System 4101
Concrete Maturity Meter

USERS GUIDE
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DWS ELECTRONICS
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IMPORTANT NOTICE

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Introduction

The System 4101 Maturity Meter provides accurate, predicable concrete strength determination by monitoring the concrete temperature via disposable thermocouple wires. Some of the benefits of using this meter on the construction site include:

- form and shoring removal time prediction
- loading and post-tensioning time prediction
- control of winter heating and insulation requirements
- accelerated construction scheduling

Years of experience using data logging electronics in construction environments are behind the System 4101 Maturity Meters Design. The use of thermocouple wires for temperature sensing enables long or short cable runs and allows flexibility in the placement of the temperature sensors. As well, low cost, type "T" thermocouple wire is used with connections made via quick-connect thermocouple jacks.

The computerized nature of this meter provides features previously unavailable in concrete maturity meters:

- complete conformance to ASTM C1074-87 specification for estimating concrete strength
- simultaneous calculation of 2 different maturity factors
- programmability of equation constants, meter ID #, date and time, serial port parameters, and phone #
- meter to meter data transfer
- data output to a computer, modem or printer

Despite the flexibility designed into this meter, it's operation is easily understood through the use of a large 32 display and well designed keyboard layout. In addition, there is an extensive on-screen help menu available.

Please familiarize yourself with this manual before using the meter. There are some helpful hints that could save you time and money.

Meter Operation

Introduction

The System 4101 Concrete Maturity Meter is capable of performing many functions relating to concrete strength estimation and quality control. Although it is quite complex in design, learning to use it effectively is straight forward.

The meter is designed to be as user friendly as possible. A help facility is provided that gives general information about the meter and its use. The various features and functions are easily accessed through the use of the simple keyboard layout. The best way to become familiar with this meter is to follow the tutorial presented here and then to read though the rest of this manual.

If you want to know more about the applying the maturity concept to concrete strength estimation, please refer to ASTM C1074-87, "Estimating Concrete Strength by the Maturity Method".

Turning The Meter On and Off

To manually turn on the meter press the **<ENTER>** key (power on). The time and date will be displayed on the top line of the display and the meter ID # will be displayed on the lower line. After 2 seconds, the "Present Values" menu is displayed. This is the menu that is used to display the current channel temperatures and calculated maturity factors.

The meter may be manually turned off by pressing the **<EXIT>** key (power off) anywhere in the Present Values menu.

The meter will automatically turn off 30 seconds after the last keypress.

Viewing Present Values

Channel temperatures, temperature-time factors and equivalent age factors can be viewed in the Present Values menu. To change the selected channel, press the **<UP>** and **<DOWN>** keys. To change to temperature-time values or equivalent age values, press the **<ENTER>** key.

Refer to the Alarms section for information on channel alarm indicators (OFF, LTA, HTA).

Accessing The Menus

There are 6 software menus available on the meter that may be called up on the display:

1. Present Values
2. Help Info
3. Recording Control
4. Viewing Recorded Data/Meter Status
5. Parameter Setup
6. Communications menu

Press the **<REC>** key once to get to the **Recording Control menu**. Press the same key again to get to the **Parameter Setup menu**. Press the **<EXIT>** key to return to the Present Values menu.

Press the **<VIEW>** key once to get the the **Viewing Data/Status menu**. Press the same key again to get to the **Communications menu**. Press the **<EXIT>** key to return to the Present Values menu.

Use the **<UP>** and **<DOWN>** arrow keys to change the function selected within each menu. Use the **<ENTER>** key to activate the function selected. Use the **<EXIT>** to "back out" of functions and menus etc.

Help Info

The Help Information menu may be activated anywhere in the **Present Values menu**. It contains more than 200 lines of information in 8 sub-menus. Press the **<UP>** and **<DOWN>** arrow keys together to activate this menu and then follow the instructions displayed. There are 8 separate sub-menus to choose from. To cancel the help menu, just press the **<EXIT>** key.

Using The Menus

Recording Control

There are 3 items in the Recording menu:

1. Start Recording
2. Stop Recording
3. Erase

After the meter is placed in **record mode**, it automatically powers itself off and "wakes up" when its time to take temperature measurements. Temperature measurements are made every 1/2 hour up to 48 hours and then once an hour after that. The temperature-time factors and equivalent age factors are calculated and stored each time a temperature measurement is made. These factors may be reviewed in the Present Values menu at any time during recording.

The **erase function** clears out all recorded values and resets the memory pointers. It is not necessary to clear the memory before starting a new recording. Separate records are kept of each recording and the data from all recordings can be output to a computer or printer for viewing at a later date via the COM PORT.

The **current recording data** can be reviewed in the **Data Viewing menu** but previous recordings can only be output via the COM PORT. This also applies to any recording data transfer from another meter.

There are 327 days of recording capacity (x 4 channels) when the memory is erased. Each time a new recording is started, the number of days available for recording will be displayed. If the battery voltage becomes too low, the recording will automatically stop. The battery can be replaced during recording if so desired without loss of memory.

Constants (datum temperature etc.) may not be altered during recording.

Viewing Recorded Data

When reviewing recorded data and calculations, the channel # is selected and then the following information is displayed:

- channel #
- hour # (Hr)
- temperature (T)
- temperature-time factor (TTF)
- equivalent age factor (Age)

The <UP> and <DOWN> arrow keys are used to scan back and forth in the recorded data. Holding down either key causes auto scrolling. Only the current data being recorded or which has just been recorded may be viewed. Data that has previously been recorded but which has not been erased cannot be reviewed. This also applies to data transfers from other meters. This "hidden" data may only be output to a printer, computer or modem. It may also be transferred to another meter.

Viewing Meter Status

This function displays the following:

- available memory (in days)
- memory used (in days)
- battery voltage (minimum 5.5V)
- memory & clock backup circuit integrity

This function should be selected each time the meter is used to determine the condition of the battery and the available memory.

Parameter Setup

The following items may have their values or settings altered in this menu:

1. Datum Temperature [-10]
2. Activation Energy Constant [5000]
3. Equivalent Age Temperature [20]
4. Date & Time [PST]
5. Meter ID # [0]
6. Temperature Sensing Calibration [calibrated]
7. Memory Initialization [erased]
8. Phone # (for modem dialing) [blank]

The default values for these parameters when shipped from the factory are indicated in square brackets. Before using the meter, always check for proper parameter settings. The required settings will depend on the type of concrete being used and the expected temperature range. To gain familiarity with the subject of selecting parameters refer to ASTM C1074-87.

WARNING

Do not perform a memory initialization or calibration unless you are able to calibrate the temperature sensing circuitry. These functions are only to be used after the replacement of the clock/memory backup battery or if a memory corruption has occurred. To properly calibrate the temperature sensing circuitry, an ice bath (0°C) and a "hot" bath (30 to 40°C) must be prepared. There should be 4 thermocouple cables available for insertion into the baths. A thermometer accurate to 0.5°C should be used to determine the temperature of the "hot" bath. Follow the prompts on the display. Consult the factory if you experience problems.

The phone # can only be entered thru the use of a computer or data terminal. Do not try to enter a telephone # unless the appropriate equipment is available. When the prompt appears on the computer terminal display, enter the phone number without any spaces. Be sure to include all the required digits. ie. the phone number (416) 929-1000 should be entered as "14169291000".

The **<UP>** and **<DOWN>** arrow keys are used to change the values/settings (the scrolling feature can be activated by holding down the keys) in most of the parameter setup functions.

Recorded Data Output

There are 3 different ways to output recorded data from the meter. They are:

- formatted output to a serial printer or computer
- transfer meter-to-meter
- formatted output via modem

The **formatted output** is clearly labeled and can be included directly in reports using the Data Output Function. This Formatted Information may be sent directly to a serial printer or to a computer first, then to a printer or it may be imported into a spreadsheet program like Lotus 123(tm) for graph presentation of the data. Be sure to set the **baud rate** to match the printer/computer specifications.

There are times when a modem must be used to transmit the data over phone lines. The **modem transfer function** auto-dials the phone # stored in memory and waits for a proper connection before transmitting the formatted output. The transmitting modem should use the "AT" command set. The computer being used at the other end should have an autoanswer modem attached to it that is operating at the same baud rate as the maturity meter.

Almost any communications program may be used to record the transmitted data. Programs such as Perfect Link(tm) should be set to log data to a file before the phone call is placed. As soon as the phone call is autoanswered, the transmitted information will start to appear on the computer screen. When the call is completed, the data logging can be turned off and the file may then be edited with a standard ASCII file editor or it may be printed or imported into spreadsheets like Lotus 123(tm).

The **meter-to-meter transfer function** allows one meter to be used for data collection from all the meters on a construction site to a single meter and then data is then output from the collection meter to a printer, computer, modem etc.

The required cables for various equipment interconnections are described in the section The Communications Port. They may be ordered from distributors of this meter.

Alarm Conditions

The meter checks both the battery voltage and the memory and clock backup circuitry integrity every time it powers up and continuously monitors these voltages during meter operation. Warning messages will be displayed if there is a problem. The 6V Lead Acid battery should be recharged before the voltage drops below 5.5 volts.

The temperature sensing alarms include:

- low temperature, below -10°C (LTA)
- high temperature, above +90°C (HTA)
- channel off (unplugged) (OFF)

These alarms are displayed in the following menus:

- Present Values
- View Recorded Data
- Output Data
- Modem Output

Read the section on battery maintenance and check the battery voltage before the meter is used. Make sure that the meter lid has been fastened down securely so that the O-ring seal is water tight.

The Communications Port

Introduction

The communications port uses standard RS-232-C interface signals. This is the same standard used by IBM PC serial ports and serial printers. The handshaking protocol is XON/XOFF which eliminates the need for complex cables. If a serial printer is being purchased for use with the system 4101 maturity meter, make sure the XON/XOFF feature is included. Handshaking with an IBM PC is not as important because computers can normally accept data as quickly as the maturity meter can send it. Most communications programs do allow for XON/XOFF handshaking if required.

Modem Implementation

Before a modem can be used with the system 4101 maturity meter to transmit data remotely to another computer, some modem configuration requirements must be fulfilled. Check the modem manual to setup the transmitting modem for:

- "AT" command set
- DTR forced "ON"
- asynchronous operation
- proper BAUD rate (300/1200/2400)
- data format: 8 data bits
  1 start bit
  2 stop bits
  No parity
- DCD under modem control (not forced "ON")

The receiving modem must be configured for auto answering.

Modems vary from manufacturer to manufacturer and in a few cases, DCD (data carrier detect) can not be placed under modem control if DTR is forced "ON". DCD must become active when a communications link has been established with the answering modem. One way to get around this problem is to provide a positive voltage signal loop back from a modem output or test signal pin to the DTR pin. Then there is no longer any requirement to force DTR "ON" and DCD should be able to provide the required signaling to the system 4101 maturity meter.

Cables

There are 5 cables available for the system 4101 maturity meter:

A. 25 pin D shell serial cable for IBM PC
B. 25 pin D shell to 9 pin D shell serial adaptor cable for IBM PC
C. 25 pin D shell serial cable for modem
D. 25 pin D shell serial cable for serial printer
E. Meter to Meter Transfer Cable.

Cable B is required for IBM PC's with the smaller 9 pin D shell serial connector. It converts cable A's 25 pin connector to a 9 pin connector.

If the serial printer in use requires a female connector, use a "gender changer" adaptor. This and other cable supplies are available at local computer supply stores. Alternatively, cables may be obtained from distributors of this meter. Use the Connector Pinouts section of this manual to assemble cables for custom requirements.

Connector Pinouts

The following information may be helpful in assembling custom cables for non-standard applications.

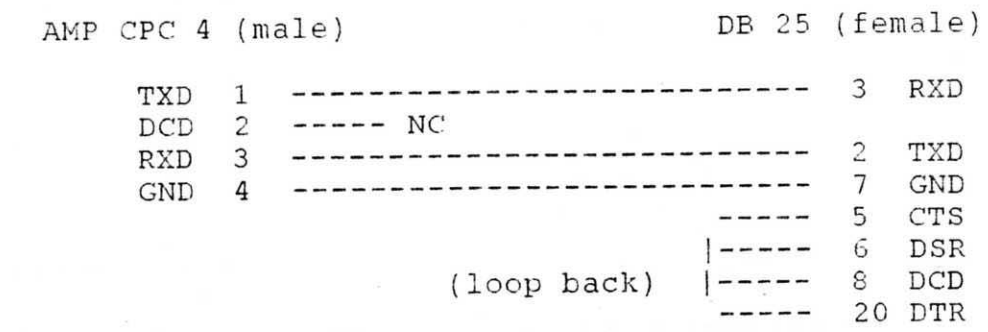
System 4101 Communications Port Connector:

1 - TXD

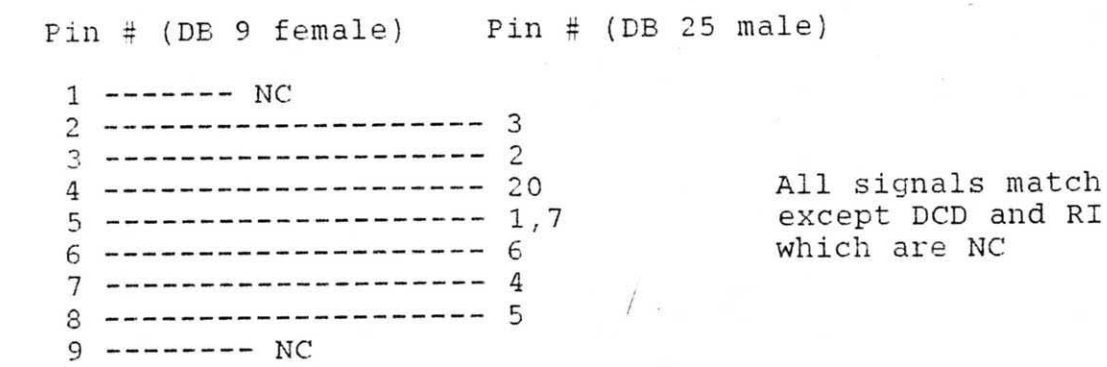
3 - RXD 2 - DCD

4 - GND

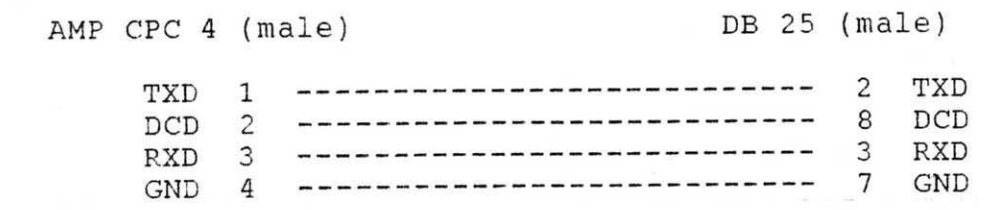
Maturity Meter to IBM PC Cable:



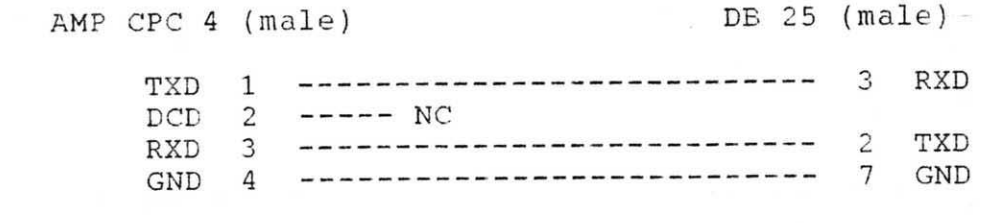
9 Pin Female to 25 Pin Male D Shell Adaptor Cable:



Maturity Meter to Modem Cable:



Maturity Meter to Printer Cable:



Maturity Meter to Maturity Meter Transfer Cable:

AMP CPC 4 (male)				AMP CPC 4 (male)	
TXD	1	----------		3	RXD
DCD	2	----- NC	NC -----	2	DCD
RXD	3	----------		1	TXD
GND	4	----------		4	GND

IBM PC Serial Port 25 Pin D shell, male type connector:

Pin #	Description		Direction
1	Frame Ground	GND	
2	Transmit Data	TXD	Output
3	Receive Data	RXD	Input
4	Request to Send	RTS	Output
5	Clear to Send	CTS	Input
6	Data Set Ready	DSR	Input
7	Ground	GND	
8	Carrier Detect	DCD	Input
20	Terminal Ready	DTR	Output
22	Ring Indicator	RI	Input

IBM PC Serial Port 9 Pin D shell, male type connector:

Pin #	Description		Direction
1	Carrier Detect	DCD	Input
2	Receive Data	RXD	Input
3	Transmit Data	TXD	Output
4	Terminal Ready	DTR	Output
5	Ground	GND	
6	Data Set Ready	DSR	Input
7	Request to Send	RTS	Output
8	Clear to Send	CTS	Input
9	Ring Indicator	RI	Input

Standard Loop Back for XON/XOFF Handshaking:

- Connect inputs DCD, DSR and CTS to output DTR

Modem 25 pin D shell, Female type connector

Pin #	Description		Direction
1	Frame Ground	GND	
2	Transmitted Data	TXD	Input
3	Received Data	RXD	Output
4	Request to Send	RTS	Input
5	Clear to Send	CTS	Output
6	Data Set Ready	DSR	Output
7	Ground	GND	
8	Carrier Detect	DCD	Output
20	Terminal Ready	DTR	Input
22	Ring Indicator	RI	Output

Field Preparation

Thermocouples

Thermocouple temperature sensors are used because they are economical and rugged. They are ideally suited to maturity meter applications as different length cables, deep sensor placement and complex form work are easily accommodated.

"T" type thermocouples made of copper - constantan are used. They are available in a wide range of wire sizes and insulation types, and are inexpensive. Thermocouple wire can be purchased from most wire companies and is available (along with standard connectors) from distributors of this meter.

Cable Preparation

To prepare a thermocouple temperature transducer you will need a length of "T" type thermocouple wire of 24 gauge or larger size and a standard "T" type thermocouple plug. These plugs are included with the meter and they are available through Maturity Meter distributors or any of a number of different manufacturers. For long cable runs use heavier gauge wire and if the situation warrants, consider the use of armoured cable.

The thermocouple wire has a polarity to it, the copper being the (+) side and the constantan (silver in color) being the (-) side. Disassemble the plug, separate the wire pair one inch (1") and strip half an inch (1/2") off of each lead. Making sure that the polarity is correct, connect the wires to the plug and reassemble.

To form the temperature transducer at the other end of the wire, strip the wire end as above but this time twist the two leads together (use a pair of pliers to insure that the connection is solid). The point where the wire leads are twisted together forms the temperature transducer. To make as permanent a connection as possible it is recommended that the wires be soldered as well. To prevent damage or corrosion, plastic dipping using a material such as "PLASTI-DIP" is also recommended.

Thermocouple cables may be prepared at the office so that site installation is accomplished in as efficient a manner as possible. Cables may be reused by cutting off old cables at the concrete interface and following the same procedure as for a new cable.

Meter and Thermocouple Placement

When using the meter on the construction site you should keep the following points in mind:

- the most common cause of Maturity Meter failures is from accidental damage. Secure the meter away from high traffic areas, material that might be moved when you're not around, and take care in transporting them.

- long cable runs can be a problem if routed through high traffic areas or around material that might be moved. Try to keep the cable lengths as short as possible while making it easy to read the meter's display.

- Concrete is very dense and can rip thermocouple wires when being poured. Vibrators are often used which can cause the reinforcing bars and mesh to vibrate violently. To reduce the possibility of transducer failure, carefully place the wires around the reinforcing bars. Make sure the wiring is done before the forms are completed. For critical areas, wire more than one thermocouple so that you have a backup if a transducer "open circuit" occurs.

- The exterior surface of the meter may be kept clean by protecting it in a case. Contact with wet concrete is to be avoided.

To avoid over estimating the concrete strength, try to place the temperature sensor in a cooler section of the concrete placement. See ASTM standard C1074-87 for more information.

Appendix

Battery Maintenance

The Maturity Meter uses a rechargeable Sealed Lead Acid battery. It is an excellent battery, which will stand up to rough operating conditions like low and high temperature extremes. Under normal conditions the battery charge life will be more than 1 year.

Using the meter continuously for long periods (eg. reviewing recorded data on the display) will increase battery drain significantly. The battery charge life will be reduced to 60 hours if the meter is left on continuously. If the meter is manually powered on for short periods of time on (meter recording only), the battery charge life will be greatly extended. Recharge the battery fully if the voltage is less than 5.5 volts. Use the Meter Status menu to read the battery voltage.

Meter operation above or below 20°C temperature will reduce the battery capacity slightly.

To avoid backup battery drain during storage, always fully charge the battery and stop recording before storage.

Meter Care and Attention

The Maturity Meter is housed in a polycarbonate enclosure which is an extremely strong material. It resists scratching, maintains its flexibility over a wide range of temperatures and is impervious to most solvents. With occasional washing the enclosure will stay looking good for a long time.

Cement is hydroscopic in nature and contact with the enclosure will eventually cause the lid machine screws to become devoid of lubrication. A drop of oil will make the screws easier to loosen.

The thermocouple jacks should be kept free of any dirt or concrete dust. Electrical contact cleaner is not recommended but alcohol and a small wire brush could clean out stubborn dirt.

Maturity Concept Theory

In the last few years there has been a good deal of investigative work done in area of concrete strength determination through electronic temperature measurement. This work is based on the findings of J.M. Plowman, who first advanced the time-temperature rate of gain of strength in portland cement concrete in 1947.

There are various methods of relating the concrete time-temperature data to strength, but most methods employ the integrated value of temperature with time. The "maturity value" is given by:

$$M = SUM[t(T + 10)]$$

where M = Maturity (degrees C * hours)
T = Average concrete temperature (degrees C)
t = Duration of curing (hours)

Interpolation of integrated temperature values on pre-determined strength versus time-temperature graphs enables instant strength calculations. Because concrete continues to gain strength down to about -10 degrees Celcius this value is usually used as the integration "datum temperature".

An alternate way to determine concrete strength is via the "equivalent age" calculation. This calculation enables strength comparisons between a laboratory cured concrete cylinder at temperature 'X' and the concrete being monitored at the job site. The calculation uses the laboratory temperature 'X' ("equivalent age temperature") and the concrete "activation energy" constant to compare the relative curing time of the construction concrete to the laboratory concrete.

Although different concrete mix designs exhibit similar curing characteristics, each should be tested to determine its exact strength/maturity relationship.

Maturity Values are converted to strength estimates through the use of prediction equations. **The subject of converting maturity values to concrete strength estimates is dealt with extensively in the ASTM (American Society for Testing and Materials) Standard C1074-87.** Anyone using maturity meters should obtain a copy of this standard either through your local library or directly through ASTM. This standard also provides instructions on how to select maturity function constants (parameters) for different types of concrete and gives clear example calculations.

Specifications

Temperature Measurement

Sensor Measurement Range	-10°C to +90°C
Accuracy	±1°C
Thermocouple Wire	Type T

Data Recording

Memory Capacity	32K bytes
Data Capacity	10 months x 4 channels
Recording Interval	Every 1/2 hour up to 48 hours Every 1 hour thereafter

Communications

I/O Port	Serial RS-232C
Handshaking	Xon/Xoff
Modem Control	DCD
Data Format	ASCII
Baud Rates	300, 1200, 2400, 4800, 9600 (selectable)

Batteries

Computer Power	6V 2.4 AHr Lead Acid Battery (Panasonic LCR6V2.4P)
Charge Life	Up to 1 Year at 20°C
Memory/Clock Backup	3.6V Lithium 1/2AA, 0.750 AH
Service Life	Up to 10 years ar 20°C

Mechanical

Dimensions	7.8" x 4.7" x 2.9"
Case Material	Polycarbonate
Weight	2.9 lbs
Thermocouple Connectors	Omega SMP-T-M(plug)
I/O Connector	AMP CPC-1: 206429-1(plug), 206062-1(clamp), 66103-2(pins)

Environmental

Operating Temperature	-20°C to +50°C
Enclosure	Splash Resistant, Impact Resistant

Maturity Value Calculations

Programming:

Datum Temperature Range	-20°C to +40°C
Equivalent Age Temperature	0°C to +40°C
Activation Energy Constant	0 to 20000°K

Maximum Maturity Values Displayed:

Temperature-Time Factor	99999°C hours
Equivalent Age Factor	9999 hours

Part Number	Manuf.	Description	Qty	Unit Cost	Source	Designator Numbers
Semiconductors						
P80C32 or P80C51FA	MHS Intel	8 bit microprocessor, 12MHz, CMOS	1	7.15	Semad	U7
27C256-20	NEC	32K x 8 CMOS EPROM, 200ns	1	7.04	Future	U10
43256-15L or -12L	NEC	32K x 8 CMOS RAM, low power, 150ns	1	17.50	ITT-RAE	U13
74HC/HCT373		Octal D type latch	2	0.51	Zentronics	U6, U8
74HC/HCT374		Octal D flip flop	1	0.55	ITT-RAE	U5
74HC/HCT138		3 to 8 line decoder	1	0.44	Zentronics	U9
74HC/HCT00		Quad 2 input NAND	1	0.23	Future	U11
74HC02		Quad 2 input NOR	1	0.25	ITT-RAE	U4
74HC/HCT08		Quad 2 input AND	1	0.23	Future	U12
74HC32		Quad 2 input OR	3	0.23	Future	U1, U2, U3
MAX690CPA	Maxim	Processor Supervisor	1	5.58	Future	U15
ICL7170-IPG or -AIPG	Intersil	Real Time Clock	1	7.46	ITT-RAE	U14
4011		Quad 2 input NAND	1	0.18	ITT-RAE	U21
4051		8 input Analog MUX	1	0.33	Future	U18
TL080-CN or -CP	TI	Single Op-amp	1	0.49	Future	U20
TL064-CN or -CP	TI	Quad Op-amp	1	1.50	Future	U17
LM2931-AZ-5.0	National	5 Volt Low Dropout Regulator, TO-92	1	0.69	Zentronics	U19
AD7523-AD or -JN	Intersil ADI Exar	8 bit CMOS D/A	1	2.89	Zentronics	U16
ICL7660CPA	Intersil Exar	DC to DC converter	1	1.67	Zentronics	U28
1403-AN or -AU	ADI	2.5 Volt Reference	1	2.95	Future	U24
AD592AN	ADI	Temperature Transducer	1	6.90	BBD	U25
OP-07EN or LT1001CN8	ADI LTI LTI	Op-Amp	4	1.95	ITT-RAE	U22, U23, U26, U27
1N4148		Signal Diode	7	0.02	Zentronics	D1, D2, D3, D4, D6, D11, D12
1N5344B		8.2V/5W Zener Diode	1	0.90	ITT-RAE	D8
1N5817 or 1N5819		Schottky Diode	4	0.27	ITT-RAE	D5, D7, D9, D10
2N3904		NPN Transistor	3	0.05	Zentronics	Q4, Q5, Q7
2N3906		PNP Transistor	4	0.05	ITT-RAE	Q1, Q2, Q3, Q6
IRFF120		FET Transistor	1	1.76	ITT-RAE	Q8
Crystals						
MP-1-12.000	Mtron	12 MHz, HC18/U	1	0.81	ITT-RAE	CX1
MMCC-1	Mtron	32.768 KHz, "At" Cut, Series Crystal	1	0.54	ITT-RAE	CX2

Part Number	Manuf.	Description	Qty	Unit Cost	Source	Designator Numbers
Capacitors						
CN15A150K1 or SR151A150JAA AVX	Centralab	15pF/50V NPO mono, 0.1" spacing	2	0.28	Future	C23, C24
CN15A330K1	Centralab	33pF/50V mono, radial, 0.1" spacing	2	0.11	ITT-RAE	C17, C18
UDW104M1	Thomson	0.1uF/50V mono, radial, 0.1" spacing	45	0.07	ITT-RAE	C1,C2,C3,C4,C5,C6,C7,C8,C9,C10,C11,C14, C15,C16,C20,C21,C22,C25,C27,C28,C29,C30, C31,C32,C33,C34,C35,C36,C37,C38,C39,C40, C41,C42,C43,C44,C45,C46,C47,C48,C49,C50, C51,C57,C58
C330C105M5U1CA	Kemet	1uF/50V mono, radial, 0.2" spacing	2	0.55	ITT-RAE	C54, C55
TAP106M16SP	ITT	10uF/16V Tantalum, radial, 0.1" spacing	8	0.25	Future	C12, C13, C19, C52, C53, C56, C59, C61
TAP156M10	ITT	150uF/10V Tantalum, radial, 0.1" or 0.2" spacing, 0.25" dia. max, 0.5" length max	1	1.59	ITT-RAE	C26
TLB1C222MCA	Nichicon	2200uF/16V Electrolytic	1	0.88	ITT-RAE	C60
Resistors						
1R0		0.25w, 5%, tape on reel	1	0.008	Intek	R53
47R0			2	0.008	Intek	R26, R27
1K0			1	0.008	Intek	R12
4K7			2	0.008	Intek	R6, R7
10K0			2	0.008	Intek	R2, R11
22K0			1	0.008	Intek	R1
27K0			2	0.008	Intek	R3, R8
100K0			4	0.008	Intek	R18, R19, R20, R50
470K0			3	0.008	Intek	R4, R9, R10
1M0			3	0.008	Intek	R5, R13, R28
412R0		0.25w, 1%, 50ppm/C, tape on reel	4	0.025	Zentronics	R34, R38, R44, R48
806R0			1	0.025	Zentronics	R30
1K0			8	0.025	Zentronics	R35, R36, R39, R40, R42, R43, R46, R47
10K0			1	0.025	Zentronics	R21
60K4			1	0.025	Zentronics	R31
100K0			2	0.025	Zentronics	R29, R32
110K0			6	0.025	Zentronics	R15, R17, R33, R37, R45, R49
121K0			1	0.025	Zentronics	R51
374K0			5	0.025	Zentronics	R22, R23, R24, R25, R52
1M0			2	0.025	Zentronics	R14, R16
MFP RNC55J40R2BS	TTI	40.2 ohm, 0.25w, 0.5%, 25ppm/C, taped	1	0.42	TTI	R41
RSN2	Piher	4.7 ohm, 2w, 5%	1	0.13	ITT-RAE	R54
L101C103	Beckman	10 Kohm x 9 common SIP	1	0.25	ITT-RAE	RS1
L083C103	Beckman	10 Kohm x 4 isolated SIP	1	0.19	ITT-RAE	RS3
L103C104	Beckman	100 Kohm x 5 isolated SIP	1	0.19	Zentronics	RS2
66/68 WR100	Beckman	100 ohm, 20 turn potentiometer	4	1.54	ITT-RAE	RP2, RP3, RP4, RP5
66/68 WR20K	Beckman	20 Kohm, 20 turn potentiometer	1	1.54	ITT-RAE	RP1

Part Number	Manuf.	Description	Qty	Unit Cost	Source	Designator Numbers
Batteries						
TL5101T/P	Tadiran	3.6V Lithium, 1/2AA, 850 mAH, solder tabs	1	7.43	In Stock	B1
LC36V2.4P	Panasonic	6V, 2.4AHr, Sealed Lead Acid Battery	1	10.20	Micropower	B2
Connectors & Plugs						
FSK-22A-14	Ansley	14 Conductor Flex Strip for LCD	1	4.80	Marshall	LCD1
22-23-2061	Molex	6 x 1 Row Straight Pin Contact for Power	1	0.42	Zentronics	P3
22-23-2051	Molex	5 x 1 Row Straight Pin Contact for Kybd	1	0.34	ITT-RAE	P1
22-23-2041 or 1100-6-104-01 Methode	Molex	4 x 1 Row Straight Pin Contact for Comm Port	1	0.40	ITT-RAE	P2
AW104/11.2/Z36	Assman	0.1" Single Row Header Pins, 2 x 1	1	0.11	Intek	JP1
22-01-2041	Molex	Female Housing to Mate with above, 4 x 1	1	0.15	Zentronics	
22-01-2061	Molex	Female Housing to Mate with above, 6 x 1	1	0.22	Zentronics	J3
08-50-0114	Molex	Contact Pins for above, Tin	10	0.06	Zentronics	
RMJ-T-S	Omega	Panel Jack, Type T, Subminiature	4	2.19	Omega	
SMP-T-M	Omega	Plug, Type T, Male, Subminiature, 2 spare	6	1.97	Omega	
206430-1	AMP CPC-1	Square Flange Receptacle	2	1.55	ITT-RAE	
206903-1	AMP CPC-1	Sealing Cap with Plastic Strap	2	2.04	ITT-RAE	
66105-2	AMP CPC-1	Socket Contact, Tin	8	0.23	ITT-RAE	
2-640362-3	AMP	28 Pin Machine Contact IC Socket for PROM	1	0.28	ITT-RAE	
T-2002	Waldom	22-16 Gauge Ring Terminal for Shielding Wire, #6 Hole Size (Top Housing)	1	0.10	ITT-RAE	
T-2021	Waldom	22-16 Gauge Ring Terminal for Shielding Wire, #8 Hole Size (Bottom Housing)	1	0.10	ITT-RAE	
SS-1187	Waldom	Female 0.187" Faston Terminals for Bat	2	0.10	ITT-RAE	
General						
LM16255 or GMD16202 or 3802-09-032 or EA-D16025AR	Sharp Stanley IEE EPSON	2 x 16 character LCD, wide temperature (Sharp is prefered)	1	19.50	Future	
14454	Brady	2 x 3 membrane keyboard, 3/4" centers	1	13.98	ITT-RAE	
33.122008	Rose	Polycarbonate Enclosure	1	29.12	Memco	
10052251-00	Rose	Set of 4 rubber feet	1	3.60	Memco	
Front Label	Sytek	See Spec Sheet	1	8.00	Sytek	
ID Label	Sytek	See Spec Sheet	1	0.70	Sytek	
PCB	Sterling	2 Layer Printed Circuit Board	1	17.65	Sterling Circuits	
3145	Silicon	RTV Silicon Sealant Tube	0.1	15.00	In Stock	
MS-455N	Miller-Stephenson	Milshield Conductive Coating Spray Can	0.25	16.00	Miller-Stephenson	
422	MG Chemicals	Conformal Coating Spray Can	0.25		In Stock	
MW-24-T	Watt-Pearson	Type T Thermocouple Wire, 24 gauge	50 ft	0.20	Watt	

Part Number	Manuf.	Description	Qty	Unit Cost	Source	Designator Numbers
8503	Belden	22 Gauge Stranded Hook-Up Wire: Grey	14.5"	0.01	ITT-RAE	
		Yellow	5.0"	0.01	ITT-RAE	
		Red	5.0"	0.01	ITT-RAE	
		Black	9.5"	0.01	ITT-RAE	
Hardware						
#8-32 x 1/4"		Machine Screw, Pan Head, for Bottom Housing Shielding Wire	1		All Hardware Supplied by Assembly House	
#8		Internal Star Washer for above	1			
#6-32 x 1/2"		Machine Screw, Pan Head, for PCB Mounting	4			
#6		Internal Star Washer for above	5			
#6-32 x 1/2"		Machine Screw, Flat Head, for Top Housing Shielding Wire	1			
#6-32		Hex Nuts for above	2			
#4-40 x 1/2"		Machine Screw, Flat Head, Black, for Com Port and Charge Port Mounting	8			
#4-40 x 5/8"		Machine Screw, Pan Head, Black, for Com Port and Charge Port Mounting	2			
#4-40		Hex Nut for above	10			
#4		Internal Star Washer for above	10			
#4		Flat Washer, Black	2			
#2-56 x 3/4"		Machine Screw, Pan Head, for LCD Mounting	4			
608-009	Spae-naur	#2 Clearance, 3/16" x 5/8" standoff	4			
Custom		Brass PCB Mounting Standoff, 1.44", See Specification Drawing	4			
Custom		Aluminum Battery Strap, 0.040" See Specification Drawing	1	3.00	Candu	
P-756NKC	PMP	#2 PC Board Captive Press Nuts	4	0.07	Deskin Sales	
Packaging Materials						
MB0812	Force Field	Anti-static Bag, 8" x 12", Metallized	1	0.91	ITT-RAE	
JL0202	Force Field	Anti-static Sticker	1	(inc)	ITT-RAE	
Custom	Instabox	Cardboard Box	1	4.17	Instabox	
Custom	A-Z Sponge	Foam Insert	1	(inc)	A-Z Sponge	
Manual		Operating Guide	1		office photocopy & bind	
Accessories						
206429-1	AMP CPC-1	Plug Size 11-4	1	1.99	ITT-RAE	
206062-1	AMP CPC-1	Cable Clamp	2	2.14	ITT-RAE	
66103-2	AMP CPC-1	Pin Contact, Tin	6	0.20	ITT-RAE	
BA3630	Armaco	6V, 300mA AC/DC Wall Adaptor	1	8.50	ITT-RAE	

The above parts are required for the assembly of any of the cables listed in the operating guide appendix

Introduction

Full ESD protection must be provided at all times during assembly and testing. This includes the use of wrist straps, mats and proper handling and storage containers.

To assist in the Assembly and Quality Control of the Model 4101 Concrete Maturity Meter, a sample of a working meter should be partially disassembled and made available for reference.

Printed Circuit Board Assembly

Obtain a copy of the parts placement drawing before starting.

1. Mask off holes for the following components:

   - PCB standoff holes (4)
   - LCD mounting holes (4)
   - B1 pads
   - LCD1
   - All 8 Thermocouple inputs
   - U25
   - P2, P3
   - one pad of R53 (install this component but leave one lead straight for later test and assembly)

* QA all boards for correct masking before stuffing.

2. Stuff all components (except those listed above) into PCB while taking note of polarity sensitive devices. U10 is a 28 pin socket.

* QA all boards for correct component lead forming, placement, position etc. before wave soldering.

3. Wave solder boards. Wash and Dry.

4. Perform any required rework to seat floated components, etc.

5. Press in the 4 captive nuts (this may have to be done before the PCB is stuffed).

6. Serialize the board.

7. Hand stuff the following components:

- LCD1 connector flex strip
- U25 (solder side mounting)
- P2 " " "
- P3 " " "

* QA all boards for proper soldering and general assembly workmanship at this point.

8. Solder B1 to solder side of the board and then immediately apply a 6V source to the PCB via a test cable to P3. Remove 6V source and then measure voltage across U13 pins 14 and 28. Remove B1 if voltage is less than 3.5 volts and note problem on travel card. Send board to the repair center (see "Battery/Charge Port Wiring Details" for P3 pinout).

9. Solder LCD module onto 14 contact flex strip. Do not mount to PCB with hardware at this point.

Printed Circuit Board Testing

1. Insert the Production Test Program Eprom into socket U10. This program tests the hardware operation of the PCB. The messages are sent to both the serial port (P2) and the LCD. Use the travel card to note any problems encountered during this test. If any portion of the test fails, send PCB to the repair center.

2. The watchdog timer must be disabled during the initial stages of testing. This is accomplished by ensuring that one side of R53 is disconnected. (Note: After testing is completed, finish soldering R53 onto PCB).

3. Plug in a spare membrane keyboard into connector P1.

4. Connect a terminal to P2 using a est cable. Set baud rate to 9600.

5. Insert 6V battery or attach leads from a 6V power supply via P3 Test Plug (circuit damage will result if applied voltage is greater than 8.5 volts).

6. Press any key on the lower row of the keyboard to turn unit on. Adjust display contrast using RP1. Look at terminal if no activity is present on the LCD.

A description of the test software follows:

Initial Power Up

1. Memory locations are checked to see if previously stored test pattern data is intact. If data is present, program jumps to Backup Memory Test, otherwise the message "Backup RAM FAIL" appears. This is a normal message during Initial Power Up.

LCD Testing

1. Display is written to and status data is read back.

Serial Port

1. Characters are sent to the terminal. These characters must be typed in correctly or this test will fail.
2. If both LCD and serial port tests fail then '00' and 'FF' values are alternately sent to the D/A (slowly). This causes a square wave output waveform on U17/ pin 1 which is for debug purposes only (indicates proper processor operation).

RAM Memory Testing

1. All RAM memory locations are tested.

EPROM Testing

1. Test patterns located in the EPROM memory are examined.

CLOCK Testing

1. The Clock (U14) is programmed for normal operation.
2. Programmed values are read back and verified.
3. Time increment (seconds) is checked.

D/A Ramp output

1. A saw tooth waveform is output on U17/ pin 1 for 5 seconds for debug purposes only.

Keyboard

1. Values are read from keyboard in a defined order.

Battery Voltages

1. Each battery voltage is read and displayed. If the voltage is out of range, a failure message is displayed.

Memory Backup

1. Test patterns are written to RAM and CLOCK.
2. The power is turned off.
3. Turn power back on by pressing a key on the lower row of the membrane keyboard.
4. If memory is intact then the test will continue from here.

Temperature Measurement

1. Use a wire to short out the PCB pads for TC input #1.
2. The temperature value is measured and displayed. If the measured temperature is out of range, a failure message is displayed.
3. Repeat for channels 2, 3 and 4

Watchdog timer

1. A message is displayed requesting the replacement of the watchdog jumper (R53). Press the Resistor back in place and press ENTER on the membrane keyboard.
2. The meter should turn off in less than 2 seconds.

Printed Circuit Board Repair

Obtain copies of the schematics and a functional meter before starting. Visually inspect the board for clean solder joints, shorts, opens, correct component placement and polarities etc. before starting. Use the Production Test Software and disable the watchdog timer.

If the meter failed one of the software tests debug the associated circuitry. If there is no meter operation check the following:

1. Power up the meter. Disable the processor auto power off circuitry by installing a shorting block at JP1. Check all power supply lines for proper voltage levels.

2. Look at processor ALE, RD, WR and oscillator pins for proper operation. Check reset signal for proper operation (enabling the watchdog will reset the processor every 1.6 seconds).

3. Look for debug waveforms on U17/ pin 1.

Enclosure Assembly

1. Mask off outside of enclosure Top and Bottom Housings and LCD window area as noted in the Model 4101 Top Cover Machining Detail Drawing. Spray the inside surfaces with an even coating of the Metalized EMI spray. Let dry thoroughly. Mask off the Bottom Housing internal bosses and the Top Housing #6 screw mounting hole area and apply a complete coating of conformal spray. Remove all masking and then let dry thoroughly.

2. Machine enclosure Top and Bottom housings as per the Model 4101 Machining Detail Drawings.

3. Mount panel jacks (RMJ-T-S).

4. Cut thermocouple (TC) wires to 5" lengths and strip both ends.

5. Attach TC wires to the panel jack screw terminals while taking note of the polarity of the wires.

6. Prepare the Com Port and Charging Port Wire/Connector Assemblies as per "Model 4101 Com Port Wiring Details" and "Model 4101 Charging Port Wiring Details" Diagrams.

7. Mount the Com Port and Charging Port Connectors using the black flat head #4-40 x 1/2 screws, star washers and nuts with the Sealing cap strap being attached by the bottom right Black Pan Head $4-40 x 5/8" screw and flat washer (use the bottom left screw for the charging port).

8. Seal TC screw terminals, "socket tunnels" on the panel jacks and both of the Ports with silicone #3145. **Use additional silicone sealant on the connector/enclosure interfaces to provide a watertight barrier.**

9. Push or Tap the custom Brass standoffs into place after dispensing a small drop of Loctite Black Max adhesive in each plastic boss.

10. Attach the 6 Volt Panasonic Battery with Silicon 3145. Immediately install the battery strap using #4-40 Flat Head screws through the bottom of the enclosure. These mounting holes must be sealed to retain a water tight barrier.

11. Attach the #8 shield wire ring terminal to the Bottom Housing top right internal plastic boss using a #8-32 x 1/4" screw and star washer.

12. Attach the #6 shield wire ring terminal to the Top Housing using the flat head #6-32 x 1/2" screw, star washer and 2 nuts.

13. Attach the Black and Red quick dis-connect leads from the Battery Charge Port Assembly to the battery terminals (note correct polarity).

14. Attach the membrane keyboard and Top Label to the Top Housing.

Meter Final Assembly

1. Insert latest software EPROM into the U10 PCB socket and then mount display using #2-56 hardware and standoffs.

2. Solder on TC wires from the solder side of the board with the silver wires going to the common center holes. Position PCB onto Standoffs.

3. Plug Com Port and Charge Port cables into P2 and P3 connectors. Mount the PCB on the standoffs using #6-32 x 1/2" screws and star wahers.

4. Connect membrane keyboard connector to P1 and replace Top Cover. Turn on/off meter to check for proper operation.

5. Attach ID label to the Bottom Housing.

Meter Calibration

2 temperature baths are required for this calibration. One bath is to be at 0°C (ice bath) and the other is to be at 30 to 40°C. The "hot" bath must be at a known temperature. Both baths are to have thermometers accurate to within 0.5°C installed. The containers should be well insulated. Occasionally check the "ice" bath for proper temperature. Each bath is to have 4 TC sensor cables available for connection to the meters being calibrated. **Do not handle the circuit boards for 5 minutes before this test is conducted.**

1. Connect the "ice" bath sensors to the meter.

2. Power up the meter. Trim the RP2 - RP5 potentiometers (channel 1 to 4) for 0.000 volts at the following points:

Channel 1	U18/ pin 13
2	14
3	15
4	12

Use U18/pin 8 as the ground reference point for all measurements. Make the above measurements as quickly as possible to avoid component self heating effects (which will cause the voltages to drift). If the voltage is out of range, check the TC wires for proper mounting polarities. Turn the meter power off as soon as these trims have been made.

3. Turn the meter power on. Go to the setup menu and select the **Memory Initialization** mode. Once the memory has been cleared, select the **Calibration** mode. Follow the display prompts. When the "hot" bath is requested, disconnect the "ice" bath sensors and connect the "hot" bath sensors to the meter. Carefully read the "hot" bath temperature and enter into the meter when requested.

4. After the calibration is complete, check the displayed temperature on all channels in the "hot" and "ice" baths. Reading should be within 1 degree of actual temperatures. If there is a problem, repeat the above procedure.

5. Apply a small amount of Silicone sealant to the tops of the potentiometers.

6. Also set the time and date and adjust the LCD contrast.

Packaging

The meters are to be shipped with the following accessories:

- 4x10 foot TC sensors
  [soldered and plastic coated on one end, attached to TC plugs (SMP-T-M) on the other end]
- 1 spare TC plug
- Users Guide
- Warranty Policy/Service Information Card

Travel Card

The travel card should be produced on cardboard stock with the following information:

- meter serial number
- board revision level
- date
- technicians initials

Software Test (Pass/Fail):

- system failure
- display
- serial port
- RAM
- EPROM
- Clock
- D/A
- Keyboard
- Batteries
- Memory Backup
- Temperature Measurements
- Watchdog Timer

Final Assembly Test:

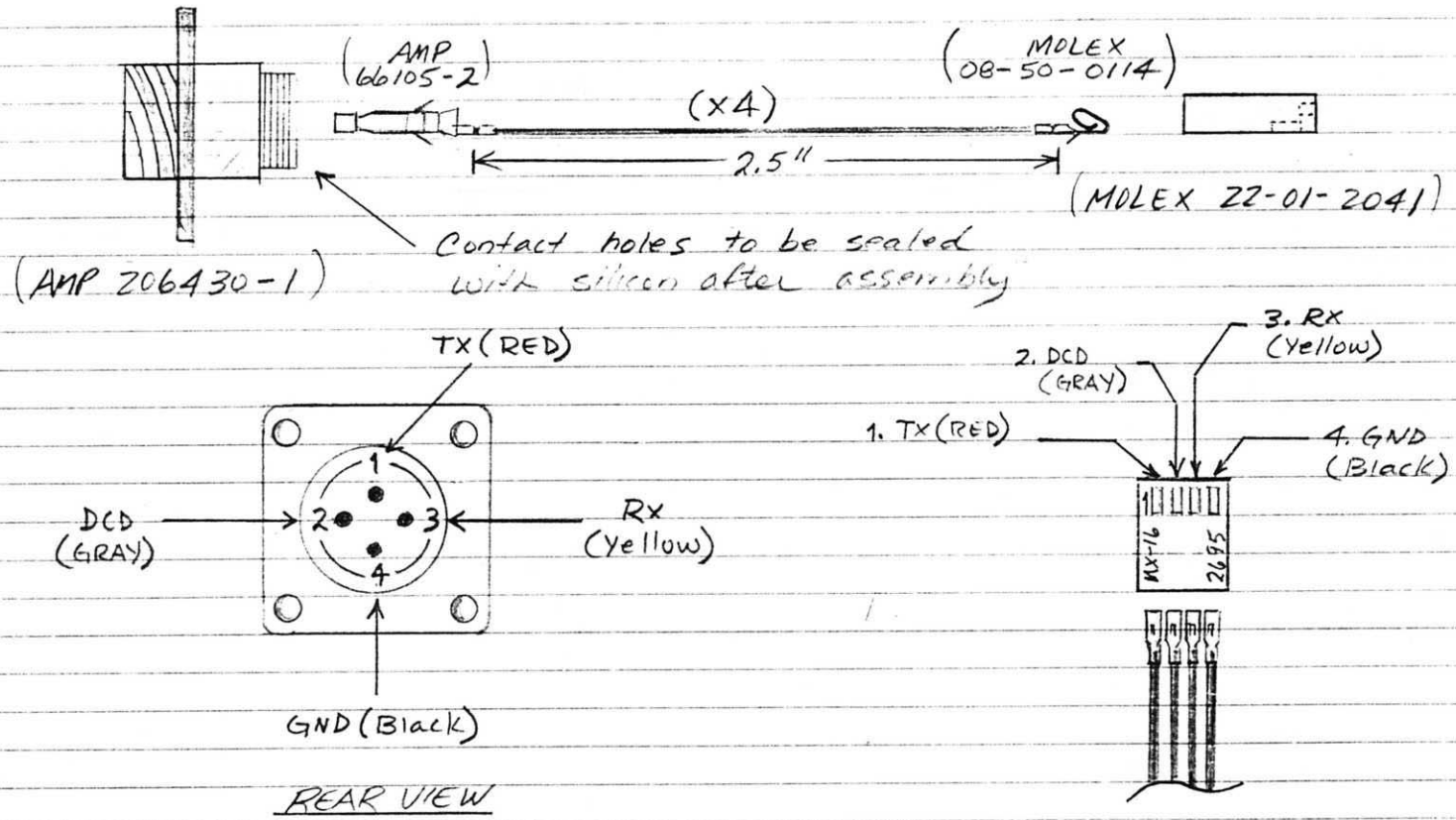
- memory initialization
- calibration
- display contrast adjust
- set date and time

+ Repair Center Comments

DNS ELECTRONICS

CMM4101 - COM. PORT WIRING DETAILS

17 JULY 89

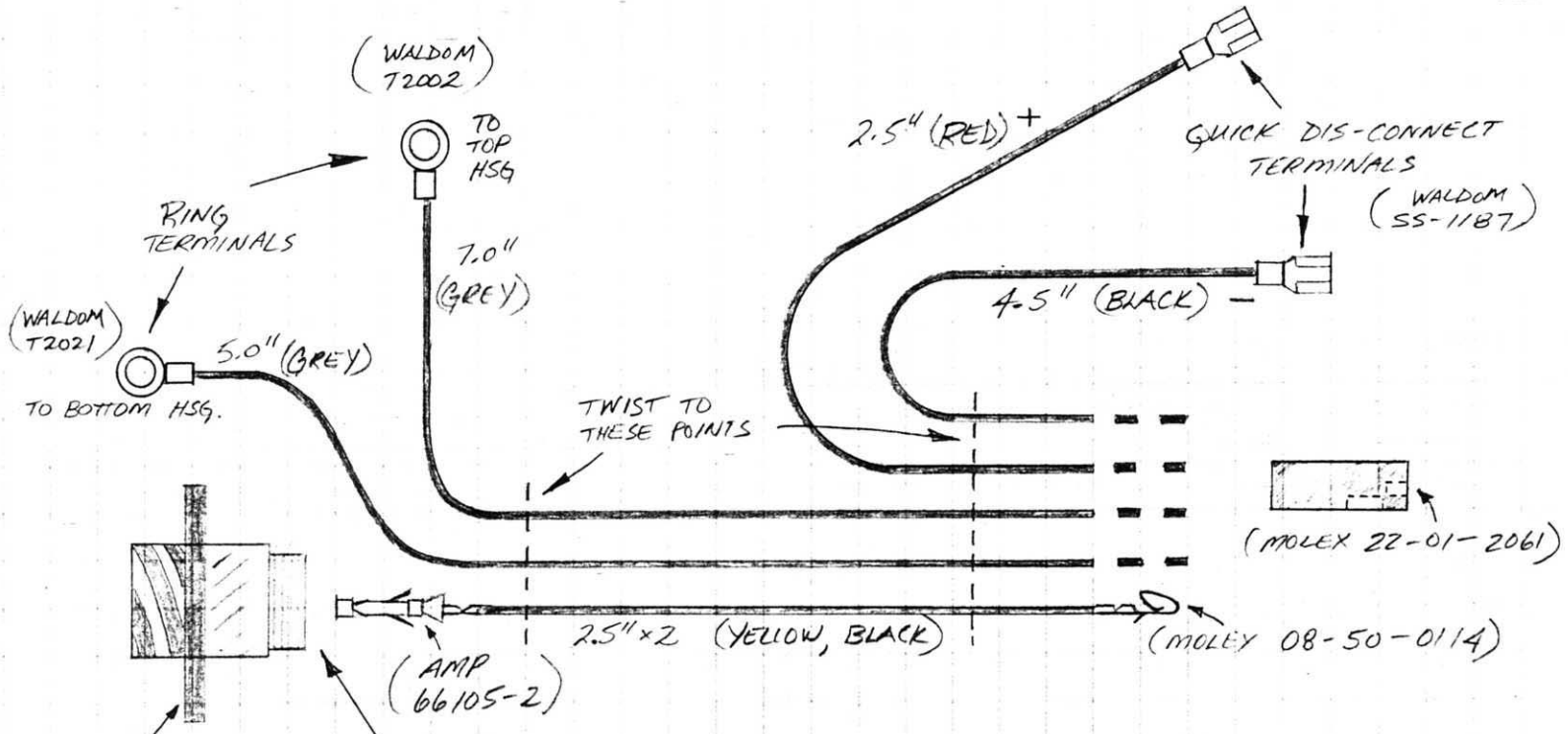


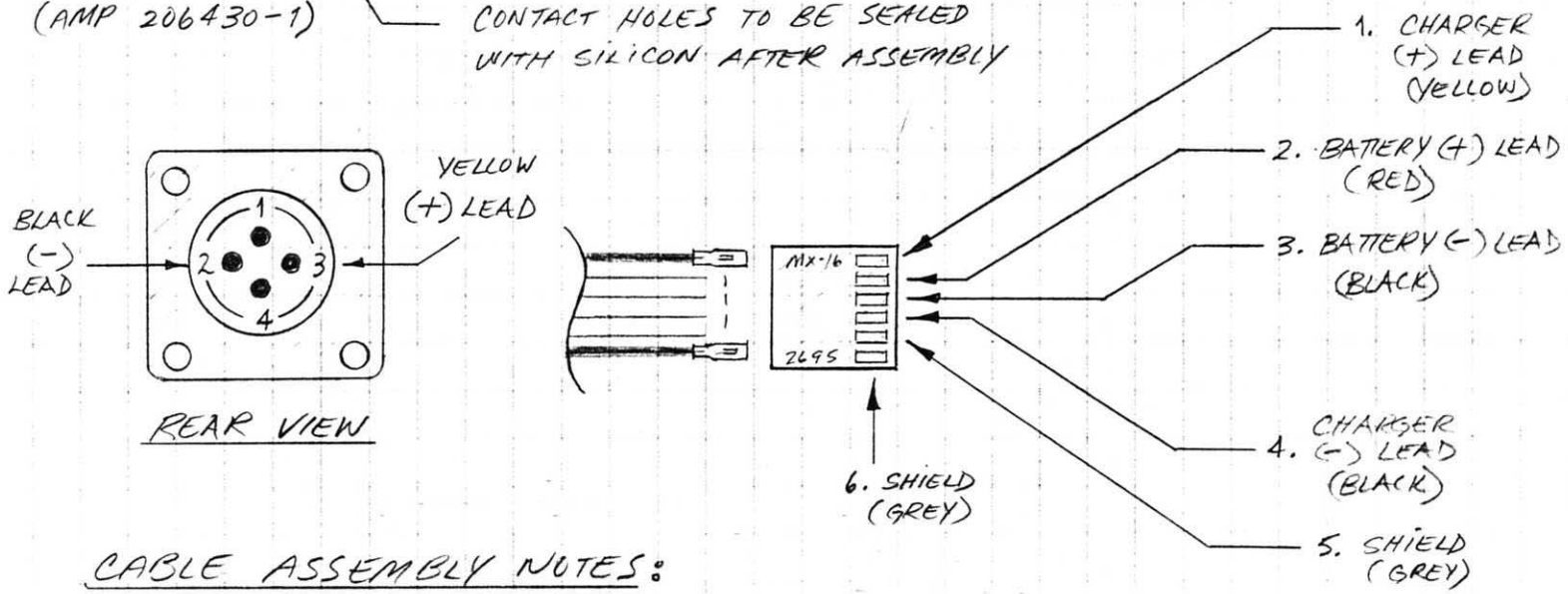
CABLE ASSEMBLY NOTES:

- Crimp Amp socket contacts and Molex pin terminals to precut 2.5" wire lengths. (4 per cable: Red, Yellow Gray, Black.
- Insert socket contacts into the AMP square flange receptacle and seal this end with silicon #3145.
- To complete, insert Molex pins into the pin sleeve (22-01-2041) following the above diagram. Twist the four signal wires together for better appearance.

CMM4101 - BATTERY CHARGE PORT WIRING DETAILS

17 JULY 89





CABLE ASSEMBLY NOTES:

① CRIMP SOCKET CONTACTS, RING TERMINALS, & QUICK DISCONNECT TERMINALS TO THE APPROPRIATE WIRE LENGTHS AND COLOURS. SEE ABOVE DIAGRAM.

2.5"	RED	- BATTERY (+) TERMINAL
2.5"	YELLOW	- CHARGER (+) LEAD
4.5" + 2.5"	BLACK	- UNSWITCHED GND :- BATTERY (−) TERMINAL - CHARGER (−) LEAD.
5.0" + 7.0"	GREY	- TOP & BOTTOM CASE SHIELDS.

CMM4101 – CHARGE PORT
DETAILS CON'T

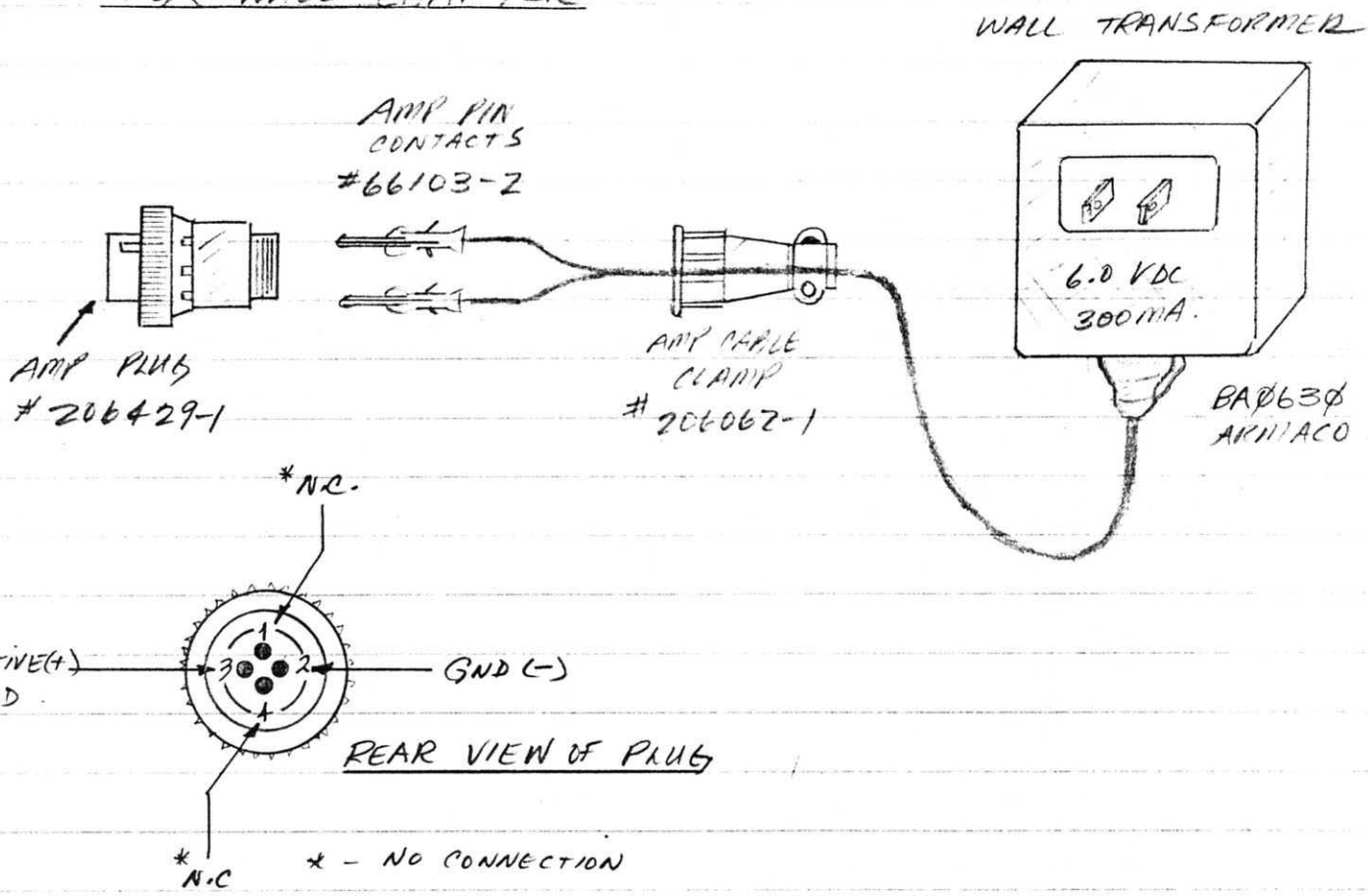
17 JULY 89.

(2) CRIMP MOLEX PIN TERMINALS TO THE OPEN WIRE ENDS. THEN INSERT THESE PINS INTO THE MOLEX PIN HOUSING (22-01-2061) AS SHOWN ON THE PREVIOUS PAGE.

(3) TIE WRAP OR TWIST WIRES TOGETHER TO FORM A NEAT CABLE BUNDLE.

(4) TO COMPLETE, INSERT THE AMP SOCKET CONTACTS INTO THE AMP SQUARE FLANGE RECEPTACLE AND SEAL THIS END WITH SILICON #3145.

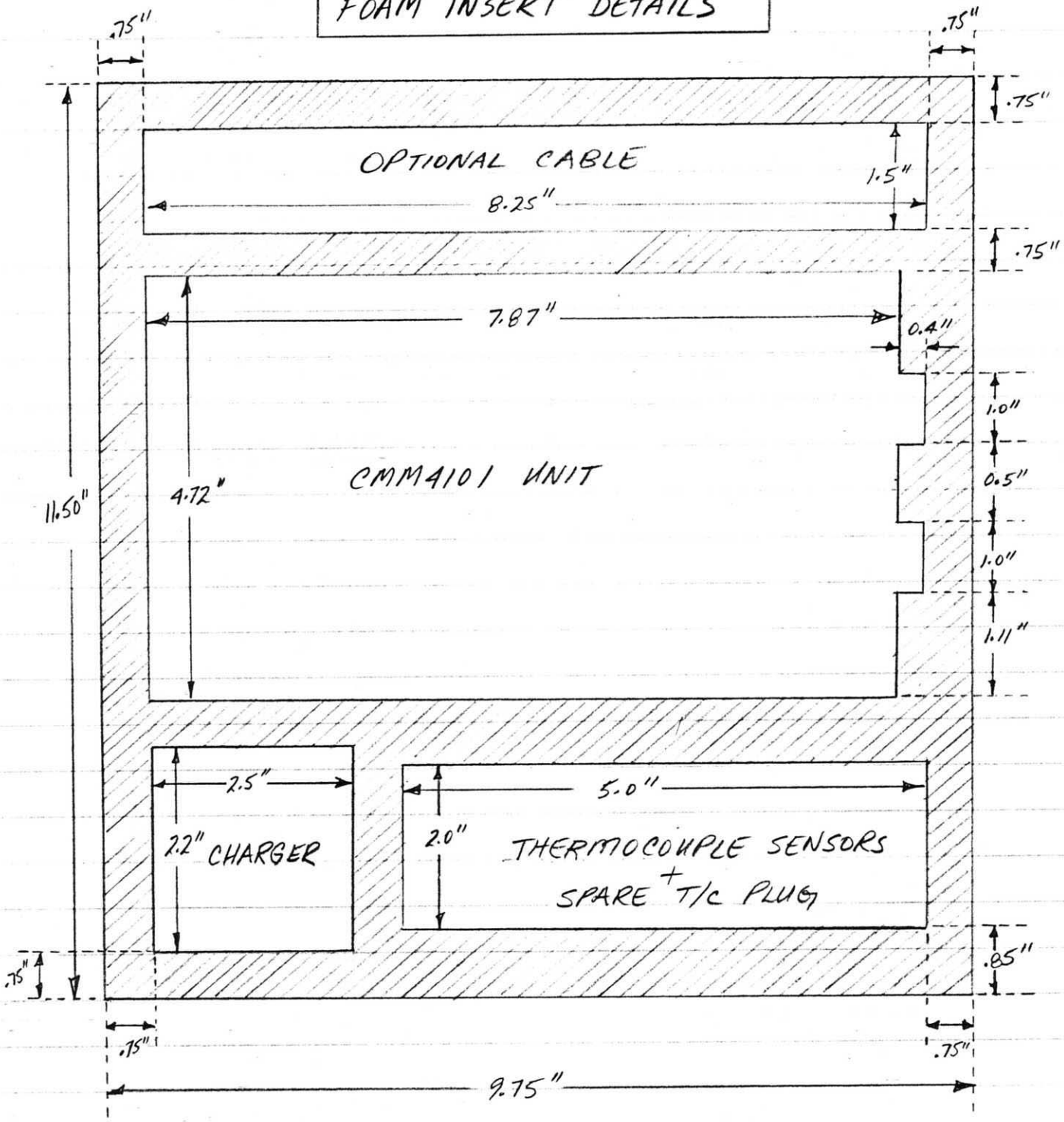
CMM9101 - MATING CABLE FOR WALL CHARGER



CABLE ASSEMBLY NOTES:

1) CLIP-OFF EXISTING WALL X-FORMER (CHARGER) PLUG AND SPLIT POSITIVE + NEGATIVE LEADS APART TO A .75" LENGTH.
2) CRIMP AMP PIN CONTACTS TO EACH LEAD AND THEN FEED THESE THRU THE CABLE CLAMP.
3) TO COMPLETE, INSERT PINS INTO THE PLUG AS PER ABOVE DIAGRAM. SCREW CLAMP ASSEMBLY ONTO THE PLUG AND TIGHTEN CLAMP.

CMM4101	AUG 4/89
FOAM INSERT DETAILS	



DETAILS:

① TOP + BOTTOM FOAM INSERTS - 11.5" × 9.75" × 0.5" CHARCOAL # 2090

② MIDDLE FOAM INSERT - DIE CUT - 11.5 × 9.75 × 3.0" CHARCOAL # 1237

③ BOX: 175lb WHITE INSIDE DIMENSIONS 11.5" × 9.75 × 4.125"

CMM4101 REV. 2.0 COMPONENT LAYOUT