MODEL 2480
SOLARFLOW PLUS

DANIEL MEASUREMENT AND CONTROL

ENRON ENHANCED SOLARFLOW PLUS
APPLICATION MANUAL

"ENRON AGA3, W/MODBUS PROTOCOL"

8-2481-008 W/GROSS METHOD
8-2481-009 W/DETAIL METHOD

Part Number 3-9004-013
Revision C

MAY 1999

DANIEL

Year 2000 Warranty

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ii) recognize and accept the year 2000 and every succeeding fourth year as leap years;

iii) recognize and accept 29 February in the year 2000 and every succeeding fourth year;

iv) record, store, process, sequence, present and output calendar dates and data related to dates falling on or after 1 January 2000, in the same manner and with the same functionality as they do on or before 31 December 1999 and without errors or omissions; and

v) lose no functionality with respect to the introduction into them of dates or data related to dates falling on or after 1 January 2000;

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DANIEL INDUSTRIES, INC.
MODEL 2480 SOLARFLOW PLUS
ENRON ENHANCED SOLARFLOW PLUS
ENRON AGA3, WITH MODBUS PROTOCOL
APPLICATION MANUAL

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1.0 INTRODUCTION

The Model 2480 Enhanced SolarFlow Plus software applications have been designed to implement as many of the commonly required features of natural gas flow computers as possible. These applications have been designed to be compatible with existing Model 2480 support programs with minimal changes to those programs. Even with the enhanced features, field upgrades of existing units will be simple and easy. There are no hardware changes. This enhanced software will calculate volumetric flow rate using equations 3-6b and 3-7 from API Chapter 14.3, part 3.

1.1 SCOPE OF THIS MANUAL

This manual includes sections on:

- Calculation modules for "2480 MODB AGA3" (AGA3 Single)
- Field wiring connections for applicable inputs and outputs
- Default user report listing
- Channel assignments for the unit
- Default data log list
- Default alarm list
- MODBUS communications

1.2 PRODUCT FEATURES

This enhanced software has many commonly requested features resident in the firmware. All of these features are available regardless of the application for which the device is configured in the field. The primary features of the Enhanced Model 2470 SolarFlow Plus software are as follows:

- Serves as a 1 run orifice meter application using the new flow equations
- Supports AGA-8 according to the new standard (both detail and gross methods)
    - Due to memory constraints, there will be two EPROMS - one for detail, the other for gross. Each has identical function and channel assignments, except that the AGA8 calculation mode is not switchable between GROSS and DETAIL. Channels specific to one mode are reserved in the other EPROM.
- Allows the user access to spare analog inputs and their scales
- Provides one contact closure pulse output based on station volume
- Supports MODBUS communications

1.3 "ENHANCED" APPLICATIONS

The following enhanced application using flow rate equations from API Chapter 14.3 is included in this manual.

2480 MODB AGA3

1.4 CALCULATIONS

The calculations in the SolarFlow Plus are divided into two distinct processes. These are as follows:

- Analog input sampling
- Rate and volume calculation cycle

These processes are usually operating autonomously without regard for the state of the other. Only when the rate calculation process is ready to begin a new cycle does it signal the sampling process that new inputs are required for a flow calculation. Upon receiving this signal, the sampling process transfers the inputs that have accumulated to the calculation process, and begins new accumulations.

1.4.1 ANALOG INPUT SAMPLING

Each 0.5 seconds all analog inputs are sampled. Six A/D conversions are done on each input in two groups of three successive samples. The time between these groups is about 10 milliseconds. The middle value in each group is kept and the average of the two values is considered the raw analog input value for that 0.5-second sample.

The samples are added to five running sums which will be converted to average values and placed in SolarFlow Plus Channels 19 - 23 at the beginning of the next calculation cycle. These five values are simple arithmetic averages of the inputs for the cycle. In addition to these five averages, "flow time" averages are kept for four inputs to be used in the flow calculation. These four values are flow averages for differential pressure, measured static pressure in PSIG, temperature, and flow extension.

The flow extension is the square root of the differential pressure times the *upstream, absolute static pressure*. If the pressure is measured from the downstream tap, it is corrected to reflect upstream pressure before the extension is calculated. A meter is considered to be flowing if the differential pressure for that meter is above the cut-off value. If no flow occurs for an entire calculation cycle, straight averages are kept for all inputs.

1.4.2 FLOW RATE EQUATIONS

The SolarFlow calculates volumetric flow rate using equations 3-6b and 3-7 from API Chapter 14.3 Part 3. These equations are:

$$Q_b = (14.73/P_b) * (T_b/519.67) * (Z_b/Z_s) * Q_v \qquad \text{Eqn. 3-7}$$

$$Q_v = 7709.61 * C_d * E_v * Y * d^2 * F_{WV} * \qquad \text{Eqn. 3-6b}$$

$$\text{sqrt}(P_{f1} * h_w * Z_s / (G_r * Z_{f1} * T_f))$$

where :

Q_b	=	volumetric flow rate in SCFH at base conditions
Q_v	=	volumetric flow rate in SCFH at standard conditions
P_b	=	base pressure in PSIA
T_b	=	base temperature in Rankine
Z_b	=	gas compressibility at base conditions
Z_s	=	gas compressibility at standard conditions
C_d	=	orifice discharge coefficient
E_v	=	velocity of approach factor
Y	=	expansion factor
F_{wv}	=	water vapor factor
d	=	temperature corrected orifice diameter
P_{f1}	=	upstream pressure in PSIA
T_f	=	flowing temperature in Rankine
h_w	=	differential pressure in InH2O
G_r	=	real gas relative density at standard conditions
Z_{f1}	=	flowing compressibility at $P_{f1} * T_f$

Standard conditions = 14.73 PSIA and 519.67 Rankine

All compressibility values are calculated in accordance with AGA Report No. 8, 1992. For equations consult AGA Report No. 8. Due to memory constraints, there will be two EPROMS. The AGA8-1992 GROSS (short form) calculation method is available with EPROM 8-2481-008. The AGA8-1992 DETAIL (full analysis) method is available with EPROM 8-2481-009.

All input gravity values used in the SolarFlow Plus are assumed to be for reference conditions of 14.73 PSIA and 60 °F. This assumption is consistent with calculation examples given in API Chapter 14.3, Part 3. If the operator indicates that the input gravity is the ideal relative density, the ideal value is converted to G_r before the flow rate calculation is run. This value is internal to the flow rate calculation, and does not replace the specific gravity value in the SolarFlow Plus channels.

The quantity, $\sum$ sqrt(P_{f1} * h_w), is stored as a separate entity in the SolarFlow Plus channel, FLOW EXTN, and is stored in the data log by default. This is in accordance with the COGM document on electronic flow meters.

1.4.3 RATE AND VOLUME CALCULATION

The SolarFlow Plus recalculates rates, volumes, and compressibility on a continuous basis. The duration of this calculation cycle depends on the configuration chosen. The length of each cycle is fixed, to ensure that no calculation cycle crosses a log period boundary. The cycle periods for various configurations are:

NUMBER OF METERS	AGA-8 DETAIL	AGA-8 GROSS (SHORT FORM)
1	20 SEC	10 SEC

At the beginning of each cycle, the analog input averages accumulated during the preceding cycle are transferred to the SolarFlow Plus channels. Using these inputs, a new flow calculation is done for each configured meter run. The flowing compressibility is calculated first, followed by the instantaneous flow rate. The rates and volumes are updated last. After all meters have been done, the station rates and volumes are updated.

1.4.4 LOGGING

The logging function is a part of the calculation cycle process. At the end of each cycle, the SolarFlow Plus updates all of the running averages for the log. For channels in the log definition designated as averages, "flow averages" are kept based on flowing conditions for the appropriate meter run. For channels which are associated with all runs (such as specific gravity or common temperature), averages are kept based on the flowing condition of the primary meter run. Straight time averages are kept for an item if the associated meter run is shut-in for the entire log period.

After updating the log averages, the SolarFlow Plus determines if it is time to make another data log entry and makes the new log if necessary.

Log averages are kept in accordance with the Enron EGM specification.

1.5 VOLUME PULSE OUTPUT

SolarFlow Plus provides a contact closure output based on station volume. The output has a volume per pulse channel and a pulse period channel for configuration. A volume accumulator holds the volume since the last pulse was output. When the accumulator exceeds the volume per pulse, this volume is subtracted from the accumulator, and a pulse is output. The accumulation is done once each calculation cycle.

1.6 ENHANCED SOFTWARE MISCELLANEOUS CONDITION BITS

The Misc. column of a data log printout indicates system conditions that occurred or were present during the log interval by replacing a dot with a number that identifies a specified condition. These numbers represent a designated system condition regardless of the ALARM setup in the SolarFlow Plus menu. These condition bits cannot be activated, deactivated, or acknowledged. They will appear on the SolarFlow Plus data log. The Channel 30 system alarm (SYS ERROR) equals these miscellaneous bits converted to decimal representation if they occur. An exception is that a cold start will not cause a SYS ERROR occurrence caused only by a cold start. Note that normally Channel 30 is 0.0. The data log will show the Misc. dots as follows:

Date	Time	METR TEMP	METR PRES	DIFF PRES	TODAY VOL	U-Range	O-Range	Misc.
MM/DD/YY	HH:MM	xxxx	xxxx	xxxx	xxxx	.....	.....	.....

The enhanced version of these miscellaneous bits is as follows:

Dot No.	System Conditions	Weight in CH 30
8	System Failure	1.0
7	Cold Start	2.0
6	Warm Start	4.0
5	Designates Daily Log	8.0
4	Chromatograph Communications Failure	16.0
3	Reserved	32.0
2	Floating Point Error	64.0
1	Reserved	128.0

Any condition that occurs will be shown in Channel 30 as a decimal number. For example if dot No. 2 (Floating Point Error) had occurred, the binary number would be converted to decimal 64.0. This number would be < > 0.0 and it would be seen in Channel 30 (SYS ERROR) as the decimal number. Counting the dots from left to right, it would show in the data log as decimal 2 in the second position under Misc.

The following table shows the SolarFlow Plus channels assigned for connecting analog inputs to the unit.

CH	TRANSMITTER TYPE	WIRE COLOR	TB2 PIN NO.	TB2 PIN LABEL
20	Daniel Model 224 millivolt static pressure transmitter, (Factory wired, if installed inside SolarFlow Plus enclosure.)	Yellow Green White Black	10 11 12 13	PWR + SIG + SIG - PWR -
	- or -			
20	Statham Series 36, 1-5 VDC static pressure transmitter, (Factory wired, if installed inside SolarFlow Plus enclosure.)	Blue Red Black	7 8 9	SP +12 V GND
21	External, RTD temperature transducer, (To be installed by user, cable supplied.)	* # #	14 15 16	TEMP GND GND
22	External, DP transmitter, (To be installed by user.)	Blue Black Red	4 5 6	DP1 +12V GND

* Amber with Black tracer or Red
\# Amber or White

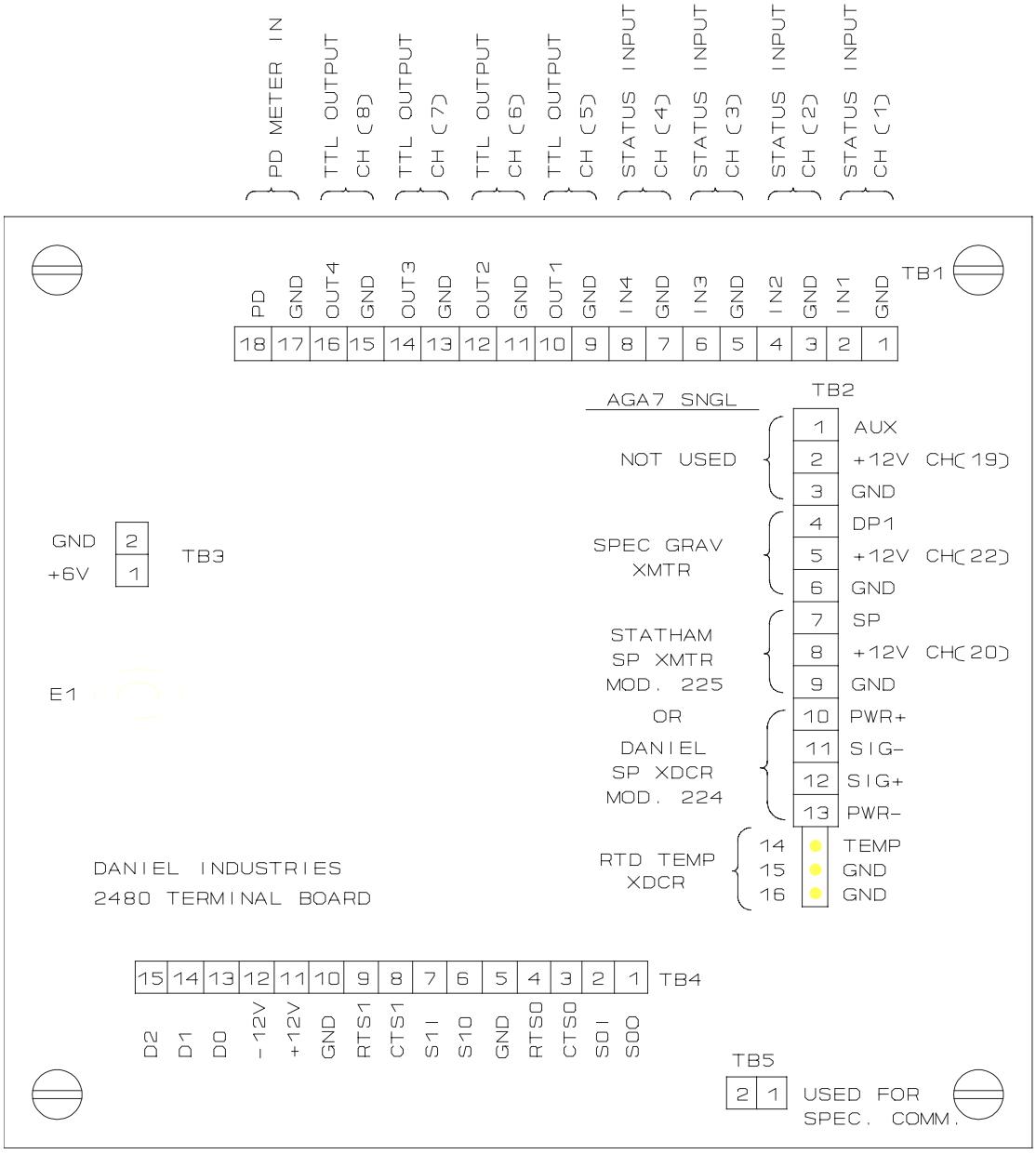

Figure 1-1. Terminal Board Connections

1.7 MODBUS COMMUNICATIONS

The defaults for Master Serial Port Communications Protocol for Enron Modbus are:

1200 Baud
Even parity
7 Data bits
1 Stop bit

All Modbus registers are four byte IEEE floating point.

1.7.1 SETTING THE MODBUS COMMUNICATION ADDRESS

In order for the SolarFlow Plus to respond to a MODBUS protocol poll, the unit must be configured properly. The discrete input cable status points must indicate that the foreign protocol is active, the unit's MODBUS address must match the address in the message, and the remote protocol baud rate must be set to the proper value. The proper cable status values for MODBUS communication are:

	TB4 PIN NO.
D0 = low (grounded)	13
D1 = high (open)	14
D2 = high (open)	15

The MODBUS Address for communications with the SolarFlow Plus is set in the SETUP LOCATION menu by changing the Location ID (LOC ID). The baud rate is set by the "PCOMM RATE" variable, and the Request To Send Delay for radio keying may be set via the "RTS DELAY" variable. This must be done on site with a laptop or HandHeld Data Terminal.

1.7.2 SUPPORTED FUNCTION CODES

Following are supported function codes for the SolarFlow Plus MODBUS Protocol:

Fn 01	Read Boolean Registers
Fn 03	Read Registers
Fn 06	Write Single Register
Fn 16	Write Multiple Registers

1.7.3 LOCAL AND REMOTE COMMUNICATIONS

When no local device (laptop) is plugged into the SolarFlow Plus, the remote protocol will function normally. However, when any local device is plugged in, the remote communications port becomes immediately inoperable. If the SolarFlow Plus is busy sending or receiving a MODBUS message, and a local device is plugged in, the remote communications is interrupted and will fail. As soon as the local device is unplugged, the remote communications port will become active, and the message may be retried.

1.7.4 WRITING DATA TO THE SOLARFLOW PLUS

When a MODBUS write command is sent to a SolarFlow Plus unit, the data is immediately written directly to the SolarFlow Plus database. This is done before responding to the poll. Data may be immediately read back from the 2480.

The SolarFlow Plus dedicates the 700 series registers to archive files. Each archive in the SolarFlow Plus corresponds to a single MODBUS register number. Archive files are read only, and are accessed using the MODBUS function code 3. Each poll for data returns one archive record. All types of archive records start with a 12 byte time stamp.

The historical data log record is user definable in the SolarFlow Plus. The periodic and daily logs have the same format.

1.8 REGISTERS

1000 Series Registers - The Boolean registers in the SolarFlow Plus may be read or written using function 1. A request for these registers with any other function code will result in an error. This is consistent with the Gould MODBUS definition. 1000 Series registers are read only in the 2480; there is no write capability for the 1000 series registers.

3000 Series Registers - The 3000 series registers are 16 bit integers. These are accessed using function codes 3 and 1. When transmitted, the high order byte is sent first. This is consistent with the Gould MODBUS definition. 3000 Series registers are read only in the 2480; there is no write capability for the 3000 series registers.

5000 Series Registers - (Long integers) The SolarFlow Plus has no 32 bit integer registers. This register series is reserved to maintain compatibility with certain other Daniel Industries instrumentation.

7000 Series Registers - (Floating Point Data) The 7000 series registers are defined to be IEEE single precision floating point data. When transmitted, the exponent byte is transmitted first followed by the mantissa bytes in order of decreasing significance. For host computers using Intel microprocessors, this implies that the bytes are received in backwards order from their proper order in memory. This convention was chosen for compliance with the Gould convention of transmitting the high order byte of a 16 bit integer first.

9000 Series Registers - (Strings) The SolarFlow Plus can transmit and receive certain text string points. The 9000 series registers are reserved for this type of data. When a string register is transmitted or received, 20 bytes of data are transferred (the maximum length of the string is less than 20, and varies for each register). The string is terminated with a null character. For instance, a text string of length 10 would have a null in the 11th byte and 9 pad characters whose value is indeterminate.

1.8.1 GENERAL MODBUS MESSAGE FORMAT

Each message, either to or from the SolarFlow, conforms to the following general format:

PACKAGE HEADER / MODBUS MESSAGE / TRAILER

For the SolarFlow Plus MODBUS Ascii implementation, the header consists of an ascii ':' character. The package trailer consists of the LRC followed by a CRLF (carriage return and line feed). This framing is consistent with Gould MODBUS, and a description of the LRC calculation may be found in Gould's documentation. The data contained in the message portion is binary data, but is transmitted in Ascii Hex format. This means that each byte of binary data will be transmitted as two bytes which are the Ascii Hex representation of the data.

For the MODBUS RTU protocol (not currently supported in the SolarFlow Plus), the package header is not transmitted information, but is defined as a time duration of longer than 3 character transmission times in which no data is received. The transmitted data begins with the message itself. The package trailer is the CRC-16. The data transmitted in the message portion is transmitted in raw binary format.

Other than the differences noted above, the Ascii and RTU versions of the MODBUS protocol are identical. The remainder of this document makes no further distinction between them.

1.8.2 MODBUS ERROR MESSAGES

When the SolarFlow receives a proper MODBUS message format, but the content of the message is in error, an error response is returned to the host. The format of the error response is:

ADDRESS / FN CODE + 80 H / ERROR CODE

Valid error codes are:

1 - Illegal Function code
2 - Illegal Data Address (register number)
3 - Illegal Data Value

1.8.3 SUPPORTED FUNCTION CODES

Read Boolean Registers (Fn 01)

This function is used to retrieve the value of one or more boolean registers. The format of the message and response is consistent with the Gould definition.

Poll format:

ADDRESS / FN CODE (01) / START REG / REG COUNT

Response format:

ADDRESS / FN CODE / BYTE COUNT / DATA

The data is returned packed eight bits (registers) per byte, with bit 0 of the first data byte being the first requested register, bit 1 the next register etc...

Read Registers (03)

This function is used to retrieve the value of one or more registers. The byte count of the response will depend on the data type implied by the register number. For instance, reading two string registers will return 40 bytes of data.

Poll format:

ADDRESS / FN CODE (03) / START REG / REG COUNT

Response format:

ADDRESS / FN CODE / BYTE COUNT / DATA

Write Single Register (06)

This function is used to set the value of a register. The byte length of the data field is dependent on the data type implied by the register number. Only floating point registers are writeable in the 2480.

Poll format:

ADDRESS / FN CODE (06) / REGISTER / VALUE

Response format:

ADDRESS / FN CODE / REGISTER / VALUE

To write a register, the register number and the new value are sent to the SolarFlow Plus. The response to this poll is an echo of the command. If a read only register is specified, an error is returned.

Write Multiple Registers (Fn 16)

This function is used to set the value of one or more registers. The byte length of the data field is dependent on the data type implied by the register number. Only floating point registers are writeable in the 2480.

Poll format:

ADDR / FN CODE / STRT REG / REG CNT / BYTE CNT / DATA

Response format:

ADDR / FN CODE / STRT REG / REG CNT

The byte count field is a single byte containing the number of bytes of data in the data field. The data is sent in the format determined by the register number.

If any of the registers implied by the start register and the register count are read only, an error response will be returned.

1.8.4 READING OR SETTING THE SOLARFLOW PLUS TIME

The SolarFlow Plus time may be set using the floating point date/time registers. These are 7019/7020 or 7051/7052. Either set has the same effect. The date and/or time may be written individually or together.

1.8.5 READING ARCHIVE DATA

To read data from a SolarFlow Plus Archive file, the host issues a poll using function code 3. The start register field specifies the archive register number, and the field normally used for register count is redefined to be the record index. The record index is a 16-bit unsigned integer which is incremented each time a new record is entered in an archive. There is a separate index for each archive file. When the index eventually reaches 840 for hourly archives, or 35 for daily archives, it increments back to one (1) on the next record.

The record index is initialized to zero (0) on unit coldstart. To retrieve the very first record entered in the archive, the host would issue a poll for record #1. If the host asks for a record which does not exist (such as the 100th entry in an archive with only 90 records), the unit returns a blank record which is all zeroes.

To assist the host in determining which data has been previously read from a unit, the SolarFlow Plus maintains the last index number read and the current value of the index for each archive. These indexes are made available to the host computer in the 3000 series registers. Since some ambiguity always exists in the SolarFlow Plus as to which records have been transferred to the host without communication errors, the host should keep its own copies of the last successfully retrieved record index.

Poll format:

ADDRESS / FN CODE (03) /ARCHIVE # / RECORD #

Response format:

ADDRESS / FN CODE /BYTE COUNT / DATA

The SolarFlow Plus always returns exactly one record. To retrieve all previously unreported archive records, the host should poll the SolarFlow Plus for the current record index and last index read. The difference between these values is the number of unreported records (after accounting for the MODULO 840 or 35). If these values are not the same, the host should poll the unit for records after the last reported index up to and including the most current index.

Because of irregularities in logging from such circumstances as system shut downs, power ups, and clock changes, the time stamps on sequential records may not always be in order. The record index associated with the data indicates the actual sequence of the creation of the records.

1.9 ARCHIVE FILES (700 SERIES REGISTERS)

The SolarFlow Plus dedicates the 700 series registers to archive files. Each archive in the SolarFlow corresponds to a single MODBUS register number. Archive files are read only, and are accessed using the MODBUS function code 3. Each poll for data returns one archive record.

The historical data log record in the Enron SolarFlow Plus has a fixed format. The periodic and daily logs have the same format.

The format of the retrieved archive record for an orifice meter is:

Date Stamp	YYMMDD.0
Time Stamp	hhmmss.0
Average Flowing Differential	4 byte IEEE Float
Average Flowing Pressure	4 byte IEEE Float
Average Flowing Temperature	4 byte IEEE Float
Integrated Flow Extension	4 byte IEEE Float
Volume for log period	4 byte IEEE Float
Energy for log period	4 byte IEEE Float
Log Time (duration in minutes)	4 byte IEEE Float

The format of the retrieved archive record for a Turbine/PD meter is:

Date Stamp	YYMMDD.0
Time Stamp	hhmmss.0
Flow Time in minutes	4 byte IEEE Float
Average Flowing Pressure	4 byte IEEE Float
Average Flowing Temperature	4 byte IEEE Float
Uncorrected Volume for period	4 byte IEEE Float
Volume for log period	4 byte IEEE Float
Energy for log period	4 byte IEEE Float
Log Time (duration in minutes)	4 byte IEEE Float

The general format of the retrieved event record is:

Event Bit Map	2 bytes
Register Number	2 bytes
Time Stamp	hhmmss.0
Date Stamp	YYMMDD.0
Old Value	4 byte IEEE Float
New Value	4 byte IEEE Float

The Enron Enhanced 2480 SolarFlow is capable of storing the 100 most recent events.

The Boolean registers in the SolarFlow Plus may be read using function 1. A request for these registers with any other function code will result in an error. The format of the messages sent and received by the SolarFlow for these function codes works exactly as detailed in the Gould MODBUS documentation.

The 3000 series registers are 16-bit integers. These are accessed using function code 3. When transmitted, the high order byte is sent first. This is consistent with the Gould MODBUS definition. The format of the messages sent and received by the SolarFlow for these function codes works exactly as detailed in the Gould MODBUS documentation.

The SolarFlow has no 32-bit integer registers. This register series is reserved to maintain compatibility with certain other Daniel Industries instrumentation.

The 7000 series registers are defined to be IEEE single precision floating point data. When transmitted, the exponent byte is transmitted first followed by the mantissa bytes in order of decreasing significance. For host computers using Intel microprocessors, this implies that the bytes are received in backwards order from their proper order in memory. This convention was chosen for compliance with the Gould convention of transmitting the high order byte of a 16-bit integer first.

The SolarFlow Plus can transmit and receive certain text string points. The 9000 series registers are reserved for this type of data. When a string register is transmitted or received, 20 bytes of data are transferred (the maximum length of the string is less than 20, and varies for each register). The string is terminated with a null character. For instance, a text string of length 10 would have a null in the 11th byte and 9 pad characters whose value is indeterminate.

1.10 SOLARFLOW PLUS MODBUS REGISTER ASSIGNMENTS

Register	Description	(Read/Write)
Archives		
701-702	Reserved	
703	35 Days Daily Run #1	R
704	840 Records Hourly Run #1	R
705-720	Reserved	
Booleans		
1001-1018	SolarFlow Channels 1-18	R
1019-1024	Reserved	
1025-1044	Alarm Active Status 1-20	R
1045-1048	Reserved	
1049-1068	Alarm Enable Status 1-20	R
1069-1072	Reserved	
1073-1092	Alarm Acknowledge Status 1-20	R
1093-1096	Reserved	
1097-1104	Analog Input Source (Live/Fixed) 1-5	R
1105-1112	Reserved	

NOTES:

(1) Alarm acknowledged = 0; 1 = needs to be acknowledged.

(2) Analog source bits: input 1 = channel 19; fixed value = 1, live value = 0.

(3) Output 1 = Channel 27; 1 = fixed value, 0 = live data.

SOLARFLOW PLUS MODBUS REGISTER ASSIGNMENTS (CONTINUED)

Register	Description	(Read/Write)
16 bit Integers		
3001	Last Read Hourly Log Index	R
3002	Current Hourly Log Index	R
3003	Last Read Daily Log Index	R
3004	Current Daily Log Index	R
3005	Current Number of Events	R
3006-3010	Reserved	
3011	Contract Hour(0-23)	R
3012	Periodic Data Log Interval Code	R
3013-4099	Reserved	

The data log interval code is:

0 = logging disabled
1 = 5 minute logs
2 = 15 minute logs
3 = 30 minute logs
4 = hourly logs
5 = 4 hour log period
6 = daily logging only

32 bit Integers

None

SOLARFLOW PLUS MODBUS REGISTER ASSIGNMENTS (CONTINUED)

Register	Description	(Read/Write)
IEEE float		
7001	Manufacturer's ID number	R
7002	RTU Operating System ID number	R
7003	RTU Firmware Revision Number	R
7004	Calculation Module Number 12 = 2480 AGA3 single w/AGA8 Detail 13 = 2480 AGA3 single w/AGA8 Gross	R
7005-7009	Reserved	
7010	Location ID	R
7011	Unit ID	R
7012-7018	Reserved	
7019	Current Date	R/W
7020	Current Time	R/W
7021	Last Read Hourly Log Index	R
7022	Current Hourly Log Index	R
7023	Last Read Daily Log Index	R
7024	Current Daily Log Index	R
7025	Current Number of Events	R
7026-7030	Reserved	
7031	Contract Hour(0-23)	R
7032-7042	Reserved	
7043	Yesterday's Volume Run #1	R
7044-7047	Reserved	

SOLARFLOW PLUS MODBUS REGISTER ASSIGNMENTS (CONTINUED)

Register	Description	(Read/Write)
7048	Current Station Energy Rate	R
7049	Today's Station Accumulated Energy	R
7050	Yesterday's Station Accumulated Energy	R
7051	Date (MMDDYY.0)	R
7052	Time (hhmm.ss)	R
7053	Current Battery Voltage	R
7054	Current Station Flow Rate	R
7055	Today's Station Accumulated Volume	R
7056	Yesterday's Station Accumulated Volume	R
7057	Current Flow Rate Run #1	R
7058	Reserved	
7059	Current Differential Pressure Run #1	R
7060	Current Pressure Run #1	R
7061	Current Temperature Run #1	R
7062	Current Uncorrected Volume Run #1	R
7063	Current Volume Run #1	R
7064	Current Energy Run #1	R
7065-7070	Reserved	
7071	Spare Analog Input #1	R
7072-7074	Reserved	
7075	Current Number of Events	R
7076	Current Hourly Index Pointer (1-840)	R
7077 Previous Hour	Date	R
7078 Previous Hour	Time	R
7079 Previous Hour	Avg DP 1	R
7080 Previous Hour	Avg Pressure 1	R
7081 Previous Hour	Avg Temperature 1	R

SOLARFLOW PLUS MODBUS REGISTER ASSIGNMENTS (CONTINUED)

Register		Description	(Read/Write)
7082	Previous Hour	Extension 1	R
7083	Previous Hour	Volume 1	R
7084	Previous Hour	Energy 1	R
7085	Previous Hour	Flow Time	R
7086-7094		Reserved	R
7093-7094		Reserved	
7095		Current Number of Events	R
7096		Current Hourly Index Pointer (1-840)	R
7097	Previous Day	Date	R
7098	Previous Day	Time	R
7099	Previous Day	Avg DP	R
7100	Previous Day	Avg Pressure 1	R
7101	Previous Day	Avg Temperature 1	R
7102	Previous Day	Extension 1	R
7103	Previous Day	Volume 1	R
7104	Previous Day	Energy 1	R
7105	Previous Day	Flow Time	R

SOLARFLOW PLUS MODBUS REGISTER ASSIGNMENTS (CONTINUED)

Register	Description	(Read/Write)
7106-7120	Reserved	
7121-7360	SolarFlow Channels 1-240	R/W
7361-7370	Hi,Lo Scale values, channels 19-23	R/W
7371-7400	Reserved	
7401-7420	Alarm limit values, Alarms 1-20	R/W
7421-7500	Reserved	
7501-7508	Live Analog Inputs 1-5	R

String

9001	Location ID (10 chars max)	R
9002	Location Name (15 chars max)	R
9003	Unit ID (10 chars max)	R
9004	Unit Name (15 chars max)	R
9005	Calculation Module Name (15 chars exactly)	R

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SECTION 2

2.0 ENHANCED SOLARFLOW PLUS CHANNEL ASSIGNMENTS

The enhanced SolarFlow Plus supports 240 channels. The first 28 channels have the same special meaning as in the past. The remaining channels are the calculation channels which contain all rates, volumes, calculated results and configuration entries. The calculation channels begin with the "system" channels which apply to the whole unit without regard for a specific meter tube, followed by groups of channels for information specific to each of the meter tubes. Most of the supported applications do not use all of the channels defined. The channels not used by a particular configuration are reserved if that application has been selected, and are not available for other purposes.

2.1 CHANNEL ONE THROUGH 18 ASSIGNMENTS

Assignments for the multiple usage application Channels one through 18 are tabulated as follows.

CH	LABEL	INPUT OUTPUT	0-LABEL	1-LABEL	DEFAULT	DESCRIP
001 through 004 are reserved for later use						
005	VP 1	OUT	OFF	ON	OFF	Volume pulse output 1
006 through 018 reserved for later use						

2.2 CHANNEL 19 THROUGH 240 ASSIGNMENTS

Assignments for the Enhanced SolarFlow Plus software Channels 19 through 28 are shown here for reference only. The column labeled DP in the table indicates the number of digits displayed past the decimal point. Channel assignments 20 through 26 may change depending on the requirements for the individual application. Refer to the section specifying the particular assignments for your desired application for the actual assignments.

CH	LABEL	UNITS	DP	DEFAULT	DESCRIPTION
019	SPARE 1	%	1	0.0	
020	FLOW PRES1	PSIG	1	0.0	Analog flow pressure
021	DIFF PRES1	InH20	1	0.0	Analog differential pressure
O22	FLOW TEMP1	DEG F	1	0.0	Analog flowing temperature
023	BATTERY	VOLTS	2	0.00	Scale 2.4-12.2
024-028 RESERVED					
029	VERSION		1	1.0	Software version
030	SYS ERROR		0	0	System alarm
031	DP CUTOFF	InH20	2	0.25	
032	ZFLOW LIM	SEC	0	15	Low flow cutoff
033	ATMS PRES	PSIA	2	14.70	Atmospheric pressure
034	PRES BASE	PSIA	2	14.73	Pressure base
035	TEMP BASE	DEG F	0	60	Temperature base
036	ORIF MTRL	(None)	0	1	Orifice material 0=carbon steel 1=stainless steel 2=monel

CH	LABEL	UNITS	DP	DEFAULT	DESCRIPTION
037	PIPE MTRL	(None)	0	0	Pipe material 0=carbon steel 1=stainless steel 2=monel
038	TREF ORIF	DEG F	1	68.0	Reference temp of orifice plate
039	TREF PIPE	DEG F	1	68.0	Reference temp of pipe
040	VISCOSITY	#/FTS	7	0.0000069	Fluid viscosity
041	SPEC HEAT		2	1.30	Specific heat ratio
042	SG SELECT		0	1	Input Specific Gravity 0=ideal, 1=real
043	AGA8 MTHD		0	0	AGA-8 Method 0=detail 1=GR, CO2, BTU 2=GR, CO2, N2
044	ZS		6	1.000000	Standard compressibility
045	ZB		6	1.000000	Base compressibility
046	MOL WT		4	16.8000	Calculated by AGA-8
047	B		6	0.000000	AGA-8 2nd virial coeff.
048	C		6	0.000000	AGA-8 3rd virial coeff.
049	D		6	0.000000	AGA-8 reduced density
050	K3		6	0.000000	AGA-8 mixture size param
051	SPEC GRAV	(None)	4	0.5861	Current SG
052	BTU	(None)	1		Current BTU
053	METHANE	MOL%	3	95.515	Methane MOL%
054	N2	MOL%	3	0.166	Nitrogen MOL%
055	CO2	MOL%	3	0.916	Carbon dioxide MOL%

CH	LABEL	UNITS	DP	DEFAULT	DESCRIPTION
056	ETHANE	MOL%	3	2.798	Ethane MOL%
057	PROPANE	MOL%	3	0.351	Propane MOL%
058	H2O	MOL%	3	0.000	Water MOL%
059	H2S	MOL%	3	0.000	Hydrogen Sulphide MOL%
060	HYDROGEN	MOL%	3	0.000	Hydrogen MOL%
061	CO	MOL%	3	0.000	Carbon Monoxide MOL%
062	OXYGEN	MOL%	3	0.000	Oxygen MOL%
063	I-BUTANE	MOL%	3	0.093	I-butane MOL%
064	BUTANE	MOL%	3	0.077	Butane MOL%
065	I-PENTANE	MOL%	3	0.000	I-pentane MOL%
066	PENTANE	MOL%	3	0.000	Pentane MOL%
067	HEXANE	MOL%	3	0.084	Hexane MOL%
068	HEPTANE	MOL%	3	0.000	Heptane MOL%
069	OCTANE	MOL%	3	0.000	Octane MOL%
070	NONANE	MOL%	3	0.000	Nonane MOL%
071	DECANE	MOL%	3	0.000	Decane MOL%
072	HELIUM	MOL%	3	0.000	Helium MOL%
073	ARGON	MOL%	3	0.000	Argon MOL%
074	LOG TIME	MIN	1	0.0	Duration of log
075	CLOSE LOGS	(None)	0		End of log
076	VPP 1	MCF	1	100.0	Volume per pulse 1
077	PP 1	SEC	0	1	Pulse period 1

CH	LABEL	UNITS	DP	DEFAULT	DESCRIPTION
078-103 RESERVED					
104	FW MODE		0	0	0= Disabled 1= Operator entered 2= Calculated
105	H20 CNTENT	LB/MM	0	0	Water content; LBS per million cubic feet
106	FW FACTOR		5	1.00000	Water vapor factor
107-119 RESERVED					
120	ORIF DIAM1	IN	3	1.000	Meter 1 orifice diameter
121	PIPE DIAM1	IN	3	4.000	Meter 1 pipe diameter
122	TAP LCTN1	(None)	0	0	Tap location 0=downstream 1=upstream
123	METR FCTR1	PPCF	1	1.0	Meter factor in pulses per actual cubit foot
124	CORR OD1	IN	4	0.0000	Temp corrected orifice diameter 1
125	CORR PD1	IN	4	0.0000	Temp corrected pipe
126	CORR BETA1	(None)	5	0.00000	Temp corrected Beta ratio
127	EV1	(None)	5	1.00000	Velocity of approach factor
128	CD 1	(None)	6	0.600000	Coefficient of discharge
129	ZF 1	(None)	6	1.000000	Flowing compressibility
130	Y FCTR 1	(None)	6	1.000000	Expansion factor
131	FLOW PRES1	PSIG	1	0.0	Analog flowing pressure
132	FLOW TEMP1	DEG F	1	0.0	Analog flowing temperature

CH	LABEL	UNITS	DP	DEFAULT	DESCRIPTION
133	Reserved				
134	FLW EXTN 1	NONE	3	0.000	$\sum$ sqrt(H_w * P_f)
135	CORR FCTR1	%	2	0.00	
136	FLW TIME 1	MIN	2	0.00	Flow time
137	FLOW RATE1	MCF/H	1	0.0	Hourly flow rate
138	FLOW RATE1	MCF/D	1	0.0	Daily flow rate
139	LOG VOL 1	MCF	0	0	Logged accumulated volume
140	TODAY VOL1	MCF	0	0	Daily accumulated volume
141	YSDAY VOL1	MCF	0	0	Ysday's accumulated volume
142	TOT VOL 1	MCF	0	0	Total accumulated volume (Rolls over @ 10,000,000)
143	ERATE 1	DTH/D	1	0.0	Energy flow rate/day
144	LOG ENRGY1	DTH	0	0	Logged accumulated energy
145	TDY ENRGY1	DTH	0	0	Today's accumulated energy
146	YSY ENRGY1	DTH	0	0	Ysday's accumulated energy
147	TOT ENRGY1	DTH	0	0	Total accumulated energy (Rolls over @ 10,000,000)
148-240 RESERVED					
* All totals roll over at 10,000,000 so adjust your units accordingly.					

SECTION 3

3.0 SINGLE ORIFICE APPLICATION (SNGL)

Section 3 covers the individual requirements for the ENRON 2480 single orifice enhanced application configured to calculate volumetric flow rate using equations from API Chapter 14.3, Part 3. The single orifice application "2480 MODB AGA3" supports measurement on a single meter tube. This application supports MODBUS communications. Any unused analog input should be jumpered to ground.

When the SolarFlow Plus is configured for a new application, all channels are set to default values, and the Alarm definitions, Log definition, User Report list, and Analog Input channels are set to the values corresponding to the configuration chosen. The event log remains intact, but the data log is emptied.

3.1 FIELD WIRING CONNECTIONS

Before exchanging your EPROM set for working installations, make sure that all previous data is recorded as needed. Make sure that your slide switch settings are set in accordance with the information in paragraph 1.9. No changes should be required unless the previously used application has been significantly different. Configurations for this application include the static pressure and DP transmitter(s) associated with meter 1 installed within the Model 2480 enclosure with all other transmitters installed externally, or with *all* transmitters installed externally.

The wiring configuration for the single orifice analog inputs is shown in this section.

A field wiring diagram is provided in the Model 2480 System Reference Manual. The following information furnishes necessary details for wiring both internal and external transmitters.

The following table shows the SolarFlow Plus channels assigned for connecting analog inputs to the unit.

CH	TRANSMITTER TYPE	WIRE COLOR	TB2 PIN NO.	TB2 PIN LABEL
20	Daniel Model 224 millivolt static pressure transmitter, (Factory wired, if installed inside SolarFlow Plus enclosure.)	Yellow Green White Black	10 11 12 13	PWR + SIG + SIG - PWR -
	- or -			
20	Statham Series 36, 1-5 VDC static pressure transmitter, (Factory wired, if installed inside SolarFlow Plus enclosure.)	Blue Red Black	7 8 9	SP +12 V GND
21	External, RTD temperature transducer, (To be installed by user, cable supplied.)	* # #	14 15 16	TEMP GND GND
22	External, DP transmitter, (To be installed by user.)	Blue Black Red	4 5 6	DP1 +12V GND

* Amber with Black tracer or Red
\# Amber or White

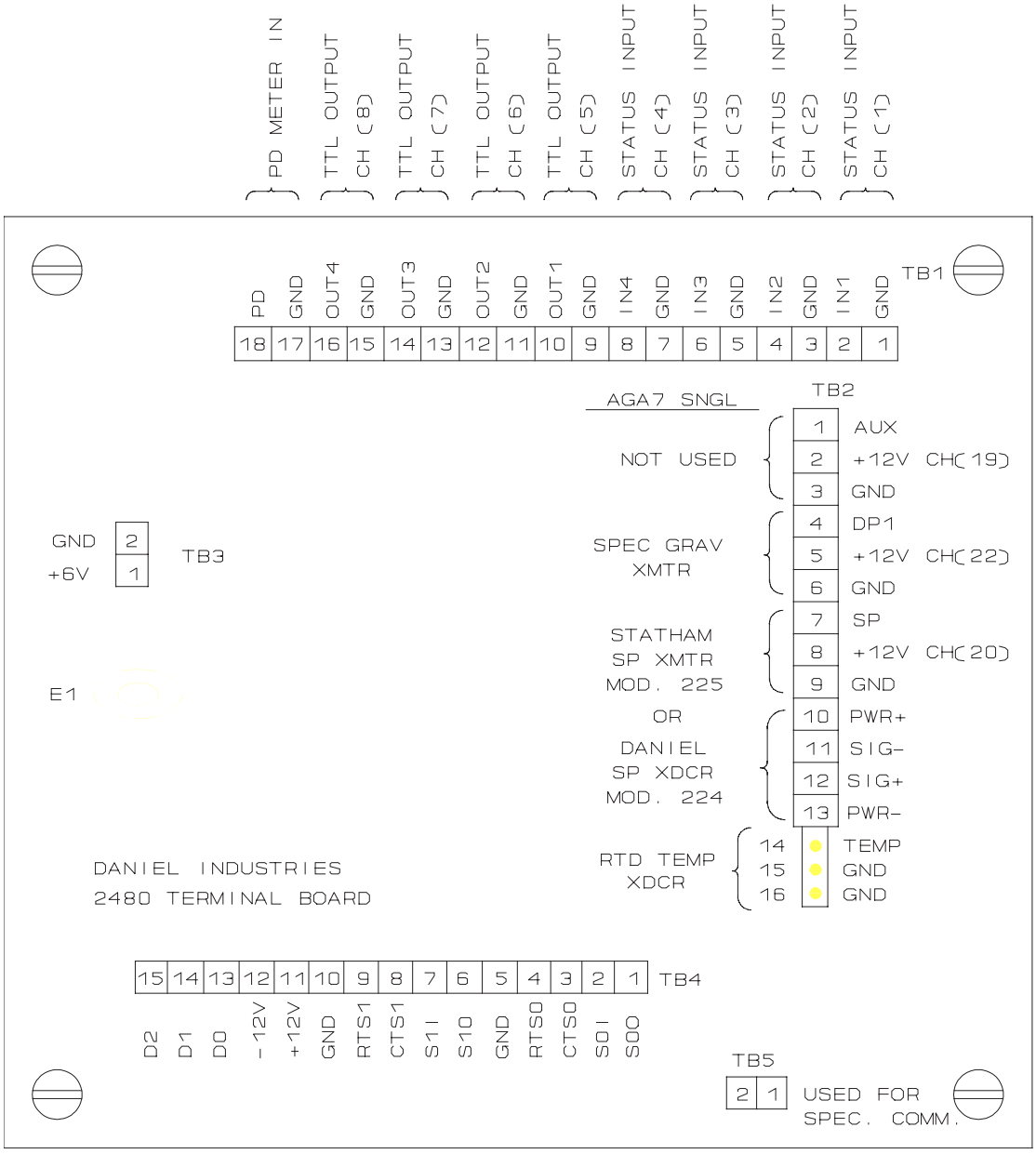

Figure 3-1. Terminal Board Connections

3.2 OUTPUT SIGNAL CONNECTIONS

All output signals from a SolarFlow Plus unit installed in a hazardous location must be isolated by means of intrinsic safety barriers.

This application has one TTL output for corrected station volume on channel 5. The volume per pulse and the pulse period of the output may be changed using the HHDT. Prompts for changing the volume per pulse (VPP1) and pulse period (PP1) are included in the discussion of the CONFIG submenu of the SETUP UNIT menu.

3.2.1 TTL LEVEL SIGNAL OUTPUTS

TTL level output for channel FIVE (5) is available at the terminal board TB1 shown in the following table.

CH NO.	SIGNAL DESCRIPTION	LABEL	TB1 PIN NO.	TB1 LABEL	SIGNAL TYPE
5	Volume pulse output 1	VP1	10 9	OUT1 GND	TTL Output Common

3.3 USER REPORT (CHANNEL 0)

Channel zero (0) is a predefined report list containing a report header and the channel data shown in the following table. The SolarFlow Plus unit displays the Users Report on the front panel in a scrolling format.

CHANNEL NUMBER	CHANNEL LABEL	DESCRIPTION
Header	--	Time, date, and location data
023	BATTERY	Current battery voltage
020	METR PRES	Live pressure in PSIG
021	DIFF PRESS	Live DP, value in inches of water
022	FLOW TEMP	Live temperature in degrees Fahrenheit (^{o}F)
138	FLOW RATE	Flow rate
142	TOT VOL	Total volume
140	TODAY VOL	Today's volume in MCFD
141	YSDAY VOL	Yesterday's volume in MCFD

3.4 DATA LOG LIST CONTENTS

The following items are included on the data log. The data log is set to a 1-hour log interval. The default contract hour is 7:00 am.

CHANNEL NUMBER	CHANNEL LABEL	DECIMAL PLACES	DIGITS	LOGGING TYPE
021	DIFF PRES	1	4	AVERAGE
131	FLOW PRES1	1	6	AVERAGE
132	FLOW TEMP1	1	4	AVERAGE
134	FLW EXTN 1	2	6	SNAPSHOT & ZERO
139	LOG VOL1	1	6	SNAPSHOT & ZERO
144	LOG ENRGY1	1	6	SNAPSHOT & ZERO
136	FLOW TIME	1	6	SNAPSHOT & ZERO

3.5 ALARM DEFINITIONS

The following is a listing of the Alarm definitions for this application. Note that the alarms will show up in the event log.

Number of Retries: 5 for alarms 1 through 19, 0 (none) for alarm 10

ALARM NO.	ALARM CONDITION	ALARM MESSAGE	Z
1	C(23) < Z	BATTERY low	6.0
2	C(20) < Z	FLOW PRES1 low	0
3	C(21) < Z	DIFF PRES1 low	0
4	C(22) < Z	FLOW TEMP1 low	0
5-7	Reserved		
8	C(26) < Z	SPARE 1 low	0
9	C(138) < Z	FLOW RATE1 low	0
10	Reserved		
11	C(20) > Z	FLOW PRES1 high	1000
12	C(21) > Z	DIFF PRES1 high	100
13	C(22) > Z	FLOW TEMP1 high	150
14-16	Reserved		
17	C(26) > Z	SPARE 1 high	100
18	C(138) > Z	FLOW RATE1 high	100000
19	Reserved		
20	C(30) < > Z	SYS ERROR	0

WARRANTY CLAIM REQUIREMENTS

To make a warranty claim, you, the Purchaser, must:

1. Provide Daniel with proof of the Date of Purchase and proof of the Date of Shipment of the product in question.

2. Return the product to Daniel within twelve (12) months of the date of original shipment of the product, or within eighteen (18) months of the date of original shipment of the product to destinations outside of the United States. The Purchaser must prepay any shipping charges. In addition, the Purchaser is responsible for insuring any product shipped for return, and assumes the risk of loss of the product during shipment.

3. To obtain Warranty service or to locate the nearest Daniel office, sales, or service center call (281) 897-2900, Fax (281) 897-2901, or contact:

   Daniel Measurement Services
   19203 Hempstead Highway
   Houston, Texas 77065

   When contacting Daniel for product service, the purchaser is asked to provide information as indicated on the following "Customer Problem Report".

   Daniel Measurement Services offers both on call and contract maintenance service designed to afford single source responsibility for all its products.

   Daniel Industries, Inc. reserves the right to make changes at any time to any product to improve its design and to insure the best available product.

DANIEL INDUSTRIES, INC.
CUSTOMER PROBLEM REPORT

FOR FASTEST SERVICE, COMPLETE THIS FORM, AND RETURN IT ALONG WITH THE AFFECTED EQUIPMENT TO CUSTOMER SERVICE AT THE ADDRESS INDICATED BELOW.

COMPANY NAME:_____

TECHNICAL CONTACT:_____ PHONE:_____

REPAIR P. O. #:_____ IF WARRANTY, UNIT S/N: _____

INVOICE ADDRESS:_____

_____

_____

SHIPPING ADDRESS:_____

_____

_____

RETURN SHIPPING METHOD:_____

EQUIPMENT MODEL #:_____ S/N:_____FAILURE DATE: _____

DESCRIPTION OF PROBLEM: _____

_____

_____

WHAT WAS HAPPENING AT TIME OF FAILURE? _____

_____

ADDITIONAL COMMENTS: _____

_____

_____

REPORT PREPARED BY:_____ TITLE:_____

IF YOU REQUIRE TECHNICAL ASSISTANCE, PLEASE FAX OR WRITE THE MAIN CUSTOMER SERVICE DEPARTMENT AT:

DANIEL MEASUREMENT SERVICES
ATTN: CUSTOMER SERVICE
19203 HEMPSTEAD HIGHWAY
HOUSTON, TEXAS 77065

PHONE: (281) 897-2900
FAX: (281) 897-2901

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DANIEL