

# MODEL 2480

# SOLARFLOW PLUS

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**DANIEL MEASUREMENT AND CONTROL**

**ENRON ENHANCED SOLARFLOW PLUS  
APPLICATION MANUAL**

**"ENRON AGA7, W/MODBUS PROTOCOL"**

8-2482-008 W/GROSS METHOD  
8-2482-007 W/DETAIL METHOD

**Part Number 3-9004-014  
Revision A**

**FEBRUARY 2000**

***DANIEL***

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**DANIEL INDUSTRIES, INC.  
MODEL 2480 SOLARFLOW PLUS  
ENRON ENHANCED SOLARFLOW PLUS  
ENRON AGA7, WITH MODBUS PROTOCOL  
APPLICATION MANUAL**

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## **SECTION 1**

### **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.

### **1.1 SCOPE OF THIS MANUAL**

This manual includes sections on:

- Calculation modules for "2480 MODB AGA7" (AGA7 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 turbine/PD 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 AGA7



## 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 AND UNCORRECTED RATE CALCULATION (AGA-7)

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 eight running sums which will be converted to average values and placed in SolarFlow Plus Channels 19 - 26 at the beginning of the next calculation cycle. These eight values are simple arithmetic averages of the inputs for the cycle. In addition to these eight averages, "flow time" averages are kept for four inputs to be used in each configured meter run (i.e. eight averages total in a 2-run configuration). These values are flow averages for measured static pressure in PSIG, temperature, specific gravity (regardless of source), and BTU content (regardless of source).

A meter is considered to be flowing if the uncorrected flow rate for that meter is above zero. If no flow occurs for an entire calculation cycle, straight averages are kept for all inputs.

Each 0.5 seconds, the uncorrected flow rates for each configured meter are updated. The uncorrected flow rate is:

$$Q_u = (\text{PULSES})/(\text{METER FACTOR} * T_r)$$

where

$Q_u$	=	Uncorrected rate in actual cubic feet/h (ACF/H)
Pulses	=	The number of pulses used in rate calculation
Meter Factor	=	In pulses per actual cubic foot/hour (PP/CF)
$T_r$	=	Time in hours over which the pulses were received $T_r$ may vary between 2.5 and 60 seconds.

SolarFlow Plus attempts to provide the best rate approximation possible while still providing a responsive uncorrected rate value. At very low input frequencies the rate is smoothed over as much as 60 seconds; at frequencies above approximately 160Hz the rate is smoothed over a period of 2.5 seconds. The approximate uncertainty and bounce in the uncorrected rate value is shown vs. frequency as follows:

<u>Frequency</u>	<u>Uncertainty</u>
< 2 pulses/minute (ppm)	N/A -- rate = 0.0
2-4 ppm	~ 3%
4-10 ppm	< 2%
10 ppm - 6.5Hz	~ 1%
6.5Hz - 160Hz	≤ 0.25%
> 160Hz	< 0.25%

**1.4.2 FLOW RATE EQUATIONS**

The SolarFlow Plus AGA-7 applications calculate volumetric flow rate using the following equations:

$$Q_b = 0.001 * Q_u * CF \text{ (correction factor)}$$

$$V_u = PP / \text{(meter factor)}$$

$$V_c = V_u * CF$$

$$CF = \frac{(P_f + P_{atm})}{(P_b)} * \frac{(T_b + 459.67)}{(T_f + 459.67)} * \frac{Z_b}{Z_f} * F_{wv}$$

where :

- $Q_b$  = volumetric flow rate in MCFH at base conditions
- $V_u$  = uncorrected volume this cycle
- $V_c$  = corrected volume this cycle
- CF = correction factor
- $P_b$  = base pressure in PSIA
- $P_{atm}$  = atmospheric pressure in PSIA
- $P_f$  = line pressure in PSIG
- $Z_b$  = gas compressibility at base conditions
- $Z_f$  = gas compressibility at flowing conditions
- $F_{wv}$  = water vapor factor
- $T_f$  = flowing temperature in DEG F
- $T_b$  = base temperature in DEG F
- pp = pulses received this calculation cycle

All compressibility values are calculated in accordance with AGA Report No. 8, 1992. The operator may select the DETAIL (full analysis) or GROSS (short form) method for compressibility calculation. For equations consult AGA Report No. 8. 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 AGA Report No. 8. 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.

### 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:

<b>NUMBER OF METERS</b>	<b>AGA-8 DETAIL</b>	<b>AGA-8 GROSS (SHORT FORM)</b>
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:

<b>DOT NO.</b>	<b>SYSTEM CONDITIONS</b>	<b>WEIGHT ON CH 30</b>
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	10	PWR +
		Green	11	SIG +
		White	12	SIG -
		Black	13	PWR -
- or -				
20	Statham Series 36, 1-5 VDC static pressure transmitter, (Factory wired, if installed inside SolarFlow Plus enclosure.)	Blue	7	SP
		Red	8	+12 V
		Black	9	GND
21	External, RTD temperature transducer, (To be installed by user, cable supplied.)	*	14	TEMP
		#	15	GND
		#	16	GND
22	External, DP transmitter, (To be installed by user.)	Blue	4	DP1
		Black	5	+12V
		Red	6	GND

\* Amber with Black tracer or Red

# Amber or White

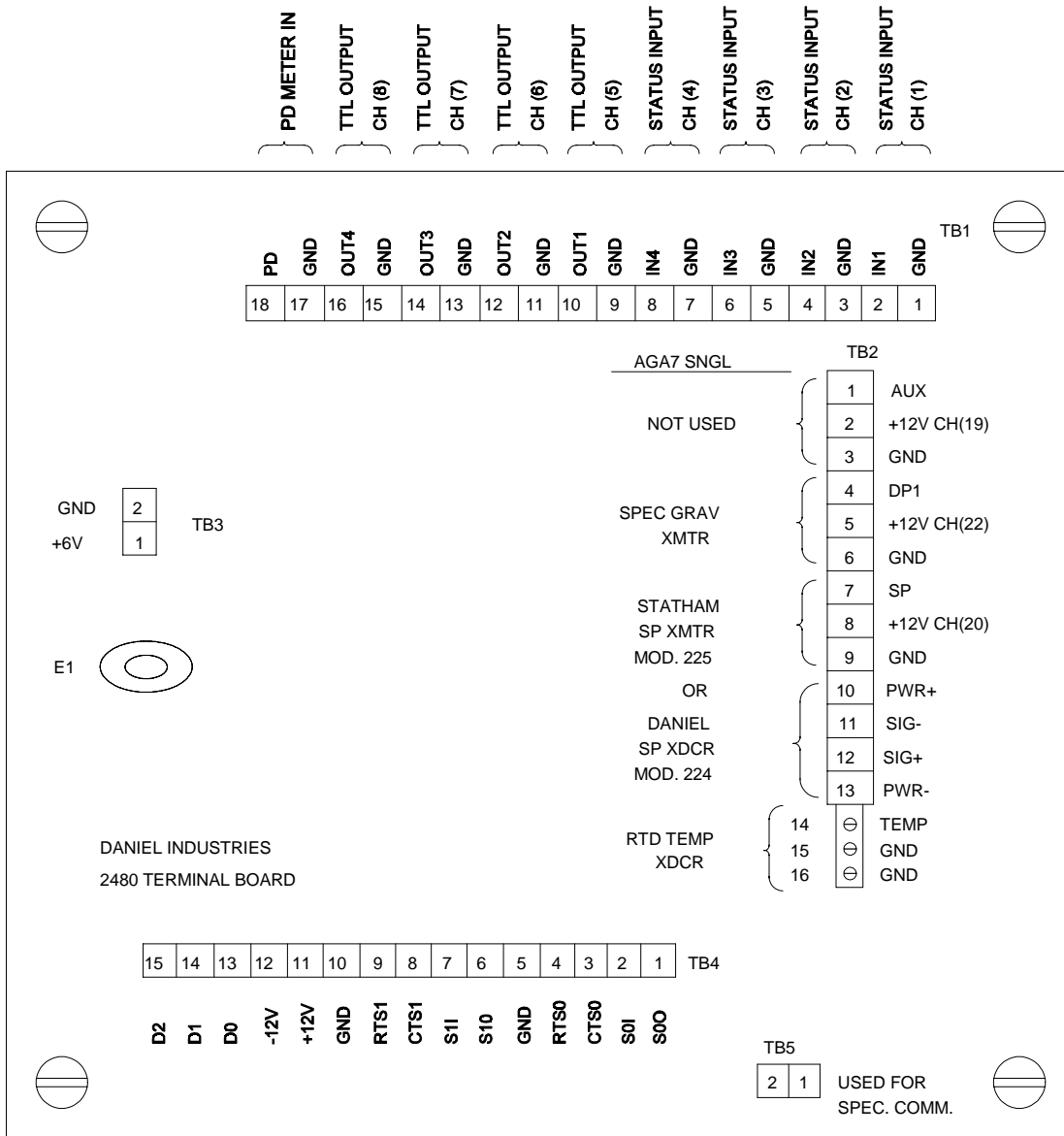


Figure 1-1. Terminal Board Connections



## **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:

	<b><u>TB4 PIN NO.</u></b>
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**

<u>Register</u>	<u>Description</u>	<u>(Read/Write)</u>
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)**

<u>Register</u>	<u>Description</u>	<u>(Read/Write)</u>
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)**

<u>Register</u>	<u>Description</u>	<u>(Read/Write)</u>
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	R
	12 = 2480 AGA3 single w/AGA8 Detail	
	13 = 2480 AGA3 single w/AGA8 Gross	
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)**

<u>Register</u>	<u>Description</u>	<u>(Read/Write)</u>
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	Reserved	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	Reserved	R
7080	Previous Hour    Avg Pressure 1	R
7081	Previous Hour    Avg Temperature 1	R



**SOLARFLOW PLUS MODBUS REGISTER ASSIGNMENTS (CONTINUED)**

<u>Register</u>	<u>Description</u>	<u>(Read/Write)</u>
7082	Reserved	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	R
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	Reserved	R
7100	Previous Day Avg Pressure 1	R
7101	Previous Day Avg Temperature 1	R
7102	Reserved	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)**

<u>Register</u>	<u>Description</u>	<u>(Read/Write)</u>
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

**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	RESERVED				
022	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
031-032 RESERVED					
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
036-041 RESERVED					
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

CH	LABEL	UNITS	DP	DEFAULT	DESCRIPTION
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%
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%

CH	LABEL	UNITS	DP	DEFAULT	DESCRIPTION
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
078-122 RESERVED					
123	METR FCTR1	PPCF	1	1.0	Meter factor in pulses per actual cubit foot
124-128 RESERVED					
129	ZF 1	(None)	6	1.000000	Flowing compressibility
130 RESERVED					
131	FLOW PRES1	PSIG	1	0.0	Analog flowing pressure
132	FLOW TEMP1	DEG F	1	0.0	Analog flowing temperature
133-134 RESERVED					
134	FLW EXTN 1	NONE	3	0.000	$\sum \text{sqrt}(H_w * P_i)$
135	CORR FCTR1	%	2	0.00	
136	FLW TIME 1	MIN	2	0.00	Flow time

CH	LABEL	UNITS	DP	DEFAULT	DESCRIPTION
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	UNCR RATE1	MACFD	1	0	Uncorrected rate/day
149	LOG UVOL1	MACFD	0	0	Uncorrected logged volume 1
150	TDY UVOL1	MACFD	0	0	Uncorrected today's volume 1
151	YSY UVOL1	MACFD	0	0	Uncorrected yesterday's volume 1
152	TOT UVOL1	MACFD	0	0	Uncorrected total volume 1

<b>CH</b>	<b>LABEL</b>	<b>UNITS</b>	<b>DP</b>	<b>DEFAULT</b>	<b>DESCRIPTION</b>
153-240 RESERVED					
* All totals roll over at 10,000,000 so adjust your units accordingly.					



## **SECTION 3**

### **3.0 SINGLE TURBINE/PD APPLICATION**

Section 3 covers the individual requirements for the single turbine/PD application configured to calculate volume and flow rate using equations from section 1.4. The single turbine/PD application supports measurement on a single meter tube.

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 - INPUT CONNECTIONS****3.1.1 ANALOG INPUT CONNECTIONS**

Analog inputs for the single-meter AGA-7 application of the Model 2480 SolarFlow Plus are connected in accordance with the following table.

The following table shows the Solarflow Plus channels assigned for connecting analog inputs to the unit. Drawing number DE-11284 in Appendix C of the model 2480 System Reference Manual provides field wiring detail for connecting the inputs. Figure 3-1 illustrates the terminal board connections for this application.

<b>CH</b>	<b>TRANSMITTER TYPE</b>	<b>WIRE COLOR</b>	<b>TB2 PIN NO.</b>	<b>TB2 PIN LABEL</b>
20	Daniel Model 224 millivolt static pressure transmitter. (Factory wired, if installed inside SolarFlow Plus enclosure.)	Yellow	10	PWR +
		Green	11	SIG +
		White	12	SIG -
		Black	13	PWR -
- OR -				
20	Statham series 36, 1-5 VDC static pressure transmitter. (Factory wired, if installed inside SolarFlow Plus enclosure.)	Blue	7	SP
		Red	8	+12 V
		Black	9	GND
21	External, RTD temperature transducer. (To be installed by user. Cable supplied with connector.)	- <sup>2</sup>	14	TEMP
		- <sup>3</sup>	15	GND
		- <sup>3</sup>	16	GND
22	External, Specific Gravity transmitter. (To be installed by user.)	- <sup>1</sup>	4	DP1
		- <sup>1</sup>	6	GND

- See NOTES, next page -

**NOTES:** Footnotes for preceding table:

<sup>1</sup> Interconnect wiring to be supplied by user.

<sup>2</sup> Amber with Black tracer or Red.

<sup>3</sup> Amber or White.

**3.1.2 PD/TURBINE METER INPUT CONNECTIONS**

<b>INPUT DESCRIPTION</b>	<b>WIRE COLOR</b>	<b>TB1 PIN NO.</b>	<b>TB1 PIN LABEL</b>
PD/Turbine Meter, maximum frequency of 50 Hz. (For pulse inputs up to a maximum frequency of 5 KHz, see section 6.5 of the Model 2480 SolarFlow Plus System Reference Manual, part number 3-9000-497, regarding the Daniel Model 1882 Preamplifier.)	- <sup>1</sup>	17	GND
	- <sup>1</sup>	18	PD

**NOTES:** Footnotes for preceding table:

<sup>1</sup> Interconnect wiring to be supplied by user.

**MODEL 2480 SOLARFLOW PLUS ENHANCED SINGLE METER RUN AGA-7**

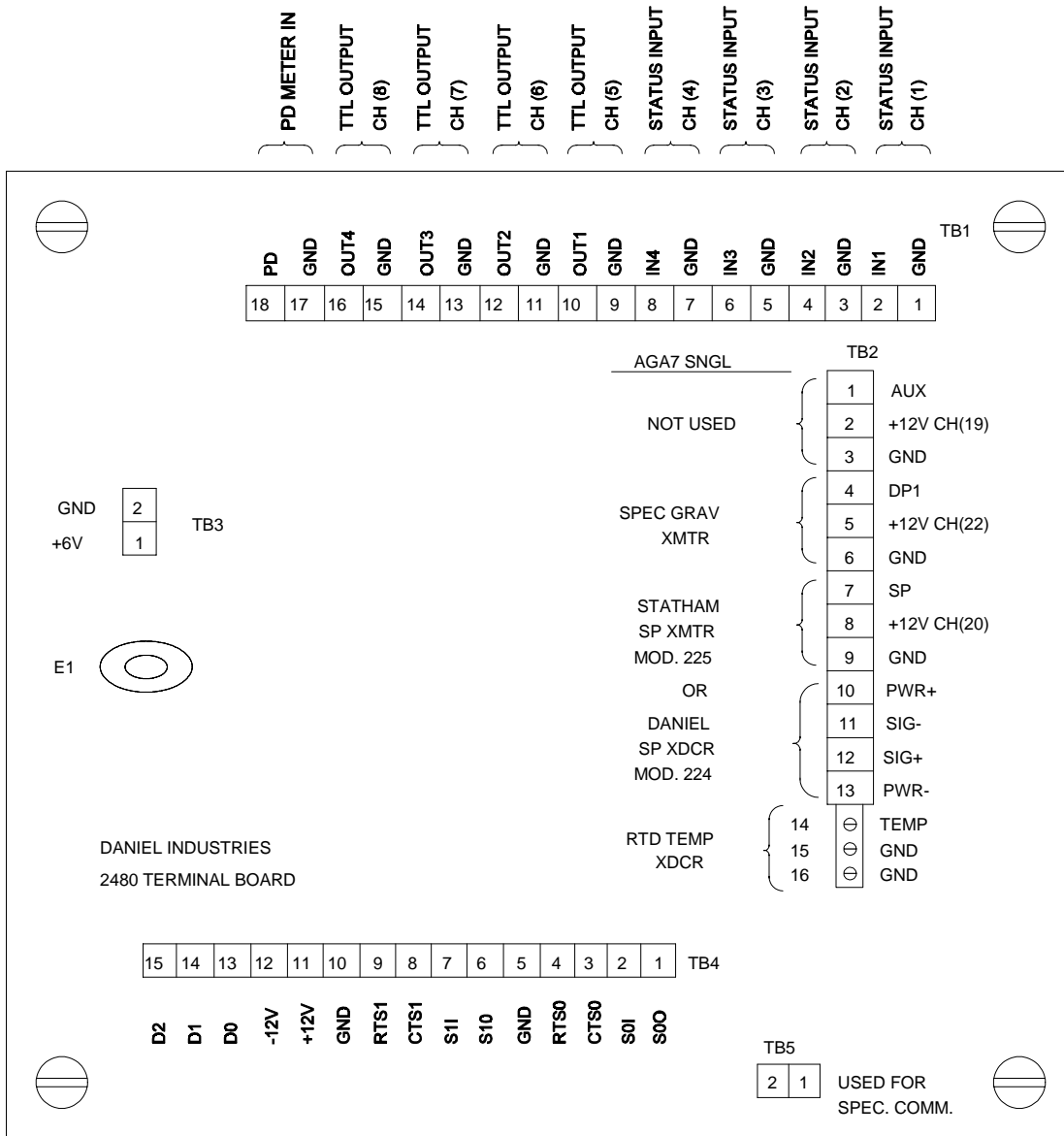


Figure 3-1. Terminal Board Connections

**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.

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

**3.3 USER REPORT (CHANNEL 0)**

The User Report (Channel 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 User Report on the front panel in a scrolling format.

<b>CHANNEL NUMBER</b>	<b>CHANNEL LABEL</b>	<b>DESCRIPTION</b>
Header	--	Time, date, and location data
020	FLOW PRES1	Live pressure meter No.1 in PSIG
022	FLOW TEMP1	Live temperature in degrees Fahrenheit (°F)
148	UNCR RATE1	Uncorrected flow rate, meter No.1
138	FLOW RATE1	Hourly flow rate for meter No.1
142	TOT VOL 1	Total accumulated volume for meter No. 1
140	TODAY VOL1	Today's volume
141	YSDAY VOL1	Yesterday's volume

**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.

<b>CHANNEL NUMBER</b>	<b>CHANNEL LABEL</b>	<b>DECIMAL PLACES</b>	<b>DIGITS</b>	<b>LOGGING TYPE</b>
136	FLW TIME 1	2	6	SNAPSHOT & ZERO
020	FLOW PRES1	1	6	AVERAGE
022	FLOW TEMP1	1	4	AVERAGE
149	LOG UVOL 1	1	6	SNAPSHOT & ZERO
139	LOG VOL 1	1	6	SNAPSHOT & ZERO
144	LOG ENRGY1	1	6	SNAPSHOT & ZERO
074	LOG 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 20

ALARM NO.	ALARM CONDITION	ALARM MESSAGE	X	Y
1	C(23) < X	BATTERY low	10.8	
2	C(20) < X	FLOW PRES1 low	0	
3*	RESERVED			
4	C(22) < X	FLOW TEMP1 low	0	
5*- 8*	RESEVED			
9	C(138) < X	FLOW RATE1 low	0	
10*	RESERVED			
11	C(20) > Y	FLOW PRES1 high		1000
12*	RESERVED			
13	C(22) > Y	FLOW TEMP1 high		150
14* - 17*	RESERVED			
18	C(138) > Y	FLOW RATE1 high		100000
19*	RESERVED			
20	C(30) < > X	SYS ERROR	0	

\* This alarm should be disabled in this application.



When the ALARM menu is entered using the HHDT the user may modify the X or Y values shown in the above alarm conditions by changing the values for LOW and HIGH. This enables the user to adjust the alarm limit(s) to match the requirements.

The value for X is represented by LOW on the HHDT ALARM SETUP menu. The value for Y is represented by HIGH on the HHDT ALARM SETUP menu.

The ALARM menu is also used to acknowledge alarms and to activate or deactivate alarms.

To acknowledge an alarm condition displayed on the LCD of SolarFlow Plus, enter the ALARM menu of the HHDT and select the ACKNOWLEDGE sub-menu. Any existing unacknowledged alarms are displayed and the HHDT prompts: "ACKNOWLEDGE ? Y/N". Press the ENTER key to acknowledge the alarm. Once this has been done and the user has logged off SolarFlow Plus the activated alarm is displayed with the message "ACKNOWLEDGED" following the alarm condition. If the alarm condition no longer exists and has not been acknowledged it remains on the LCD until acknowledged.

To activate or deactivate alarms, enter the HHDT ALARM menu and select the SETUP sub-menu. The HHDT displays the various alarms that are available in the program. Scroll to the desired alarm and press the ENTER key at the desired alarm condition. The HHDT provides four options; STAT, LOW, HIGH, and ALT. Press ENTER at the STAT option. The HHDT shows either ON or OFF and prompts OK?. To turn off the alarm, press the NO key until OFF is displayed, then press ENTER.

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## 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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**LE PRÉSENT APPAREIL NUMÉRIQUE N'ÉMET PAS DES BRUITS RADIOÉLECTRIQUES DÉPASSANT LES LIMITES APPLICABLES AUX APPAREILS NUMÉRIQUES DE CLASSE A PRESCRITES DANS LE RÉGLEMENT SUR LE BROUILLAGE RADIOÉLECTRIQUE ÉDICTÉ PAR LE MINISTÈRE DES COMMUNICATIONS DU CANADA.**

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