
R Squared	0.999800
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.916858
Std Err of Coef.	0.003282

FIGURE III 112

GLOTZL CELL 9537 (SITE 3)

PACKER MDF 200*100*12 (DRY)



9537 LOW STRESS CYCLING

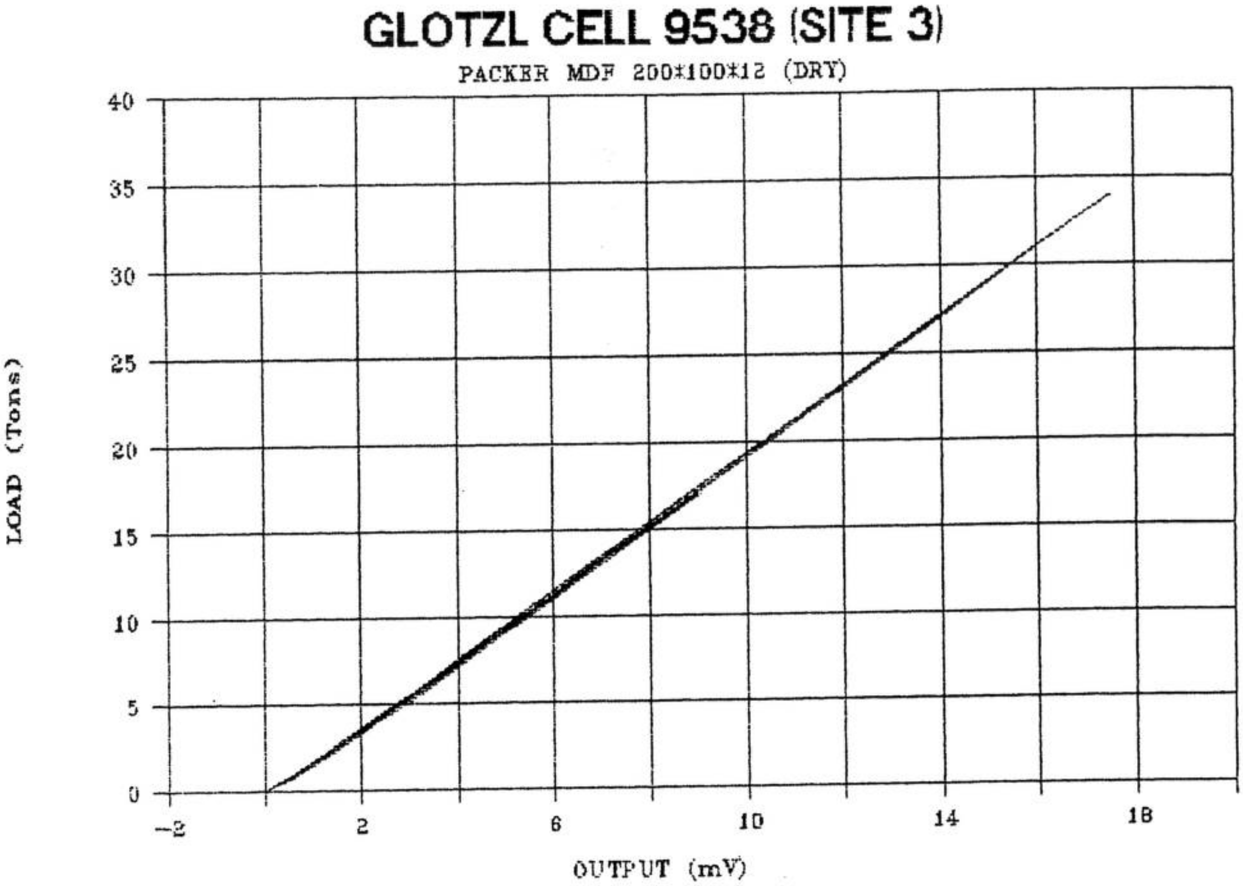
Regression Output:	
Constant	-0.74233
Std Err of Y Est	0.205004
R Squared	0.998402
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.723665
Std Err of Coef.	0.008360

9537 HIGH STRESS CYCLING

Regression Output:	
Constant	-1.07816
Std Err of Y Est	0.309286
R Squared	0.999091
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.819362
Std Err of Coef.	0.006654



9538 LOW STRESS CYCLING

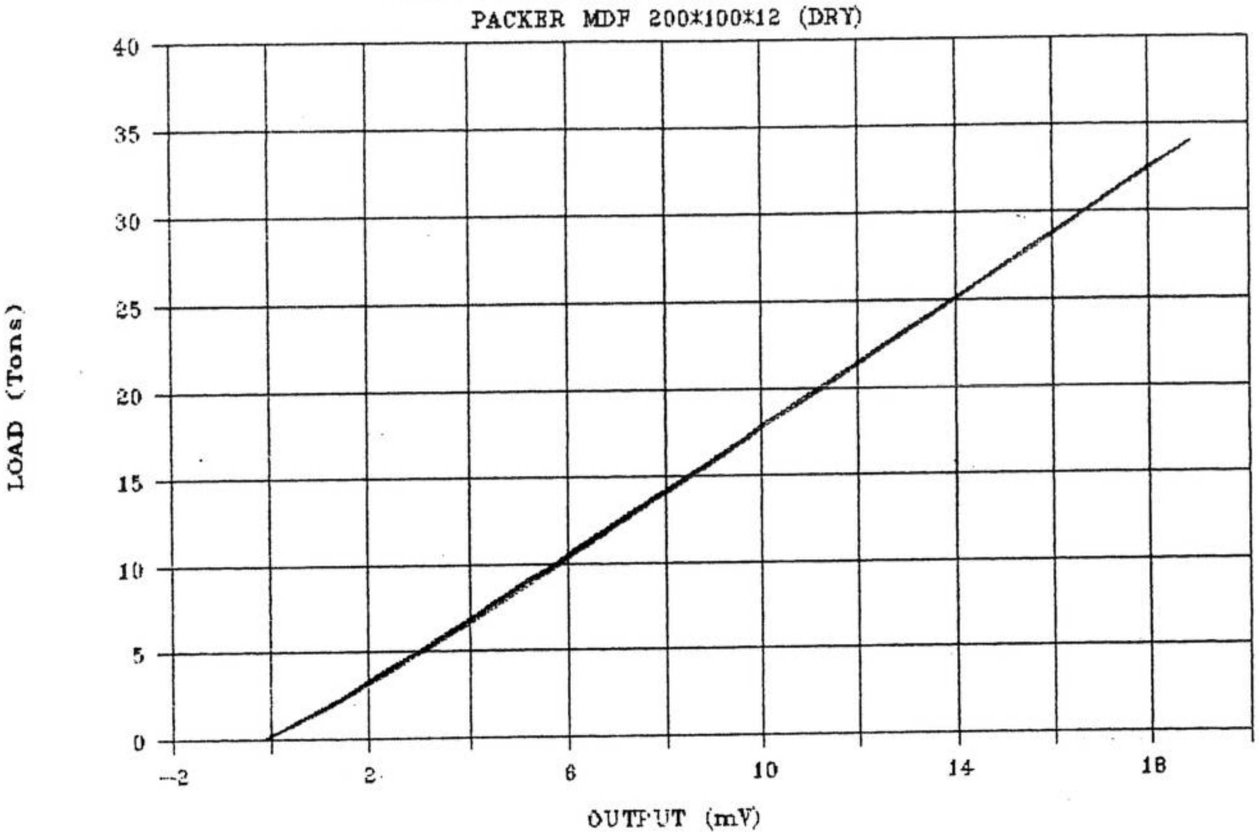
Regression Output:	
Constant	-0.32507
Std Err of Y Est	0.128626
R Squared	0.999371
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.918236
Std Err of Coef.	0.005834

9538 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.33319
Std Err of Y Est	0.121020
R Squared	0.999860
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.959801
Std Err of Coef.	0.002803

FIGURE III 114

GLOTZL CELL 0563 (SITE 4)



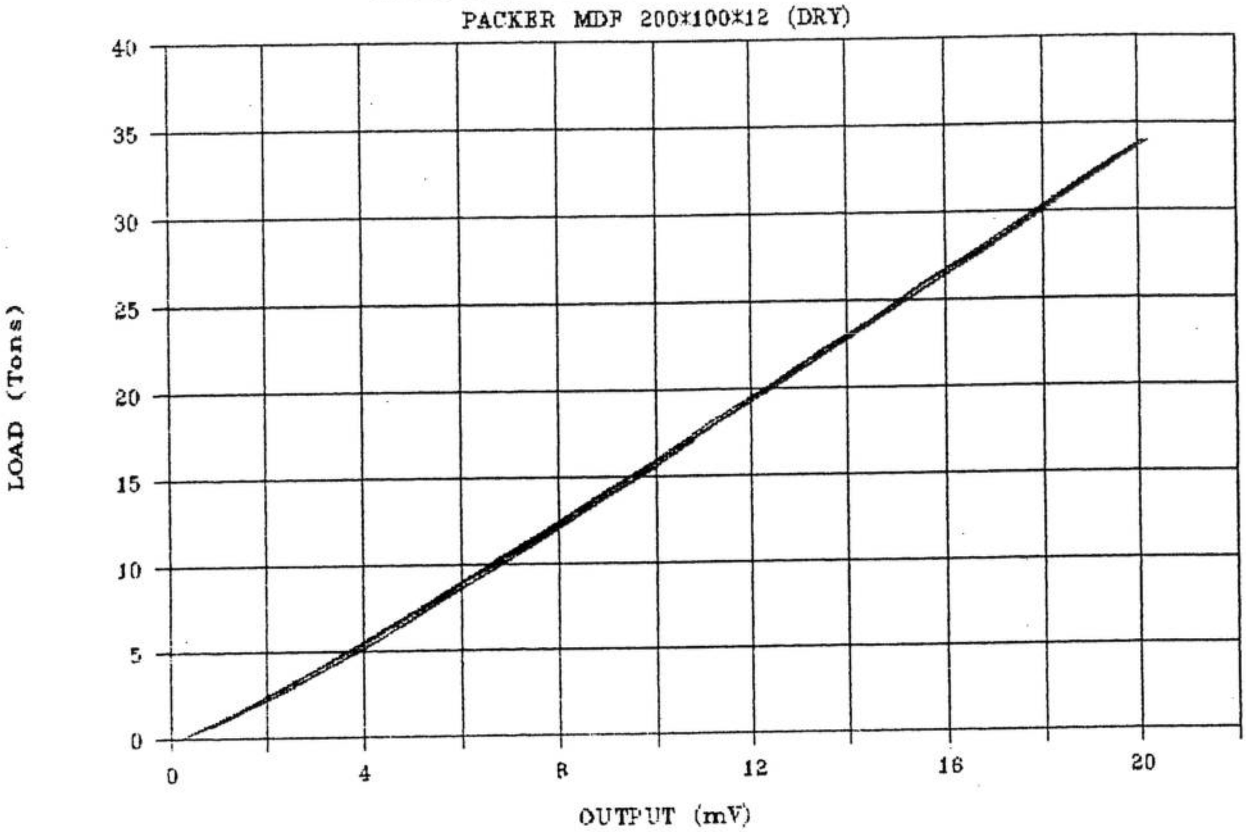
0563 LOW STRESS CYCLING

Regression Output:	
Constant	-0.09809
Std Err of Y Est	0.151787
R Squared	0.999124
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.778276
Std Err of Coef.	0.006383

0563 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.37940
Std Err of Y Est	0.191010
R Squared	0.999653
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.816958
Std Err of Coef.	0.004102

GLOTZL CELL 0566 (SITE 4)

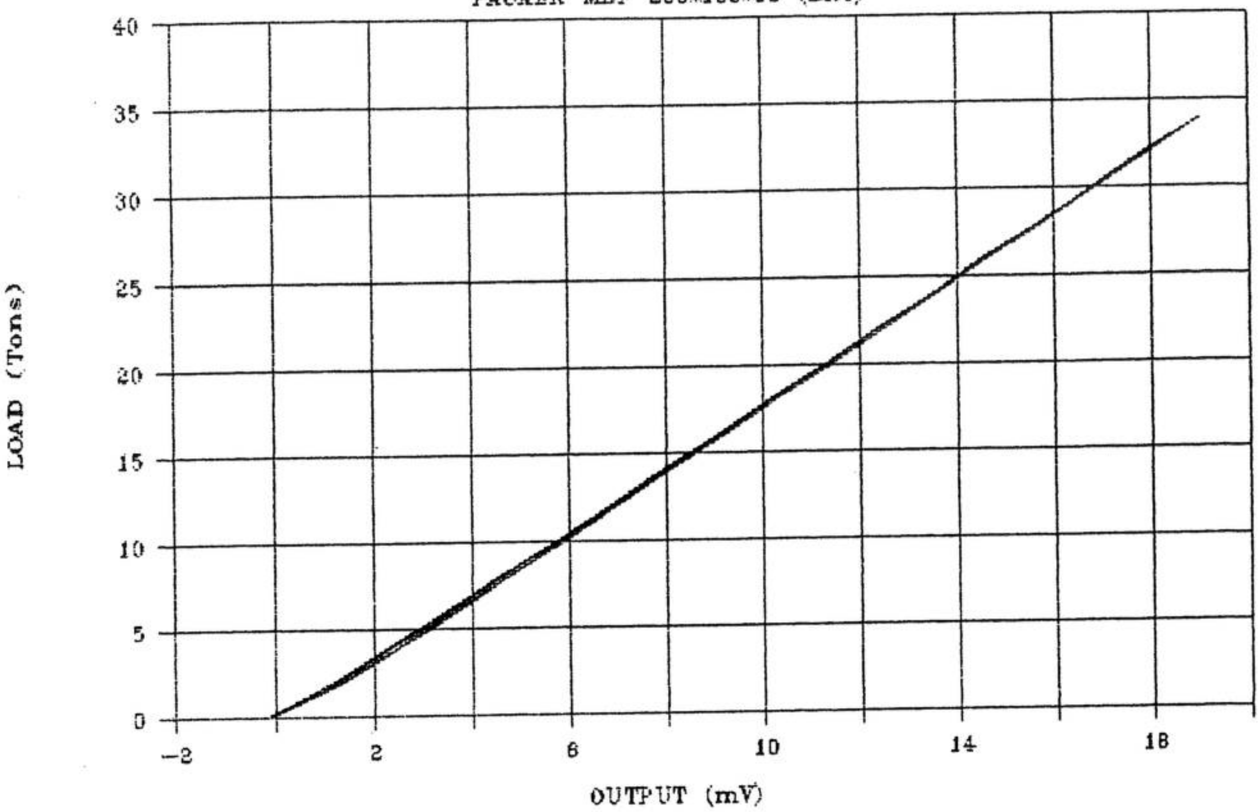



```
  0566   LOW STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                      -1.62078
Std Err of Y Est              0.119267
R Squared                     0.998954
No. of Observations                 50
Degrees of Freedom                  48

X Coefficient(s)  1.719691
Std Err of Coef.  0.008029
```

```
  0566   HIGH STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                      -1.95251
Std Err of Y Est              0.171788
R Squared                     0.999594
No. of Observations                 58
Degrees of Freedom                  56

X Coefficient(s)  1.780199
Std Err of Coef.  0.004791
```

GLOTZL CELL 0567 (SITE 4)

PACKER MDF 200*100*12 (DRY)



0567 LOW STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

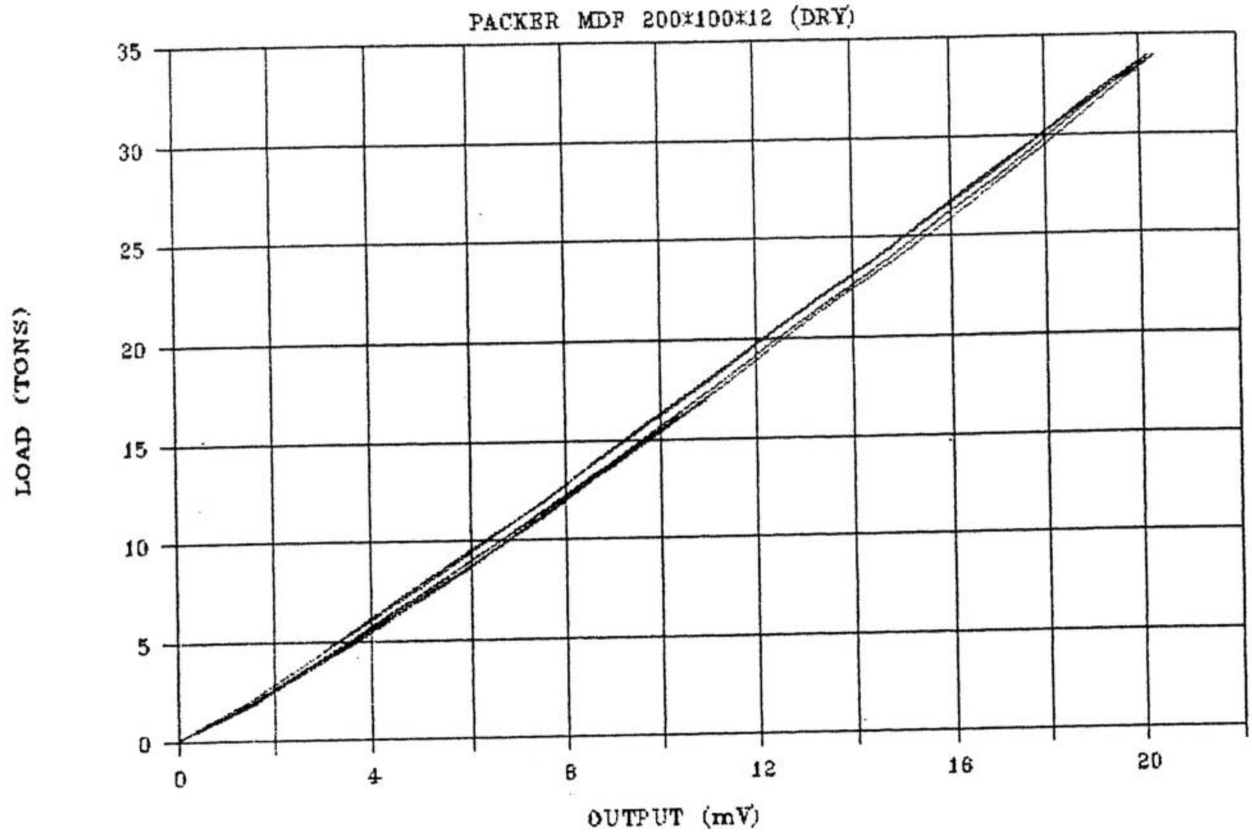
Constant	-0.46726
Std Err of Y Est	0.127063
R Squared	0.998813
No. of Observations	50
Degrees of Freedom	48
X Coefficient(s)	1.800603
Std Err of Coef.	0.008957

0567 HIGH STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-0.48807
Std Err of Y Est	0.102429
R Squared	0.999855
No. of Observations	58
Degrees of Freedom	56
X Coefficient(s)	1.813922
Std Err of Coef.	0.002910

FIGURE III117

GLOTZL CELL 0568 (SITE 4)



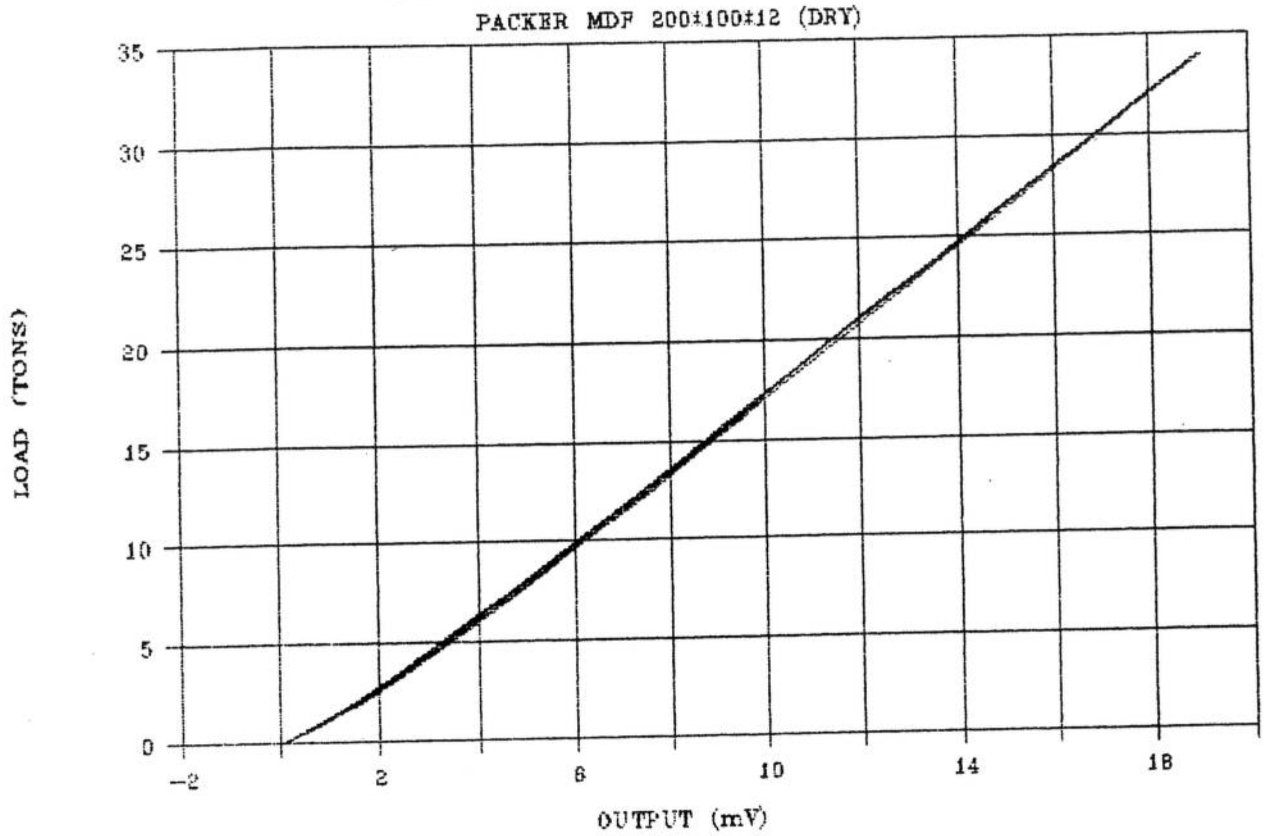
0568 LOW STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-0.97829
Std Err of Y Est	0.120018
R Squared	0.998941
No. of Observations	50
Degrees of Freedom	48
X Coefficient(s)	1.638090
Std Err of Coef.	0.007696

0568 HIGH STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-1.28538
Std Err of Y Est	0.334459
R Squared	0.998462
No. of Observations	58
Degrees of Freedom	56
X Coefficient(s)	1.730550
Std Err of Coef.	0.009074

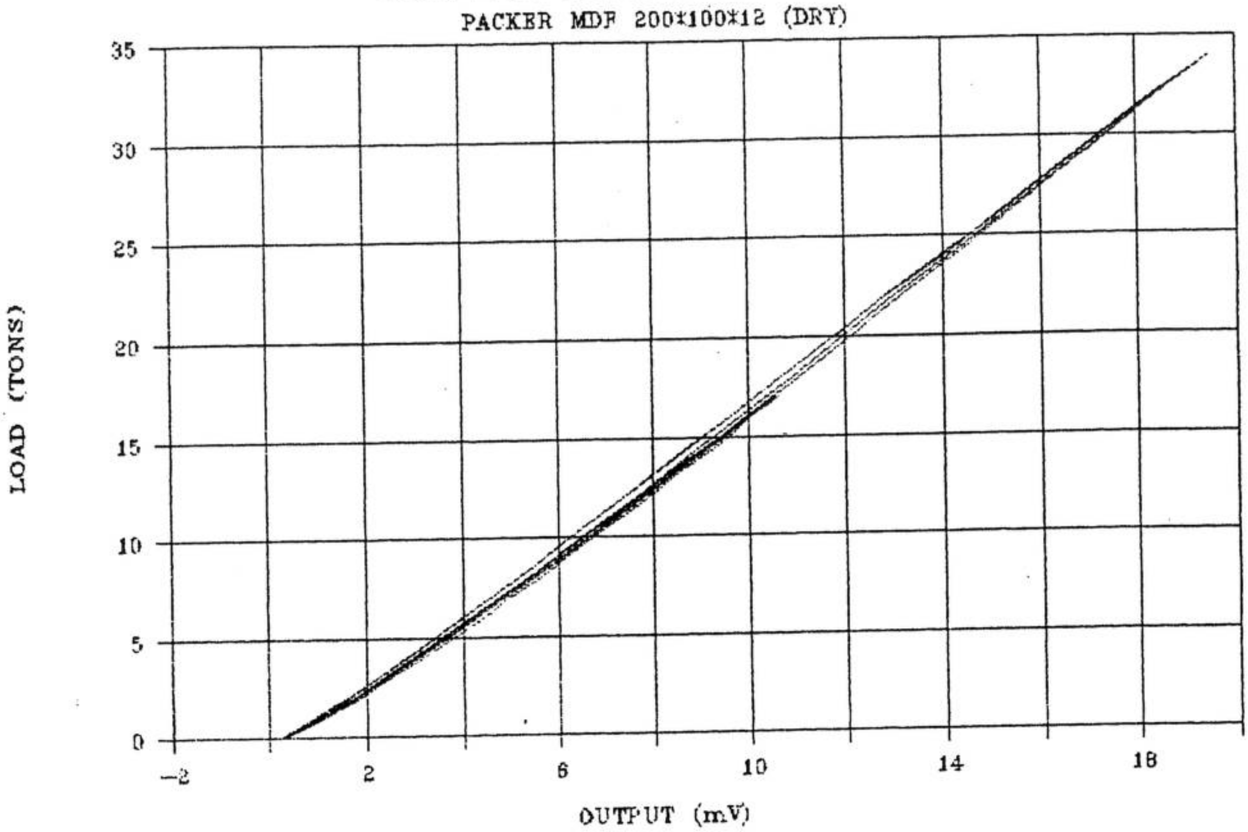
GLOTZL CELL 0570 (SITE 4)




```
  0570    LOW STRESS CYCLING
(initial 4 Tons not considered)
          Regression Output:
Constant                          -1.16783
Std Err of Y Est                  0.090138
R Squared                         0.999402
No. of Observations                     50
Degrees of Freedom                      48

X Coefficient(s)   1.827163
Std Err of Coef.   0.006446
```

```
  0570    HIGH STRESS CYCLING
(initial 4 Tons not considered)
          Regression Output:
Constant                          -1.34354
Std Err of Y Est                  0.122279
R Squared                         0.999794
No. of Observations                     58
Degrees of Freedom                      56

X Coefficient(s)   1.857942
Std Err of Coef.   0.003559
```

GLOTZL CELL 0571 (SITE 4)

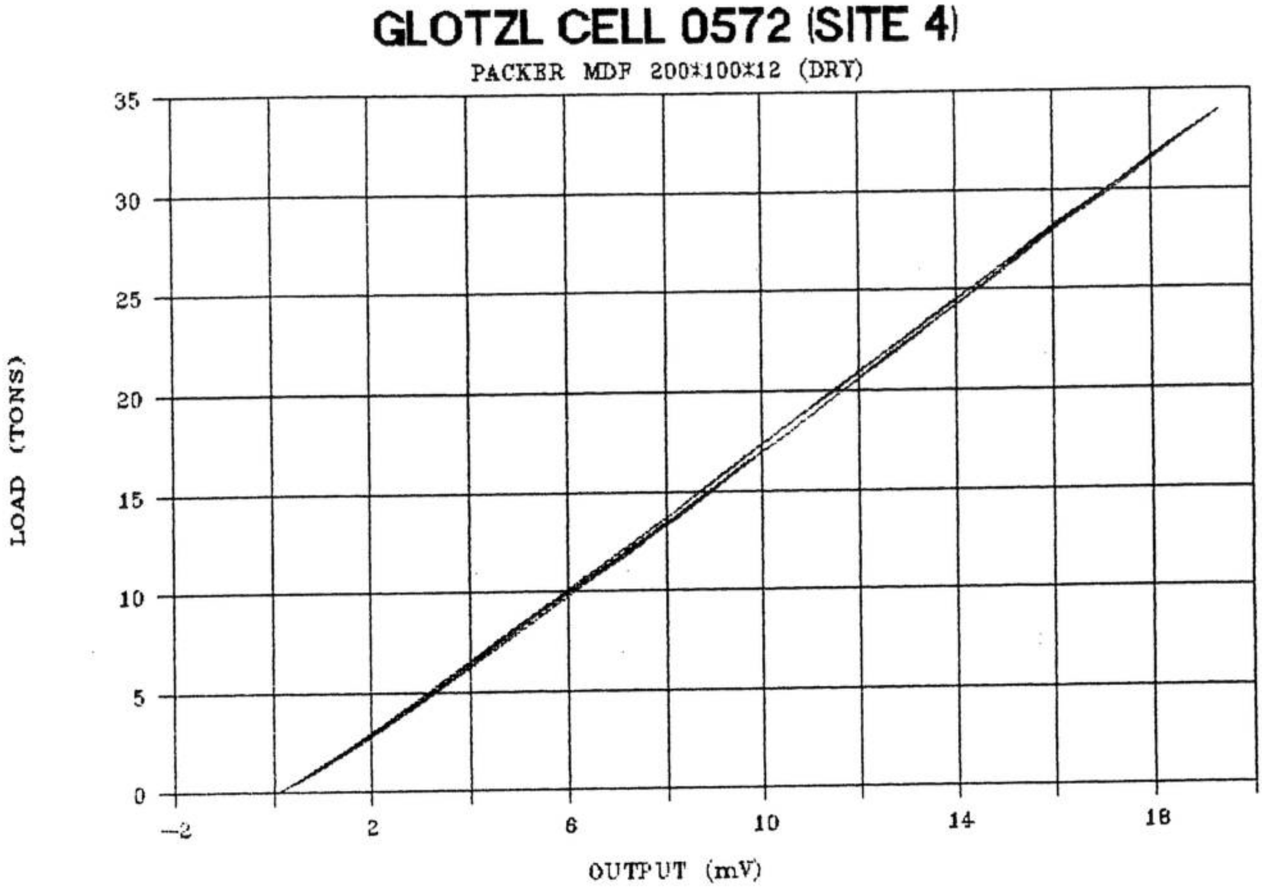


0571 LOW STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-1.49782
Std Err of Y Est	0.154157
R Squared	0.998253
No. of Observations	50
Degrees of Freedom	48
X Coefficient(s)	1.743689
Std Err of Coef.	0.010527

0571 HIGH STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-1.72494
Std Err of Y Est	0.244267
R Squared	0.999179
No. of Observations	58
Degrees of Freedom	56
X Coefficient(s)	1.830553
Std Err of Coef.	0.007007



0572 LOW STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-0.83981
Std Err of Y Est	0.077690
R Squared	0.999556
No. of Observations	50
Degrees of Freedom	48

X Coefficient(s)	1.778333
Std Err of Coef.	0.005407

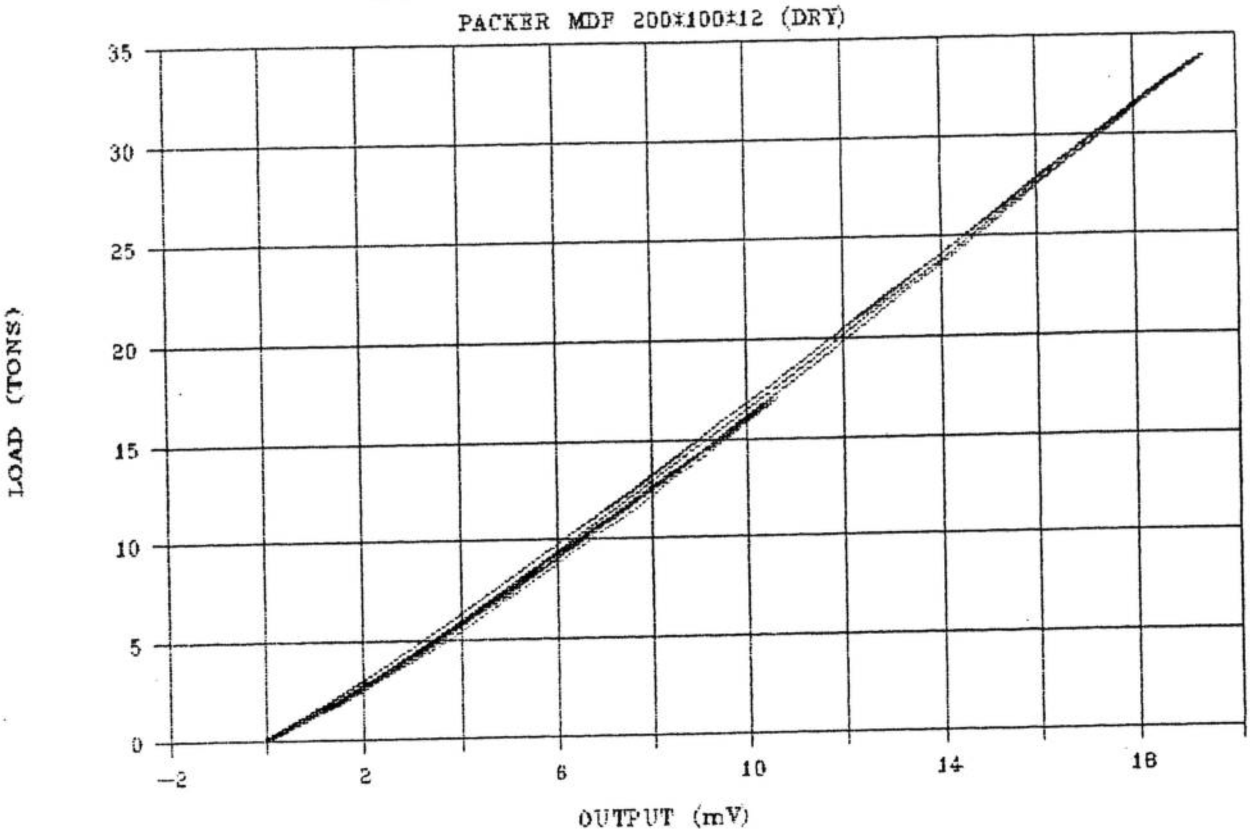
0572 HIGH STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-0.89874
Std Err of Y Est	0.157957
R Squared	0.999657
No. of Observations	58
Degrees of Freedom	56

X Coefficient(s)	1.804312
Std Err of Coef.	0.004465

FIGURE III 121

GLOTZL CELL 0574 (SITE 4)

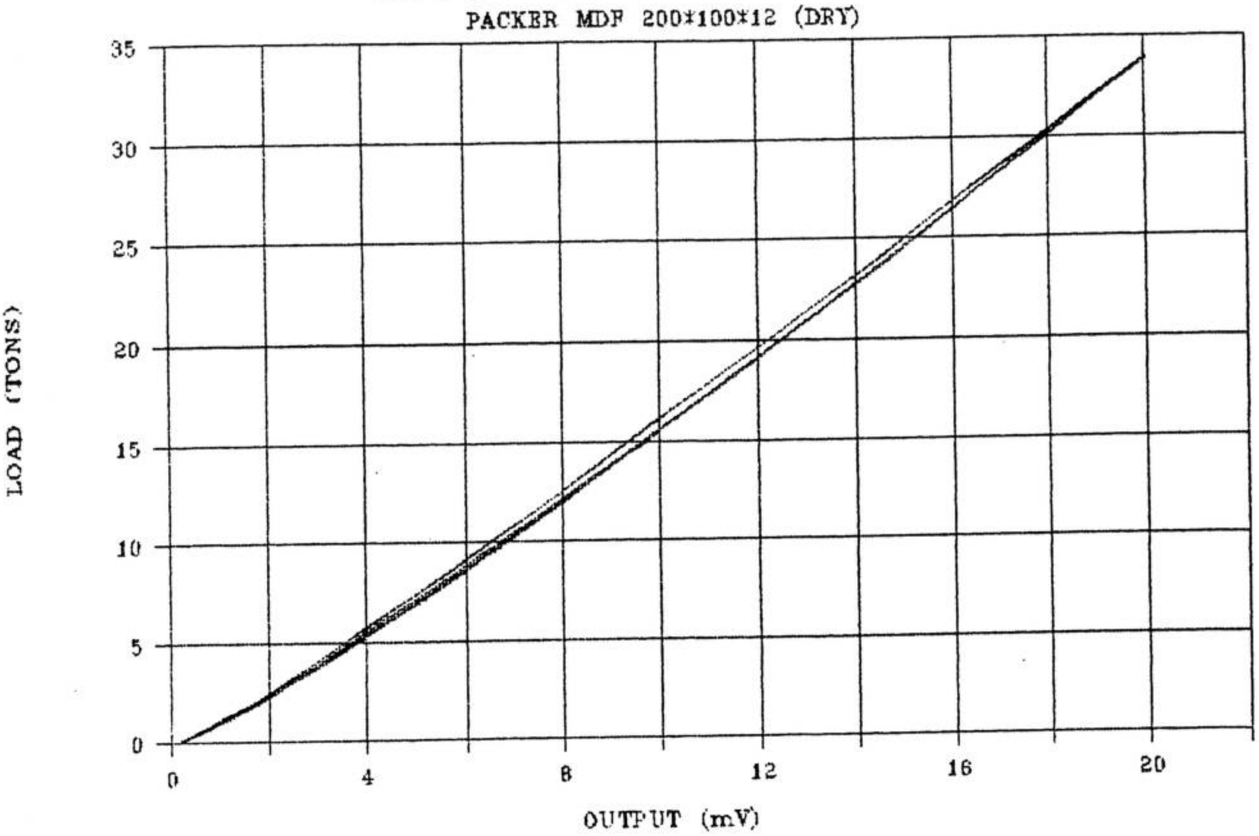



```
  0574    LOW STRESS CYCLING
(initial 4 Tons not considered)
          Regression Output:
Constant                         -1.16063
Std Err of Y Est                 0.171145
R Squared                        0.997847
No. of Observations                    50
Degrees of Freedom                     48

X Coefficient(s)  1.706848
Std Err of Coef.  0.011442
```

```
  0574    HIGH STRESS CYCLING
(initial 4 Tons not considered)
          Regression Output:
Constant                         -1.49075
Std Err of Y Est                 0.271377
R Squared                        0.998987
No. of Observations                    58
Degrees of Freedom                     56

X Coefficient(s)  1.821122
Std Err of Coef.  0.007746
```

FIGURE III12

GLOTZL CELL 0575 (SITE 4)

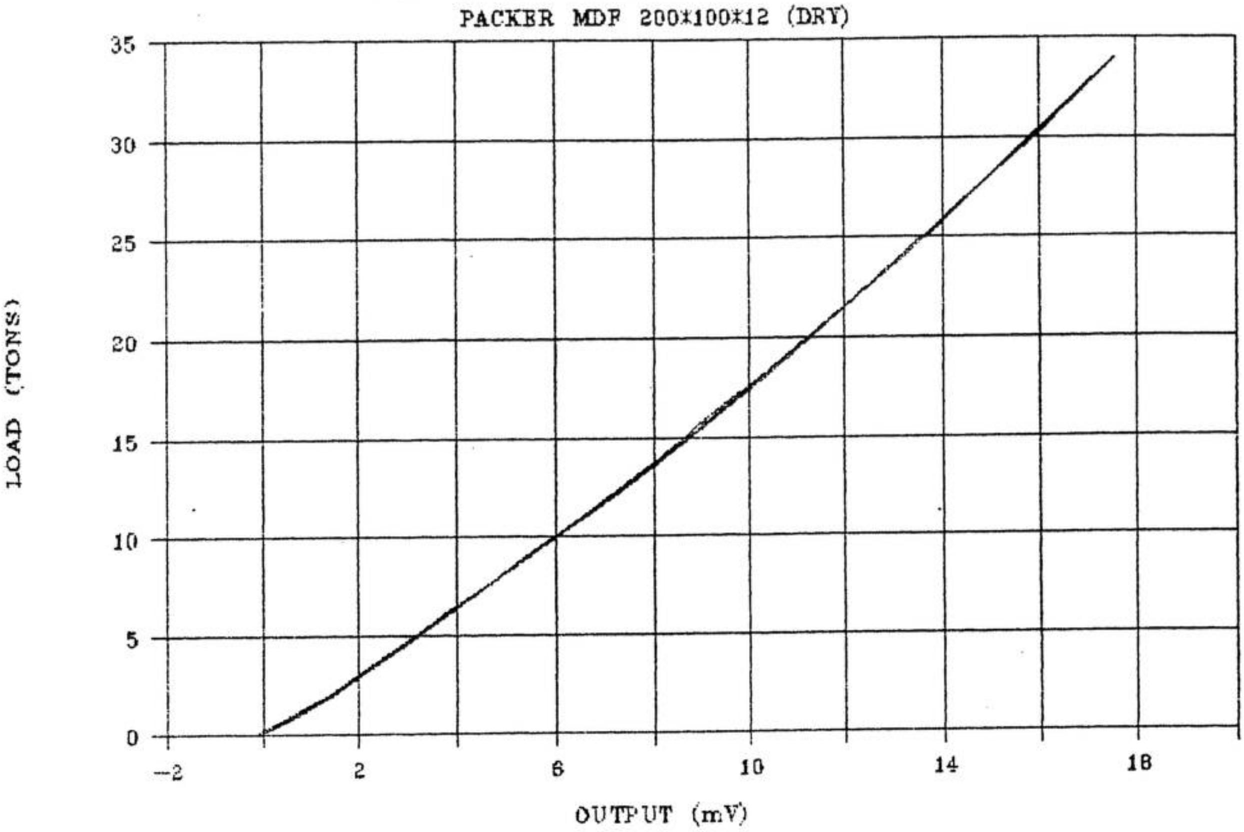



```
  0575   LOW STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                        -1.46238
Std Err of Y Est                0.117174
R Squared                       0.998990
No. of Observations                   50
Degrees of Freedom                    48

X Coefficient(s)   1.695071
Std Err of Coef.   0.007775
```

```
  0575   HIGH STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                        -1.86299
Std Err of Y Est                0.236721
R Squared                       0.999229
No. of Observations                   58
Degrees of Freedom                    56

X Coefficient(s)   1.779753
Std Err of Coef.   0.006602
```

FIGURE III123

GLOTZL CELL 0576 (SITE 4)

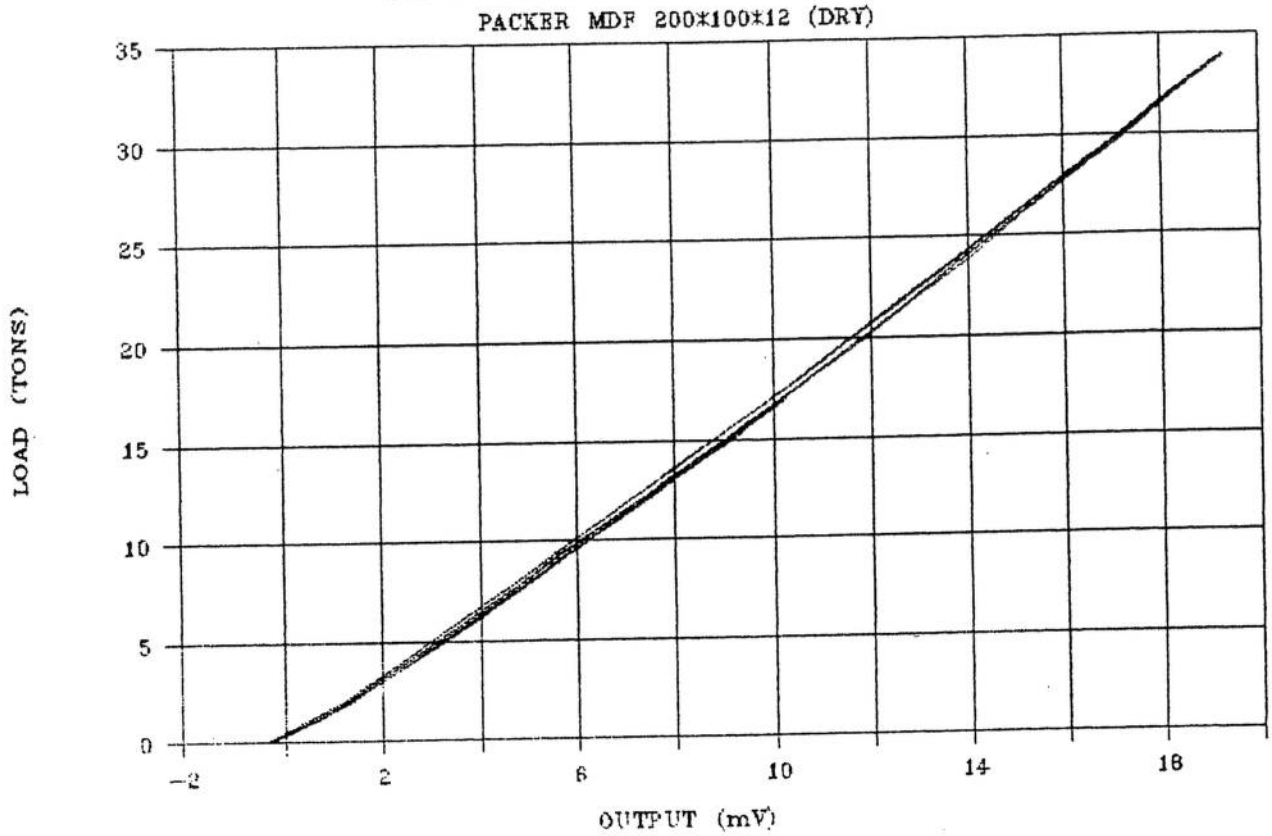



```
  0576    LOW STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                        -0.92398
Std Err of Y Est                0.051296
R Squared                       0.999806
No. of Observations                   50
Degrees of Freedom                    48

X Coefficient(s)  1.830966
Std Err of Coef.  0.003675
```

```
  0576    HIGH STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                        -2.29605
Std Err of Y Est                0.400578
R Squared                       0.997794
No. of Observations                   58
Degrees of Freedom                    56

X Coefficient(s)  2.020181
Std Err of Coef.  0.012691
```

FIGURE III 12

GLOTZL CELL 0577 (SITE 4)

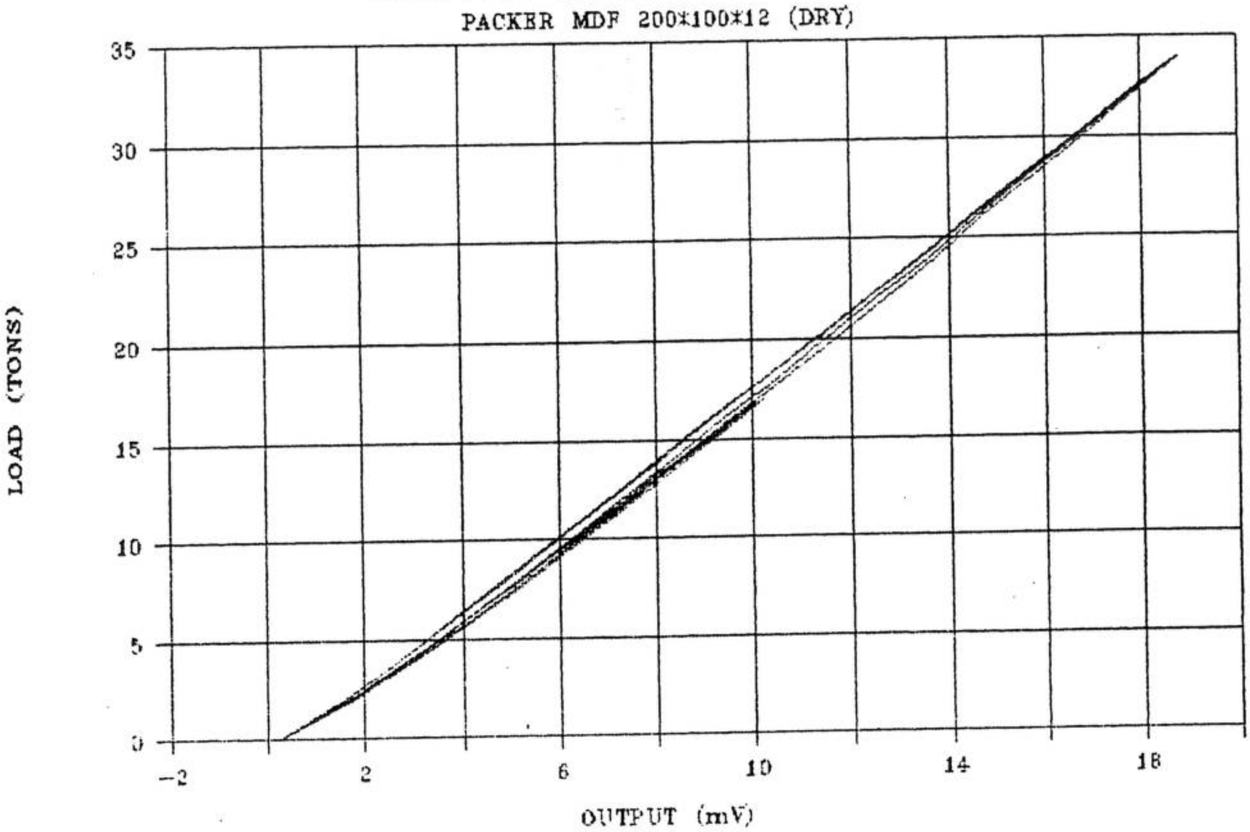



```
  0577   LOW STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                     -0.50999
Std Err of Y Est              0.124036
R Squared                     0.998869
No. of Observations                 50
Degrees of Freedom                  48

X Coefficient(s)  1.706540
Std Err of Coef.  0.008287
```

```
  0577   HIGH STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                     -0.93354
Std Err of Y Est              0.233377
R Squared                     0.999251
No. of Observations                 58
Degrees of Freedom                  56

X Coefficient(s)  1.797667
Std Err of Coef.  0.006574
```

FIGURE III 125

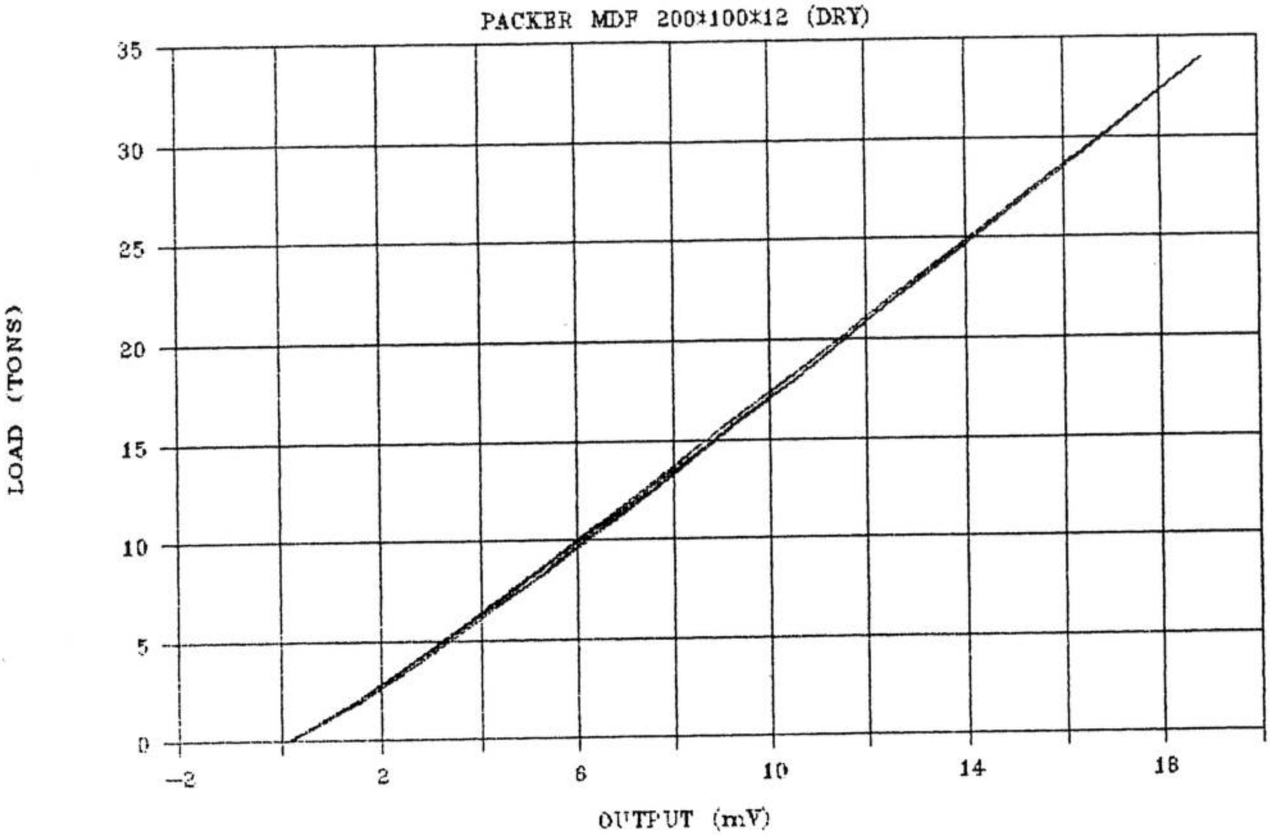
GLOTZL CELL 0578 (SITE 4)




```
  0578    LOW STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                       -1.60894
Std Err of Y Est               0.151220
R Squared                      0.998319
No. of Observations                  50
Degrees of Freedom                   48

X Coefficient(s)  1.823509
Std Err of Coef.  0.010799
```

```
  0578    HIGH STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                       -1.61543
Std Err of Y Est               0.296986
R Squared                      0.998787
No. of Observations                  58
Degrees of Freedom                   56

X Coefficient(s)  1.896049
Std Err of Coef.  0.008827
```

GLOTZL CELL 0579 (SITE 4)



0579 LOW STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-1.08805
Std Err of Y Est	0.095267
R Squared	0.999332
No. of Observations	50
Degrees of Freedom	48

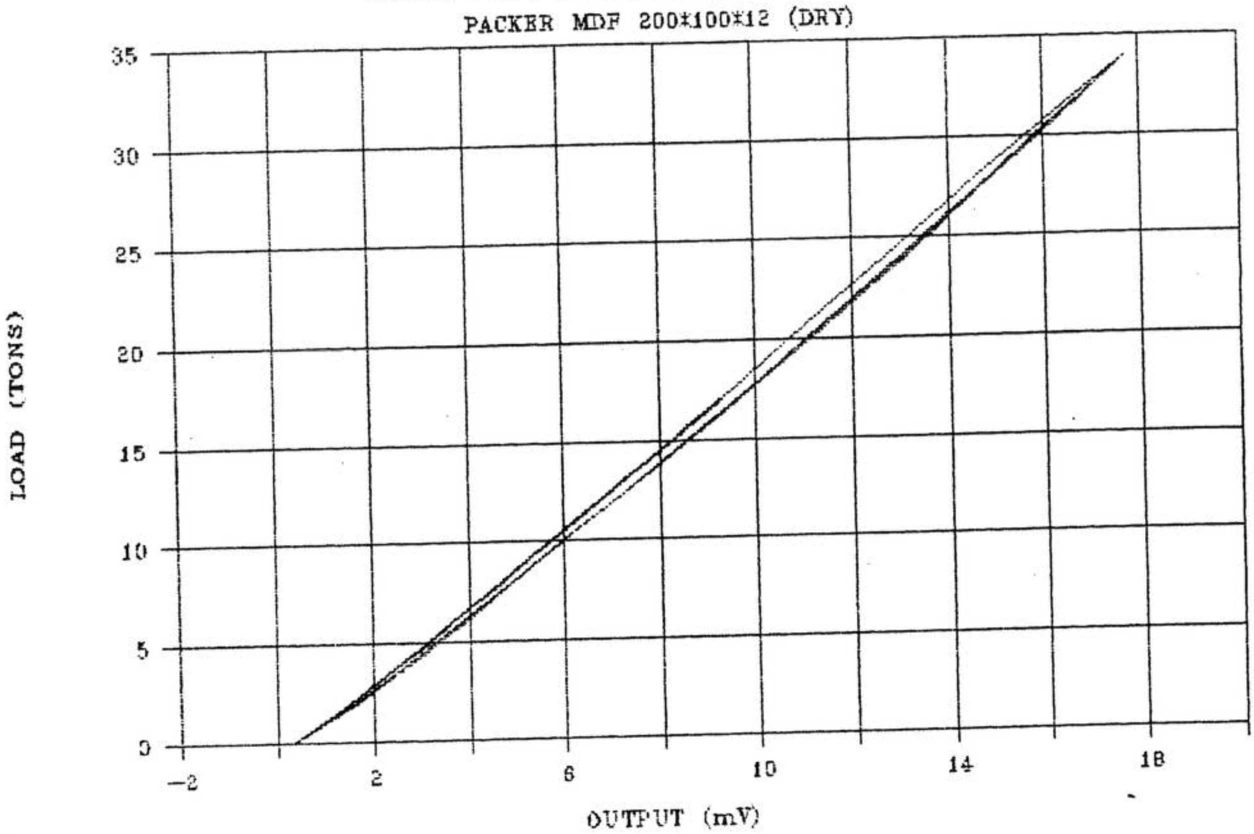
X Coefficient(s)	1.812033
Std Err of Coef.	0.006757

0579 HIGH STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-1.38579
Std Err of Y Est	0.156603
R Squared	0.999662
No. of Observations	58
Degrees of Freedom	56

X Coefficient(s)	1.870289
Std Err of Coef.	0.004589

GLOTZL CELL 9527 (SITE 4)



9527 LOW STRESS CYCLING

Regression Output:	
Constant	-0.90638
Std Err of Y Est	0.099849
R Squared	0.999621
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.913223
Std Err of Coef.	0.004516

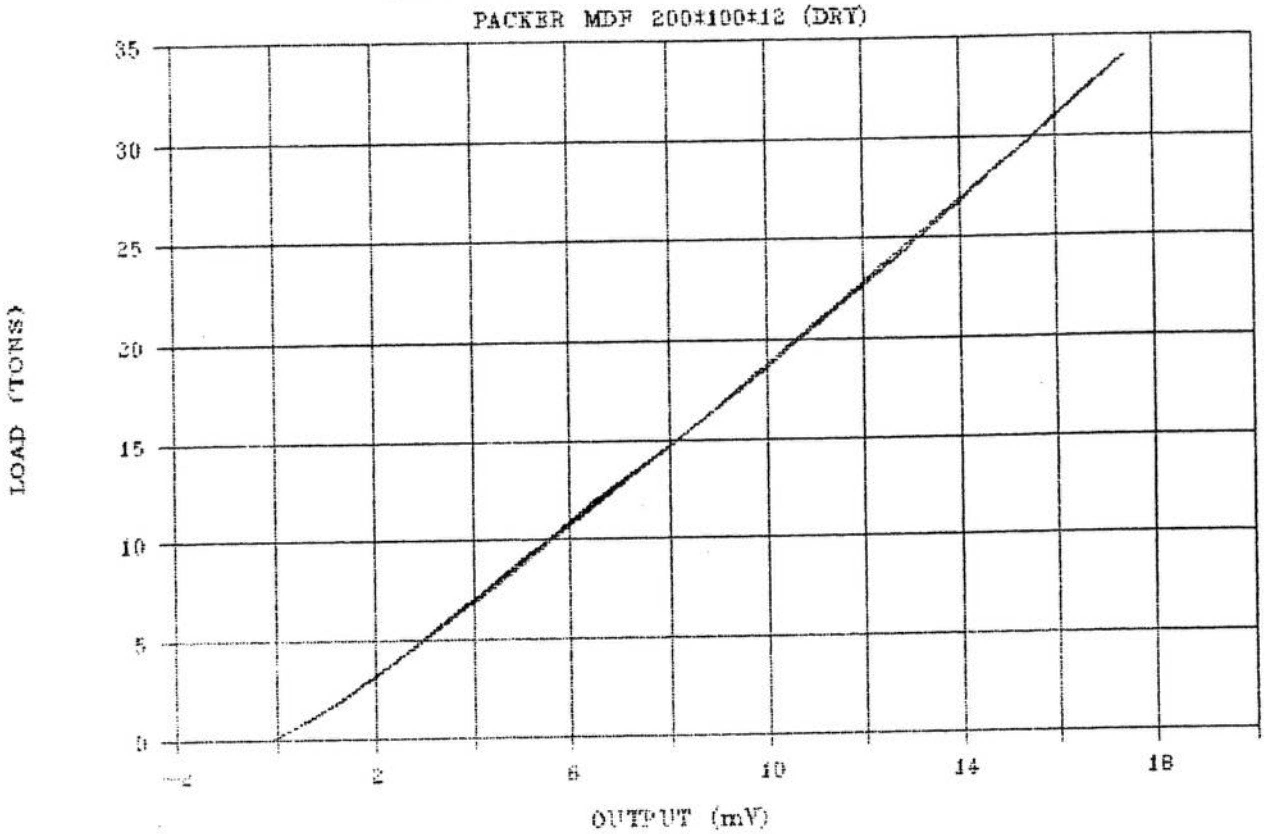
9527 HIGH STRESS CYCLING

Regression Output:	
Constant	-1.46277
Std Err of Y Est	0.403050
R Squared	0.998456
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.973865
Std Err of Coef.	0.009410

FIGURE III128

GLOTZL CELL 9528 (SITE 4)



9528 LOW STRESS CYCLING

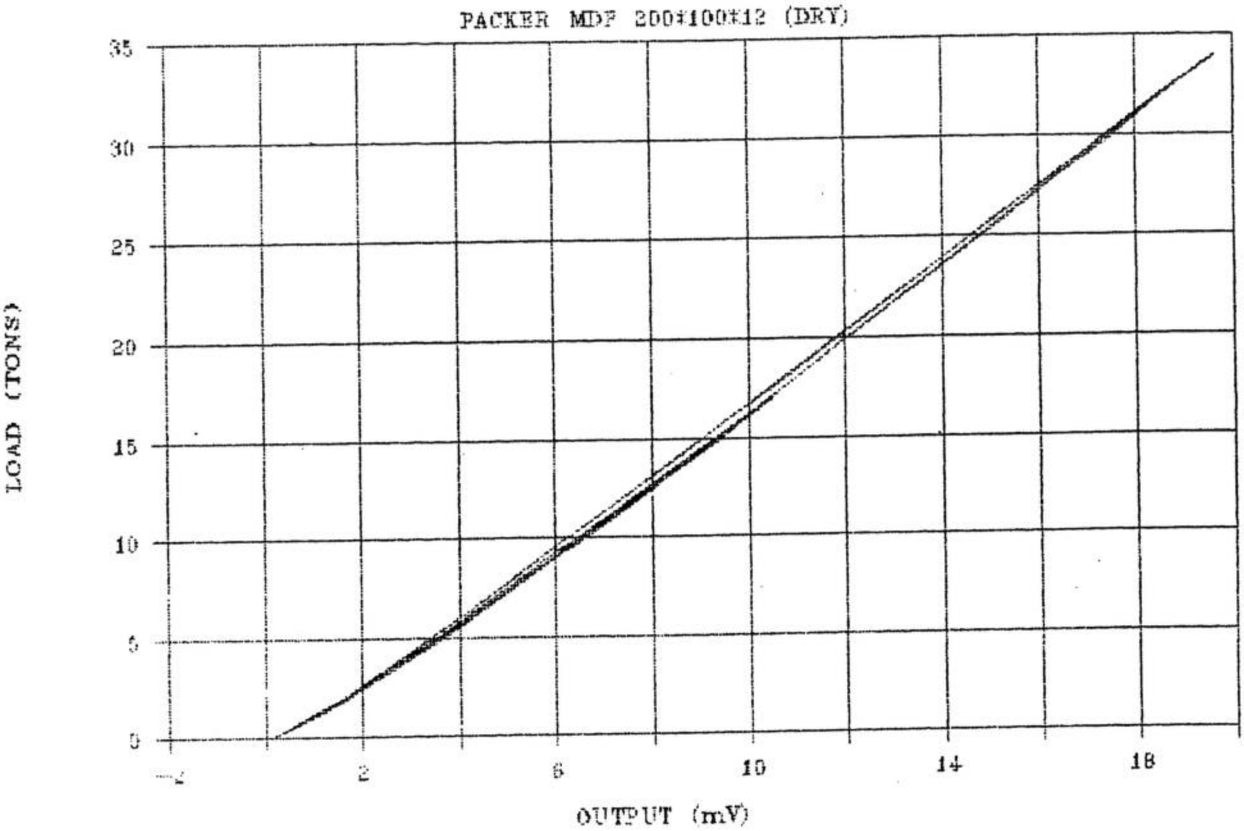
Regression Output:	
Constant	-0.34425
Std Err of Y Est	0.181354
R Squared	0.998750
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.868945
Std Err of Coef.	0.008017

9528 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.77326
Std Err of Y Est	0.337555
R Squared	0.998917
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.966409
Std Err of Coef.	0.007850

FIGURE III 128

GLOTZL CELL 9529 (SITE 4)



9529 LOW STRESS CYCLING

Regression Output:

Constant	-0.81024
Std Err of Y Est	0.225667
R Squared	0.998064
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.672459
Std Err of Coef.	0.008930

9529 HIGH STRESS CYCLING

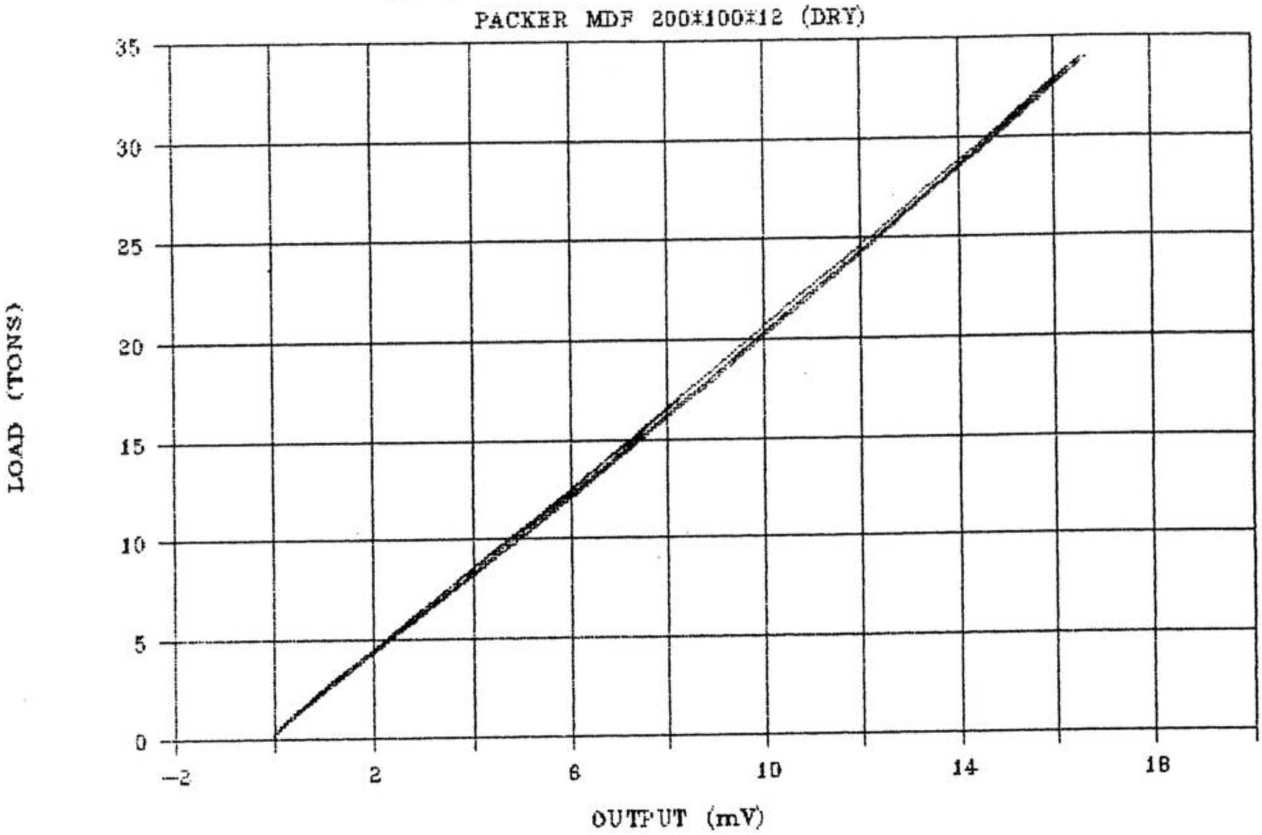
Regression Output:

Constant	-1.10809
Std Err of Y Est	0.325385
R Squared	0.998994
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.775105
Std Err of Coef.	0.006830

FIGURE III129

GLOTZL CELL 9530 (SITE 4)



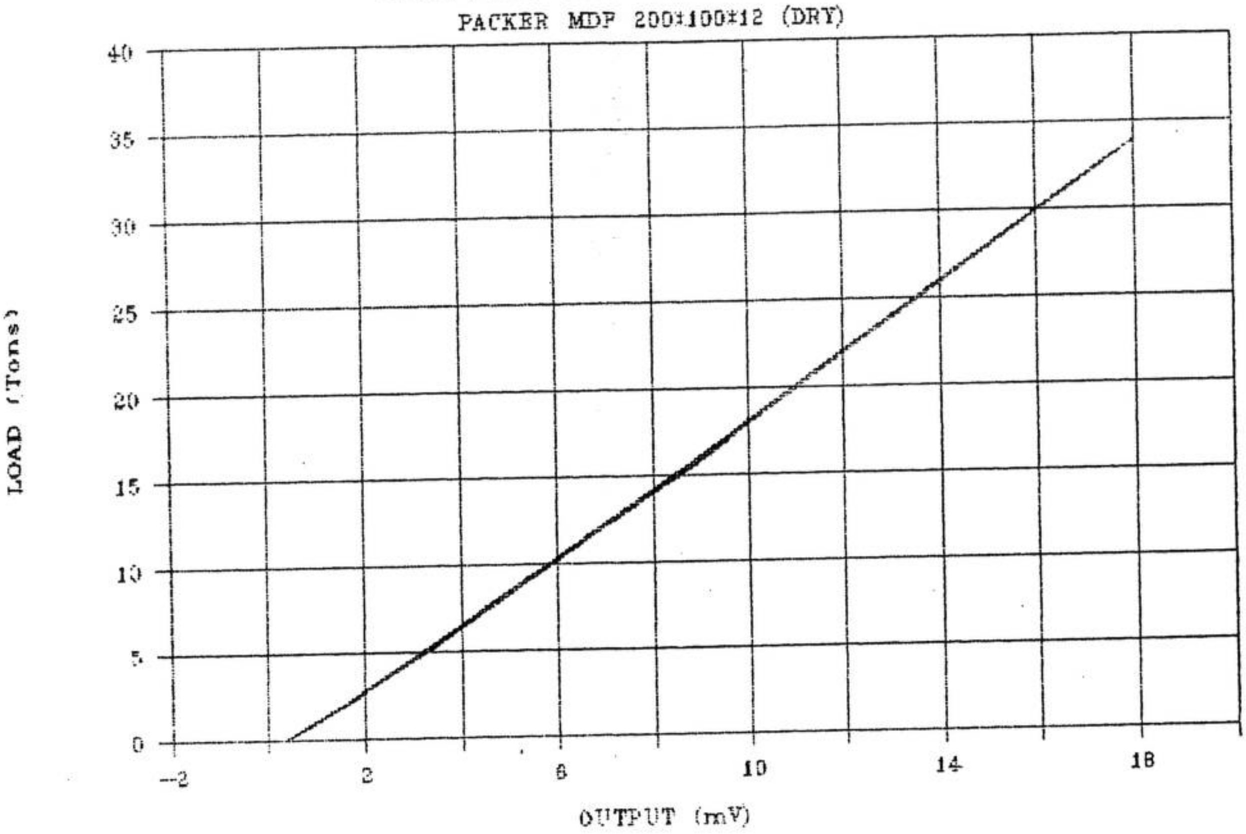
9530 LOW STRESS CYCLING

Regression Output:	
Constant	0.451901
Std Err of Y Est	0.073924
R Squared	0.999792
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	2.011341
Std Err of Coef.	0.003515

9530 HIGH STRESS CYCLING

Regression Output:	
Constant	0.220977
Std Err of Y Est	0.173942
R Squared	0.999712
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	2.021706
Std Err of Coef.	0.004157

GLOTZL CELL 9531 (SITE 4)



9531 LOW STRESS CYCLING

Regression Output:	
Constant	-0.92205
Std Err of Y Est	0.104450
R Squared	0.999585
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.862446
Std Err of Coef.	0.004599

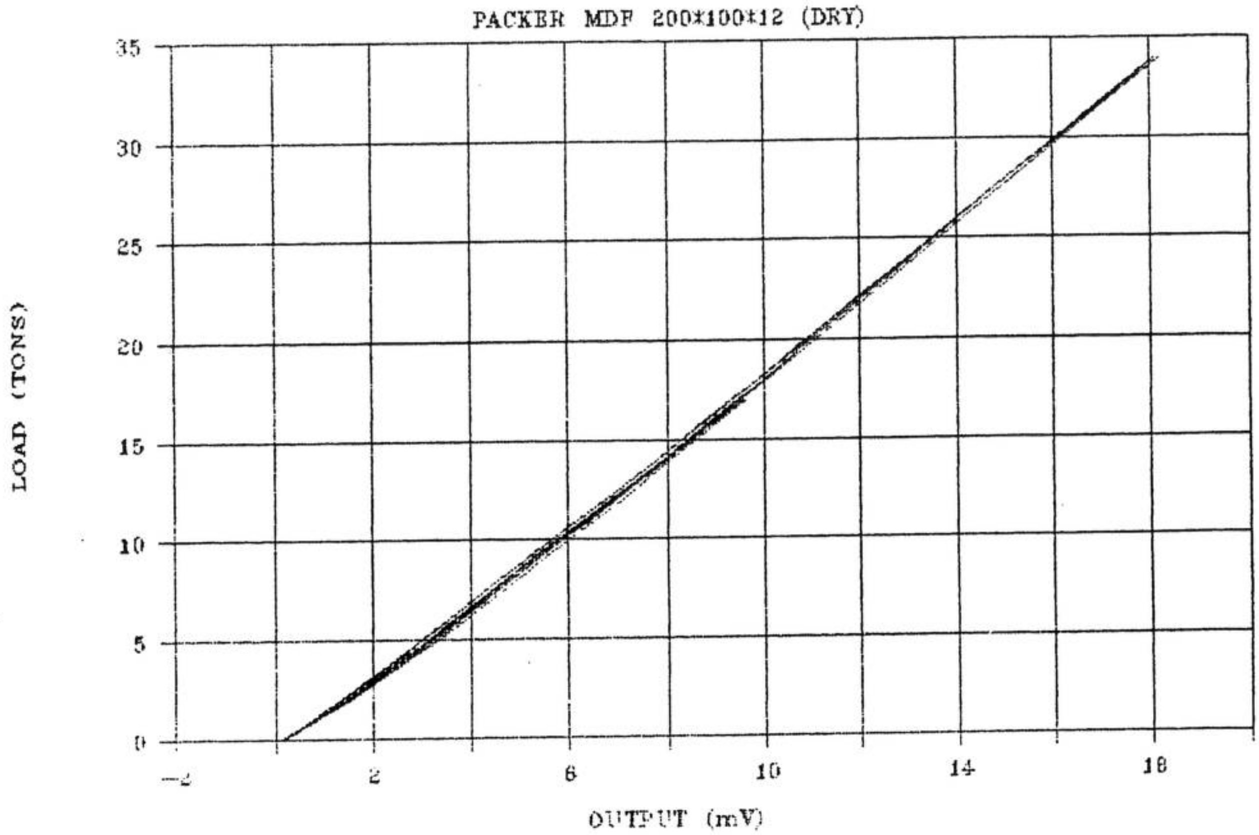
9531 HIGH STRESS CYCLING

Regression Output:	
Constant	-1.19161
Std Err of Y Est	0.195144
R Squared	0.999638
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.939101
Std Err of Coef.	0.004473

FIGURE III 1

GLOTZL CELL 9532 (SITE 4)



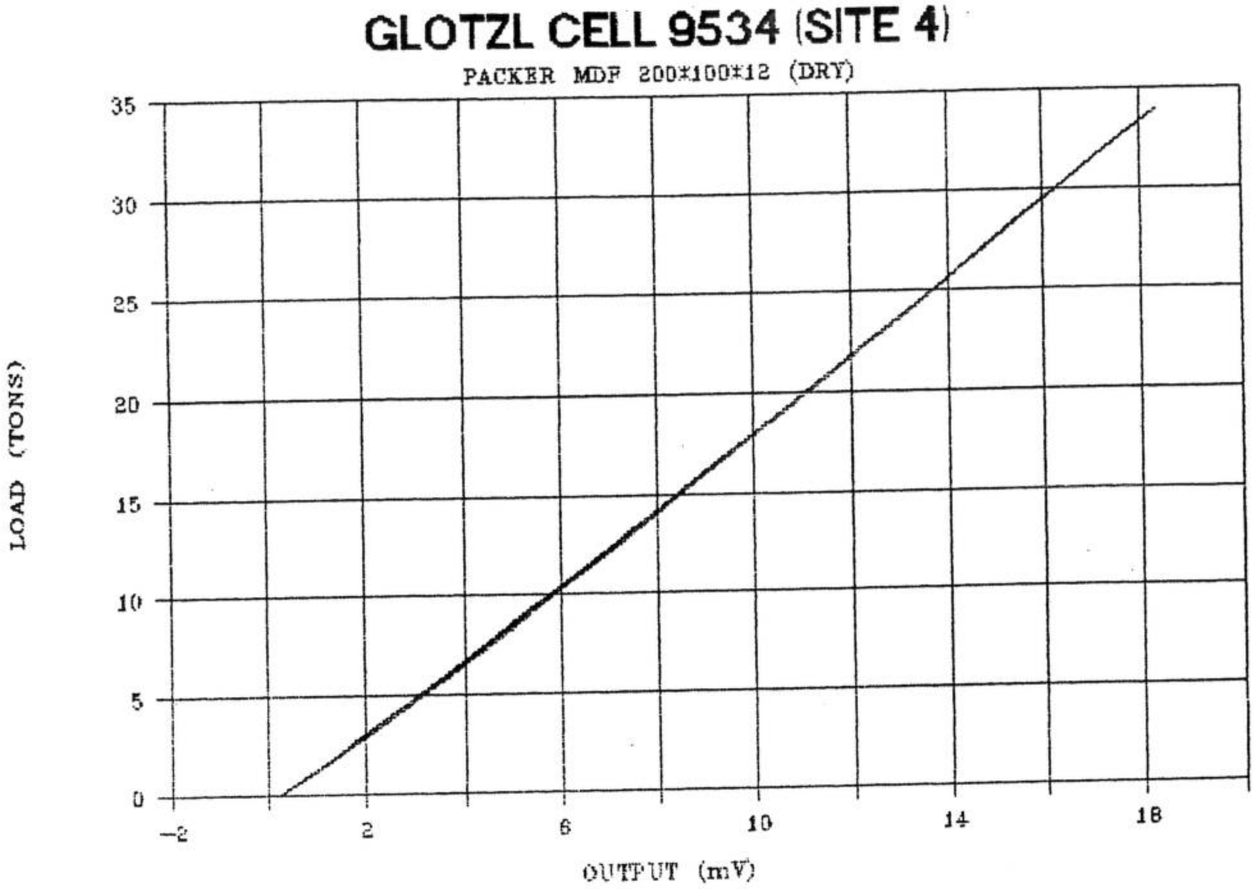
9532 LOW STRESS CYCLING

Regression Output:		
Constant		-0.71149
Std Err of Y Est		0.212387
R Squared		0.998285
No. of Observations		70
Degrees of Freedom		68
X Coefficient(s)	1.828964	
Std Err of Coef.	0.009190	

9532 HIGH STRESS CYCLING

Regression Output:		
Constant		-0.83603
Std Err of Y Est		0.226186
R Squared		0.999513
No. of Observations		70
Degrees of Freedom		68
X Coefficient(s)	1.907577	
Std Err of Coef.	0.005101	

FIGURE III 132



9534 LOW STRESS CYCLING

Regression Output:

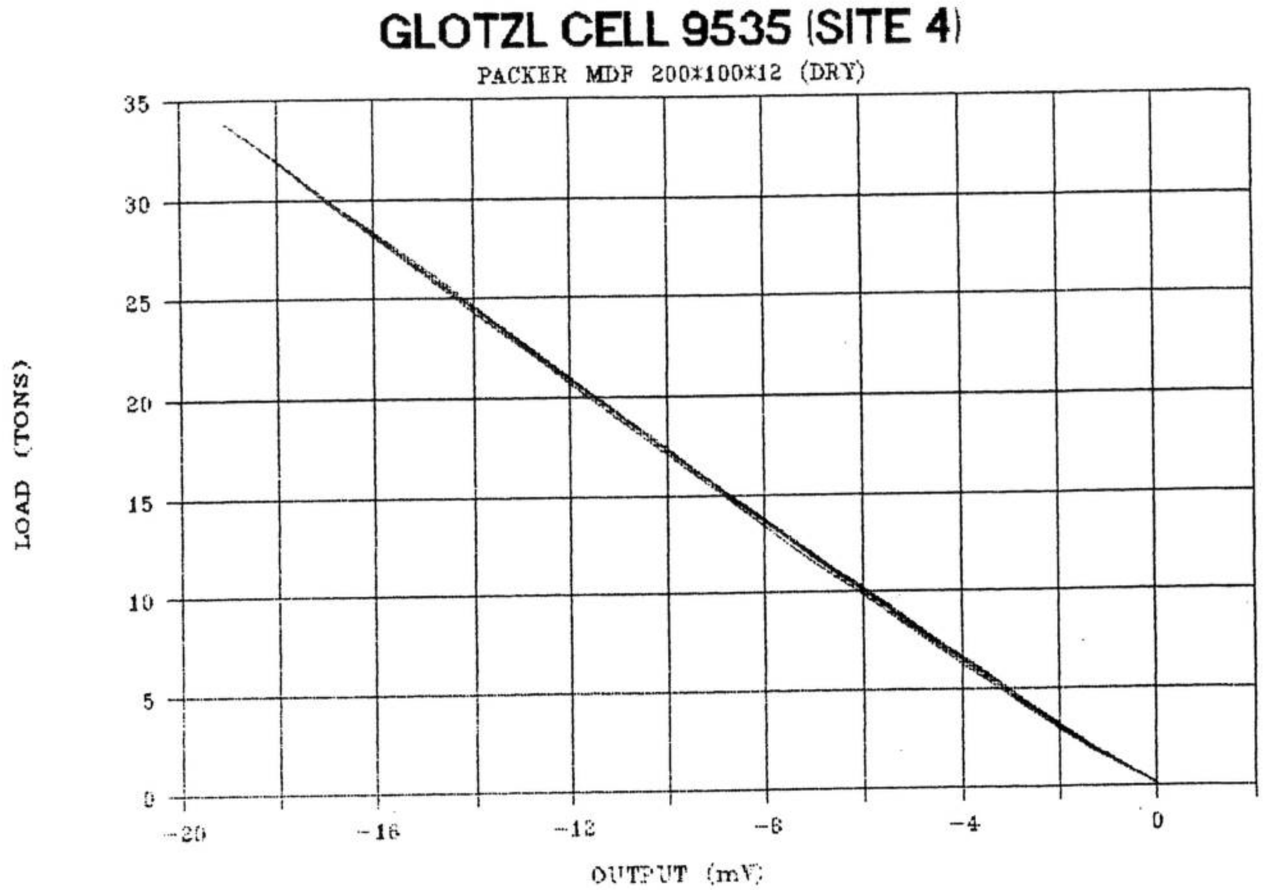
Constant	-0.67254
Std Err of Y Est	0.102246
R Squared	0.999602
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.845215
Std Err of Coef.	0.004460

9534 HIGH STRESS CYCLING

Regression Output:

Constant	-0.89901
Std Err of Y Est	0.152970
R Squared	0.999777
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.895080
Std Err of Coef.	0.003426

FIGURE III 13



9535 LOW STRESS CYCLING

Regression Output:

Constant	-0.29196
Std Err of Y Est	0.148929
R Squared	0.999157
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	-1.74177
Std Err of Coef.	0.006134

9535 HIGH STRESS CYCLING

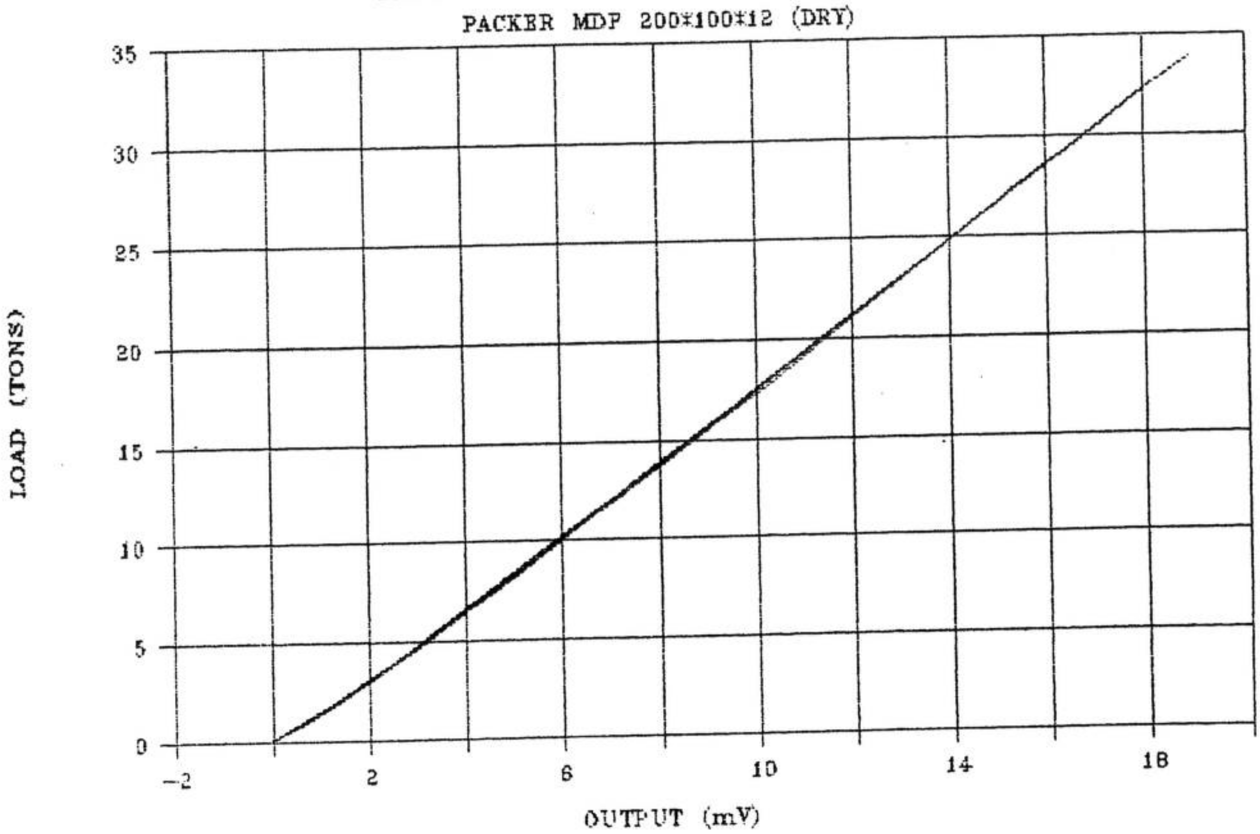
Regression Output:

Constant	-0.54942
Std Err of Y Est	0.231940
R Squared	0.999488
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	-1.79216
Std Err of Coef.	0.004914

FIGURE III 134

GLOTZL CELL 9536 (SITE 4)



0563 LOW STRESS CYCLING

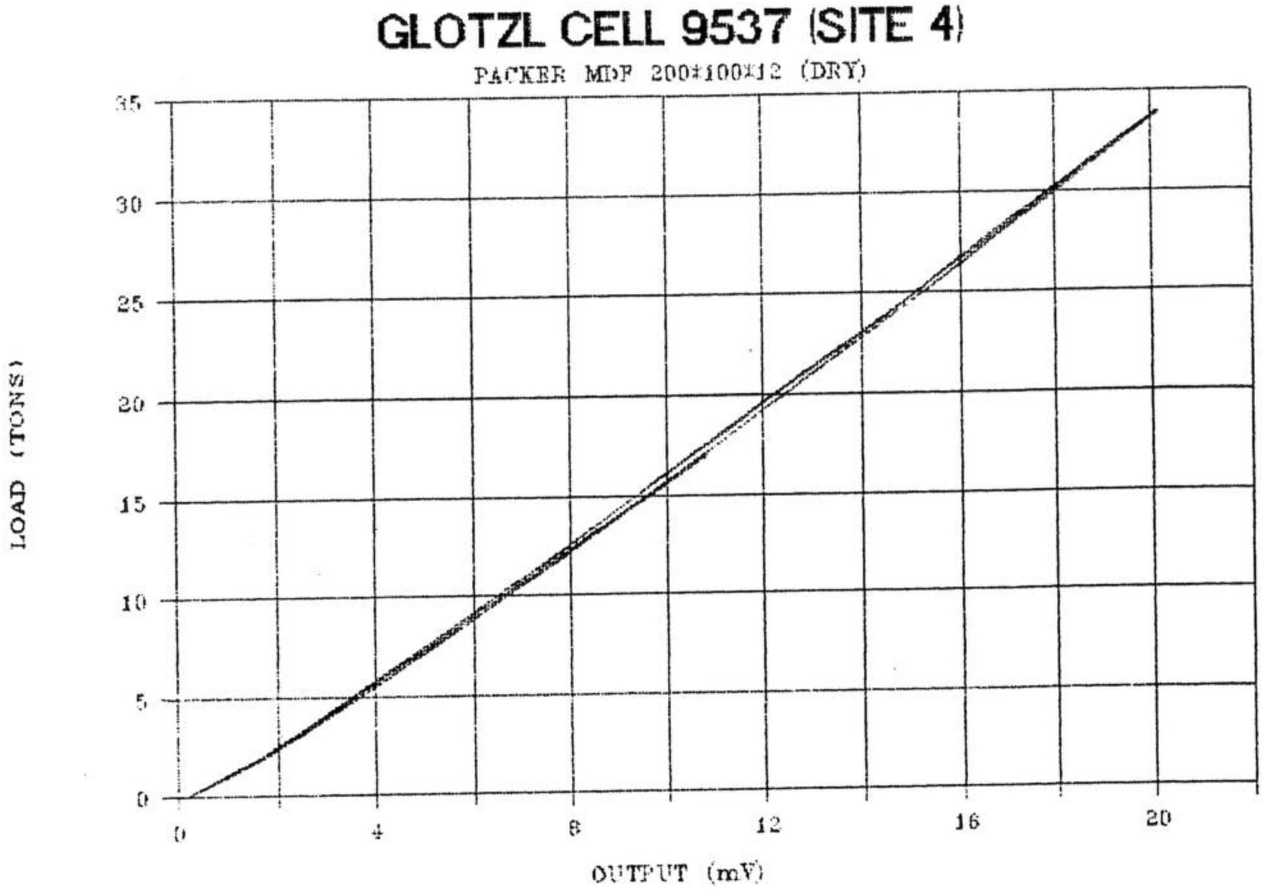
Regression Output:

Constant	-0.09809
Std Err of Y Est	0.151787
R Squared	0.999124
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.778276
Std Err of Coef.	0.006383

0563 HIGH STRESS CYCLING

Regression Output:

Constant	-0.37940
Std Err of Y Est	0.191010
R Squared	0.999653
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.816958
Std Err of Coef.	0.004102



9537 LOW STRESS CYCLING

Regression Output:

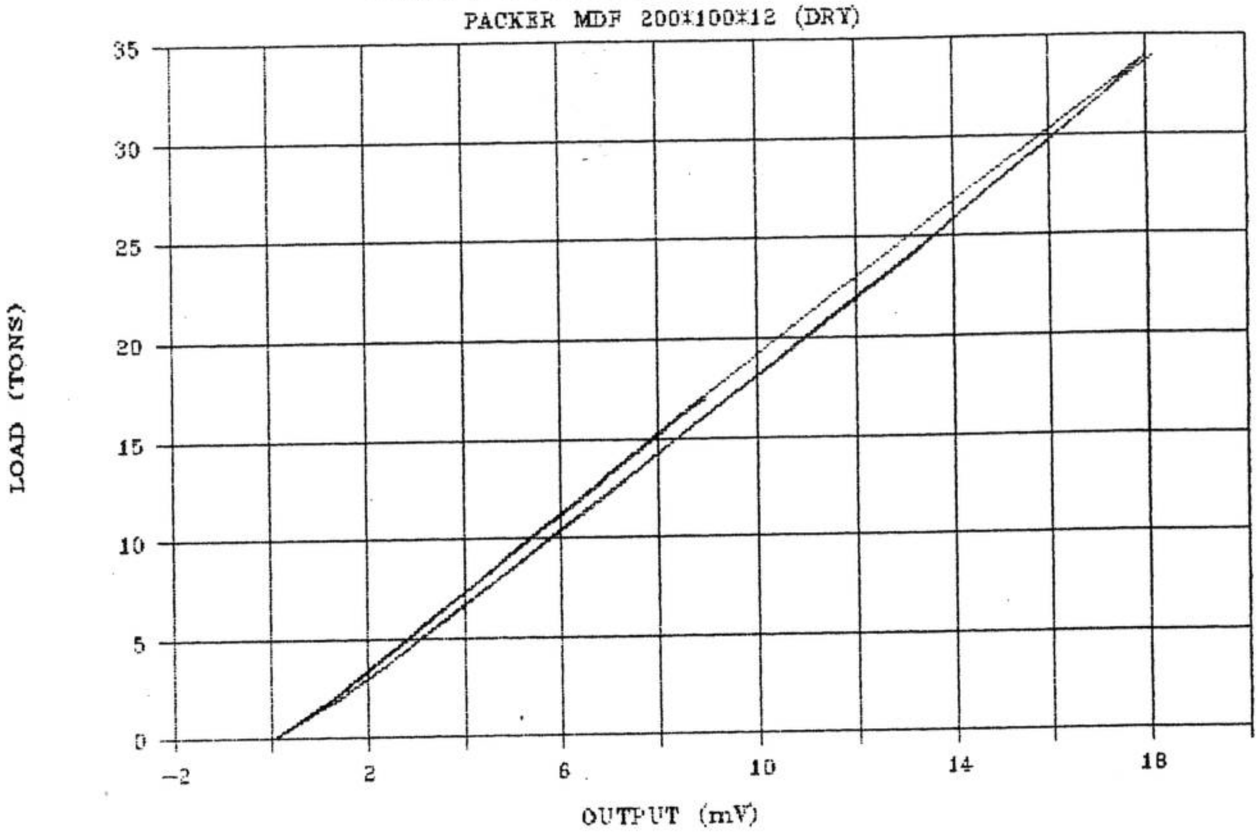
Constant	-0.76351
Std Err of Y Est	0.165059
R Squared	0.998964
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.627982
Std Err of Coef.	0.006355

9537 HIGH STRESS CYCLING

Regression Output:

Constant	-1.13145
Std Err of Y Est	0.310013
R Squared	0.999086
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.724968
Std Err of Coef.	0.006323

GLOTZL CELL 9538 (SITE 4)



9538 LOW STRESS CYCLING

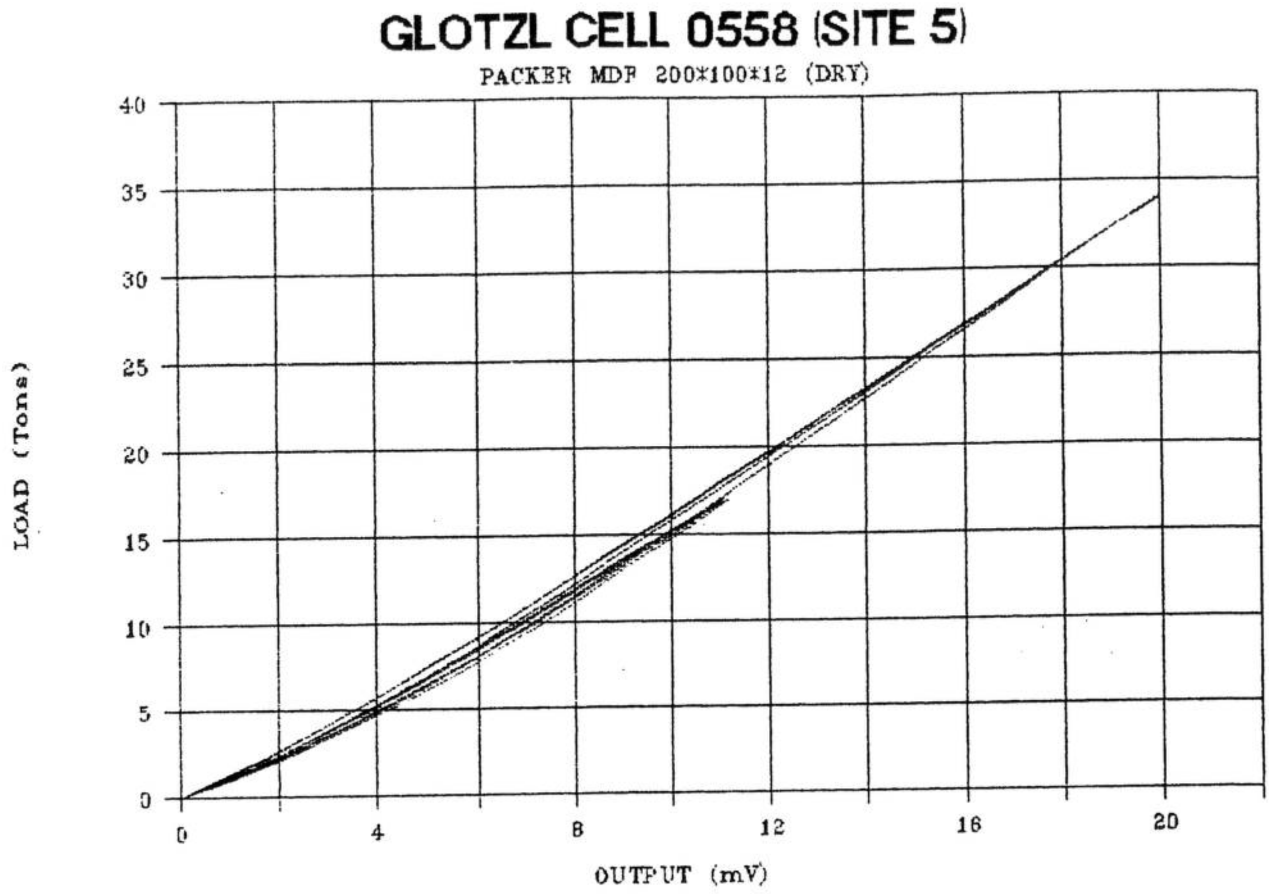
Regression Output:	
Constant	-0.42216
Std Err of Y Est	0.099661
R Squared	0.999622
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.941498
Std Err of Coef.	0.004575

9538 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.67481
Std Err of Y Est	0.382724
R Squared	0.998608
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.907383
Std Err of Coef.	0.008634



0558 LOW STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

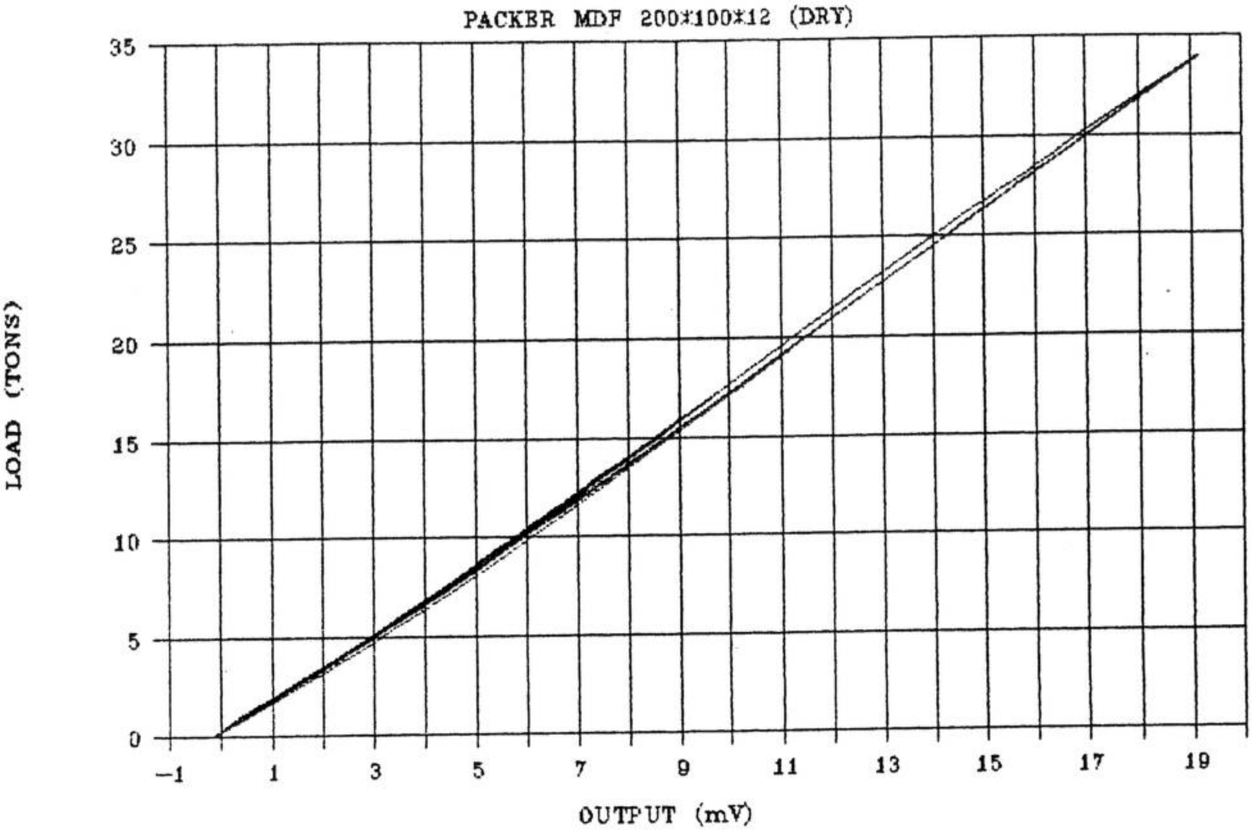
Constant	-1.85805
Std Err of Y Est	0.286065
R Squared	0.993985
No. of Observations	50
Degrees of Freedom	48
X Coefficient(s)	1.682429
Std Err of Coef.	0.018889

0558 HIGH STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-2.08534
Std Err of Y Est	0.341367
R Squared	0.998398
No. of Observations	58
Degrees of Freedom	56
X Coefficient(s)	1.800776
Std Err of Coef.	0.009638

FIGURE III 138

GLOTZL CELL 0559 (SITE 5)



0559 LOW STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-0.50279
Std Err of Y Est	0.076659
R Squared	0.999568
No. of Observations	50
Degrees of Freedom	48

X Coefficient(s)	1.812626
Std Err of Coef.	0.005438

0559 HIGH STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

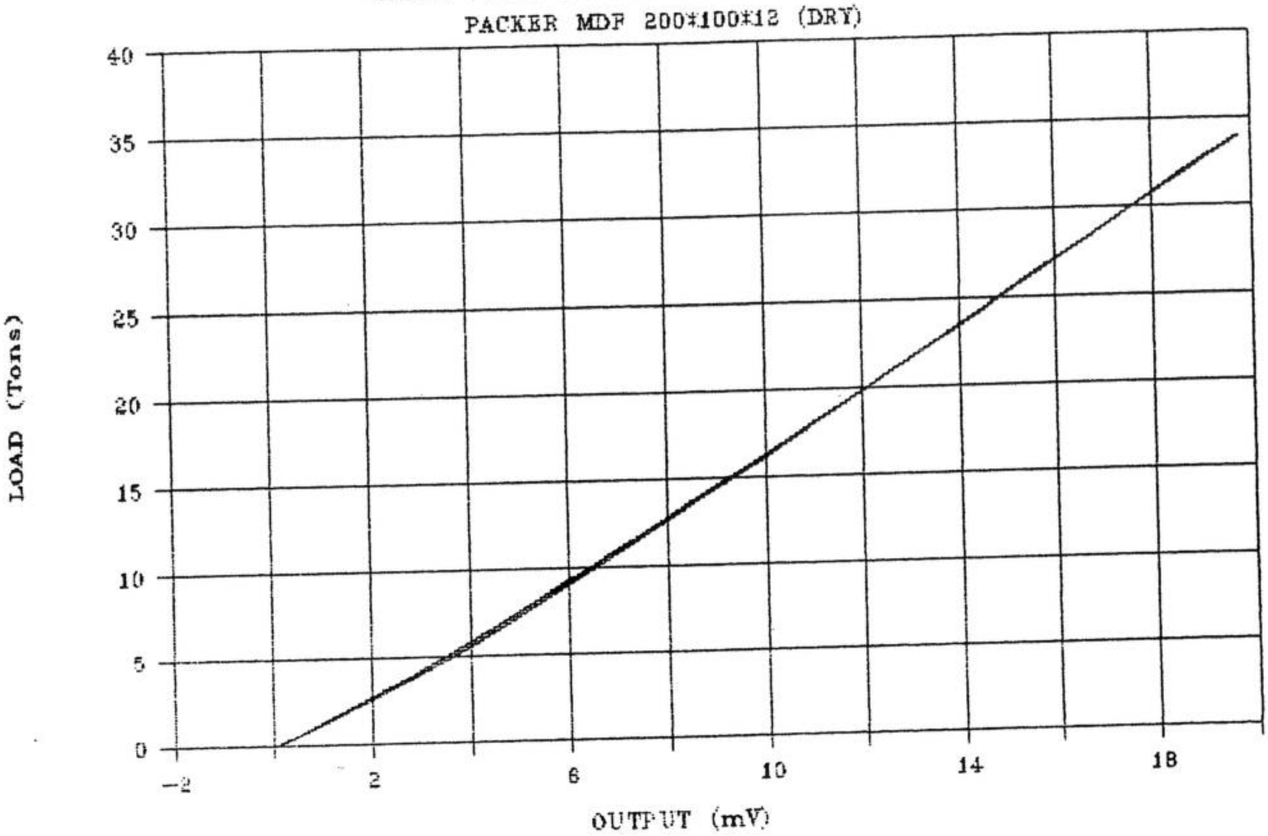
Constant	-0.80596
Std Err of Y Est	0.170283
R Squared	0.999601
No. of Observations	58
Degrees of Freedom	56

X Coefficient(s)	1.816495
Std Err of Coef.	0.004846

FIGURE III.13

GLOTZL CELL 0560 (SITE 5)

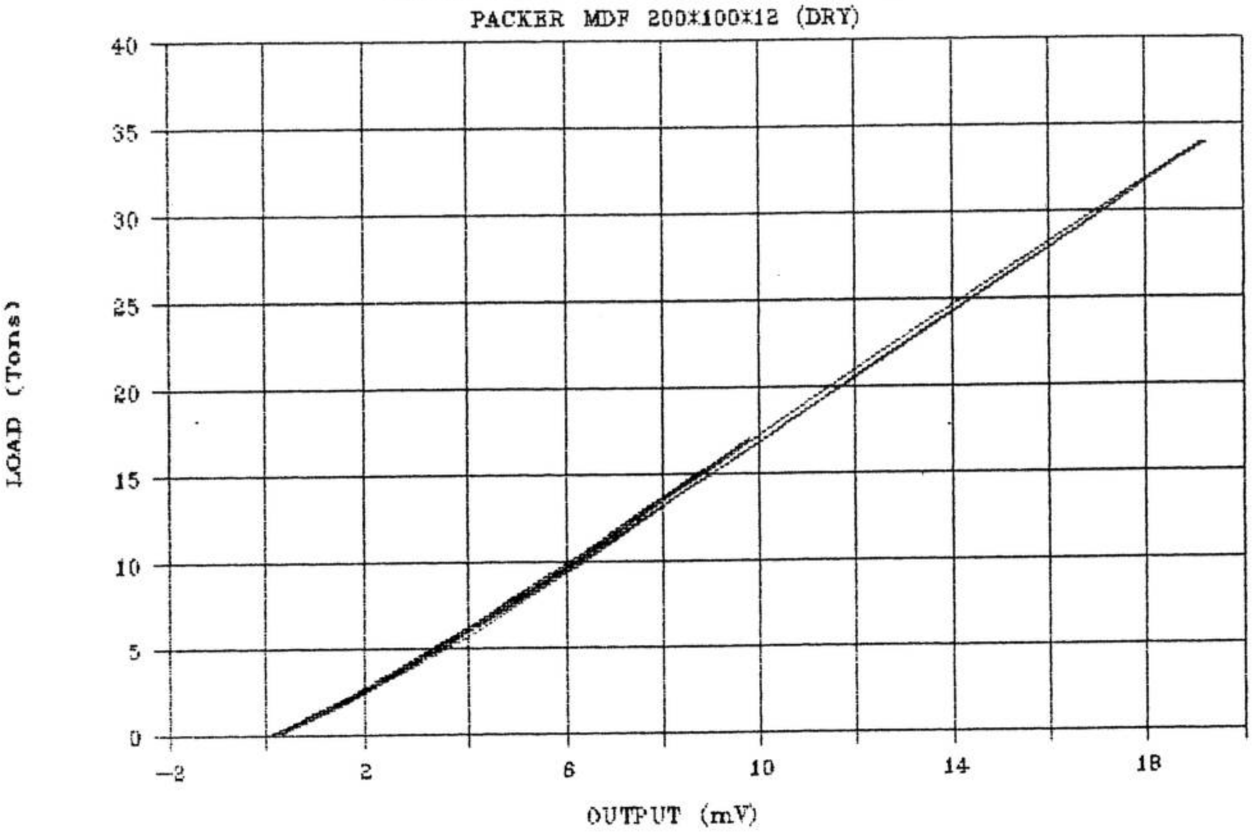
PACKER MDF 200*100*12 (DRY)




```
  0560    LOW STRESS CYCLING
(initial 4 Tons not considered)
          Regression Output:
Constant                      -1.31200
Std Err of Y Est              0.092272
R Squared                     0.999374
No. of Observations                 50
Degrees of Freedom                  48

X Coefficient(s)  1.751439
Std Err of Coef.  0.006325
```

```
  0560    HIGH STRESS CYCLING
(initial 4 Tons not considered)
          Regression Output:
Constant                      -1.67671
Std Err of Y Est              0.102395
R Squared                     0.999855
No. of Observations                 58
Degrees of Freedom                  56

X Coefficient(s)  1.800560
Std Err of Coef.  0.002888
```

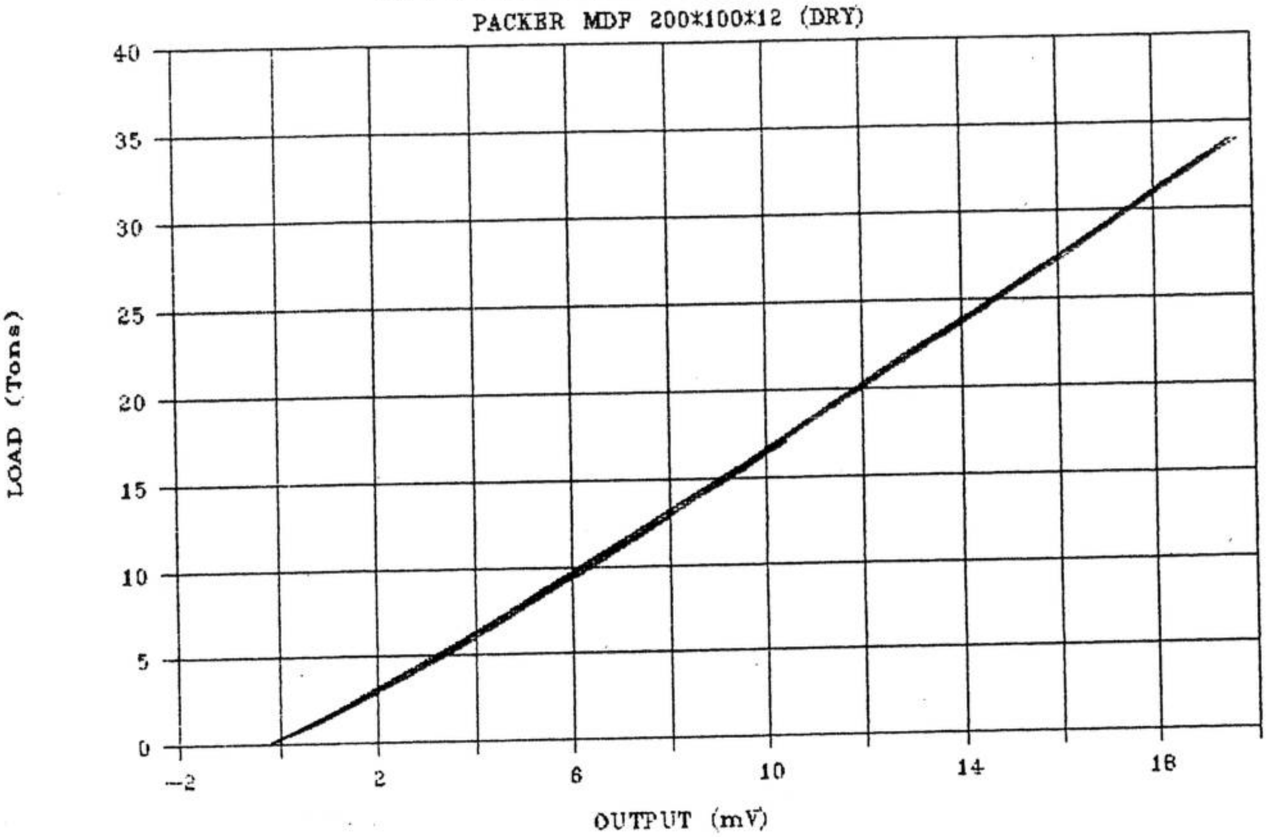
GLOTZL CELL 0561 (SITE 5)




```
 0561    LOW STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                        -1.33397
Std Err of Y Est                0.111457
R Squared                       0.999087
No. of Observations                   50
Degrees of Freedom                    48

X Coefficient(s)   1.859233
Std Err of Coef.   0.008112
```

```
 0561    HIGH STRESS CYCLING
(initial 4 Tons not considered)
         Regression Output:
Constant                        -1.63236
Std Err of Y Est                0.148327
R Squared                       0.999697
No. of Observations                   58
Degrees of Freedom                    56

X Coefficient(s)   1.855175
Std Err of Coef.   0.004311
```

GLOTZL CELL 0562 (SITE 5)



0562 LOW STRESS CYCLING
(initial 4 Tons not considered)

Regression Output:

Constant	-0.72480
Std Err of Y Est	0.117293
R Squared	0.998988
No. of Observations	50
Degrees of Freedom	48
X Coefficient(s)	1.703678
Std Err of Coef.	0.007823

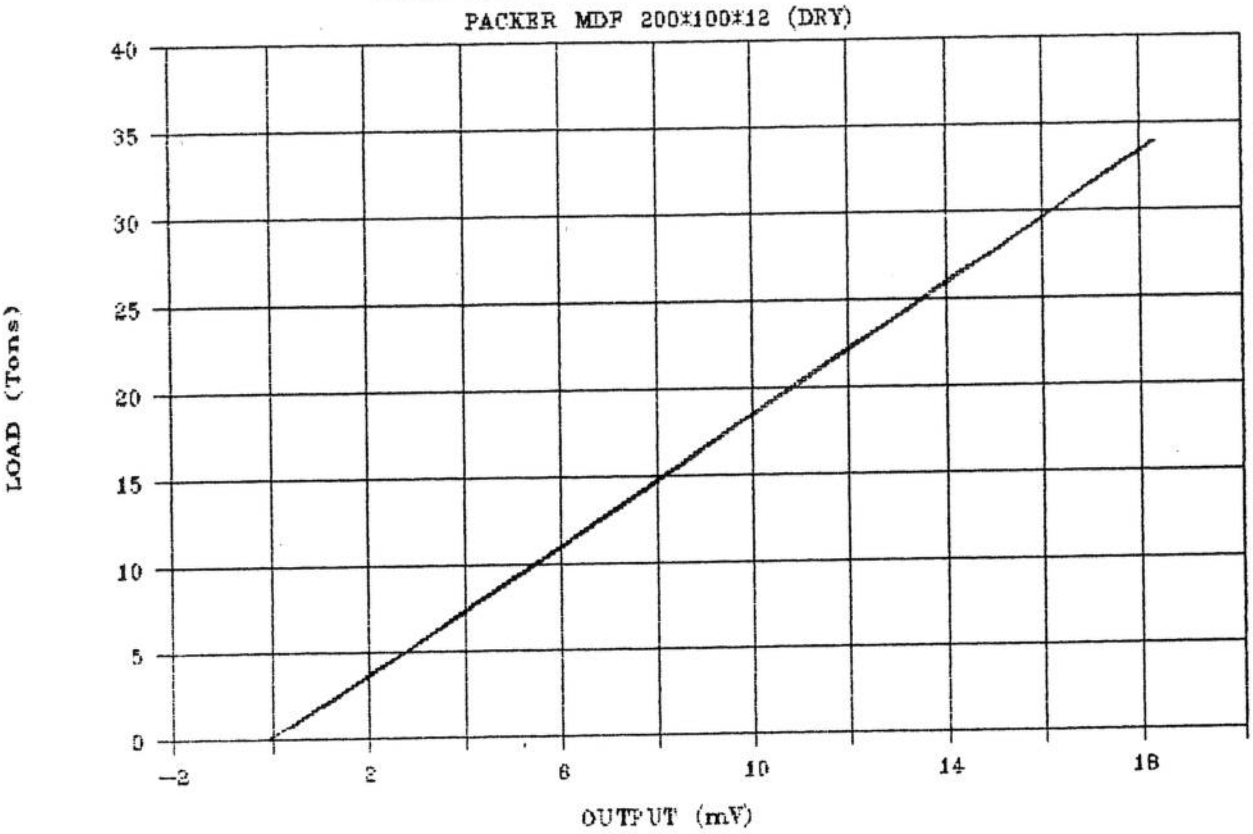
0562 HIGH STRESS CYCLING
(initial 4 Tons not considered)

Regression Output:

Constant	-1.10215
Std Err of Y Est	0.164392
R Squared	0.999628
No. of Observations	58
Degrees of Freedom	56
X Coefficient(s)	1.778644
Std Err of Coef.	0.004581

FIGURE III 142

GLOTZL CELL 0563 (SITE 5)



0563 LOW STRESS CYCLING

Regression Output:

Constant	0.074306
Std Err of Y Est	0.050181
R Squared	0.999904
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.827545
Std Err of Coef.	0.002168

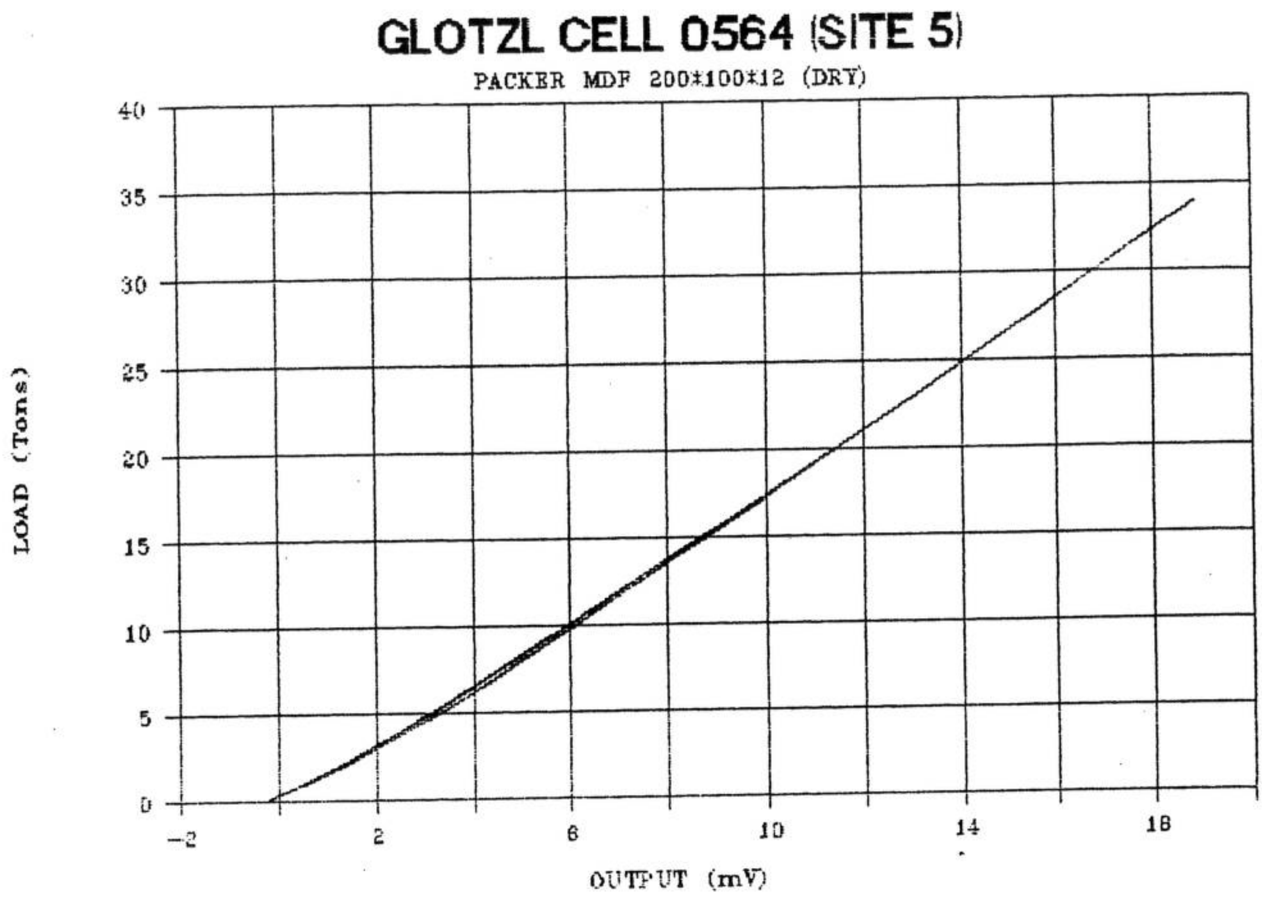
0563 HIGH STRESS CYCLING

Regression Output:

Constant	-0.08580
Std Err of Y Est	0.103488
R Squared	0.999898
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.855590
Std Err of Coef.	0.002269

FIGURE II14

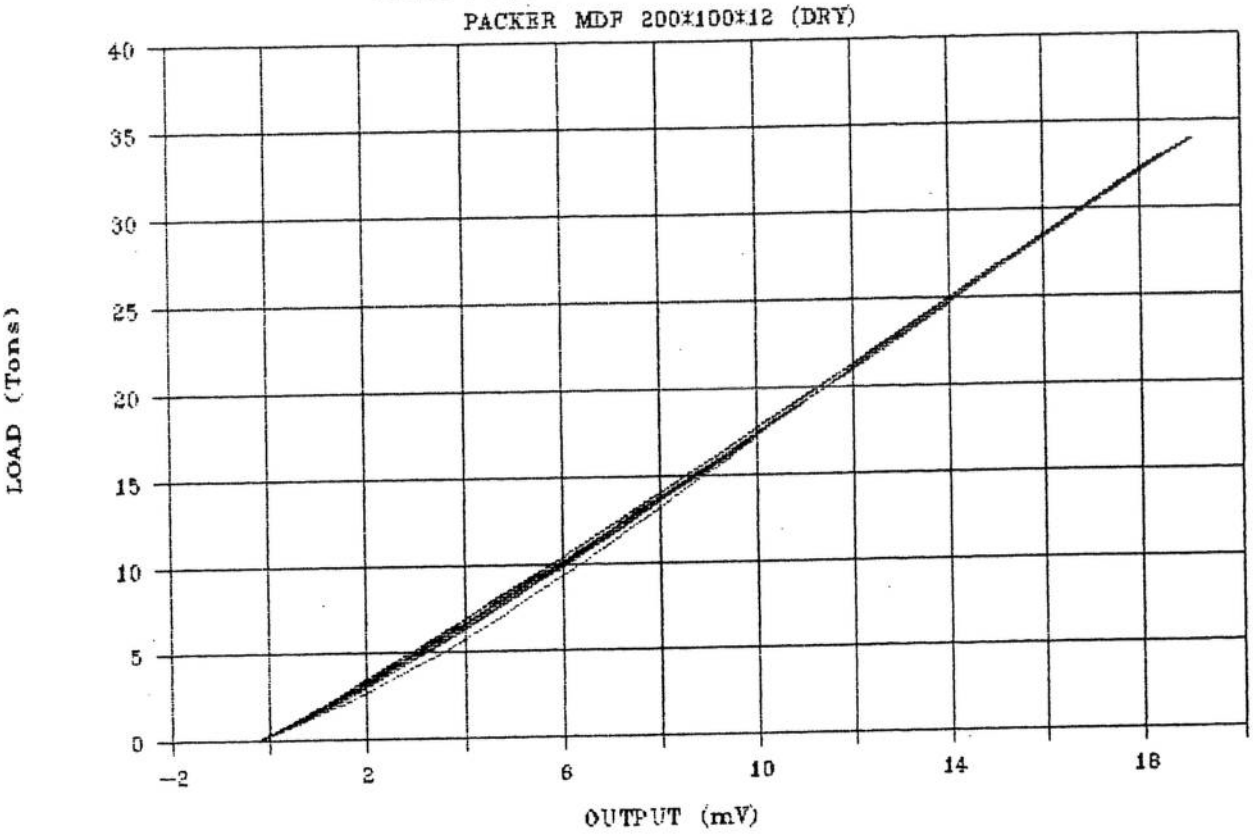



```
  0564    LOW STRESS CYCLING
(initial 4 Tons not considered)
          Regression Output:
Constant                        -0.93026
Std Err of Y Est                0.131159
R Squared                       0.998735
No. of Observations                   50
Degrees of Freedom                    48

X Coefficient(s)  1.814452
Std Err of Coef.  0.009318
```

```
  0564    HIGH STRESS CYCLING
(initial 4 Tons not considered)
          Regression Output:
Constant                        -1.17214
Std Err of Y Est                0.110924
R Squared                       0.999830
No. of Observations                   58
Degrees of Freedom                    56

X Coefficient(s)  1.859420
Std Err of Coef.  0.003231
```

FIGURE III 144

GLOTZL CELL 0565 (SITE 5)



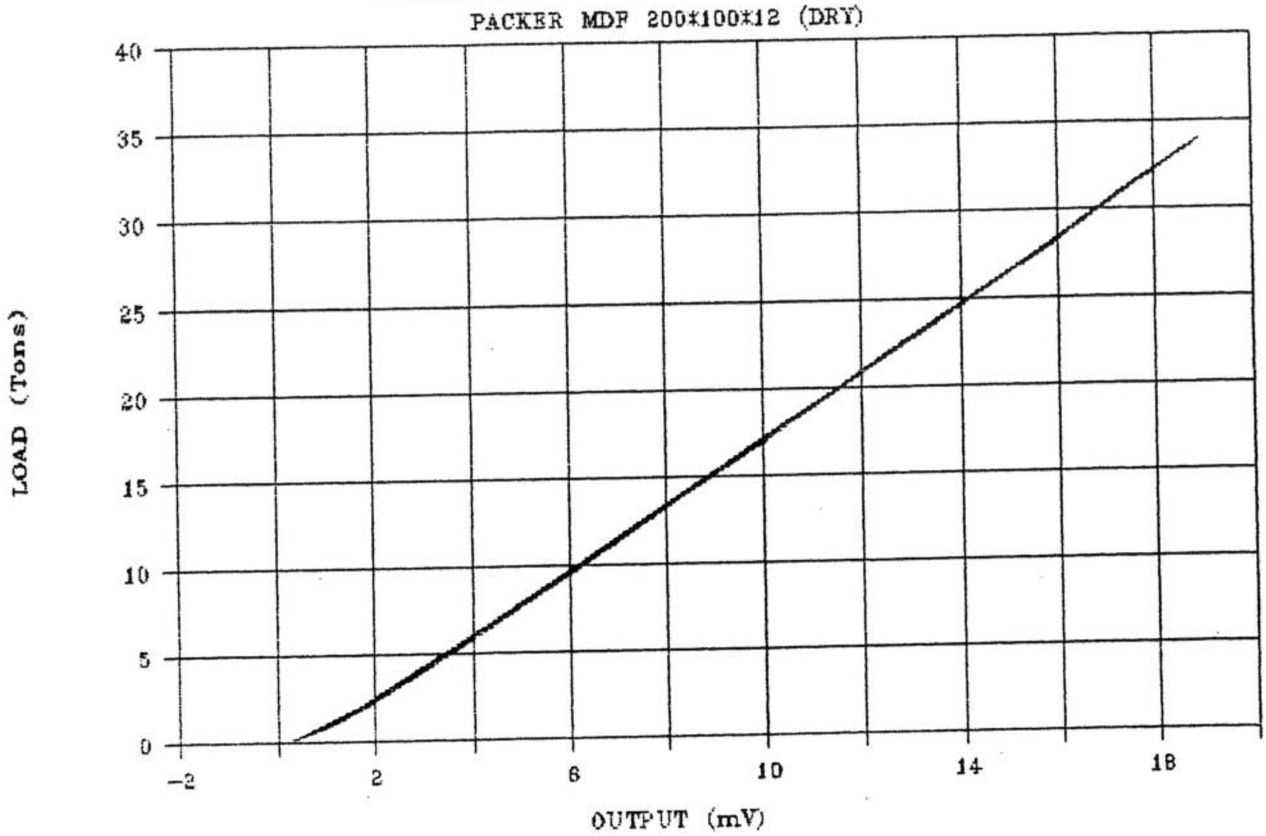
0565 LOW STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-0.79013
Std Err of Y Est	0.324287
R Squared	0.992271
No. of Observations	50
Degrees of Freedom	48
X Coefficient(s)	1.790474
Std Err of Coef.	0.022807

0565 HIGH STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-0.69106
Std Err of Y Est	0.168037
R Squared	0.999611
No. of Observations	58
Degrees of Freedom	56
X Coefficient(s)	1.824857
Std Err of Coef.	0.004804

GLOTZL CELL 0566 (SITE 5)



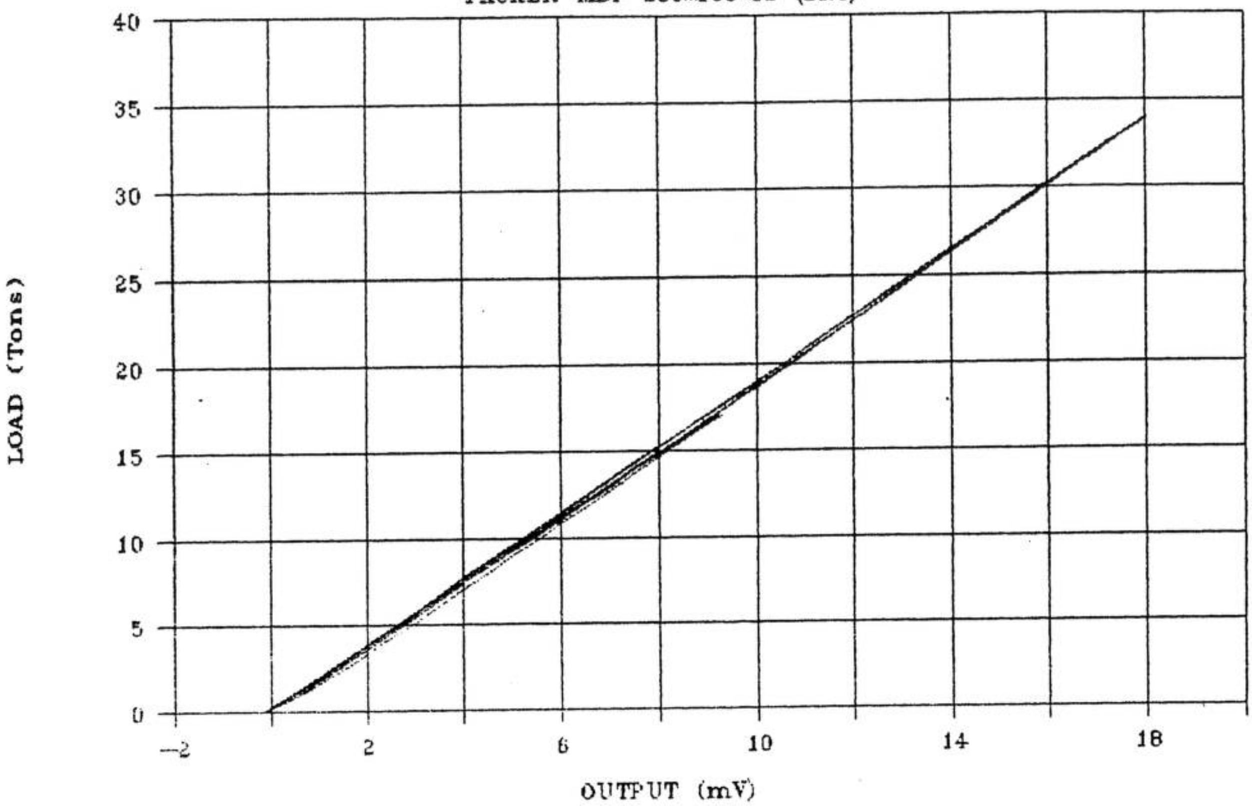

```
 0566   LOW STRESS CYCLING
(initial 4 Tons not considered)
        Regression Output:
Constant                        -1.46918
Std Err of Y Est                0.067699
R Squared                       0.999663
No. of Observations                   50
Degrees of Freedom                    48

X Coefficient(s)  1.844622
Std Err of Coef.  0.004887
```

```
 0566   HIGH STRESS CYCLING
(initial 4 Tons not considered)
        Regression Output:
Constant                        -1.67023
Std Err of Y Est                0.095649
R Squared                       0.999874
No. of Observations                   58
Degrees of Freedom                    56

X Coefficient(s)  1.881782
Std Err of Coef.  0.002819
```

FIGURE II146

GLOTZL CELL 0567 (SITE 5)

PACKER MDF 200*100*12 (DRY)



0567 LOW STRESS CYCLING

Regression Output:

Constant	0.049450
Std Err of Y Est	0.171730
R Squared	0.998879
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s) 1.837693
Std Err of Coef. 0.007464

0567 HIGH STRESS CYCLING

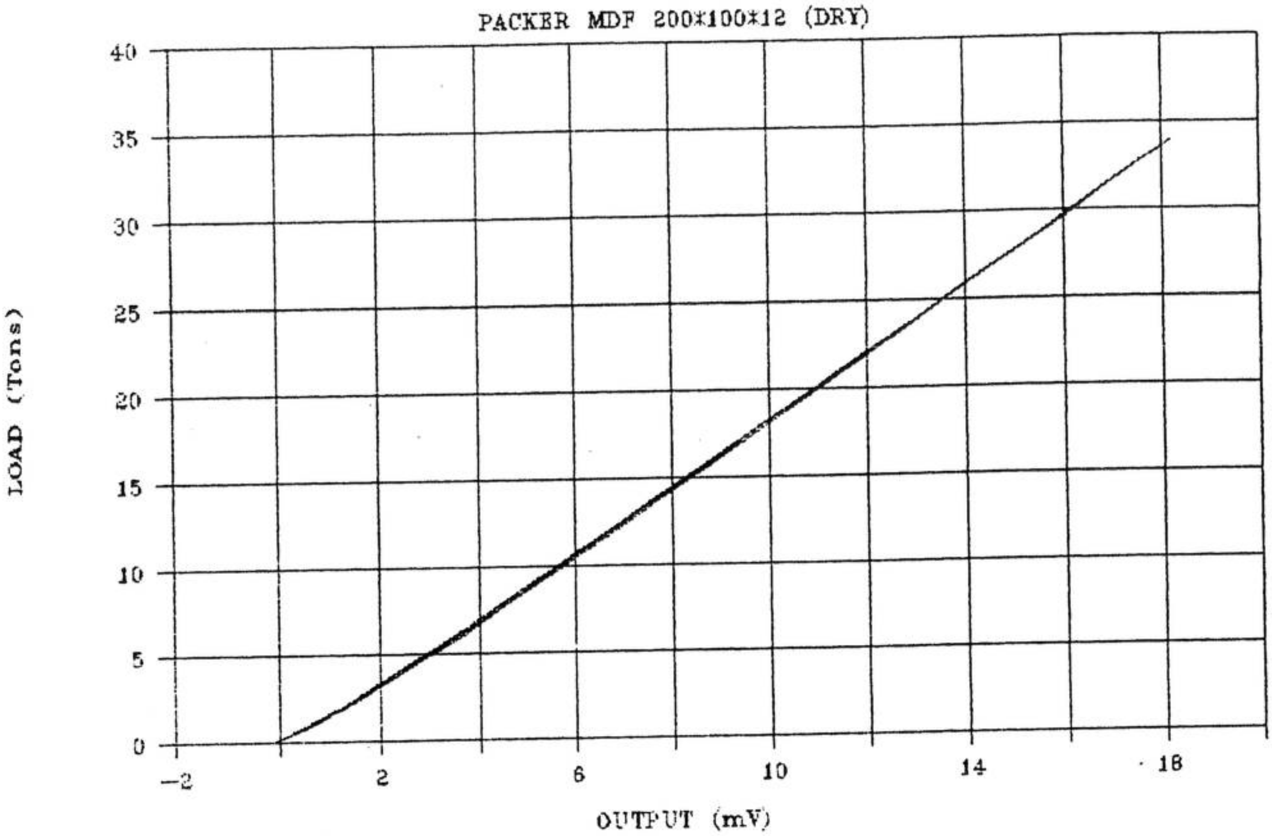
Regression Output:

Constant	0.039636
Std Err of Y Est	0.137828
R Squared	0.999819
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s) 1.881591
Std Err of Coef. 0.003065

FIGURE III14

GLOTZL CELL 0568 (SITE 5)



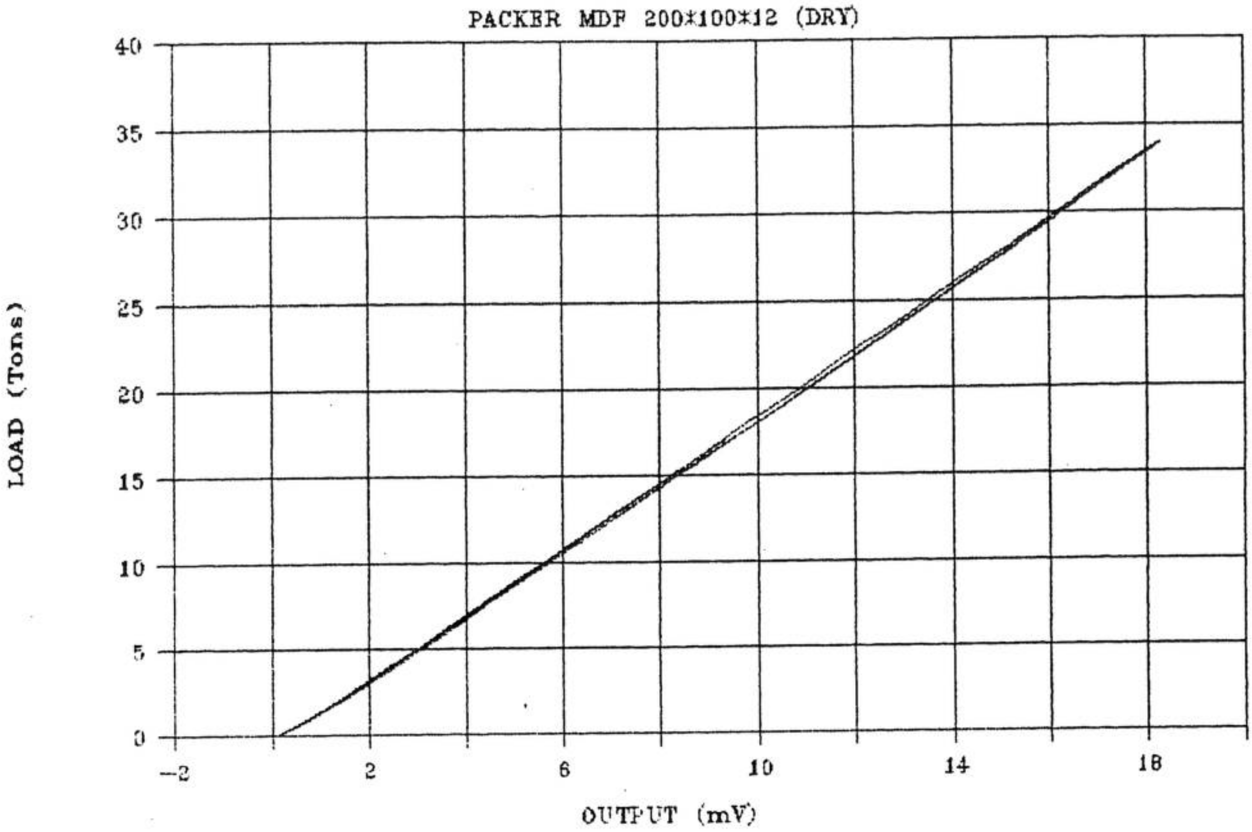
0568 LOW STRESS CYCLING

Regression Output:		
Constant		-0.25258
Std Err of Y Est		0.143476
R Squared		0.999217
No. of Observations		70
Degrees of Freedom		68
X Coefficient(s)	1.819817	
Std Err of Coef.	0.006174	

0568 HIGH STRESS CYCLING

Regression Output:		
Constant		-0.48006
Std Err of Y Est		0.227226
R Squared		0.999509
No. of Observations		70
Degrees of Freedom		68
X Coefficient(s)	1.880025	
Std Err of Coef.	0.005050	

GLOTZL CELL 0570 (SITE 5)



0570 LOW STRESS CYCLING

Regression Output:

Constant	-0.45793
Std Err of Y Est	0.078686
R Squared	0.999764
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.862304
Std Err of Coef.	0.003464

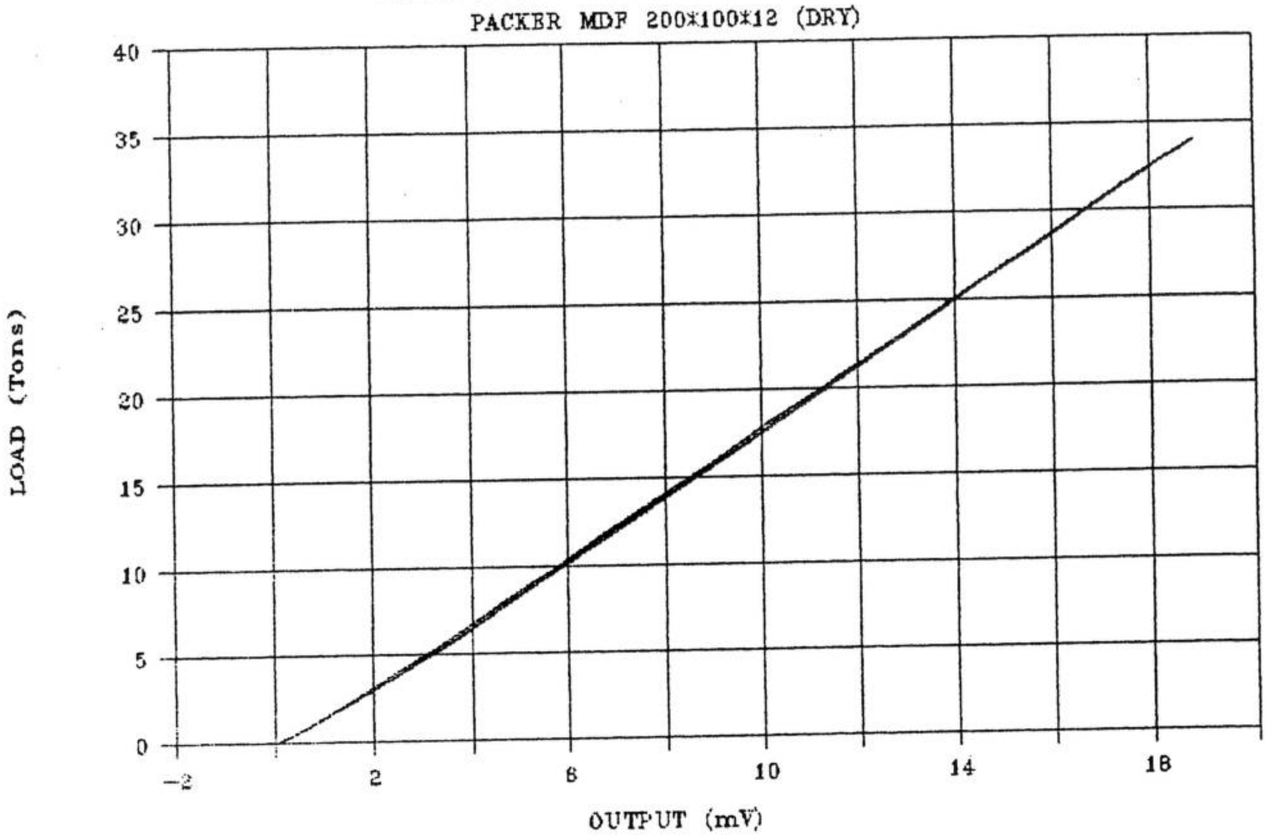
0570 HIGH STRESS CYCLING

Regression Output:

Constant	-0.66916
Std Err of Y Est	0.170024
R Squared	0.999725
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.885639
Std Err of Coef.	0.003790

GLOTZL CELL 0572 (SITE 5)



0572 LOW STRESS CYCLING
(initial 4 Tons not considered)

Regression Output:

Constant	-0.59898
Std Err of Y Est	0.093802
R Squared	0.999353
No. of Observations	50
Degrees of Freedom	48

X Coefficient(s)	1.806114
Std Err of Coef.	0.006631

0572 HIGH STRESS CYCLING

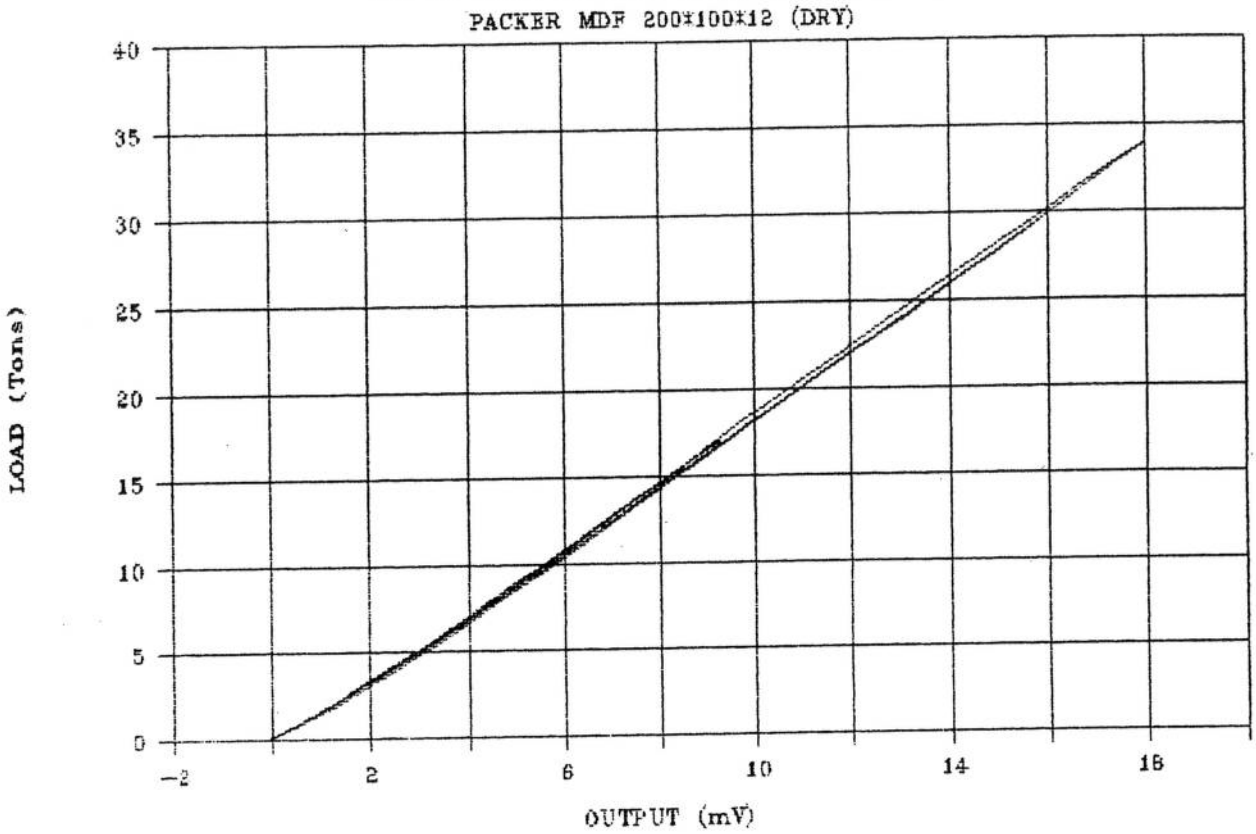
Regression Output:

Constant	-0.58631
Std Err of Y Est	0.162637
R Squared	0.999748
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.827441
Std Err of Coef.	0.003513

FIGURE III 150

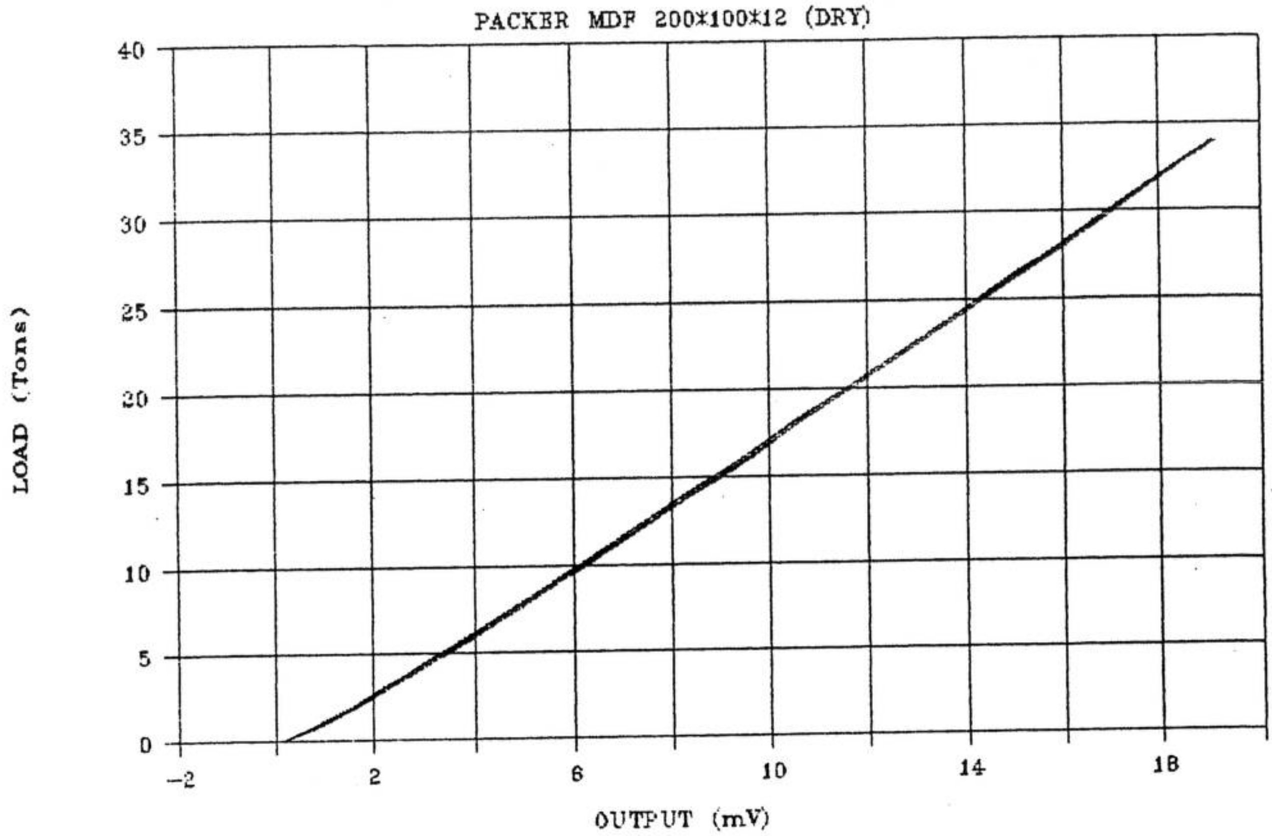
GLOTZL CELL 0574 (SITE 5)




```
  0574    LOW STRESS CYCLING
(initial 4 Tons not considered)
          Regression Output:
Constant                        -0.67114
Std Err of Y Est                0.057410
R Squared                       0.999757
No. of Observations                   50
Degrees of Freedom                    48

X Coefficient(s)  1.914161
Std Err of Coef.  0.004300
```

```
  0574    HIGH STRESS CYCLING
(initial 4 Tons not considered)
          Regression Output:
Constant                        -1.06465
Std Err of Y Est                0.174871
R Squared                       0.999579
No. of Observations                   58
Degrees of Freedom                    56

X Coefficient(s)  1.940305
Std Err of Coef.  0.005316
```

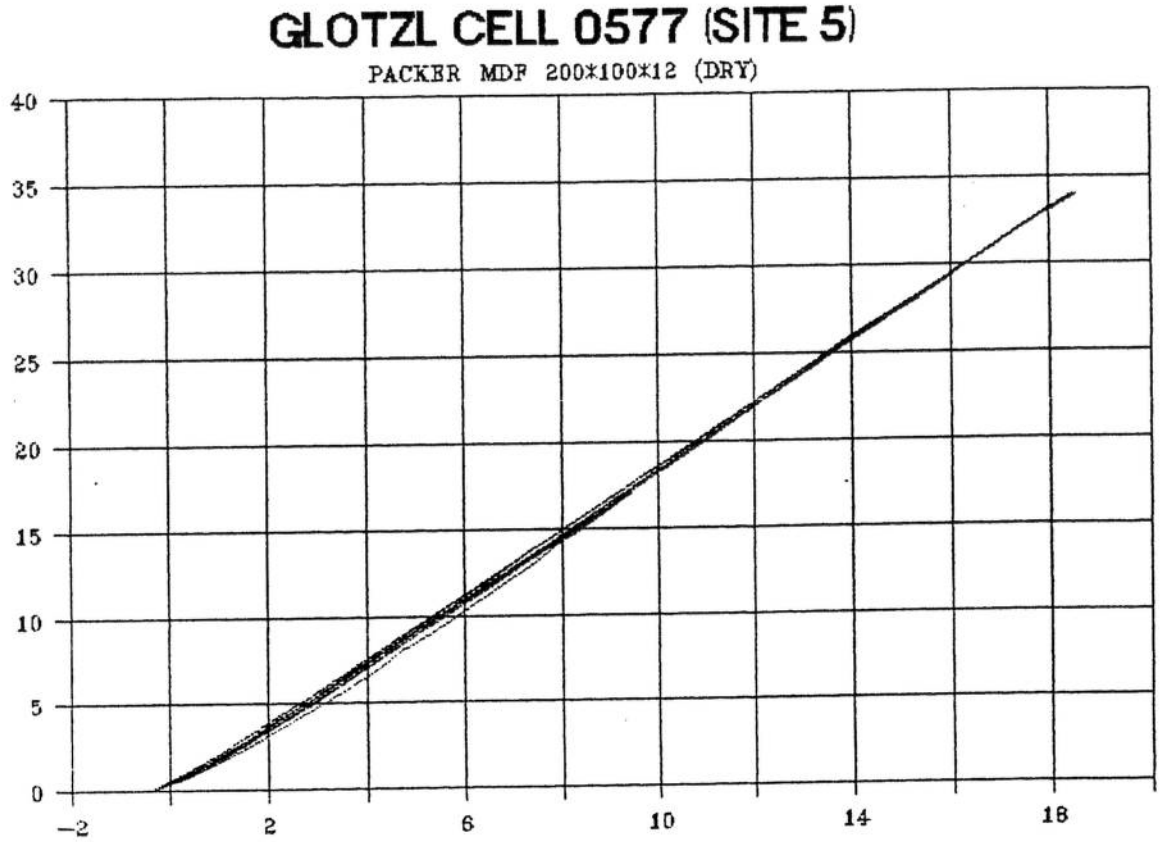
GLOTZL CELL 0575 (SITE 5)




```
 0575   LOW STRESS CYCLING
(initial 4 Tons not considered)
        Regression Output:
Constant                      -1.11820
Std Err of Y Est              0.064621
R Squared                     0.999693
No. of Observations                 50
Degrees of Freedom                  48

X Coefficient(s)   1.792043
Std Err of Coef.   0.004532
```

```
 0575   HIGH STRESS CYCLING
(initial 4 Tons not considered)
        Regression Output:
Constant                      -1.38127
Std Err of Y Est              0.124987
R Squared                     0.999785
No. of Observations                 58
Degrees of Freedom                  56

X Coefficient(s)   1.845638
Std Err of Coef.   0.003614
```

FIGURE II152



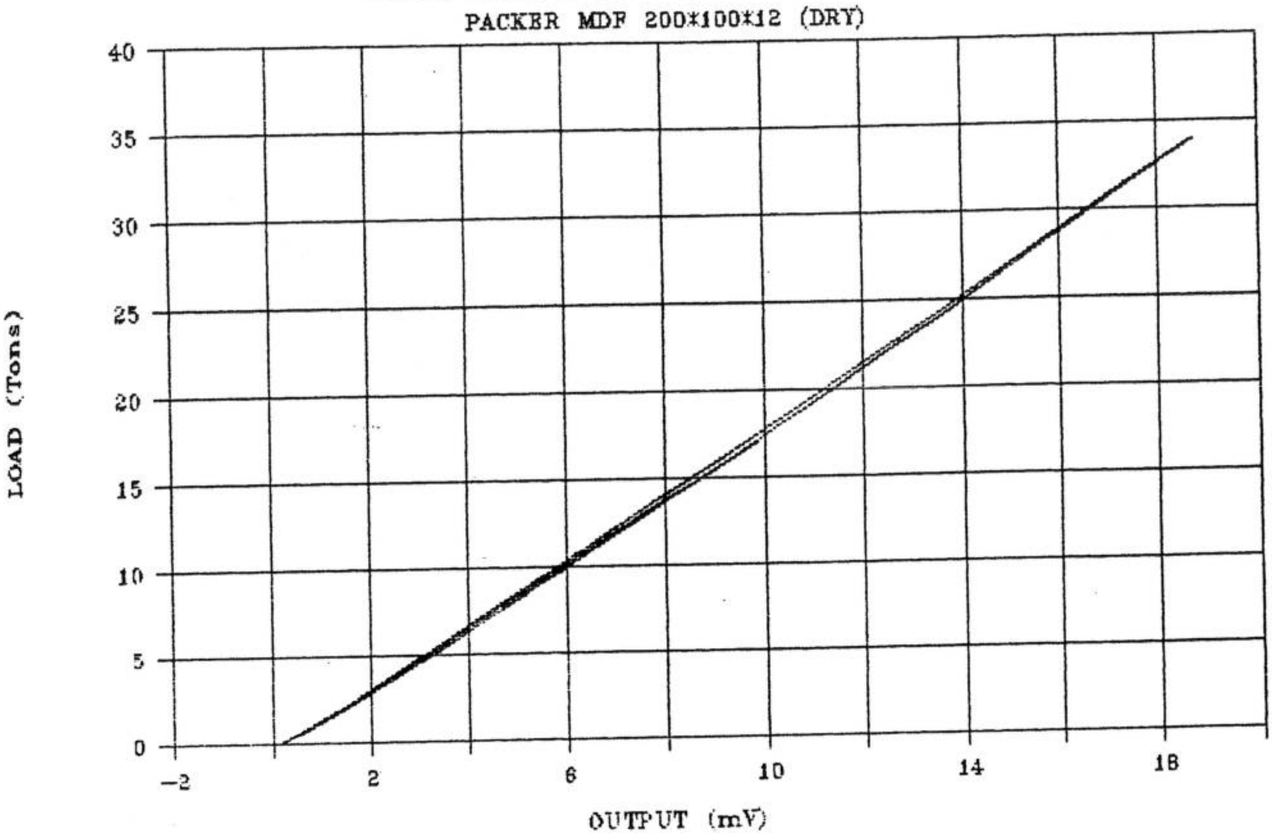
0577 LOW STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-0.24283
Std Err of Y Est	0.245717
R Squared	0.995562
No. of Observations	50
Degrees of Freedom	48
X Coefficient(s)	1.831278
Std Err of Coef.	0.017646

0577 HIGH STRESS CYCLING
(initial 4 Tons not considered)
Regression Output:

Constant	-0.00313
Std Err of Y Est	0.151574
R Squared	0.999684
No. of Observations	58
Degrees of Freedom	56
X Coefficient(s)	1.841829
Std Err of Coef.	0.004374

GLOTZL CELL 0579 (SITE 5)



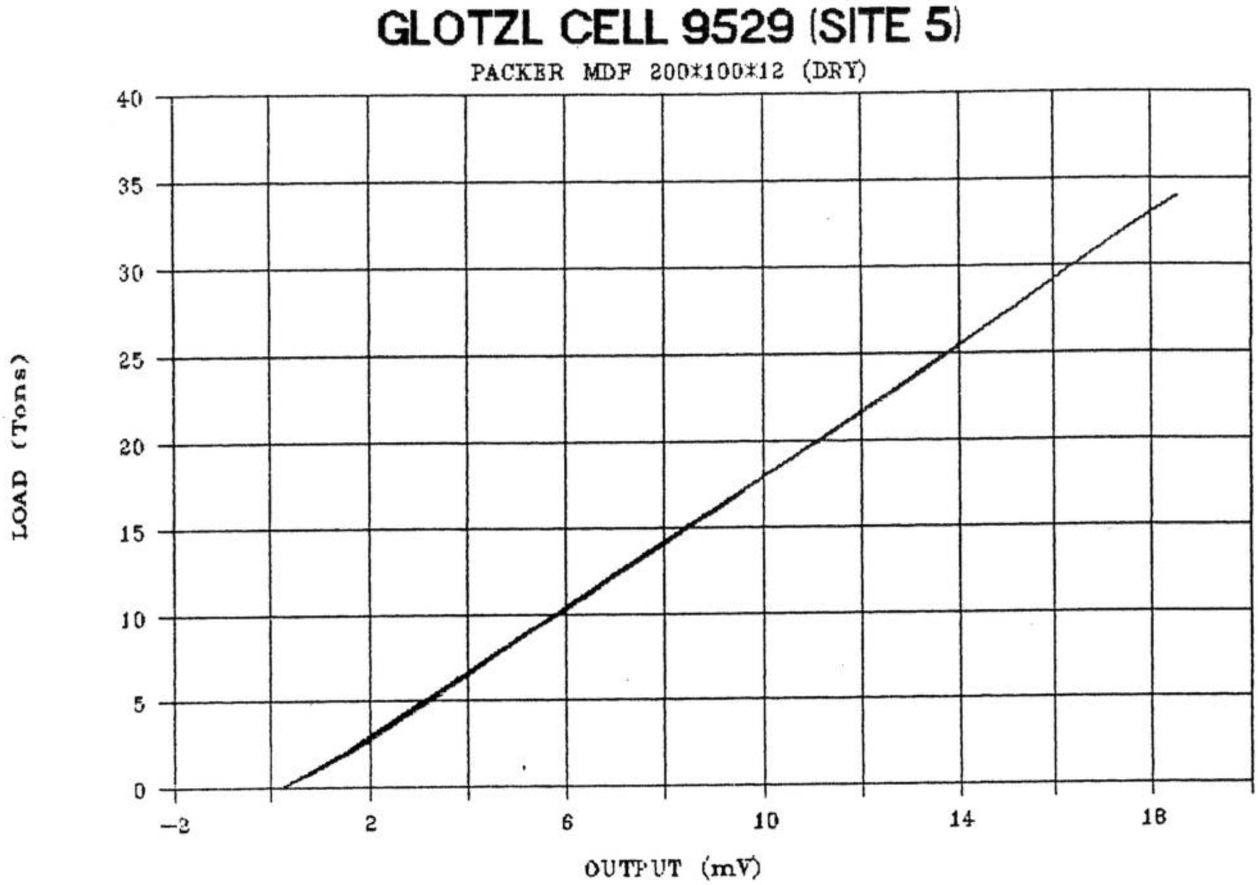
0579 LOW STRESS CYCLING

Regression Output:	
Constant	-0.57465
Std Err of Y Est	0.129505
R Squared	0.999362
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.777297
Std Err of Coef.	0.005442

0579 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.75120
Std Err of Y Est	0.207014
R Squared	0.999592
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.845113
Std Err of Coef.	0.004515

FIGURE III154



9529 LOW STRESS CYCLING

Regression Output:	
Constant	-0.70742
Std Err of Y Est	0.121923
R Squared	0.999435
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.839871
Std Err of Coef.	0.005304

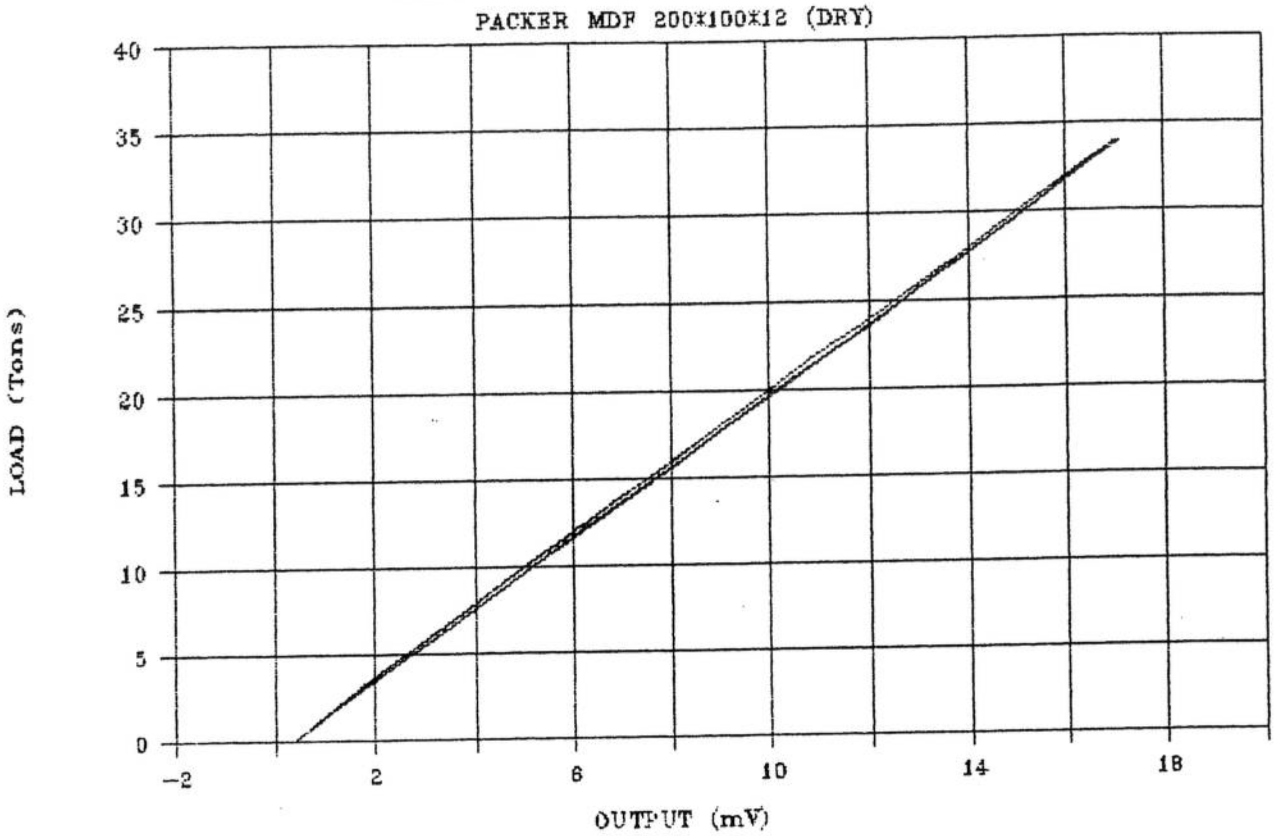
9529 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.77924
Std Err of Y Est	0.130374
R Squared	0.999838
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	1.872993
Std Err of Coef.	0.002886

FIGURE III 155

GLOTZL CELL 9531 (SITE 5)



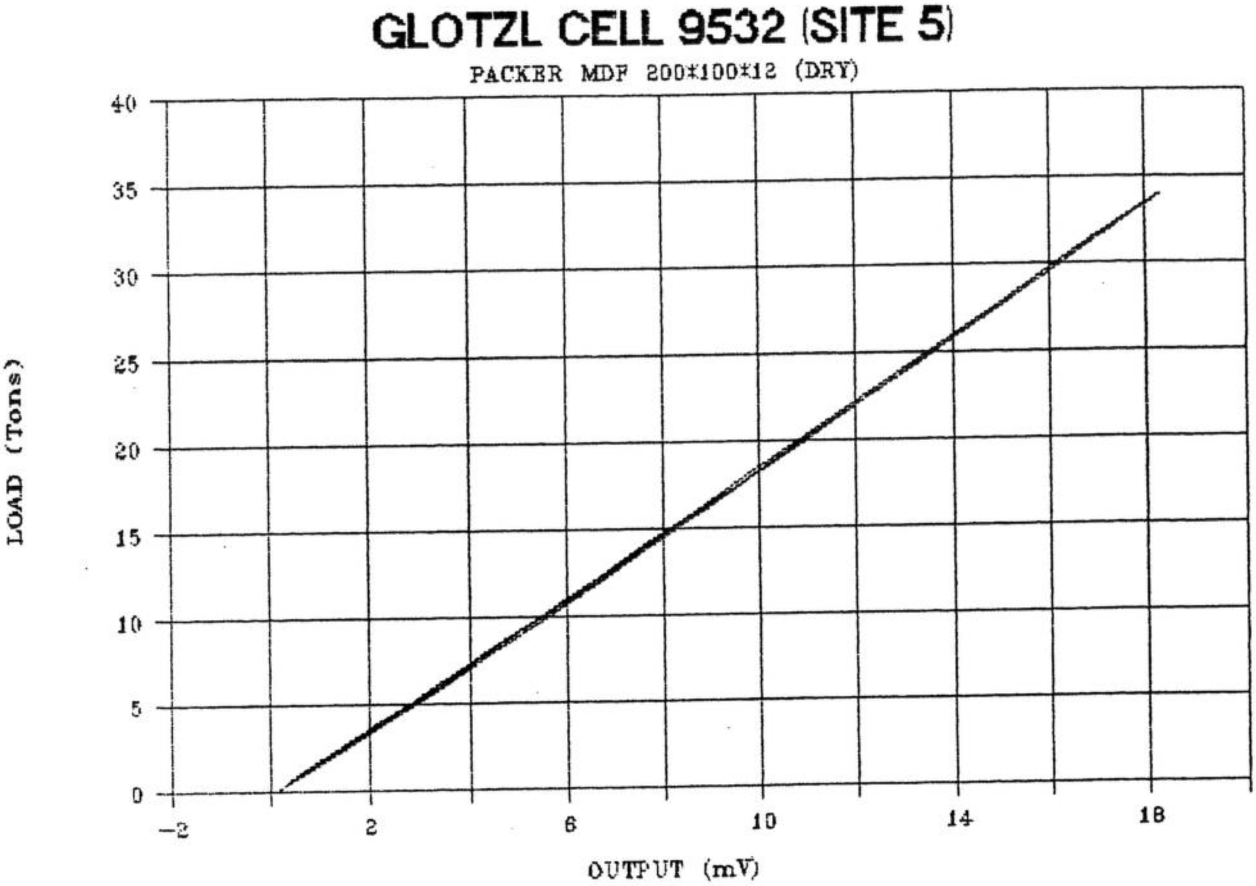
9531 LOW STRESS CYCLING

Regression Output:	
Constant	-0.50868
Std Err of Y Est	0.105930
R Squared	0.999573
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	2.075440
Std Err of Coef.	0.005198

9531 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.50647
Std Err of Y Est	0.156789
R Squared	0.999766
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	2.024233
Std Err of Coef.	0.003751

FIGURE III 156



9532 LOW STRESS CYCLING

Regression Output:

Constant	-0.18282
Std Err of Y Est	0.052674
R Squared	0.999894
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.860505
Std Err of Coef.	0.002316

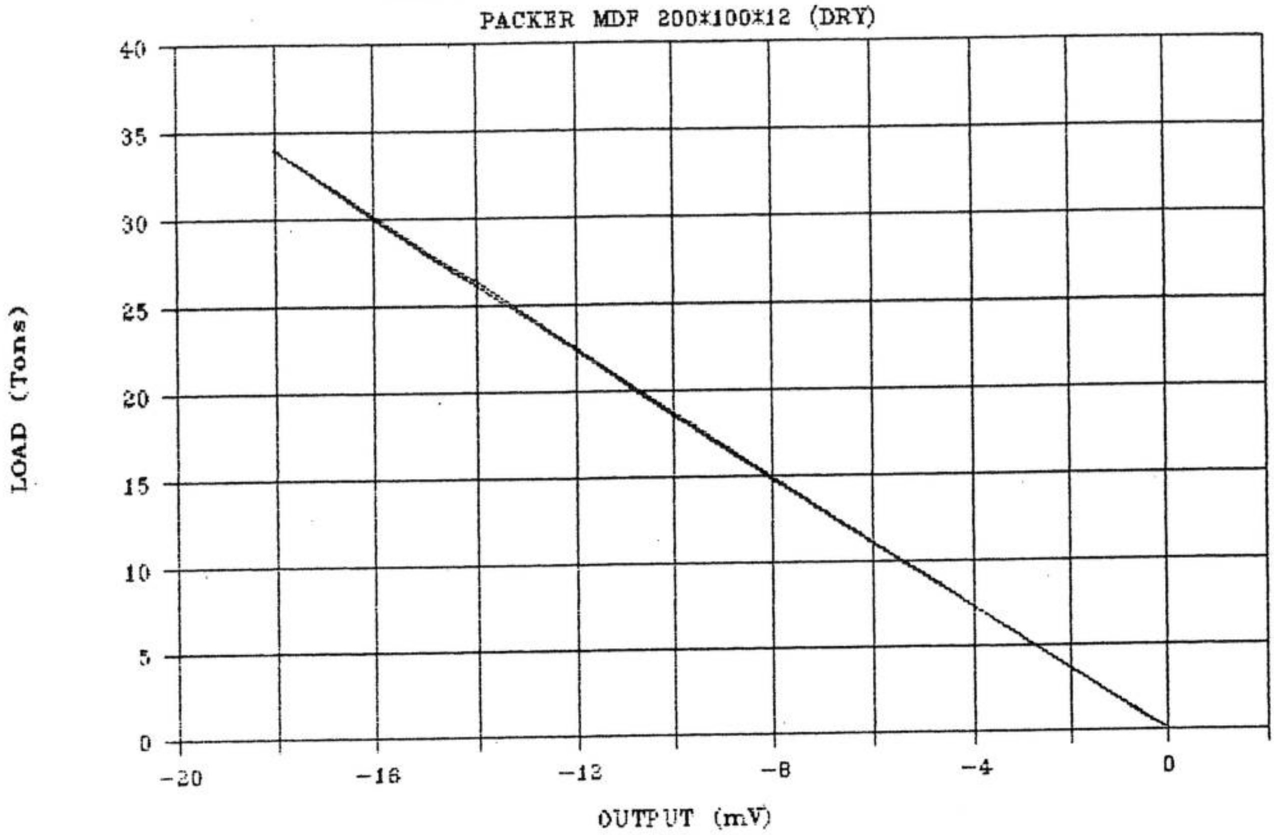
9532 HIGH STRESS CYCLING

Regression Output:

Constant	-0.37601
Std Err of Y Est	0.112043
R Squared	0.999880
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.873971
Std Err of Coef.	0.002481

FIGURE III 15

GLOTZL CELL 9535 (SITE 5)



9535 LOW STRESS CYCLING

Regression Output:

Constant	-0.03136
Std Err of Y Est	0.034187
R Squared	0.999955
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	-1.85463
Std Err of Coef.	0.001498

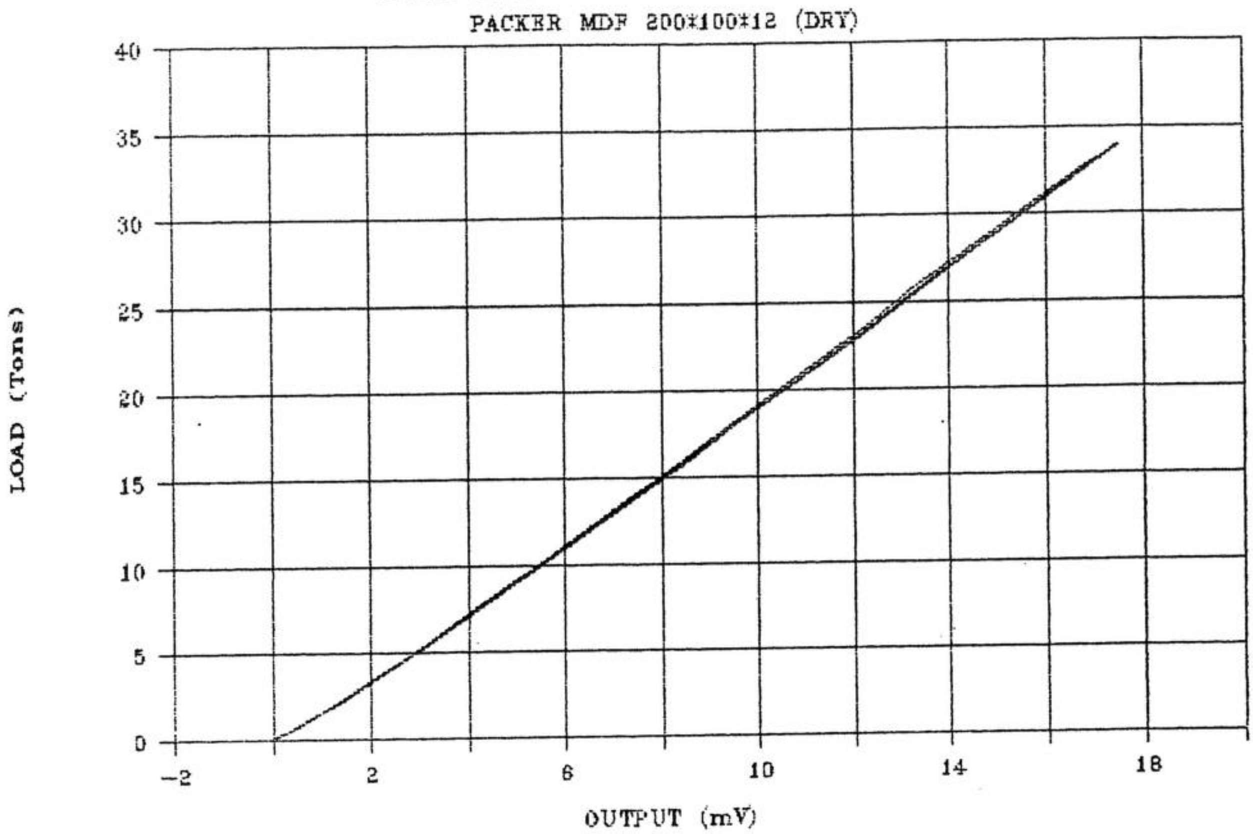
9535 HIGH STRESS CYCLING

Regression Output:

Constant	-0.17927
Std Err of Y Est	0.110828
R Squared	0.999883
No. of Observations	70
Degrees of Freedom	68

X Coefficient(s)	-1.88686
Std Err of Coef.	0.002471

GLOTZL CELL 9536 (SITE 5)



9536 LOW STRESS CYCLING

Regression Output:

Constant	-0.37476
Std Err of Y Est	0.146177
R Squared	0.999187
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.914875
Std Err of Coef.	0.006619

9536 HIGH STRESS CYCLING

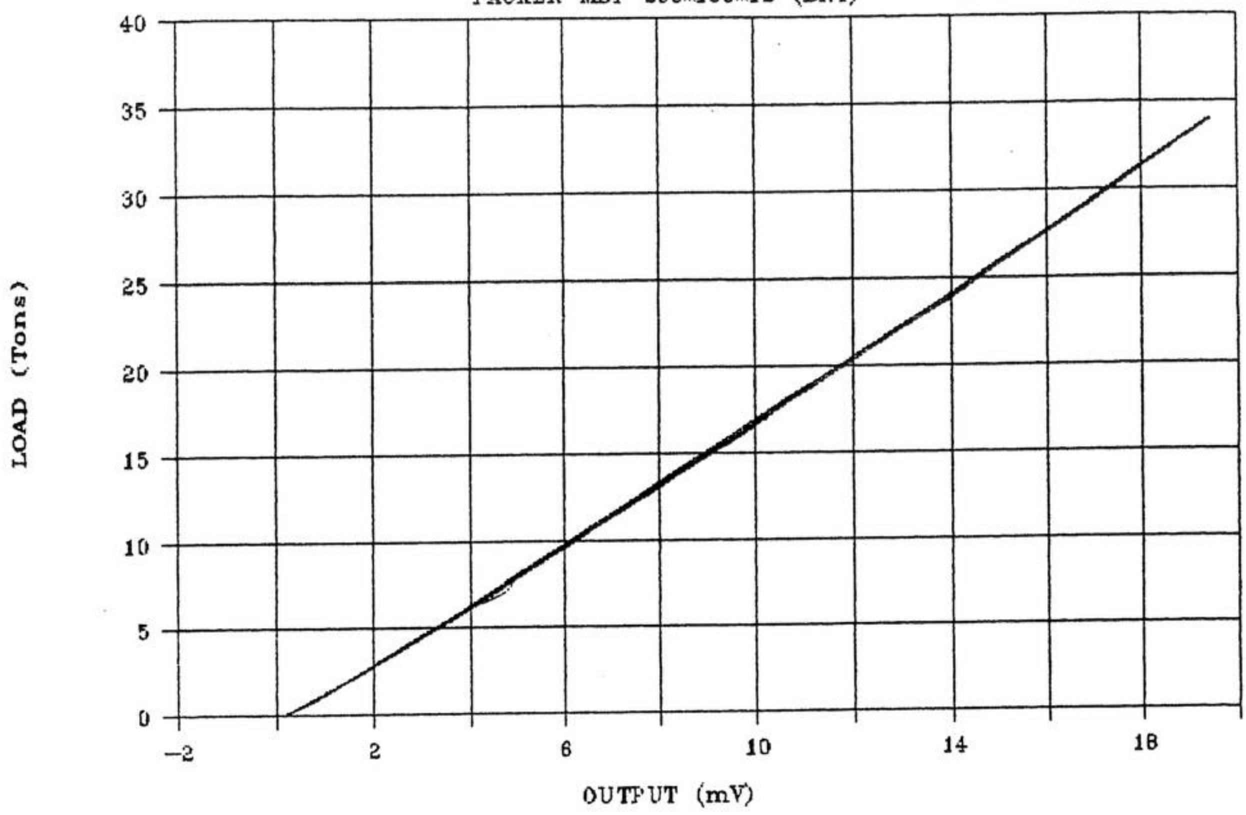
Regression Output:

Constant	-0.63053
Std Err of Y Est	0.225301
R Squared	0.999517
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.969624
Std Err of Coef.	0.005246

FIGURE III 15

GLOTZL CELL 9537 (SITE 5)

PACKER MDF 200*100*12 (DRY)



9537 LOW STRESS CYCLING

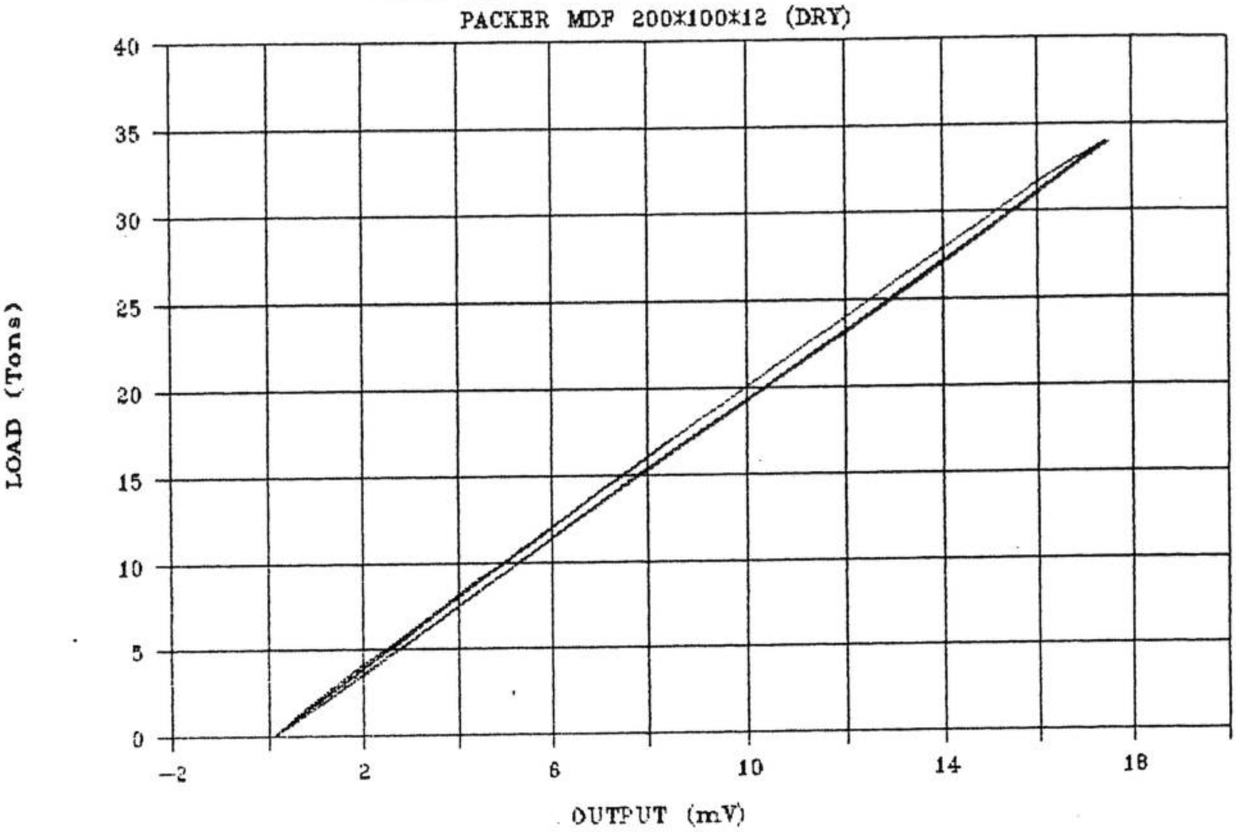
Regression Output:	
Constant	-0.55834
Std Err of Y Est	0.104688
R Squared	0.999583
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.701996
Std Err of Coef.	0.004213

9537 HIGH STRESS CYCLING

Regression Output:	
Constant	-0.80508
Std Err of Y Est	0.194030
R Squared	0.999642
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.776194
Std Err of Coef.	0.004074

FIGURE III 160

GLOTZL CELL 9538 (SITE 5)



9538 LOW STRESS CYCLING

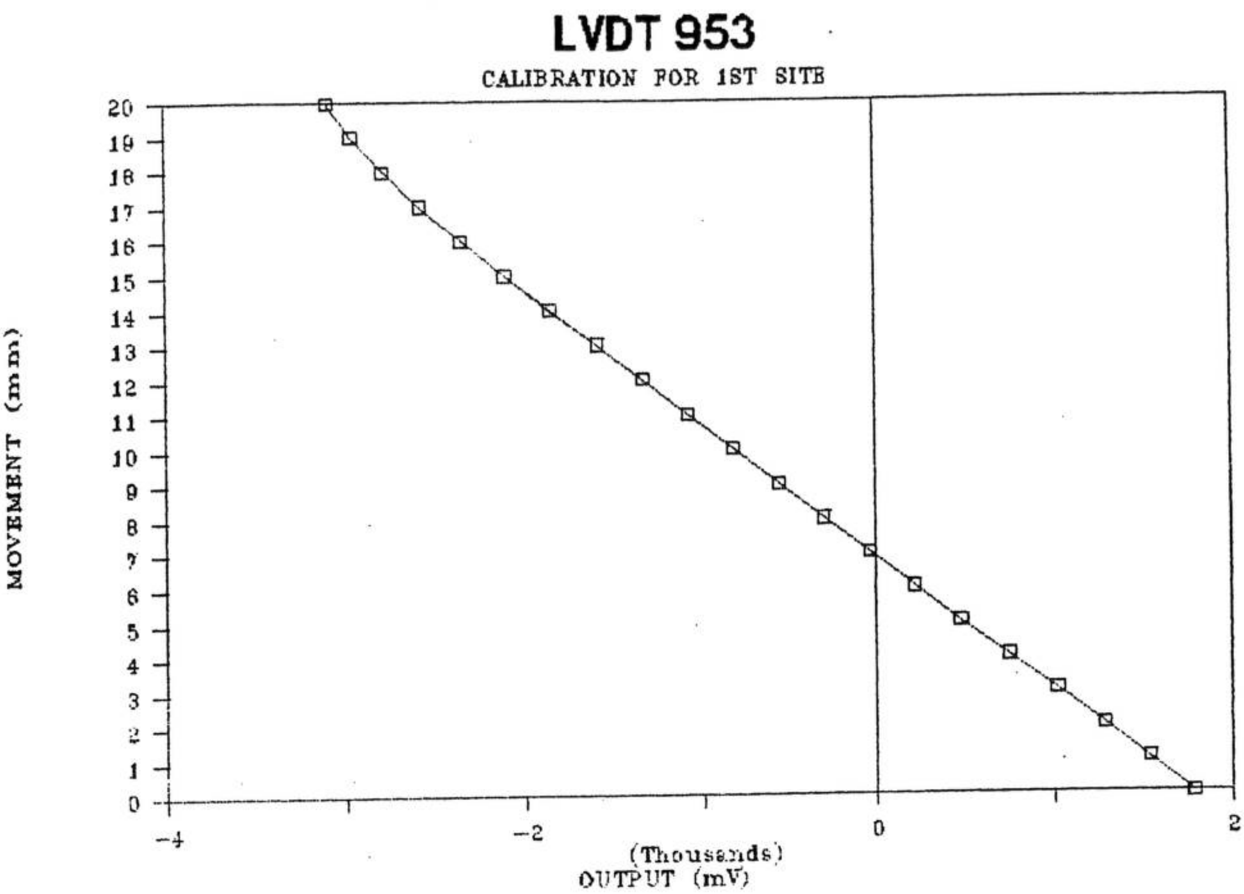
Regression Output:

Constant	-0.08933
Std Err of Y Est	0.077762
R Squared	0.999770
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	2.017854
Std Err of Coef.	0.003709

9538 HIGH STRESS CYCLING

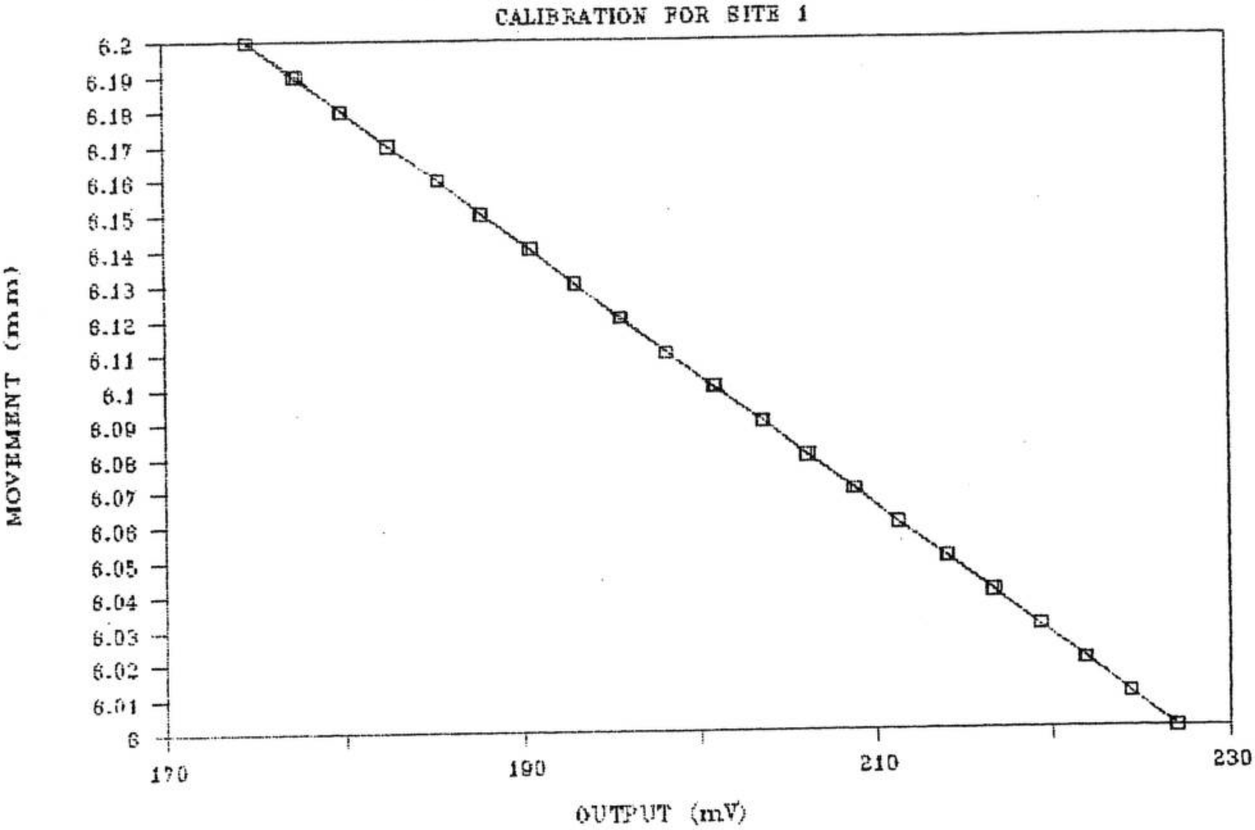
Regression Output:

Constant	-0.23828
Std Err of Y Est	0.278034
R Squared	0.999265
No. of Observations	70
Degrees of Freedom	68
X Coefficient(s)	1.967444
Std Err of Coef.	0.006468



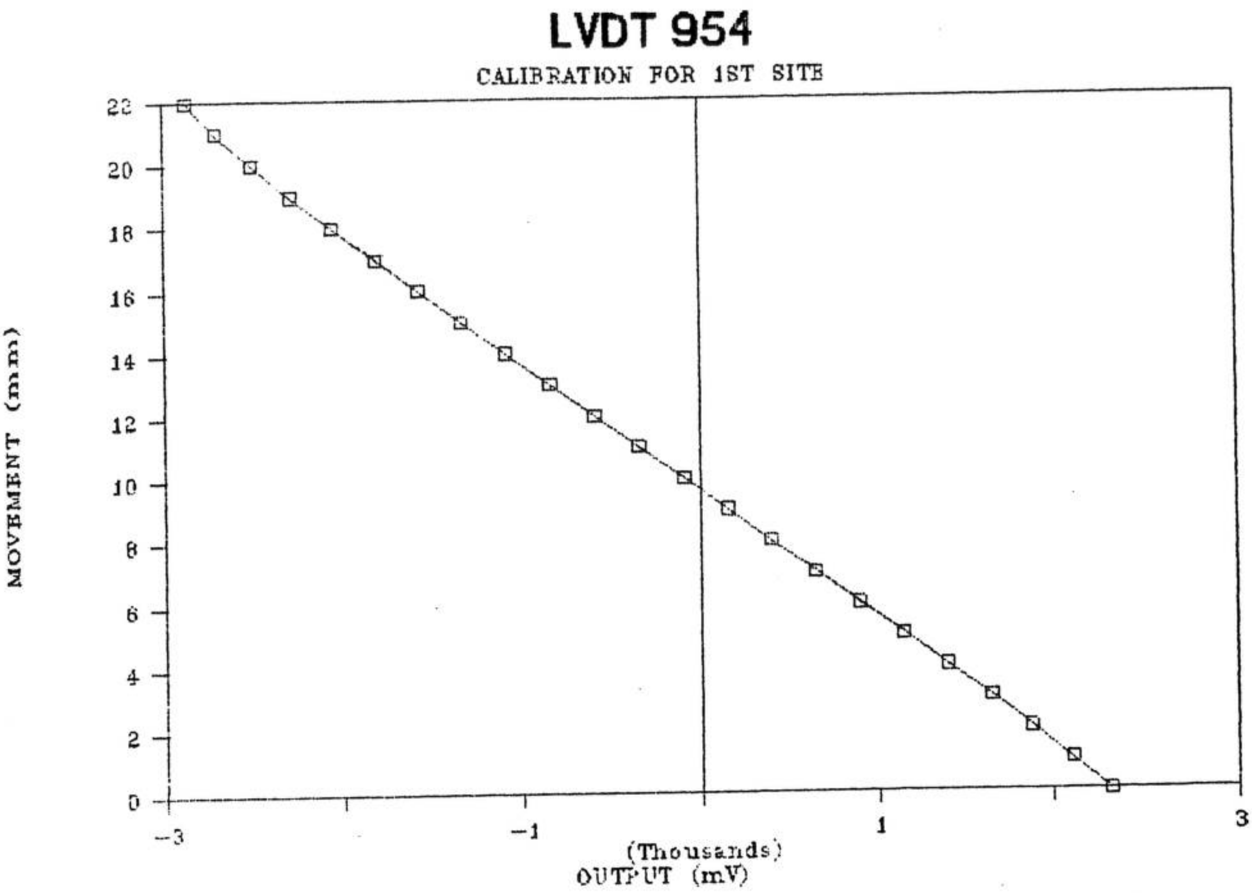

```
LVDT 953 (CENTRAL +- 5mm)
          Regression Output:
Constant                        6.871373
Std Err of Y Est                0.005440
R Squared                       0.999997
No. of Observations                   22
Degrees of Freedom                    20

X Coefficient(s)   -0.00382
Std Err of Coef.    0.000001
```

LVDT 953 (0.01mm INCS.)



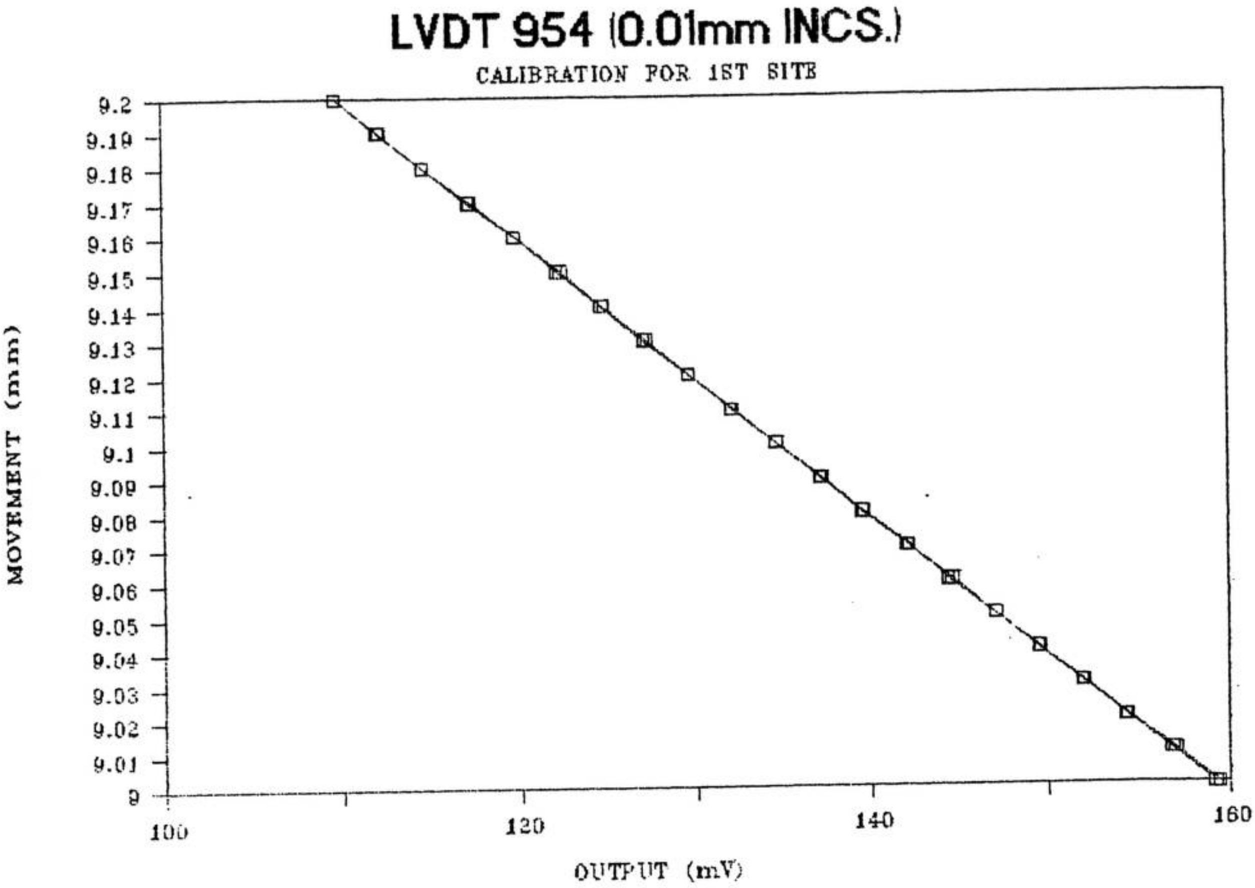

```
LVDT 953 (0.01mm INCS.)
          Regression Output:
Constant                        6.868055
Std Err of Y Est                0.000332
R Squared                       0.999970
No. of Observations                   41
Degrees of Freedom                    39

X Coefficient(s)   -0.00382
Std Err of Coef.    0.000003
```

FIGURE III 163




```
LVDT 954 (CENTRAL +- 5mm)
          Regression Output:
Constant                          9.639344
Std Err of Y Est                  0.007054
R Squared                         0.999995
No. of Observations                     22
Degrees of Freedom                      20

X Coefficient(s)   -0.00403
Std Err of Coef.    0.000001
```

FIGURE III 164



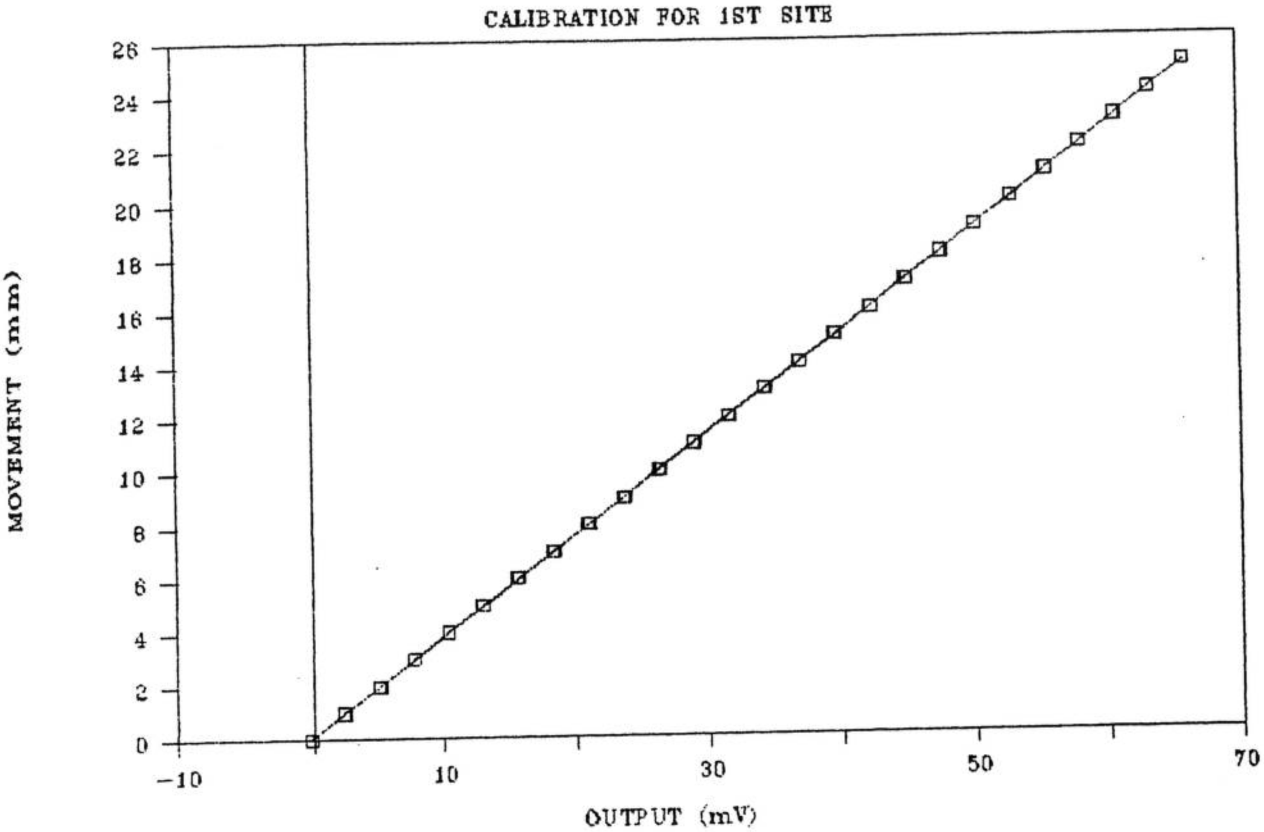
LVDT 954 (0.01mm INCS.)

Regression Output:

Constant	9.643592
Std Err of Y Est	0.000371
R Squared	0.999962
No. of Observations	41
Degrees of Freedom	39
X Coefficient(s)	-0.00403
Std Err of Coef.	0.000003

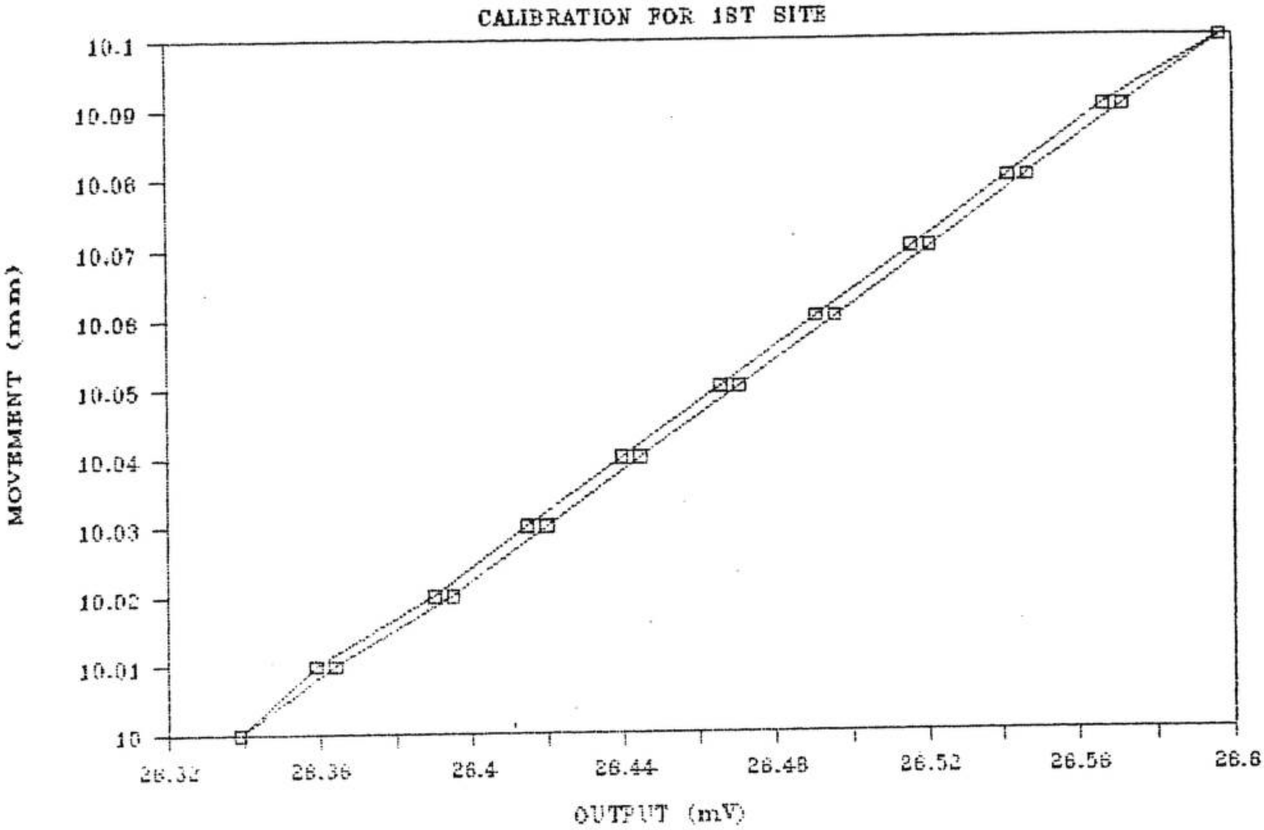
FIGURE III165

LSC TRANSDUCER




```
LSC (1mm INCS.)
          Regression Output:
Constant                        0.072518
Std Err of Y Est                0.015037
R Squared                       0.999995
No. of Observations                   51
Degrees of Freedom                    49

X Coefficient(s)   0.377190
Std Err of Coef.   0.000107
```

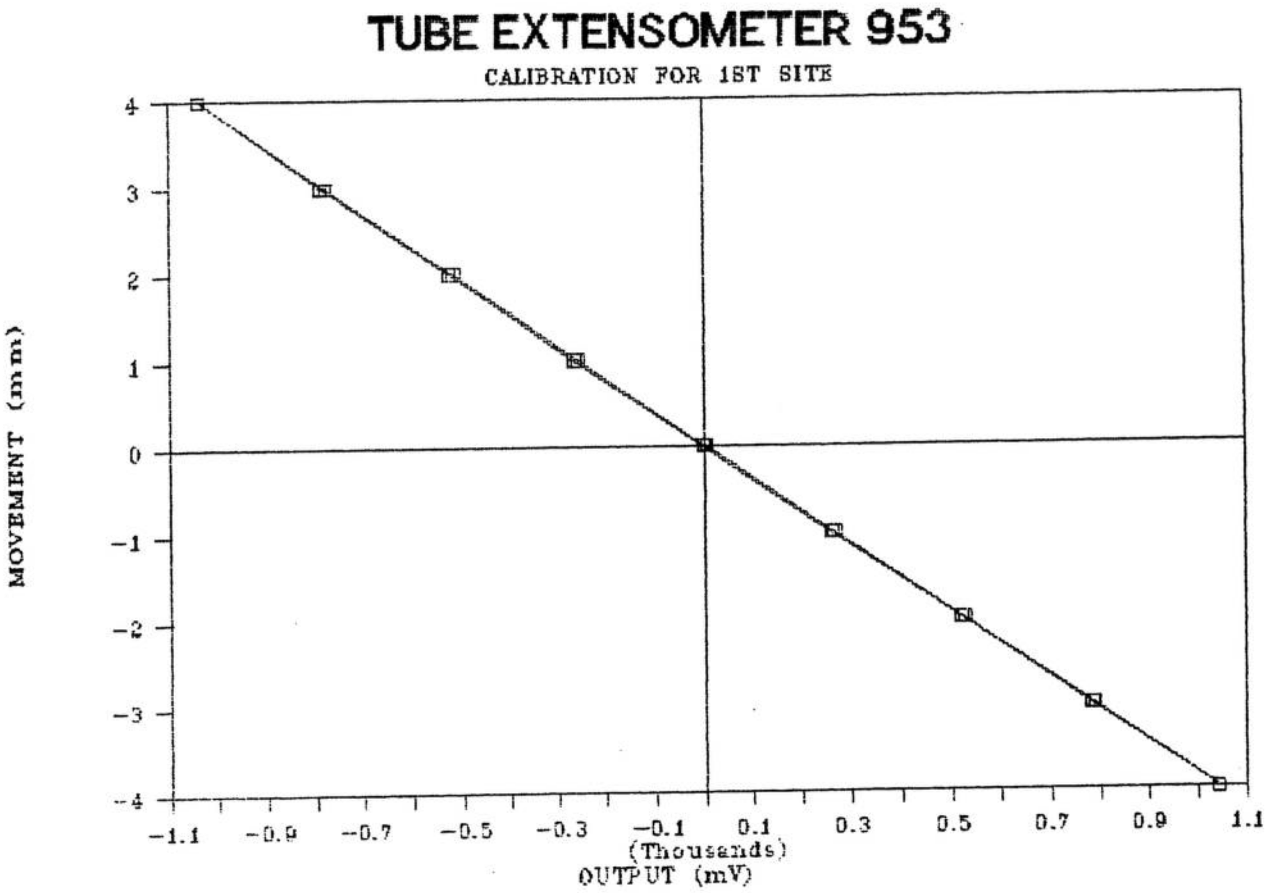
LSC TRANSDUCER (0.01mm INCS.)



LSC (0.01mm INCS.)

Regression Output:	
Constant	-0.22891
Std Err of Y Est	0.001095
R Squared	0.998823
No. of Observations	21
Degrees of Freedom	19
X Coefficient(s)	0.388357
Std Err of Coef.	0.003057

FIGURE III 167

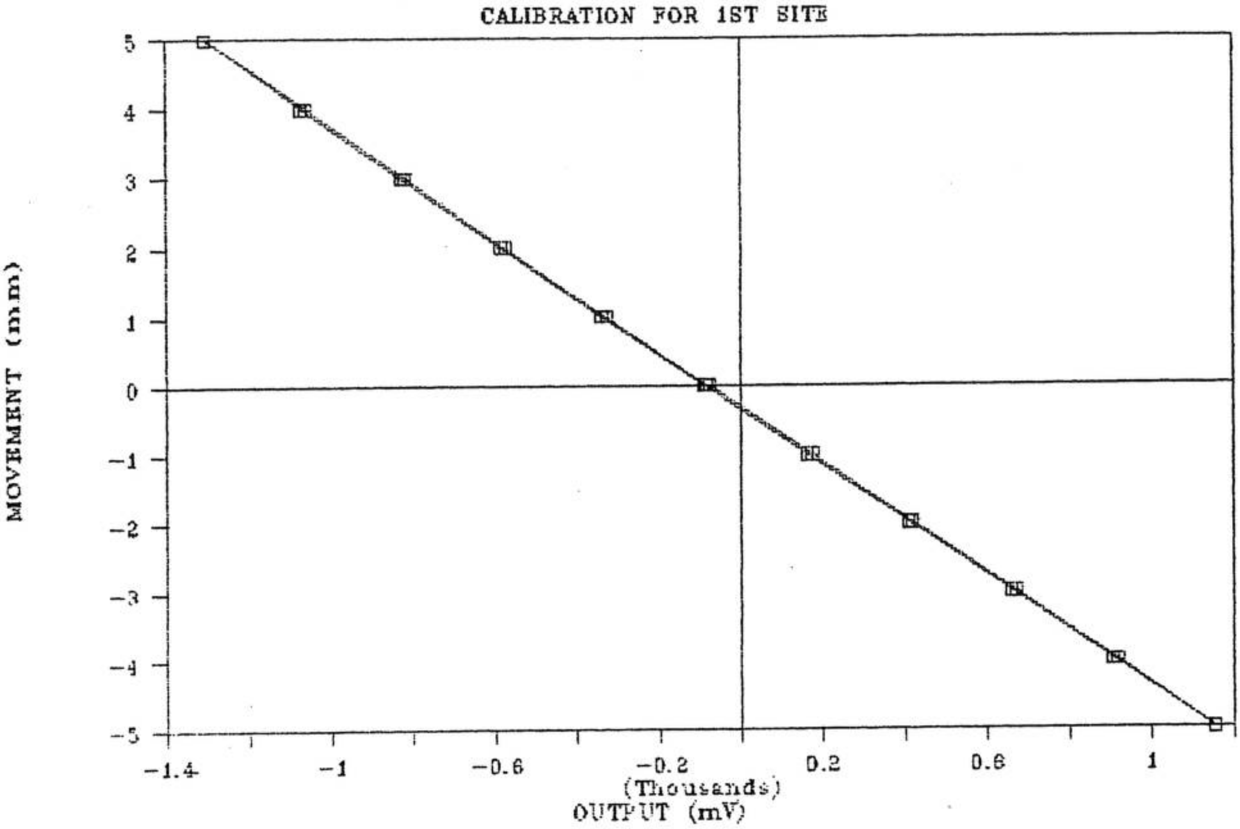


TE 953

Regression Output:	
Constant	0.007598
Std Err of Y Est	0.015124
R Squared	0.999961
No. of Observations	17
Degrees of Freedom	15

X Coefficient(s)	-0.00383
Std Err of Coef.	0.000006

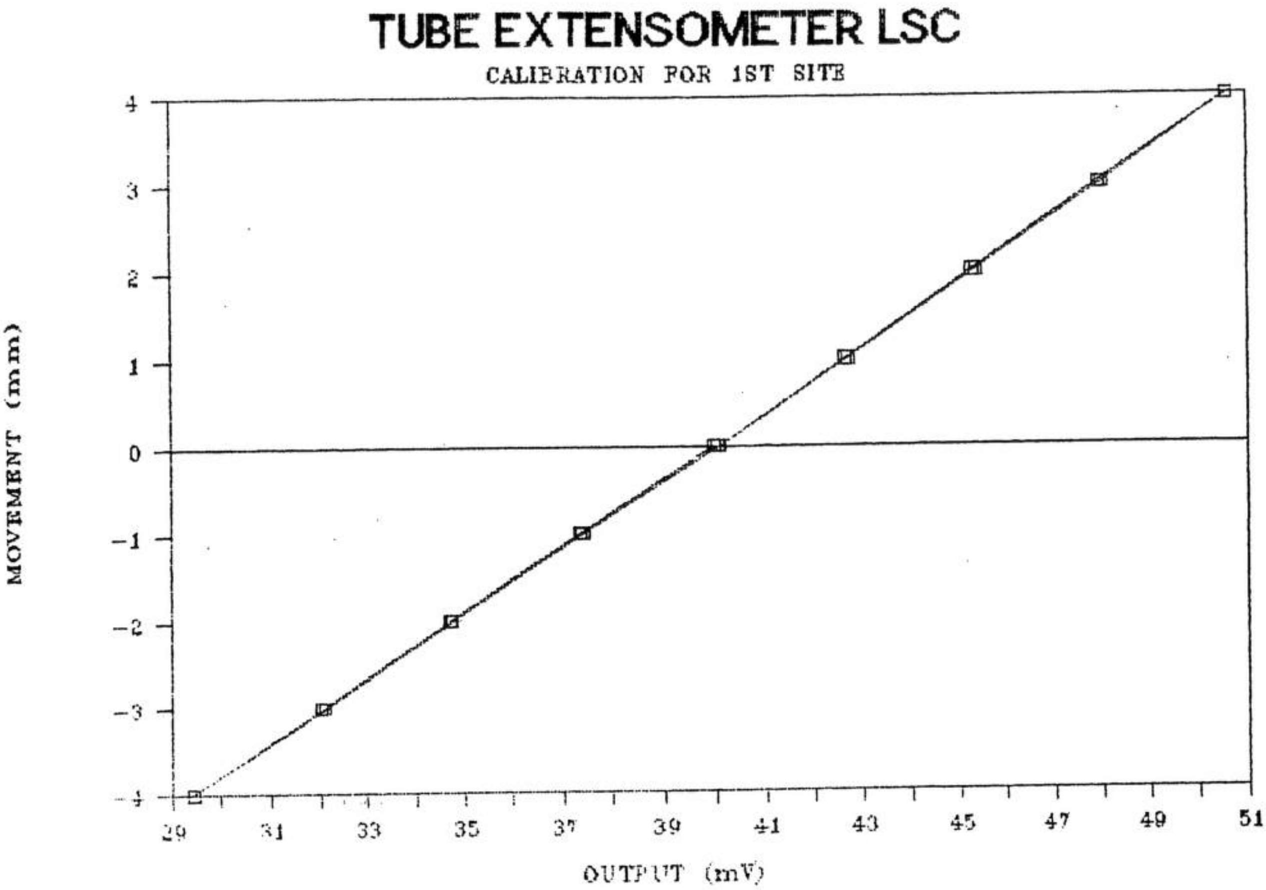
TUBE EXTENSOMETER 954



TE 954

Regression Output:		
Constant		-0.32884
Std Err of Y Est		0.020146
R Squared		0.999954
No. of Observations		21
Degrees of Freedom		19
X Coefficient(s)	-0.00404	
Std Err of Coef.	0.000006	

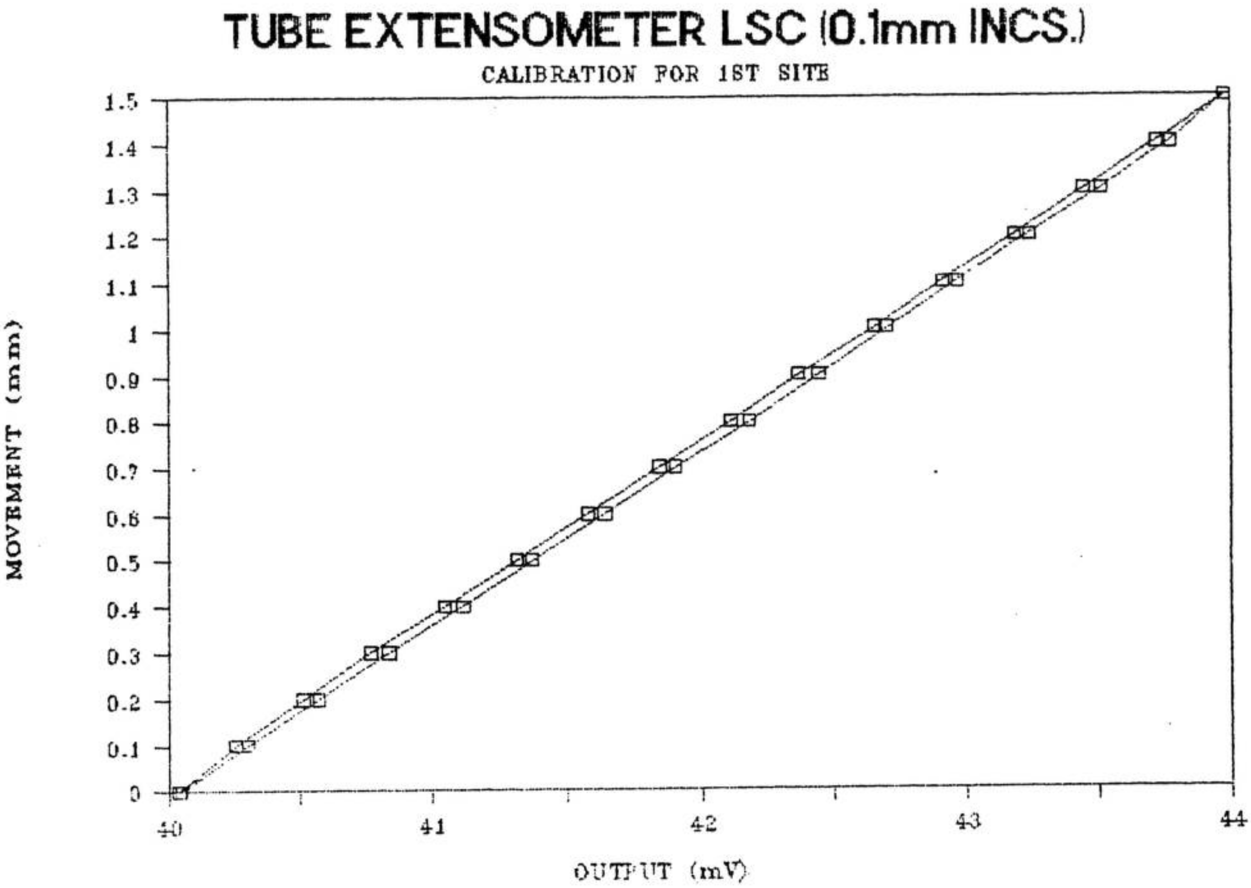
FIGURE III 169



TE LSC

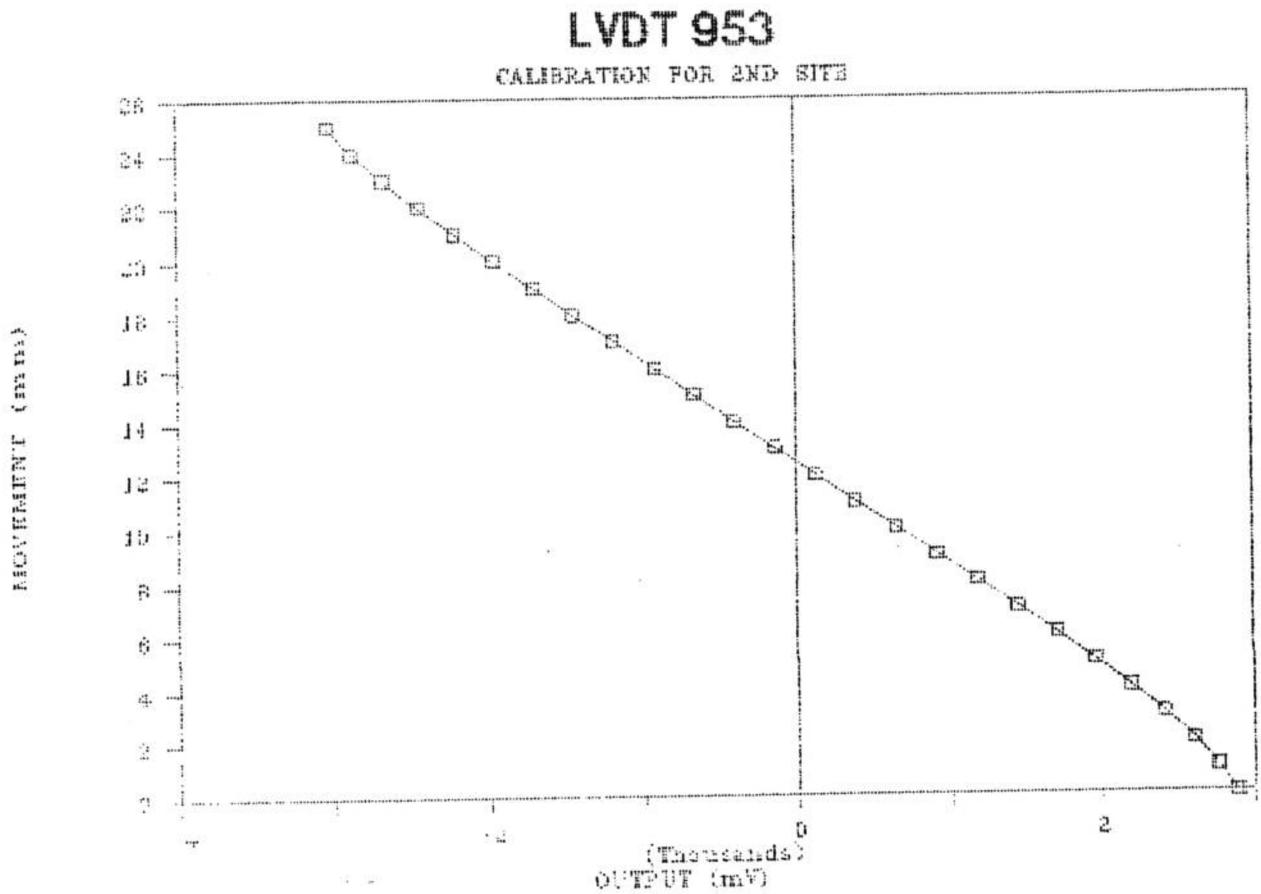
	Regression Output:
Constant	-15.1091
Std Err of Y Est	0.013367
R Squared	0.999969
No. of Observations	17
Degrees of Freedom	15

X Coefficient(s)	0.377395
Std Err of Coef.	0.000537



TE LSC (0.1mm incs.)

Regression Output:	
Constant	-15.0231
Std Err of Y Est	0.013085
R Squared	0.999201
No. of Observations	31
Degrees of Freedom	29
X Coefficient(s)	0.375395
Std Err of Coef.	0.001970

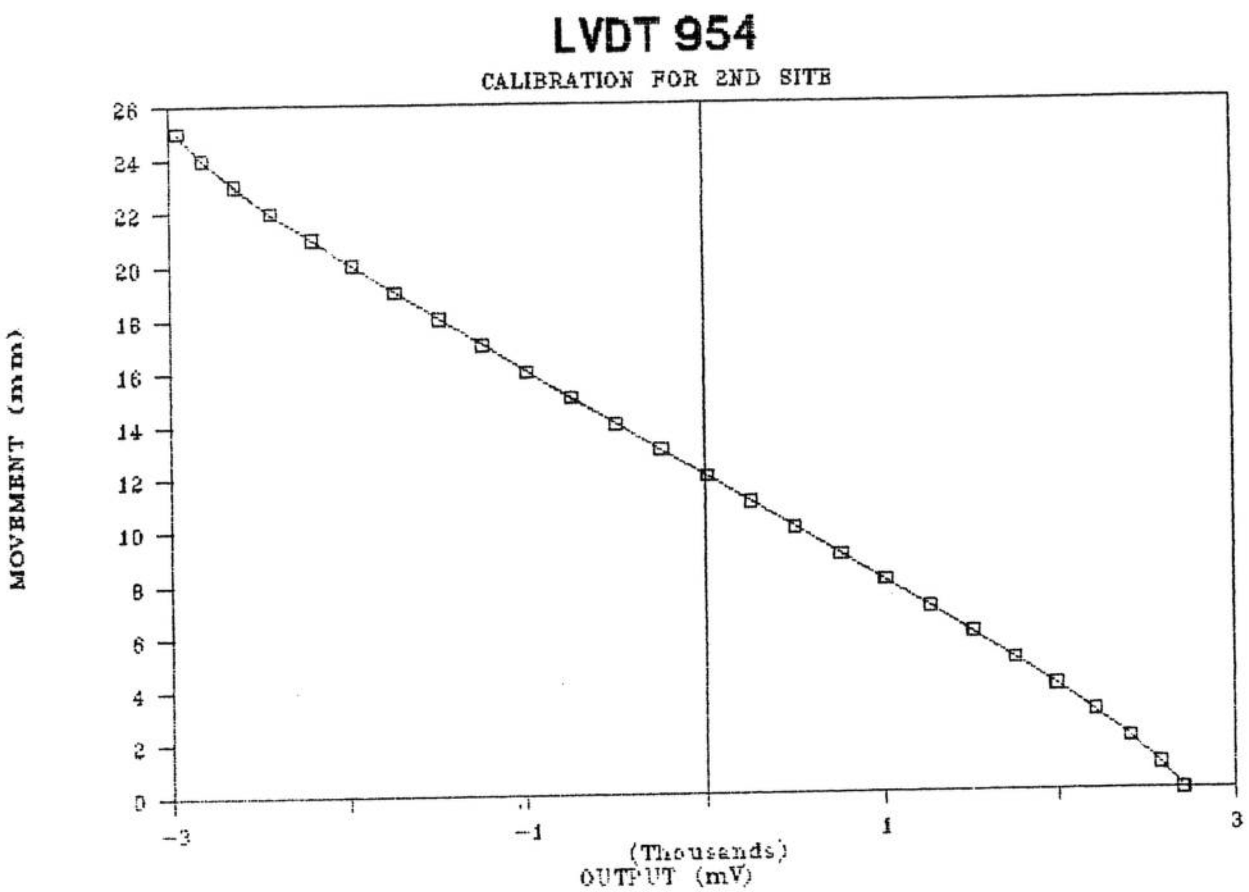


LDVT 953 (CENTRAL +- 5mm)

Regression Output:

Constant	12.47561
Std Err of Y Est	0.005875
R Squared	0.999996
No. of Observations	22
Degrees of Freedom	20
X Coefficient(s)	-0.00380
Std Err of Coef.	0.000001

FIGURE III 172



LDVT 954 (CENTRAL +- 5mm)

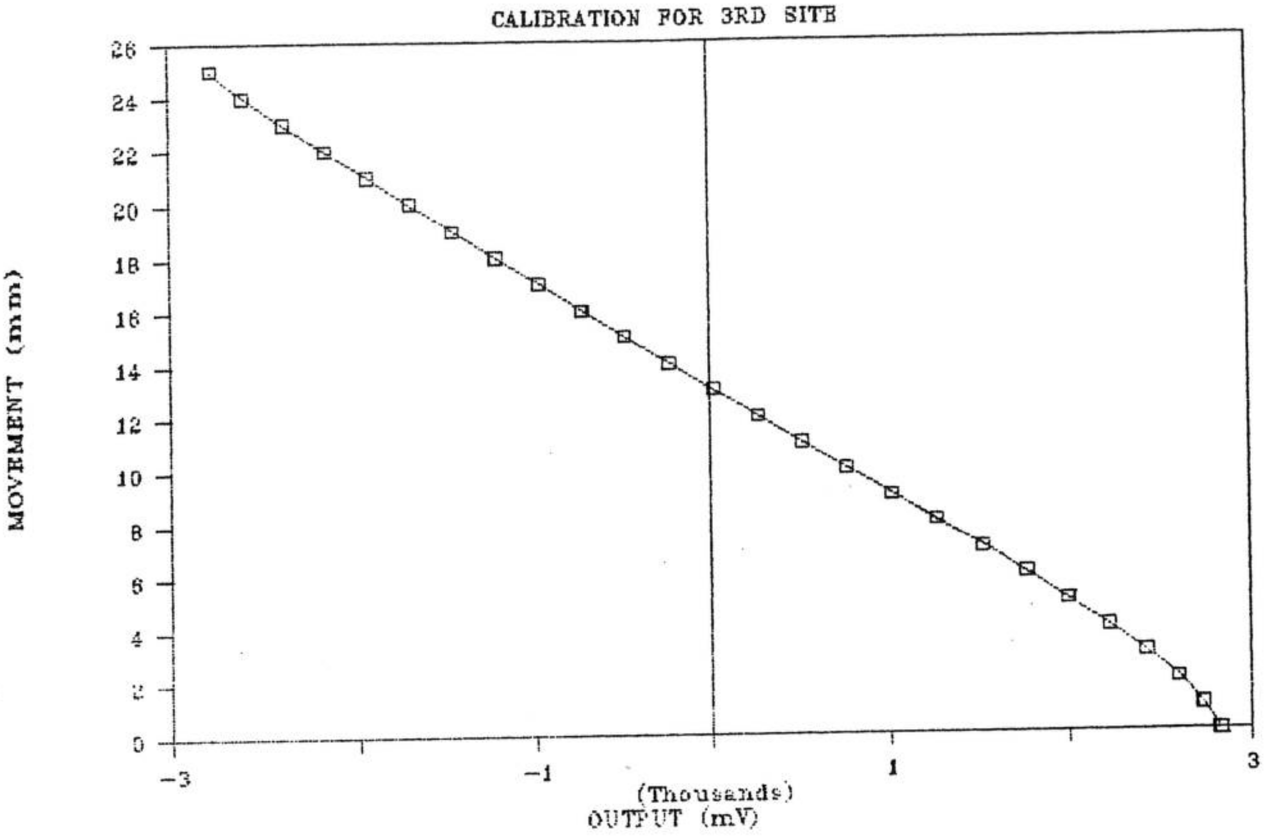
Regression Output:

Constant	12.06243
Std Err of Y Est	0.009199
R Squared	0.999992
No. of Observations	22
Degrees of Freedom	20

X Coefficient(s)	-0.00401
Std Err of Coef.	0.000002

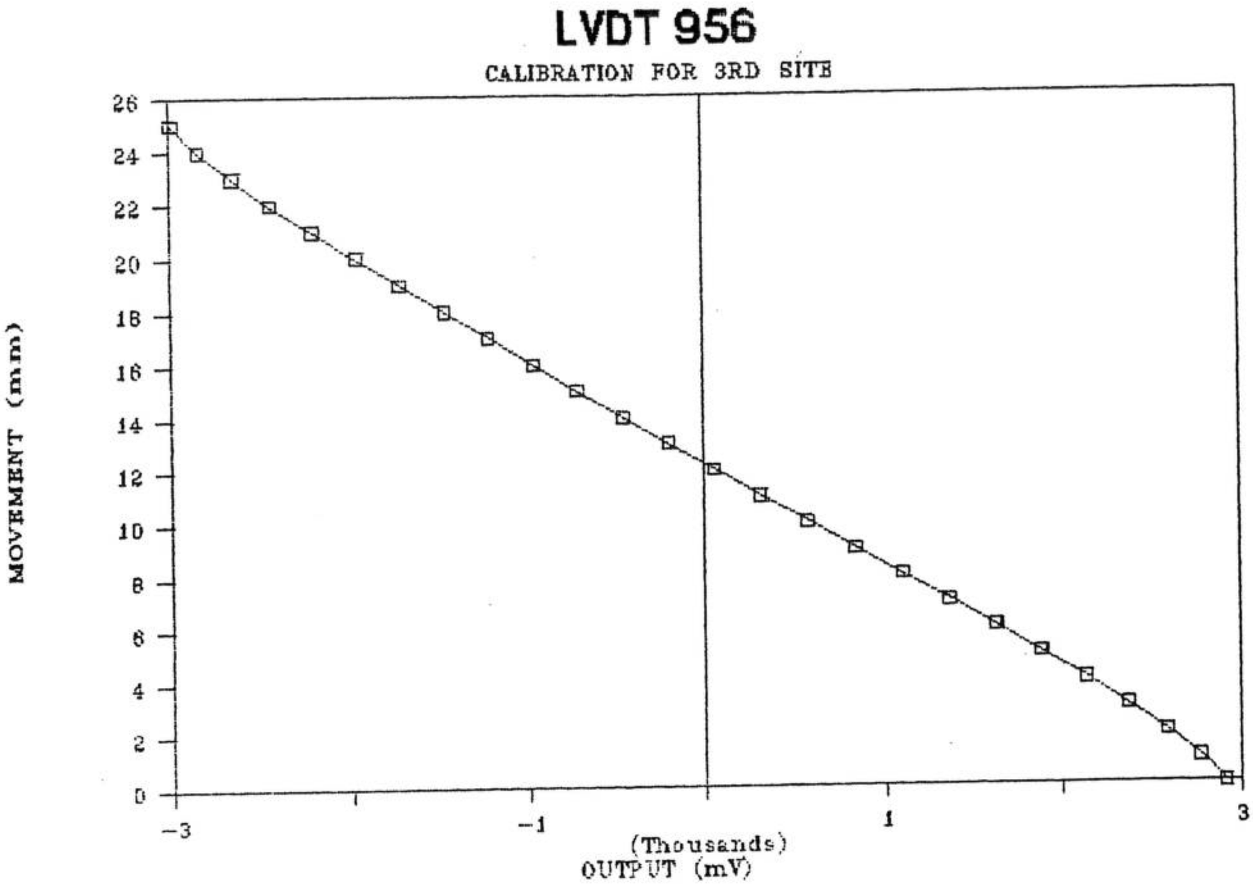
FIGURE III 173

LVDT 955




```
LDVT 955 (CENTRAL +- 5mm)
          Regression Output:
Constant                        13.09420
Std Err of Y Est                0.006470
R Squared                       0.999996
No. of Observations                   22
Degrees of Freedom                    20

X Coefficient(s)  -0.00402
Std Err of Coef.   0.000001
```

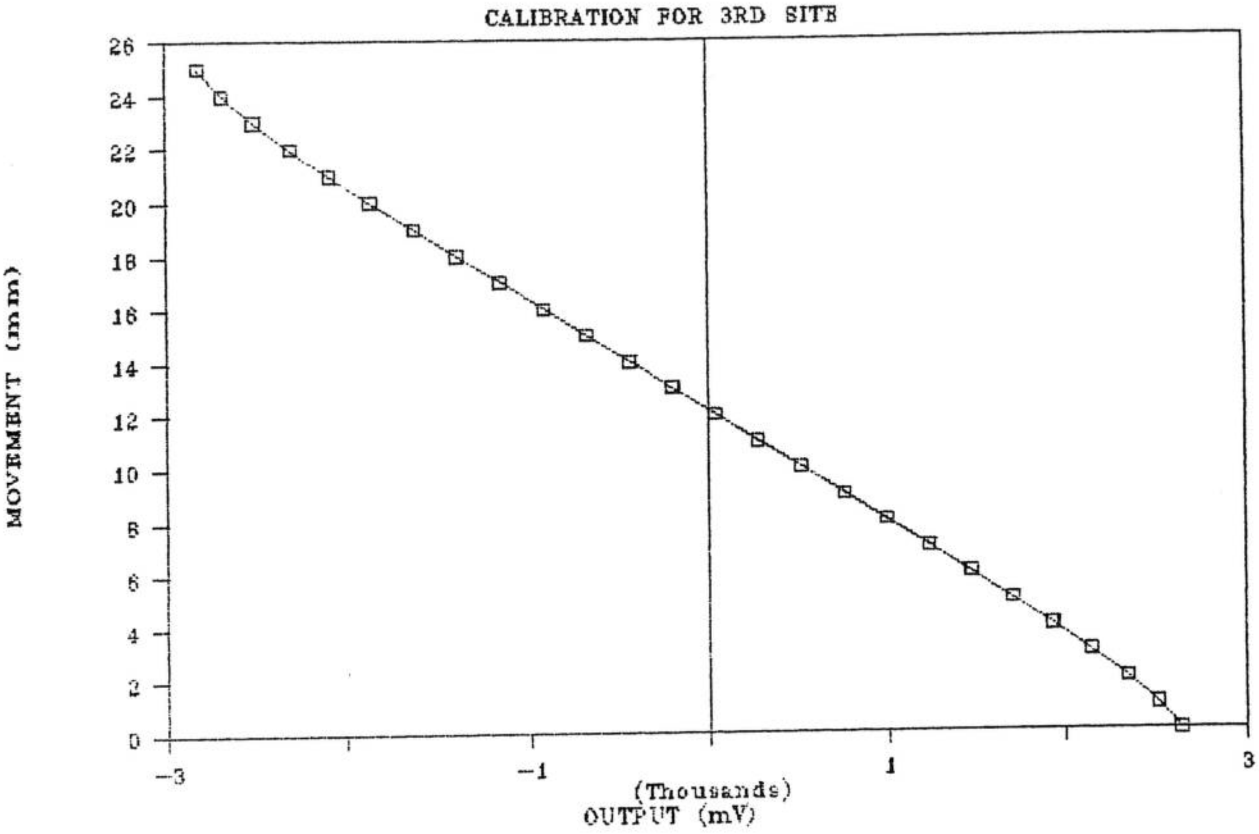
FIGURE III 174



LDVT 956 (CENTRAL +- 5mm)

Regression Output:	
Constant	12.25597
Std Err of Y Est	0.014617
R Squared	0.999980
No. of Observations	22
Degrees of Freedom	20
X Coefficient(s)	-0.00388
Std Err of Coef.	0.000003

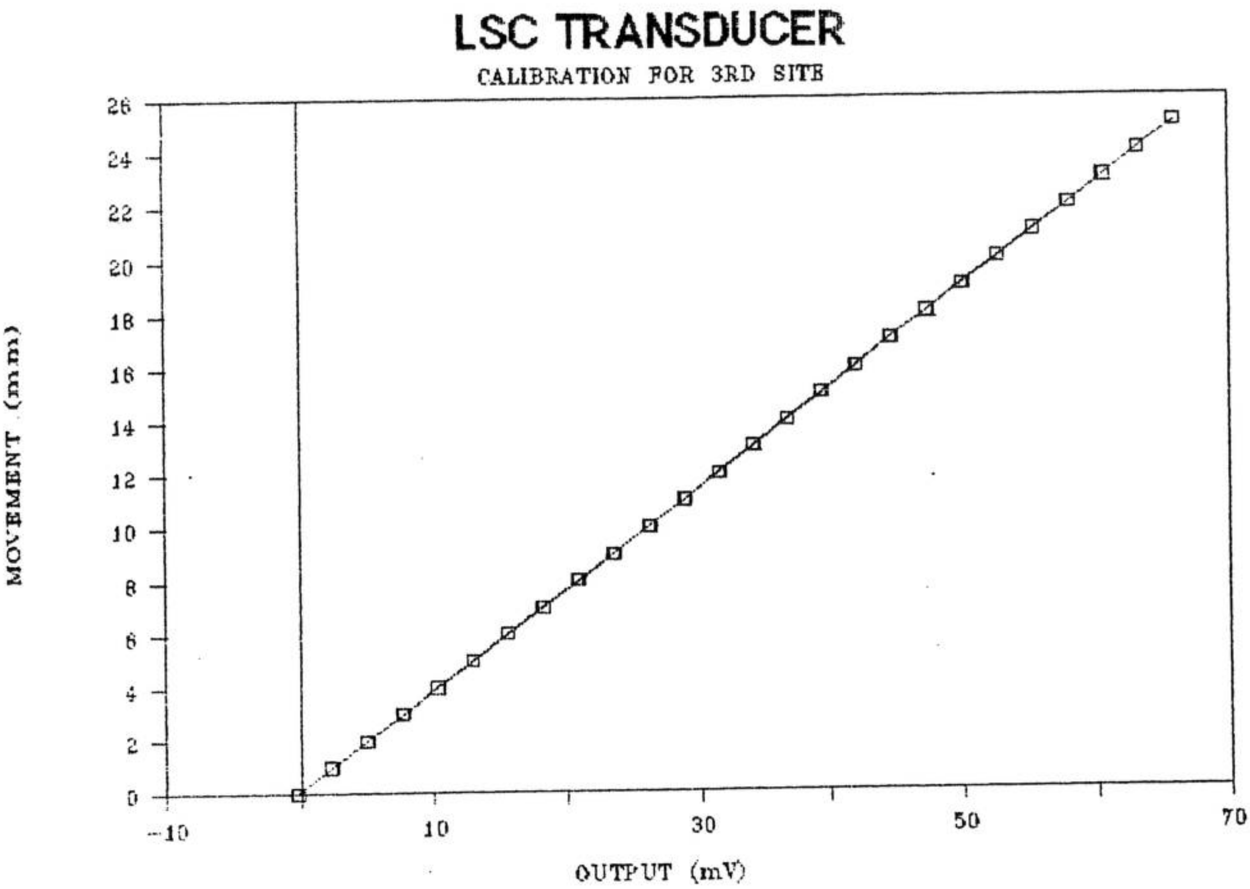
FIGURE III 175



LDVT 977 (CENTRAL +- 5mm)

Regression Output:

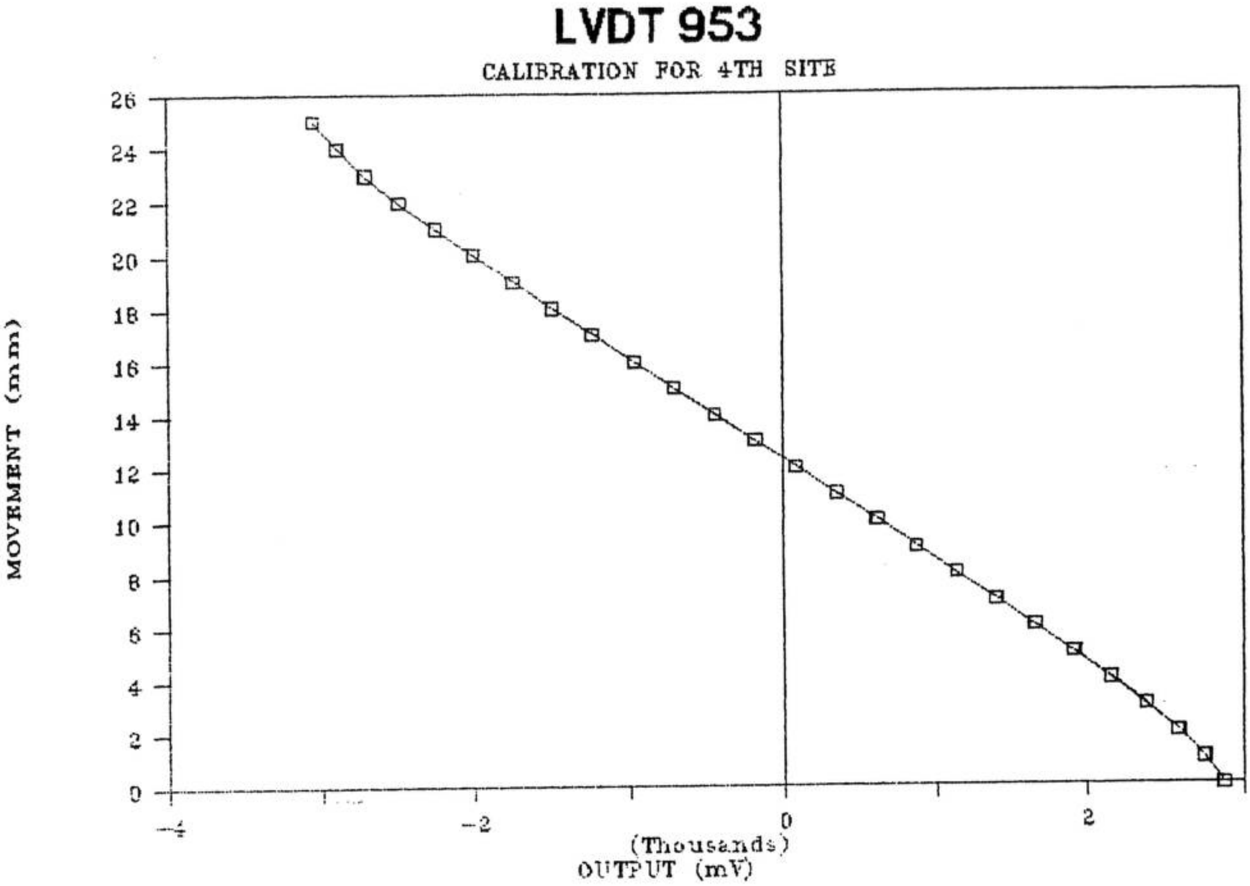
Constant	12.17415
Std Err of Y Est	0.007537
R Squared	0.999994
No. of Observations	22
Degrees of Freedom	20
X Coefficient(s)	-0.00418
Std Err of Coef.	0.000002



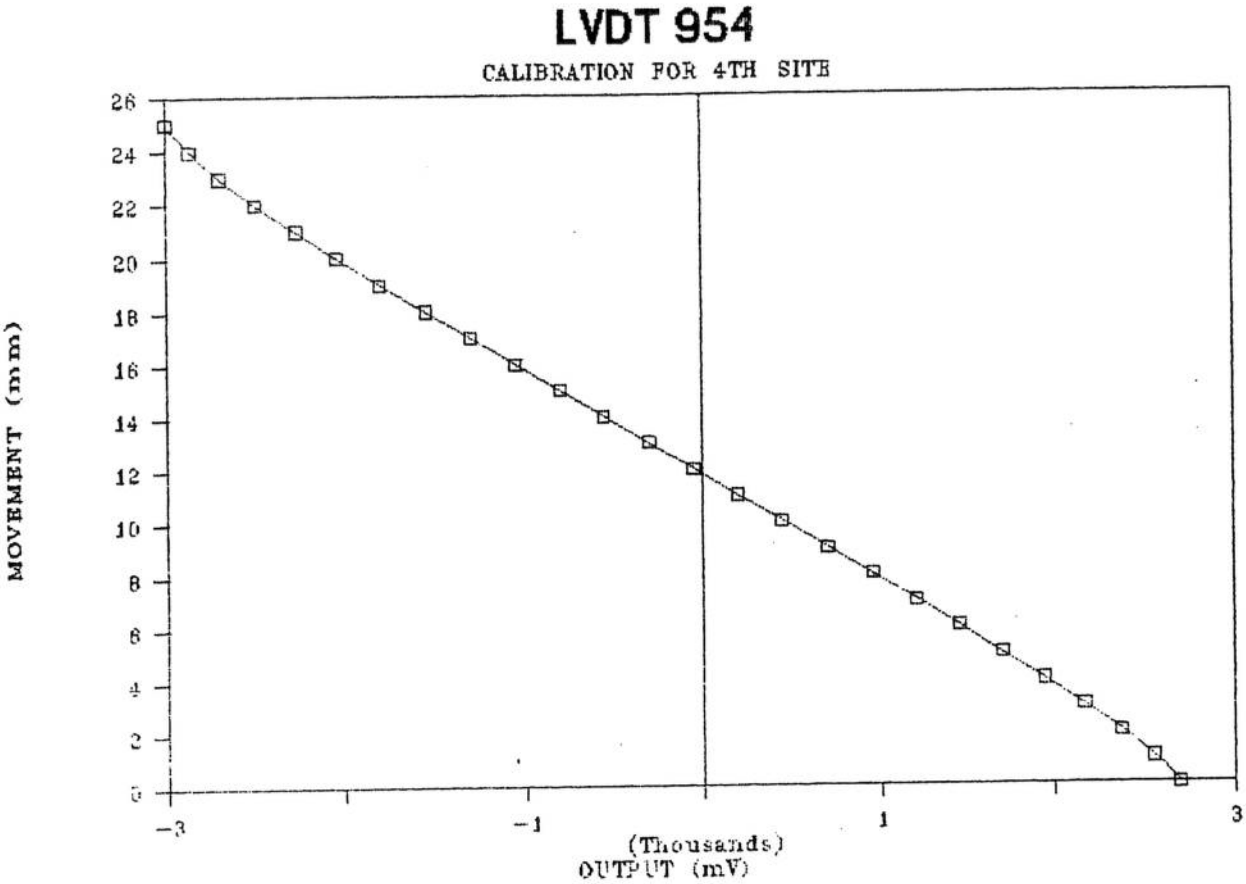
LSC

Regression Output:	
Constant	0.108023
Std Err of Y Est	0.016230
R Squared	0.999995
No. of Observations	51
Degrees of Freedom	49

X Coefficient(s)	0.377323
Std Err of Coef.	0.000116



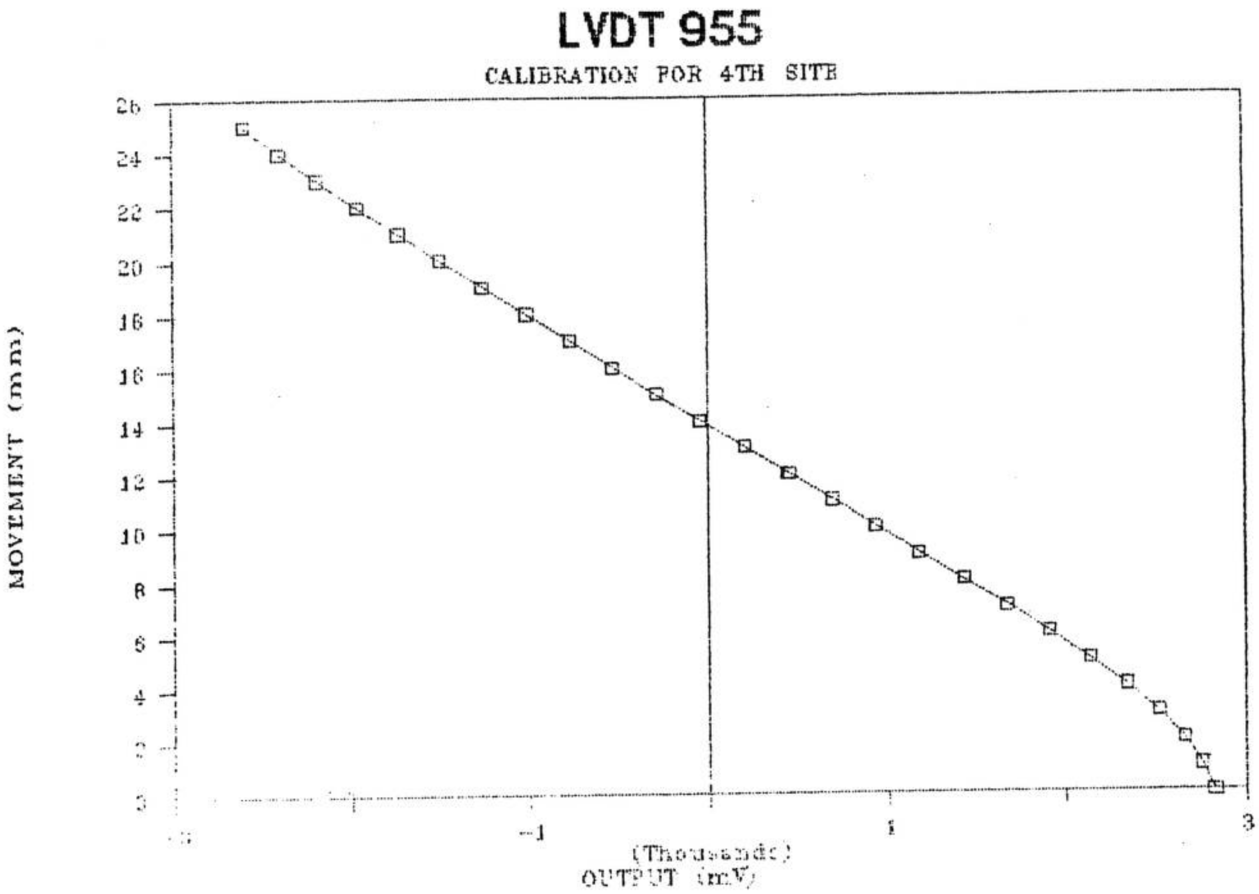

```
LDVT 953 (CENTRAL +- 5mm)
         Regression Output:
Constant                    12.34322
Std Err of Y Est            0.008022
R Squared                   0.999994
No. of Observations               22
Degrees of Freedom                20

X Coefficient(s)  -0.00381
Std Err of Coef.  0.000002
```



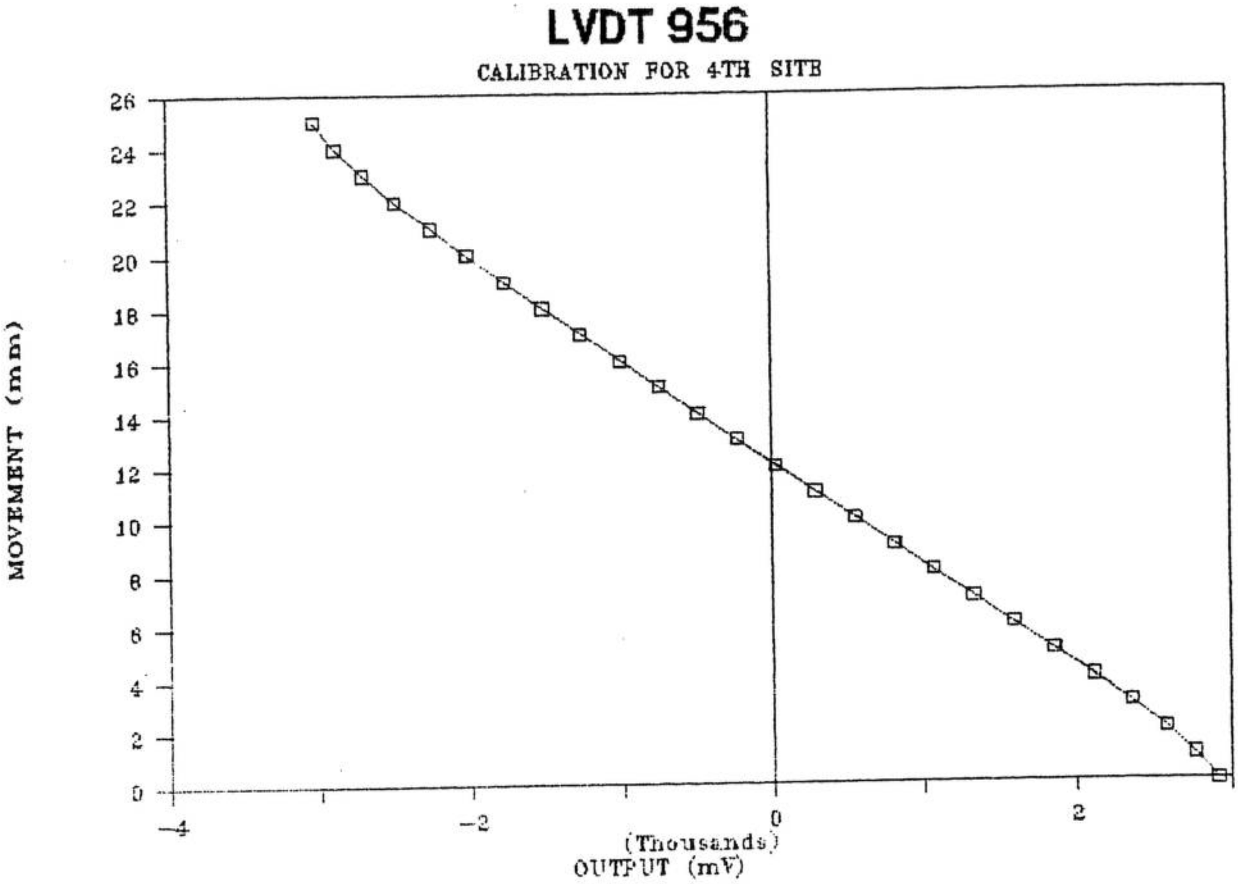
LVDT 954 (CENTRAL +- 5mm)
Regression Output:

Constant	11.81653
Std Err of Y Est	0.009750
R Squared	0.999991
No. of Observations	22
Degrees of Freedom	20

X Coefficient(s)	-0.00398
Std Err of Coef.	0.000002




```
LVDT 955 (CENTRAL +- 5mm)
         Regression Output:
Constant                      13.85268
Std Err of Y Est              0.003222
R Squared                     0.999999
No. of Observations                 22
Degrees of Freedom                  20

X Coefficient(s)   -0.00410
Std Err of Coef.   0.000000
```

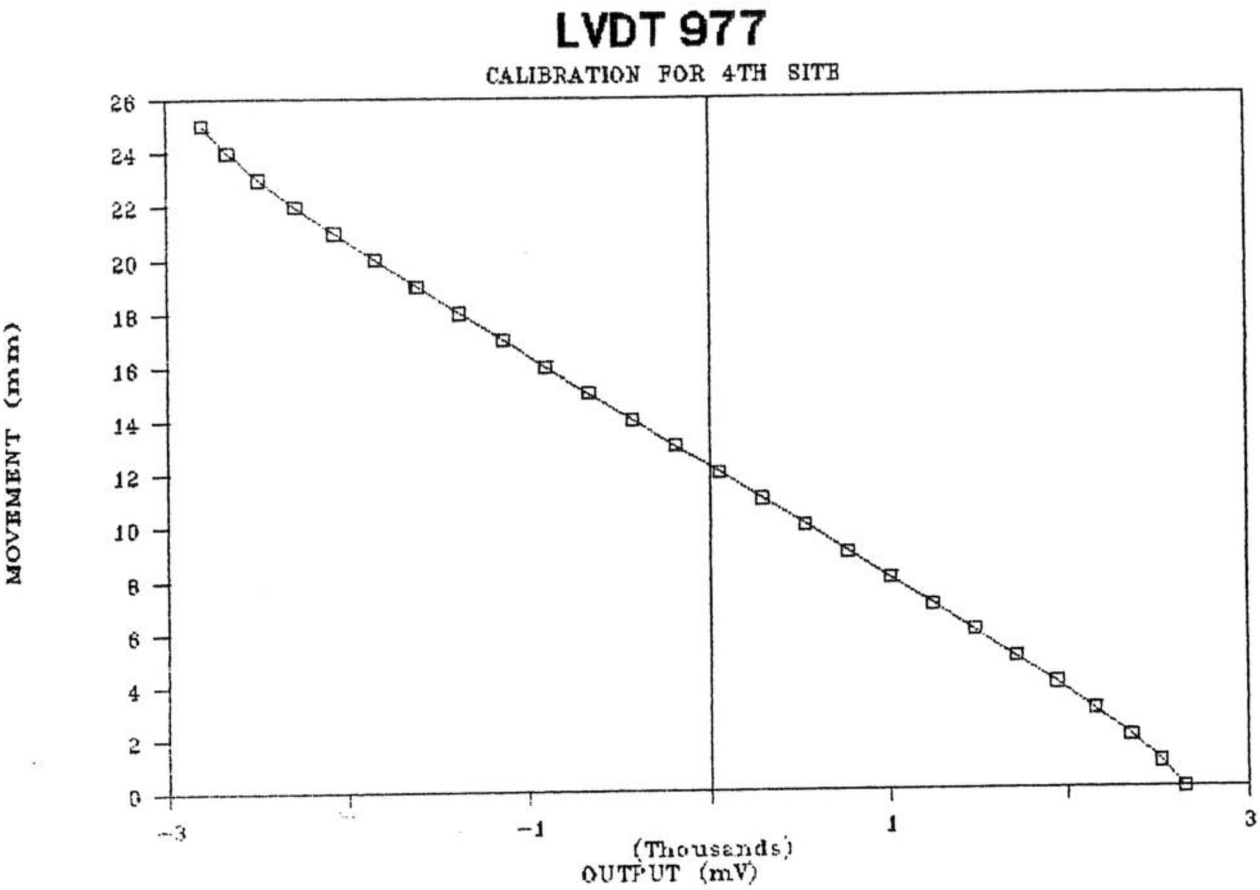


LDVT 956 (CENTRAL +- 5mm)

Regression Output:	
Constant	12.13347
Std Err of Y Est	0.015964
R Squared	0.999976
No. of Observations	22
Degrees of Freedom	20

X Coefficient(s)	-0.00386
Std Err of Coef.	0.000004

FIGURE III181



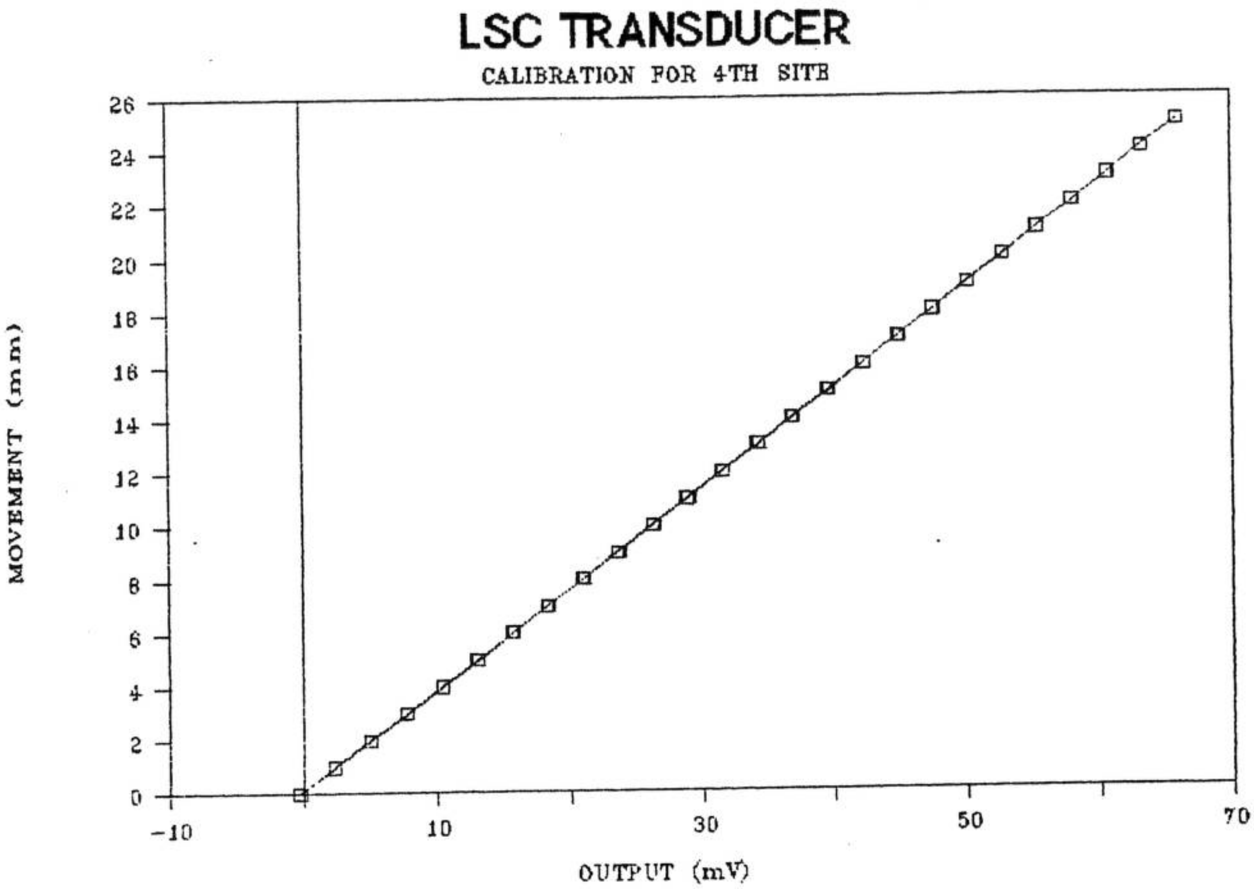
LDVT 977 (CENTRAL +- 5mm)

Regression Output:

Constant	12.23107
Std Err of Y Est	0.007467
R Squared	0.999994
No. of Observations	22
Degrees of Freedom	20

X Coefficient(s)	-0.00419
Std Err of Coef.	0.000002

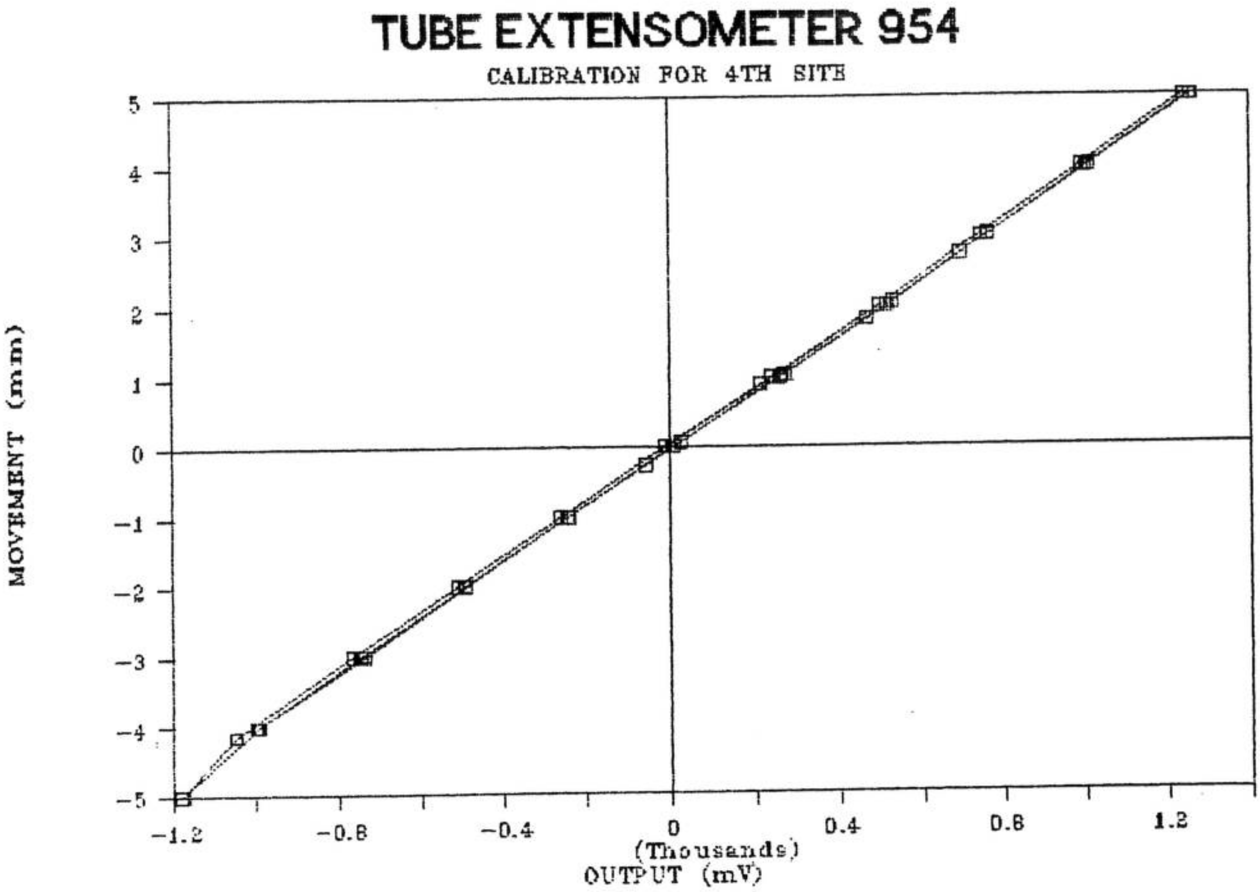
FIGURE III182



LSC

Regression Output:	
Constant	0.080397
Std Err of Y Est	0.015849
R Squared	0.999995
No. of Observations	51
Degrees of Freedom	49
X Coefficient(s)	0.377120
Std Err of Coef.	0.000113

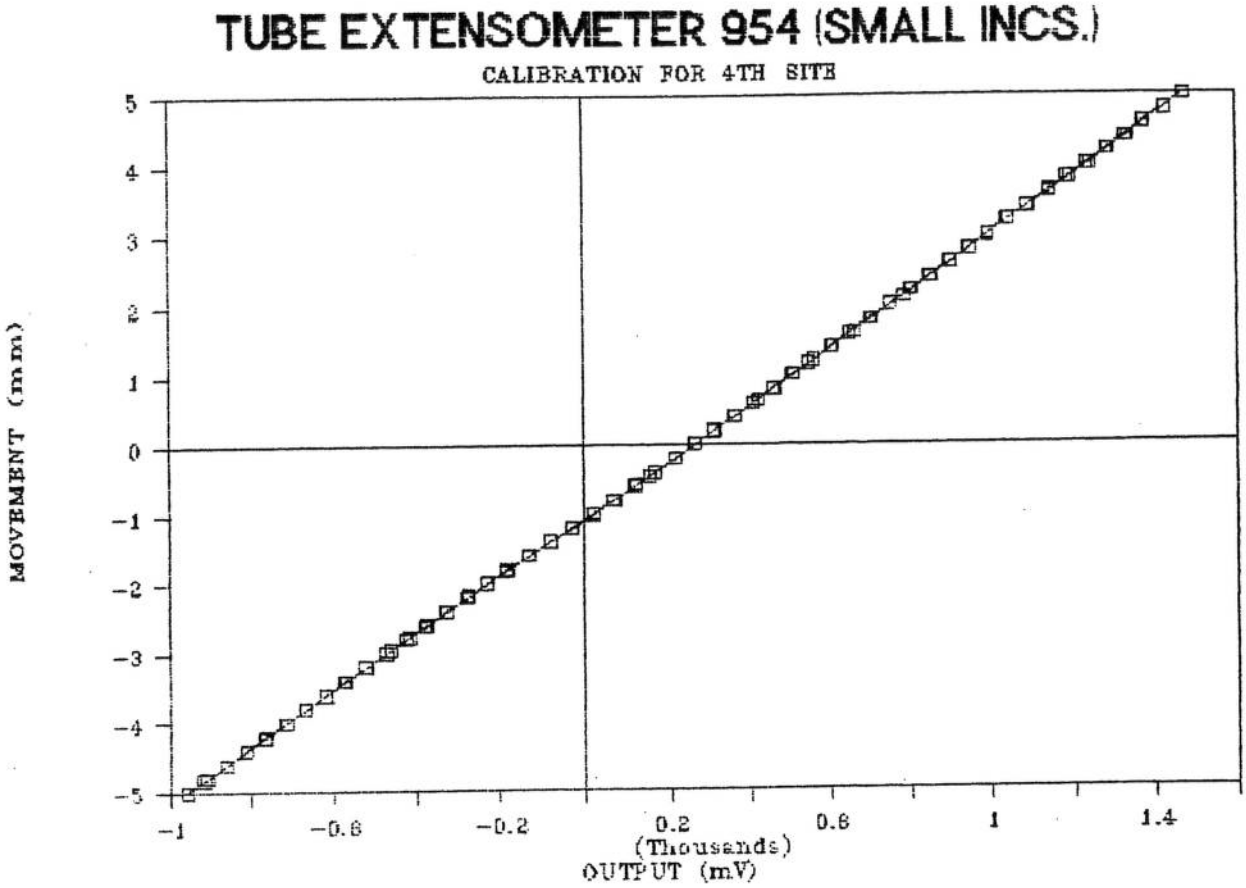
FIGURE III 183



TE 954 (CENTRAL +- 4mm)

Regression Output:	
Constant	0.034743
Std Err of Y Est	0.003659
R Squared	0.999998
No. of Observations	15
Degrees of Freedom	13
X Coefficient(s)	0.003979
Std Err of Coef.	0.000001

FIGURE III 184



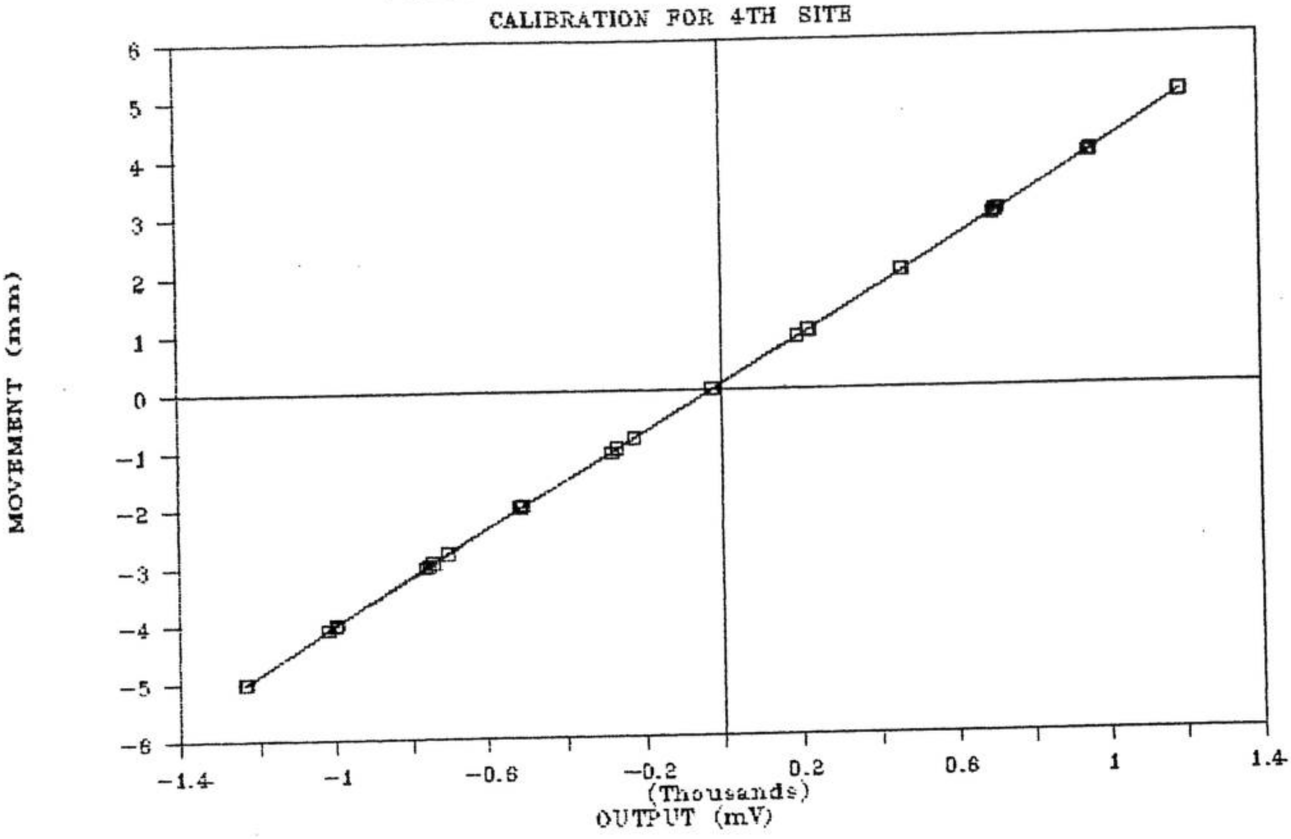
TE954 (0.2mm INCREMENTS)

Regression Output:

Constant	-1.07952
Std Err of Y Est	0.012224
R Squared	0.999982
No. of Observations	101
Degrees of Freedom	99
X Coefficient(s)	0.004093
Std Err of Coef.	0.000001

FIGURE II185

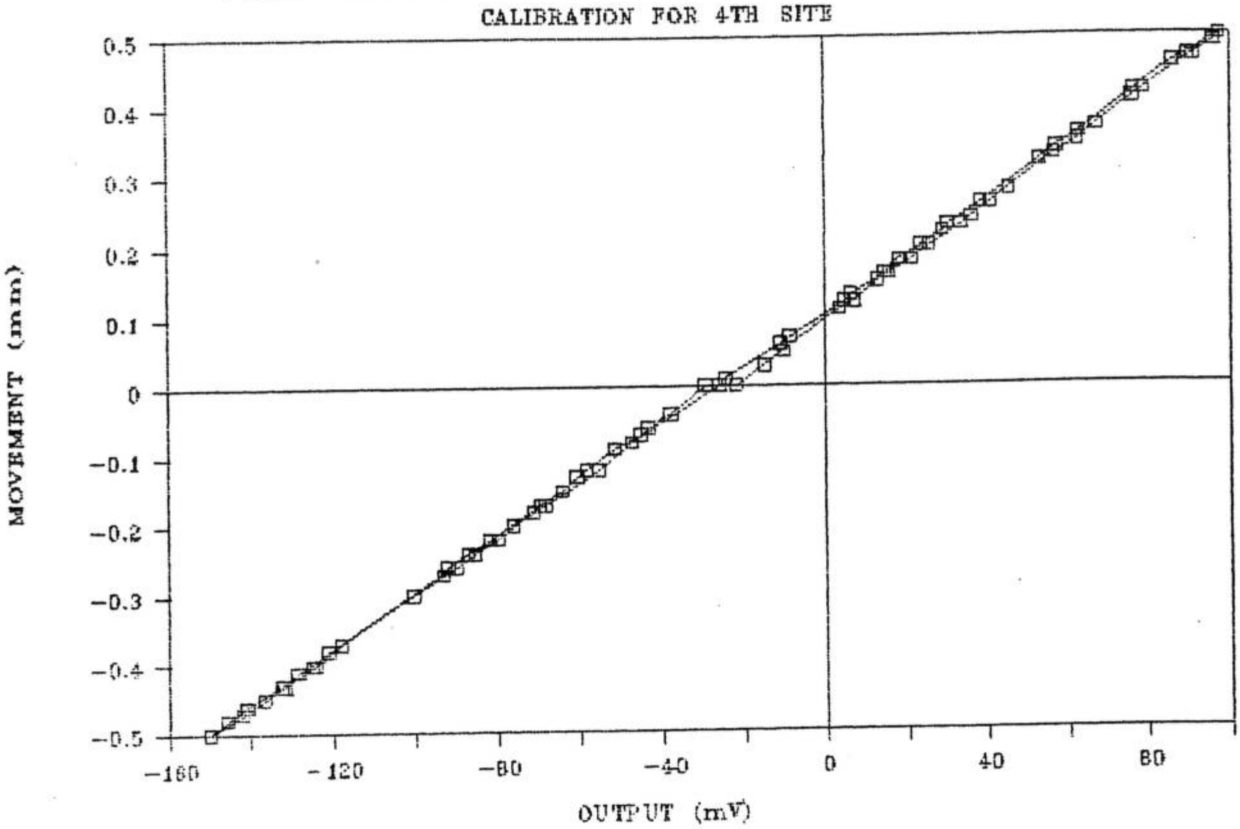
TUBE EXTENSOMETER 955




```
TE 955
          Regression Output:
Constant                          0.089126
Std Err of Y Est                  0.007075
R Squared                         0.999994
No. of Observations                     63
Degrees of Freedom                      61

X Coefficient(s)  0.004107
Std Err of Coef.  0.000001
```

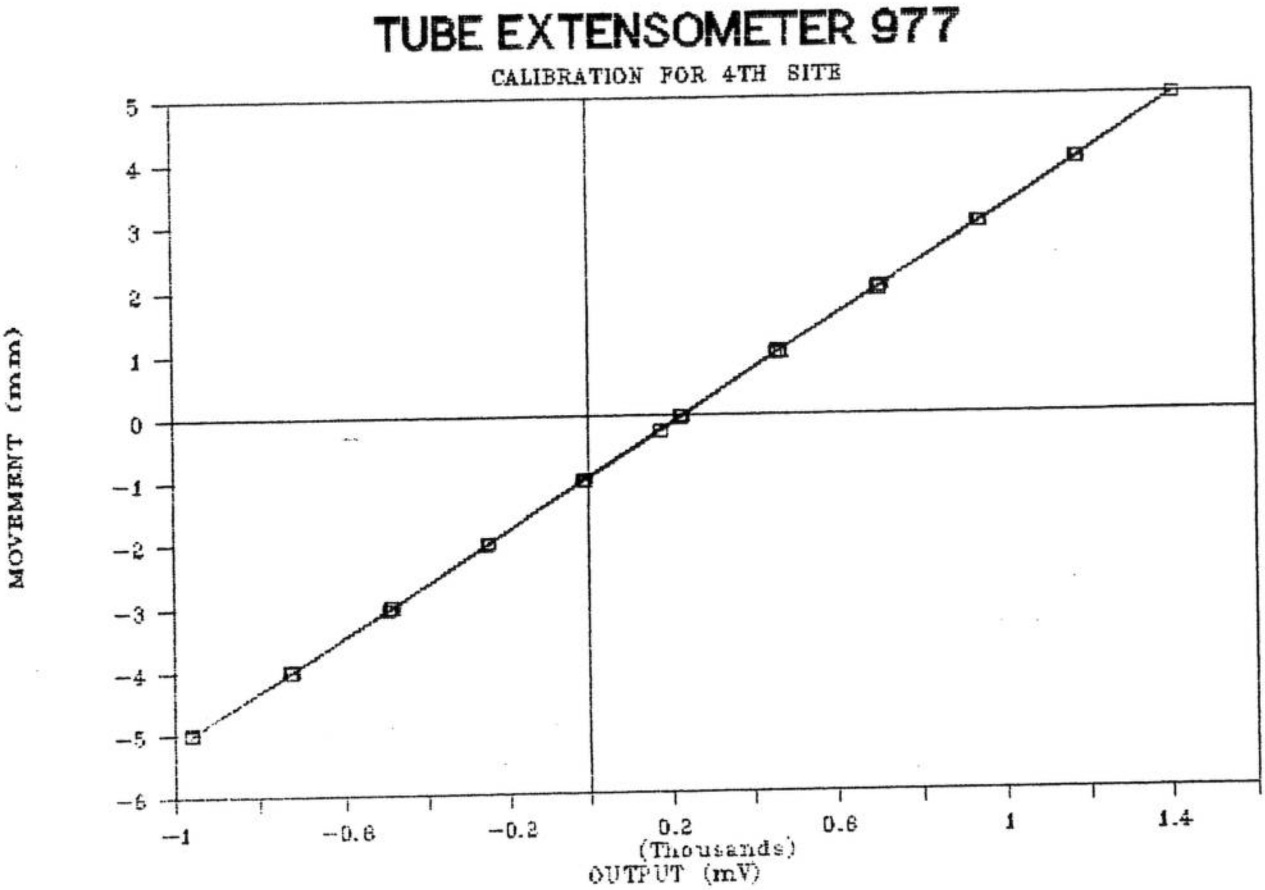
FIGURE III 186

TUBE EXTENSOMETER 955 (SMALL INCS.)




```
TE 955 (SMALL INCS.)
          Regression Output:
Constant                     0.103482
Std Err of Y Est             0.006071
R Squared                    0.999569
No. of Observations                73
Degrees of Freedom                 71

X Coefficient(s)  0.004008
Std Err of Coef.  0.000009
```

FIGURE III 187



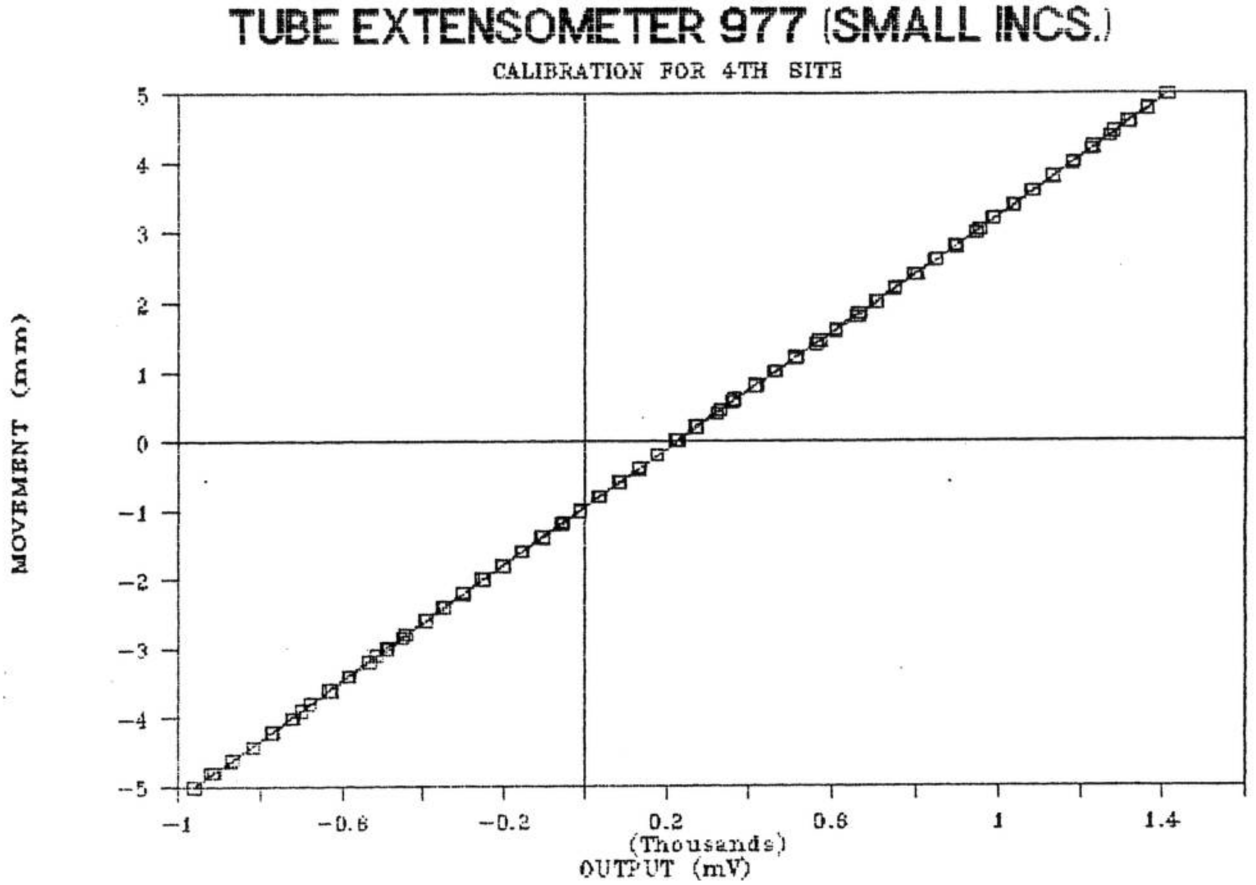
TE 977

Regression Output:

Constant	-0.96073
Std Err of Y Est	0.012378
R Squared	0.999981
No. of Observations	63
Degrees of Freedom	61

X Coefficient(s)	0.004201
Std Err of Coef.	0.000002

FIGURE III.188



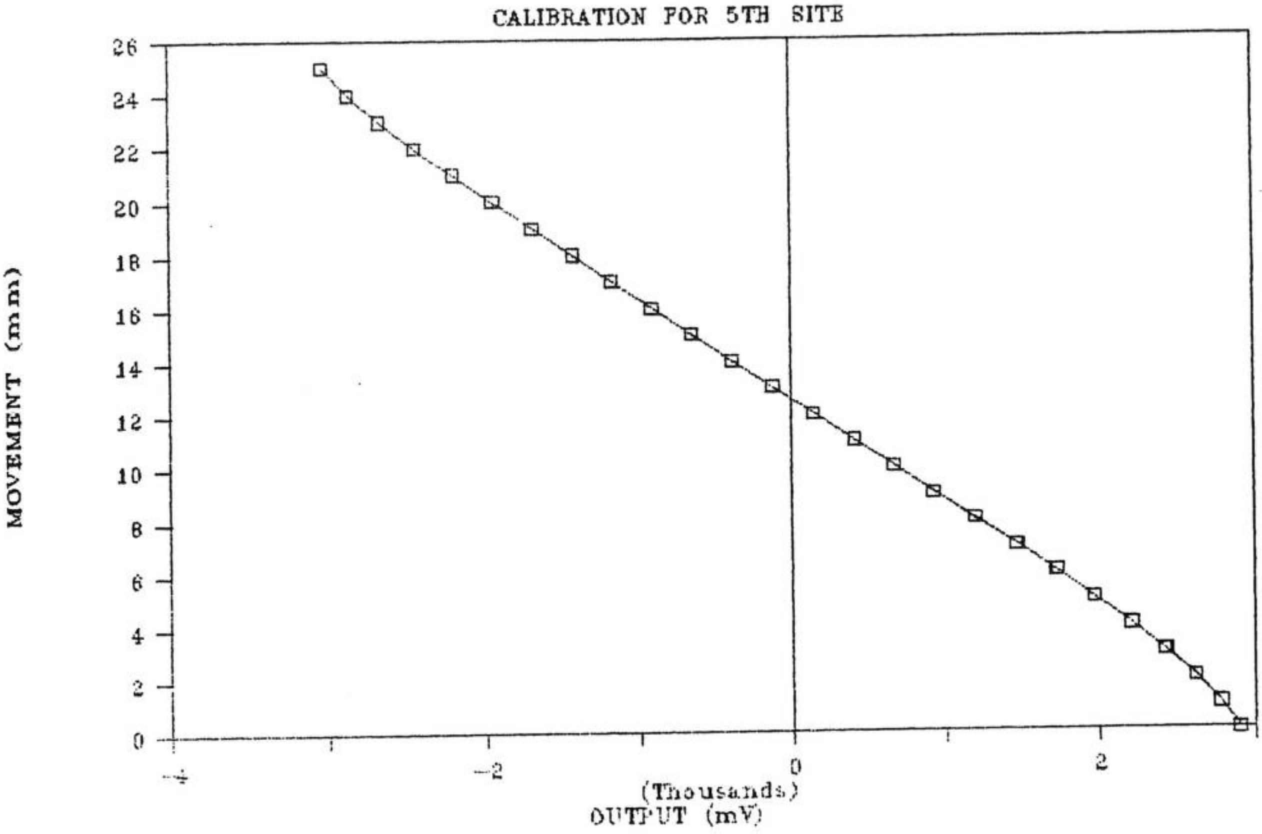
TE 977 (0.2mm INCREMENTS)

Regression Output:	
Constant	-0.95735
Std Err of Y Est	0.010792
R Squared	0.999986
No. of Observations	100
Degrees of Freedom	98

X Coefficient(s)	0.004203
Std Err of Coef.	0.000001

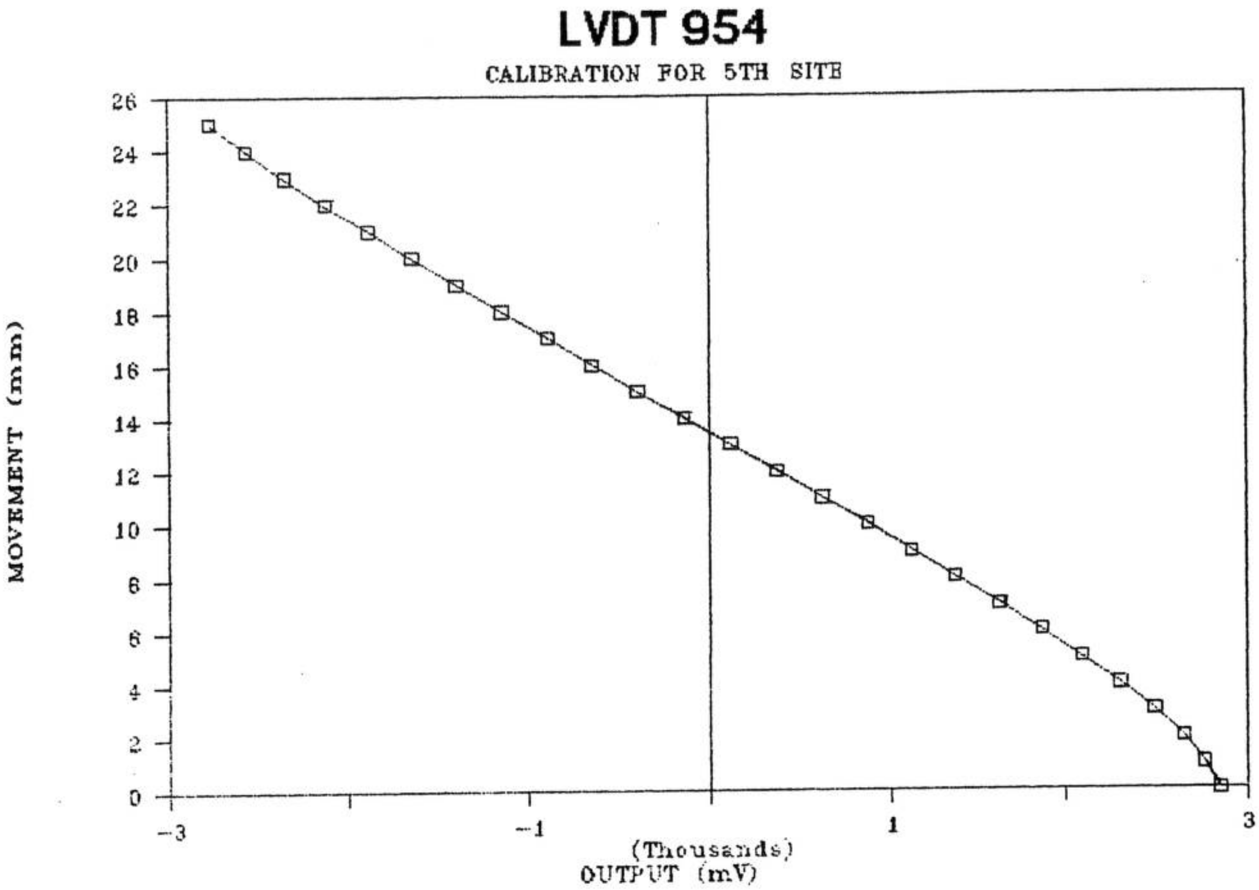
FIGURE III 189

LVDT 953



LDVT 953 (CENTRAL +- 5mm)

	Regression Output:	
Constant		12.34322
Std Err of Y Est		0.008022
R Squared		0.999994
No. of Observations		22
Degrees of Freedom		20
X Coefficient(s)	-0.00381	
Std Err of Coef.	0.000002	

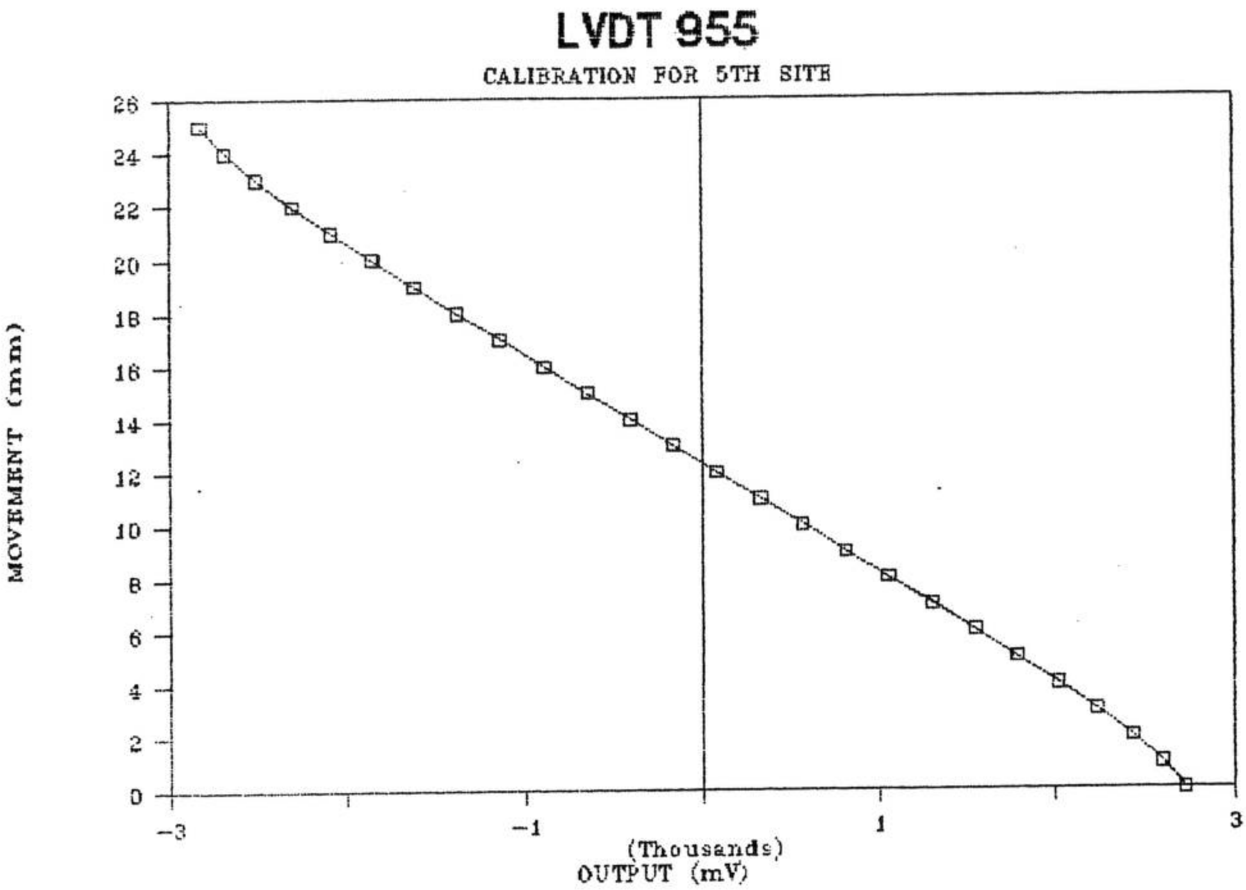


LVDT 954 (CENTRAL +- 5mm)

Regression Output:

Constant	13.46499
Std Err of Y Est	0.005161
R Squared	0.999997
No. of Observations	22
Degrees of Freedom	20

X Coefficient(s)	-0.00397
Std Err of Coef.	0.000001

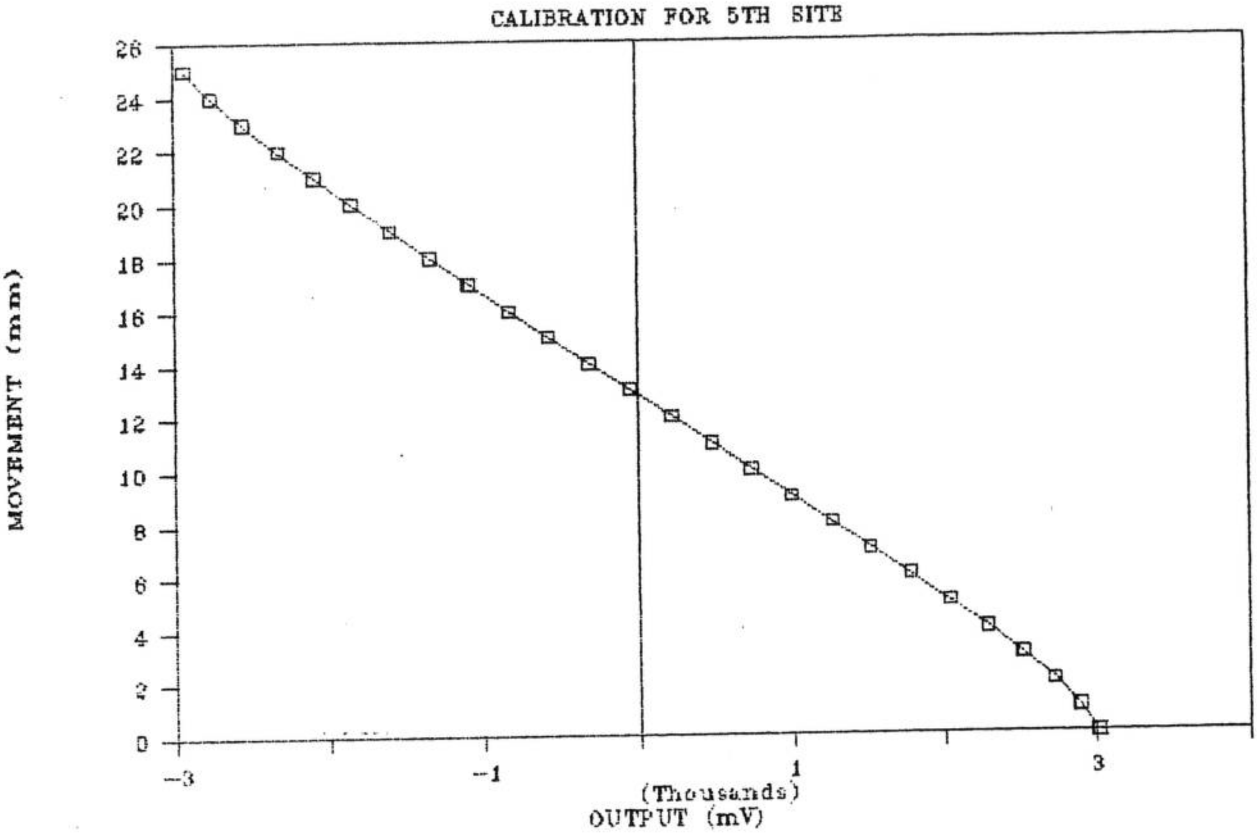


LVDT 955 (CENTRAL +- 5mm)

Regression Output:	
Constant	12.33833
Std Err of Y Est	0.007978
R Squared	0.999994
No. of Observations	22
Degrees of Freedom	20
X Coefficient(s)	-0.00410
Std Err of Coef.	0.000002

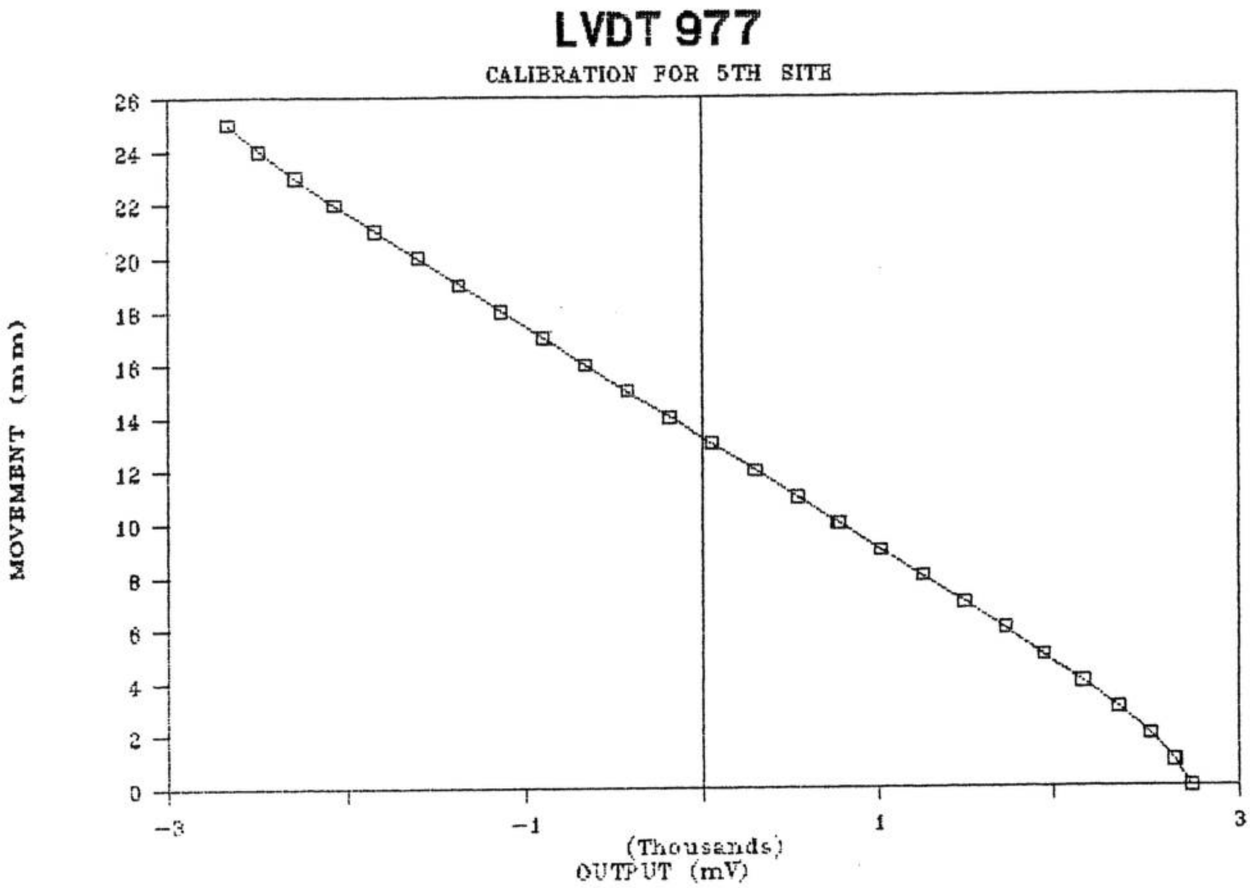
FIGURE III 192

LVDT 956



LVDT 956 (CENTRAL +- 5mm)

Regression Output:	
Constant	12.82952
Std Err of Y Est	0.012577
R Squared	0.999985
No. of Observations	22
Degrees of Freedom	20
X Coefficient(s)	-0.00384
Std Err of Coef.	0.000003



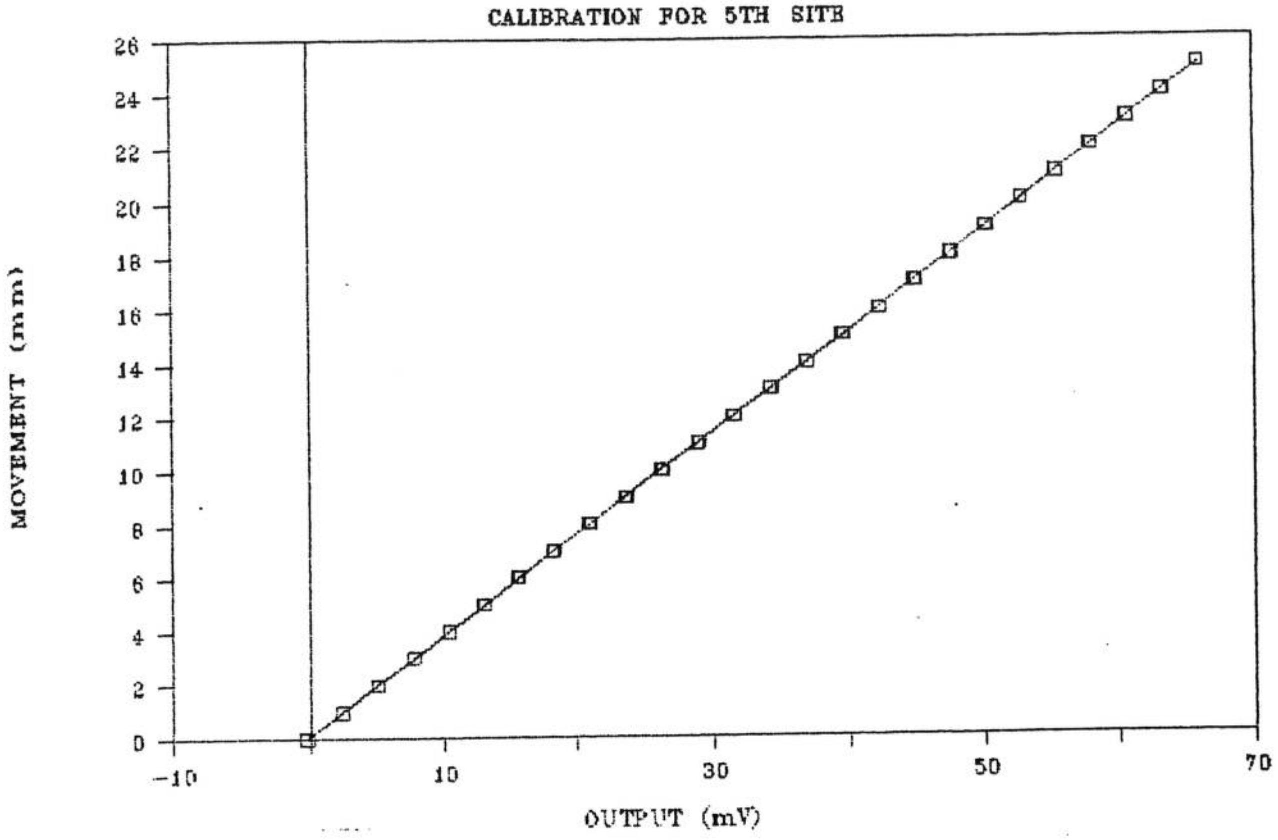
LVDT 977 (CENTRAL +- 5mm)
Regression Output:

Constant	13.24228
Std Err of Y Est	0.005143
R Squared	0.999997
No. of Observations	22
Degrees of Freedom	20

X Coefficient(s)	-0.00418
Std Err of Coef.	0.000001

FIGURE III194

LSC TRANSDUCER



LSC

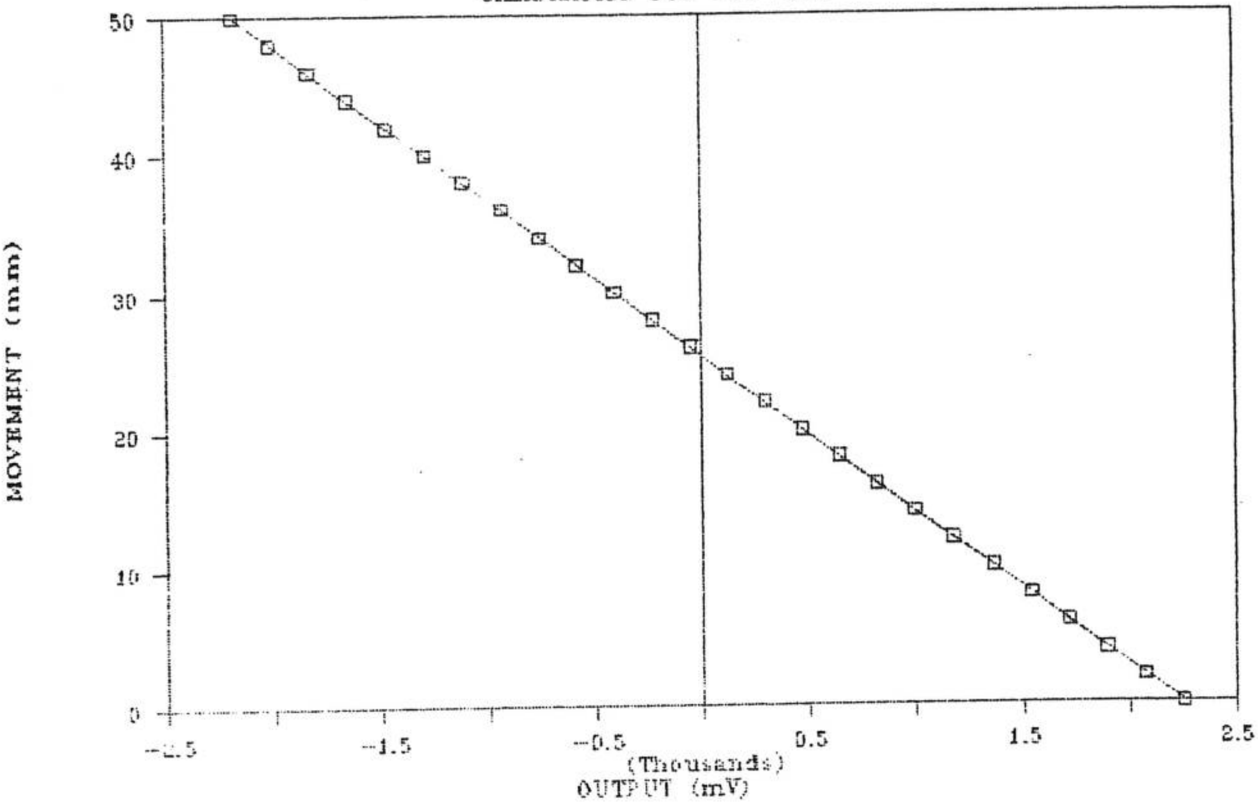
Regression Output:	
Constant	0.079847
Std Err of Y Est	0.016565
R Squared	0.999995
No. of Observations	51
Degrees of Freedom	49

X Coefficient(s)	0.376952
Std Err of Coef.	0.000118

FIGURE II 195

LVDT 653

CALIBRATION FOR 1ST SITE



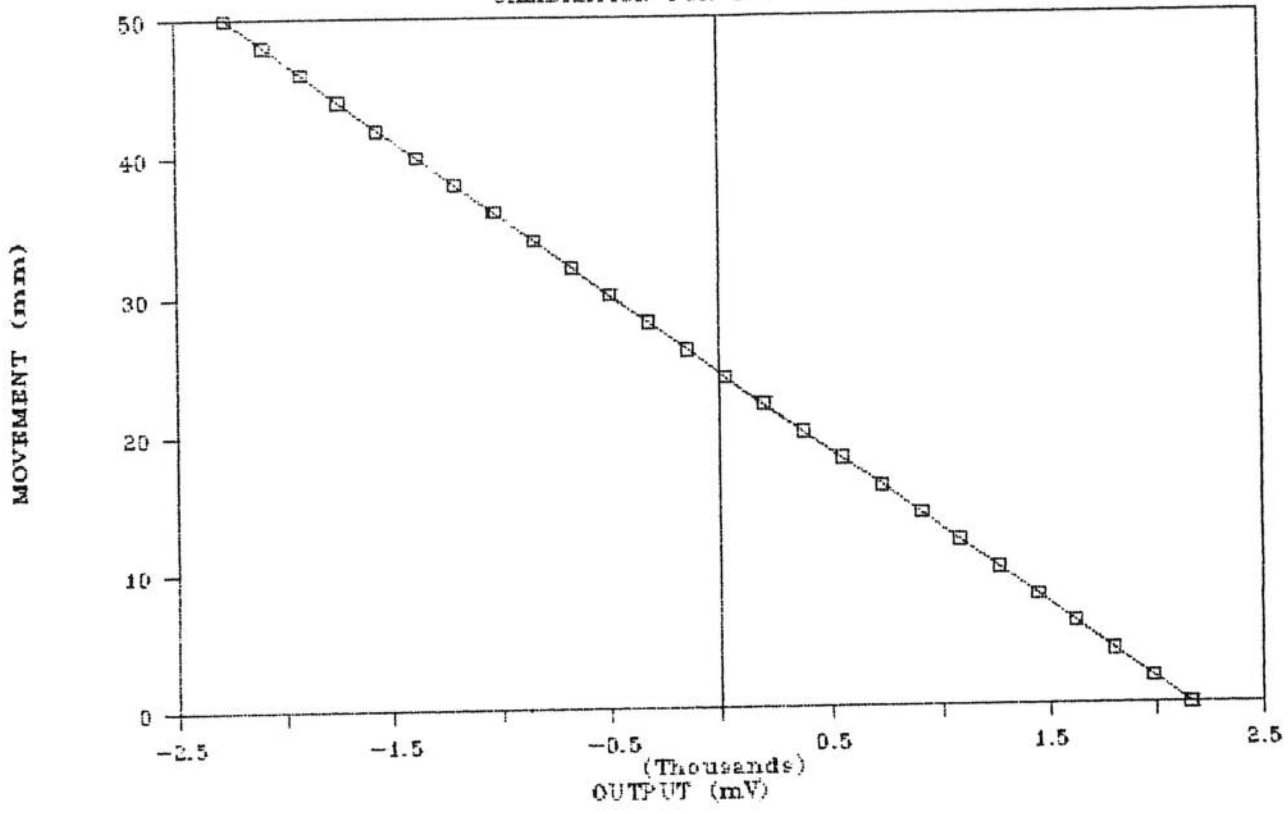
LDC 653

Regression Output:

Constant	25.40008
Std Err of Y Est	0.064078
R Squared	0.999981
No. of Observations	51
Degrees of Freedom	49
X Coefficient(s)	-0.01128
Std Err of Coef.	0.000006

LVDT 654

CALIBRATION FOR 1ST SITE

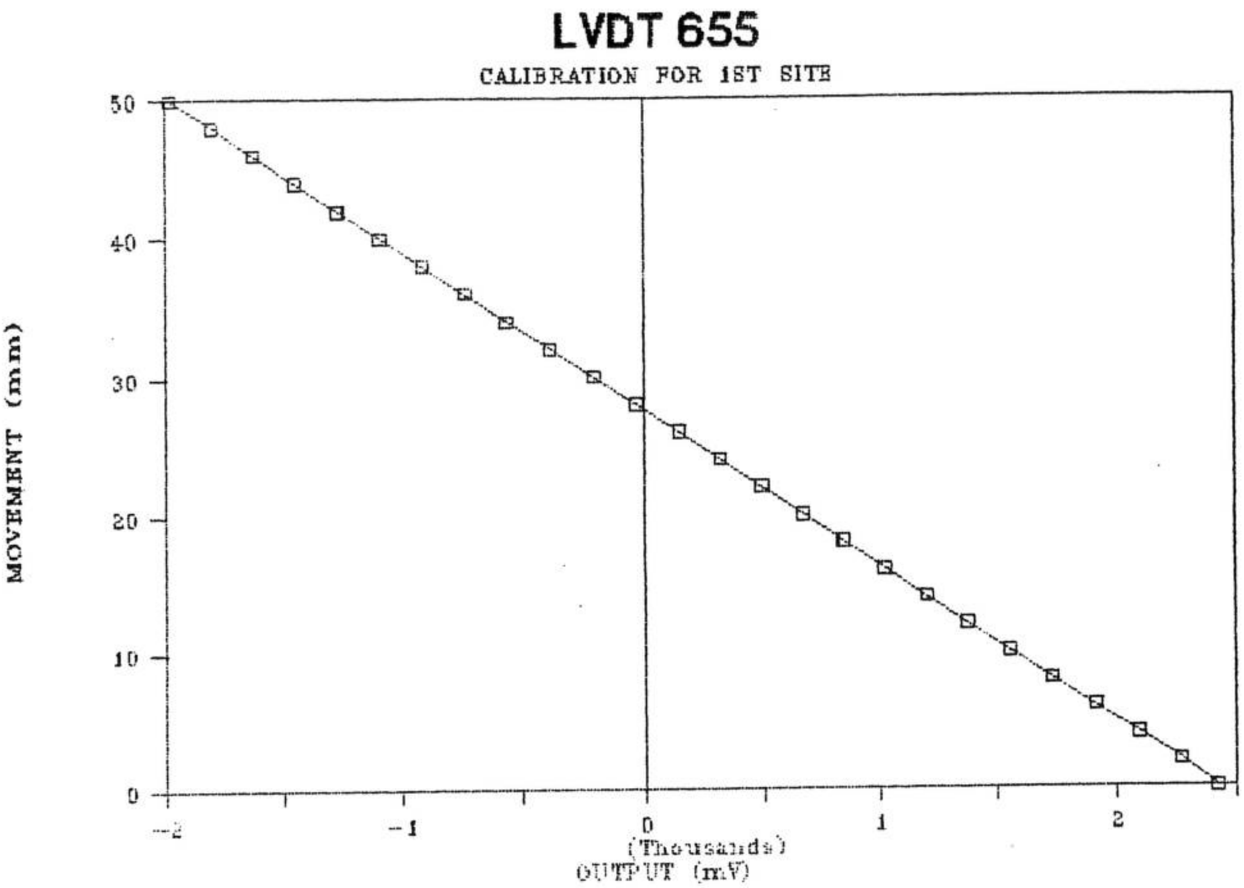


LDC 654

Regression Output:

Constant	24.37758
Std Err of Y Est	0.073430
R Squared	0.999976
No. of Observations	51
Degrees of Freedom	49
X Coefficient(s)	-0.01130
Std Err of Coef.	0.000007

FIGURE II 197

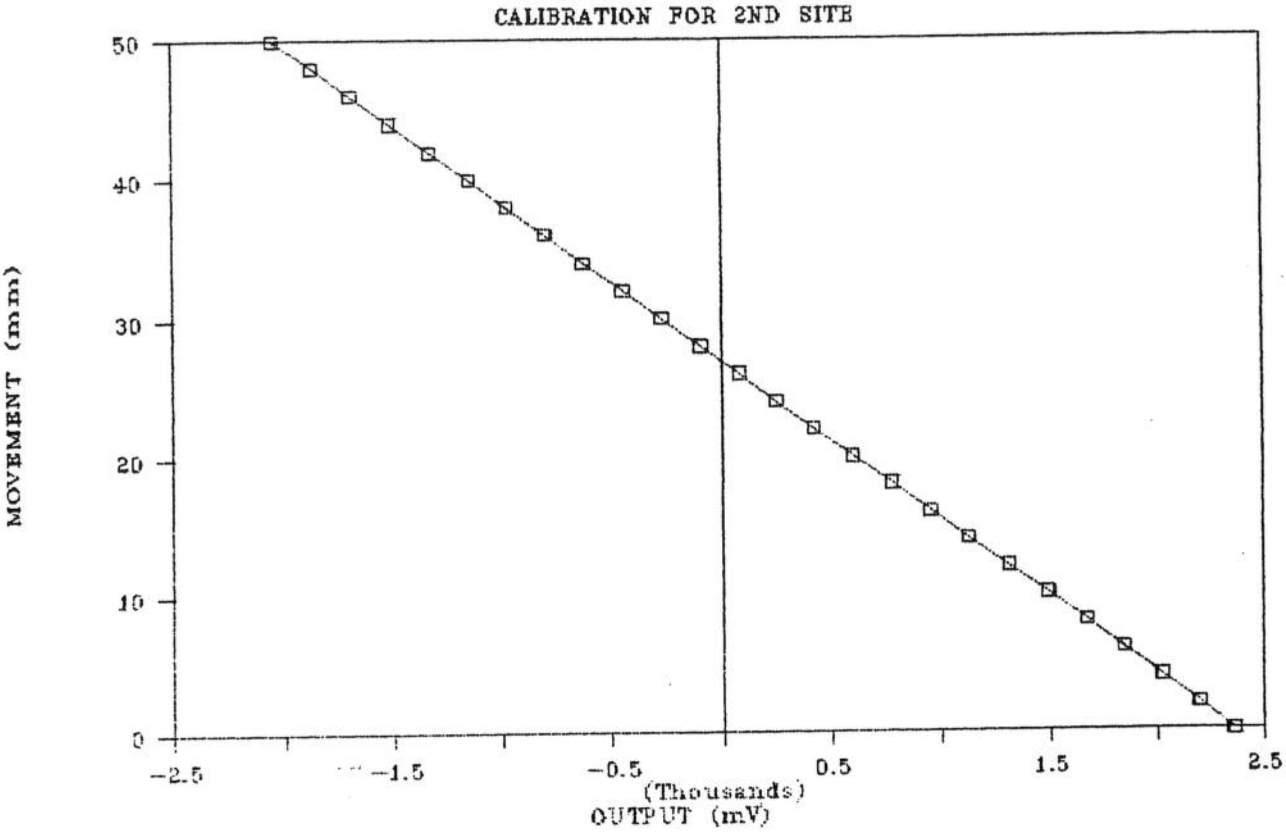


LDC 655

Regression Output:	
Constant	27.66195
Std Err of Y Est	0.070235
R Squared	0.999978
No. of Observations	51
Degrees of Freedom	49

X Coefficient(s)	-0.01132
Std Err of Coef.	0.000007

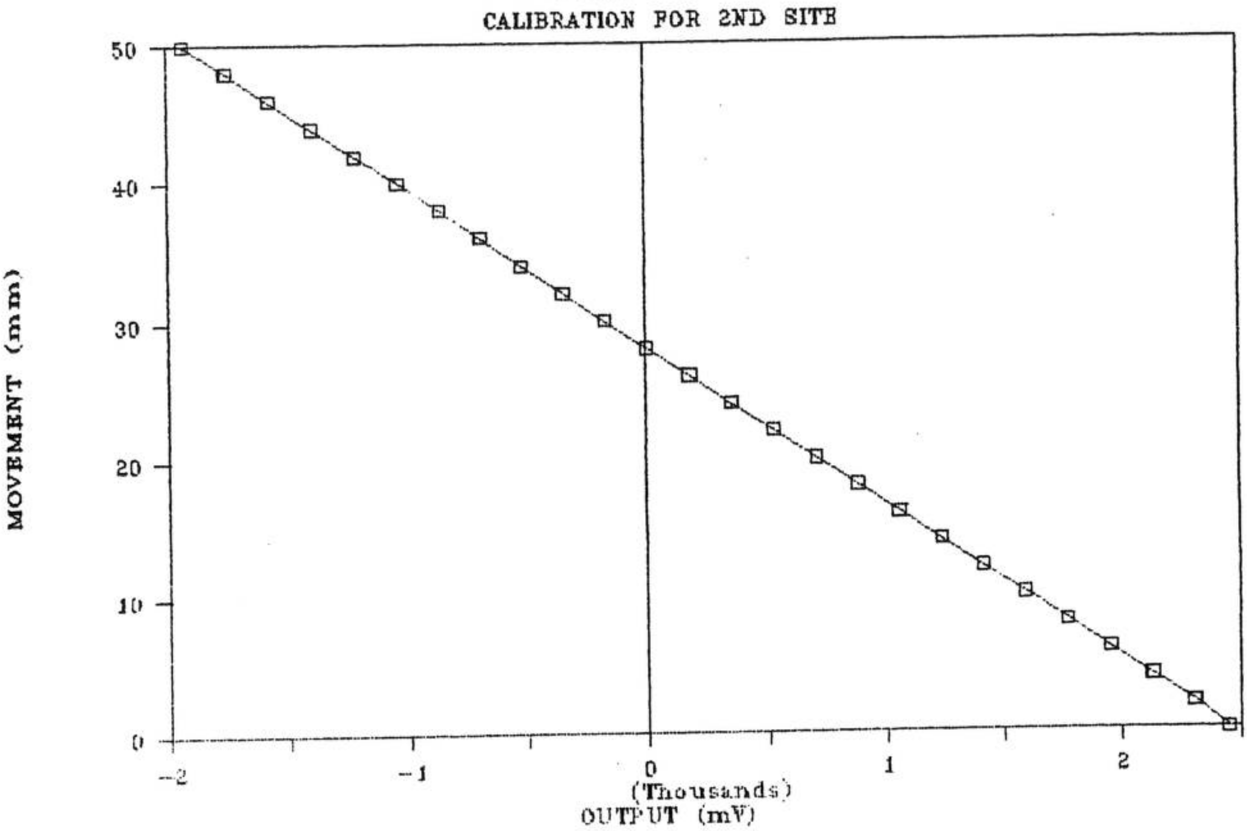
LVDT 653




```
LDC 653
          Regression Output:
Constant                      26.91548
Std Err of Y Est              0.068333
R Squared                     0.999979
No. of Observations                 51
Degrees of Freedom                  49

X Coefficient(s)  -0.01134
Std Err of Coef.  0.000007
```

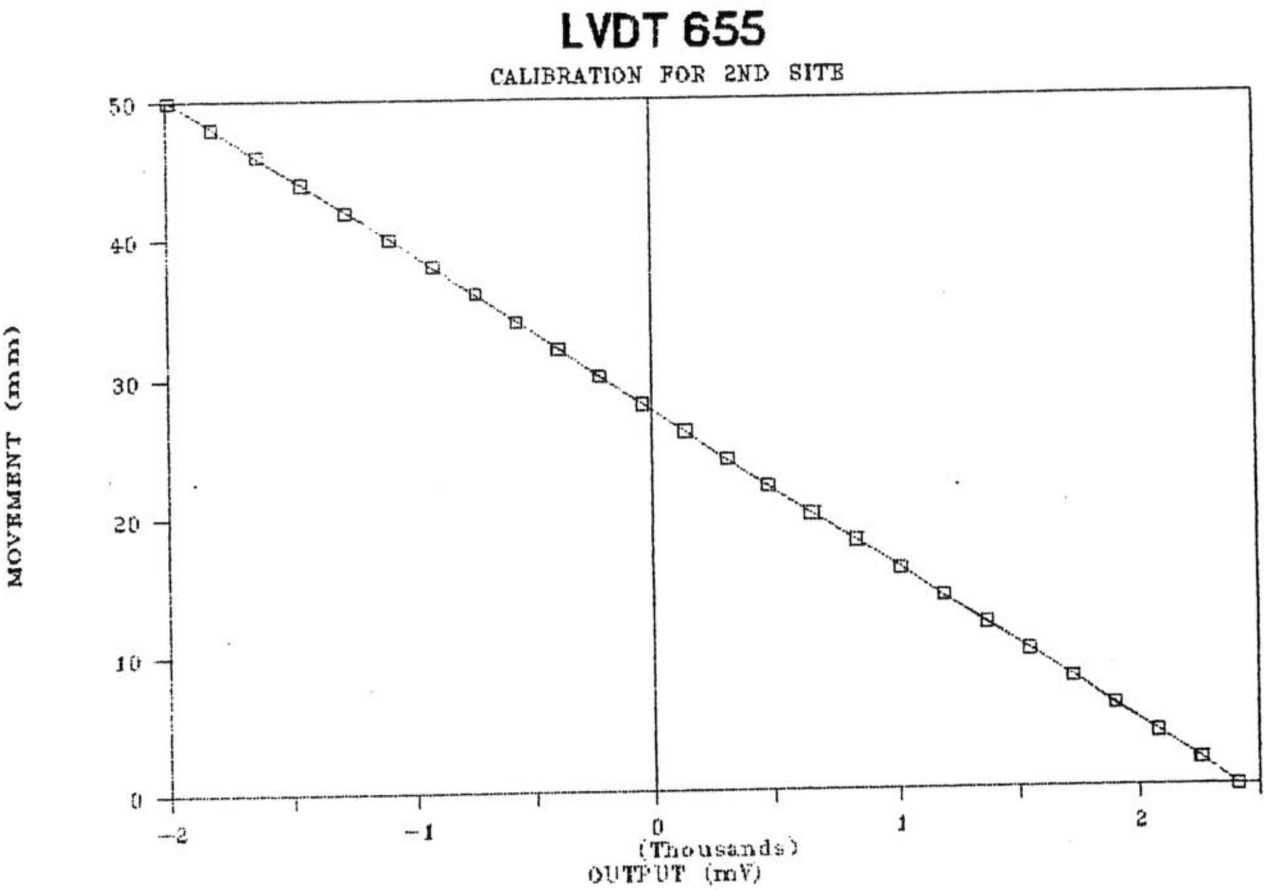
FIGURE III.199

LVDT 654



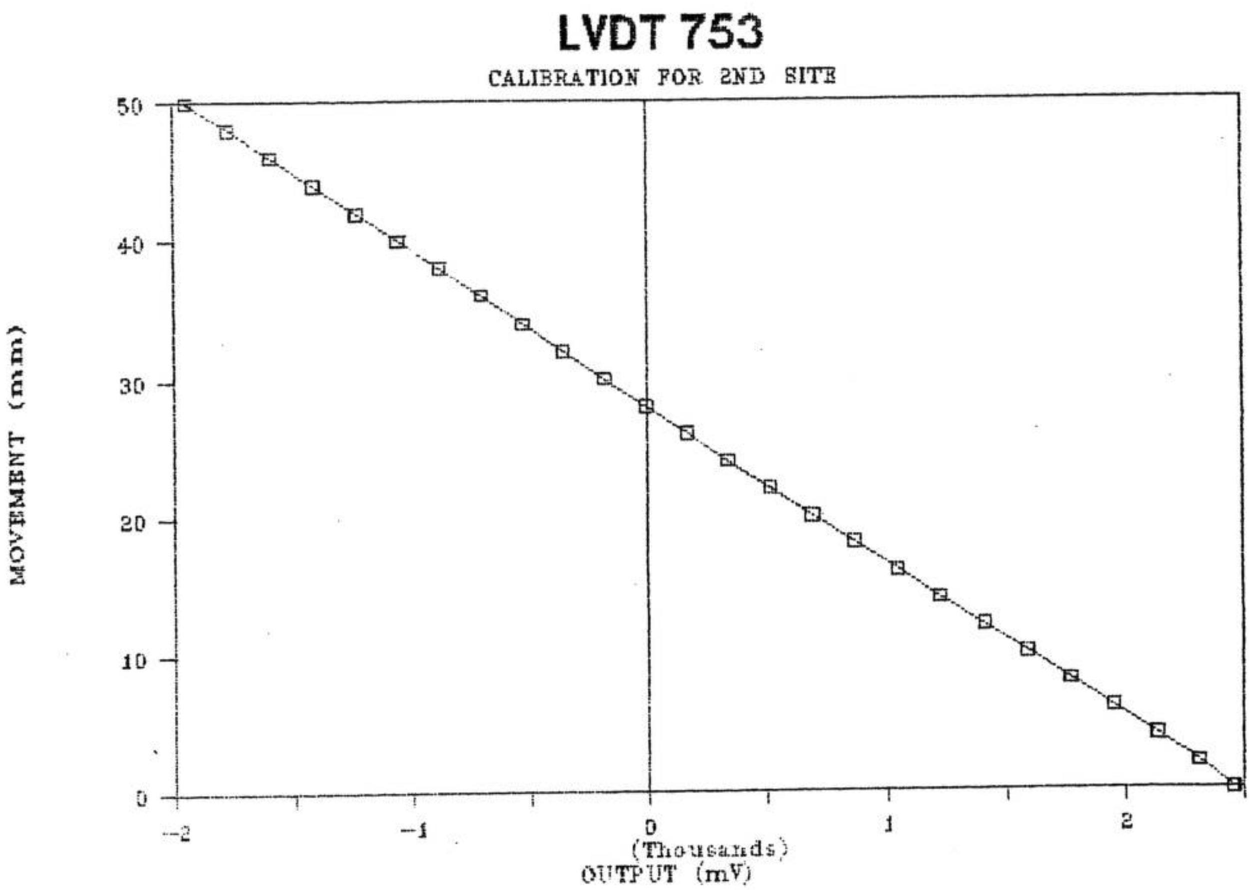

```
LDC 654
          Regression Output:
Constant                        28.10893
Std Err of Y Est                0.094593
R Squared                       0.999960
No. of Observations                   51
Degrees of Freedom                    49

X Coefficient(s)   -0.01135
Std Err of Coef.   0.000010
```

FIGURE III 200




```
LDC 655
          Regression Output:
Constant                         27.54861
Std Err of Y Est                 0.066687
R Squared                        0.999980
No. of Observations                    51
Degrees of Freedom                     49

X Coefficient(s)     -0.01133
Std Err of Coef.     0.000007
```

FIGURE III 201



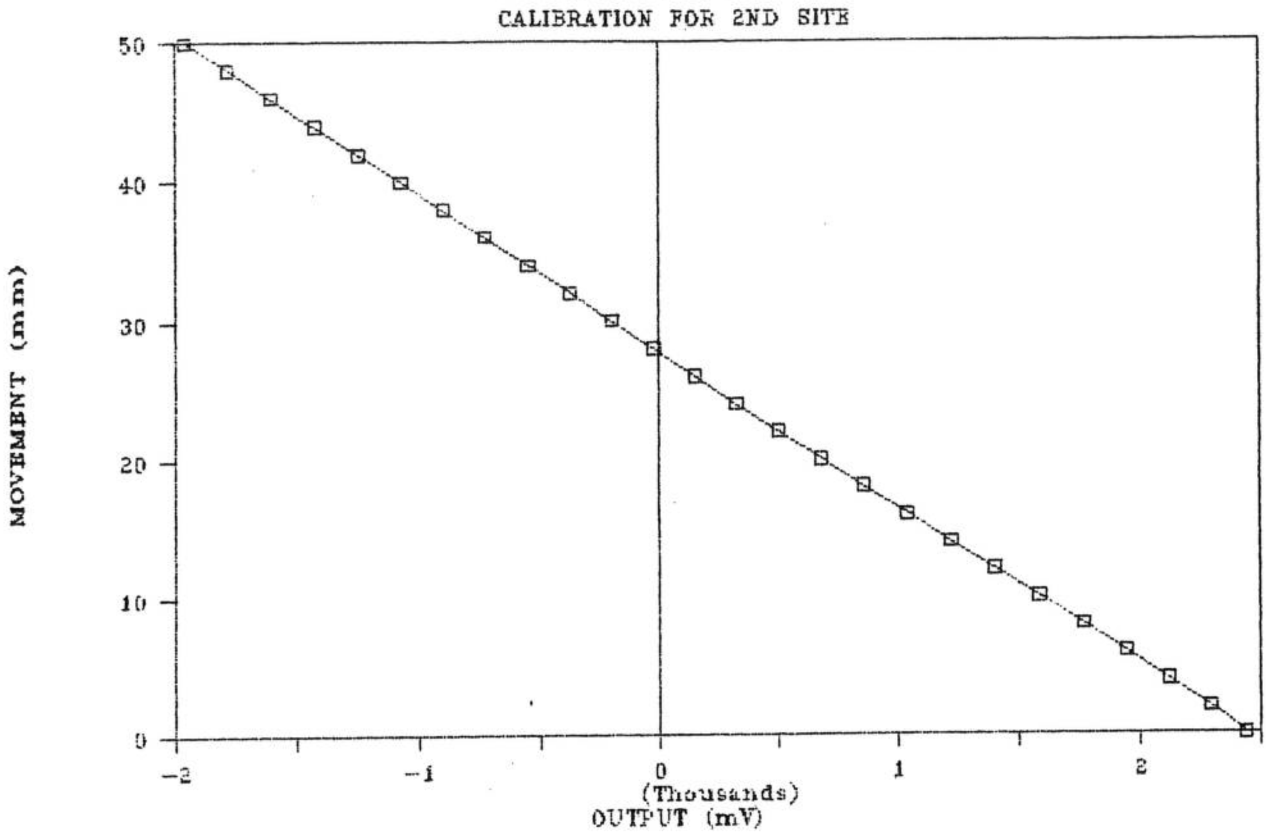
LDC 753

Regression Output:	
Constant	27.98869
Std Err of Y Est	0.098001
R Squared	0.999957
No. of Observations	51
Degrees of Freedom	49

X Coefficient(s)	-0.01130
Std Err of Coef.	0.000010

FIGURE III 20

LVDT 754



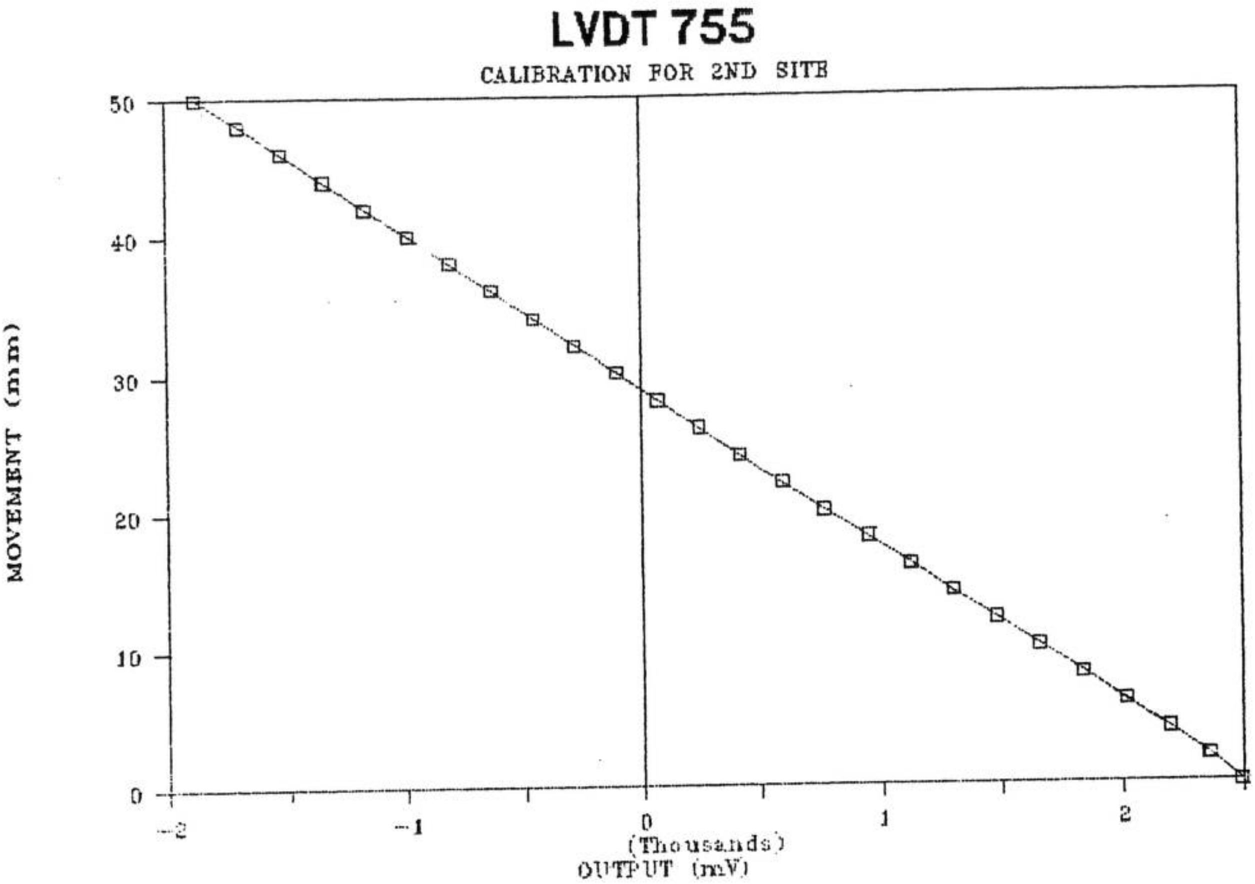
LDC 754

Regression Output:

Constant	27.84548
Std Err of Y Est	0.101881
R Squared	0.999954
No. of Observations	51
Degrees of Freedom	49

X Coefficient(s)	-0.01129
Std Err of Coef.	0.000010

FIGURE III 203

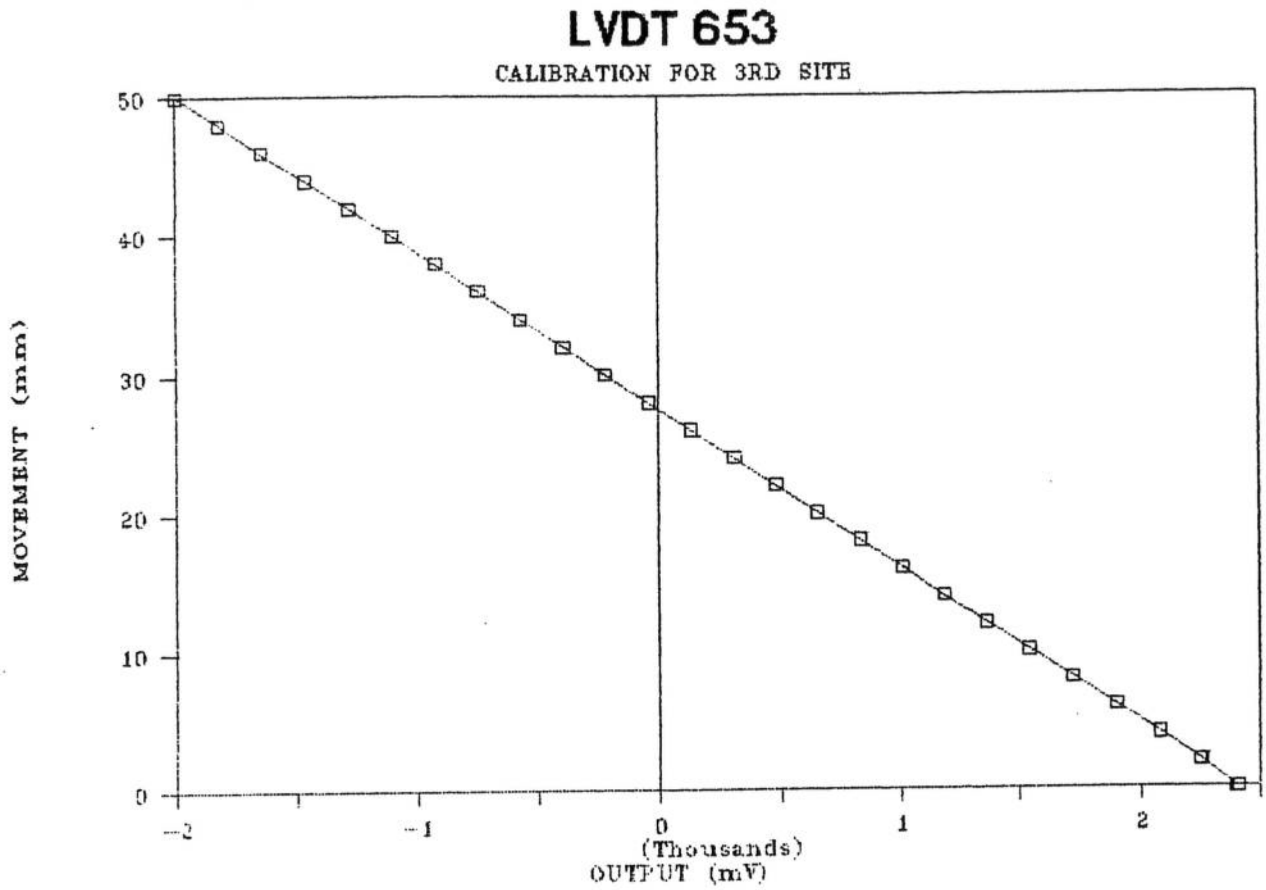


LDC 755

Regression Output:

Constant	28.80098
Std Err of Y Est	0.121339
R Squared	0.999934
No. of Observations	51
Degrees of Freedom	49
X Coefficient(s)	-0.01135
Std Err of Coef.	0.000013

FIGURE III204

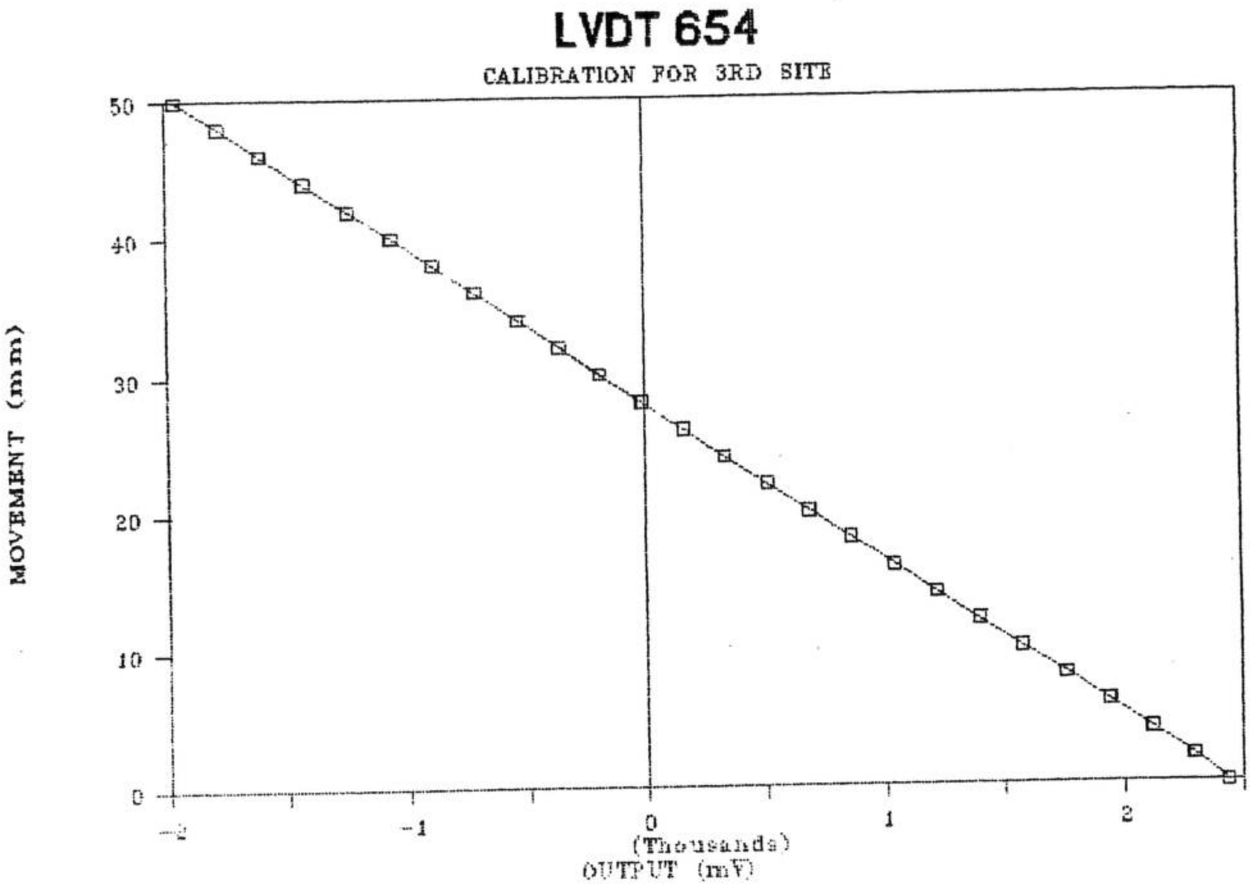


LDC 653

Regression Output:	
Constant	27.51957
Std Err of Y Est	0.077063
R Squared	0.999973
No. of Observations	51
Degrees of Freedom	49

X Coefficient(s)	-0.01132
Std Err of Coef.	0.000008

FIGURE III205

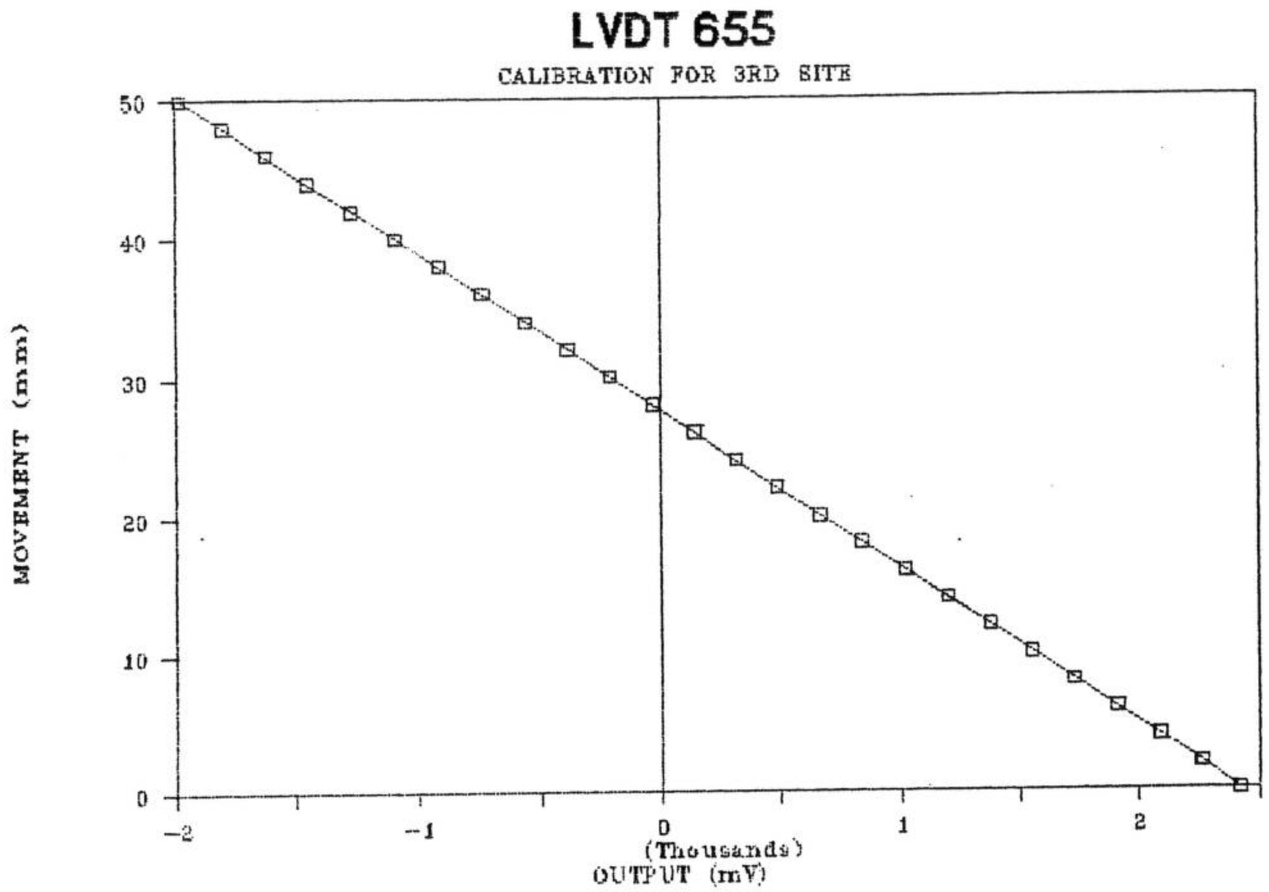


LDC 654

Regression Output:

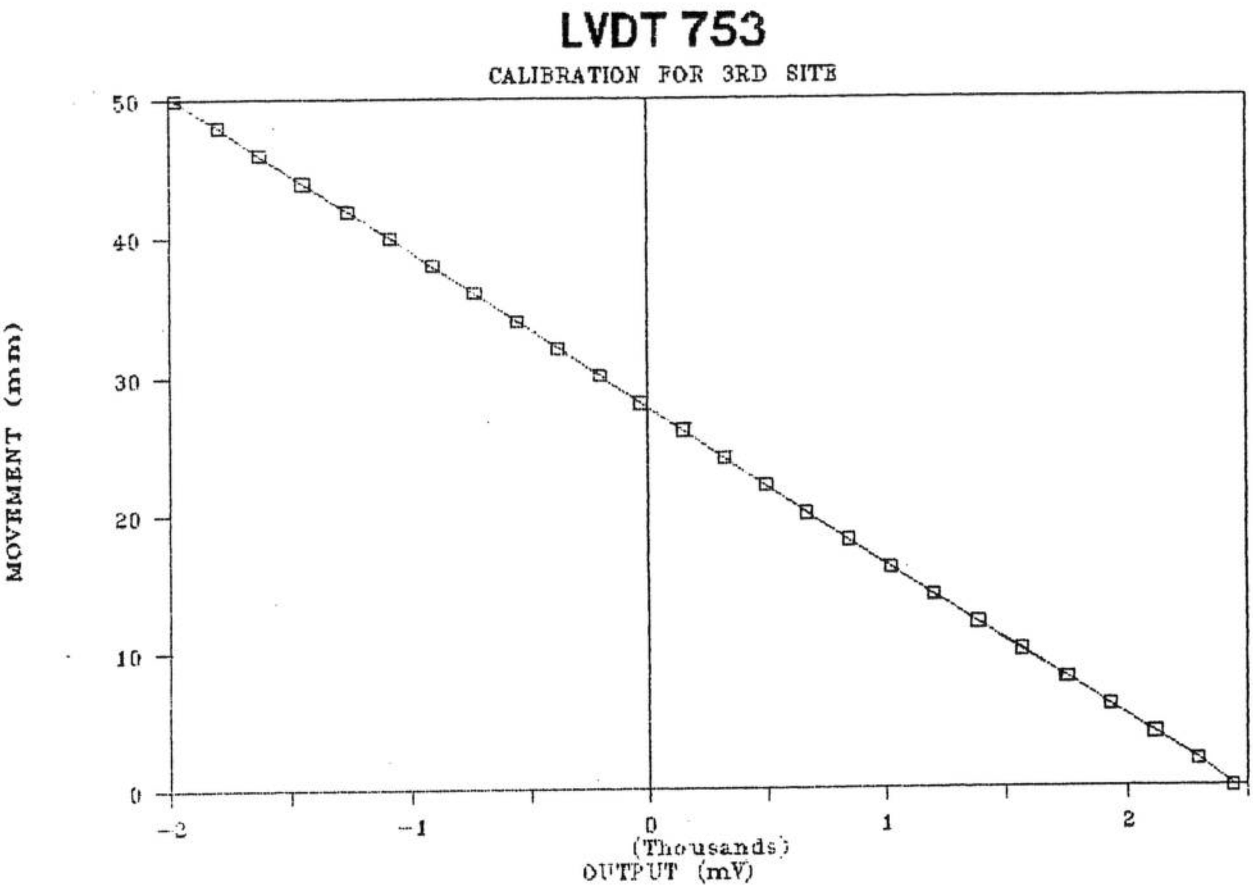
Constant	27.89180
Std Err of Y Est	0.089903
R Squared	0.999964
No. of Observations	51
Degrees of Freedom	49
X Coefficient(s)	-0.01132
Std Err of Coef.	0.000009

FIGURE III2




```
LDC 655
          Regression Output:
Constant                       27.62782
Std Err of Y Est               0.068584
R Squared                      0.999979
No. of Observations                  51
Degrees of Freedom                   49

X Coefficient(s)   -0.01133
Std Err of Coef.   0.000007
```

FIGURE III 207



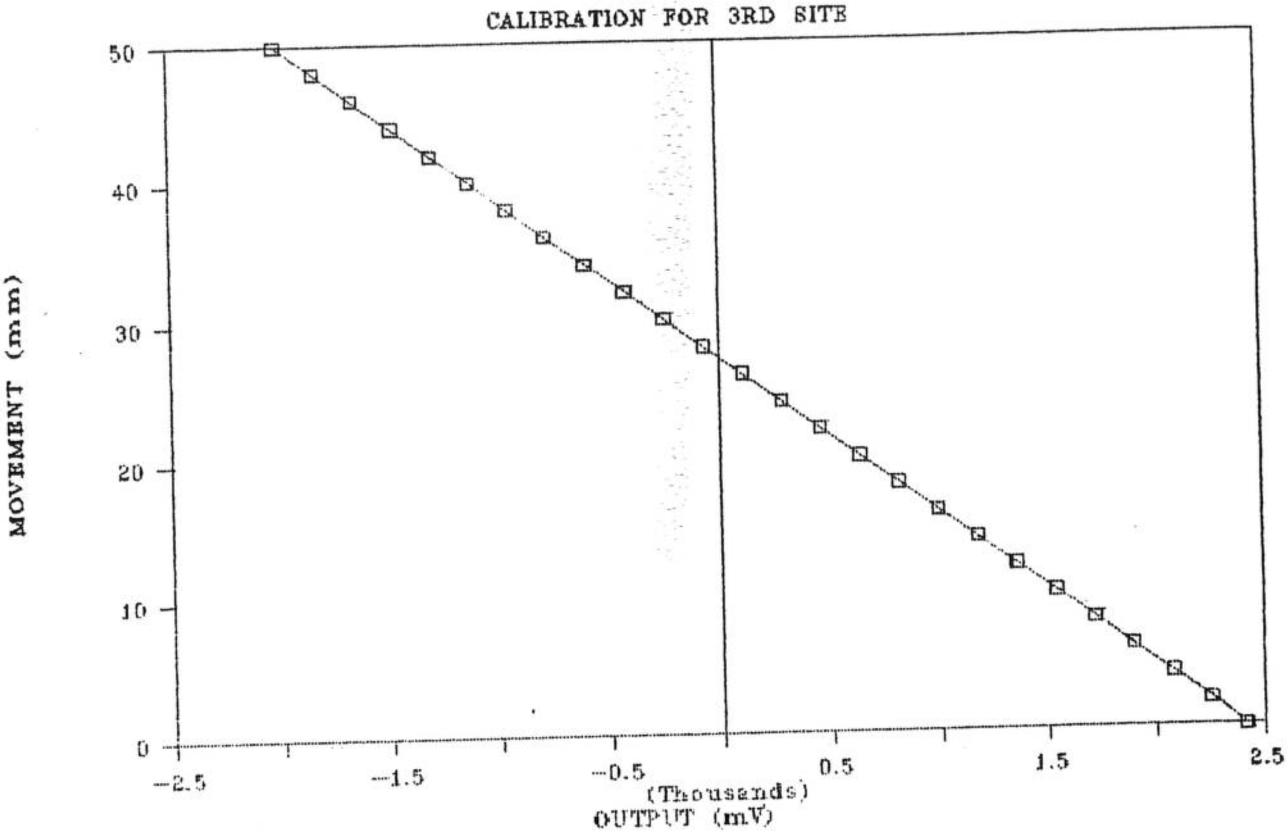
LDC 753

Regression Output:	
Constant	27.71153
Std Err of Y Est	0.093489
R Squared	0.999961
No. of Observations	51
Degrees of Freedom	49

X Coefficient(s) -0.01128
Std Err of Coef. 0.000010

FIGURE III 2

LVDT 754



LDC 754

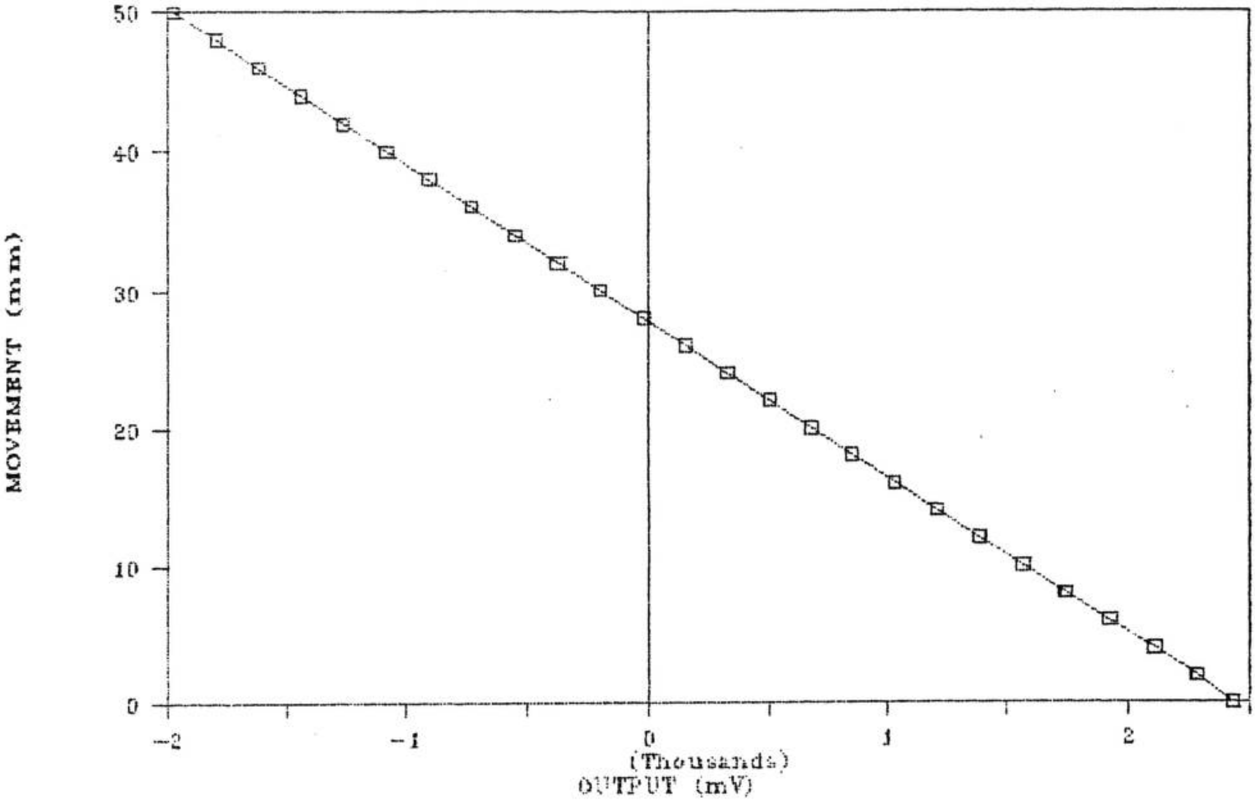
Regression Output:

Constant	27.31631
Std Err of Y Est	0.093326
R Squared	0.999961
No. of Observations	51
Degrees of Freedom	49
X Coefficient(s)	-0.01126
Std Err of Coef.	0.000009

FIGURE III 209

LVDT 755

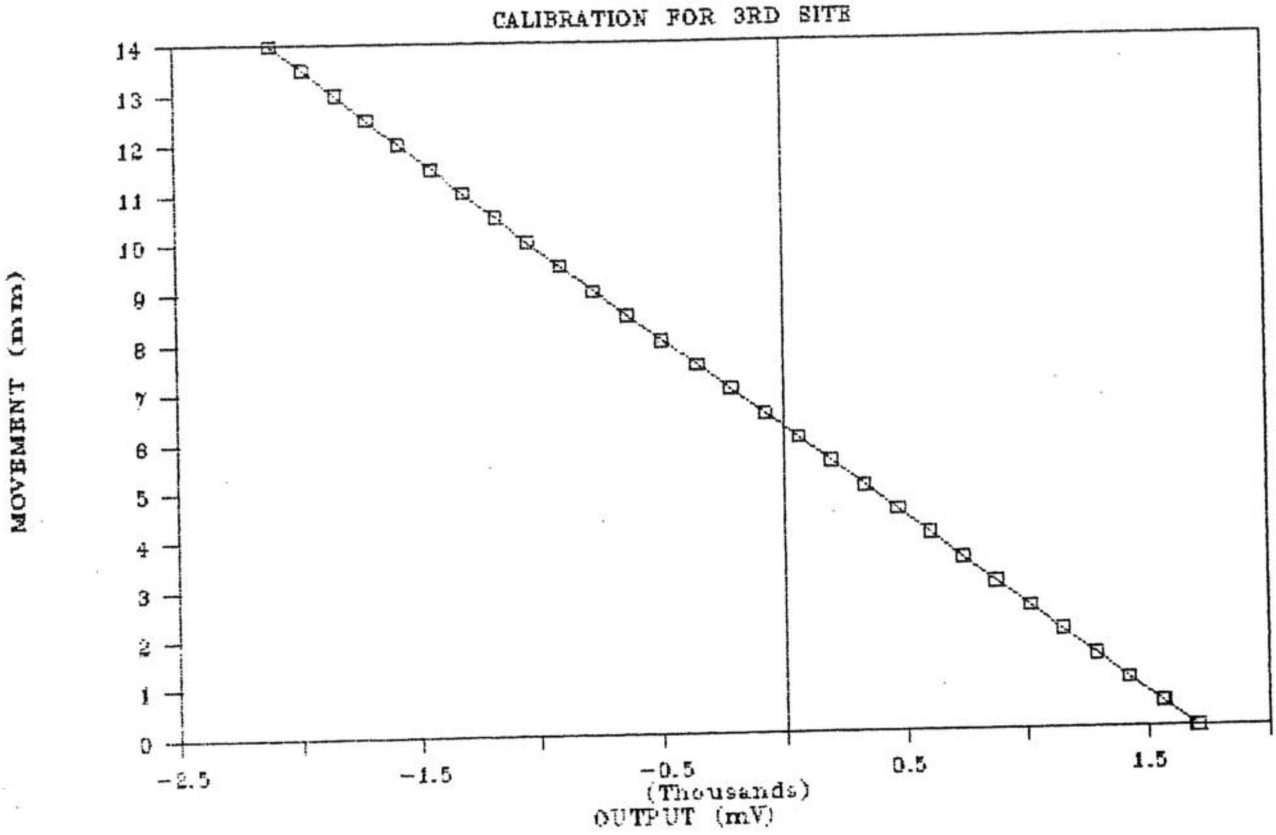
CALIBRATION FOR 3RD SITE



LDC 755

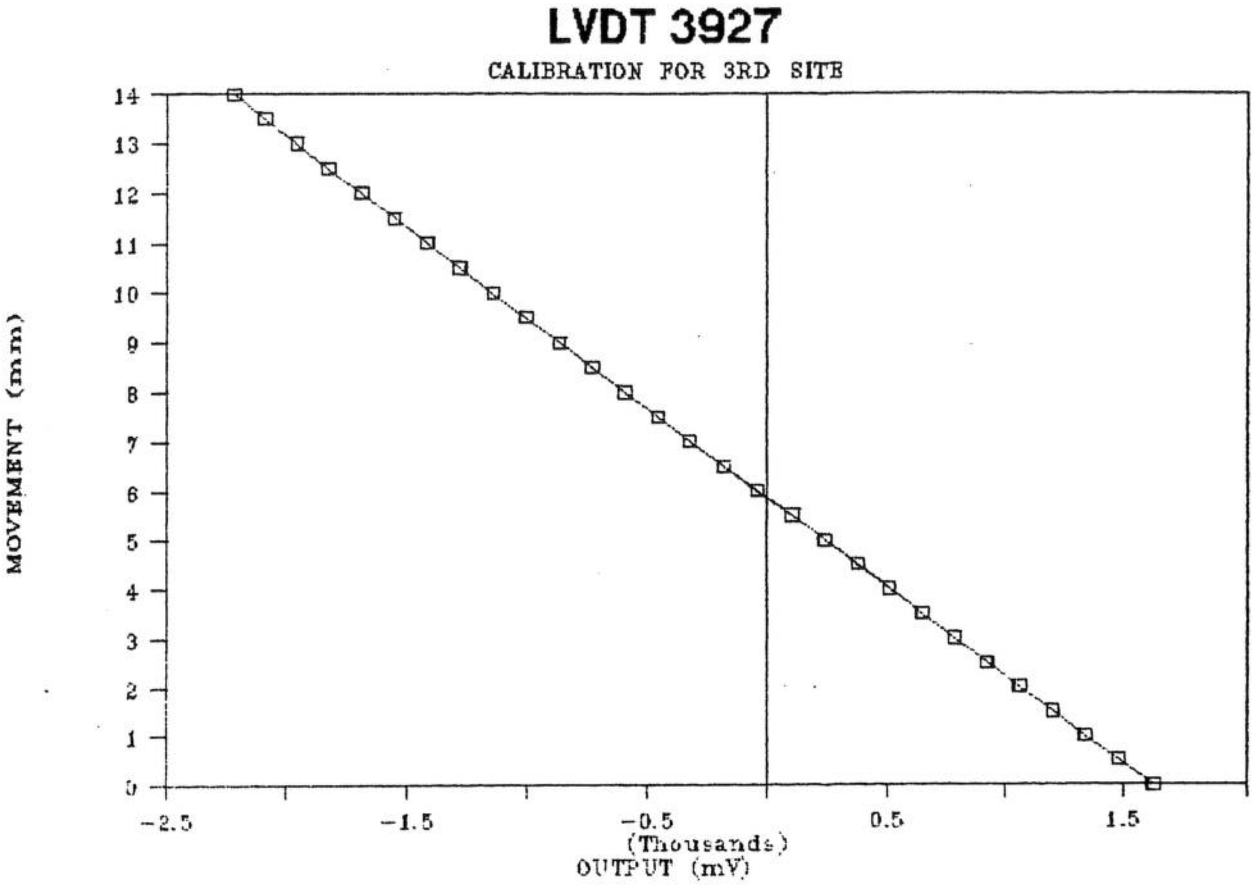
Regression Output:	
Constant	27.76541
Std Err of Y Est	0.073442
R Squared	0.999976
No. of Observations	51
Degrees of Freedom	49
X Coefficient(s)	-0.01130
Std Err of Coef.	0.000007

LVDT 3926



LVDT 3926

Regression Output:	
Constant	6.233758
Std Err of Y Est	0.012903
R Squared	0.999990
No. of Observations	57
Degrees of Freedom	55
X Coefficient(s)	-0.00366
Std Err of Coef.	0.000001



LVDT 3927

Regression Output:

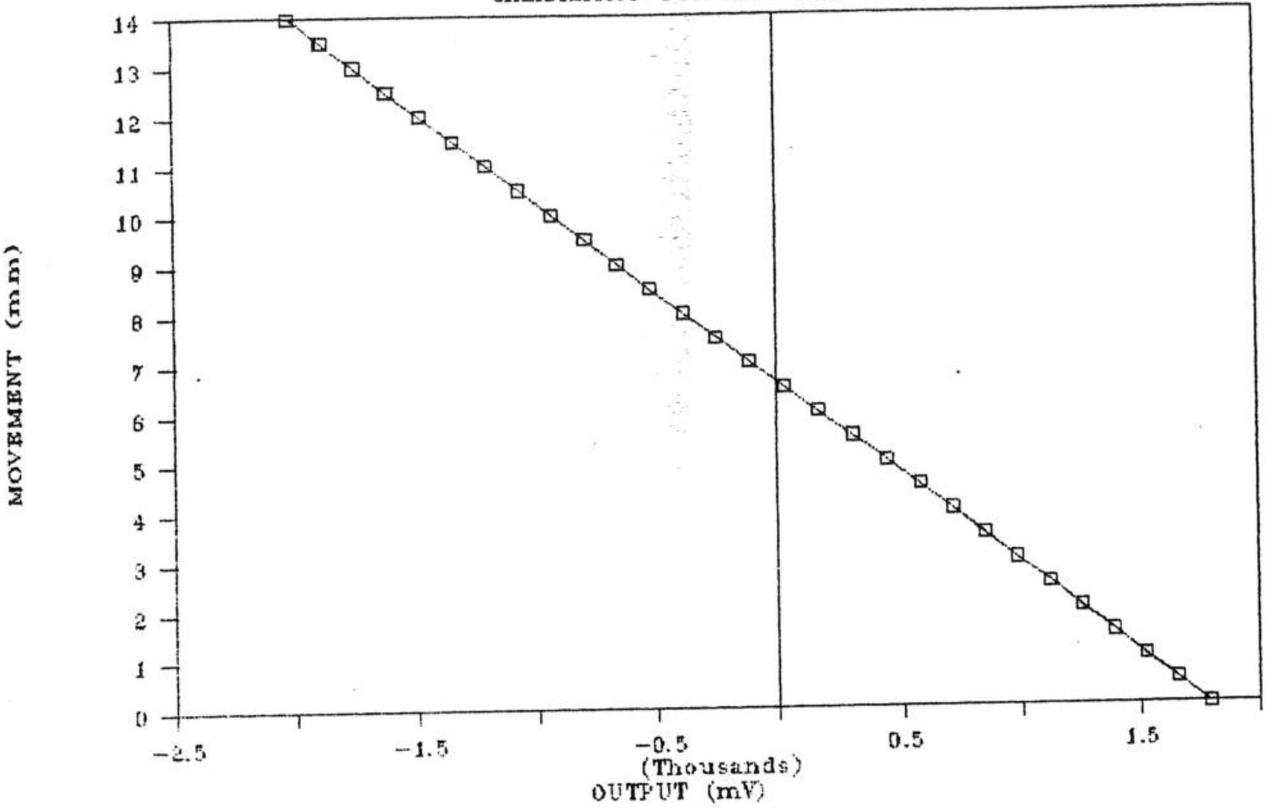
Constant	5.874910
Std Err of Y Est	0.021781
R Squared	0.999972
No. of Observations	57
Degrees of Freedom	55

X Coefficient(s)	-0.00363
Std Err of Coef.	0.000002

FIGURE III 21

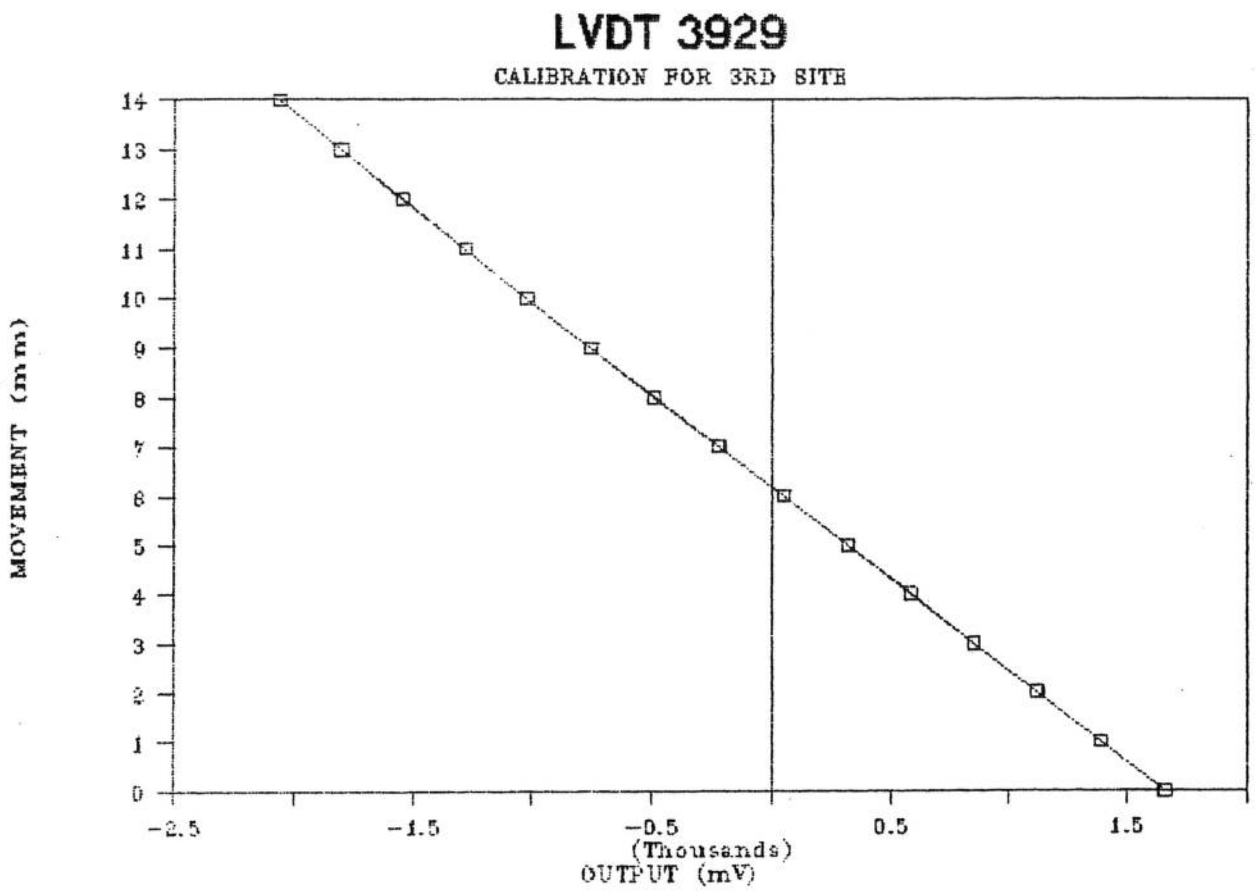
LVDT 3928

CALIBRATION FOR 3RD SITE



LVDT 3928

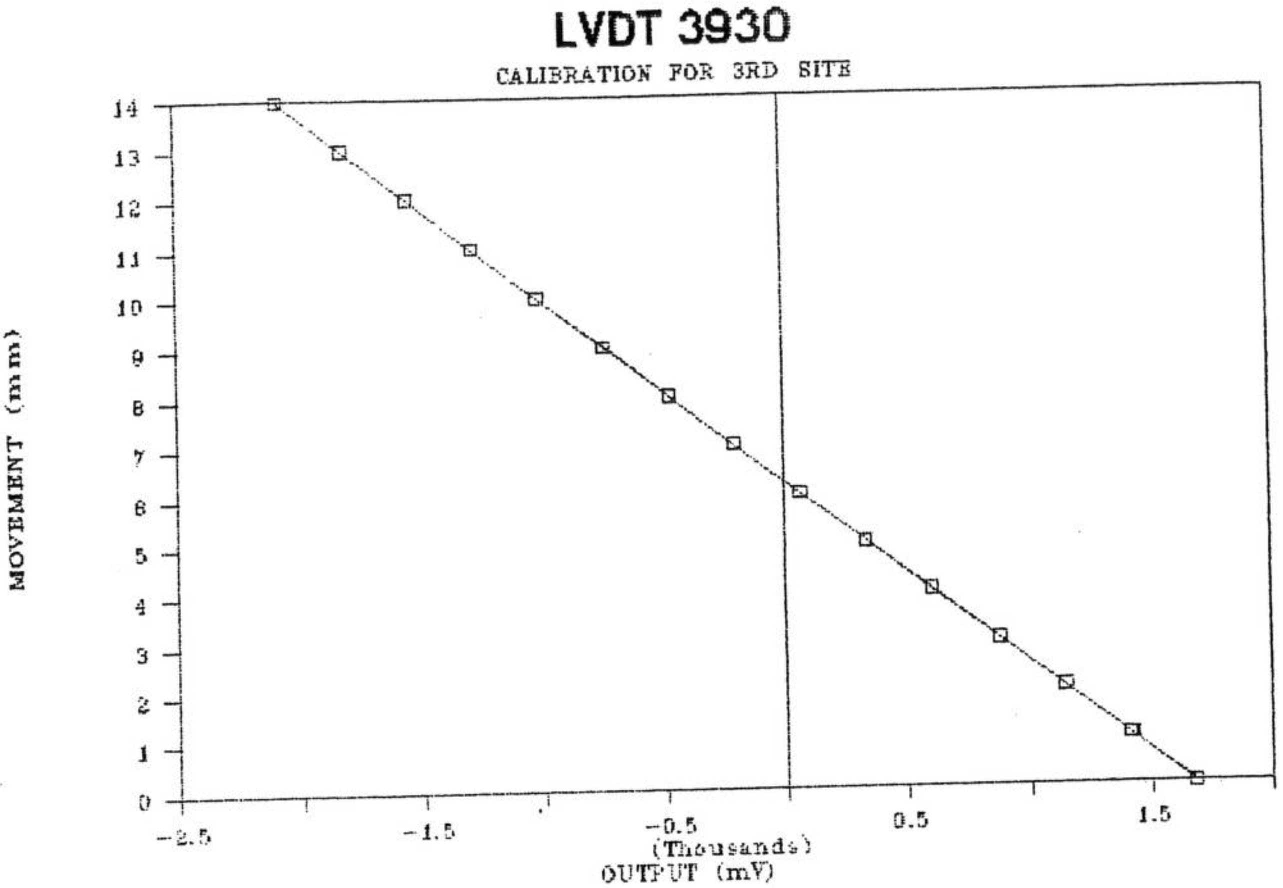
	Regression Output:
Constant	6.603776
Std Err of Y Est	0.007360
R Squared	0.999996
No. of Observations	57
Degrees of Freedom	55
X Coefficient(s)	-0.00366
Std Err of Coef.	0.000000



LVDT 3929

Regression Output:	
Constant	6.200321
Std Err of Y Est	0.025798
R Squared	0.999964
No. of Observations	29
Degrees of Freedom	27
X Coefficient(s)	-0.00374
Std Err of Coef.	0.000004

FIGURE III 214

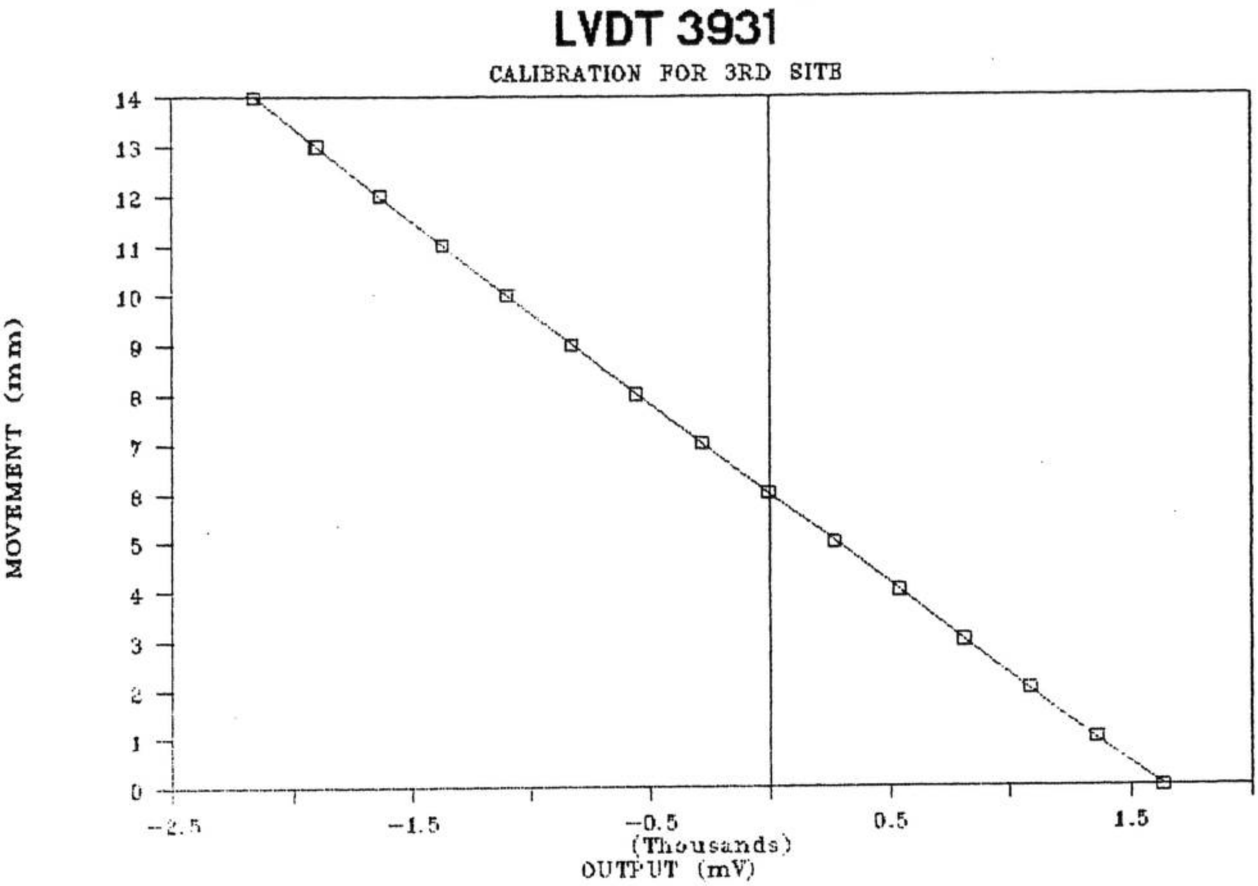


LVDT 3930

Regression Output:

Constant	6.248087
Std Err of Y Est	0.007770
R Squared	0.999996
No. of Observations	29
Degrees of Freedom	27
X Coefficient(s)	-0.00370
Std Err of Coef.	0.000001

FIGURE III 215

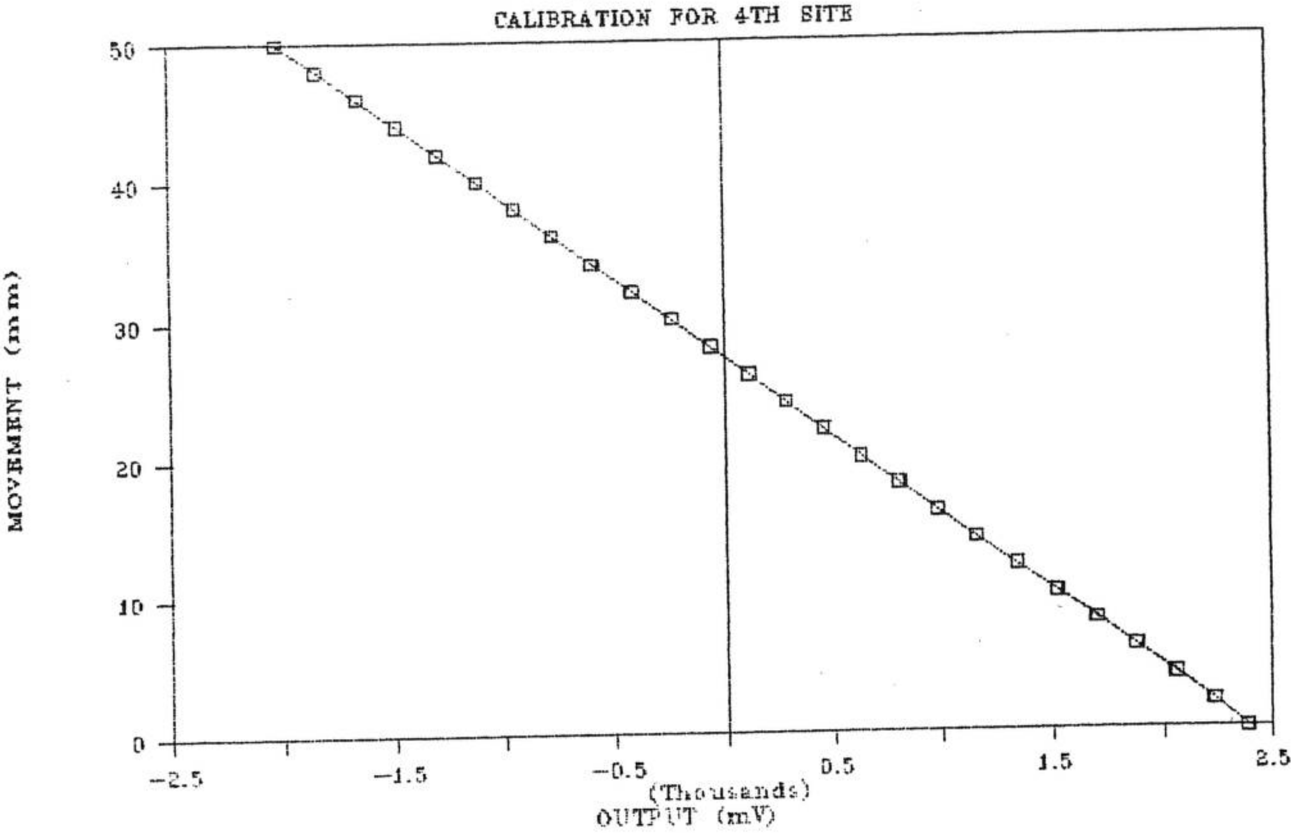


LVDT 3931

Regression Output:	
Constant	5.995565
Std Err of Y Est	0.021075
R Squared	0.999976
No. of Observations	29
Degrees of Freedom	27
X Coefficient(s)	-0.00367
Std Err of Coef.	0.000003

FIGURE II2

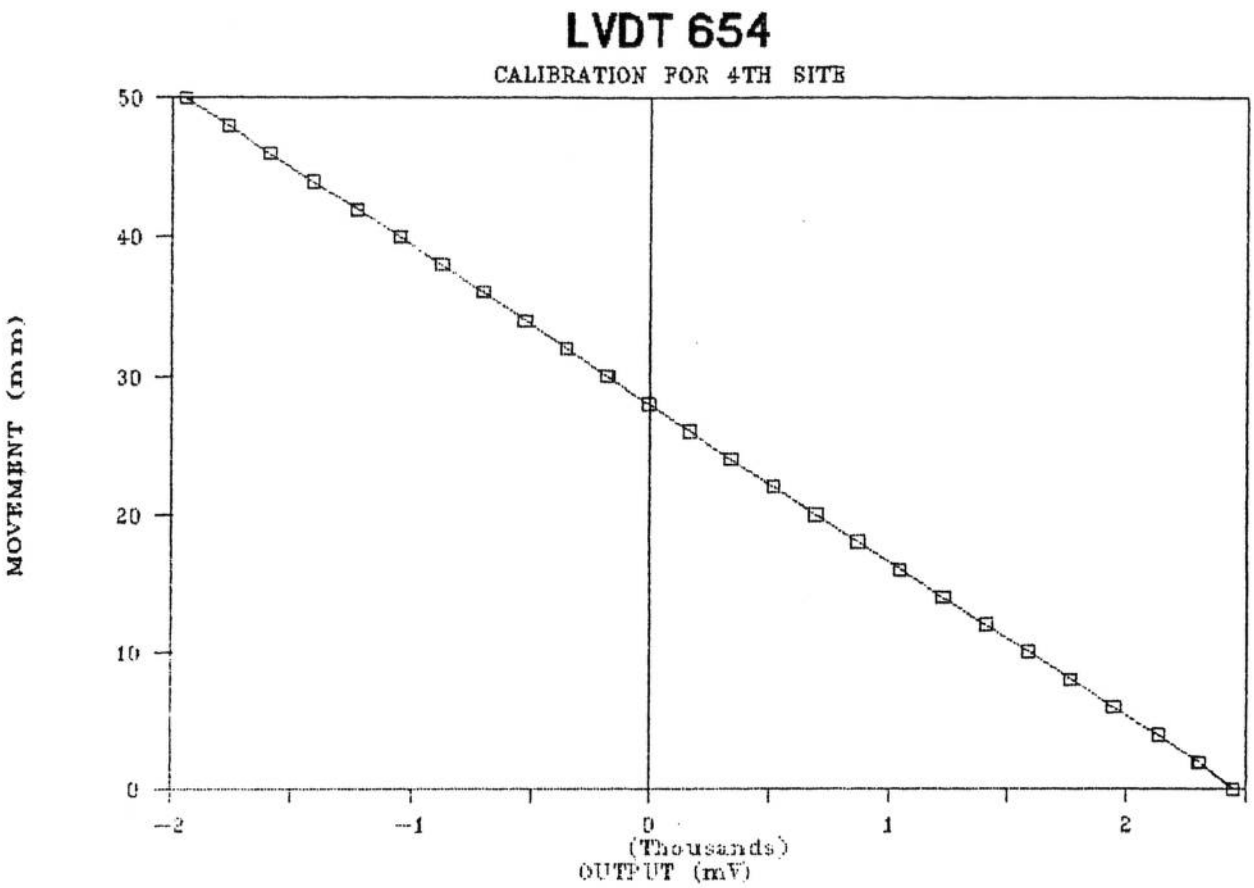
LVDT 653



LDC 653

Regression Output:	
Constant	27.28136
Std Err of Y Est	0.073239
R Squared	0.999976
No. of Observations	51
Degrees of Freedom	49
X Coefficient(s)	-0.01134
Std Err of Coef.	0.000007

FIGURE III217



LDC 654

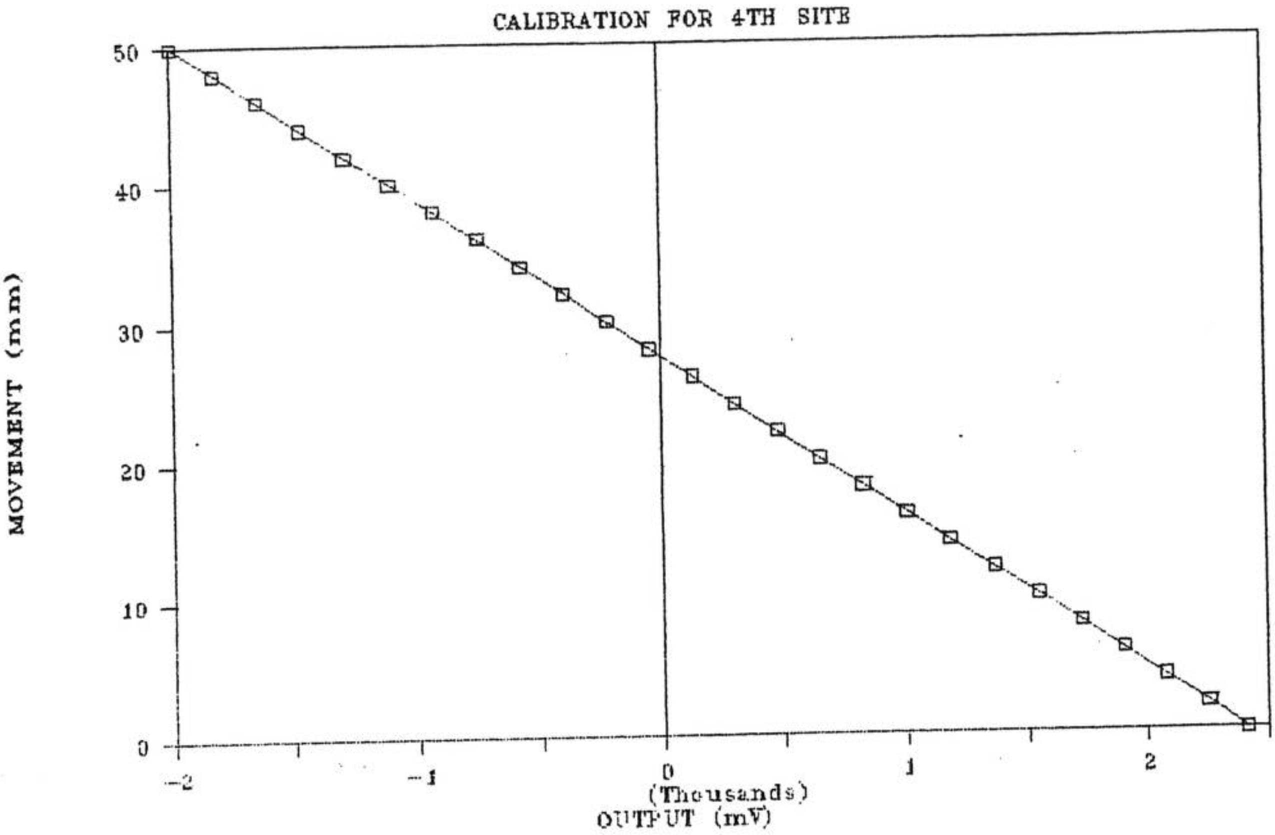
Regression Output:

Constant	27.99271
Std Err of Y Est	0.092034
R Squared	0.999962
No. of Observations	51
Degrees of Freedom	49

X Coefficient(s)	-0.01133
Std Err of Coef.	0.000009

FIGURE III 21

LVDT 655



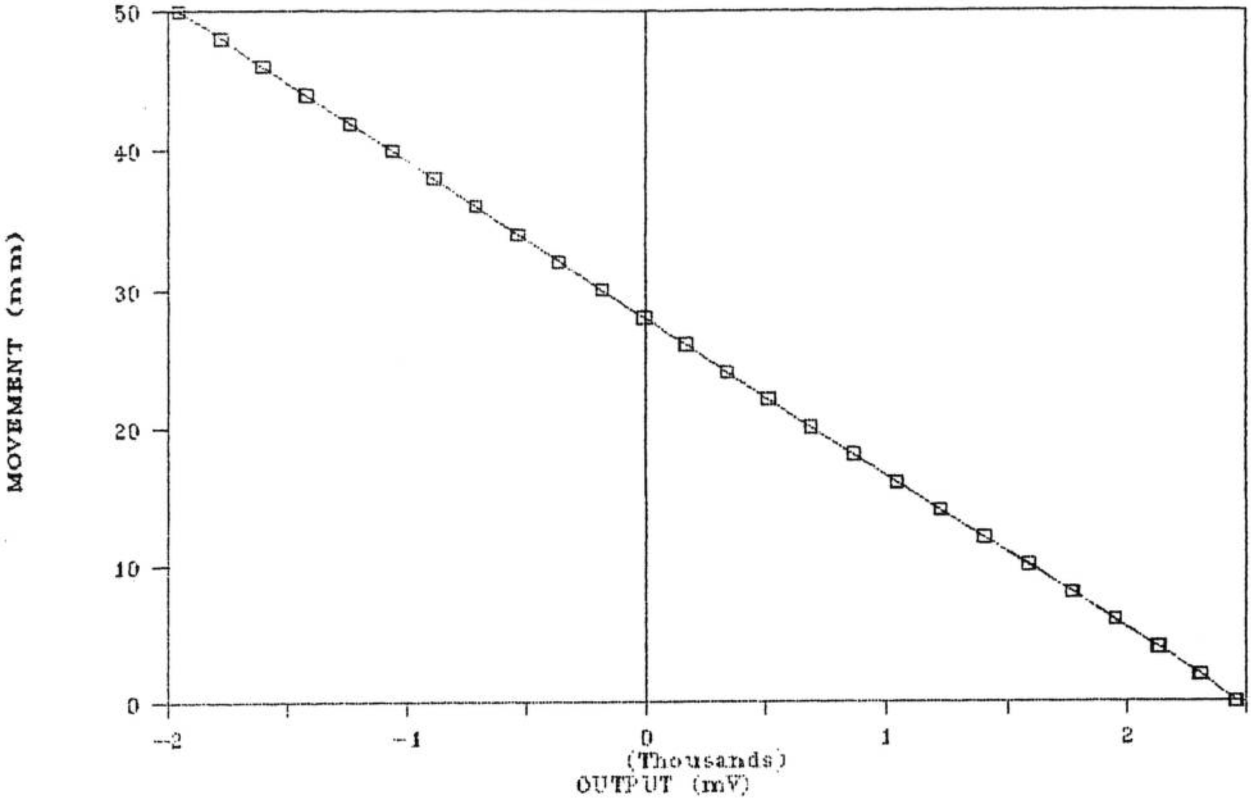
LDC 655

Regression Output:	
Constant	27.50072
Std Err of Y Est	0.064903
R Squared	0.999981
No. of Observations	51
Degrees of Freedom	49
X Coefficient(s)	-0.01132
Std Err of Coef.	0.000006

FIGURE III 219

LVDT 753

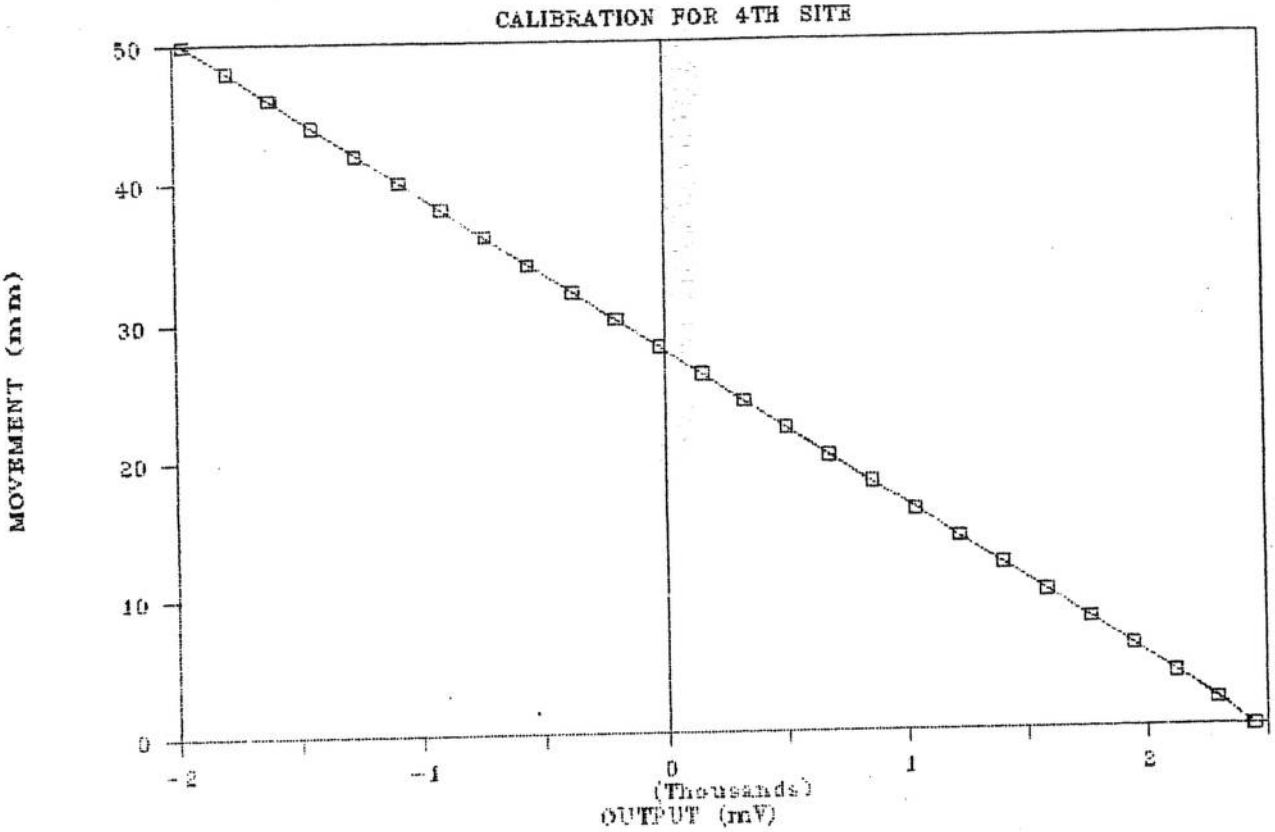
CALIBRATION FOR 4TH SITE



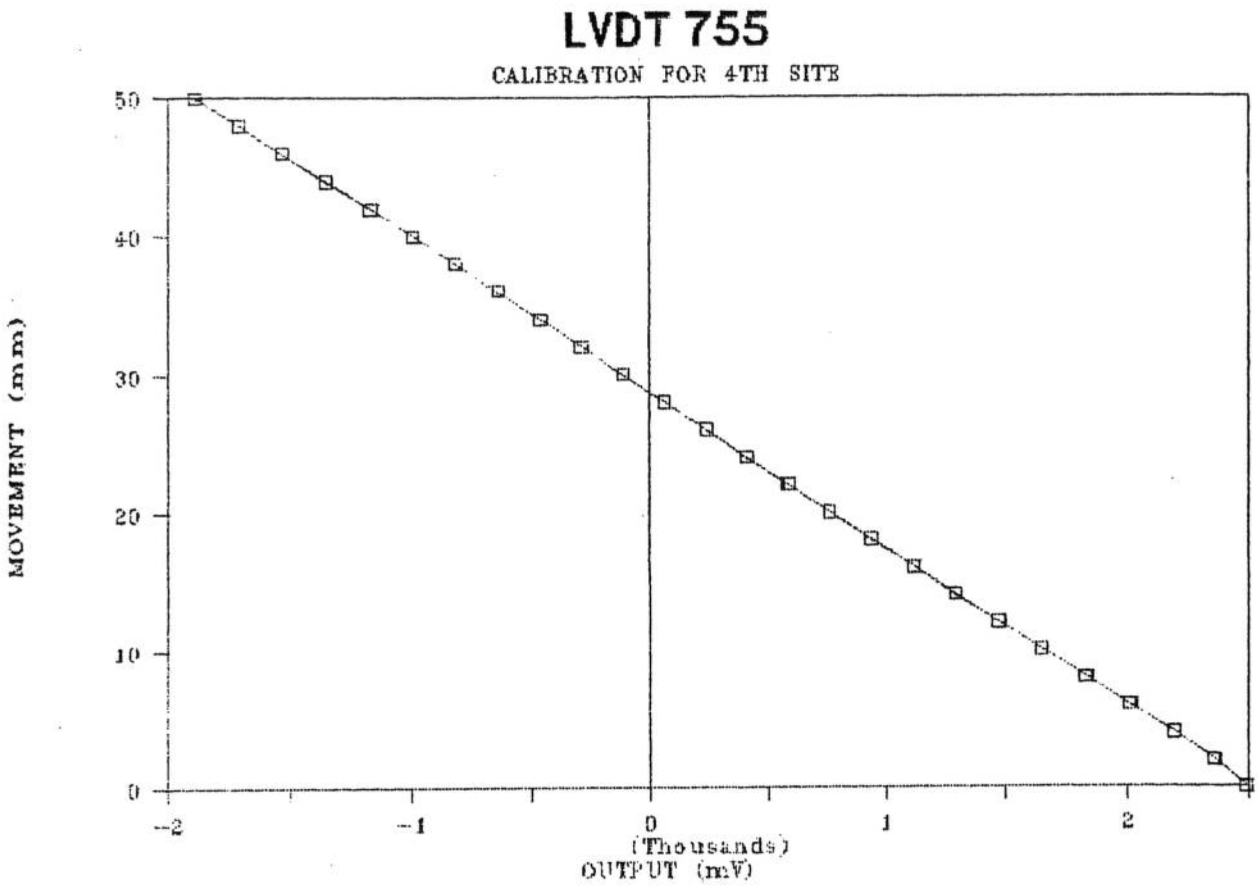
LDC 753	
Regression Output:	
Constant	27.94908
Std Err of Y Est	0.095433
R Squared	0.999959
No. of Observations	51
Degrees of Freedom	49
X Coefficient(s)	-0.01129
Std Err of Coef.	0.000010

FIGURE III22(

LVDT 754



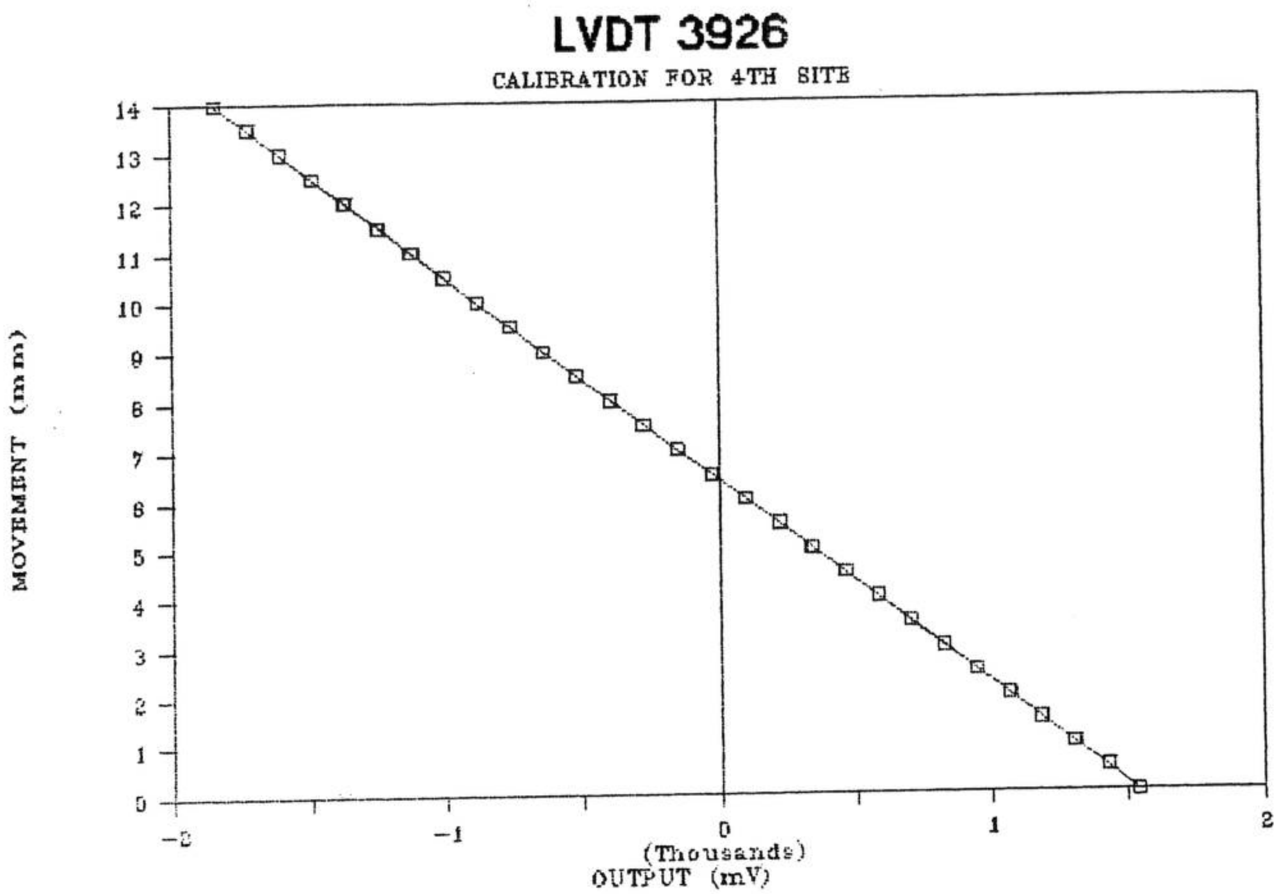

```
LDC 754
           Regression Output:
Constant                      27.82892
Std Err of Y Est              0.101932
R Squared                     0.999953
No. of Observations                 51
Degrees of Freedom                  49

X Coefficient(s)   -0.01127
Std Err of Coef.   0.000010
```



LDC 755

Regression Output:	
Constant	28.72160
Std Err of Y Est	0.055771
R Squared	0.999985
No. of Observations	49
Degrees of Freedom	47
X Coefficient(s)	-0.01130
Std Err of Coef.	0.000006

FIGURE III22

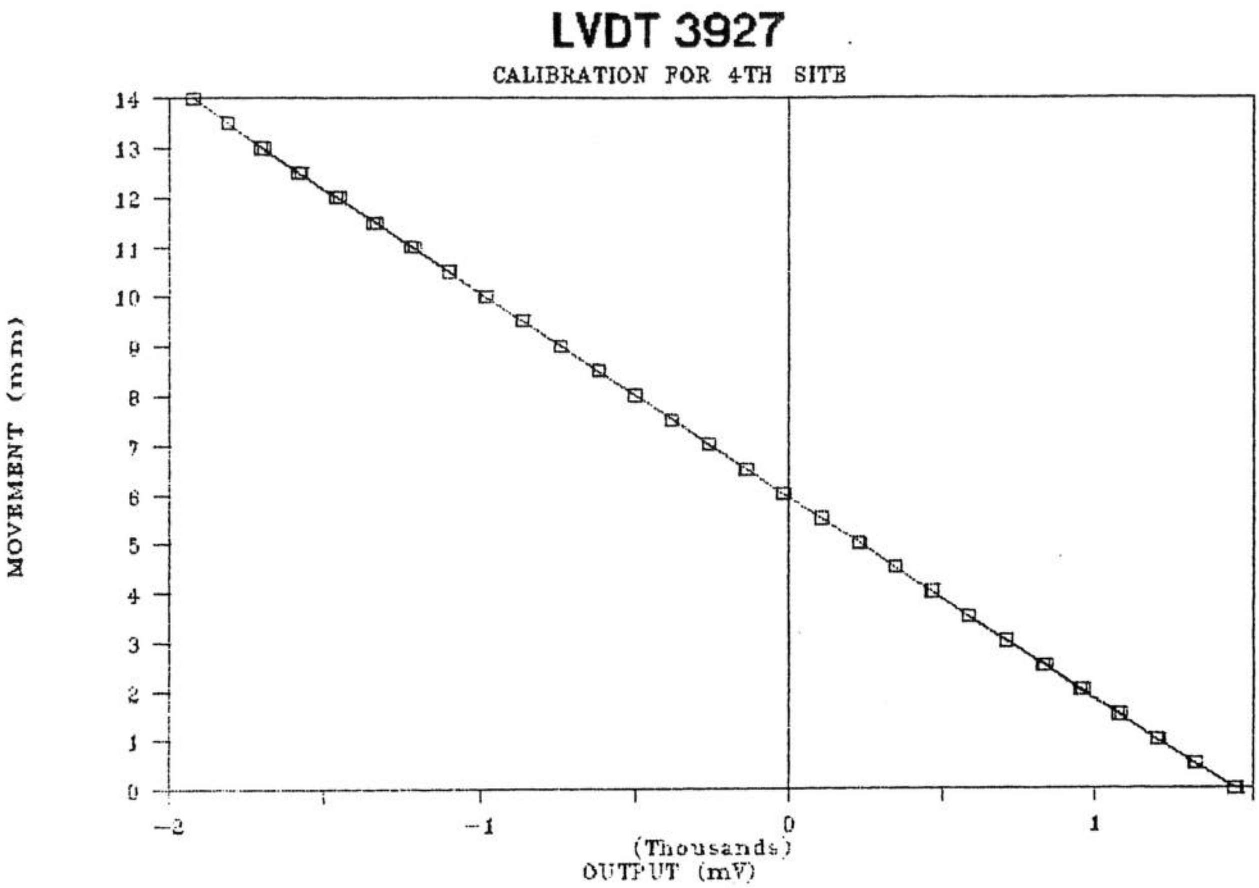


LVDT 3926

Regression Output:

Constant	6.390089
Std Err of Y Est	0.013577
R Squared	0.999989
No. of Observations	57
Degrees of Freedom	55
X Coefficient(s)	-0.00411
Std Err of Coef.	0.000001

FIGURE III223



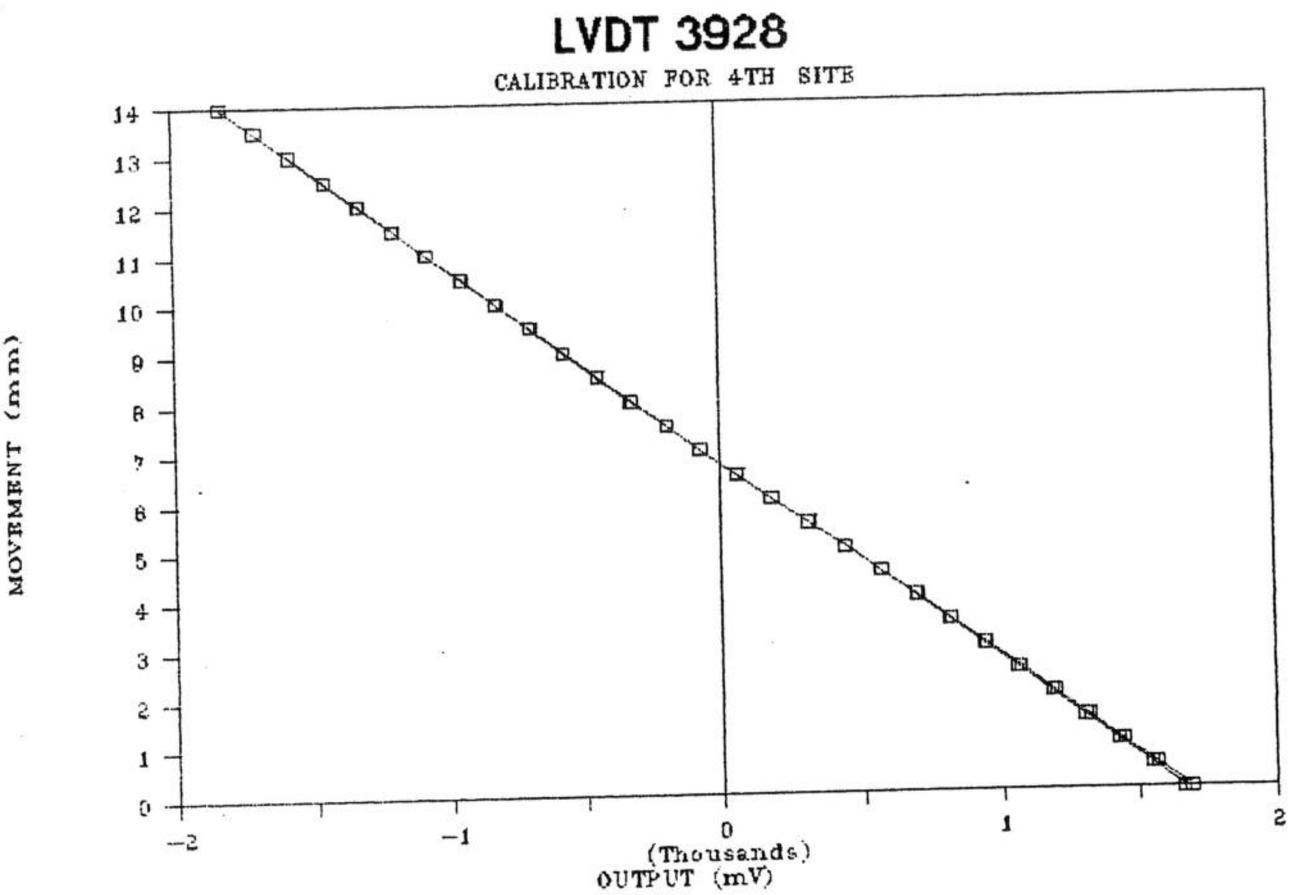
LVDT 3927

Regression Output:

Constant	5.950926
Std Err of Y Est	0.024559
R Squared	0.999965
No. of Observations	57
Degrees of Freedom	55

X Coefficient(s)	-0.00414
Std Err of Coef.	0.000003

FIGURE III22



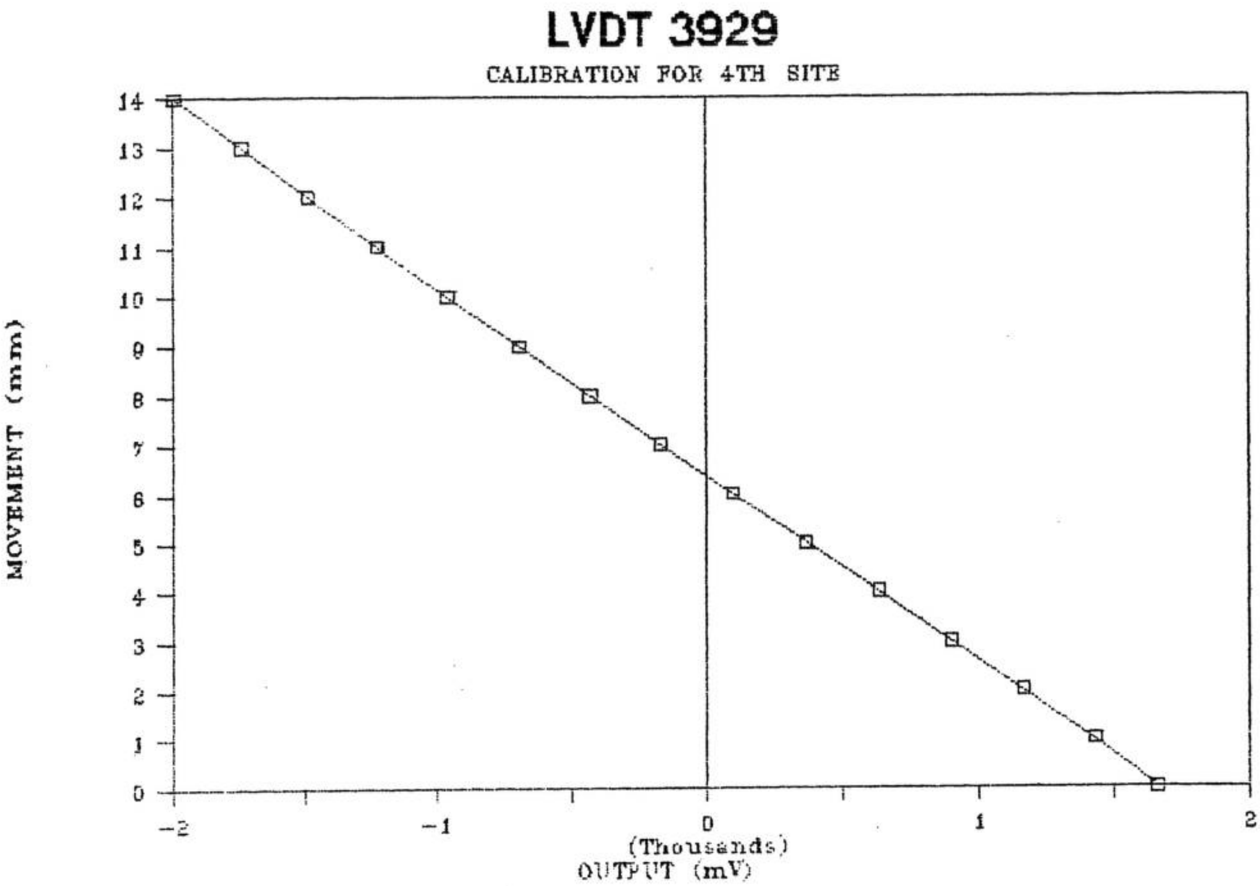
LVDT 3928

Regression Output:

Constant	6.724406
Std Err of Y Est	0.020803
R Squared	0.999975
No. of Observations	57
Degrees of Freedom	55

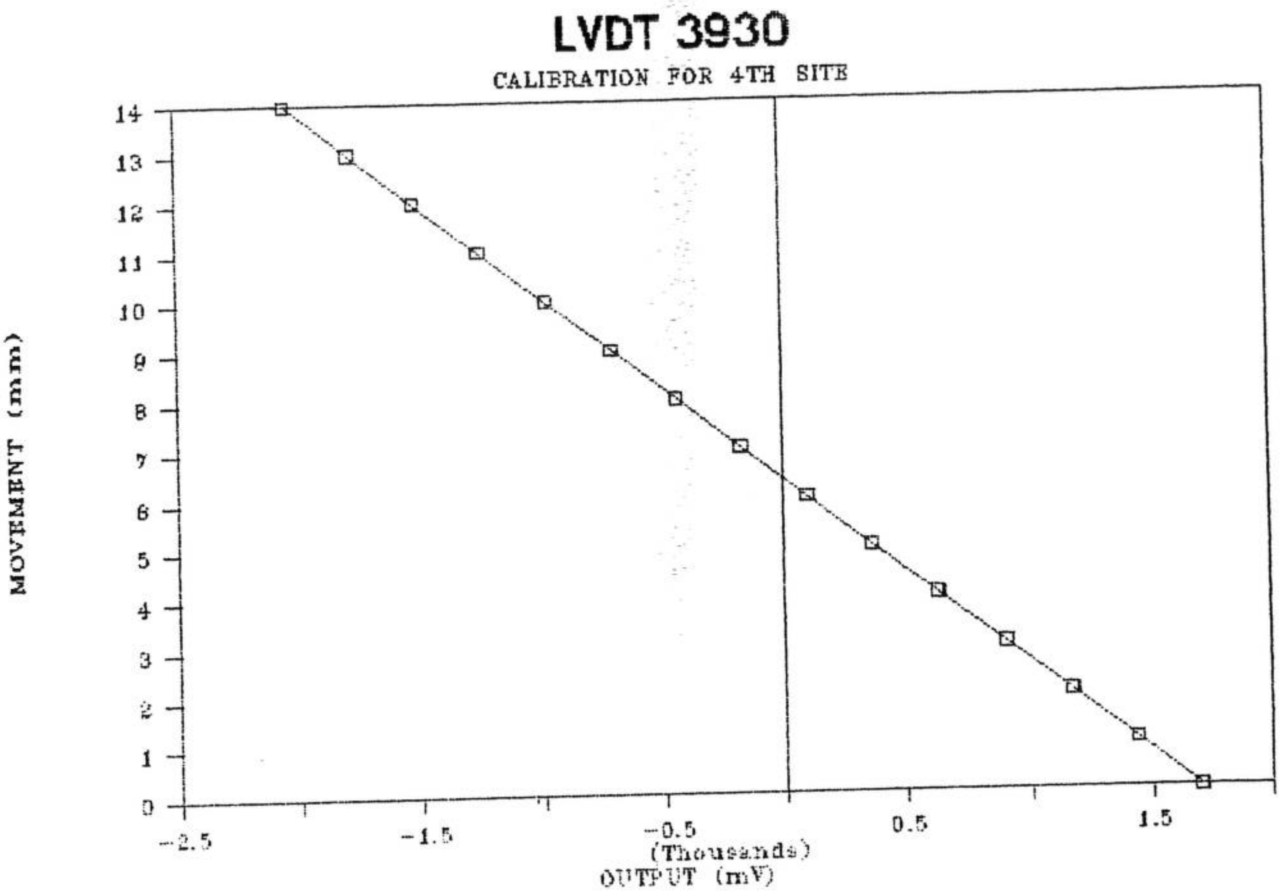
X Coefficient(s)	-0.00398
Std Err of Coef.	0.000002

FIGURE III 225



LVDT 3929

	Regression Output:
Constant	6.388612
Std Err of Y Est	0.031720
R Squared	0.999946
No. of Observations	29
Degrees of Freedom	27
X Coefficient(s)	-0.00379
Std Err of Coef.	0.000005

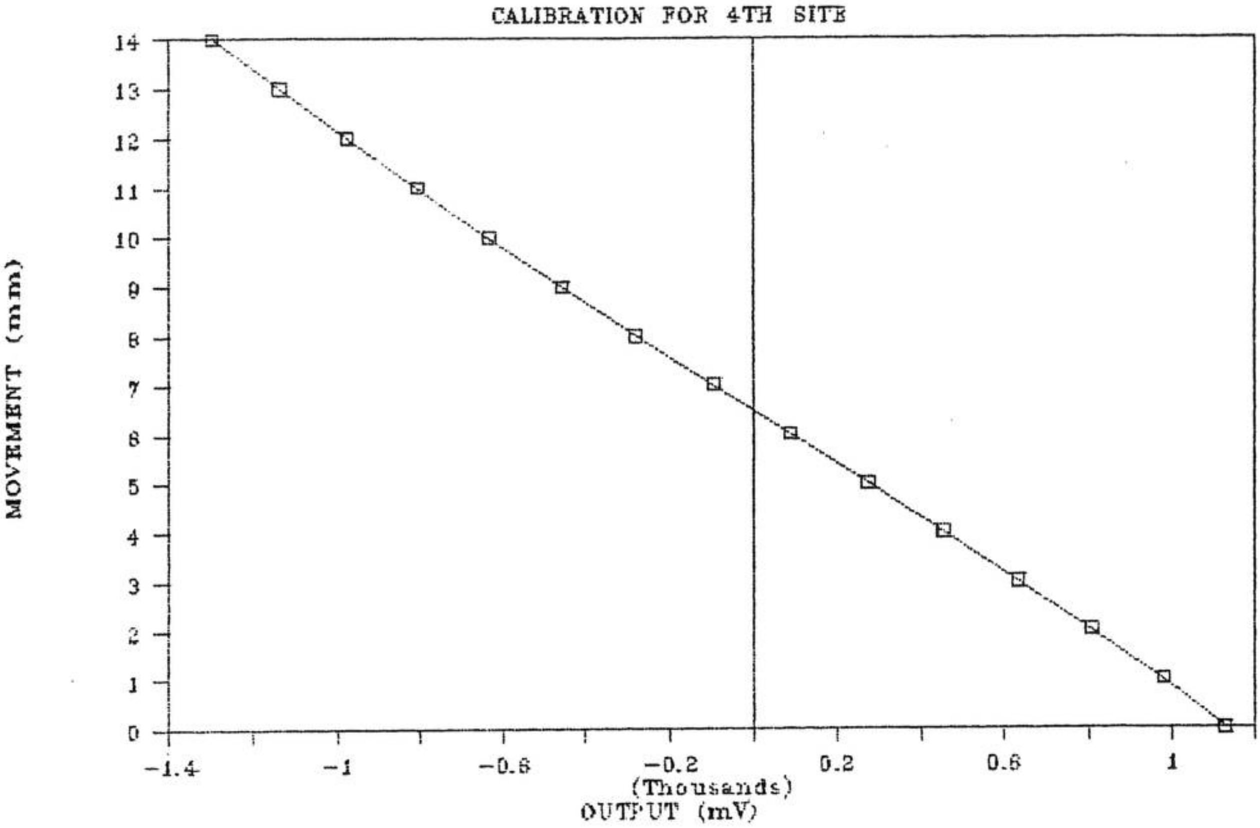


LVDT 3930

Regression Output:	
Constant	6.374161
Std Err of Y Est	0.006257
R Squared	0.999997
No. of Observations	29
Degrees of Freedom	27
X Coefficient(s)	-0.00372
Std Err of Coef.	0.000001

FIGURE II227

LVDT 3931

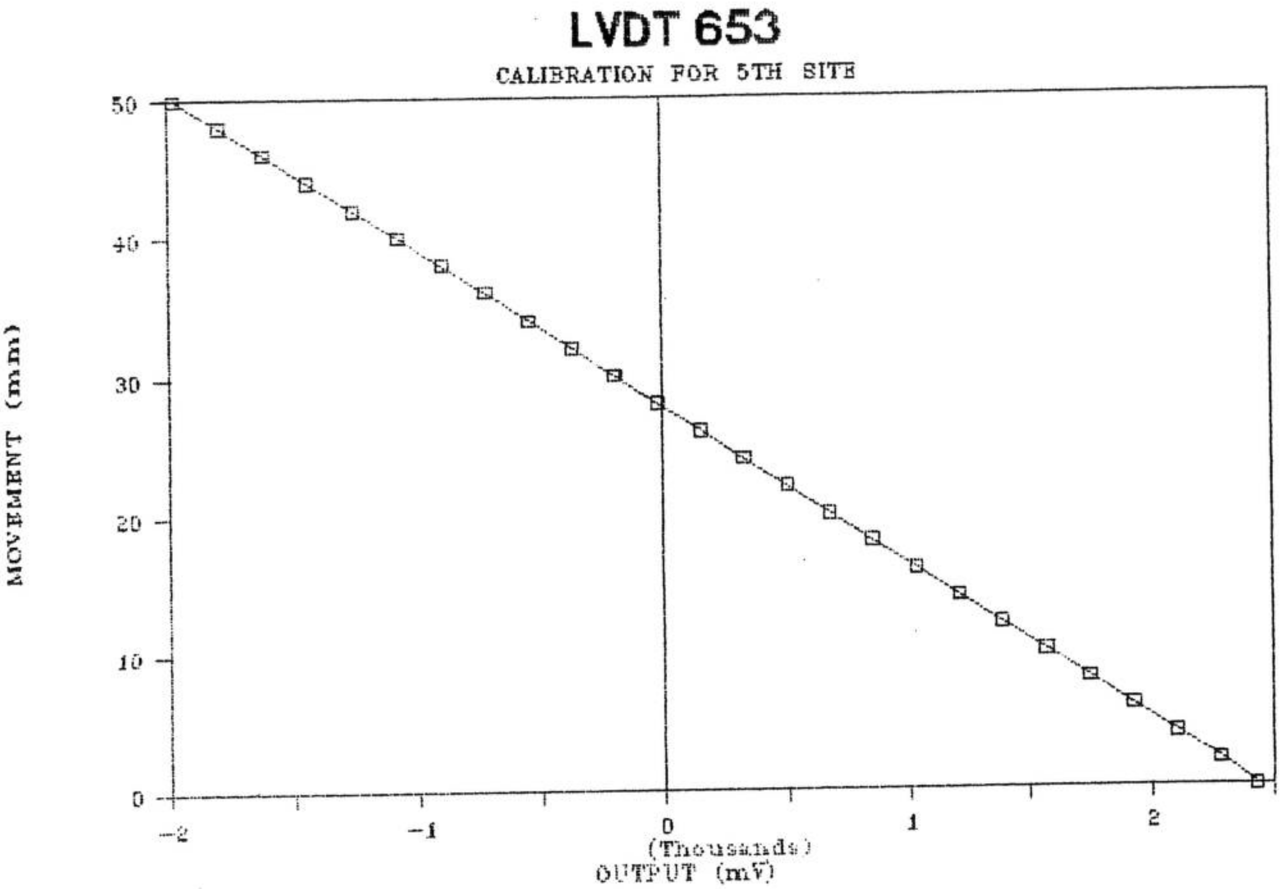


LVDT 3931

Regression Output:

Constant	6.500124
Std Err of Y Est	0.074331
R Squared	0.999707
No. of Observations	29
Degrees of Freedom	27
X Coefficient(s)	-0.00564
Std Err of Coef.	0.000018

FIGURE II2:

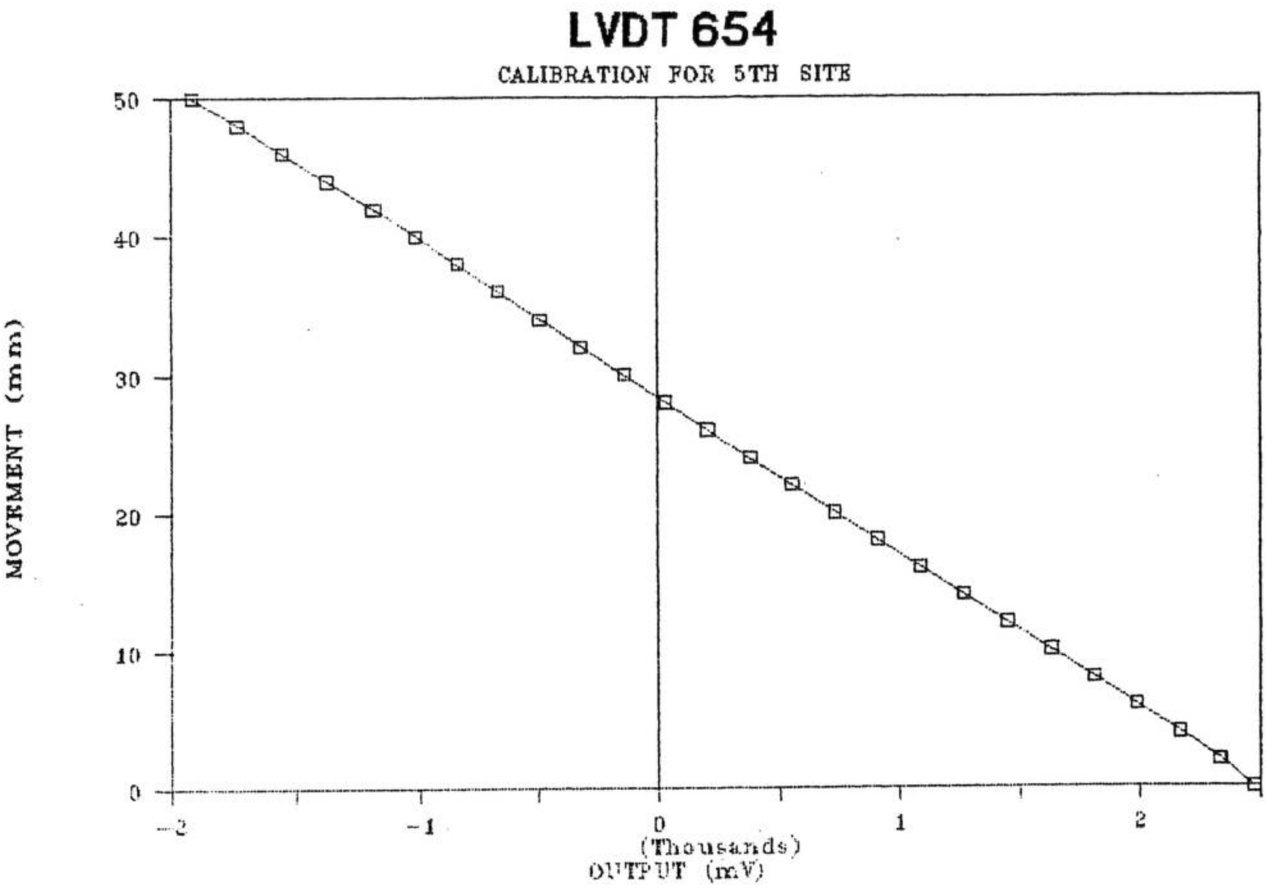


LDC 653

Regression Output:	
Constant	27.77193
Std Err of Y Est	0.084109
R Squared	0.999968
No. of Observations	51
Degrees of Freedom	49

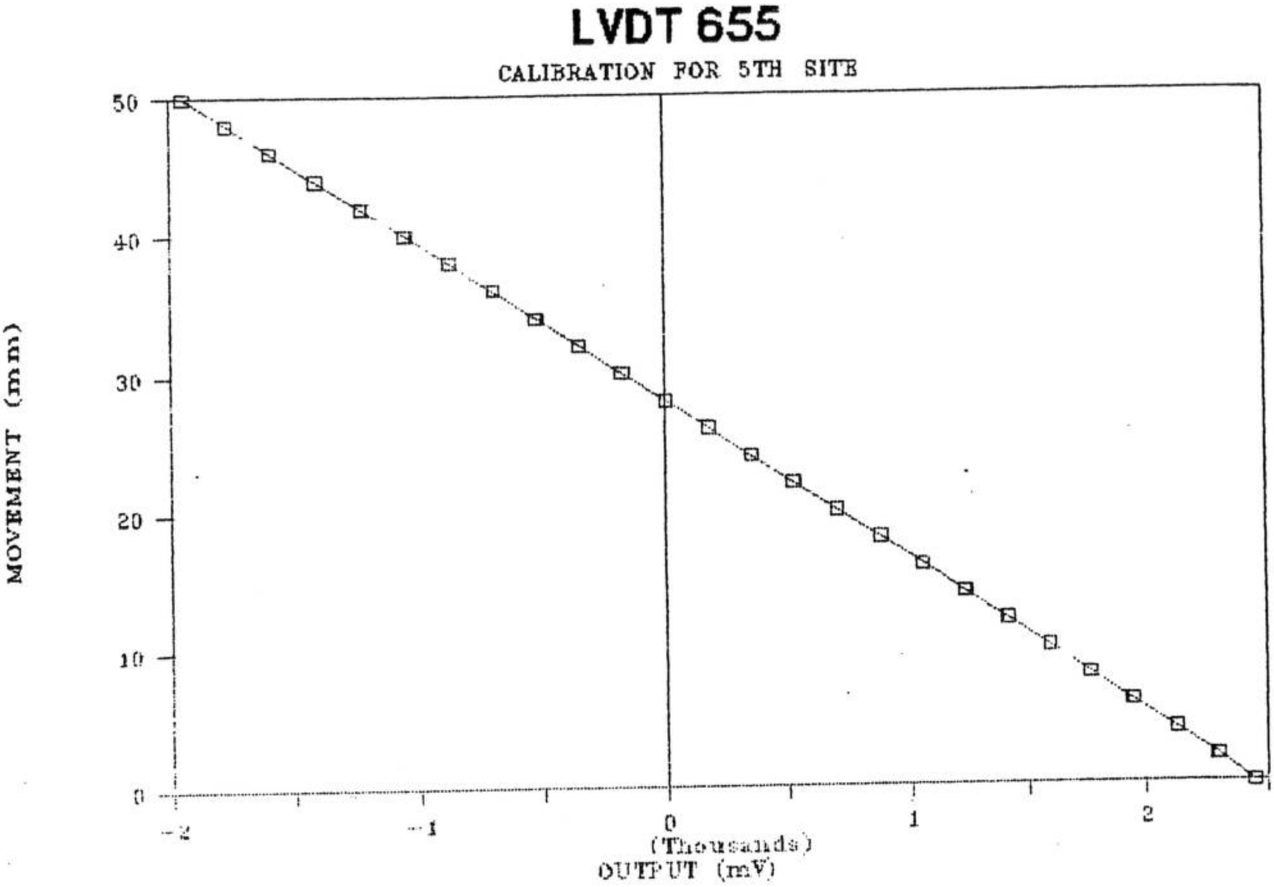
X Coefficient(s)	-0.01132
Std Err of Coef.	0.000009

FIGURE III 229




```
LDC 654
            Regression Output:
Constant                        28.43574
Std Err of Y Est                0.074811
R Squared                       0.999973
No. of Observations                   49
Degrees of Freedom                    47

X Coefficient(s)  -0.01131
Std Err of Coef.   0.000008
```

FIGURE III 2

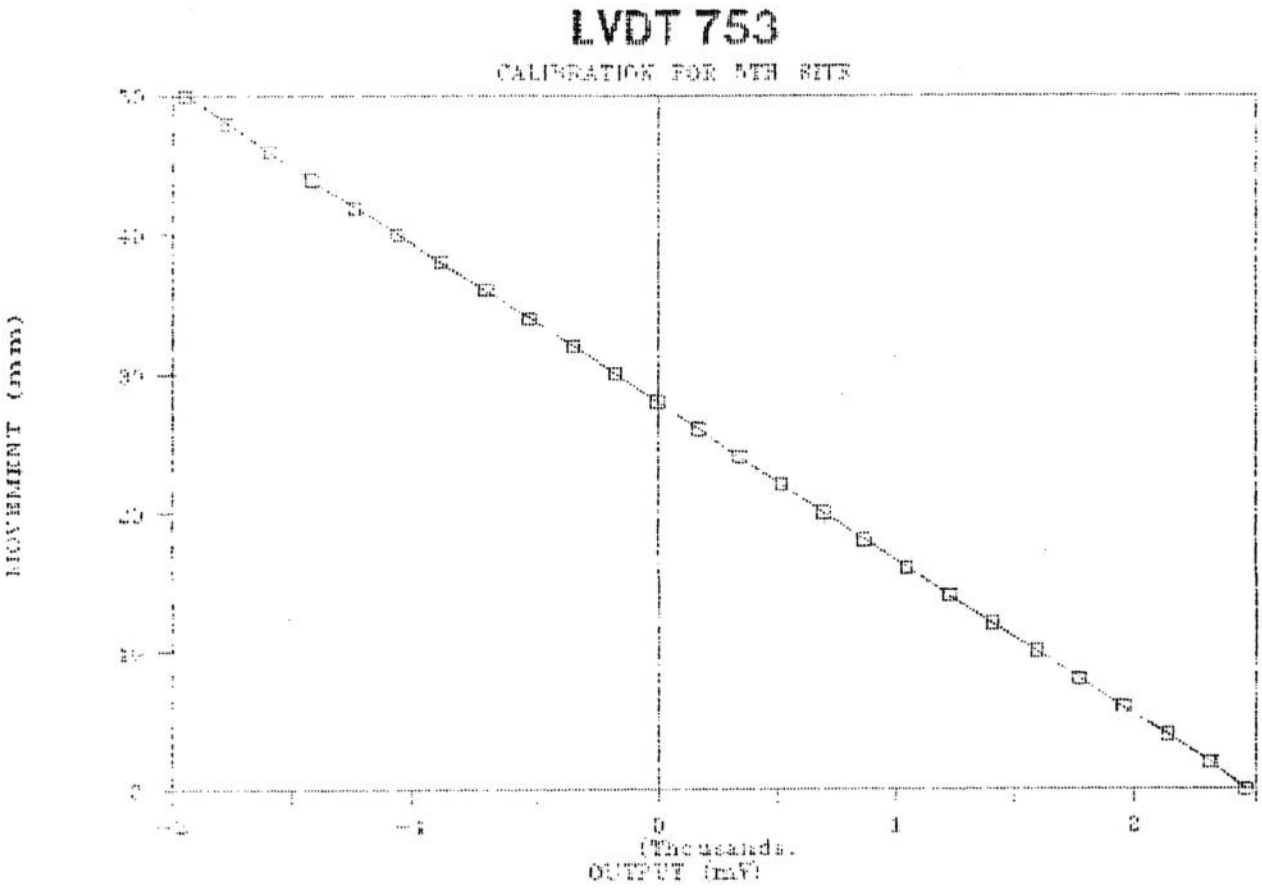


LDC 655

Regression Output:	
Constant	28.05432
Std Err of Y Est	0.082841
R Squared	0.999969
No. of Observations	51
Degrees of Freedom	49

X Coefficient(s)	-0.01133
Std Err of Coef.	0.000008

FIGURE III231



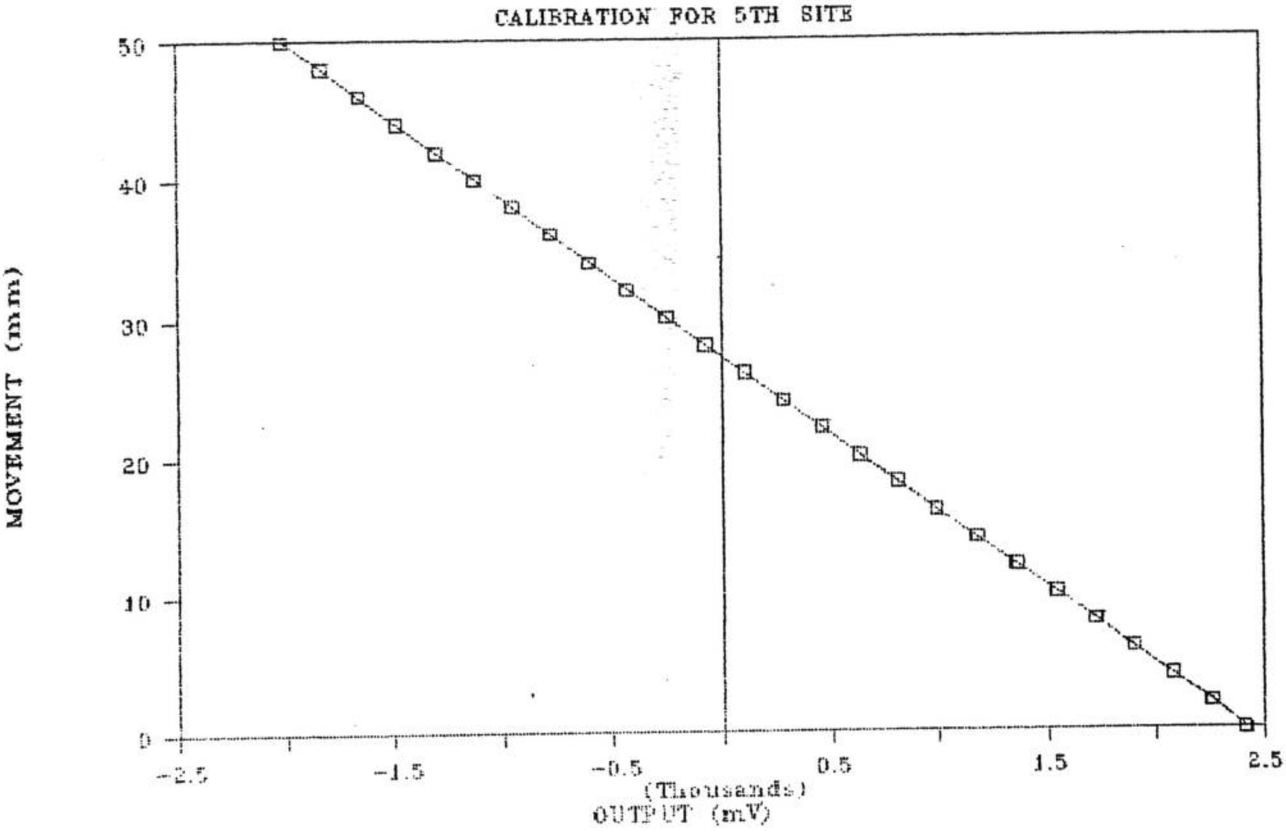
LDC 753

Regression Output:	
Constant	27.98069
Std Err of Y Est	0.098485
R Squared	0.999957
No. of Observations	51
Degrees of Freedom	49

X Coefficient(s)	-0.01128
Std Err of Coef.	0.000010

FIGURE II23

LVDT 754



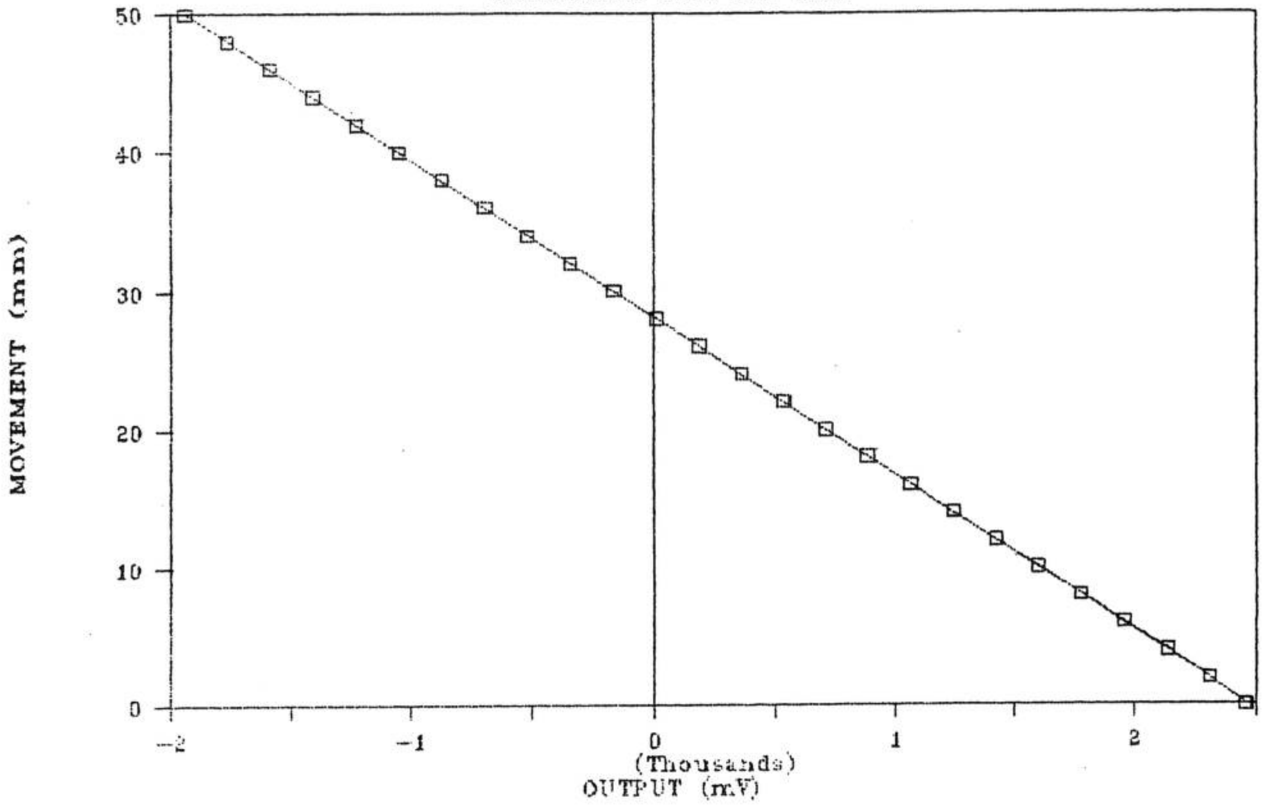
LDC 754

Regression Output:	
Constant	27.30564
Std Err of Y Est	0.092050
R Squared	0.999962
No. of Observations	51
Degrees of Freedom	49
X Coefficient(s)	-0.01125
Std Err of Coef.	0.000009

FIGURE III233

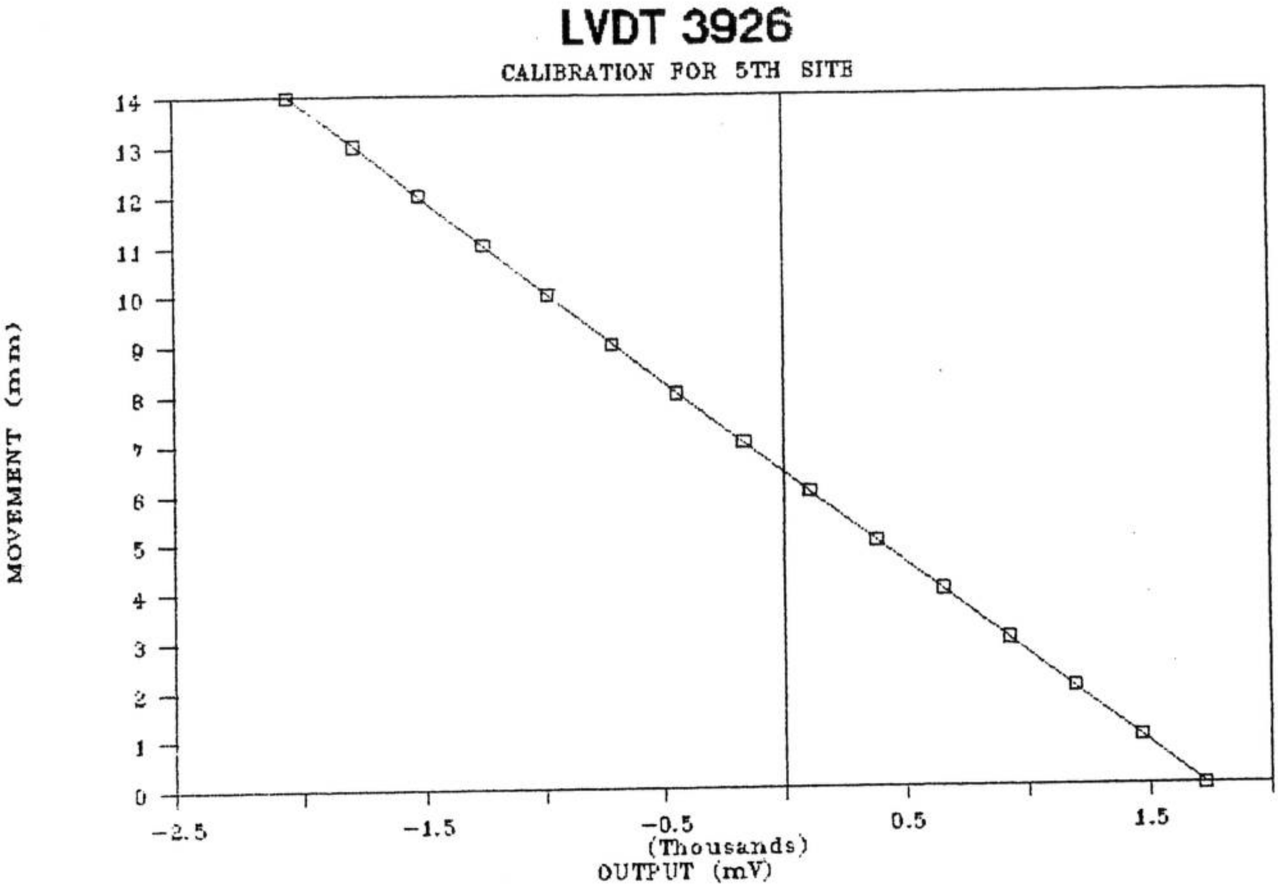
LVDT 755

CALIBRATION FOR 5TH SITE



LDC 755 Regression Output:	
Constant	28.11563
Std Err of Y Est	0.083979
R Squared	0.999968
No. of Observations	51
Degrees of Freedom	49
X Coefficient(s)	-0.01131
Std Err of Coef.	0.000009

FIGURE II23

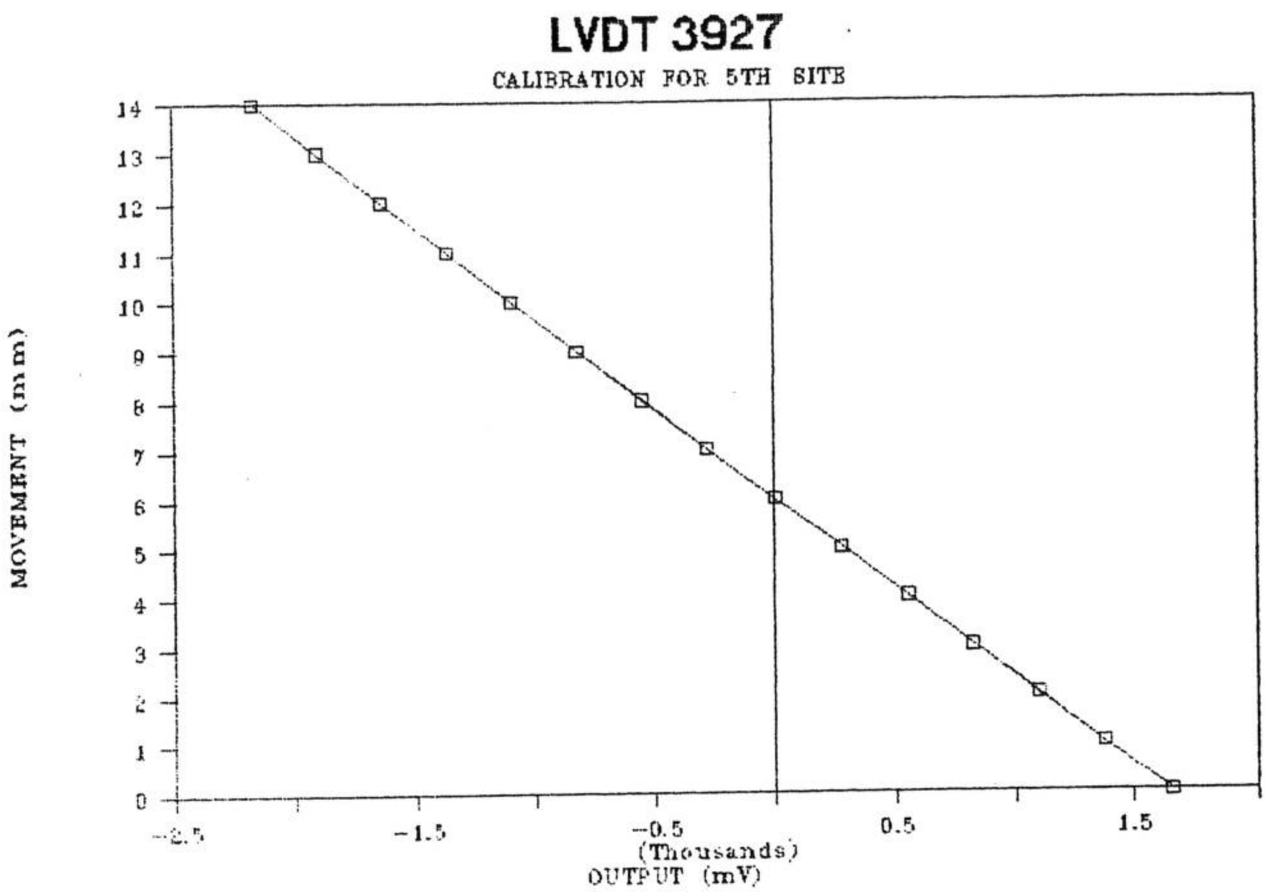


LVDT 3926

Regression Output:

Constant	6.406004
Std Err of Y Est	0.015377
R Squared	0.999987
No. of Observations	29
Degrees of Freedom	27
X Coefficient(s)	-0.00368
Std Err of Coef.	0.000002

FIGURE III235



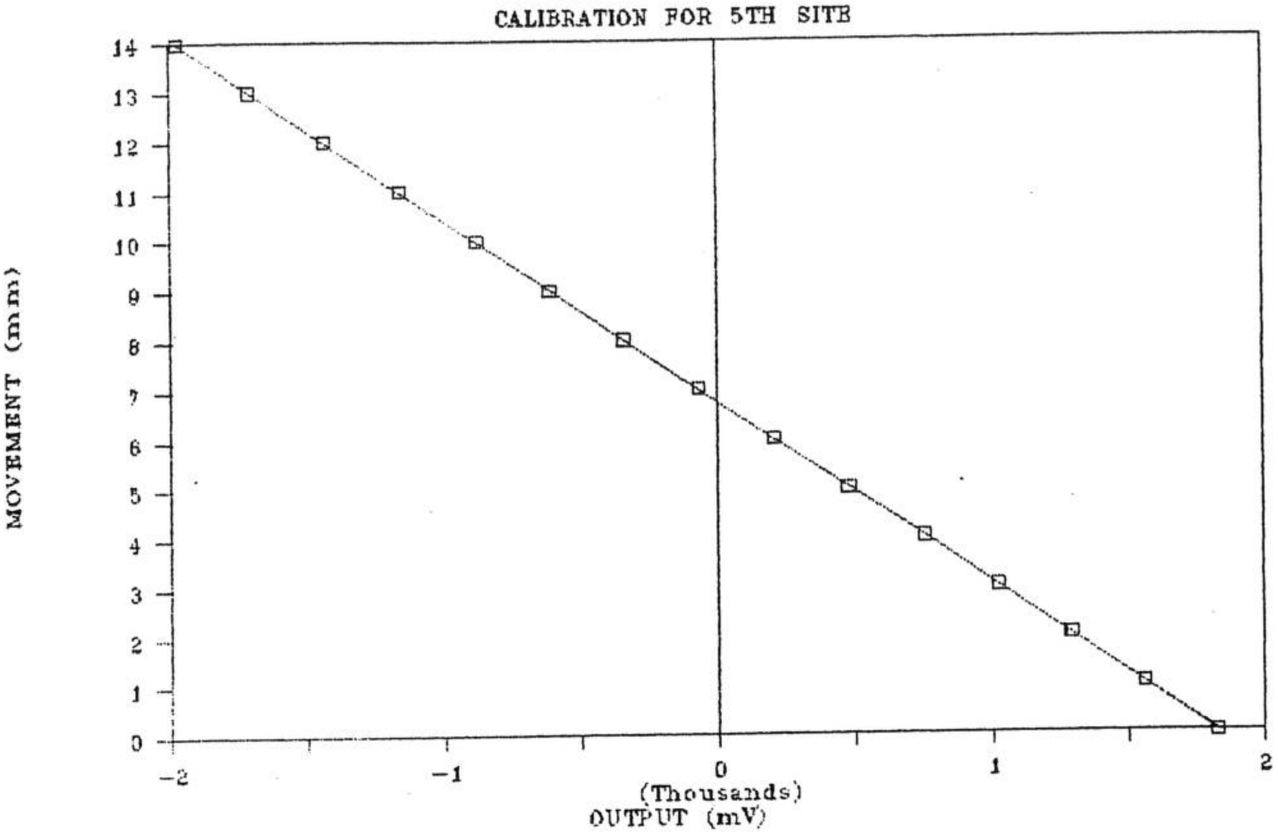
LVDT 3927

Regression Output:	
Constant	6.028121
Std Err of Y Est	0.019538
R Squared	0.999979
No. of Observations	29
Degrees of Freedom	27

X Coefficient(s) -0.00364
Std Err of Coef. 0.000003

FIGURE III2

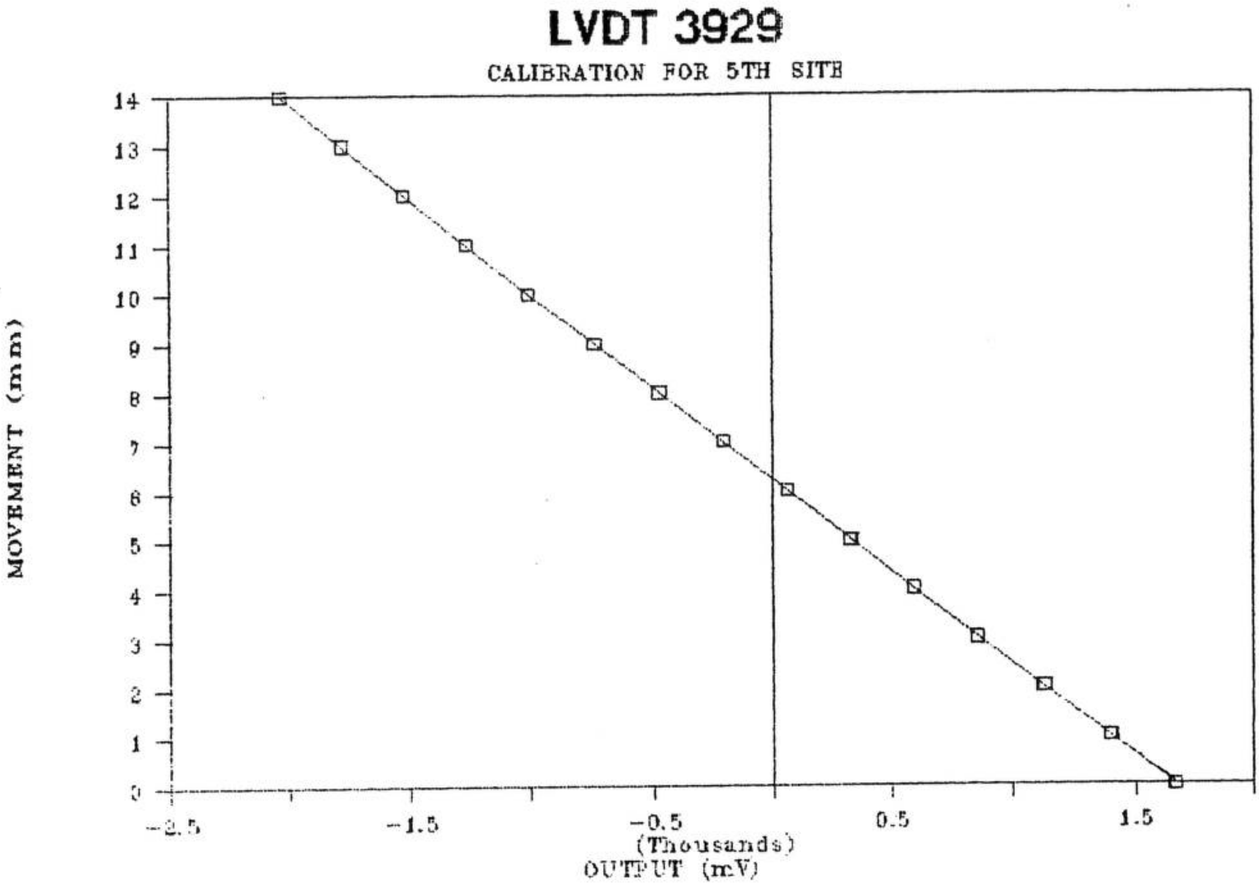
LVDT 3928



LVDT 3928

Regression Output:	
Constant	6.746848
Std Err of Y Est	0.011006
R Squared	0.999993
No. of Observations	29
Degrees of Freedom	27

X Coefficient(s)	-0.00367
Std Err of Coef.	0.000001

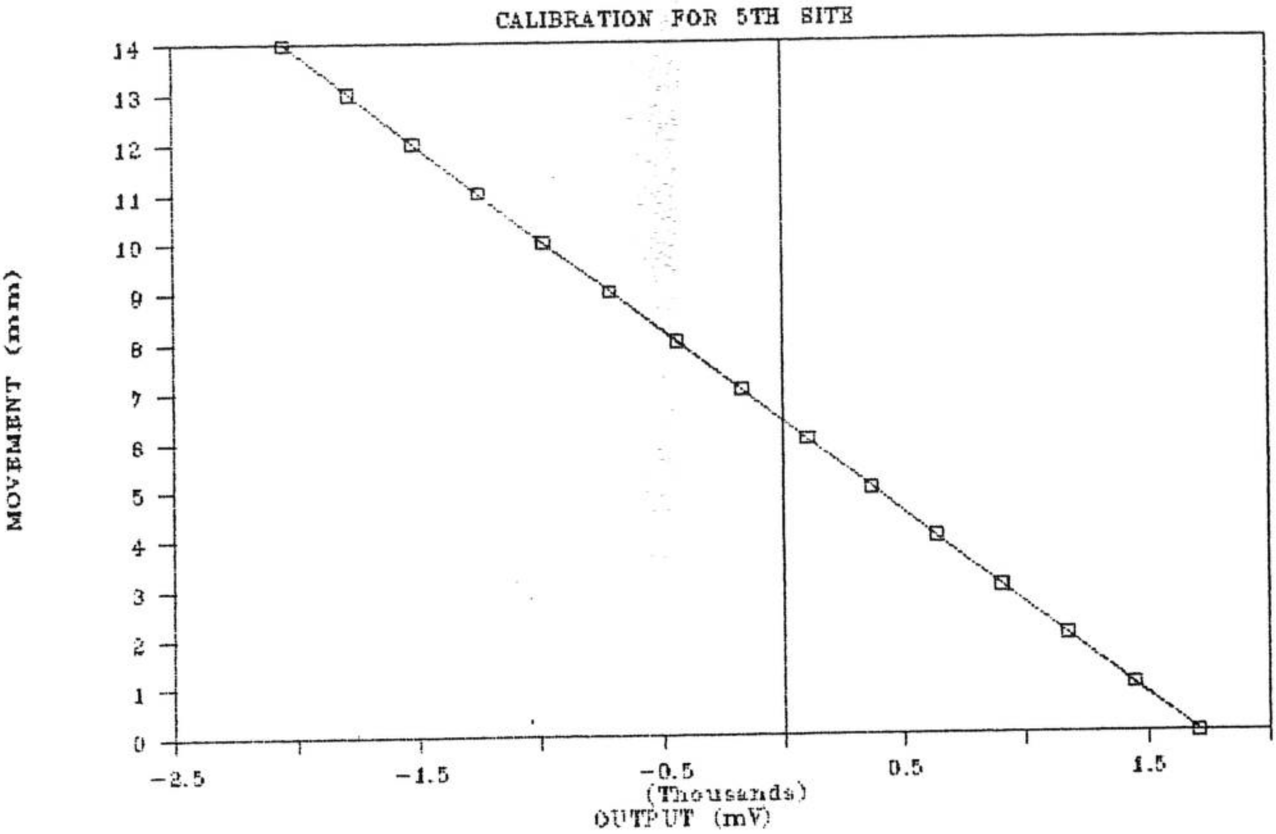


LVDT 3929

Regression Output:	
Constant	6.257808
Std Err of Y Est	0.025038
R Squared	0.999966
No. of Observations	29
Degrees of Freedom	27
X Coefficient(s)	-0.00376
Std Err of Coef.	0.000004

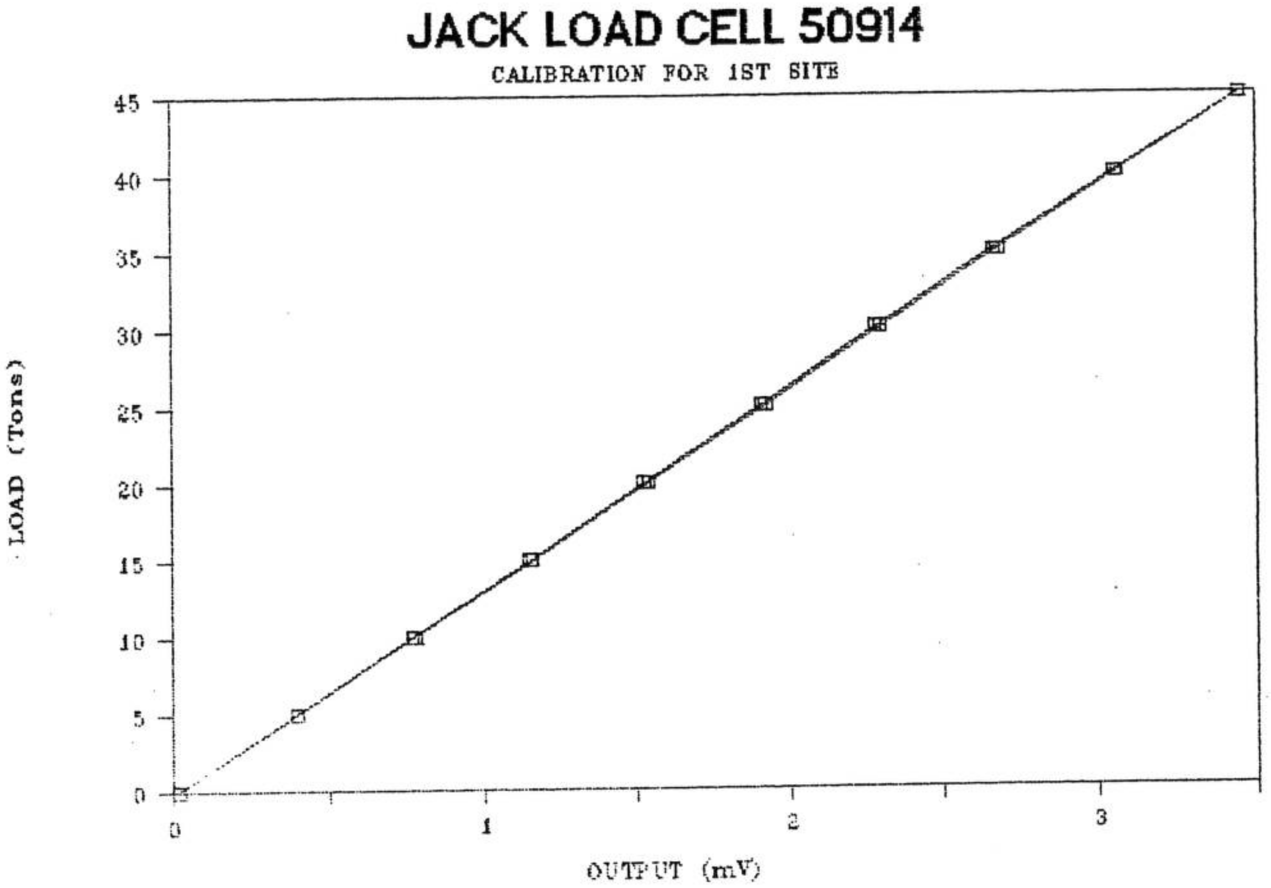
FIGURE II 2

LVDT 3930




```
LVDT 3930
          Regression Output:
Constant                        6.377225
Std Err of Y Est                0.006273
R Squared                       0.999997
No. of Observations                   29
Degrees of Freedom                    27

X Coefficient(s)   -0.00371
Std Err of Coef.    0.000001
```

FIGURE II239

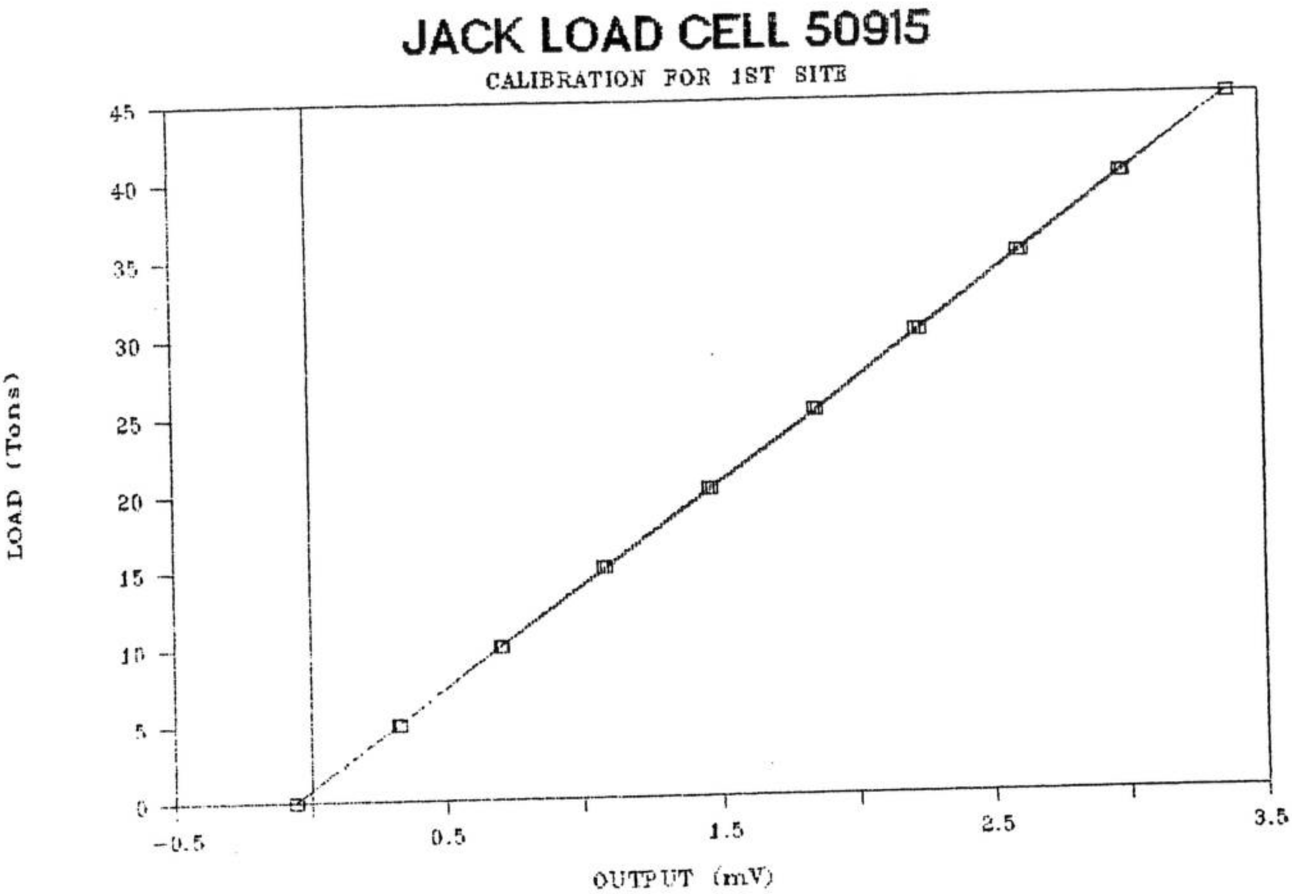


LOAD CELL S/N 50914

Regression Output:	
Constant	-0.19871
Std Err of Y Est	0.084683
R Squared	0.999966
No. of Observations	19
Degrees of Freedom	17

X Coefficient(s)	13.13250
Std Err of Coef.	0.018555

FIGURE III2



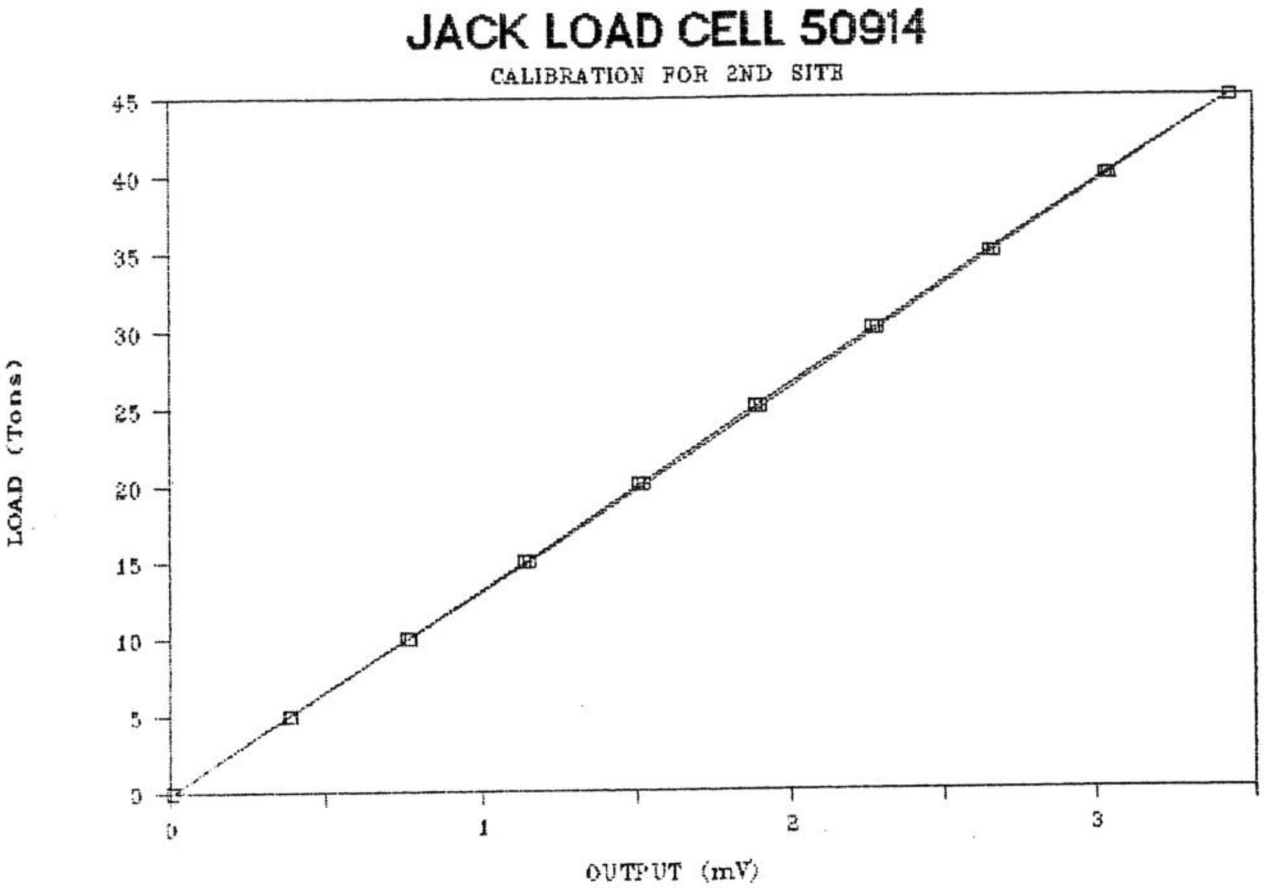
LOAD CELL S/N 50915

Regression Output:

Constant	0.763361
Std Err of Y Est	0.086262
R Squared	0.999964
No. of Observations	19
Degrees of Freedom	17

X Coefficient(s)	13.08326
Std Err of Coef.	0.018830

FIGURE III 24



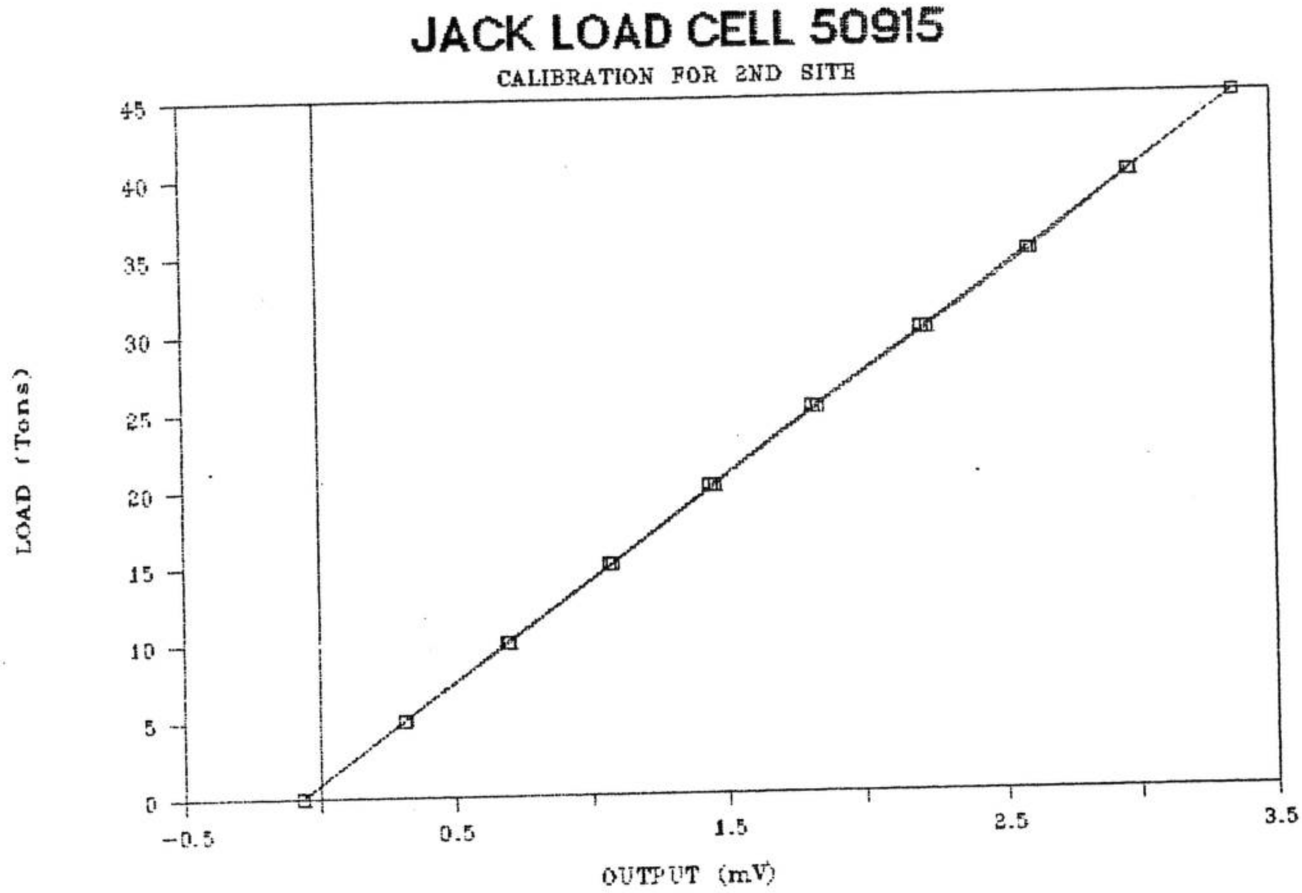
LOAD CELL S/N 50914

Regression Output:

Constant	-0.08887
Std Err of Y Est	0.089772
R Squared	0.999961
No. of Observations	19
Degrees of Freedom	17

X Coefficient(s)	13.17252
Std Err of Coef.	0.019730

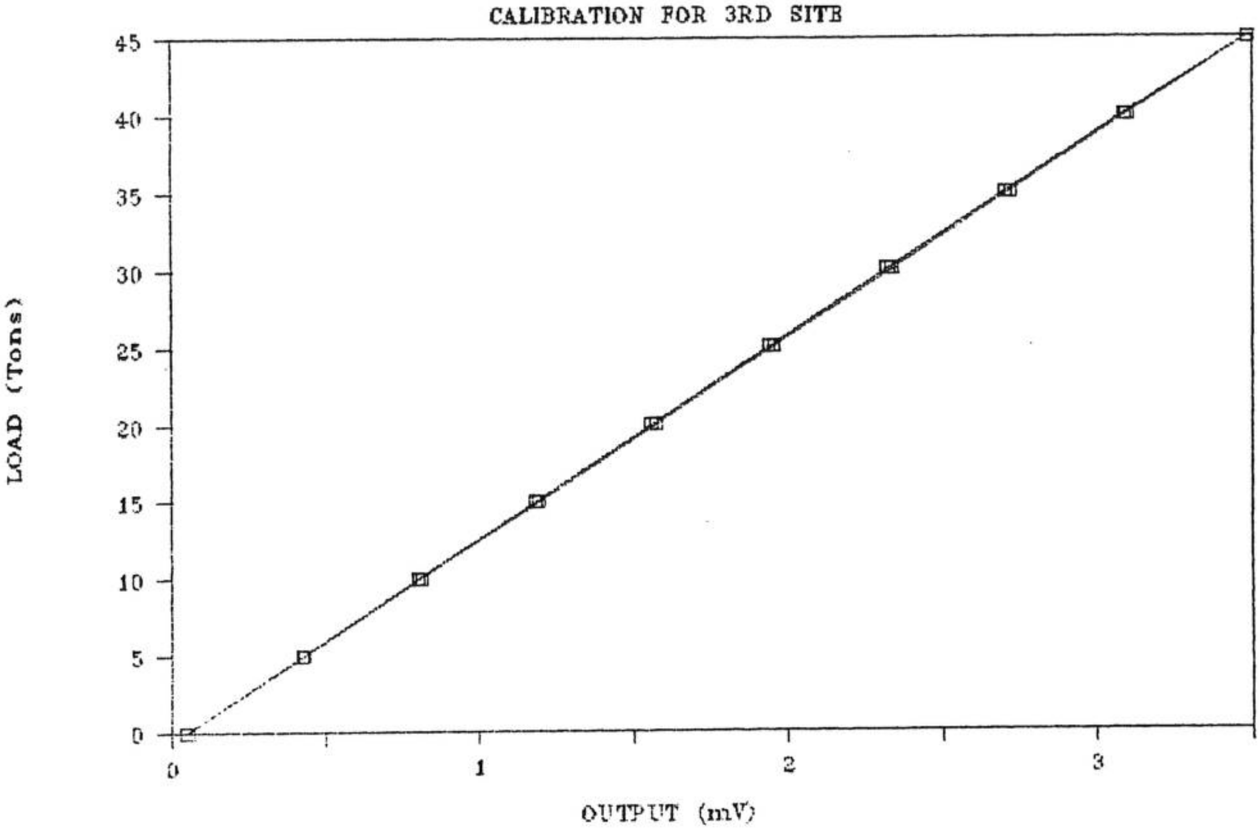
FIGURE III2



LOAD CELL S/N 50915

Regression Output:	
Constant	0.876103
Std Err of Y Est	0.095262
R Squared	0.999957
No. of Observations	19
Degrees of Freedom	17
X Coefficient(s)	13.14182
Std Err of Coef.	0.020888

JACK LOAD CELL 50912



LOAD CELL S/N 50912

Regression Output:

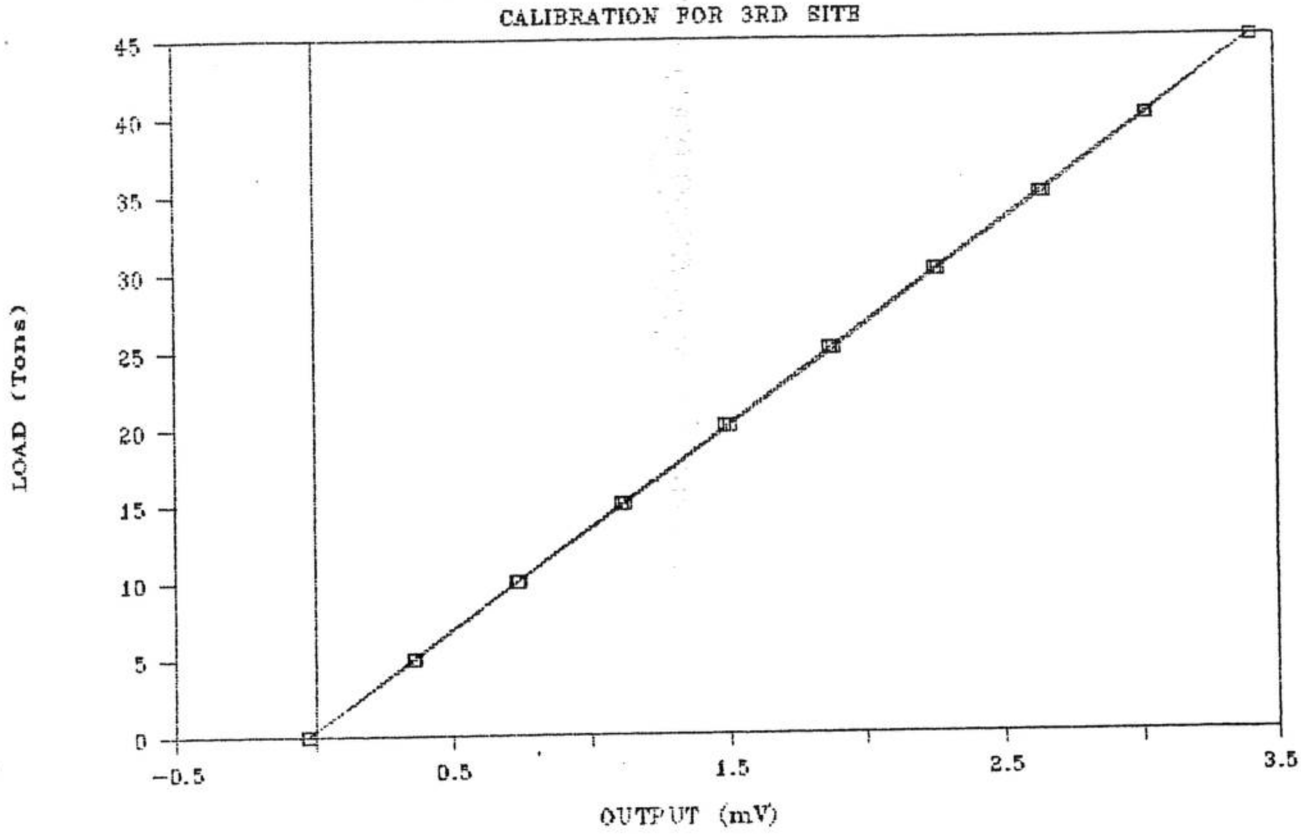
Constant	-0.62014
Std Err of Y Est	0.097430
R Squared	0.999955
No. of Observations	19
Degrees of Freedom	17

X Coefficient(s)	13.11916
Std Err of Coef.	0.021327

FIGURE III 2

JACK LOAD CELL 50913

CALIBRATION FOR 3RD SITE

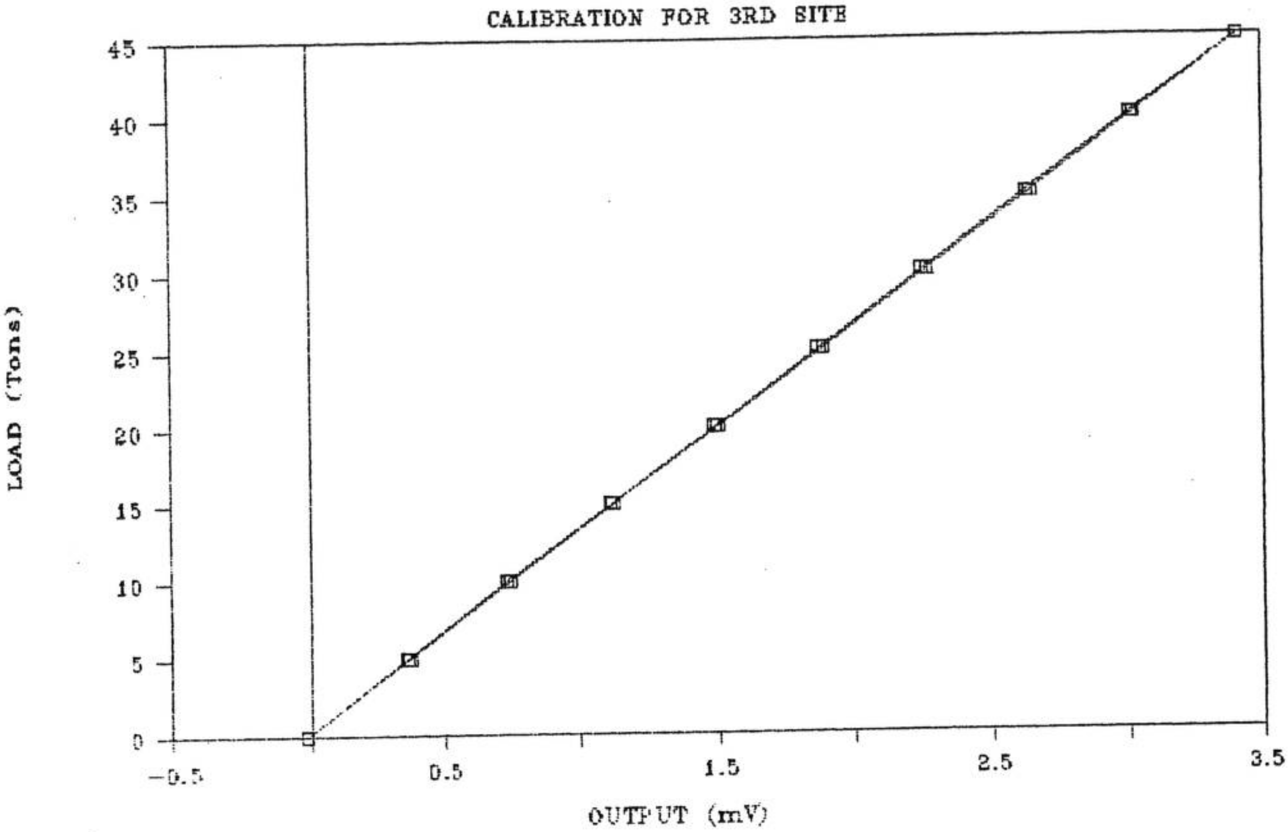


LOAD CELL S/N 50913

Regression Output:	
Constant	0.355623
Std Err of Y Est	0.089125
R Squared	0.999962
No. of Observations	19
Degrees of Freedom	17
X Coefficient(s)	13.10527
Std Err of Coef.	0.019488

JACK LOAD CELL 50914

CALIBRATION FOR 3RD SITE

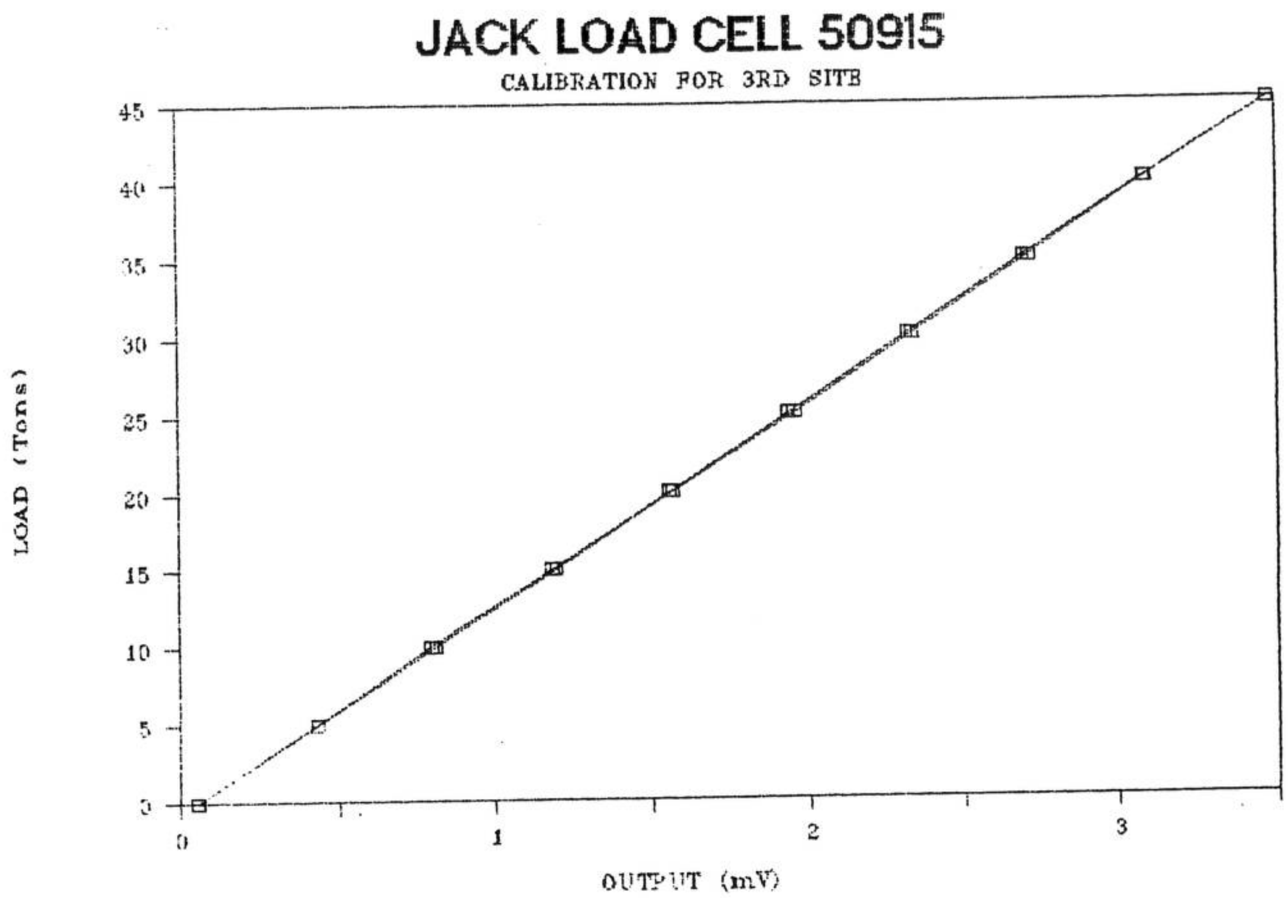


LOAD CELL S/N 50914

Regression Output:	
Constant	0.208386
Std Err of Y Est	0.090524
R Squared	0.999961
No. of Observations	19
Degrees of Freedom	17

X Coefficient(s)	13.15404
Std Err of Coef.	0.019868

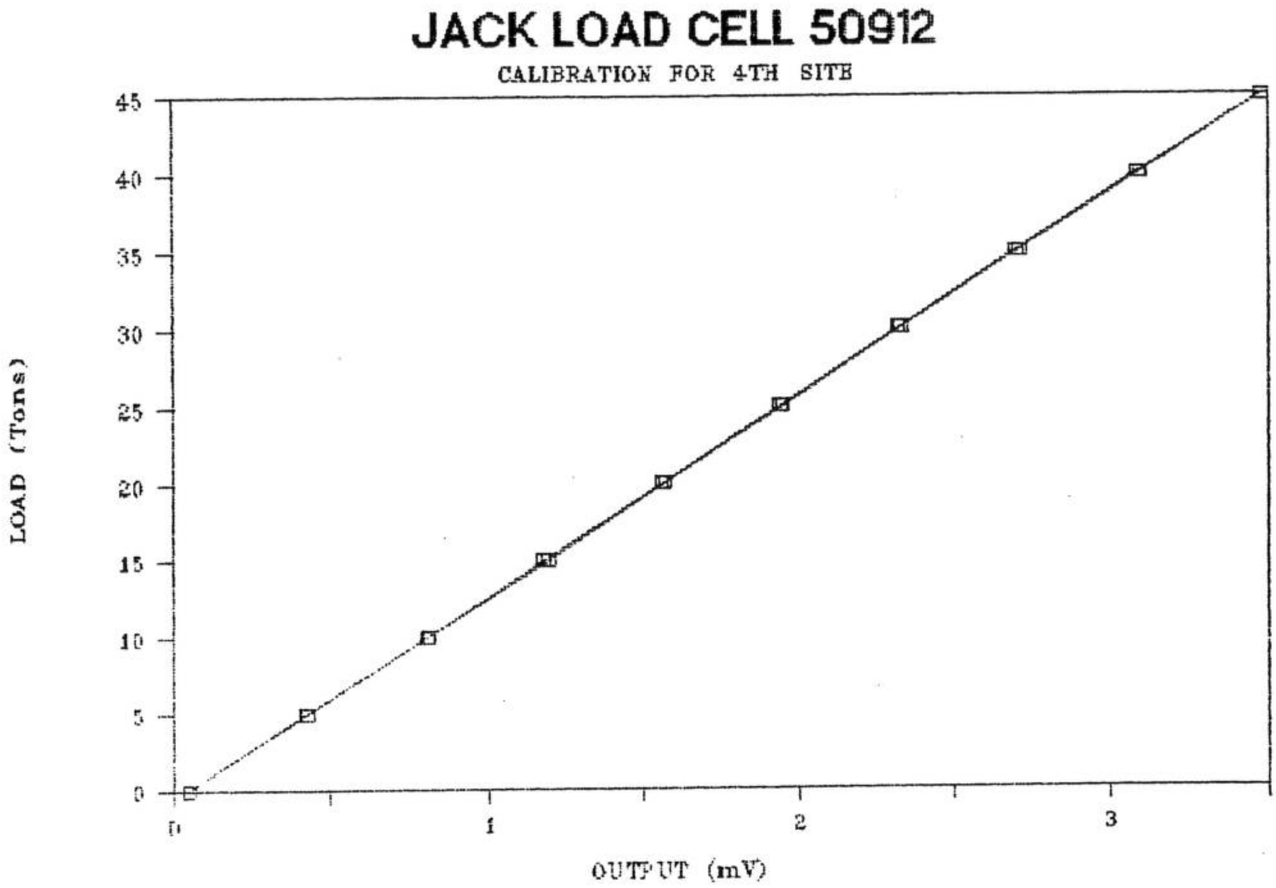
FIGURE II



LOAD CELL S/N 50915

Regression Output:	
Constant	-0.66367
Std Err of Y Est	0.097554
R Squared	0.999954
No. of Observations	19
Degrees of Freedom	17
X Coefficient(s)	13.15679
Std Err of Coef.	0.021415

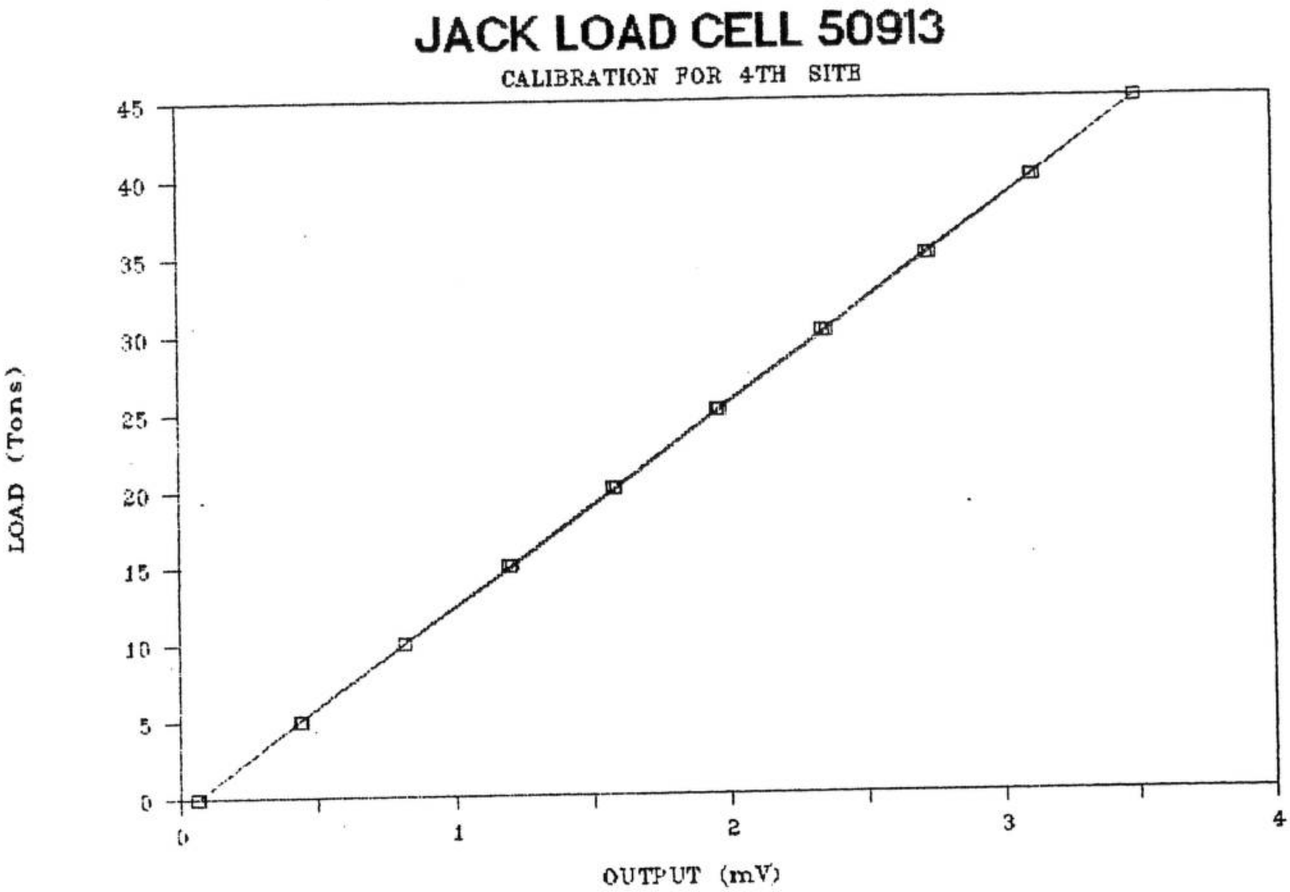
FIGURE III24



LOAD CELL S/N 50912

Regression Output:	
Constant	-0.64868
Std Err of Y Est	0.072185
R Squared	0.999975
No. of Observations	19
Degrees of Freedom	17
X Coefficient(s)	13.13747
Std Err of Coef.	0.015823

FIGURE VI

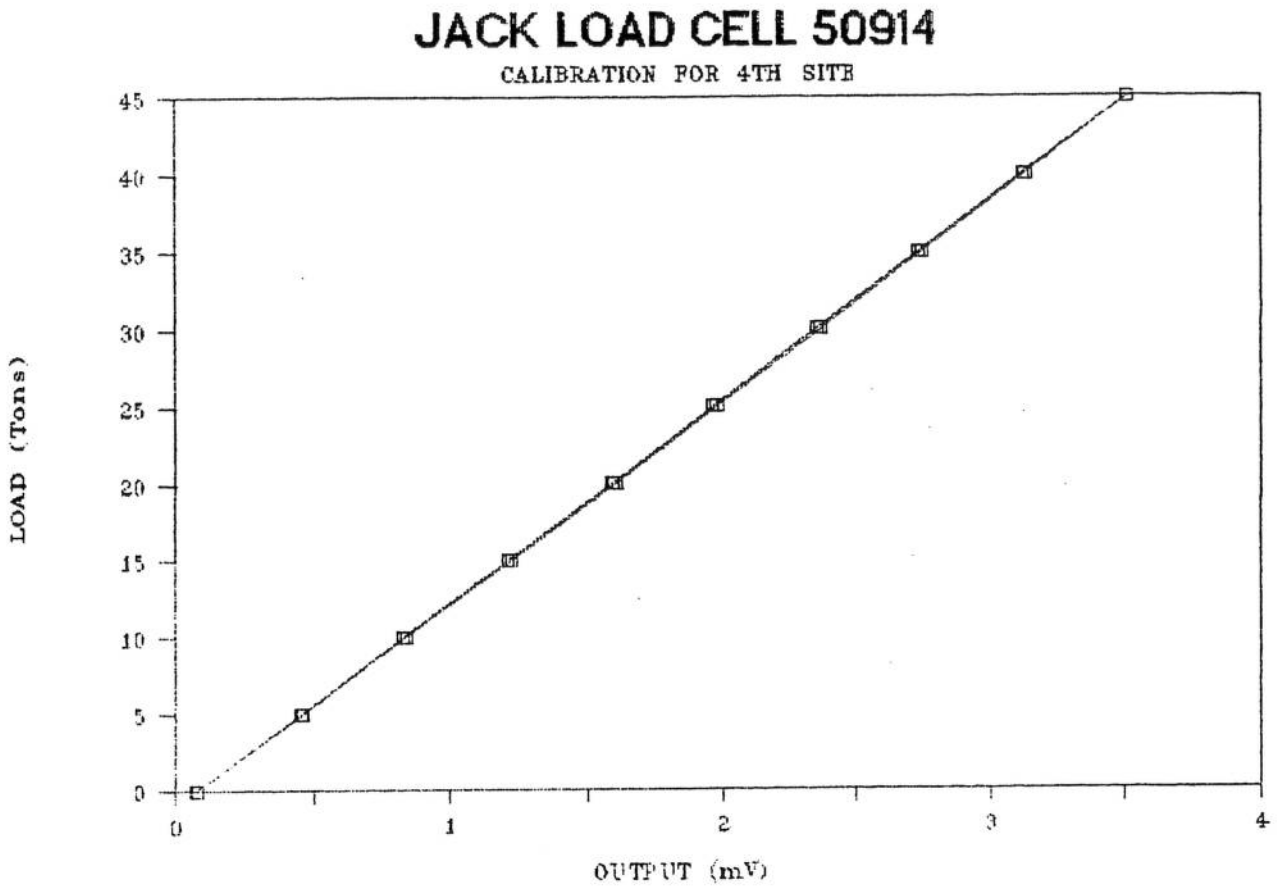


LOAD CELL S/N 50913

Regression Output:	
Constant	-0.76371
Std Err of Y Est	0.089700
R Squared	0.999961
No. of Observations	19
Degrees of Freedom	17

X Coefficient(s)	13.09865
Std Err of Coef.	0.019604

FIGURE II 249



LOAD CELL S/N 50914

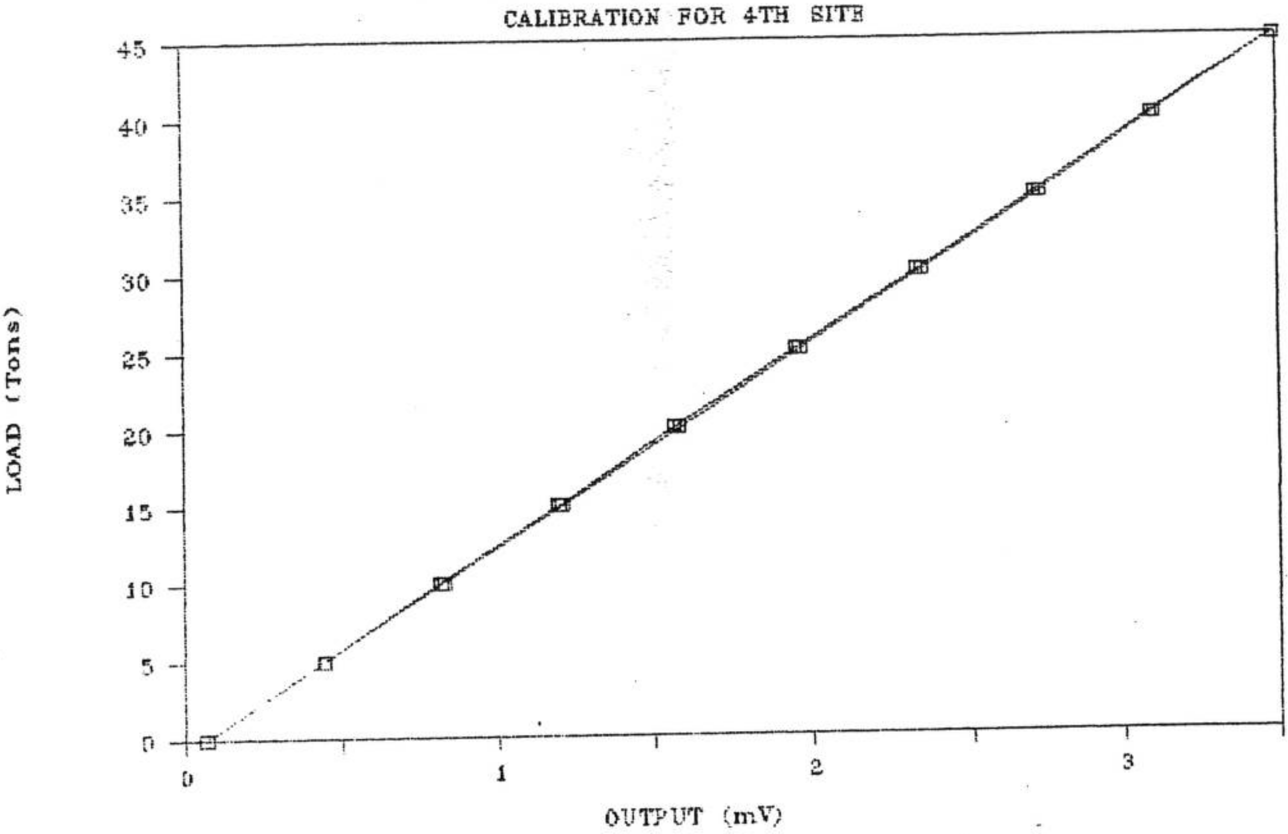
Regression Output:	
Constant	-0.96566
Std Err of Y Est	0.094467
R Squared	0.999957
No. of Observations	19
Degrees of Freedom	17

X Coefficient(s)	13.10876
Std Err of Coef.	0.020662

FIGURE III.2

JACK LOAD CELL 50915

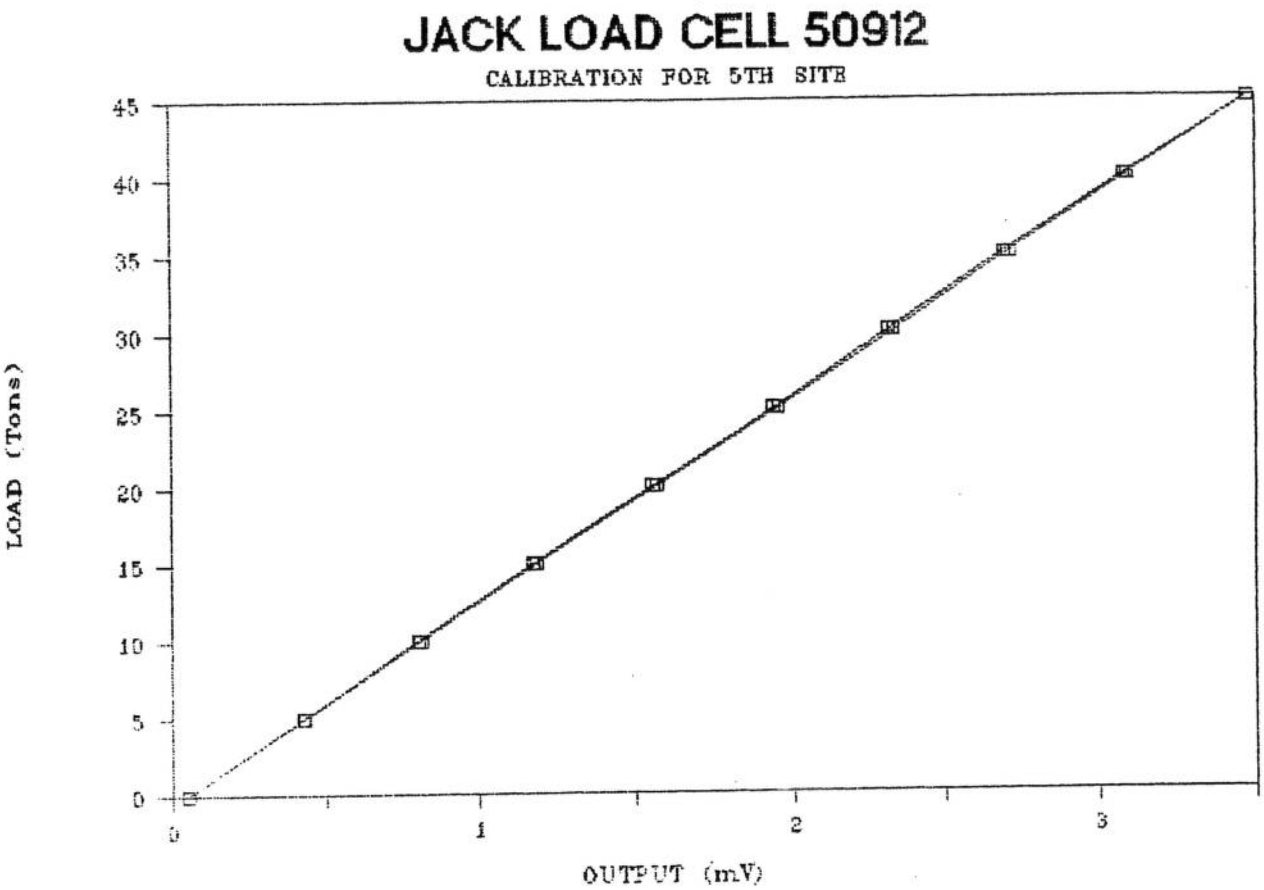
CALIBRATION FOR 4TH SITE



LOAD CELL S/N 50915

Regression Output:	
Constant	-0.83529
Std Err of Y Est	0.097927
R Squared	0.999954
No. of Observations	19
Degrees of Freedom	17
X Coefficient(s)	13.16331
Std Err of Coef.	0.021508

FIGURE XI2

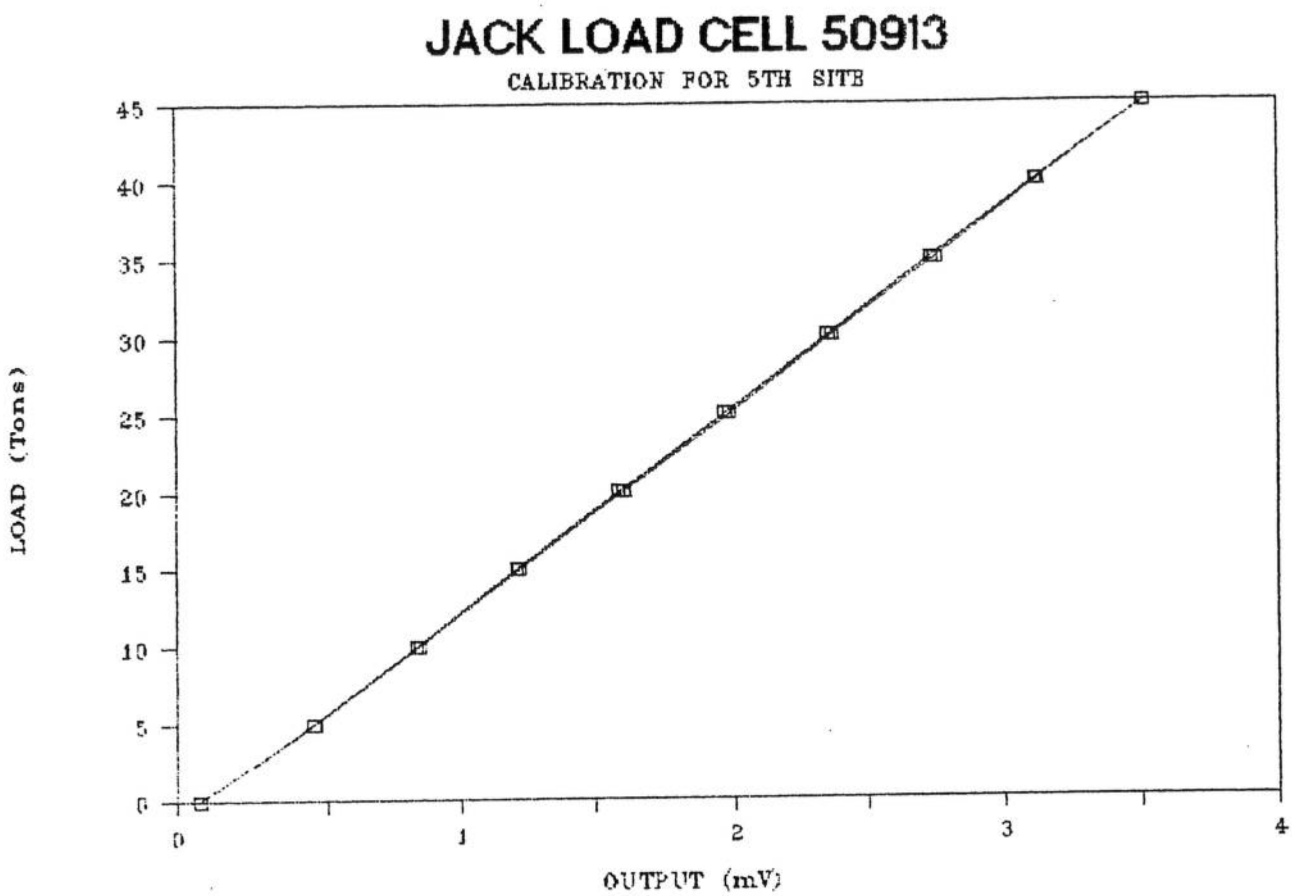


LOAD CELL S/N 50912

Regression Output:	
Constant	-0.63024
Std Err of Y Est	0.095040
R Squared	0.999957
No. of Observations	19
Degrees of Freedom	17

X Coefficient(s)	13.15750
Std Err of Coef.	0.020864

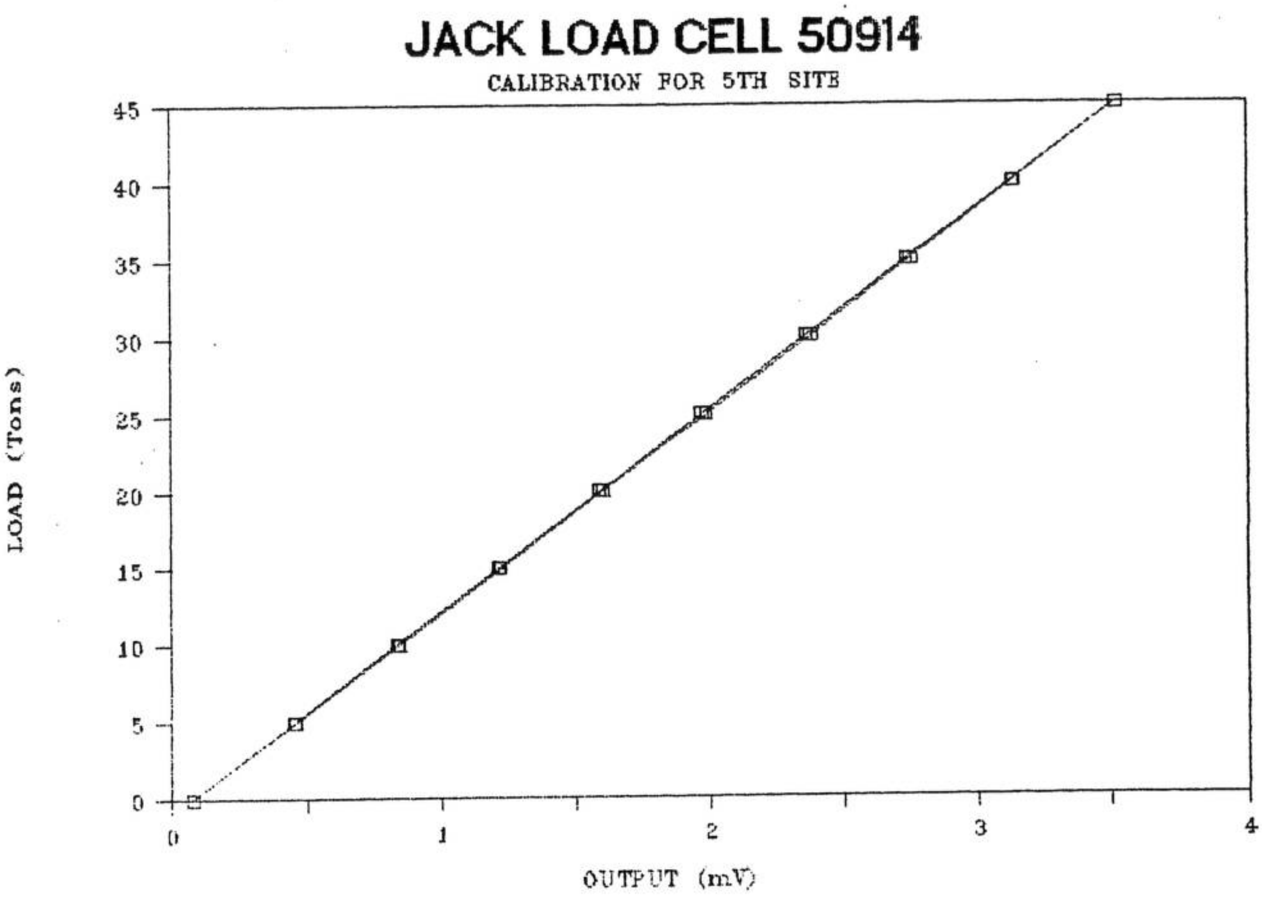
FIGURE III 2



LOAD CELL S/N 50913

	Regression Output:
Constant	-0.96436
Std Err of Y Est	0.096693
R Squared	0.999955
No. of Observations	19
Degrees of Freedom	17

X Coefficient(s)	13.10719
Std Err of Coef.	0.021146



LOAD CELL S/N 50914

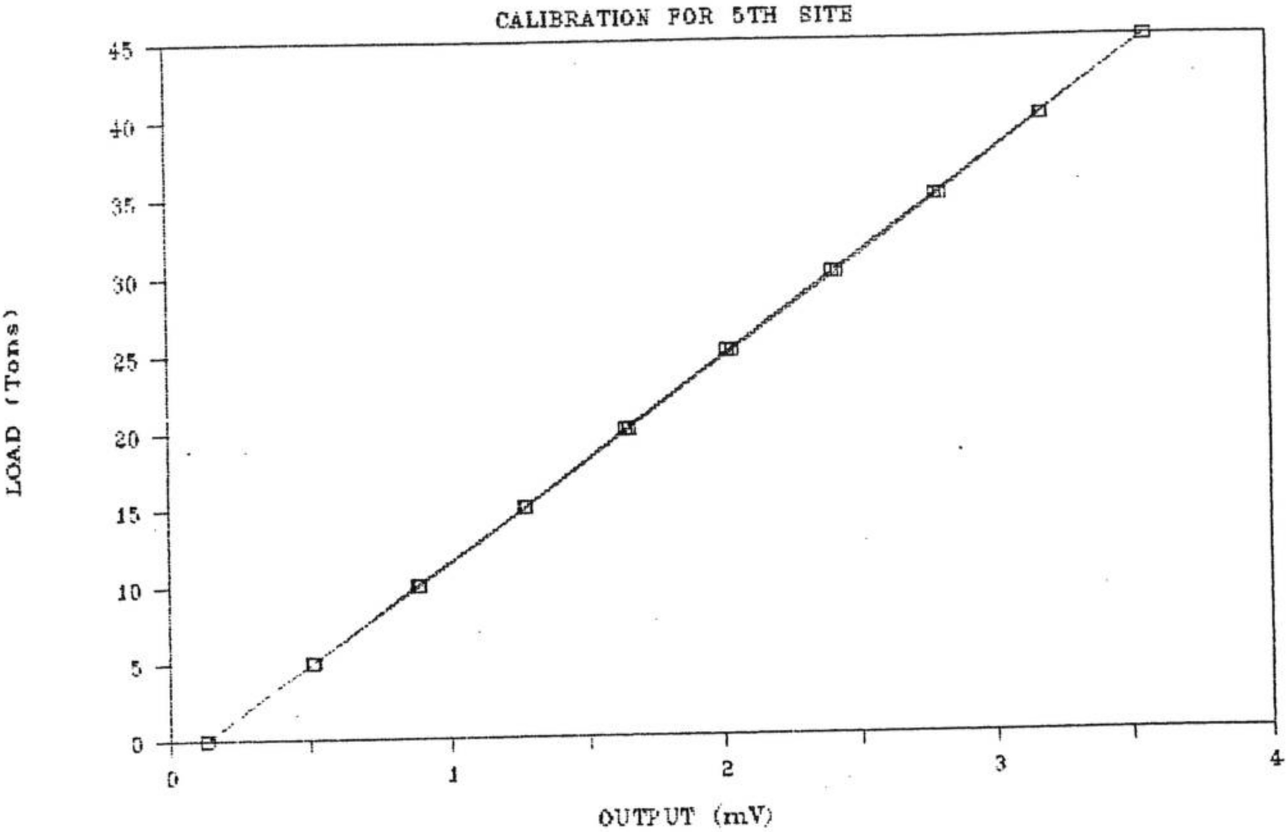
Regression Output:	
Constant	-0.96556
Std Err of Y Est	0.092218
R Squared	0.999959
No. of Observations	19
Degrees of Freedom	17

X Coefficient(s)	13.06461
Std Err of Coef.	0.020102

FIGURE III 25

JACK LOAD CELL 50915

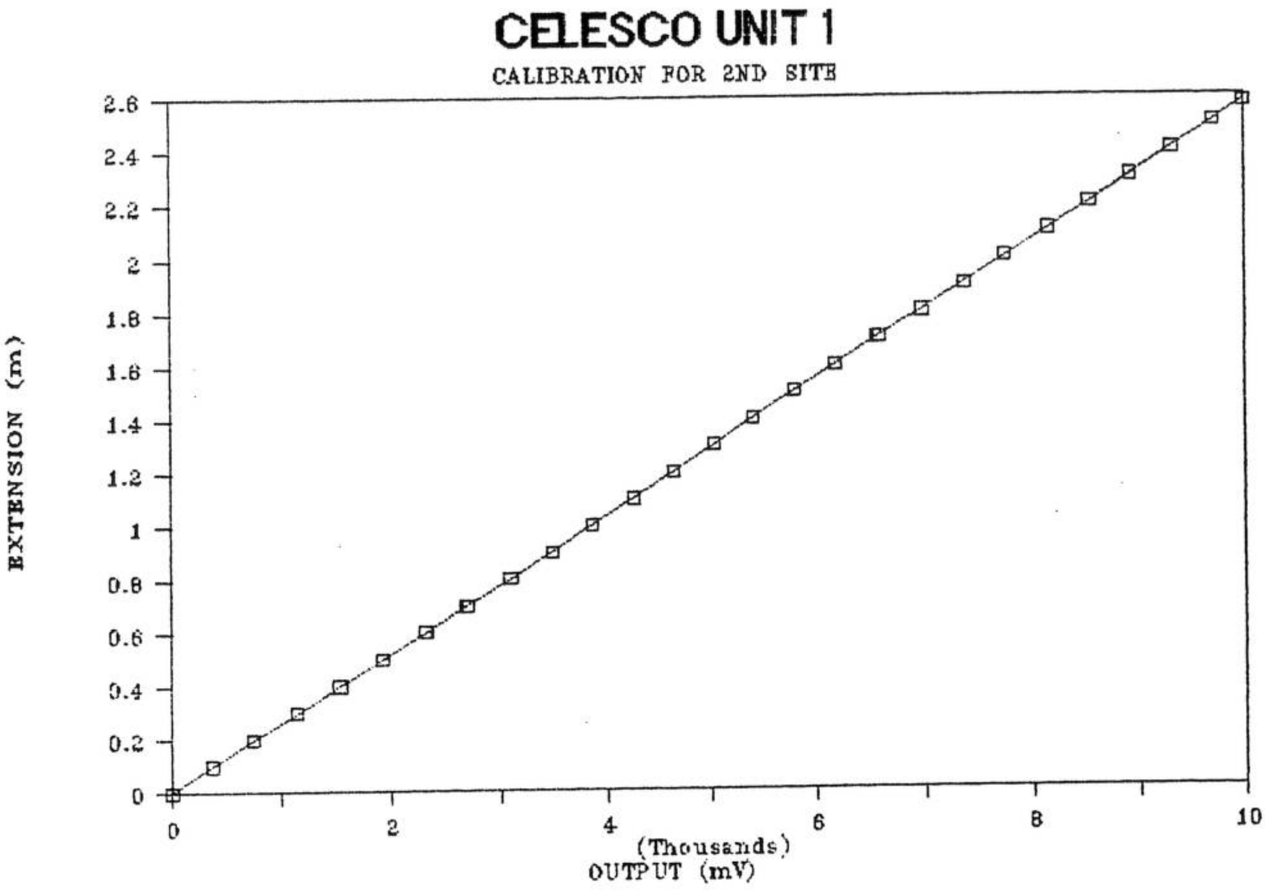
CALIBRATION FOR 5TH SITE



LOAD CELL S/N 50915

Regression Output:	
Constant	-1.71856
Std Err of Y Est	0.107542
R Squared	0.999945
No. of Observations	19
Degrees of Freedom	17
X Coefficient(s)	13.12537
Std Err of Coef.	0.023552

FIGURE III 255



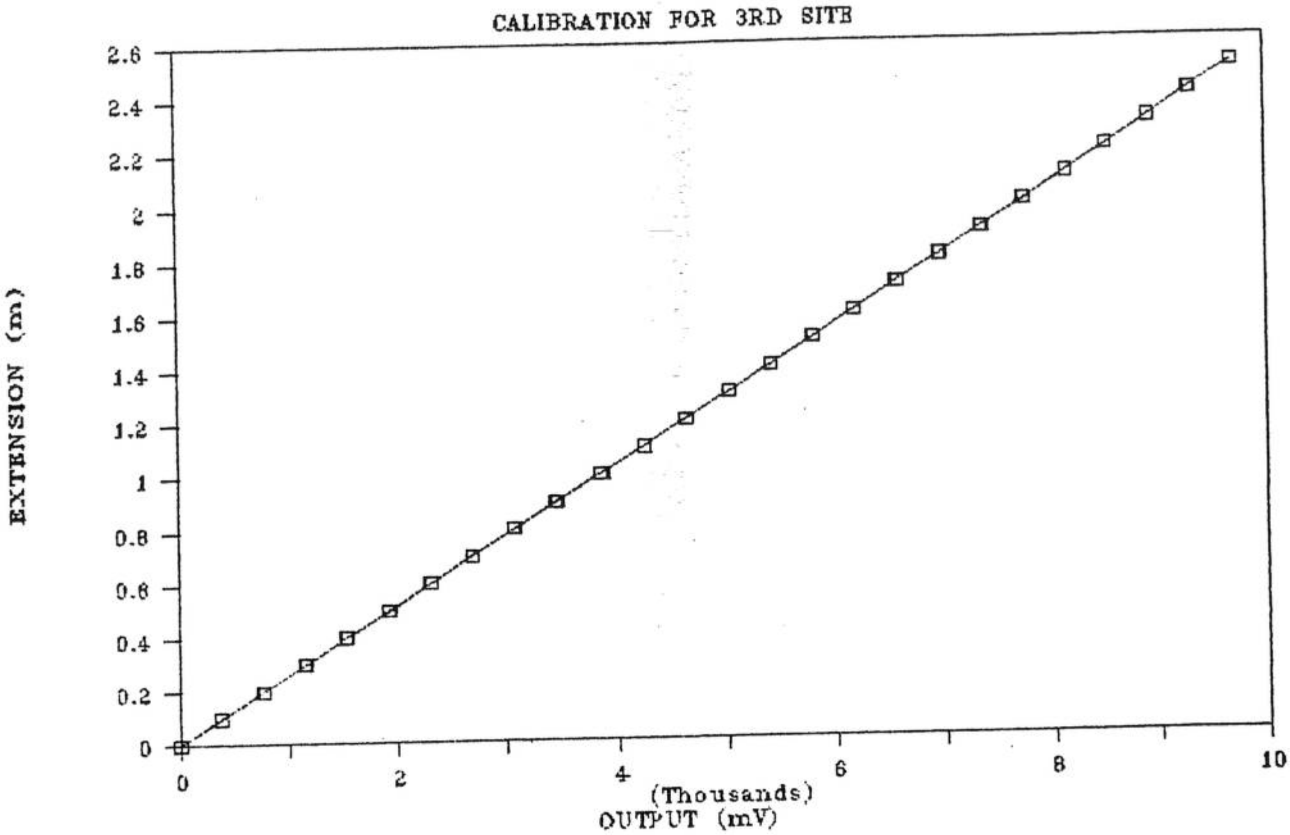
CELESCO (O -2.575 m)

Regression Output:	
Constant	0.003601
Std Err of Y Est	0.001099
R Squared	0.999998
No. of Observations	53
Degrees of Freedom	51

X Coefficient(s)	0.000257
Std Err of Coef.	0.000000

FIGURE III256

CELESCO UNIT 1

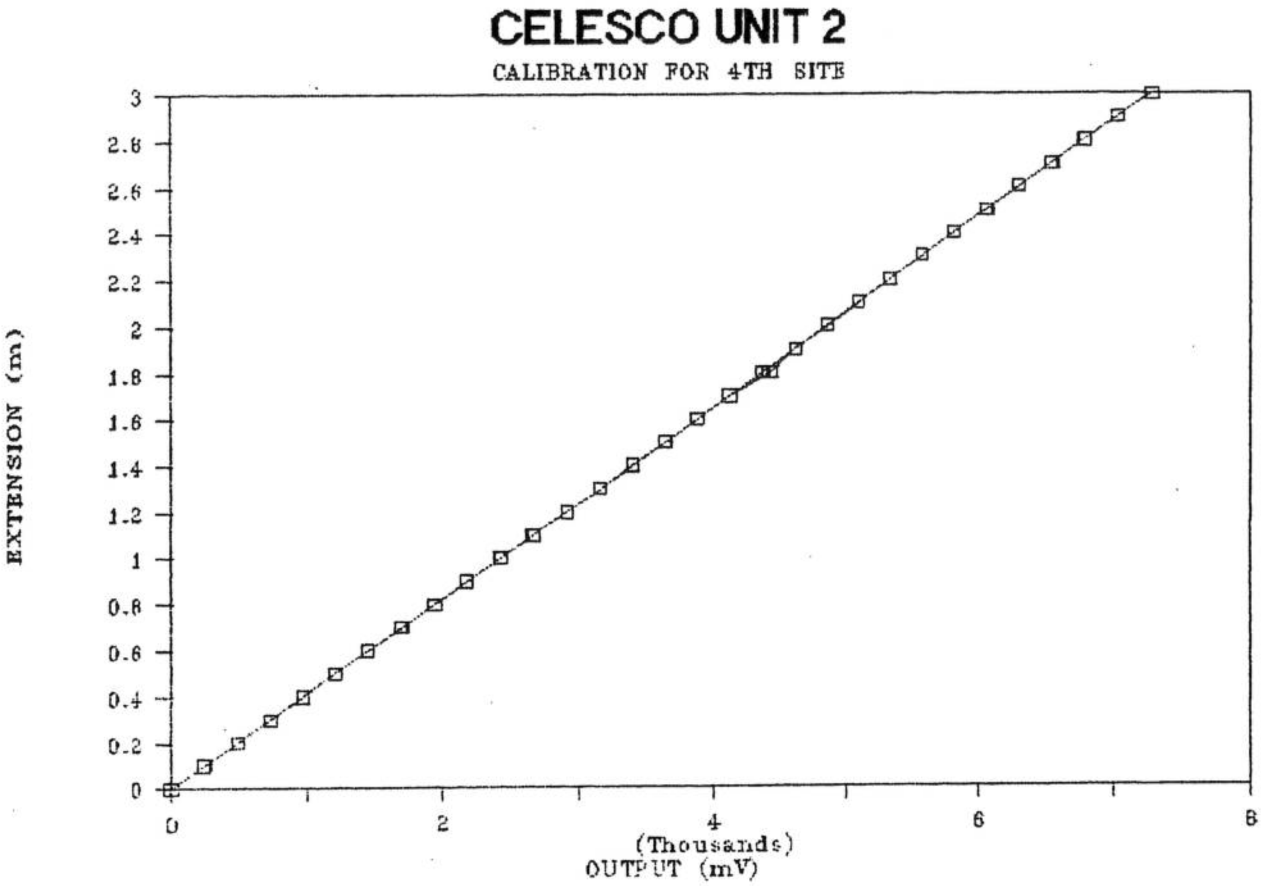


CELESCO (0-2.5m)

Regression Output:

Constant	0.002494
Std Err of Y Est	0.001280
R Squared	0.999997
No. of Observations	51
Degrees of Freedom	49

X Coefficient(s)	0.000257
Std Err of Coef.	0.000000

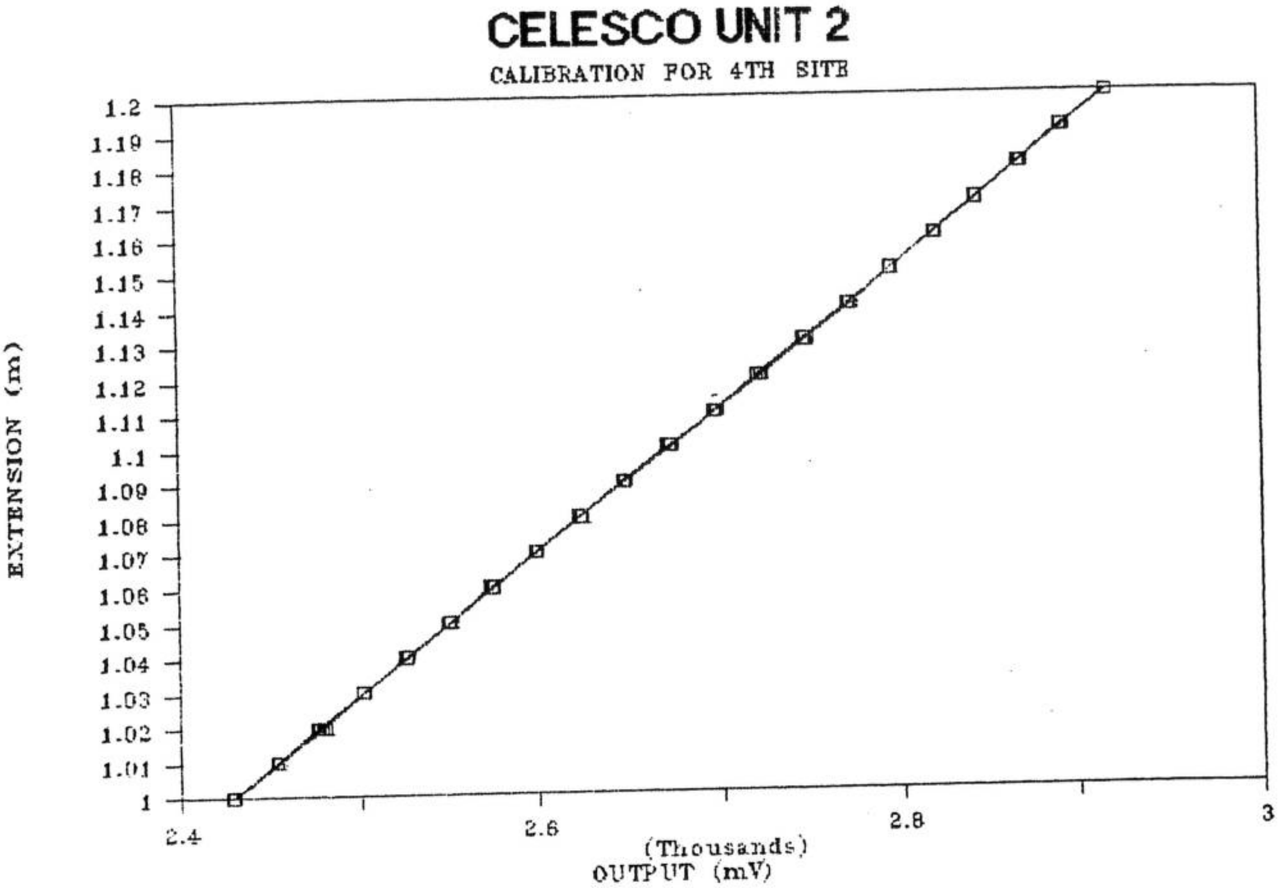


CELESCO (0-3.0m)

Regression Output:	
Constant	-0.00060
Std Err of Y Est	0.000610
R Squared	0.999999
No. of Observations	61
Degrees of Freedom	59

X Coefficient(s)	0.000411
Std Err of Coef.	0.000000

FIGURE III 2

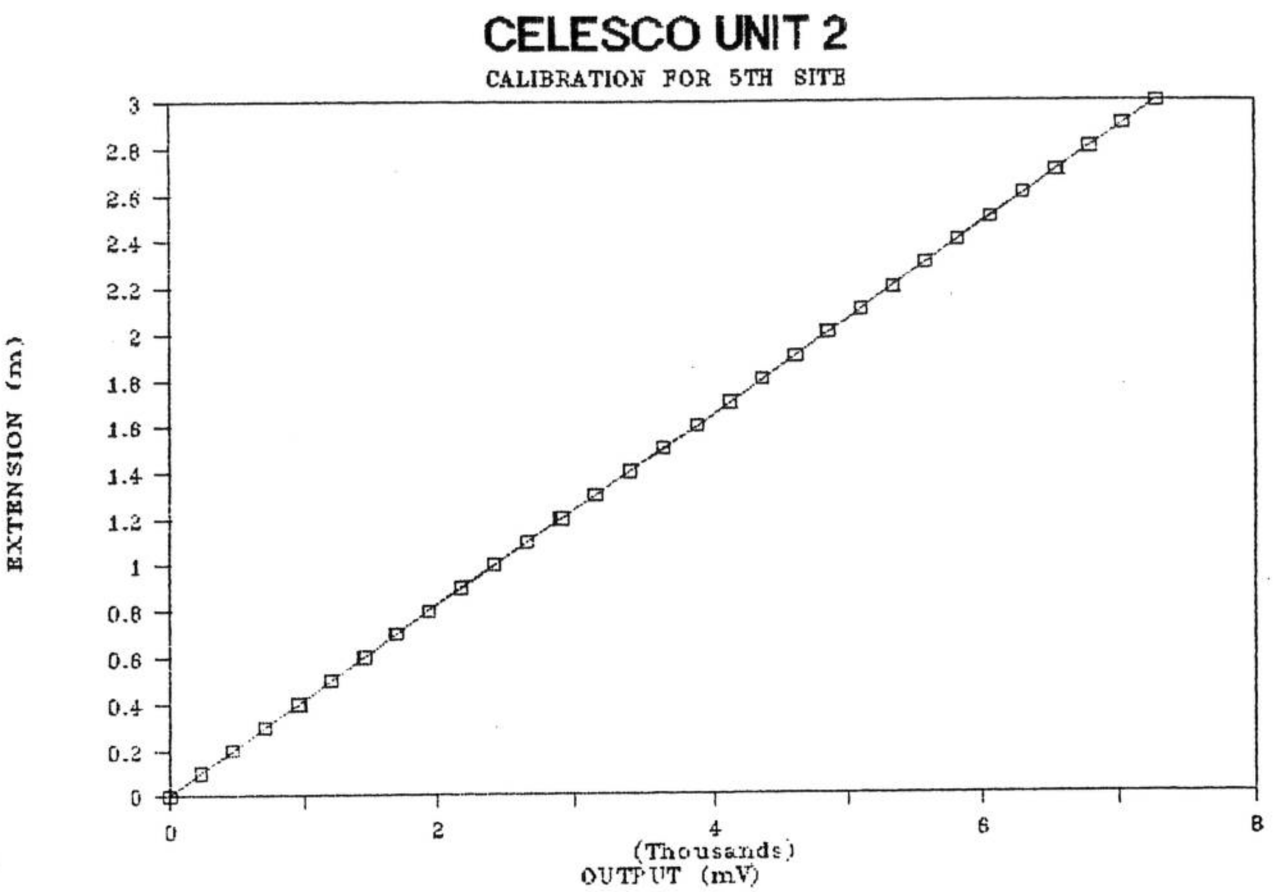


CELESCO (1.0-1.2m)

Regression Output:	
Constant	0.005774
Std Err of Y Est	0.000234
R Squared	0.999985
No. of Observations	41
Degrees of Freedom	39

X Coefficient(s)	0.000409
Std Err of Coef.	0.000000

FIGURE III 259



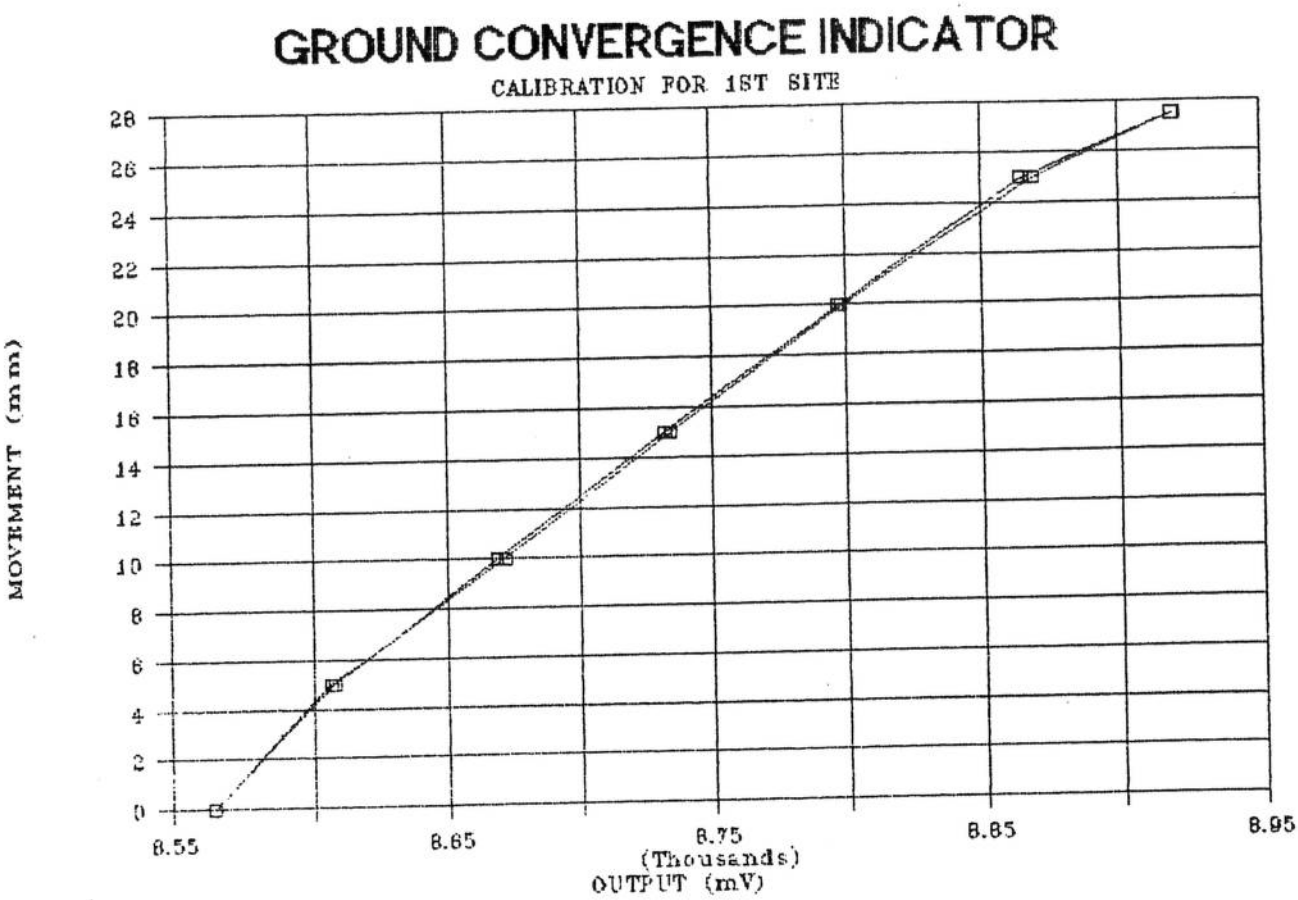
CELESCO (0-3.0m)

Regression Output:

Constant	0.002554
Std Err of Y Est	0.000983
R Squared	0.999998
No. of Observations	61
Degrees of Freedom	59

X Coefficient(s)	0.000411
Std Err of Coef.	0.000000

FIGURE III.2



GROUND CONVERGENCE INDICATOR
BASED ON 25mm TO 5 mm MOVEMENT

Regression Output:

Constant	683.0133
Std Err of Y Est	0.170312
R Squared	0.999651
No. of Observations	5
Degrees of Freedom	3

X Coefficient(s)	-0.07675
Std Err of Coef.	0.000826