INSTRUCTION MANUAL

VIBRATING WIRE DISPLACEMENT TRANSDUCERS

JM Series

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1 GENERAL DESCRIPTION

The JM-Series jointmeter is used to measure movements such as:

- the opening or closing of cracks in dams, bridges, etc
- the amount of opening of contraction joints in concrete dams, or interfaces between rock and concrete

The jointmeter, depending on the model, can be either embedded or surface mounted, or integrated into a borehole extensometer.

The JM assembly is comprised of the following elements:

- a vibrating wire displacement transducer
- a telescopic protective housing
- 2 anchors (JM-S)
- a protective casing for embedment
- a thermistor
- an electrical cable.

A vibrating wire sensing element is linked to a spring and a connecting rod at the other end for displacement measurement. As the connecting rod is pulled out from the gage body, the spring is elongated causing an increase in tension which is sensed by the vibrating wire element. This change is measured with the readout unit.

2 INSTALLATION

2.1 PRELIMINARY TESTS

Upon receiving the jointmeter, the general condition of the jointmeter should be checked and a reading taken (including the thermistor), with the shaft extended approximately 20% of the range of the instrument. Refer to the calibration certificate supplied with each sensor. A stable reading should be seen if the shaft is held stationary. Stable readings can be difficult to obtain when the gage is not attached to the structure to be monitored.

To check the reading, follow the instructions given in the ‘’Reading procedure’’ Section of this manual.

WARNING : DO NOT ROTATE THE SHAFT OF THE DISPLACEMENT TRANSDUCERS. THIS CAN CAUSE IRREPARABLE DAMAGE TO THE INSTRUMENT. WITNESS PIN IS ON THE SHAFT AND SLOT ON THE BODY TO SERVE AS A GUIDE FOR ALIGNMENT.

2.2 DISPLACEMENT TRANSDUCER INSTALLATION

2.2.1 JM-S – CRACKMETER

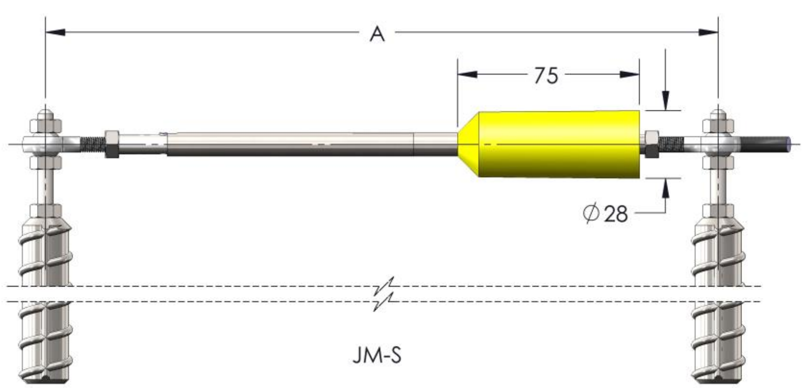
The threaded rods at each end of the JM can be connected to the rebar anchors for injection or to expandable anchors. The threaded rods can even be used directly to fix the JM to a metal structure in which two holes have previously been made.

Before installing the crackmeter, it is important to determine the starting point of the original measure, either in the center of the span or primarily in compression or tension. The crackmeter itself can serve as a template setup. Read the sensor with a reading station to determine the starting point and thus locate the holes in the structure. Refer to the calibration certificate.

In concrete structures or rocks, rebars are grouted into the material and the rod ends are then screwed into the rebars. Drill (2) 50mm deep holes as a minimum of the proper diameter at the proper location for the rebars. Grout the pieces of rebar (keeping the threaded end uppermost) into the concrete with quick setting cement or epoxy. Attach the gage onto the rebars.

For installation on a metal structure, drill holes (¼-28-UNF / 6.35 mm) 25 mm deep, and tapping required 20 mm. Detach one of the JM threaded rods and screw it on the structure to the desired depth using the locknuts. Adjust the tilt and height you want for the crackmeter, then repeat for the other end of JM.

After installing the anchors, a final adjustment of the position of the sensor is possible. To do this: attach to one anchor the end of the sensor fitted with the coil, then loosen lock nut located on the other sensor's end (**while holding the sensor rod to prevent it from rotating**). Unscrew or screw the thread universal joint to change its position relative to the sensor. Tighten the lock nut and secure the sensor to the other anchor.

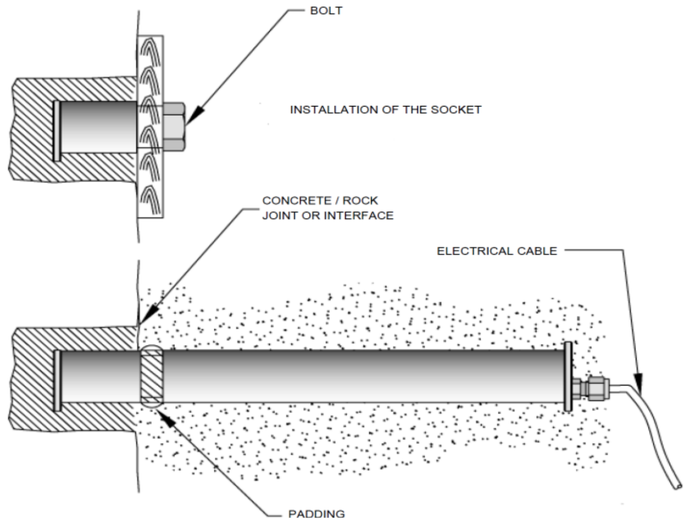


(Dimensions are in mm)

2.2.2 JM-E – EMBEDMENT JOINTMETER

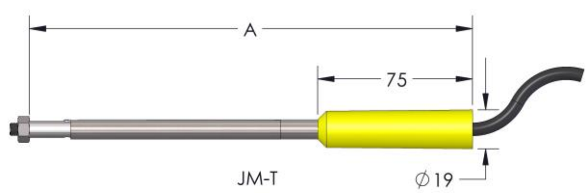
The JM-E embedment jointmeter consists of 2 parts: the socket and the gage by itself. The socket is installed in the first lift of concrete. The finished face of the socket must be accessible for installing the gage on the second lift. There is a protective plug with a 5/16" – 18 threads.

After the forms of the first lift are dismantled, the socket is exposed. The plug is then removed and grease is put on the thread of the socket to ease installation of the gage. Place thread-locking compound to secure the gage to the socket and screw the gage into the socket. Secure the body of the gage and cable for the second lift of concrete. Another set of readings should be taken before concrete is set. Please adjust the gage allowing compression. Avoid pouring concrete directly onto the instrument or cable. Do not use mechanical vibrators in the immediate area of the jointmeter or cable. If necessary, hand place and/or puddle the concrete around the jointmeter. Take a reading before and after pouring of the concrete.



2.2.3 JM-T – DISPLACEMENT TRANSDUCER

The JM-T displacement transducer can be configured to be installed in borehole extensometers, in which case it is called JM-T.

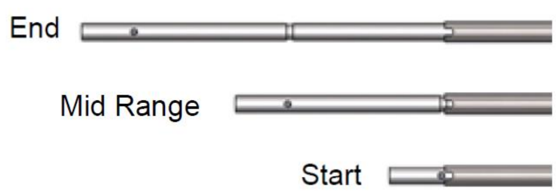


(Dimensions are in mm)

2.2.4 DIMENSIONS

Dimensions to take into considerations when installing any JM are given in table below:

Model		Position	Extent of measurement in mm						
			25	50	100	150	200	250	300
JM-T (without joint)	Length (A) (mm)	Start	214.5	270	388	514	634	746	864
		Mid range	227	295	438	589	734	871	1014
		End	239.5	320	488	664	834	996	1164
JM-S (with joint)	Length (A) (mm)	Start	277	332	450	576	697	808	926
		Mid range	289.5	357	500	651	797	933	1076
		End	302	382	550	726	897	1058	1226
JM-E	Length (A) (mm)	Start	383	432	602	772	-	-	-
		Mid range	-	-	-	-	-	-	-
		End	-	-	-	-	-	-	-



2.3 CABLES AND SPLICES

At all times during the installation, any cable must be protected against mechanical damages and against lightening when exposed outdoor. A large grounded metal cage placed over the cable bundle combined with direct grounding of all leads and shields are an effective way to prevent lightening damage to the instruments. Cable splices are to be avoided. If necessary, use only the manufacturer's approved standard or high-pressure splice kit. Splicing instructions are included with the splice kit.

3 READING PROCEDURE

Readings and temperature are taken either directly to the end of the cable, or by means of a switch panel, using the reading station MB-3TL.

The reading station comes with a cord that has 4 alligator clips at one end. Connect the alligator clips to the gauge according to the following table.

Cables IRC-41A and IRC-390	Color of the clip	Sensor cable
Coil (+)	Red	Red
Coil (-)	Black	Black
Temperature (-)	White	White
Temperature (+)	Green	Green
Armoring (drain)	Non	Drain wire

Wiring code for electrical cables

The vibrating strings and thermistors are normally insensitive to polarity changes, but if difficulties are encountered when reading the gauge, check if the polarity is consistent with the legend of connection.

TO OBTAIN A READING, SET READOUT TO ''HZ^2 + THERMISTOR'' WHEN USING A MB-3TL AND TO POSITION C OR B (FREQUENCY SWEEP). PLEASE REFER TO THE INSTRUCTION MANUAL OF THE MB-3TL FOR MORE DETAILS ABOUT READING PROCEDURE

The MB-3TL stimulates the sensor at intervals of two seconds and displays the sensor reading and the temperature (in degrees Celsius). For measuring the displacements, apply the following equation based on the linear units displayed on the MB-3TL:

$$D = A \cdot L^2 + B \cdot L + C$$

where D = displacement in millimetres

A, B, C = calibration factors

L = reading in LINEAR units (LU)

Example:

With L = 6 000 LU

A = -1.0839E-08 mm/LU^2

B = 4.6608E-03 mm/LU

C = -1.4810E+01 mm

We get: D = 12.76 mm

Note that increasing readings in D units indicate increasing displacement. To get the relative displacement, just subtract the initial reading to the current reading.

$$D_r = D - D_0$$

where D_r = relative displacement in millimetres

D = current reading in millimetres

D_0 = initial reading in millimetres

If the frequency is measured, convert it into LINEAR units using the following equation:

$$\mathbf{L = k\ (F^2 / 1000)}$$

where L = reading in LU

k = gage constant for displacement transducer = 1.00

F = frequency in Hz

Example:

With F = 1 739 Hz,

We get: L = 1.0 (1739^2 /1000) = 3 024.1 LU

CALIBRATION DATA SHEET
VIBRATING WIRE DISPLACEMENT TRANSDUCER

Model: JM-T
Serial number: 057C12909
Range: 200 mm
Thermistor type: 3 kohms
Cable model: IRC-41A
Cable length: 10 ft

Color code: red & black (coil) green & white (thermistor)

Displacement mm	Reading LU	F. S. Error %
50,00	3579,9	0,01
100,00	5209,7	-0,02
150,00	6822,2	0,02
200,00	8427,4	-0,01
	Max. error (%):	0,02

A: 7,2933E-08 mm/LU^2
B: 3,0074E-02 mm/LU
C: -5,8612E+01 mm

Displacement is calculated with the following equation:

$$D = AL^2 + BL + C$$

D : Displacement in mm
A,B,C: Calibration factors
L : Current reading in linear units (LU)

Temperature Effect:

Each JM is provided with a thermistor.

Temperature changes affect the readings of a sensor. Taking temperature effects into consideration while monitoring a structure is critical for data interpretation. It is important to note that the temperature effect also applies to the structure on which the sensor is fixed to. It is therefore recommended to install the sensor in advance to gather temperature effect data on the structure-sensor system without other influences. It is afterwards easier to determine temperature's influence on the structure-sensor system.

If the objective is temperature effect monitoring on the structure, then the sensor temperature effect needs to be removed. It is possible to use the temperature compensation formula (to obtain an estimation of temperature effect) with the following considerations:

- The temperature compensation does not take into account the temperature effect on the structure. This formula was developed by placing a sensor in an environmental chamber.
- The coefficient was determined at the sensor's mid-range.

The formula for the temperature's effect on the sensor regardless of structure:

$$D_r = (D - D_0) - K(T - T_0)$$

where

D_r = relative displacement in millimetres

D = actual reading in millimetres

D_0 = initial reading in millimetres

K = thermal coefficient of sensor in mm/°C

T = actual temperature in degree Celsius

T_0 = initial temperature in degree Celsius

Range of the JM (mm)	K (mm/°C)	(%FS/°C)
25	-0.00825	-0.033
50	-0.016	-0.032
100	-0.026	-0.026
200	-0.044	-0.022
300	-0.057	-0.019

4 TROUBLESHOOTING

Maintenance and troubleshooting of vibrating wire transducers are required. Periodically check cable connections and terminals. The transducers themselves are sealed and cannot be opened for inspection.

4.1 UNSTABLE READING

- Check if the same troubles occur with other instruments. If so, compare cable routes or check the readout unit.

- Is the shield drain wire correctly connected to the readout unit?

- Isolate the readout unit from the ground by placing it on a piece of wood or similar non-conductive material.

- Check the battery of the readout unit.

- Check for nearby sources of electrical noise such as motors, generators, electrical cables or antennas. If noise sources are nearby, shield the cable of move it.

- If a data logger is used to take the readings, are the swept frequency excitation settings well adjusted? Use the calibration sheet and the frequency - LU for the frequency range

- The sensor may have gone outside its range. See previous records.

- The sensor body may be shorted to the shield. Check the resistance between the shield drain and the sensor housing.

- Check the integrity of the cable.

- The sensor may have been damaged by shocks.

4.2 NO READING

- Check the battery of the readout unit.

- Check if the same troubles occur with other instruments. If so, the readout unit may be defective. Please contact Roctest.

- If a data logger is used to take the readings, are the swept frequency excitation settings well adjusted? Use the calibration sheet and the frequency - LU for the frequency range. Make sure the reading doesn't exceed the range of the sensor.

- The sensor may have gone outside its range. See previous records.

- Check the coil resistance. Nominal coil resistance is 190Ω ± 10Ω, plus cable resistance

(22 gage copper = approximately 0.07Ω/m).

- If the resistance is high or infinite, a cut cable must be suspected.
- If the resistance is low or near zero, a short must be suspected.
- If resistances are within the nominal range and no reading is obtained, the transducer is suspect and the factory should be consulted.

- Cuts or shorts are located, the cable may be spliced in accordance with Roctest recommended procedures.

- The sensor may have been damaged by shocks or water may have penetrated inside its body. There is no remedial action.

If troubles occur when reading the temperature, this is likely due to a cable cut or short because of the technology used (simple thermistor). Check the cable and splice it in accordance with recommended procedures.

5 CONVERSION TABLE (TEMPERATURE)

Temp. °C	Types of resistances			Temp. °C	Types of resistances		
	2K	3K	10K		2K	3K	10K
-50		201100	670500	1	6208	9310	31030
-49		187300	670500	2	5900	8851	29500
-48		174500	624300	3	5612	8417	28060
-47		162700	581700	4	5336	8006	26690
-46		151700	542200	5	5080	7618	25400
-45		141600	440800	6	4836	7252	24170
-44		132200	472000	7	4604	6905	23020
-43		123500	411700	8	4384	6576	21920
-42		115400	384800	9	4176	6265	20880
-41		107900	359800	10	3980	5971	19900
-40	67320	101000	336500	11	3794	5692	18970
-39	63000	94480	315000	12	3618	5427	18090
-38	59000	88460	294900	13	3452	5177	17260
-37	55280	82870	276200	14	3292	4939	16470
-36	51800	77660	258900	15	3142	4714	15710
-35	48560	72810	242700	16	3000	4500	15000
-34	45560	68300	227700	17	2864	4297	14330
-33	42760	64090	213600	18	2736	4105	13680
-32	40120	60170	200600	19	2614	3922	13070
-31	37680	56510	188400	20	2498	3748	12500
-30	35400	53100	177000	21	2388	3583	11940
-29	33280	49910	166400	22	2284	3426	11420
-28	31300	46940	156500	23	2184	3277	10920
-27	29440	44160	147200	24	2090	3135	10450
-26	27700	41560	138500	25	2000	3000	10000
-25	26080	39130	130500	26	1915	2872	9574
-24	24580	36860	122900	27	1833	2750	9165
-23	23160	34730	115800	28	1756	2633	8779
-22	21820	32740	109100	29	1682	2523	8410
-21	20580	30870	102900	30	1612	2417	8060
-20	19424	29130	97110	31	1544	2317	7722
-19	18332	27490	91650	32	1481	2221	7402
-18	17308	25950	86500	33	1420	2130	7100
-17	16344	24510	81710	34	1362	2042	6807
-16	15444	23160	77220	35	1306	1959	6532
-15	14596	21890	72960	36	1254	1880	6270
-14	13800	20700	69010	37	1203	1805	6017
-13	13052	19580	65280	38	1155	1733	5777
-12	12352	18520	61770	39	1109	1664	5546
-11	11692	17530	58440	40	1065	1598	5329
-10	11068	16600	55330	41	1024	1535	5116
-9	10484	15720	52440	42	984	1475	4916
-8	9932	14900	49690	43	945	1418	4725
-7	9416	14120	47070	44	909	1363	4543
-6	8928	13390	44630	45	874	1310	4369
-5	8468	12700	42340	46	840	1260	4202
-4	8032	12050	40170	47	808	1212	4042
-3	7624	11440	38130	48	778	1167	3889
-2	7240	10860	36190	49	748	1123	3743
-1	6876	10310	34370	50	720	1081	3603
0	6532	9796	32660	51	694	1040	3469

Temp. °C	Types de résistances			Temp. °C	Types de résistances		
	2K	3K	10K		2K	3K	10K
52	668	1002	3340	102	128	192.2	640.3
53	643	965.0	3217	103	125	186.8	622.1
54	620	929.6	3099	104	121	181.5	604.4
55	597	895.8	2986	105	118	176.4	587.5
56	576	863.3	2878	106	114	171.4	571.0
57	555	832.2	2774	107	111	166.7	555.1
58	535	802.3	2675	108	108	162.0	540.0
59	516	773.7	2580	109	105	157.6	524.9
60	498	746.3	2488	110	102	153.2	510.7
61	480	719.9	2400	111	99	149.0	496.4
62	463	694.7	2316	112	97	145.0	483.1
63	447	670.4	2235	113	94	141.1	469.8
64	432	647.1	2157	114	91	137.2	457.4
65	416	624.7	2083	115	89	133.6	444.9
66	402	603.3	2011	116	87	130.0	433.4
67	388	582.6	1942	117	84	126.5	421.8
68	375	562.8	1876	118	82	123.2	410.7
69	363	543.7	1813	119	80	119.9	399.6
70	350	525.4	1752	120	78	116.8	389.4
71	339	507.8	1693	121	76	113.8	379.2
72	327	490.9	1636	122	74	110.8	369.4
73	316	474.7	1582	123	72	107.9	360.1
74	306	459.0	1530	124	70	105.2	350.8
75	296	444.0	1479	125	68	102.5	341.9
76	286	429.5	1431	126	67	99.9	333.0
77	277	415.6	1385	127	65	97.3	324.6
78	268	402.2	1340	128	63	94.9	316.6
79	260	389.3	1297	129	62	92.5	308.6
80	251	376.9	1255	130	60	90.2	301.1
81	243	364.9	1215	131	59	87.9	293.5
82	236	353.4	1177	132	57	85.7	286.0
83	228	342.2	1140	133	56	83.6	279.3
84	221	331.5	1104	134	54	81.6	272.2
85	214	321.2	1070	135	53	79.6	265.5
86	208	311.3	1036	136	52	77.6	259.3
87	201	301.7	1004	137	51	75.8	253.1
88	195	292.4	973.8	138	49	73.9	246.9
89	189	283.5	944.1	139	48	72.2	241.1
90	183	274.9	915.2	140	47	70.4	235.3
91	178	266.6	887.7	141	46	68.8	229.6
92	172	258.6	861.0	142	45	67.1	224.2
93	167	250.9	835.3	143	44	65.5	218.9
94	162	243.4	810.4	144	43	64.0	214.0
95	157	236.2	786.4	145	42	62.5	208.7
96	153	229.3	763.3	146	41	61.1	203.8
97	148	222.6	741.1	147	40	59.6	199.4
98	144	216.1	719.4	148	39	58.3	194.5
99	140	209.8	698.5	149	38	56.8	190.1
100	136	203.8	678.5	150	37	55.6	185.9
101	132	197.9	659.0				

Conversion Temperature~Resistance