

**Model TES-PU-20/26V**  
Uplift pressure measuring system

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Doc. # WI 6002.14  
Rev. 0  
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## 1. Introduction

TRITECH uplift pressure measurement is a precision instrumentation system designed to help civil engineers in the measurement of uplift pressure in the foundation of a concrete dam. It forms an important part of dam instrumentation. Seepage water from the reservoir area often seeps into the dam foundation and the down stream side. The study of uplift pressure has the following main purposes:

- To determine the magnitude of any hydraulic pressure that may be present at the base of a dam due to percolation or seepage of water along underlying foundation seams or joint systems after the reservoir is filled. To release this pressure, if necessary.
- To monitor seepage water from the reservoir area into the dam foundation in view of the safety of the dam structure.
- To monitor the effectiveness of the drainage system below the dam.
- To study the effectiveness of foundation grouting.

### 1.1. Typical installation in a concrete dam

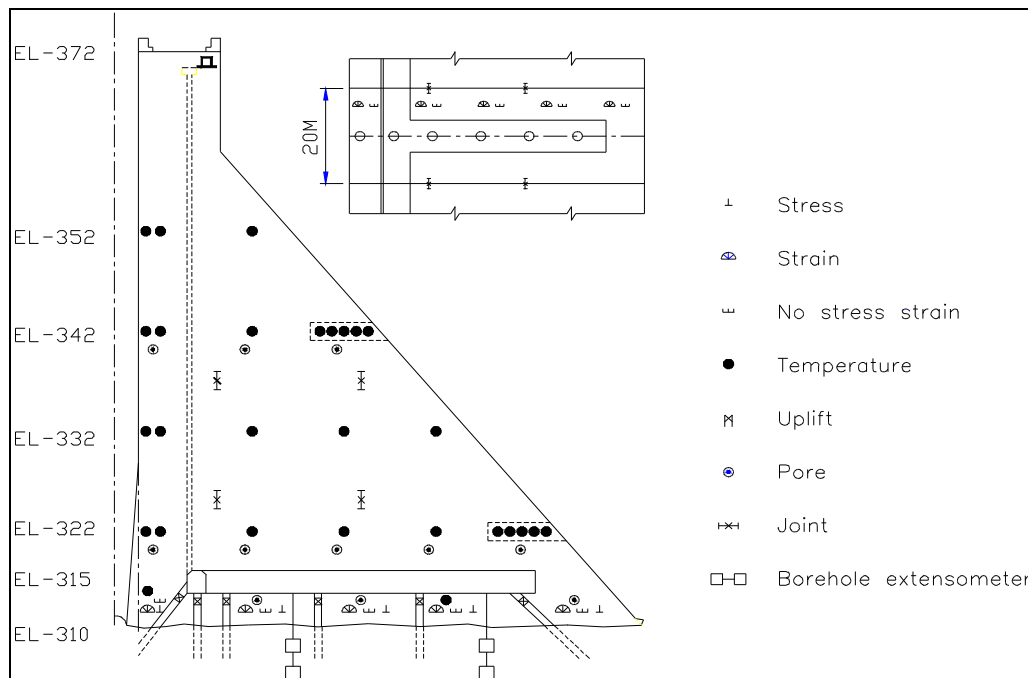


Figure 1.1

### 1.2. Uplift pressure measurement

The uplift pressure is measured mechanically by using a Bourden pressure gage or electronically by using a vibrating wire uplift pressure meter and a digital vibrating wire indicator. The uplift pressure measuring device consists of a perforated/non-perforated pipe of 50mm to 63mm  $\phi$  of adequate strength. The pipe is inserted in a drilled hole in the foundation from the instrumentation gallery to a depth upto the required location. The other end of the pipe is brought into the gallery where it is connected to an uplift pressure meter or a Bourden pressure gage.

#### 1.2.1. Mechanical method

The mechanical uplift pressure meter incorporating the Bourdon type pressure gage can be conveniently fixed to the uplift pressure pipe in the gallery. The installation of the mechanical system is very easy and requires no cable jointing and special orientation.

Mechanical measurement is economical. However, one has to go into the gallery to take the readings. It should also be noted that the vibrating wire uplift pressure meter is a much more reliable device than a Bourden type pressure gage and has a better resolution and accuracy.

### **1.2.2. Electronic method**

The development of vibrating wire sensor introduced a reliable and fast method of taking uplift pressure readings electrically. This enables remote reading as well as data storing in case the output is connected to a data acquisition system. The cable is carried from the sensor tip to the read-out unit or data logger and is protected against any possible damage during construction. For details of vibrating wire sensors and other vibrating wire instruments manufactured by TRITECH, refer to data sheet 1087-99w.

The electronic uplift pressure meter is installed with the necessary length of cable jointed with it. Proper junction boxes are available to take the signals to any distant location through multi core cables. The mounting is very simple as the meter is surface mounted and does not require to be embedded.

### **1.3. Conventions used in this manual**

**WARNING!** Warning messages calls attention to a procedure or practice, that if not properly followed could possibly cause personal injury.

**CAUTION:** Caution messages calls attention to a procedure or practice, that if not properly followed may result in loss of data or damage to equipment.

**NOTE:** Note contains important information & is set off from regular text to draw users' attention.

The user's manual is intended to provide sufficient information for making optimum use of uplift pressure measurement assembly in your applications. It covers description of the vibrating wire uplift pressure meter and its accessories, procedure for installation & maintenance of the sensor, method of taking observations and recording data. The description of the mechanical system is also covered.

To make this manual more useful we invite your valuable comments and suggestions regarding any additions or enhancements. We also request you to please let us know of any errors that you may find while going through this manual.

### **1.4. How to use this manual**

This manual is divided into a number of sections, each section containing a specific type of information. The list given below tells you where to look for in this manual if you need some specific information. It is however recommended that you read the manual from the beginning to the end to get a thorough grasp of the subject. You will find lots of unexpected information in the sections you feel you may skip.

*For measurement by Bourden gage:* See § 2 'Mechanical measurement'

*For understanding principle of vibrating wire uplift pressure meter:* See § 3.2.2. 'Operating principle'.

*For installation of VW system:* See § 5 'Installation of vibrating wire system'.

## 2. Mechanical Measurement

A system of piping is installed at several stations in the dam in the first lift just above the contact between the foundation rock and the base of the dam. The pipes extend into one or more of the lower galleries in the dam. Alternatively, holes may be drilled from the gallery down to the level upto which the drain pipes have to be installed. Drain pipes extend below the dam, both on the upstream and downstream side.

The mechanical assembly to be installed at the top of these drain pipes is detailed in figure 2.1 and the following table:

Sl.	Description	Qty.
1	Reducer (2"x1")	1
2	1" GI pipe (350 mm)	1
3	Reducer (1"x 1/2")	1
4	1/2" tee	1
5	1/2" Male nipple (50 mm)	2
6	1/2" Male nipple (150 mm)	1
7	1/2" Wheel valve-10 kg/cm <sup>2</sup> (Zalota/Hawa)	1
8	1/2" GI Socket	1
9	Brass hex. gage adopter	1
10	Teflon washer	1
11	Dial pressure gage	1

The installation is very simple and does not need a detailed description.

### 2.1. Tools & accessories

The following tools and accessories are required for proper installation of the uplift pressure measurement system:

- 2.1.1 Spanner 23/25 and 30/32 (Taparia)
- 2.1.2 Pipe wrench (30 cm)
- 2.1.3 Teflon tape (10 mm)
- 2.1.4 Thread sealant (Loctite 577)
- 2.1.5 Acetone (commercial)
- 2.1.6 Hacksaw with 300 mm blade
- 2.1.7 Pliers 160 mm (Taparia)
- 2.1.8 Waste paper basket
- 2.1.9 Cloth for cleaning (lintless)

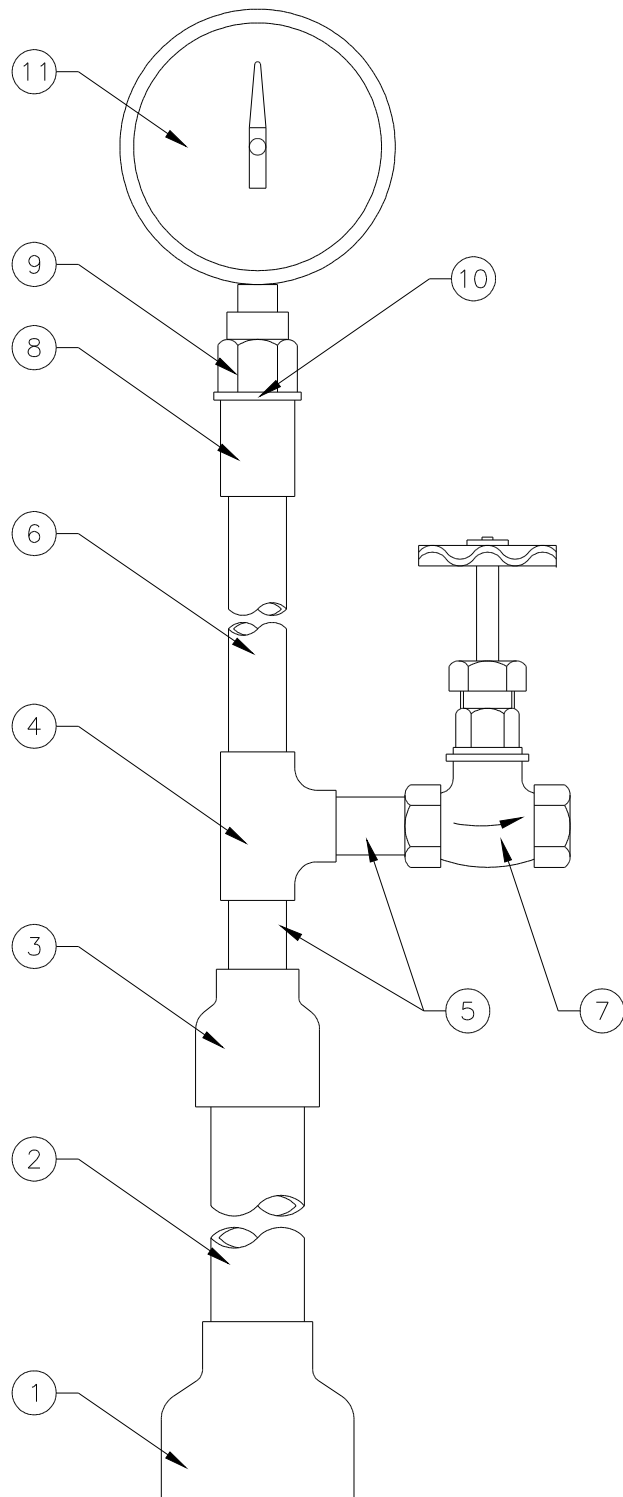


Figure 2.1

### 3. Electronic measurement

#### 3.1. General system description

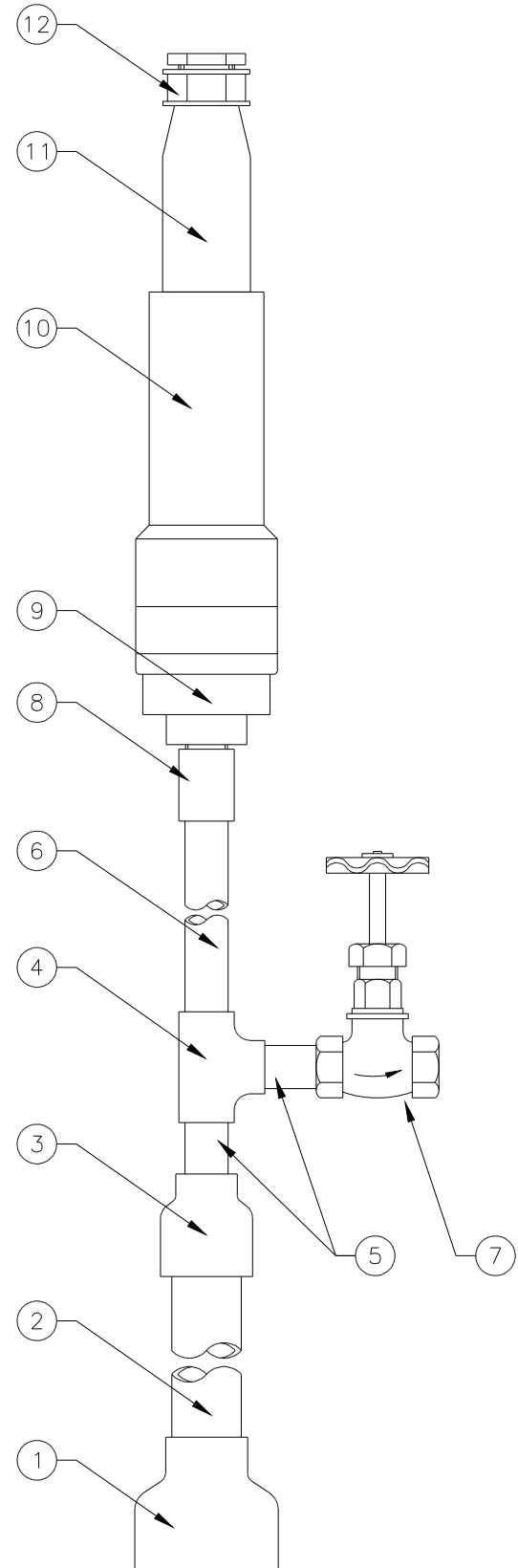
The uplift pressure meter is designed to measure uplift pressure in the foundation of the dam. The vibrating wire uplift pressure meter is fitted on the pipe coming in to the instrumentation gallery from the foundation rock. Refer to figure 3.1 and the table on this page.

The uplift pressure measuring device consists of a vibrating wire uplift pressure meter and a perforated/non-perforated pipe of 50mm to 63mm  $\phi$  with adequate strength and connecting accessories. A system of piping is installed at several stations in the dam in the first lift just above the contact between the foundation rock and the base of the dam. The pipes extend into one or more of the lower galleries in the dam. Alternatively, holes may be drilled from the gallery down to the level upto which the drain pipes have to be installed. Drain pipes extend below the dam, both on the upstream and downstream side. The other end of the pipe is brought into the gallery where it is connected to an uplift pressure meter through other accessories listed below.

Sl.	Description	Qty.
1	Reducer (2"x1")	1
2	1" GI pipe (350 mm)	1
3	Reducer (1"x 1/2")	1
4	1/2" Tee	1
5	1/2" Male nipple (50 mm)	2
6	1/2" Male nipple (150 mm)	1
7	1/2" wheel valve-10 kg/cm <sup>2</sup> (Zalota/Hawa)	1
8	1/2" socket (GI)	1
9	VW sensor	1
10	Adopter	1
11	Cable gland NG 16	1
12	Cable joint holder	1

The uplift pressure meter helps to accurately measure the uplift pressure at various locations in the foundation of the dam. Sharp increase in uplift pressure is interpreted as failure of the foundation grouting or improper drainage system. Being surface mounted, it is easy to install and requires no special orientation.

**NOTE:** The 1/2" Tee (sl. # 4) may be repositioned if it is convenient to install the sensor horizontally.



**Figure 3.1**

### 3.2. Vibrating wire pressure sensor

The heart of the electronic measurement is the TRITECH model TES-PU-20/26V vibrating wire pressure sensor. The TRITECH vibrating wire sensor is the electrical sensor of choice as its frequency output is immune to external noise & the output signal can be transmitted to long distances. It is able to tolerate wet wiring common in geotechnical applications.

#### 3.2.1. Manufacturing range

ITEM	MODEL	CAPACITY	DESCRIPTION
Uplift pressure meter		kg/cm <sup>2</sup>	The uplift pressure meter is suitable for monitoring the uplift pressure of water in the foundation of the dam and the stability of foundations of embankments in dams, tunnels and other underground works. The pressure gage is fitted on the pipe coming into the instrumentation gallery from foundation rock. A 1/2" BSP adopter is provided for the pipe connection. The adopter is installed on top of an uplift pressure meter. The height from the bottom of the uplift pipe to where the meter is mounted, should be added to the reading of the meter to get the correct pressure at the bottom of the uplift pipe.
	TES-PU-20V	3	
		5	
	TES-PU-21V	10	
		20	
	TES-PU-22V	35	
		50	
	TES-PU-23V	specify	
	TES-PU-24V		
	TES-PU-25V		
	TES-PU-26V		

#### 3.2.2. Operating principle

The vibrating wire pressure sensor basically consists of a magnetic, high tensile strength stretched wire, one end of which is anchored and the other end fixed to a diaphragm which deflects in some proportion to the applied pressure. Any change in hydrostatic pressure, deflects the diaphragm proportionally and this in turn affects the tension in the stretched wire. Thus any change in uplift pressure, directly affects the tension in the wire.

The wire is plucked by a coil magnet. Proportionate to the tension in the wire, it resonates at a frequency 'f', which can be determined as follows:

$$f = [\sigma g / \rho]^{1/2} / 2l \text{ Hz}$$

where:

$$\sigma = \text{tension of wire in kg/cm}^2$$

$$g = 980 \text{ cm/sec}^2$$

$$\rho = \text{density of wire in kg/cm}^3$$

$$l = \text{length of wire in cm}$$

The length of the wire in the uplift pressure meter is 5.5 cm. Consequently the formula can be reduced to:

$$f = 32 [\sigma]^{1/2} \text{ Hz}$$

The resonant frequency with which the wire vibrates, induces an alternating current in the coil magnet. This is read by the read out unit.

Summarizing, any variation in hydraulic pressure causes the diaphragm to deflect. This changes the tension in the wire thus affecting the frequency of vibration. Uplift pressure is proportional to the square of the frequency and the read out unit is able to display this directly in engineering units.

### 3.2.3. Specifications

Type:	Vibrating wire
Model:	TES-PU-20/21/22/23/24/25/26V
Range (kg/cm <sup>2</sup> ):	3, 5, 10, 20, 35, 50, specify
Accuracy:	± 1 % fs; (non linearity + hysteresis + repeatability)
Temperature limit	
Operational:	-20 to 70°C
Compensated:	0 to 55°C
Over range limit:	150 % of range
Over range effect:	± 0.1% fs upto 150%
Enclosure:	Stainless steel, IP-68 enclosure
Read out:	Portable vibrating wire indicator
Thermistor:	YSI 44005 or equivalent (3,000 Ohm at 25°C)

### 3.2.4. Description

The uplift pressure meter is manufactured in various capacities. Each transducer is provided with a thermistor for making correction due to temperature induced frequency changes and the correlating data for this is provided in the test report (see § 3.5). Thermistor may also be used to monitor the temperature.

A tripolar plasma surge arrestor inside the transducer housing protects the vibrating wire pluck and read coils from electrical transients such as may be induced by direct or indirect lightning strikes.

#### 3.2.4.1. Stainless steel body

The vibrating wire and coil magnet assembly is enclosed in a stainless steel body which is electron beam welded to the diaphragm. This results in a vacuum of 1/1000 torr inside the sensor resulting in it becoming immune to the effect of any ingress of water. As the uplift pressure meter is of stainless steel construction, it is not affected by normal chemical corrosion at locations in which it is used. Once properly installed, it is almost maintenance free.

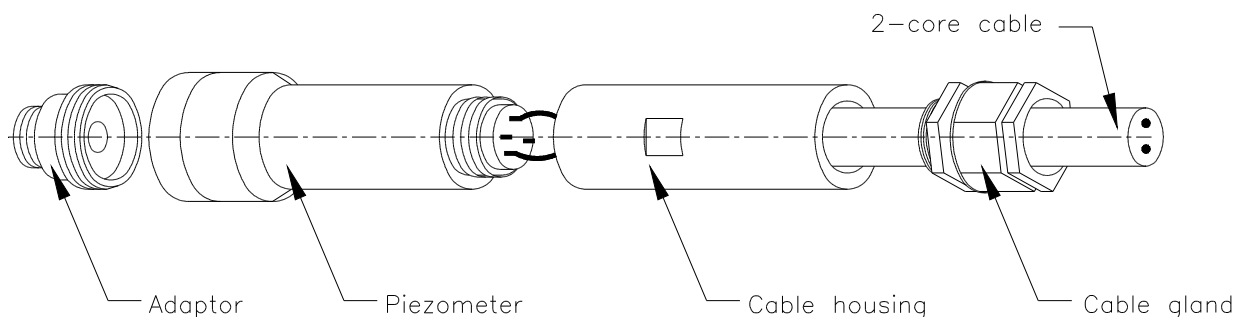


Figure 3.2

#### 3.2.4.2. Adopter

A 1/2" BSP adopter is provided for the pipe connection. The water oozing through internal pores or seams in rock formations of dam foundations, mass concrete of structures, foundation soil of structures, reclaimed land soil etc. percolates upward through the pipe to actuate the diaphragm.

### 3.2.4.3. Cable connection:

The leads from the coil magnet are terminated on a glass to metal seal which is integrally electron beam welded to the stainless steel body of the uplift pressure meter. The two pins marked red and black are connected to the coil magnet. The other two pins are free and may be used in case a thermister is required for measurement of temperature. A cable joint housing and cable gland is provided for the cable connection. For cable jointing, refer to Users Manual 6002.11/Rev 03/98.

### 3.3. **Taking readings with the model TES-DI-51V vibrating wire indicator**

The model TES-DI-51V vibrating wire indicator is a microprocessor based read-out unit for use with TRITECH's range of vibrating wire transducers. It can display the measured frequency in terms of time period, frequency, frequency squared or the value of the measured parameter directly in proper engineering units.

The TES-DI-51V indicator can store calibration coefficients of up to 100 vibrating wire transducers so that the value of the measured parameter from these transducers can be shown directly in proper engineering units.

The indicator has an internal non-volatile memory with sufficient capacity to store about 720 readings from any of the 100 programmed transducers in any combination. You can store either 720 readings from any one transducer or 7 sets of readings from all 100 transducers. Each reading is stamped with the date and time the measurement was taken.

The calibration coefficients are given in the individual **TEST CERTIFICATE** provided with each transducer. Refer to the model TES-DI-51V instruction manual WI-6002.26 for entering the transducer calibration coefficients. The gage factor and the factory zero reading (frequency) can directly be taken from the test certificate for setting up transducer coefficients in the read-out unit.

The test certificate also gives the factory zero reading in frequency<sup>2</sup> for use with transducers provided with polynomial linearity correction. For polynomial linearity correction pressure is calculated by the following equation:

$$P = A(R1)^2 + B(R1) + C \quad (\text{kg/cm}^2)$$

P = pressure in engineering unit

R1 = current reading in digits during observation

A, B, C = polynomial constants

The polynomial constants are stored in the model TES-DI-51V memory to give linearity corrected data of the parameter in engineering units. For more details refer to the instruction manual WI-6002.26 of the model TES-DI-51V

For transducers with a built in interchangeable thermistor, the model TES-DI-51V can also display and record the temperature of the transducer directly in degree Centigrade. All TRITECH vibrating wire sensors, excepting the temperature sensors have a thermistor incorporated in them for temperature measurement.

The stored readings can either be uploaded to a host computer using the serial interface or can be printed out on any text printer equipped with a RS-232C serial communications interface. The setup information (calibration coefficients) for all the channels can also be printed out for verification.

An internal 6V rechargeable sealed maintenance free battery is used to provide power to the indicator. A fully charged new battery provides nearly 60 hours of operation on a single charge. A separate battery charger is provided with the TES-DI-51V indicator to charge the internal battery from 230 V AC mains.



The TES-DI- 51V indicator is housed in a splash proof resin molded enclosure with weatherproof connectors for making connections to the vibrating wire transducer and the battery charger.

## 3.4. Sample test certificate

**TRITECH INSTRUMENTS PTE LTD**

2, Kaki Bukit, Place Tritech Building #06-00 Singapore 416180  
 Tel: 68482567 Fax: 68482568 Email: [instruments@tritech.com.sg](mailto:instruments@tritech.com.sg)

**TEST CERTIFICATE**

DWT Traceable to standard no.: NPL 1285/09/138/93

<b>Instrument</b>	Uplift pressure meter	<b>Date</b>	January 1, 1998
<b>S. no.</b>	1722	<b>Temperature</b>	14°C
<b>Capacity</b>	5.0 kg/cm <sup>2</sup>	<b>Atm. Pressure</b>	75.5 cm Hg

Input Pressure kg/cm <sup>2</sup>	Observed value		Average x 10 <sup>3</sup>	End point fit x 10 <sup>3</sup>	Deviation
	UP I x 10 <sup>3</sup>	UP II x 10 <sup>3</sup>			
0.0	6925	6925	6925	6925	0
1.0	6625	6625	6625	6630	5
2.0	6335	6335	6335	6336	0
3.0	6037	6037	6037	6041	4
4.0	5743	5743	5743	5746	4
5.0	5451	5451	5451	5451	0

**Non linearity:** 0.34 % fs  
**Gage factor:** 2.375E-02 kg/cm<sup>2</sup> / f<sup>2</sup>  
**Temperature zero shift (C)** + 0.023 %/°C fsd

**Readings at the time of shipment**

<b>Date</b>	Mar 7, 1998
<b>Factory zero reading</b>	f f <sup>2</sup>
	2630 Hz 6917 x 10 <sup>3</sup> Hz <sup>2</sup>
<b>Temperature</b>	32°C
<b>Thermistor</b>	2190 Ohm
<b>Atm. Pressure</b>	74.1cm Hg
<b>Coil resistance</b>	130 Ohm

(The user is advised to establish zero conditions in the field by recording the reading at a known temperature and barometric pressure)

**Pin configuration/wiring code:****Red & black:** signal**Green & white:** thermistor**Checked by****Tested by**

### 3.5. Thermistor - temperature resistance correlation

**Thermistor type:** Dale 1C3001-B3

#### Temperature resistance equation

$$T = 1/[A + B(\text{Ln}R) + C(\text{Ln}R)^3] - 273.2 \text{ } ^\circ\text{C}$$

T = temperature in  $^\circ\text{C}$

LnR = Natural log of thermistor resistance

A =  $1.4051 \times 10^{-3}$

B =  $2.369 \times 10^{-4}$

C =  $1.019 \times 10^{-7}$

Ohm	Temp. $^\circ\text{C}$	Ohm	Temp. $^\circ\text{C}$	Ohm	Temp. $^\circ\text{C}$
201.1k	-50	16.60K	-10	2417	+30
187.3K	-49	15.72K	-9	2317	31
174.5K	-48	14.90K	-8	2221	32
162.7K	-47	14.12K	-7	2130	33
151.7K	-46	13.39k	-6	2042	34
141.6K	-45	12.70K	-5	1959	35
132.2K	-44	12.05K	-4	1880	36
123.5K	-43	11.44K	-3	1805	37
115.4K	-42	10.86K	-2	1733	38
107.9K	-41	10.31K	-1	1664	39
101.0K	-40	9796	0	1598	40
94.48K	-39	9310	+1	1535	41
88.46K	-38	8851	2	1475	42
82.87K	-37	8417	3	1418	43
77.66K	-36	8006	4	1363	44
72.81K	-35	7618	5	1310	45
68.30K	-34	7252	6	1260	46
64.09K	-33	6905	7	1212	47
60.17K	-32	6576	8	1167	48
56.51K	-31	6265	9	1123	49
53.10K	-30	5971	10	1081	50
49.91K	-29	5692	11	1040	51
46.94K	-28	5427	12	1002	52
44.16K	-27	5177	13	965.0	53
41.56k	-26	4939	14	929.6	54
39.13K	-25	4714	15	895.8	55
36.86K	-24	4500	16	863.3	56
34.73K	-23	4297	17	832.2	57
32.74K	-22	4105	18	802.3	58
30.87K	-21	3922	19	773.7	59
29.13K	-20	3748	20	746.3	60
27.49K	-19	3583	21	719.9	61
25.95K	-18	3426	22	694.7	62
24.51K	-17	3277	23	670.4	63
23.16K	-16	3135	24	647.1	64
21.89K	-15	3000	25	624.7	65
20.70K	-14	2872	26	603.3	66
19.58K	-13	2750	27	582.6	67
18.52K	-12	2633	28	562.8	68
17.53K	-11	2523	29	525.4	70

#### 4. Tools & accessories required for installation of vw system

The following tools and accessories are required for proper cable jointing and installation of the vibrating wire uplift pressure meter (also refer users manual on cable jointing - 6002.11/Rev02/96):

- 4.1 Soldering iron 25 watt (Solder on 5102 - Vimla Engineering, Bombay)
- 4.2 Rosin 63/37 solder wire RF-3C, 30 swg (Arrow, Delhi)
- 4.3 Thread sealant (Loctite 577).
- 4.4 Cable jointing compound (MS 853 and hardener MSH 283 - Mahendra Engineering & Chemical Products Ltd.)
- 4.5 Acetone (commercial).
- 4.6 Spanner 23/25 and 30/32 (Taparia)
- 4.7 Cable joint housing (refer figure 3.2)
- 4.8 Hacksaw with 300 mm blade
- 4.9 Cable Cutter
- 4.10 Surgical blade with holder
- 4.11 Wire Stripper (Taparia).
- 4.12 Pliers 160 mm (Taparia).
- 4.13 Locking nut spanner
- 4.14 Pouring funnel.
- 4.15 Stainless steel rod 6 mm  $\phi$  150 mm length
- 4.16 Spatula
- 4.17 Rotary tin cutter
- 4.18 Fixture for jointing upto six uplift pressure meters (refer figure 4.1)
- 4.19 Tooth brush
- 4.20 Waste paper basket
- 4.21 Cloth for cleaning (lintless)
- 4.22 Wooden cable spacer
- 4.23 Wooden cable rake
- 4.24 Cotton cloth bag (200 mm x 250 mm) with integral tying string to contain the piezometer
- 4.25 Coarse brass wire mesh and tie wire
- 4.26 Digital multimeter
- 4.27 Portable pressure indicator (TES-DI-51V)
- 4.28 Pipe wrench (30 cm)

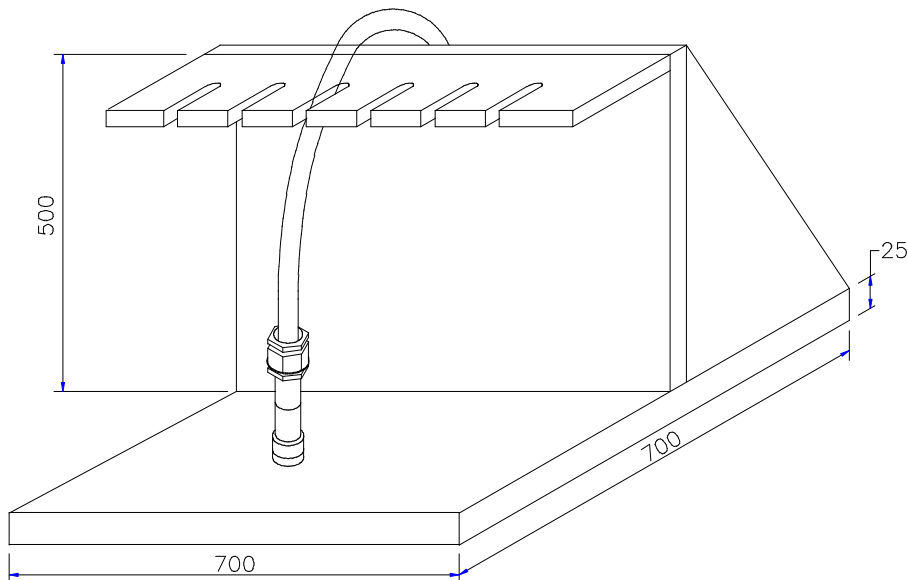


Figure 4.1

## 5. Installation of vibrating wire system

The typical layout for the uplift pressure pipe with its connecting fixtures and vibrating wire uplift pressure meter is illustrated in figures 1.1 and figure 3.1 respectively.

A system of piping is installed at several stations in the dam in the first lift just above the contact between the foundation rock and the base of the dam. Drill holes with installed drainpipes extend below the dam, both upstream and downstream of the grout curtain. The pipes extend into one or more of the lower galleries in the dam.

The pipes are fitted with a tee-section and a vibrating wire uplift pressure meter for observing water pressure. A shutoff valve is included on one leg of the tee. Although readings may be taken at any time, it is common practice to leave the shut-off valve open and to close the system the day before readings are to be taken. Then after readings are taken, the valve is reopened. Therefore in addition to the existing uplift pressures, readings taken in this manner indicate the uplift pressure that may be achieved if one or more systems of drains should become inoperative through blockage. The shut-off valve may also be kept closed and opened only when the uplift pressure builds up.

### 5.1. Preparation of the sensor before installation

5.1.1 Remove the cable joint housing from the sensor. This gives access to the four pin terminal. Two of the terminals are marked with red and black colors. These are internally wired to the coil of the magnet assembly inside the sensor. The other two terminals are utilized in case a thermistor is used for temperature measurement. Clean the terminals with a tooth brush.

**NOTE:** Do not use any acetone for cleaning the terminals as it may damage the glass to metal seal. Acetone should be used to clean the other portions of the sensor.

5.1.2 Check the working of the sensor as follows:

- The coil resistance measured by a digital multimeter between the red and black pins, should lie between 120-140 Ohm. In case thermistor is used, determine resistance at the room temperature from thermistor temperature resistance chart in § 3.5. This resistance should be equal to that between pins marked green and white. For example, in case the room temperature is 25°C, this resistance would be 3,000 Ohm.
- The resistance between any lead and the protective armour should be > 500 m Ohm.
- Connect the sensor to the TRITECH model TES-DI-51V portable readout unit and switch it on. The display will show something like:

Freq: 2629.8 Hz

where the actual figure will vary depending on the transducer connected to the indicator.

For the uplift pressure meter, the initial reading (offset) in frequency should lie between 2,250 - 2,650 Hz. This initial reading on the portable readout unit should be stable.

- Check whether sensor is responding to changes in pressure. A crude but a simple and very effective method of checking whether the sensor is responding to changes in pressure is as follows:
  - Connect sensor to the portable readout unit and remove ½" BSP adapter from the meter.
  - Press diaphragm with thumb and verify that frequency reading on the indicator decreases.
  - This change in reading ensures that the deformation produced by the pressure of the thumb on the diaphragm is transmitted to the vibrating wire sensing element.
- Shift the read-out unit display to the frequency<sup>2</sup> mode. Each sensor is provided with a test certificate giving relationship between applied pressure and output. The zero reading in frequency<sup>2</sup> given in the test certificate should not differ from the current zero reading by more than 50 (x 10<sup>3</sup>) divi-

sions after due regard to corrections made for difference in temperature, barometric pressure, height above sea level and actual cell position (whether standing up or lying down).

For example in test certificate (see § 3.4), the zero reading in frequency<sup>2</sup> at the time of dispatch is 6917 ( $\times 10^3 \text{ Hz}^2$ ). In case the temperature and the barometric pressure is the same at the place and time of installation and the sensor is placed lying down, the reading in frequency<sup>2</sup> should be between 6867 and 6967 ( $\times 10^3 \text{ Hz}^2$ ).

- 5.1.3 Connect the required length of cable to the sensor as suggested in the operating manual on cable jointing - 6002.11/Rev 03/98.

**WARNING!** Take precautions while handling the epoxy system so that skin contact is minimal. The epoxy components should never come in contact with eyes or other sensitive body parts. Wash hands very thoroughly with soap immediately after work is over.

- 5.1.4 Check the working of the sensor again following the procedure described in § 5.1.2.

**NOTE:** Remember to add the cable resistance when checking the resistance between the leads after the cable jointing. For the model ERC-10/11 cable, the resistance is 26 Ohm/km and for the model ERC-12-15 cable, the resistance is 84 Ohm/km. ( $\times 2$  for both leads). In case any other cable is used, make the necessary addition in the resistance value.

- 5.1.5 Record the initial readings including offset, barometric pressure and temperature in the field book in the format provided in § 6.

- 5.1.6 Cable should be carefully marked. Cable should be marked with permanent markers every 5m by the use of stainless steel tags tied by stainless steel wire stamped with appropriate concrete pressure cell numbers. Alternatively, plastic tabs are also available. Temporary identification is possible by writing serial number of the sensor, its code number and the location at which it is installed, on a strip of paper, placing the strip on the cable and covering it with a transparent plastic cello tape. Permanent identification is necessary for proper connections in the junction box and to insure correct splicing if cable is cut or broken.

**CAUTION:** The single most important factor leading to loss of worthwhile data from sensors is losing track of identification of the cable ends. Proper identification and marking of the cables is generally taken most casually. Care should also be taken to put an identification tag at the point where the cable comes out of the structure such that cable identity is not lost if the cable gets accidentally cut.

## 5.2. Installing the uplift pressure meter

The installation procedure comprises of the following steps:

- 5.2.1 A system of piping is installed at several stations in the dam with the top of any uplift pressure measuring pipe ending in the gallery.

- 5.2.2 Remove the plug on the pipe coming into the gallery from foundation and check the threads.

- 5.2.3 Ensure before starting the installation that the pipes are not choked. If so clean them.

- 5.2.4 Make the connections as illustrated in figure 3.1. Use Loctite or the teflon tape to make them water tight.

- 5.2.5 Connect the leads of the jelly filled cable to the respective connector pins in the junction box.

**NOTE:** For transmitting the signals to the observation room from the junction box, 10 core (5 pairs) or 20 cores (10 pairs) jelly filled cable, standardized by TRITECH may be used.

## TABLE OF CONTENTS

<b>1. INTRODUCTION</b> .....	<b>1-1</b>
1.1. TYPICAL INSTALLATION IN A CONCRETE DAM.....	1-1
1.2. UPLIFT PRESSURE MEASUREMENT .....	1-1
1.2.1. <i>Mechanical method</i> .....	1-1
1.2.2. <i>Electronic method</i> .....	1-2
1.3. CONVENTIONS USED IN THIS MANUAL .....	1-2
1.4. HOW TO USE THIS MANUAL .....	1-2
<b>2. MECHANICAL MEASUREMENT</b> .....	<b>2-1</b>
2.1. TOOLS & ACCESSORIES.....	2-1
<b>3. ELECTRONIC MEASUREMENT</b> .....	<b>3-1</b>
3.1. GENERAL SYSTEM DESCRIPTION.....	3-1
3.2. VIBRATING WIRE PRESSURE SENSOR .....	3-2
3.2.1. <i>Manufacturing range</i> .....	3-2
3.2.2. <i>Operating principle</i> .....	3-2
3.2.3. <i>Specifications</i> .....	3-3
3.2.4. <i>Description</i> .....	3-3
3.3. TAKING READINGS WITH THE MODEL TES-DI-51V VIBRATING WIRE INDICATOR .....	3-4
3.4. SAMPLE TEST CERTIFICATE.....	3-6
3.5. THERMISTOR - TEMPERATURE RESISTANCE CORRELATION .....	3-7
<b>4. TOOLS &amp; ACCESSORIES REQUIRED FOR INSTALLATION OF VW SYSTEM</b> .....	<b>4-1</b>
<b>5. INSTALLATION OF VIBRATING WIRE SYSTEM</b> .....	<b>5-1</b>
5.1. PREPARATION OF THE SENSOR BEFORE INSTALLATION.....	5-1
5.2. INSTALLING THE UPLIFT PRESSURE METER .....	5-2