System 4101

CONCRETE MATURITY METER

Technical Data

APPLICATIONS:

- Accurate, predictable concrete strength determination
- Form and shoring removal time prediction
- Loading and post-tensioning time prediction
- Control of winter heating and insulation requirements

FEATURES:

- Watertight, impact-resistant enclosure
- Microprocessor controlled
- Low power CMOS design
- Calculates "temperature-time" factor
- 4-channel operation
- Low cost, high accuracy Type "T" thermocouple sensing
- Transducer linearization
- Cold junction compensation
- Open circuit indicator
- Over and under range indicator
- Low battery indicator for both main and back-up power
- The main power source, a 9 volt lithium battery, gives up to 2 years of continuous operation
- Back-up lithium battery provides a 10-year protection for real-time clock and memory
- Main battery may be replaced without loss of memory
- Large memory capacity holds over 10 months of continuous data recording
- Transfer data to a serial printer, computer or to another System 4101 Maturity Meter
- Collect data remotely by adding a 300/1200/2400 baud MODEM (meter can auto-dial)
- Calculates "equivalent age" factor
- Alpha-numeric liquid crystal display
- Membrane keyboard
- User-friendly "HELP" menu

DESCRIPTION:

The Concrete Maturity System 4101 allows predictable strength determination of cast-in-place concrete, based on an ASTM specification C1074-87 Standard (Estimating Concrete Strength by the Maturity Method).

The 4101 calculates two factors corresponding to concrete maturity: the "temperature-time" factor (TTF) and the "equivalent-age" factor (AGE). TTF relates to the average temperature of the concrete over time to its strength. The datum temperature, a constant used in determining the TTF, is programmable to reflect various types of concrete. The "equivalent-age" factor relates the strength of in-place concrete to the strength of laboratory-cured concrete and is stated in number of hours cured. Both the

energy constant, Q, and the "equivalent age temperature" used in calculating AGE are also programmable.

The microprocessor controlled System 4101 has been built for the environment of the construction industry. A watertight, impact-resistant enclosure is used in the manufacture. The 4101 4-channel meter utilizes thermocouple temperature sensing which enables both long or short cable runs to be used without affecting accuracy. This allows great ease and flexibility in determining the placement of sensor locations. A +/− 1°C standard accuracy is obtained by combining both the use of low cost thermocouple wire and the implementation of advanced technology.

UNIT OPERATION:

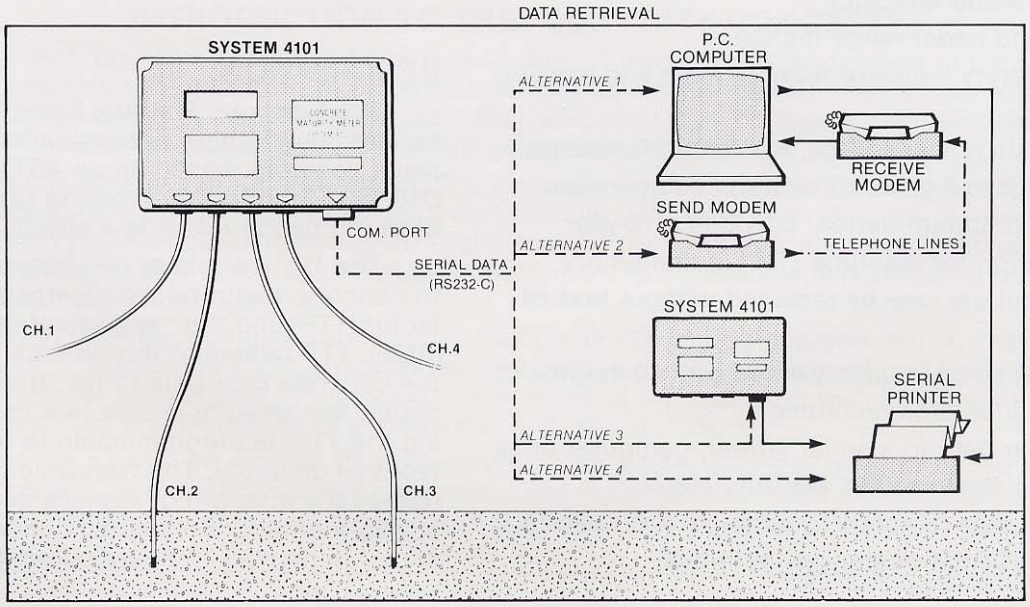
Since the System 4101 is housed in an environmentally-protected lightweight enclosure, it can be placed almost anywhere. Providing 4-channel operation, an obvious economical feature, allows 4 separate sensing points to be monitored simultaneously. Type "T" thermocouple wire has been specifically incorporated for its accurate and inexpensive sensing as well as ease of installation.

Operation of the 4101 is controlled via a 6-position membrane keyboard located on the front panel. A "HELP" menu, which is a user guide for meter operation, can be accessed through the same keyboard. This makes the System 4101 the most advanced, user-friendly Concrete Maturity Meter available.

All data and relevant information such as the current temperature and maturity factors for each individual channel is displayed on a 2-line, 32-position, alpha-numeric liquid crystal display (LCD). Meter status checks may also be viewed. These include main battery voltage, back-up circuitry integrity, recording memory available and memory used. On-screen warnings for low battery voltage, available memory, low and high temperature extremes and sensor disconnection are provided.

User-programmable features provided on the 4101 include:
- datum temperature
- activation energy constant
- equivalent age temperature
- date and time
- serial port baud rate (communication port)
- meter ID number
- phone number for auto-dialling

All maturity value information and status/indicator data is stored in memory and can therefore be retrieved for analysis or documentation purposes. Data retrieval may be executed in several ways. System 4101 may be connected directly to the serial port of a printer or computer or, if more convenient, data may be transferred from one System 4101 unit to another to allow multiple meter reports on a single printout. (Each unit's report will be individually identified). An auto-dial feature may also be utilized to transfer data from a remote location to an office facility.



A sample of a meter report is shown below. Each of the 4 channels is displayed with its corresponding temperature, temperature-time and equivalent age values. Both programmed constants and specific unit information are given to complete the report. From this data graphs can be generated using standard spread sheet programs.

System 4101 ID# 9950 Printout at FEB 21/89 09:4

Recording started at FEB 17/89 11:17P

Datum Temperature (deg C): −10
Act Energy Const (deg K): 4700
Equiv. Age Temp (deg C): 23

TTF - temperature-time factor (deg C*H)
AGE- equivalent age factor (Hr)
TMP- measured temperature (deg C)

Hour	Channel 1			Channel 2			Channel 3			Channel 4		
#	TMP	TTF	AGE	TMP	TTF	AGE	TMP	TTF	AGE	TMP	TTF	AGE
0.0	55	0	0.0	55	0	0.0	55	0	0.0	55	0	0.0
0.5	54	32	2.3	54	32	2.3	54	32	2.3	54	32	2.3
1.0	54	64	4.6	54	64	4.6	54	64	4.6	54	64	4.6
1.5	73	101	8.0	73	101	8.0	73	101	8.0	73	101	8.1
2.0	80	144	13.7	80	145	13.8	80	145	13.8	80	145	13.8
2.5	HTA	144	13.7	HTA	145	13.8	HTA	145	13.8	HTA	145	13.8
3.0	OFF	144	13.7	OFF	145	13.8	OFF	145	13.8	OFF	145	13.8
3.5	OFF	144	13.7	OFF	145	13.8	OFF	145	13.8	OFF	145	13.8
4.0	OFF	144	13.7	OFF	145	13.8	OFF	145	13.8	OFF	145	13.8
4.5	OFF	144	13.7	OFF	145	13.8	OFF	145	13.8	OFF	145	13.8
5.0	OFF	144	13.7	OFF	145	13.8	OFF	145	13.8	OFF	145	13.8
5.5	HTA	144	13.7	HTA	145	13.8	HTA	145	13.8	HTA	145	13.8
6.0	89	144	13.7	89	145	13.7	89	145	13.7	89	145	13.7
6.5	84	193	22.0	84	193	22.0	83	193	22.0	84	193	22.1
7.0	79	238	28.9	79	239	28.9	79	239	28.9	79	239	29.0
7.5	75	282	34.7	75	282	34.7	75	282	34.7	75	282	34.8
8.0	75	324	40.0	75	325	40.1	75	325	40.1	75	325	40.3
8.5	75	367	45.4	75	367	45.4	75	367	45.4	75	368	45.8
9.0	75	409	50.8	75	410	50.8	75	410	50.9	75	411	51.2
9.5	75	452	56.1	75	452	56.1	75	452	56.3	75	453	56.6
10.0	75	494	61.5	75	495	61.5	75	495	61.7	75	496	62.1
10.5	75	537	66.9	75	537	66.9	75	538	67.1	75	539	67.5
11.0	74	579	72.2	74	580	72.2	74	580	72.5	74	581	72.9

Recording stopped at FEB 18/89 10:24A

NOTE: HTA - High temperature alarm
LTA - Low temperature alarm

WORLD TEC
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SPECIFICATIONS:

Temperature Measurement:

- Sensor measurement range: −10°C to +90°C
- Accuracy: +/− 1°C
- Thermocouple wire: Type "T"

Data Record:

- Memory Capacity: 32K bytes
- Data capacity: 10 months x 4 channels
- Recording interval: Every ½ hour up to 48 hours
  Every 1 hour thereafter

Communications:

- I/O Port: Serial RS-232C
- Handshaking: XON/XOFF
- Data format: ASCII
- Baud rates: 300, 1200, 2400, 4800, 9600 (selectable)

Power:

- * 9V Kodak Ultralife Lithium (U9VL) battery
  -1.0 Amp hour capacity
  -Up to 2 years of service life at 20°C
- 3.6V Lithium, ½AA cell memory/clock battery
  -0.750 Amp hour capacity
  -10 year service life at 20°C

  * Note: Use of a standard 9-volt alkaline battery may reduce capacity up to 60%.

Mechanical:

- Dimensions: 7.8" x 4.7" x 2.9"
- Case material: Polycarbonate
- Weight: 1.75 lbs.
- Thermocouple connectors: Omega "flat pin" miniature
- I/O connector: AMP "CPC" Series 4

Environmental:

- Operating temp: −20°C to +50°C
- Enclosure: Watertight, impact-resistant

Maturity Value Calculations:

- Constant programmable range:
  - -Datum temperature: −20°C to +40°C (temperature integration base)
  - -Equivalent Age Temperature: 0 to −40°C
  - -Activation Energy Constant: 0 to 20,000°K
- Maximum maturity values displayed:
  - -Temperature-time factor: 99999°C hours
  - -Equivalent Age factor: 9999 hours

INTRODUCTION TO THE "MATURITY CONCEPT"

In the last few years there has been a good deal of investigative work done in the area of concrete strength determination through electronic temperature measurement. This work is based on the findings of J.M. Plowman, who first advanced the non-linear, time-temperature, or "Maturity Concept" of rate of gain of strength in portland cement concrete.

There are various methods of relating the concrete time-temperature data to strength, but all methods employ the integrated value of temperature with time. Interpolation of integrated temperature values on pre-determined strength versus time-temperature graphs enables instant strength calculations (if a suitable electronic instrument is available which performs the temperature integration function).

Although different concrete mix designs exhibit similar curing characteristics, each must be tested to determine its exact strength versus time-temperature relationship. This is done by making a number of cylinders, monitoring one or more of the cylinders with an integrating thermometer, and breaking pairs of cylinders at 3, 7, 14, 28 ... days.

Values are plotted on a graph (temperature-time on x axis, strength on y axis). The result of this process will be a relationship which, when used in conjunction with maturity meters, will enable instantaneous concrete strength determination in the field.