RST INSTRUMENTS LTD.

Vibrating Wire
Crackmeter VWCM
Instruction Manual

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Vibrating Wire Crackmeter VWCM Instruction Manual

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1 INTRODUCTION

The Crackmeter measures movement between two points as shown in Figure 1. Commonly, the two points are placed across construction joints or cracks.

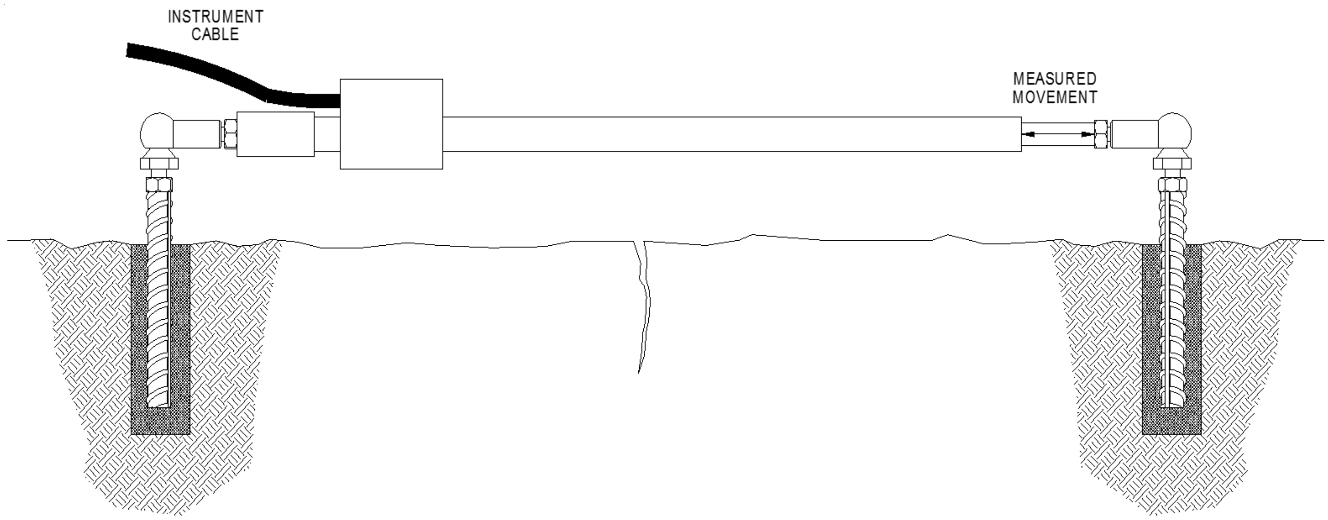

Figure 1: Crackmeter Principle of Operation

The instrument consists of an extendable shaft connected to a spring, which is further connected to a vibrating wire sensing element. As the shaft moves, the spring is proportionally stretched, further proportionally stretching the vibrating wire sensing element. The vibrating wire is very sensitive to strain changes, and emits different frequencies at different strains upon excitation.

The installation of the Crackmeter consists of drilling two holes at desired locations and grouting the two anchors in place. The Crackmeter cable should be installed away from electrical noise, and additional lightning protection may be installed if deemed necessary. The movement of the joint or crack may then be easily monitored by connecting the cable to an RST Readout. Furthermore, the Crackmeter also has a built in thermistor, and thus the temperature may also be measured.

It is recommended, depending on site conditions, to consider installing a guard to protect the instrument from debris

2 INSTALLATION

Do not rotate the Crackmeter shaft relative to its body because the connected spring and vibrating wire elements cannot be twisted. The hole on the shaft and the slot on the body should remain roughly aligned as shown in Figure 2.

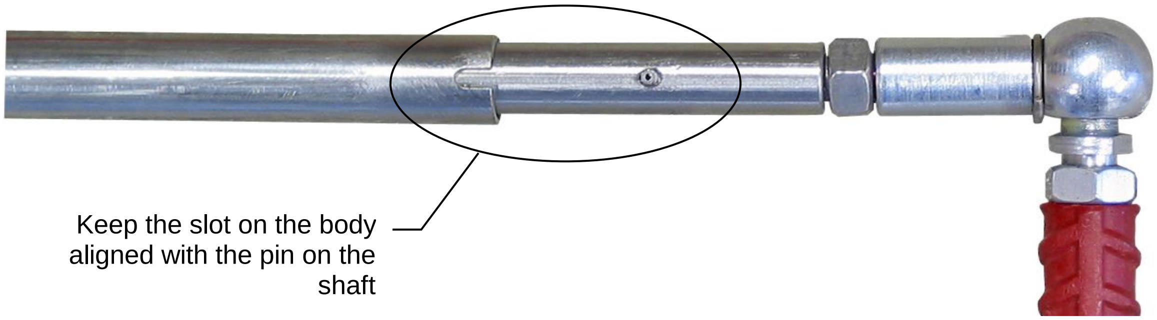

Figure 2: Instrument Shaft Alignment

Before the site installation, the instrument should be checked for proper operation. The instrument generally arrives with its shaft secured in the middle range to help protect it during shipping. Thus, connecting a readout box should show a stable reading between 5000 and 6000 Digits (Hz^2*10^{-3}).

A quick continuity check should also be performed. The resistance between the gauge leads (Red and Black wires) should be approximately 125Ω. The resistance between the thermistor leads (Green and White wires) should be approximately 3kΩ at room temperature, and it should decrease with increasing temperature, i.e. when someone squeezes the instrument. Finally, there should be infinite resistance between the shield and the other leads.

Now the instrument is ready for installation, which includes these steps:

1. Determine the anchor locations. It is important to estimate how the instrument will move in the future. For example, if the Crackmeter will be measuring the opening of a tension crack, then it may be expected for the crack to continue to open and thus the Crackmeter should be installed pre-stroked to 10% of its full range. However, if the Crackmeter is to be installed across a joint that can either open or close, then the Crackmeter will likely be installed in the midrange (50% of full range).

> Note: It may be helpful to use a spacer, clamp, or make a brace that can hold the Crackmeter in place while the Grout or Epoxy cures. **Be careful not to score the shaft as it is part of an o-ring seal.**

2. Drill two 12mm holes approximately 75mm deep by using a hammer drill.
3. Fill the holes with grout or epoxy.
4. Push in the Crackmeter anchors until they are flush with the surface, as shown in Figure 3.

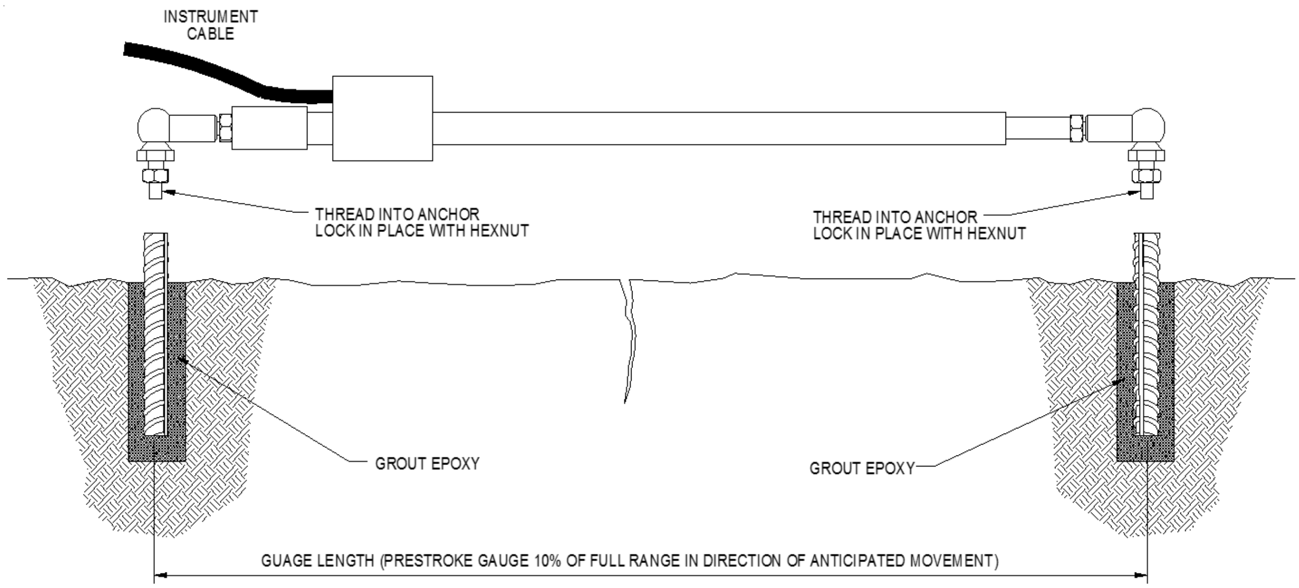

Figure 3: Installing Crackmeter

5. Check the Crackmeter output with a portable readout and make sure it is within the range of the calibration sheet. Note this output as the installation reference output. It may be used to find the movement changes that subsequently occur.

6. The Crackmeter cable should be routed away from sources of electrical interference such as power lines, motors, transformers, etc. The cable cannot run with AC power lines because it will pick up the 50 or 60Hz noise. The cable may be lengthened, and the frequency of the signals will not be affected.

The Crackmeter does not have built in lightning protection. Plasma surge arrestors can be installed close to the sensor and a ground strap would connect the arrestor to earth ground. Alternatively, a more elaborate lightning protection may be ordered from RST if deemed necessary.

3 OPERATION

After the installation is complete, initial readings can be recorded by using a RST Vibrating Wire Readout. Use the supplied wiring diagram to make the electrical connections and be sure to record relative site information to provide a unique identifier for the data. Subsequent instrument readings when referenced with the instruments initial readings will provide actual deformation (Subsequent Reading – Initial Reading = Deformation)

The readouts will output the displacement in B units ($Hz^2 x10^{-3}$) and the calibration factor, supplied with each calibration sheet, may be used to convert to linear displacement units. The readouts also output the temperature in °C. If an Ohmmeter is used directly on the green and white wires, then Appendix B may be used to convert to °C.

3.1 TEMPERATURE CORRECTION

Temperature correction may not be necessary in many cases as the Vibrating Wire Crackmeter has a small coefficient of thermal expansion. Temperature corrections may be applied for maximum accuracy or when temperature fluctuations are greater than 10°C.

Equation 1: Linear Displacement

$$Linear\ Displacement = (R_c - R_i) * CF + (T_c - T_i) * K$$

Enter the appropriate values in Equation 1 to calculate the displacement and convert readings into linear units. All subsequent readings should be subtracted from the initial reading taken to compute the distance the crack has opened, where:

R_c	Current Reading
R_i	Initial Reading
CF	Linear Calibration Factor; provided on Calibration Sheet
T_c	Current Temperature
T_i	Initial Temperature
K	Temperature Factor; see Equation 2

Equation 2: Temperature Correction Factor

$$K = ((R_c * M) + B) * CF$$

R_c	Current Reading
M	Slope; see Table 3-1
B	Constant; see Table 3-1
CF	Linear Calibration Factor; provided on Calibration Sheet

Table 3-1 Temperature Correction Factor

Stroke (mm)	25	50	100	150	200	300
Slope (M)	0.000301	0.000311	0.000399	0.000359	0.000306	0.000277
Constant (B)	-0.3186	-0.2758	-0.8128	-0.5579	-0.4498	-0.2495

4 MAINTENANCE

Most of the intricate components of the Crackmeter are sealed and do not require maintenance. It is important to check that the cable connections remain sound. Furthermore, it is important to check that the shaft does not become extended outside the permissible range, does not become fully retracted, remains free to move, and does not twist.

5 3D CRACKMETER

The 3D Crackmeter monitors the behavior of cracks, or structure joints in three directions. The VWCM-3D consists of three crackmeters and a Reference Anchor, and is installed as shown in Figure 4. The Reference Anchor is installed on one side of the crack/joint and the Crackmeters are installed on the other side. One crackmeter measures the displacement across the crack (X Axis), another one parallel to the crack (Y Axis), and a third one (Z Axis) orientated vertically. The distance between Anchors, is determined by the Sensor Stroke and the anticipated direction of movement. If the direction is unknown, then the sensors should be installed at mid stroke leaving ½ of the sensors range available to measure in either direction (see Figure 4). If the direction of movement is known then the anchor locations can be moved accordingly to utilize the full stroke of the sensor.

The VW3D Crackmeter can easily be modified or reconfigured to satisfy various site conditions, contact a RST representative for more information.

Depending on site conditions, installing a guard to protect the instrumentation is recommended.

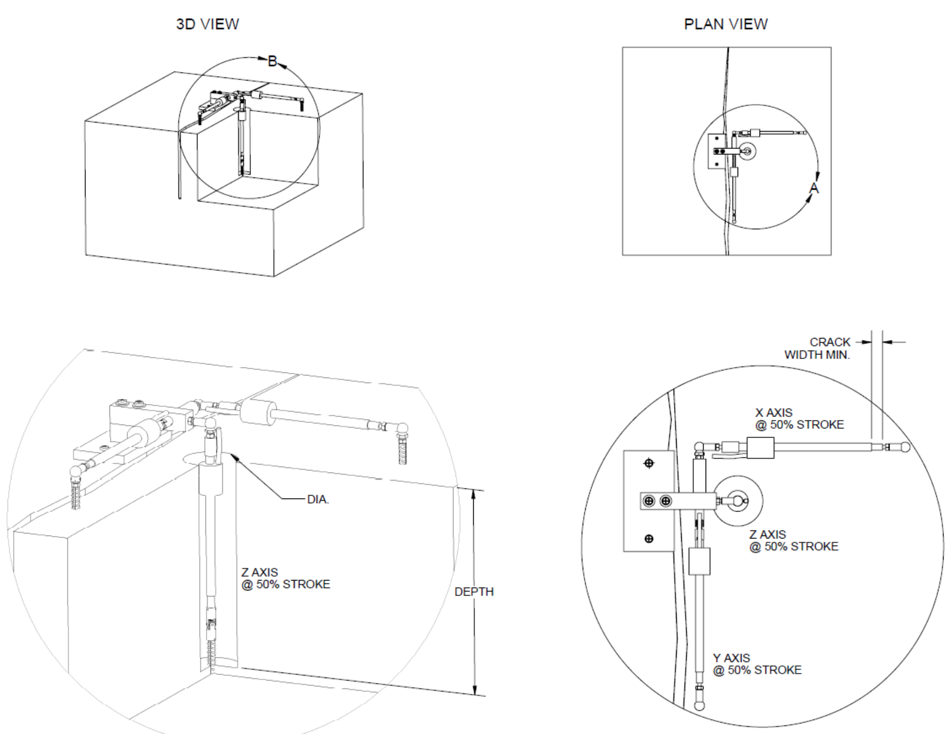

Figure 4: Submersible 3D VW Crackmeter General Arrangement

5.1 VWCM-3D INSTALLATION

Installation of the VW3D Crackmeter is similar to the regular VW Crackmeter (see Section 2), with the exception of installing 3 additional anchors, the Reference Base, and an optional knockout for the Z-Axis. It is recommended to install a protective cover over the instruments.

1. Install the Reference Base.

CAUTION: Be very careful when pre-stroking the instruments. DO NOT to rotate the shaft. The shaft is internally pinned, and at rest it is positioned in a recess to prevent it from rotating. When extended, the pin leaves the recess and the shaft could rotate.

2. Connect readout to the sensor and use a spacer or clamp to lock the Y and Z Axis sensors at mid stroke. **Be careful not to score the shaft as it is part of an o-ring seal**.

3. Connect a readout to the sensor and use a spacer or clamp to lock the X Axis sensor stroked to the width of the crack. **Be careful not to score the shaft as it is part of an o-ring seal**.

4. Install the sensors onto the installed Reference base. When installing the Y Axis, loosen the universals' setscrew, with the supplied 1/16 Allen key, so the universal can be threaded into the Reference Base, and then re-tighten the setscrew.

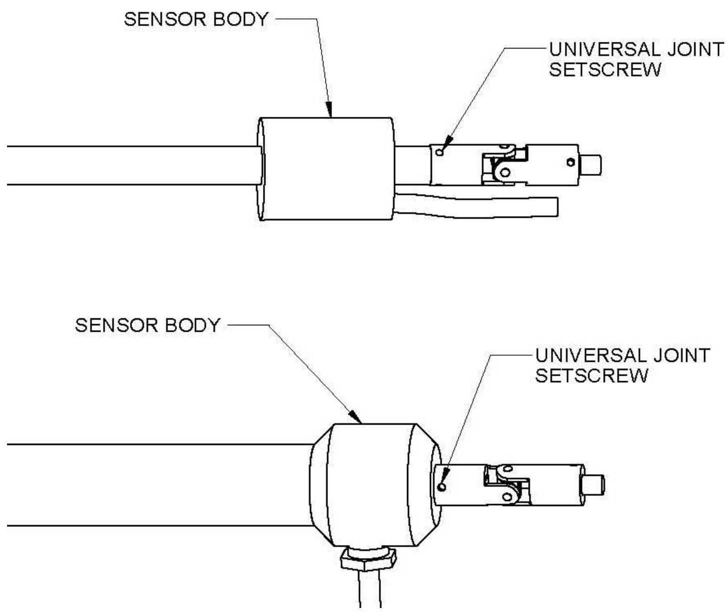

Figure 5: Installing the Y-axis on a 3D Crackmeter

5. Use the supplied drilling template or the pre-stroked sensors to mark the positions for installing their respective anchors, drill the holes and grout the anchors in place (**ensure the sensors are installed parallel/level to, the mounting surface and their respective Axis**).

6. Install a protective cover.

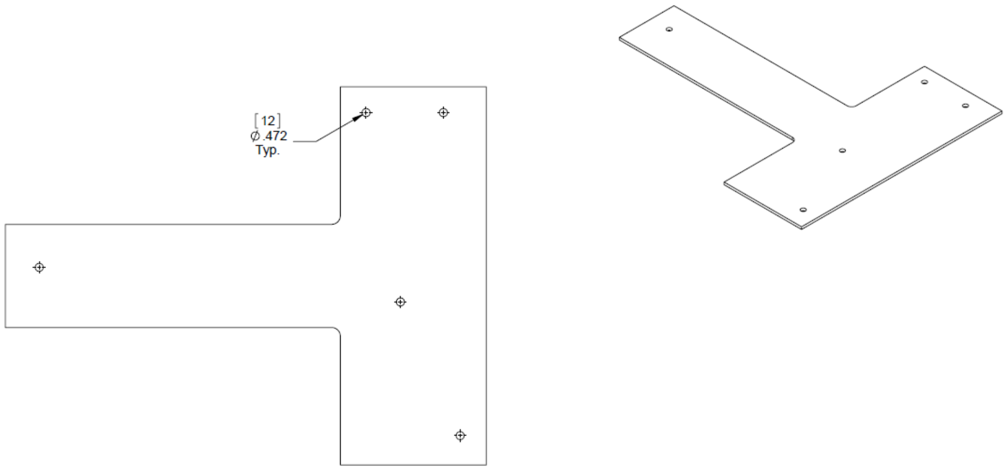

Figure 6: Drilling Template

5.2 SUBMERSIBLE 3D CRACKMETER

Installed like the 3D Crackmeter except with for the increase in probe length, due to the water tight housings. Knockout hole for Z Axis is optional.

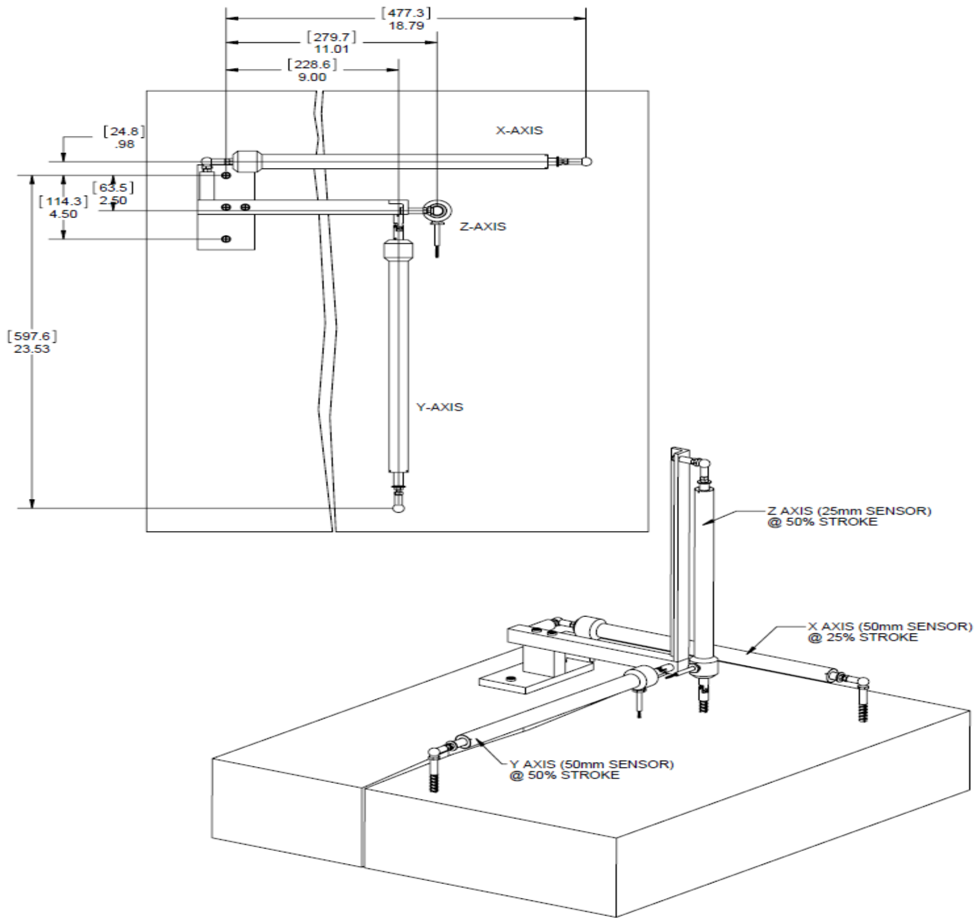

Figure 7: Submersible 3D VW Crackmeter General Arrangement

APPENDIX A: SENSOR SPECIFICATIONS

Table A-1 Sensor Specifications

Specification	Value						
Range	12.5mm	25mm	50mm	100mm	150mm	200mm	300mm
Resolution	<0.01%FS						
Accuracy	<0.1%FS						
Linearity	<0.5%FS						
Zero Stability	0.02%FS/year						
Length (Mid-range, end to end)	205mm	227mm	304mm	467mm	559mm	790mm	1100mm
Frequency Range	1200-3550Hz						
Coil Resistance	180Ω						
Temperature Range	-20 to 80°C						
Over Range	105%FS						
Rated Pressure	2MPa						

APPENDIX B: THERMISTOR TEMPERATURE DERIVATION

The following equation may be used to convert the measured thermistor resistance R (Ω) to temperature T (°C) to compensate for Temperature.

Equation 3:

$$T = \frac{1}{1.4051 * 10^{-3} + 2.369 * 10^{-4} * \ln(R) + 1.019 * 10^{-7} * (\ln(R))^3} - 273.2$$

Alternatively, the values may be looked up directly in Table 3-2.

Table B-1 Thermistor Resistance (Ω) versus Temperature (°C)

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	16.60K	-10	2417	+30	525.4	+70	153.2	+110
187.3K	-49	15.72K	-9	2317	31	507.8	71	149.0	111
174.5K	-48	14.90K	-8	2221	32	490.9	72	145.0	112
162.7K	-47	14.12K	-7	2130	33	474.7	73	141.11	113
151.7K	-46	13.39K	-6	2042	34	459.0	74	137.2	114
141.6K	-45	12.70K	-5	1959	35	444.0	75	133.6	115
132.2K	-44	12.05K	-4	1880	36	429.5	76	130.0	116
123.5K	-43	11.44K	-3	1805	37	415.6	77	126.5	117
115.4K	-42	10.86K	-2	1733	38	402.2	78	123.2	118
107.9K	-41	10.31K	-1	1664	39	389.3	79	119.9	119
101.0K	-40	9796	0	1598	40	376.9	80	116.8	120
94.48K	-39	9310	+1	1535	41	364.9	81	113.8	121
88.46K	-38	8851	2	1475	42	353.4	82	110.8	122
82.87K	-37	8417	3	1418	43	342..2	83	107.9	123
77.99K	-36	8006	4	1363	44	331.5	84	105.2	124
72.81K	-35	7618	5	1310	45	321.2	85	102.5	125
68.30K	-35	7252	6	1260	46	311.3	86	99.9	126
64.09K	-33	6905	7	1212	47	301.7	87	97.3	127
60.17K	-32	6576	8	1167	48	282.4	88	94.9	128
56.51K	-31	6265	9	1123	49	283.5	89	92.5	129
53.10K	-30	5971	10	1081	50	274.9	90	90.2	130
49.91K	-29	56.92	11	1040	51	266.6	91	87.9	131
46.94K	-28	5427	12	1002	52	258.6	92	85.7	132
44.16K	-27	5177	13	965.	53	250.9	93	83.6	134
39.13K	-25	4714	15	895.8	55	236.2	95	79.6	135
36.86K	-24	4500	16	863.3	56	229.3	96	77.6	136
34.73K	-23	4297	17	832.2	57	222.6	97	75.8	137
32.74K	-22	4105	18	802.3	58	216.1	98	73.9	138
30.87K	-21	3922	19	773.7	59	209.8	99	72.2	139
29.13K	-20	3748	20	746.3	60	203.8	100	70.4	140
27.49K	-19	3583	21	719.9	61	197.9	101	68.8	141
25.95K	-18	3426	22	694.7	62	192.2	102	67.1	142
24.51K	-17	3277	23	670.4	63	186.8	103	65.5	143
23.16K	-16	3135	24	647.1	64	181.5	104	64.0	144
21.89K	-15	3000	25	624.7	65	176.4	105	62.5	145
20.70K	-14	2872	26	603.3	66	171.4	106	61.1	146
19.58K	-13	2750	27	582.6	67	166.7	107	59.6	147
18.52K	-12	2633	28	562.8	68	162.0	108	58.3	148
17.53K	-11	2523	29	543.7	69	157.6	109	56.8	149
								55.6	150