INSTRUCTION MANUAL

VIBRATING WIRE MULTIPOINT SETTLEMENT GAGE

Model NIVOLIC SG

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1 PRODUCT

1.1 DESCRIPTION

The NIVOLIC SG is a high precision liquid level system designed to measure relative settlement in a multi-point system. It consists of a series of reservoirs connected together by a liquid line. In each reservoir, a mass is suspended to a vibrating wire transducer. Changes in elevation of water level in the reservoir modify the buoyancy force acting on the mass, thus modifying the resonant frequency of the vibration wire.

In the multipoint system, one of the reservoirs is the reference for the calculation of relative movements of all other reservoirs.

1.2 SPECIFICATIONS

Range:	150, 300, 450, 600 mm
Accuracy:	±0.5% F.S.
Resolution:	- Vibrating wire: 0.02% F.S. (Min.) - Temperature: 0.1ºC
Fluid type:	Water (optional antifreeze solution)
Cable:	- IRC-41A: 2 twisted shielded pairs, 22 AWG, with drain wire, PVC jacket, 6.4 mm OD - IRC-41AP: Identical to IRC-41A except that jacket is polyethylene - CP-455-SS: 2 twisted shielded pairs, 20 AWG, central s/s core, 11.5 mm OD - IRC-41AV vented: 2 twisted shielded pairs, 22 AWG, 2 nylon vent tubes, PVC jacket, 8.9 mm OD - IRC-390: 2 twisted shielded pairs 22 AWG, aluminium foil shield, stainless steel braided armour, 10 mm OD

2 INSTALLATION

The first step is to install the chambers. It is important to install all chambers at the same elevation at the beginning of the monitoring program since transducer range is limited and the amount of adjustment is small. It is also important to install them in a place not exposed directly to the sun.

NOTE: THE SENSOR IS VERY SENSITIVE AND CORRESPONDINGLY FRAGILE, AND MUST BE HANDLED WITH GREAT CARE.

The reference chamber should be installed either at a stable location or in a location that can be precisely surveyed. The chamber assembly has three threaded supports, which allows precise levelling of the system. The chambers should be attached and levelled with the use of a spirit level. Adjust the level by screwing the nuts on the threaded rods. When the cylinder is levelled, tighten the nuts firmly.

The next step is to attach the fluid lines. This is usually accomplished by running a large diameter tubing between chambers. The interconnecting tubing should be kept below the chambers. A heat source (hot water or heat gun) may be used to facilitate tubing installation on connectors.

2.1 FILLING FLUID LINES

Calculate the approximate volume of water required to fill the system. Fill a container with water or fluid mix, and position it higher than the chambers. Proceed to filling. The filling operation should be done very carefully to exclude air bubbles from the lines. The fluid should be introduced slowly until it appears in the chamber. When the fluid reaches the chamber, it should not be allowed to rise more than half range of settlement gauge.

Air bubbles may be difficult to be excluded from the line, especially with a long assembly.

In that case, we suggest using a vacuum pump as shown on **FIGURE 1**.

Proceed as follows:

1. Install the reservoir at least two meters higher than the chambers. Fill the reservoir with water or water/glycol mixture. Expect to use twice the quantity of mixture necessary to fill the chambers and tubing.
2. Plug the **# 4** line at both extremities.
3. Install the vacuum pump and vacuum reservoir.
4. Close the **#11** valve.
5. Turn the vacuum pump on and wait until a relative vacuum is obtained in the system.
6. Open valve **#11**. When fluid starts to flow inside the vacuum reservoir, close valve **#13** and turn off the vacuum pump. If necessary, close valve **#11** to prevent complete emptying of the reservoir.
7. Unplug both extremities of the **#4** line. Make sure that there is no water in this line.

The next step is to attach the weight to the sensor. <u>THIS OPERATION IS VERY CRITICAL AND SHOULD BE PERFORMED WITH EXTREME CARE. ROUGH OR CARELESS HANDLING DURING INSTALLATION CAN DESTROY THE LOAD SENSOR.</u>

Remember that the weight should match the appropriate chamber and transducer. Refer to the serial number.

While holding the sensor with both hands, hook the weight onto the hook on the sensor and gently lift the weight keeping the sensor body vertical.

Lower the weight into the chamber. Now, line up the holes in the chamber with the screw holes in the cap. Gently lower the cap into the chamber being careful not to jar it as the O-ring comes into contact with the chamber wall. When the cap is all the way in place, tighten the screws in place. Do not over tighten. Repeat this procedure for all the chambers. After all the weights have been installed, the system should be left to stabilize several hours.

The chambers should be filled to approximately mid-height on the weight. This is the recommended starting point. Connect the air lines and install all plugs, air filter, and moisture trap.

NOTE: IT IS RECOMMENDED TO ALWAYS KEEP A THIN LAYER OF OIL ON THE SURFACE OF THE WATER, IN ORDER TO PREVENT WATER EVAPORATION.

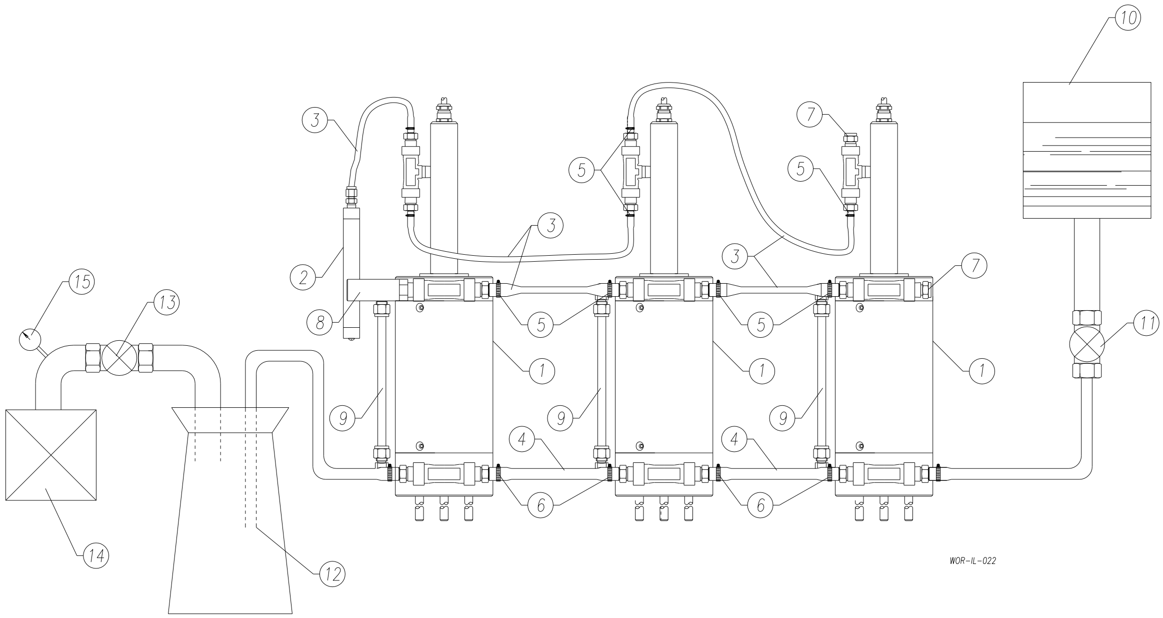

FIGURE 1: NIVOLIC Assembly.

ITEM	DESCRIPTION	ITEM	DESCRIPTION
1	NIVOLIC CHAMBER	9	SIGHT TUBE
2	DESICCANT TRAP	10	WATER/GLYCOL – FILLED RESERVOIR
3	NYLON 11 1/4”- 1/8”	11	VALVE
4	POLYETHYLENE TUBING 3/8”-1/4”	12	VACUUM RESERVOIR
5	HOSE CLAMP 1/4”	13	VALVE
6	HOSE CLAMP 3/8”	14	VACUUM PUMP
7	1/4-18 NPT PLUG	15	PRESSURE GAGE
8	AIR FILTER	16	-

Filling of the NIVOLIC SG Using a Vacuum Pump

3 DATA READING AND ANALYSIS

3.1 CALIBRATION

Each sensor in its own chamber is calibrated with the reference vessel. A specific calibration factor on a calibration data sheet is furnished at delivery. If the user utilizes a fluid mixture different from the one used for factory calibration (see calibration data sheet), then a new calibration must be performed.

3.2 INITIAL READING

The initial readings at atmospheric pressure and ambient ground temperature are obtained on the site. Temperature variations will reduce the accuracy by changing the fluid density.

3.3 READOUT PROCEDURE

To take a reading, follow the instructions contained in the MB-6T instruction manual.

3.4 RELATIVE MOVEMENT EQUATIONS (WITH MB-6T(L) READOUT)

a) LINEAR or frequency readings

The MB-6T(L) LINEAR or frequency readings are converted to settlement or heave using the equations below. They must be obtained with the GAUGE TYPE selector switch in the correct position on the MB-6T/6TL readout (position # 2).

The NIVOLIC is supplied with a temperature correction factor, which is used to correct the reading for significant variations in temperature.

To convert changes in LINEAR or frequency readings to changes in settlement or heave corrected for temperature changes, use the following equations:

Note that a positive sign (+) indicates a settlement, and a negative sign (-) indicates a heaving.

$$\mathbf{\Delta EL\ (mm) = CF\ (L_1 - L_0) - CF_{ref}\ (L_{1\ ref} - L_{0\ ref})}$$

or

$$\mathbf{\Delta EL\ (mm) = CK\ (F_1^2 - F_0^2) - CK_{ref}\ (F_1^2{}_{ref} - F_0^2{}_{ref})}$$

ΔEL (mm) with negative sign (-) indicates settlement

ΔEL (mm) with positive sign (+) indicates heave

L_0, L_1 = Initial (at installation) and current reading, in LU

F_0, F_1 = Initial (at installation) and current reading, in Hz

CF = Calibration factor in mm per LU

CK = Calibration factor in mm per Hz^2

Ref = Subscript that refers to readings and factors of the reference vessel

LU = Linear unit with K = 1.0156

b) Frequency readings (F)

To convert Frequency readings into LU, one must use the following equation:

$$L = K\left(\frac{F^2}{1000}\right) \qquad \textbf{(5)}$$

where: L = LINEAR reading in LU

K = Gage constant for all transducers = 1.0156

F = Reading in the frequency mode in Hz.

Example: F = 1739 Hz

$$L = \frac{1.0156 \times 1739^2}{(1000)} = 3071.8\ LINEAR\ units$$

3.5 CONVERSION TABLE (TEMPERATURE VS RESISTANCE)

Temp. °C	Reading in Ohms			Temp. °C	Reading in Ohms		
	With a 2K Thermistor	With a 3K Thermistor	With a 10K Thermistor		With a 2K Thermistor	With a 3K Thermistor	With a 10K Thermistor
-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

TABLE 1: Conversion Table (Continued)

Temp. °C	Reading in Ohms			Temp. °C	Reading in Ohms		
	With a 2K Thermistor	With a 3K Thermistor	With a 10K Thermistor		With a 2K Thermistor	With a 3K Thermistor	With a 10K Thermistor
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				

TABLE 1: Conversion Table

3.6 CONVERSION FACTORS

	To Convert From	To	Multiply By
LENGTH	Microns Millimetres Meters	Inches Inches Feet	3.94E-05 0.0394 3.2808
AREA	Square millimetres Square meters	Square inches Square feet	0.0016 10.7643
VOLUME	Cubic centimetres Cubic meters Litres Litres	Cubic inches Cubic feet U.S. gallon Can–Br gallon	0.06101 35.3357 0.26420 0.21997
MASS	Kilograms Kilograms Kilograms	Pounds Short tons Long tons	2.20459 0.00110 0.00098
FORCE	Newtons Newtons Newtons	Pounds-force Kilograms-force Kips	0.22482 0.10197 0.00023
PRESSURE AND STRESS	Kilopascals Bars Inches head of water* Inches head of Hg Pascal Kilopascals Kilopascals Kilopascals	Psi Psi Psi Psi Newton / square meter Atmospheres Bars Meters head of water*	0.14503 14.4928 0.03606 0.49116 1 0.00987 0.01 0.10197
TEMPERATURE	Temp. in °F = (1.8 x Temp. in °C) + 32 Temp. in °C = (Temp. in °F – 32) / 1.8		

* at 4 °C

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TABLE 2: Conversion Factors