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Äspö Hard Rock Laboratory

Prototype Repository

System for Canisters Displacement Tracking

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AITEMIN

November 2001

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Abstract

Displacement of the canisters is planned to be tracked along the duration of the experiment including tilting, and vertical and horizontal displacements using sensors anchored to the rock and attached to the canister. The tracking will be performed in deposition holes No. 3 and No. 6.

For each of the two deposition holes, six fibre optics based sensors will be installed, three of them measuring horizontal displacements of the canister and the other three measuring vertical displacements and tilting. All of them will measure distances between given points of the rock wall and the canister surface.

The data will be gathered by means of a Data Acquisition System, consisting on a Local Monitoring System, linked to the Master Database of the Experiment, and a Remote Monitoring System located at AITEMIN's headquarters in Madrid. This one will carry out the monitoring by periodically connecting via modem to the local one for checking out and receiving the displacement data. An MS Access based Particular Database will be built up upon them. The data will be also sent to the Master Database of the Experiment, managed by SKB.

The whole system is presented in this report.

Sammanfattning

Förskjutningar av kapslarna planeras att spåras under försökstiden genom att använda sensorer förankrade i berg och fastsatta mot kapseln för att mäta tippning samt vertikala och horisontella rörelser. Spårning av förskjutningar kommer att utföras på kapslar i depositionshål nr. 5 och nr. 6.

I respektive depositionshål kommer sex sensorer baserade på fiberoptik att installeras, varav tre mäter horisontell förskjutning av kapseln och tre mäter vertikal förskjutning samt tippning. Samtliga sensorer mäter avstånd mellan givna punkter på bergytan och kapselytan.

Mätdata kommer att samlas med hjälp av befintligt datainsamlingssystem som består av ett lokalt övervakningssystem som är kopplat till försökets huvuddatabas och ett fjärrövervakningssystem förlagt i AITEMIN:s högkvarter i Madrid. Den fjärranslutna övervakningen överförs periodvis via modem för kontroll och mottagande av förskjutningsdata. En MS Access-databas kommer specifikt att tillskapas baserat på dessa data. Data kommer också att skickas till Prototypförsökets huvuddatabas.

Mätsystemet presenteras i sin helhet i denna rapport.

1 Objectives

One important aspect within the repository performance is the displacement that canisters will probably undergo along the duration of the experiment. The main goal of this part of the project is to track this displacement both on its vertical and horizontal component, including as well the tilting. As an additional objective, the instrumentation of this part of the project has an innovative component due to the application of fibre optics based sensors. This will require the development of new custom made sensors nowadays not available for the harsh environment into which they are required to work.

The tracking system will be applied on emplacement hole No. 3 in Section I and No. 6. in Section II. (see Figure 1).

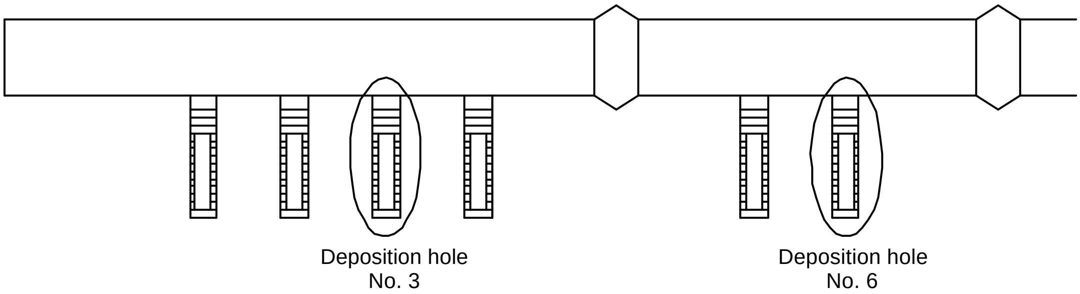


Figure 1. *Deposition holes for canister displacement measure*

2 Measuring system

2.1 Layout

For each deposition hole, six displacement sensors are foreseen, all grouped into one only measuring section, placed at the bottom of the canister, as shown in Figure 2.

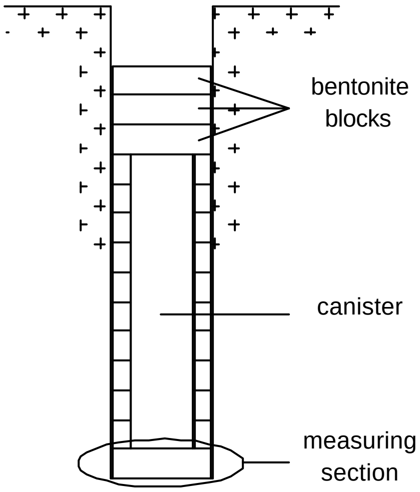


Figure 2. *Location of measuring section for each deposition hole*

Three of those sensors, named MCA30001 to MCA30003 for deposition hole No. 3 and MC6001 to MC6003 for deposition hole No. 6, will be vertically placed into holes drilled into the bentonite block. These three sensors will determine the vertical displacement of the canister, as well as any possible tilt. The points where the sensors are attached to the canister will be the same as for the horizontal sensors. Figure 3 below illustrates the position of the six sensors for deposition hole No. 3.

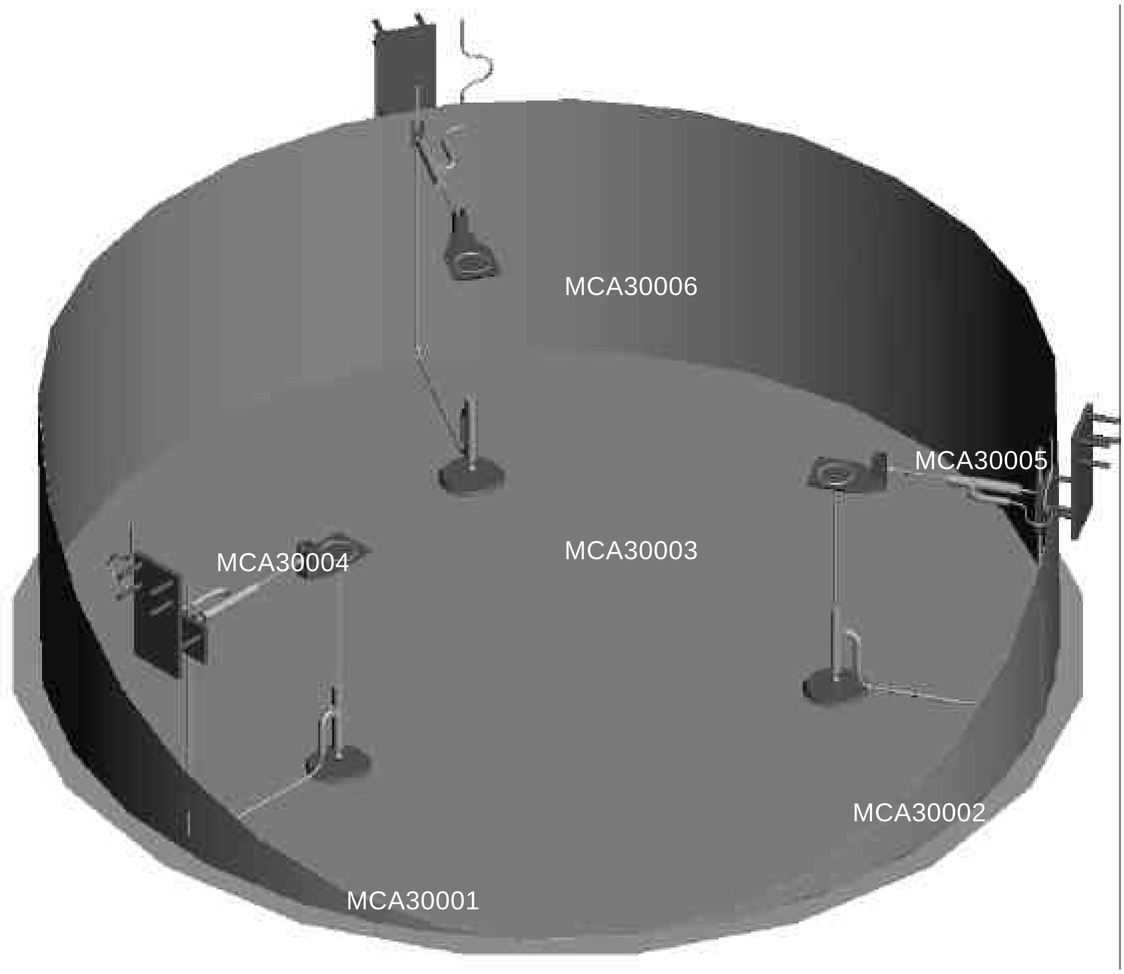


Figure 3. *General view of sensors in deposition hole No. 3*

The other three displacement sensors, named MCA30004 to MCA30006 for deposition hole No. 3 and MCA60004 to MCA60006 for deposition hole No. 6, will be placed horizontally at the top of the lower bentonite block, close to the lower lid of the canister and attached to it, in a 120º radial disposition. The sensors will be always in a horizontal position, so that the horizontal displacement of the canister can be measured. *Figure 4* shows a plan view of the sensors once installed for deposition hole No. 3. The sensors have been placed so as to avoid interfering with other sensors.

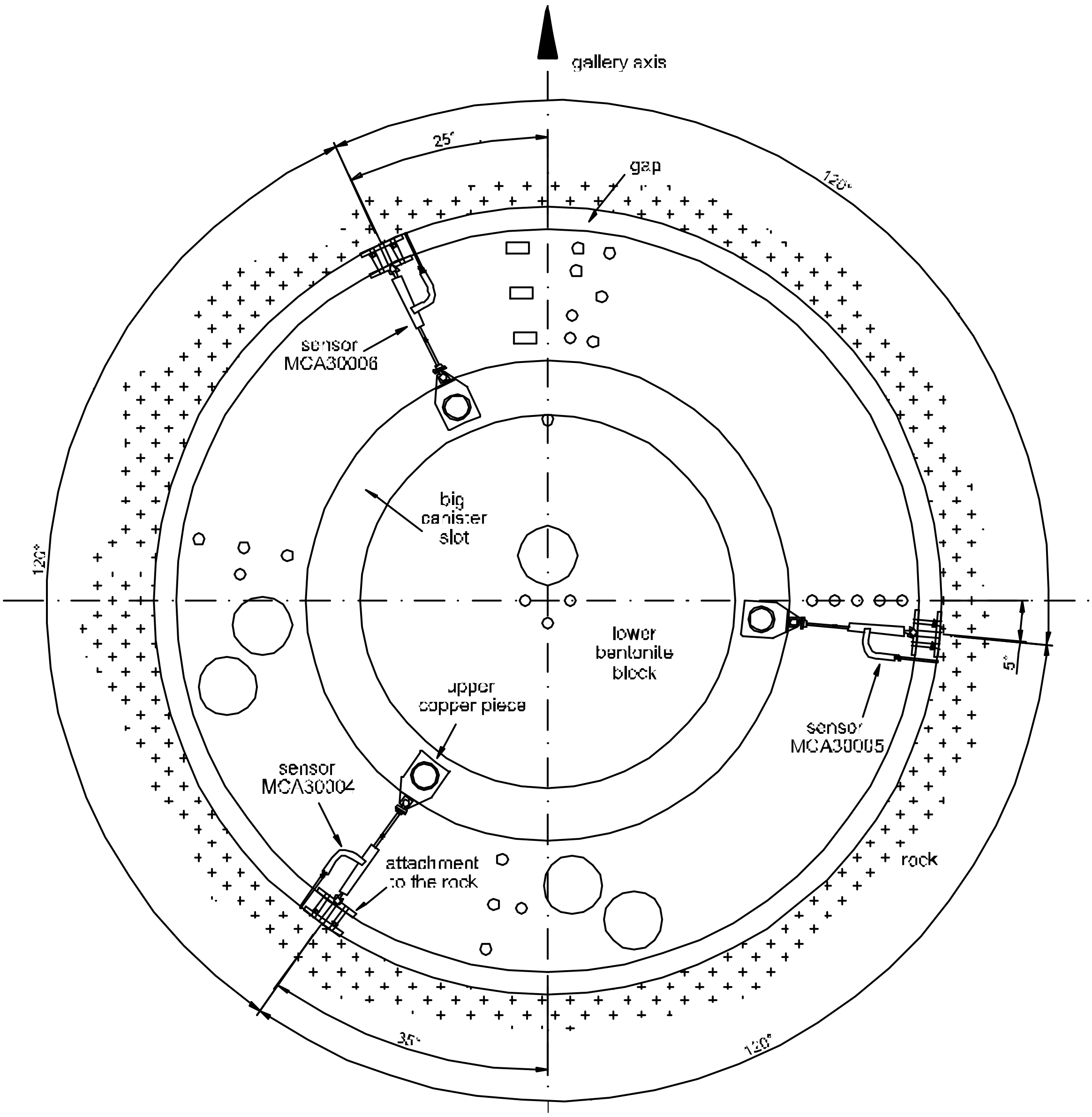


Figure 4. *Horizontal sensors*

2.2 Sensors description

The displacement sensors to be installed are fibre optics based. They comprise no electronics inside, but a Thin Film Fizeau Interferometer, that receives a broadband white light and returns a wavelength modulated light. Hence, it is assured that no electromagnetic interference will affect the readings. Besides, the use of fibre optics based sensors incorporates an innovative aspect into the project in relation with the displacement sensors conventionally used so far.

The selected sensor is the FOD 25 from Roctest (Canada). Because of the harsh working conditions for the sensors, a rugged version of this sensor will be specifically constructed in Incoloy 825 for this application by the manufacturer, assuring water tightness and corrosion resistance. The dimensions of the sensor, shown in Figure 5, are fairly small, what helps disturbing the whole system as less as possible.

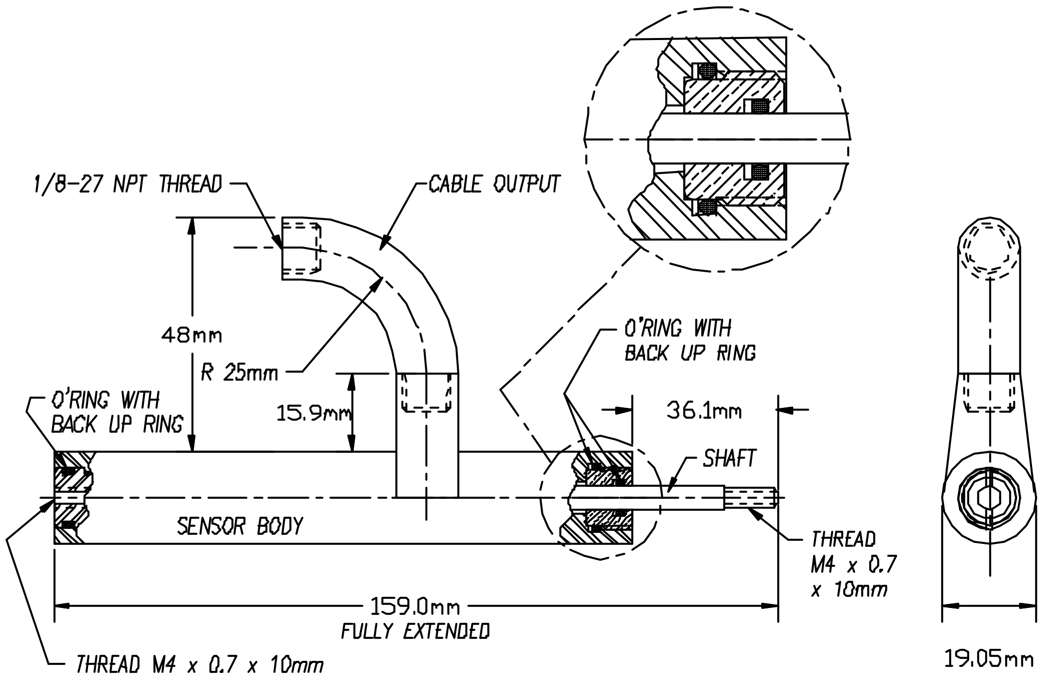


Figure 5. *Custom rugged version of FOD 25 displacement sensor from Roctest*

The main features of the sensor are:

- Model: custom rugged model FOD 25 HP from Roctest
- Range: ± 12.5 mm
- Resolution: 0.0002 mm with averaging
- Precision: 0.08 % FS
- Temp. Range: -150 ºC to 350 ºC
- Material: Incoloy 825
- Dimensions: Diameter 19.05 mm, length ≤ 159 mm
- Shaft extension: Graphite rod, 6 mm diameter
- Cable connection: kevlar reinforced fibre optics cable, diameter 4 mm
- Cable protection: ¼ " Incoloy 825 tubing (bentonite buffer)
  ¼ " Polyamide tubing (backfill)

2.3 Anchoring system

A thin copper plate lays on the concrete bed placed at the bottom of each deposition hole, to avoid water entering to the bentonite blocks through this surface during the installation phase. Each of the three vertical sensors will be anchored, on its housing side opposite to the shaft, to this copper plate by means of a circular copper piece. This piece fits exactly in a slot to be drilled in the bottom surface of the block, and is screwed to it in order to keep the sensor in place during the emplacement operations of the block. After introducing the sensors and screwing the plates, the lower surface of the block remains even, so the weight is supported by the whole surface with no risk of block breakage.

The circular copper pieces have a mechanised chamber on their the bottom surface that will be filled with high viscosity resin right before placing the block into the deposition hole. Hence, the attachment will be achieved between the three copper pieces and the copper plate by means of this resin. High viscosity resin is used in order to avoid dripping during the short time of the emplacement operation that elapses from the moment when it is applied in the three pieces to the moment when it makes contact with the copper plate, as the mechanised chambers containing it will be in an upside down position. A 3D view of the vertical sensor with this circular copper piece at the bottom is shown in Figure 6.

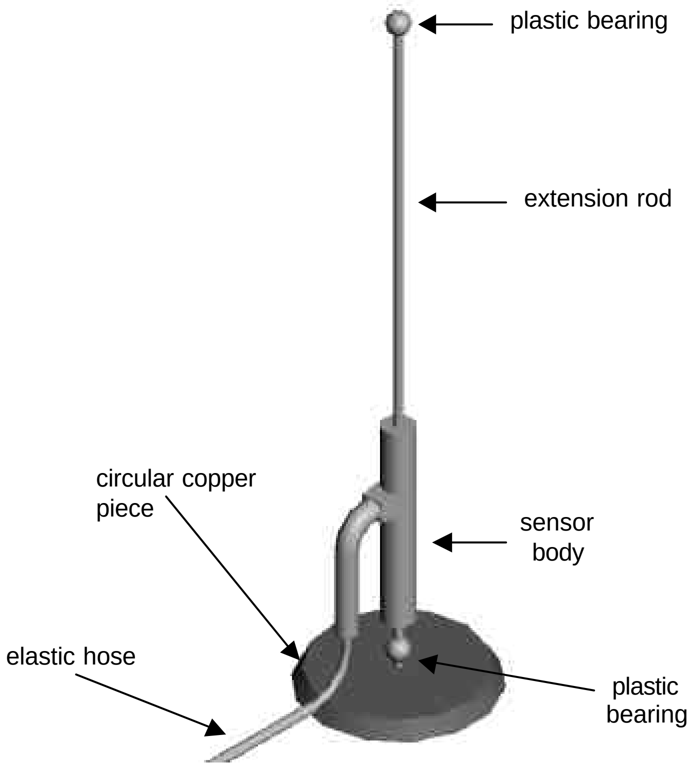


Figure 6. *3D view of vertical sensor*

At the other side of the sensor, a graphite extension rod will connect the sensor shaft to an upper copper piece that will be attached to the canister. Graphite rods have been chosen in order to reduce the thermal transmission and consequently the readings deviations due to temperature changes. The upper copper piece can be screwed to the graphite rod once the block is placed into the deposition hole containing the three vertical sensors on it. This piece is shown in Figure 7.

In case that tilting or horizontal displacement of the canister occurs, the vertical sensors will have to handle a misaligned displacement, so they will have to adjust their position in order to avoid shaft bending and extension rod bending or even breakage. For this urpose, two plastic bearings acting as rotation points will be placed close to the anchoring points, that is, between the bottom circular copper piece and the sensor housing, and at the end of the graphite extension rod, underneath the upper copper piece.

Each horizontal sensor is attached to the rock on its housing side opposite to the shaft. The attachment is made by means of two copper plates. One is placed on the rock wall and bolted to it with up to four anchoring bolts, and the other one is situated parallel and inserted into a slot drilled in the side surface of the bentonite block. Both plates are coupled rigidly by means of another three threaded bolts with the length of the gap bentonite-rock.

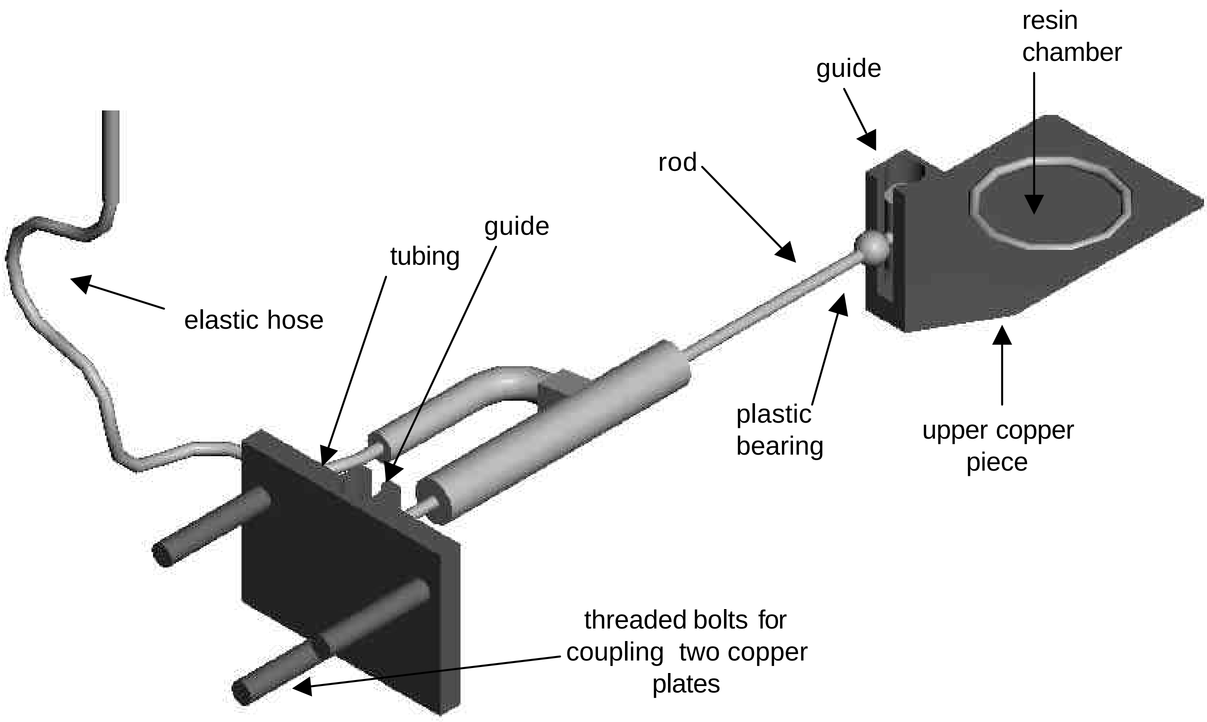


Figure 7. *3D view of horizontal sensor*

As a plastic film is foreseen lining the whole rock wall for preserving the bentonite blocks from the incoming formation water, it will be necessary to make holes on it through which passing the bolts that couples both copper plates for each of the three horizontal sensors. Once the plate is placed on the rock and bolted to it, and the other one is fitted on its slot, the hole will be sealed around the three bolts to avoid water leakage on that point. When the installation is over, the film will be removed by pulling from the top, so it must be cut all the length below the three sealed holes as it is extracted, so that it does not get jammed. For this purpose, a sharp blade will be fixed to the lower bolt between the two plates of each sensor, covering all the bolt length, and with its cutting edge facing downwards.

At the other side of the sensor, a graphite extension rod will connect the sensor shaft to the aforementioned upper copper piece for the attachment to the canister. This piece has a machined chamber that will be poured with resin right before the canister insertion operation starts. A low viscosity resin has been chosen for this purpose, on the contrary to that mentioned before for the attachment of the lower circular pieces. This resin was selected because of its long pot life, as it will have to stay liquid during a few hours from the moment of pouring to the moment of contact with the canister. A cross section of the bottom bentonite block with the canister already inserted can be seen in Figure 8.

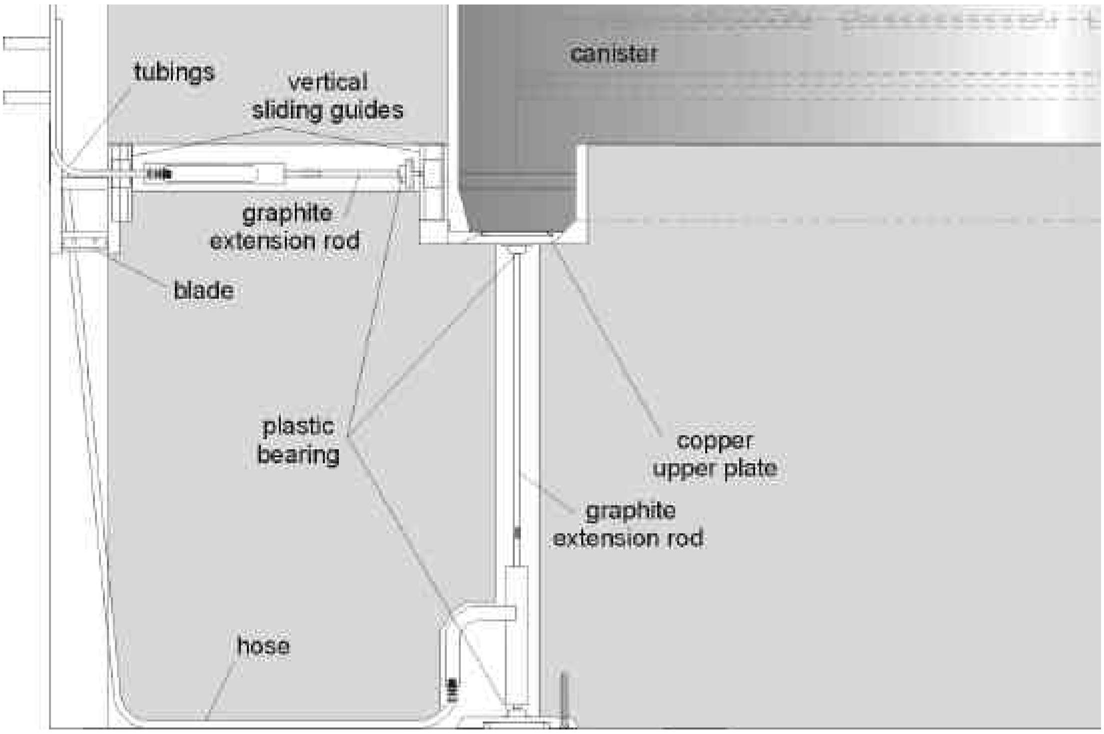
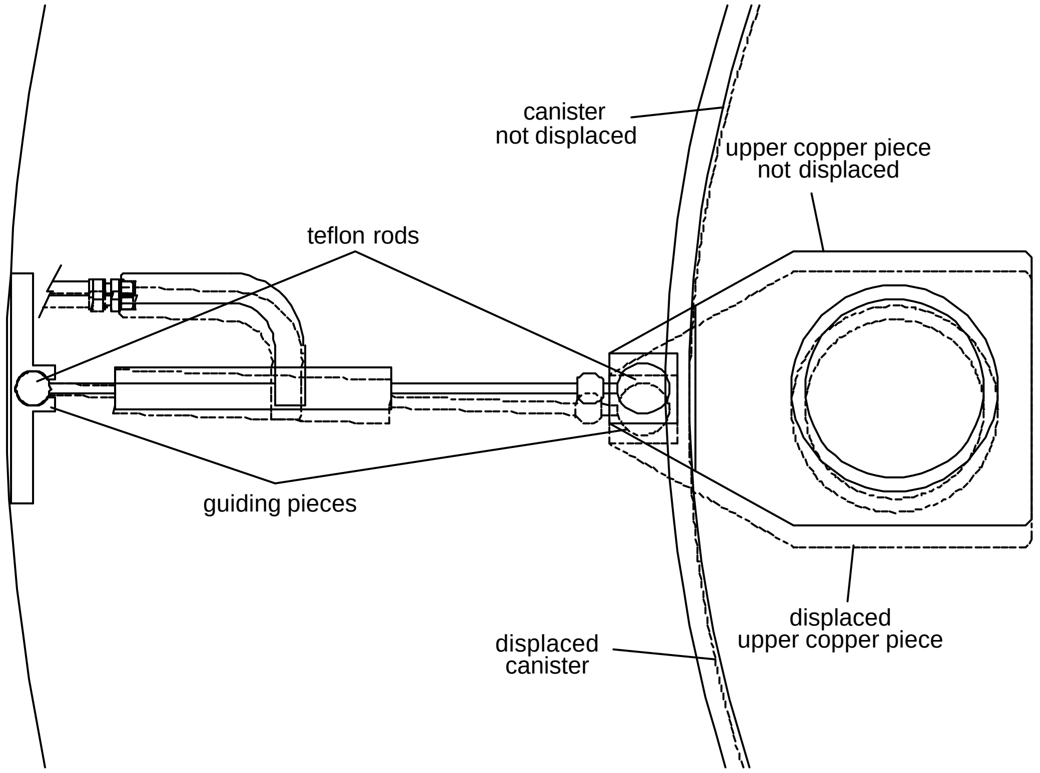


Figure 8. *Cross section of bottom bentonite block after canister insertion*

As mentioned before, the aim of the three horizontal sensors is to measure the horizontal displacement of three points at the lower lid of the canister in relation to three points of the rock. As these sensors are placed in a 120º radial disposition, any horizontal displacement of the canister will result in a misaligned displacement of at least two of the horizontal sensors, if the canister's displacement is aligned with the other one's axis, or a more likely misaligned displacement of all the horizontal sensors, if the canister's displacement is not aligned with any of them. In order to avoid damage to any of these sensors and bending or even breakage of the extension rod, they will need a certain horizontal degree of freedom. A rotating joint situated at each of the anchoring points, and as close as possible to them, will serve this purpose. These joints are shown in top and side view in Figure 9, and consist on vertical, short plastic rods attached at both ends of the sensor-graphite rod set that can slide into vertically placed copper guides. One of the guides is part of the copper plate fitted into the bentonite block at the rock side, and the other is the vertical part of the upper copper piece.



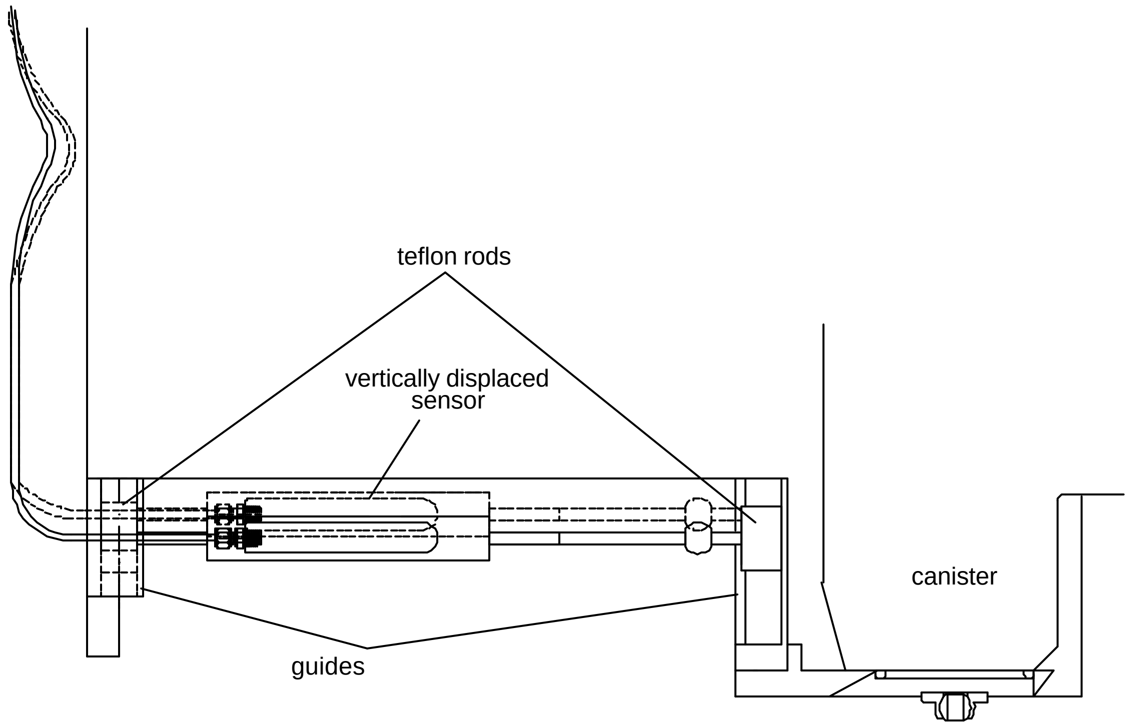


Figure 9. *Horizontal sensors' attachments*

The guides allow an axial rotation of the plastic rods so that the horizontal sensor attached to them at both ends can adjust its position in the horizontal plane when a horizontal displacement of the canister occurs. In case that vertical displacement of the canister and bentonite block occurs, both rods are displaced upwards or downwards at the same time, so the sensor is displaced vertically, but remaining always horizontal.

As above mentioned, the guide at the canister end is part of the upper copper piece. In case that tilting of the canister occurs, the piece will incline, and so will do the guide. This movement is allowed by a plastic bearing placed between the graphite extension rod and the guide.

Finally, the cable will run inserted into an Incoloy 825 tubing on its length into the buffer. This tubing will be secured on its final position so that it does not interfere with the rest of the installation in the hole. In order to allow the vertical displacement of the horizontal sensors, a 30 cm long elastic tube has been inserted as part of their tubing on its first half meter before securing it to the wall. It is in a partially bended position, so that it can unbend or bend more to absorb the movement of the sensor.

2.4 Cable outputs to the g-tunnel

As mentioned before, the cables will be 4 mm outer diameter kevlar reinforced fibre optics cables sheathed with ¼ inch outer diameter Incoloy 825 tubing on their length into the buffer, and with ¼ inch outer diameter polyamide tubing all the rest of their length. A compression fitting will serve to assure water tightness in the transition of tubings.

When reaching the top of the hole, the tubings will surround its edge up to the closest point to the gallery wall. The tubings will then be led towards the lead through entry.

The assigned entries are HG0028A01 for deposition hole No. 3 and HG0022A01 for deposition hole No.6. At the cable passthroughs, compression fittings at both sides will assure tightness between the lid and each tubing.

2.5 Supervision and data management

A Local Monitoring System (LMS) will be located on site to gather the data. It will comprise all the necessary electrical components and software packages for the monitoring of the canisters displacements: a 16 channel DMI signal conditioner from Roctest (see Technical Annex), connected to a commercial SCADA software running in a PC with a modem. (see Figure 10). The system will have enough autonomy for long time data storage.

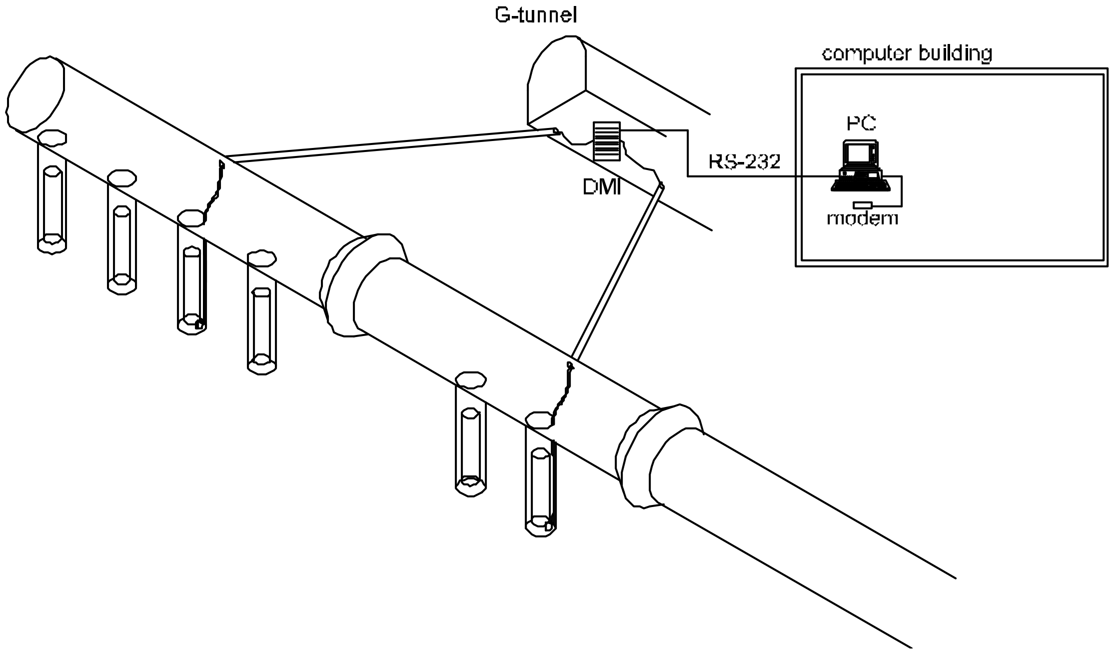


Figure 10. *Cabling and local monitoring system (Äspö)*

The supervision and data management will be carried out from a Remote Monitoring System (RMS) located in the main offices of AITEMIN in Madrid. This system will connect periodically with the local one via modem for data transmission (see Figure 11). It will comprise all equipment and software packages required for the adequate remote supervision and analysis of the test. A particular master database will be built up from the data gathered.

Reports will be generated periodically including graphical representation of the evolution of the displacements.

The main functions of the Local Monitoring System are:

- Acquisition, conversion, visualisation and storage in real time of all data provided by the displacement sensors.
- Automatic, unattended monitoring of the canisters displacement.
- Enable remote supervision from the RMS.
- Permanent and direct link with the Main Monitoring and Control System of the Experiment.
- Generation and secure storage of the particular master database.

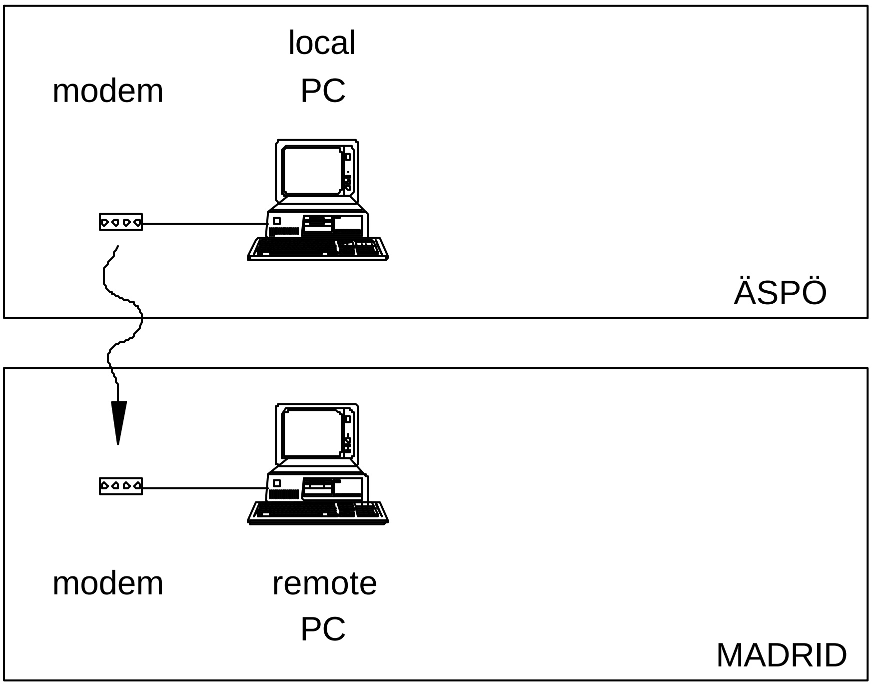


Figure 11. *Remote monitoring system (Madrid)*

The following main components are required for the LMS:

a/ Signal conditioning and data logging system (DMI 16)

b/ Host Computer (PC)

No power supply is required for the sensors as they are optic devices, with no electronics inside.

Due the special characteristics of the utilised sensors, the special DMI signal conditioning unit will be provided by the sensor manufacturer Roctest as data logging unit, what will also allow having redundancy for the data logging function, in case of computer failure. The signal conditioning and data logging system includes the following features:

- A signal conditioning suitable for any Fizeau Interferometer based sensor.
- A data logging unit, including a non-volatile memory buffer with a storing capacity of up to 50,000 readings as well as other operational parameters.
- 16 reading channels.
- RS-232 operating mode, with PC complete software included.
- Diagnostic function.
- Firmware upgradeability by upgradeable Flash ROM.
- NEMA-4 enclosure.
- 5 watts power consumption with battery backup.

The unit will be placed on a panel close to the G-tunnel wall, between the exit of the cables lead throughs HG0028A01 and HG0022A01.

The host computer of the LMS is a standard industrial computer (rugged PC) placed into the computer building. The PC running under Windows NT will read the data from the DMI signal conditioner and data logging unit, via a RS-232 connection. Then data will be processed, visualised and stored in the particular master database.

The so called FIX 32, a general purpose SCADA software from Intellution Inc., will be used for this application. It supports the following main functions:

- Continuous data acquisition from the DMI.
- Data conversion into physical units.
- Adaptation of conversion functions.
- Data presentation (text and graphical).
- Data storage into internal data base.
- Alarms generation (if needed).

The Remote Monitoring System will be located at the main office of AITEMIN in Madrid. To perform the remote supervision and data analysis functions, the following subsystems will be required at this location:

a/ Data recovery, supervision and analysis system.

b/ Data base access system.

c/ Uninterrupted Power Supply.

Both data treatment systems will be integrated in one high performance PC type computer, connected to the UPS network existing at the control office.

The data stored in the local PC will be recovered from RMS each week in order to update the particular master database, monitor the behaviour of the system, and detect monitoring malfunctions. It will be also possible to make eventual connections for real time monitoring of the test from the RMS.

The remote connection and data recovery will be performed by a well proven dedicated communications software (pcANYWHERE release 9.2 from SYMANTEC Corp.). Data presentation and remote supervision will be performed at the RMS. All data will be recorded into optical storage devices each month as back-up, and these optical disks will be stored in a fireproof enclosure for security reasons.

The local PC data base will contain the values of the measurements at least on each half an hour period. At the RMS, the particular master database will store values each 1 day period during all the experiment.

The RMS data base will be developed under MS-ACCESS software.

The data communications between LMS and RMS will be developed via standard telephone network using an adequate modem. Both LMS and RMS modems will have entry password and automatic dialling.

The access (by keyboard or by modem) to each computer of the system will be restricted by means of an specific entry password.

3 Installation procedure

A brief description of the installation of the tracking system follows; for more details, see report No. AP TD F63-00-87: “Displacement of Canisters Activity Plan”, AITEMIN, Dec 2000.

1. **Drilling of three vertical holes for hosting the vertical sensors:** the holes will be drilled from the bottom of the big canister slot of the block, down to the bottom of the block. This operation will be carried out in advance by SKB at the block manufacturing facilities.

2. **Insertion of vertical sensors in bentonite block No. 1 (lower one):** the vertical sensors will be installed into the block and secured in place. This operation will be carried out as follows:

    2.1. Firstly it will be necessary to attach the block lifting device, lift the block and secure it lifted by means of a well-built frame and a heavy duty forklift in order to work out on its lower surface the required slots for inserting the three lower circular copper pieces and the tubing, and also to widen the three vertical holes drilled in first place for hosting the cable exit of the sensors.

    2.2. Secondly, the vertical sensors with the graphite extension rod and the plastic bearing at the end will be inserted into their holes, and the lower circular copper pieces will be screwed to the block.

    2.3. At this point, the block will be brought down to the floor in order to work out the slots for hosting the horizontal sensors on the top surface of the block. These slots will be drilled in a 120º radial disposition, and aligned with the vertical holes. A wider part will be also drilled at the outer part to host the cable exit from the sensor body. Also a wider part will be drilled in the canister side to host the guide of the upper copper piece.

    2.4. Finally, the slots in the side surface of the block for hosting the copper plates will be drilled. With this slots drilled, a preliminary positioning of the horizontal sensors will be done to adjust the dimensions of the slots. This positioning will include screwing the upper copper pieces to the plastic bearing on top of the vertical sensors, and securing them in their final position by pouring bentonite powder and pellets into the vertical holes containing the vertical sensors. Additionally hand cut bentonite pieces will be used for securing in place the upper copper pieces. These bentonite pieces will fit exactly with the upper copper piece in the big canister slot and hence press against the big slot walls. Once the slots are correct, the horizontal sensors will be removed and the block will be ready for its placement into the deposition hole.

3. **Placement of block into deposition hole:** the block with the vertical sensors inside will be placed into the deposition hole. The operation will be performed as follows:

    3.1. Firstly the block lifting device will be attached, and the tubings containing the sensor cables inside will be coiled and secured in the central part of the device.

    3.2. The block will be then lifted and the resin chambers of the lower circular copper pieces will be filled with resin.

3.3. The block will be placed into the deposition hole, and the resin will glue the three circular copper plates to the thin copper plate laying on the concrete bed down the hole. This thin copper plate shall be cleaned in advance at the contact points with the resin, in order to improve as much as possible the sticking.

3.4. The tubings containing the sensor cables inside will be uncoiled and extended all the way up to the gallery and secured in place**.**

4. **Installation of horizontal sensors:** the steps for this operation are described next:

4.1. In first place the plastic film lining the rock surface will be ripped in the points where the sensors will be anchored to the rock.

4.2. Each horizontal sensor will be then placed on its final position, and so will be done with the two coupled copper plates at the rock side. The distance between the two plates will be adjusted to compensate the possible deviation from the theoretical 5 cm wideness of the gap rock-bentonite, this deviation being that of the block placement operation.

4.3. When the distances and positions are correct, the position of the coupled copper plates will be marked on the rock wall. Then the sensors and copper plates will be removed and the holes for the anchoring bolts will be drilled. Resin ampoules for chemical anchoring will be introduced on each hole and finally the copper plates will be placed again bolted. The bolts will break the ampoules and mix the resin compounds.

4.4. Finally, the horizontal sensors will be placed on their final position, and left there until the canister insertion, and the hole in the plastic film will be sealed around the plates to avoid water leakage.

5. **Insertion of blocks No. 2 to No. 11:** to be done by SKB's operators with the block lifting device.

6. **Anchoring to canister:**

6.1. Right after the insertion of the canister, the surface of the lower lid to be in contact with the resin will be cleaned and polished, so as to allow a good adherence with the resin.

6.2. An operator from AITEMIN will then mix the resin and will descent to the bottom of the hole in order to pour it into the resin chambers of the upper copper pieces. The canister descent operation will have to take less time than the pot life of the resin.

6.3. The operator from AITEMIN will also hand cut an approximately 1.5 cm high slot in the lower surface of the block No. 2 at the points right above the upper copper pieces, in order to allow them a certain vertical movement in case of canister elevation.

7. **Insertion of canister:** to be done by SKB's operators with the canister deposition machine.

8. **Passing of tubings through flange to G-tunnel:**

   8.1. First all the cables at the exit of their Incoloy 825 tubing will be passed through polyamide tubing, covering all their length up to the signal conditioner at the G tunnel.

   8.2. The flange will be placed close to the deposition hole and all the tubings will be passed through it and fitted with compression fittings on both sides.

   8.3. All the tubings will be then bundled together with zip ties, and passed through the borehole up to reach the G tunnel.

   8.4. Finally, the flange will be inserted in place and bolted.

9. **Connection of Data Acquisition System and start-up:**

   9.1. At the G-tunnel, the DMI will be placed on the reading units panel. A hole will be drilled on this panel to pass the cables through it.

   9.2. The cables will be unbundled out of the rock and connected to the DMI.

   9.3. The RS-232 serial cable will be lead along a cable tray fixed to the tunnel roof, into the computer building and up to the local PC.

   9.4. The system will be started up and communication tests will be made.

Steps 1 to 8 will be repeated for Deposition Hole No. 6.

4 Time schedule

A preliminary schedule of the planned activities for the monitoring of displacement can be found in Table 1.

Table 1. Time schedule for displacement monitoring

	Year	1999				2000				2001				2002				2003			
Tasks	**Trimester**	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1.- Contribution to Work Groups																					
2.- Displacement measuring system																					
2.1.- Test equipment and calibration syst.						X															
2.2.- Sensors preliminary tests							X	X													
2.3.- Sensors purchasing									X	X		X	X								
2.4.- Sensors preparation										X			X								
2.5.- Sensors assembly											X			X							
2.6.- Monitoring system									X	X	X										
2.7.- Supervision, acquisition and data management												X	X	X	X	X	X	X	X	X	X

Annex:

Technical DATASHEETS

PRODUCT DATASHEET

DMI SIGNAL CONDITIONER

KEY FEATURES

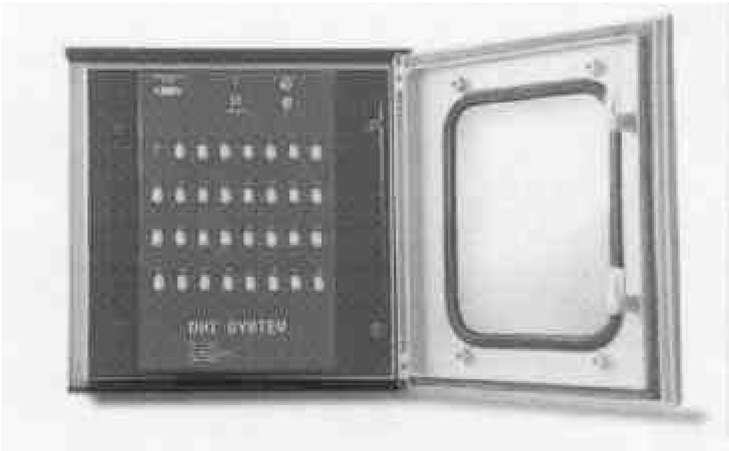
? **16 to 32 channels**

? **5O 000 samples datalogger**

? **Programmable datalogger**

? **NEMA-4 enclosure**

? **Compatible with all of FISO s fiber optic transducers**



APPLICATIONS

-Multi-points continuous monitoring

-Civil engineering

-High voltage and RF fields

-In-situ process monitoring

-Hazardous environments -Etc

THE DMI IS A MULTICHANNEL, UNIVERSAL FIBER-OPTIC SIGNAL CONDITIONER IDEALLY SUITED FOR PERFORMING MULTI-POINT TEMPERATURE, PRESSURE, STRAIN, AND DISPLACEMENT MEASUREMENTS IN APPLICATIONS HOSTILE TO NON-FIBER-OPTIC TRANSDUCERS.

The DMI conditioner is designed for applications that require continuous monitoring of a large number of measuring points. The DMI conditioner is capable of measuring the absolute cavity length of FISO Technologies' Fabry-Perot fiber-optic transducers with astonishing accuracy, providing highly accurate and reliable measurements. It is compatible with all of FISO's fiber-optic transducers, including temperature, strain, pressure, displacement, and force and load. FISO's transducers feature complete immunity to microwave and RF radiation, high-temperature operating capability, intrinsic safety, and non-invasive use. The sensors are also designed to withstand harsh and corrosive environments.

The DMI has a 0.01% FS resolution (without averaging) and 0.025% FS precision. Use of a Flash ROM allows the customer to easily upgrade the signal conditioner firmware. The DMI has a non-volatile memory buffer that can store up to 50 000 data samples and data-Iogging sequences, duration and other operational parameters are easily programmable using RS-232 remote control.

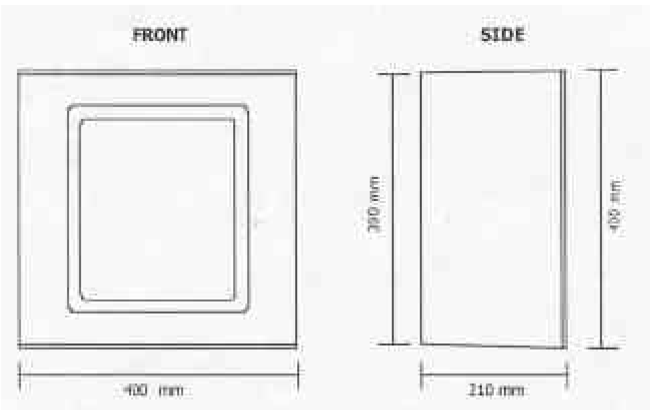
The DMI signal conditioner comes standard in a NEMA-4 enclosure that accommodates from 16 to 32 channels. RS-232 1/0 port comes standard with DMI system for control and data downloads.

FISO TECHNOLOGIES

SPECIFICATIONS

Number of channels:	16 or 32
Compatibility:	Compatible with all of FISOs line of fiber-optic transducers (see fiber-optic transducer datasheet)
Sampling rate:	20 Hz
Switching time:	150 ms (in scan mode: time to switch between two channels)
Averaging:	1 to 500 samples
Precision:	0,025% of full scale
Resolution:	0,01%of full scale
Dynamic range:	15 000 :1
Display:	None
Operating mode:	RS-232 (RS-485 optional)
Data logging:	50 000 samples; Programmable data logger
Analog outputs:	None
Communication:	RS-232 (RS-485 optional)
Diagnostic:	Yes
Upgradability firmware:	Flash ROM Upgradable
Upgradability channels:	No
Light life expectancy:	~40 000 hours of continuos use (MTBF)
Weight:	4 Kg
Enclosure:	NEMA-4 enclosure (other enclosures available)
Enclosure dimensions (WxDxH):	400 x 400x 210 mm
Power consumption:	5 Watts (10 to 14 Volt; AC/DC adapter included
Operating temperature:	-20 ºC to 40 ºC

DMI DIMENSIONS



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PRODUCT DATASHEET

FOD DISPLACEMENT TRANSDUCER

KEY FEATURES

? **Intrinsically safe**

? **Immune to EMI/RFI**

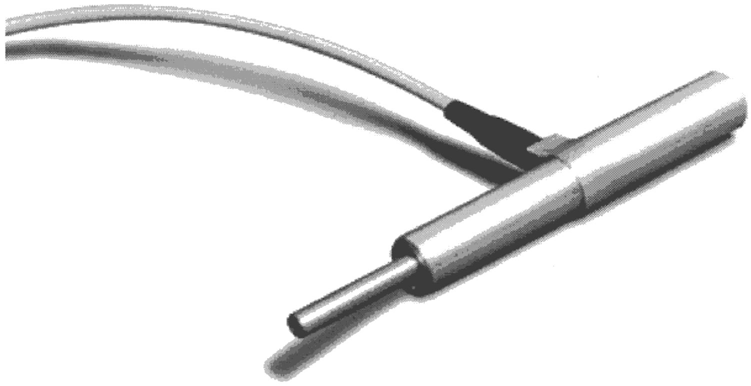
? **Up to 350 ºC (650 ºF)**

? **Accuracy of up to 0.002 mm**

? **25 mm linear stroke**

? **Aluminum or composite material housing**

? **Compatible with all of FISO's fiber-optic signal conditioners**



APPLICATIONS

– **Microwaves and RF environments**

– **In-situ process monitoring**

– **Harsh and hazardous environments**

– **High temperature environments**

– **Etc**

FISO TECHNOLOGIES' FIBER-OPTIC DISPLACEMENT TRANSDUCER FEATURES COMPLETE IMMUNITY TO EMI AND RFI, BULT -IN SAFETY FOR HAZARDOUS ENVIRONMENTS, HIGH PRECISION AND HIGH TEMPERATURE OPERATING RANGE.

The FISO's fiber-optic linear position and displacement transducer is an absolute position transducer which provides high precision measurements of position and displacement. The FOD is the fiber-optic version of the well-known Linear Variable Differential Transformer (LVDT) but unlike it, the FOD requires no energizing AC voltage or driving signal with the associated wiring. The FOD is completely immune to EMI and RFI and carries no risk of current leakage or ignition. The FOD can be packaged in a very compact form and can be located far away (up to 5 km) from the signal conditioner. These characteristics make the FOD weIl suited for difficult-to-reach locations and hazardous environments such as those containing explosive materials.

Our unique design is based on a Thin Film Fizeau Interferometer device (TFFI) mounted on a movable shaft. The T FFI can be seen as a spatially distributed Fabry-Perot cavity where the cavity length varies along the lateral position. The tip of an optical fiber is mounted so as to be facing the surface of the TFFI which is moved relative to the optical fiber extremity. By connecting this device to one of FISO Technologies' white-light fiber-optic signal conditioners, it becomes an absolute position and displacement transducer.

Compatible with all of FISO's high-performance fiber-optic signal conditioners, the fiber-optic linear position and displacement transducer combines all the desired characteristics you would expect in the ideal sensor. Its compact size, immunity to EMI/RFI, resistance to corrosive environments, high accuracy, and reliability make it the best choice for linear position and displacement measurements.

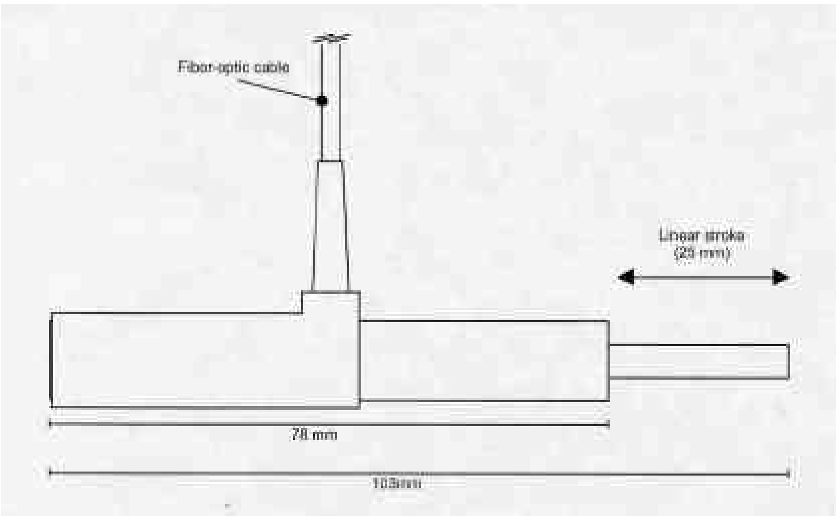
FISO TECHNOLOGIES

SPECIFICATIONS

LINEAR POSITION AND DISPLACEMENT TRANSDUCER SPECIFICATIONS

Linear Stroke:	25 mm (spring loaded shaft and other lengths optional)
Linearity:	0,08% of FS
Resolution:	0,002 mm (no averaging) and 0,0002 mm (aver<ging) with signal conditioner
Operating temperature:	Minus 150 ºC to up to 350 ºC (650 ºF); Operating temperature is FO cable dependent
EMI/RMI susceptibility:	Intrinsic immunity
Cable length:	1.5 meter length. Custom length up to 5 km and high temperature cable available
Cable material:	Polyurethane; other material available
Housing material:	Aluminum or composite material (optional)
Connector:	ST
Dimensions	103 mm length X 13 mm O.D: other size optionally available)

LINEAR POSITION AND DISPLACEMENT TRANSDUCER DIMENSIONS
(Aluminum or composite material)



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