

| REV | ACTION | DRAWN | CHECKED | APPROVED | DATE |
|-----|--------|--------------|--------------|----------|----------|
| AA | L6222 | SHORT | SHORT | HOLLAND | 98/10/14 |
| AB | D10476 | LANGBEI N | LANGBEI N | HOLLAND | 00/11/17 |
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Enron

Modbus

Protocol

For

CB181 FCUs

| | | | | | | | | | | |
|----------------------------|------------------|-----------------------------------------------------------------|-----------|------------|------------------------|-----------|------------------|--|--|--|
| PRODUCT LINE TOTALFLOW® | LEVEL 3 | ABB TOTALFLOW Division | | | | | | | | |
| DESIGN JUESCHKE | DATE 98/10/14 | TITLE ENRON MODBUS PROTOCOL FOR CB181 FCUs MODBUS | | | | | | | | |
| DRAWN SHORT | 98/10/14 | | | | | | | | | |
| CHECKED SHORT | 98/10/14 | | | | | | | | | |
| APPROVED HOLLAND | 98/10/14 | SCALE NONE | SIZE A | TYPE AI | DRAWING NO. 2018462 | REV AB | SHEET 1 OF 16 | | | |

I. Purpose

This paper describes Enron Modbus communications for Totalflow 6700 series FCUs.

II. Background

Totalflow has been asked to implement Modbus ASCII communications for transferring data between TOTALFLOW FCUs and Enron's host computer system. Modbus commands and function codes are described in section 4.11 of the document entitled "Electronic Flow Measurement RTU Technical Specification," published by Enron Corporation.

III. Modbus Description

The Modbus protocol is described in the document entitled "Gould Modbus Protocol Reference Guide" published January, 1985 by Gould Inc., Programmable Control Division, Andover, Massachusetts. Modbus uses the master, slave communications concept. Slave devices speak only when spoken to by the master. Each slave is identified by an unsigned, one byte number ranging from 1 to 247 (inclusive). A slave must send a single response to a master's request for data. The master may broadcast a message to all slaves by sending a zero in the slave address field of the broadcast message. Slaves do not send responses to the master's broadcast. Modbus messages may be one of two formats: ASCII or RTU. The ASCII format is essentially an RTU packet with the following differences:

- Has been converted to hexadecimal ASCII.
- Contains an 8 bit LRC instead of a 16 bit CRC.
- Is wrapped in a simple message frame consisting of begin frame character (:), end frame character (carriage return) and ready (linefeed).

IV. Totalflow Modbus Implementation for Enron

Totalflow's implementation of the Enron Modbus supports only ASCII mode as prescribed in the aforementioned Enron documentation. RTU mode is not described in this document. Broadcast commands are not supported. Totalflow Modbus supports a subset of the Gould Modbus defined function codes. Support has also been added for long integer, floating point, and archive record registers.

Modbus ASCII message frame format:

| | | | |
|-----|--------------------------------------|-----|-------|
| BOF | Packet | EOF | Ready |
| : | 2 x Number of bytes in Modbus packet | CR | LF |

BOF: A colon (:) character is used to indicate beginning of frame.

Packet: The packet field consists of hexadecimal ASCII characters representing the Modbus packet being sent or received. The number of characters is twice the number of bytes in the Modbus packet because each packet byte is converted into two hexadecimal ASCII characters ('0'-'9','A'-'F').

EOF/Ready: A carriage return and line feed are used to delineate end of frame.

Modbus packet formats:

Read Query

| | | | | |
|---------|----------|----------|----------|--------|
| Address | Function | Register | Quantity | LRC |
| 8-bits | 8-bits | 16-bits | 16-bits | 8-bits |

Read Response

| | | | | |
|---------|----------|------------|------------|--------|
| Address | Function | Byte Count | Data | LRC |
| 8-bits | 8-bits | 8-bits | N x 8 bits | 8-bits |

Set Query

| | | | | |
|---------|----------|----------|------------|--------|
| Address | Function | Register | Data | LRC |
| 8-bits | 8-bits | 16-bits | N x 8 bits | 8-bits |

Set Response

| | | | | |
|---------|----------|----------|------------|--------|
| Address | Function | Register | Data | LRC |
| 8-bits | 8-bits | 16-bits | N x 8 bits | 8-bits |

Address: The address field contains the slave address of the FCU intended to receive the packet. Each FCU must be assigned a unique address in the range of 1 to 247.

Function: The function code field contains a code which tells the FCU what to do or what data to send. The high order bit in this field may be set by the FCU in the response packet to indicate an error response. Function codes supported:

| Function Code | Function | Description |
|---------------|-----------------------|----------------------------------------------------------------------------------------------------------------------------------|
| 01 | Read Boolean | Reads group of boolean registers |
| 03 | Read Registers | Reads group of 16/32 bit registers |
| 05 | Set Single Boolean | Set or clear a boolean register |
| 06 | Set Single Register | Set a 16/32 bit register to specified value |
| 07 | Read Exception Status | Reads 8 bit status register |
| 16 | Set Multiple Register | Set multiple 16/32 bit registers |
| 128-143 | Exception Response | Used by FCU to indicate errors in processing function codes 1-16. FCU responds with function code + 127 for function codes 1-16. |

Register: The register field contains the register number of the FCU data item to fetch or set. For read functions, this is the starting register number. Registers are grouped by data type as described in section V below.

Quantity: The quantity field contains the number of consecutive registers to fetch or set, This field is not present in all packets. Only read query packets contain this field.

Byte Count: The byte count field contains the number of bytes of data being transferred. This field is not present in all packets. Only read response packets contain this field.

Data: The data field contains the actual data values being transferred. This field is not present in all packets. The size and format of the data values depend on the register group being accessed. The byte order of integer, long integer, and floating point data values is high to low (MSB....LSB). For archive registers, the entire record is reversed (MSB of last field first, LSB of first field last.) Boolean data is returned bit packed (8 registers / byte) for read functions. The set boolean function contains a 16 bit data field (x0000 to clear a register, xFF00 to set a register.)

LRC: The error check field consists an 8 bit longitudinal redundancy check calculated over the length of the packet field before it is converted to hexadecimal ASCII.

V. Totalflow Modbus Data

This section describes the Modbus register group numbers for Totalflow Enron FCU data. Register numbers are used to identify specific data items to be read or written. Registers are grouped by data type. Table 5.1 depicts Totalflow Enron Modbus register group numbers. For the purposes of this document GO stands for GAS Orifice meter and PI for pulse meter.

Table 5.1 Register Groups

| Registers | Type | Description |
|-----------|---------|----------------------------|
| 32 | Record | Event or Alarm Records |
| 700 | Record | Hourly or Daily Records |
| 1000 | BOOLEAN | Digital or Discrete, 1 bit |
| 3000 | INTEGER | 16 Bit integers |
| 5000 | LONG | 32 Bit integers |
| 7000 | FLOAT | 32 Bit IEEE floating point |

Table 5.2 Boolean Registers

Boolean registers are read using function code 01 or set using function code 05.

| Register | Access | Description |
|----------|------------|-------------------------------------------------------------------|
| 1001 | Read/Write | Use Sqrt /linear AP/DP avgs (1 = Sqrt) Defaulted to 0 for PI |
| 1002 | Read/Write | Use Y (GO only) |
| 1003 | Read/Write | Use F(pv) |
| 1004 | Read/Write | Use F(w) |
| 1005 | Read/Write | Use F(aux) (GO meter) |
| 1006 | Read/Write | Tap location (1 = Upstream) (GO only) |
| 1007 | Read/Write | Use calcd / fixed Cd (1 = calcd) (GO only) |
| 1008 | Read/Write | Tap Type Support (1 = supported) (GO only) |
| 1009 | Read/Write | Tap type (1 = pipe, 0 = flange) (GO only) |
| 1010 | Read/Write | RTD installed |
| 1011 | Read/Write | Use measured temperature in calcs |
| 1012 | Write Only | Reset volume |
| 1013 | Write Only | Reset Log Period |
| 1014 | Read/Write | Trip contact on Low Charger alarm |
| 1015 | Read/Write | Trip contact on DP low alarm (GO only) |
| 1016 | Read/Write | Trip contact on DP high alarm (GO only) |
| 1017 | Read/Write | Trip contact on AP low alarm |
| 1018 | Read/Write | Trip contact on AP high alarm |
| 1019 | Read/Write | Trip contact on Remote Sense |
| 1020 | Read/Write | Trip contact on volume setpoint |
| 1021 | Read/Write | Aux Contact Auto Reset (1 = yes) |
| 1022 | Read/Write | Auxiliary Contact State (0/1) |
| 1023 | Read/Write | Hold Current Analog Inputs |
| 1024 | Read Only | Attached to stream (AIU support) |
| 1025 | Read Only | First analysis received (AIU support) |
| 1026 | Read/Write | Use Fixed Analysis on error (AIU support) |
| 1027 | Read/Write | Use Fixed Water Vapor Content |
| 1028 | Write Only | Wakeup FCU from low voltage induced sleep |
| 1029 | Read/Write | Use Fixed Test Mode AP, DP(for GO, Pulse for PI), and RTD values. |
| 1030 | Read/Write | Use Live AP in Calculations (PI only) |
| 1031 | Read/Write | Use Fpb in calculations (PI only) |
| 1032 | Read/Write | Use Ftb in calculations (PI only) |

| Register | Access | Description |
|----------|------------|-------------------------------------------|
| 1033 | Read/Write | Use Faux (PI only) |
| 1034 | Read/Write | Use Fpv (PI only) |
| 1035 | Read/Write | Trip contact on ACF low alarm (PI only) |
| 1036 | Read/Write | Trip contact on ACFhigh alarm (PI only) |
| 1037 | Read Only | Security Switch |
| 1038 | Read Only | Low Lithium |
| 1039 | Read Only | Remote Sense Digital Input 1 |
| 1040 | Read Only | RTC |
| 1041 | Read Only | Digital Input 2 |
| 1042 | Read Only | Low Charger |
| 1043 | Read Only | Low Battery |
| 1044 | Read Only | Low Radio Battery |
| 1045 | Read Only | VCI Digital Input 1 |
| 1046 | Read Only | VCI Digital Input 2 |
| 1047 | Read Only | VCI Digital Input 3 |
| 1048 | Read Only | VCI Digital Input 4 |
| 1049 | Read/Write | VCI Digital Output 1 |
| 1050 | Read/Write | VCI Digital Output 2 |
| 1051 | Read/Write | VCI Digital Output 3 |
| 1052 | Read/Write | VCI Digital Output 4 |
| 1053 | Read/Write | Digital Output 1 |
| 1054 | Read/Write | Digital Output 2 |
| 1055 | Read/Write | Remote Port Operate |
| 1056 | Read/Write | Aux Port Operate |
| 1057 | Read/Write | Bus Operate |

Table 5.3 Short Integer Registers

Short integer registers are read using function code 03 or set using function code 06 or 16.

| Register | Access | Description |
|----------|--------|------------------------------------------------------|
| 3001 | | Primary element |
| 3002 | | Primary element mask |
| 3003 | | FCU volume calc. method (1 = 1985, 2 = 1992) |
| 3004 | | FCU volume calc.method mask |
| 3005 | | FCU calculation units |
| 3006 | | FCU calculation units mask |
| 3007 | | Supercomp method |
| 3008 | | Supercomp method mask |
| 3009 | | Contract Hour |
| 3010 | | Volume calculation period |
| 3011 | | Modbus Slave Address |
| 3012 | | Remote Comm Baud Rate |
| 3013 | | Remote Comm Data Bits (7 or 8) |
| 3014 | | Remote Comm Parity |
| 3015 | | Remote Comm Stop Bits (1 or 2) |
| 3016 | | Radio power up delay(milliseconds) |
| 3017 | | Xmitter key delay(milliseconds) |
| 3018 | | Xmitter unkey delay (milliseconds) |
| 3019 | | Remote Comm Protocol (0 = Totalflow, 1 = Modbus) |
| 3020 | | Remote Comm Link Establish Time (Totalflow Protocol) |
| 3021 | | Maximum Number of Events |
| 3022 | | Sequence Number of Last Event Logged |
| 3023 | | Sequence Number of Last Event Read |
| 3024 | | Sequence Number of Last Event Acknowledged |

| Register | Access | Description |
|----------|------------|------------------------------------------------------------------------------------------|
| 3025 | | Number of unacknowledged events |
| 3026 | | Maximum Number of Log Period Records |
| 3027 | | Sequence Number of current Log Period Record |
| 3028 | | Maximum Number of Day Period Records |
| 3029 | | Sequence Number of current Day Period Record |
| 3030 | | Sequence number of first Log Period Record in current day |
| 3031 | | Vol Period Counter |
| 3032 | | FCU ID |
| 3033 | | FCU ID (cont.) |
| 3034 | | FCU ID (cont.) |
| 3035 | | FCU ID (cont.) |
| 3036 | | FCU ID (cont.) |
| 3037 | | FCU Location |
| 3038 | | FCU Location (cont.) |
| 3039 | | FCU Location (cont.) |
| 3040 | | FCU Location (cont.) |
| 3041 | | FCU Location (cont.) |
| 3042 | | FCU Location (cont.) |
| 3043 | | FCU Location (cont.) |
| 3044 | | FCU Location (cont.) |
| 3045 | | FCU Location (cont.) |
| 3046 | | FCU Location (cont.) |
| 3047 | | FCU Location (cont.) |
| 3048 | | FCU Location (cont.) |
| 3049 | | Software Part Number |
| 3050 | | Software Part Number (cont.) |
| 3051 | | Software Part Number (cont.) |
| 3052 | | Software Part Number (cont.) |
| 3053 | | Software Part Number (cont.) |
| 3054 | | Software Part Number (cont.) |
| 3055 | | Software Part Name |
| 3056 | | Software Part Name (cont.) |
| 3057 | | Software Part Name (cont.) |
| 3058 | | Software Part Name (cont.) |
| 3059 | | Software Part Name (cont.) |
| 3060 | | Software Part Name (cont.) |
| 3061 | | Software Part Name (cont.) |
| 3062 | | Software Part Name (cont.) |
| 3063 | | Software Part Name (cont.) |
| 3064 | | Software Part Name (cont.) |
| 3065 | | Software Part Name (cont.) |
| 3066 | | Software Part Name (cont.) |
| 3067 | | Software Revision |
| 3068 | | Software Revision (cont.) |
| 3069 | Read/Write | No Flow Window width (PI Meter) |
| 3070 | Read/Write | Remote Port Schedule (1= use time of day and duration 2= every n hours for duration) |
| 3071 | Read/Write | Remote Port Hour to Start Comm (0=midnite 23=11pm) |
| 3072 | Read/Write | Remote Port Minute to Start Comm (0=top of hour, to 59) |
| 3073 | Read/Write | Remote Port Comm Duration in Minutes |
| 3074 | Read | Remote Port Schedule Status On, Off |
| 3075 | Read/Write | Remote Port Schedule Comm Interval Hours |
| 3076 | Read/Write | Remote Port Schedule Comm Off Hour |
| 3077 | Read/Write | Remote Port Exception Retry Attempts |

| Register | Access | Description |
|-----------|------------|----------------------------------------------|
| 3078 | Read/Write | Aux Port Schedule (see Remote Port Schedule) |
| 3079 | Read/Write | Aux Port Hour to Start Comm |
| 3080 | Read/Write | Aux Port Minute to Start Comm |
| 3081 | Read/Write | Aux Port Comm Duration in Minutes |
| 3082 | Read | Aux Port Schedule Status |
| 3083 | Read/Write | Aux Port Schedule Comm Interval Hours |
| 3084 | Read/Write | Aux Port Schedule Comm Off Hour |
| 3085 | Read/Write | Aux Port Exception Retry Attempts |
| 3086 | Read/Write | AuxB Port Hour to Start Comm |
| 3087 | Read/Write | AuxB Port Minute to Start Comm |
| 3088 | Read/Write | AuxB Port Comm Duration in Minutes |
| 3089 | Read | AuxB Port Schedule Status |
| 3090 | Read/Write | AuxB Port Schedule Comm Interval Hours |
| 3091 | Read/Write | AuxB Port Schedule Comm Off Hour |
| 3092 | Read/Write | AuxB Port Exception Retry Attempts |
| 3093-3112 | Read/Write | General Purpose User Registers |
| 3113 | Read/Write | Valve Control Interface Feature Flag Word 1 |
| 3114 | Read/Write | Valve Control Interface Feature Flag Word 2 |
| 3115 | Read/Write | Valve Control Interface Command Word 1 |
| 3116 | Read/Write | Valve Control Interface Command Word 2 |
| 3117 | Read/Write | Valve Control Interface Status Word 1 |
| 3118 | Read/Write | Valve Control Interface Status Word 2 |
| 3119 | Read/Write | Valve Control DP Gain |
| 3120 | Read/Write | Valve Control AP Gain |
| 3121 | Read/Write | Valve Control FR Gain |
| 3122 | Read/Write | Valve Control Extension Word |
| 3123 | Read/Write | Valve Control Manual Pulse Width |
| 3124 | Read/Write | Valve Control Calculated Pulse Width |
| 3125 | Read/Write | Valve Control DP Low Override Delay |
| 3126 | Read/Write | Valve Control Intermitter On Duration |
| 3127 | Read/Write | Valve Control Intermitter Off Duration |
| 3128 | Read/Write | Valve Control Intermitter On Remaining |
| 3129 | Read/Write | Valve Control Intermitter Off Remaining |
| 3130 | Read/Write | Valve Control Shut-in Close Duration |
| 3131 | Read/Write | Valve Control Shut-in Close Remaining |

Table 5.4 Long Integer Registers

Access to long integer data is an extension of the Gould Modbus ASCII protocol.
Long integer registers are read using function code 03 or set using function code 06 or 16.

| Register | Access | Description |
|----------|--------|---------------------------------------------------------------|
| 5001 | | Date / Time |
| 5002 | | Volume Log period |
| 5003 | Read | Log Period Counter |
| 5004 | | Log Period Start Date/Time |
| 5005 | | Day Period Start Date/Time |
| 5006 | | AIU Date/Time |
| 5007 | | AIU Stream ID |
| 5008 | | Modbus Security Seed |
| 5009 | Read | Extended Feature Flags |
| 5010 | Read | Cold Start Date |
| 5011 | Read | Total RAM size |
| 5012 | Read | Total Banked RAM size |
| 5013 | Read | Total Free Banked RAM |
| 5014 | Read | Volume calc period in seconds |
| 5015 | Read | Total flow time in seconds for last volume calculation period |
| 5016 | Read | Last volume calculation period error flags |
| 5017 | Read | PI channel 0 one second pulse count |
| 5018 | Read | PI channel 1 one second pulse count |
| 5019 | Read | PI channel 0 volume calc period pulse count |
| 5020 | Read | PI channel 1 volume calc period pulse count |

Table 5.5 Floating Point Registers

Access to floating point data is an extension of the Gould Modbus ASCII protocol.
Floating point registers are read using function code 03 or set using function code 06 or 16.

| Register | Access | Description |
|----------|------------|--------------------------------------------------------|
| 7001 | Read Only | Manufacturer ID Number (Always 6000) |
| 7002 | Read Only | Operating System Number (PROM Part#) |
| 7003 | Read Only | Operating System Revision (PROM Rev) |
| 7004 | Read/Write | System Date |
| 7005 | Read/Write | System Time |
| 7006 | Read/Write | Contract Hour |
| 7007 | Read Only | Day Period Record Position |
| 7008 | Read Only | Log Period Record Position |
| 7009 | Read Only | Number of Events since last Ack |
| 7010 | Read/Write | Station ID (0 if non-numeric ID entered) |
| 7011 | Read Only | Current battery voltage |
| 7012 | Read Only | Current charger voltage |
| 7013 | Read Only | Current AP |
| 7014 | Read Only | Current DP |
| 7015 | Read Only | Current Temp |
| 7016 | Read Only | Current flow rate (MCF/Day) |
| 7017 | Read Only | Current energy rate (MMBTU/Day) |
| 7018 | Read Only | Accumulated Energy since start of contract day (MMBTU) |
| 7019 | Read Only | Accumulated Volume since start of contract day (MCF) |
| 7020 | Read Only | Previous Hour Average DP (GO only) |

| | | |
|------|-----------|--------------------------|
| 7021 | Read Only | Previous Hour Average AP |
| 7022 | Read Only | Previous Hour Average TF |

| Register | Access | Description |
|----------|------------|-----------------------------------------|
| 7023 | Read Only | Previous Hour Uncorrected volume (MACF) |
| 7024 | Read Only | Previous Hour volume (MCF) |
| 7025 | Read Only | Previous Hour energy (MMBTU) |
| 7026 | Read Only | Previous Hour Flow Time (MMMM.SS) |
| 7027 | Read Only | Previous Hour Time (MMMM.SS) |
| 7028 | Read Only | Previous Day Average DP (GO only) |
| 7029 | Read Only | Previous Day Average AP |
| 7030 | Read Only | Previous Day Average TF |
| 7031 | Read Only | Previous Day Uncorrected volume (MACF) |
| 7032 | Read Only | Previous Day volume (MCF) |
| 7033 | Read Only | Previous Day energy (MMBTU) |
| 7034 | Read Only | Previous Day Flow Time (MMMM.SS) |
| 7035 | Read Only | Previous Day Time (MMMM.SS) |
| 7036 | Read/Write | Fixed Analysis BTU |
| 7037 | Read/Write | Fixed Analysis Gravity |
| 7038 | Read/Write | Fixed Analysis CO2 |
| 7039 | Read/Write | Fixed Analysis N2 |
| 7040 | Read/Write | Fixed Analysis Methane |
| 7041 | Read/Write | Fixed Analysis Ethane |
| 7042 | Read/Write | Fixed Analysis Propane |
| 7043 | Read/Write | Fixed Analysis IButane |
| 7044 | Read/Write | Fixed Analysis NButane |
| 7045 | Read/Write | Fixed Analysis IPentane |
| 7046 | Read/Write | Fixed Analysis NPentane |
| 7047 | Read/Write | Fixed Analysis NHexane |
| 7048 | Read/Write | Fixed Analysis NHeptane |
| 7049 | Read/Write | Fixed Analysis NOctane |
| 7050 | Read/Write | Fixed Analysis NNonane |
| 7051 | Read/Write | Fixed Analysis H2S |
| 7052 | Read/Write | Fixed Analysis Hydrogen |
| 7053 | Read/Write | Fixed Analysis Helium |
| 7054 | Read/Write | Fixed Analysis Oxygen |
| 7055 | Read/Write | Fixed Analysis Carbon Monoxide |
| 7056 | Read/Write | Fixed Analysis Argon |
| 7057 | Read/Write | Fixed Analysis NDecane |
| 7058 | Read/Write | Fixed Analysis H2O |
| 7059 | Read/Write | Fixed temperature |
| 7060 | Read/Write | Temperature bias |
| 7061 | Read/Write | Temperature base |
| 7062 | Read/Write | Pressure base |
| 7063 | Read/Write | Ratio of specific heats |
| 7064 | Read/Write | Viscosity |
| 7065 | Read/Write | Fixed Cd |
| 7066 | Read/Write | Fixed F(aux) |
| 7067 | Read/Write | Fixed F(t) for NX19 |
| 7068 | Read/Write | Fixed F(p) for NX19 |
| 7069 | Read/Write | Zba - Z of air at base |
| 7070 | Read/Write | Orifice diameter |
| 7071 | Read/Write | Orifice plate coef. of expansion |
| 7072 | Read/Write | Pipe diameter |
| 7073 | Read/Write | Pipe coef. of expansion |

| | | |
|------|------------|---------------------------------------|
| 7074 | Read/Write | Fixed barometric pressure |
| 7075 | Read/Write | Fixed Water Vapor Content (LBS/MMSCF) |
| 7076 | Read/Write | Water Content Bias (LBS/MMSCF) |

| Register | Access | Description |
|----------|------------|------------------------------------|
| 7077 | Read Only | Last Calc Period diff. Pressure |
| 7078 | Read Only | Last Calc Period abs. pressure |
| 7079 | Read Only | Last Calc Period flowing temp |
| 7090 | Read Only | Last Calc Period volume (SCF) |
| 7081 | Read Only | Last Calc Period Extension |
| 7082 | Read Only | Last Calc Period C' |
| 7083 | Read Only | Last Calc Period Y |
| 7084 | Read Only | Last Calc Period F(pv) |
| 7085 | Read Only | Last Calc Period F(w) |
| 7086 | Read Only | Last Calc Period F(aux) |
| 7087 | Read Only | Last Calc Period Qv |
| 7088 | Read Only | Last Calc Period Fip |
| 7089 | Read Only | Last Calc Period Ev |
| 7090 | Read Only | Last Calc Period Orif Diameter |
| 7091 | Read Only | Last Calc Period Pipe Diameter |
| 7092 | Read Only | Last Calc Period Rhob |
| 7093 | Read Only | Last Calc Period qm |
| 7094 | Read Only | Last Calc Period Cd |
| 7095 | Read Only | Last Calc Analysis BTU |
| 7096 | Read Only | Last Calc Analysis Gravity |
| 7097 | Read Only | Last Calc Analysis CO2 |
| 7098 | Read Only | Last Calc Analysis N2 |
| 7099 | Read Only | Last Calc Analysis Methane |
| 7100 | Read Only | Last Calc Analysis Ethane |
| 7101 | Read Only | Last Calc Analysis Propane |
| 7102 | Read Only | Last Calc Analysis IButane |
| 7103 | Read Only | Last Calc Analysis NButane |
| 7104 | Read Only | Last Calc Analysis IPentane |
| 7105 | Read Only | Last Calc Analysis NPentane |
| 7106 | Read Only | Last Calc Analysis NHexane |
| 7107 | Read Only | Last Calc Analysis NHeptane |
| 7108 | Read Only | Last Calc Analysis NOctane |
| 7109 | Read Only | Last Calc Analysis NNonane |
| 7110 | Read Only | Last Calc Analysis H2S |
| 7111 | Read Only | Last Calc Analysis Hydrogen |
| 7112 | Read Only | Last Calc Analysis Helium |
| 7113 | Read Only | Last Calc Analysis Oxygen |
| 7114 | Read Only | Last Calc Analysis Carbon Monoxide |
| 7115 | Read Only | Last Calc Analysis Argon |
| 7116 | Read Only | Last Calc Analysis NDecane |
| 7117 | Read Only | Last Calc Analysis H2O |
| 7118 | Read/Write | DP Zero cutoff (GO only) |
| 7119 | Read/Write | DP low limit (GO only) |
| 7120 | Read/Write | DP hi limit (GO only) |
| 7121 | Read/Write | AP lo limit |
| 7122 | Read/Write | AP hi limit |
| 7123 | Read/Write | Tf low limit |
| 7124 | Read/Write | Tf high limit |
| 7125 | Read/Write | Flow Rate low limit |
| 7126 | Read/Write | Flow Rate high limit |

| | | |
|------|------------|--------------------------------------|
| 7127 | Read/Write | Volume Set Point for contact |
| 7128 | Read Only | Accumulated Volume Rollover Setpoint |
| 7129 | Write Only | Places User Site Code in Event Log |
| 7130 | Read Only | AP low calibration |

| Register | Access | Description |
|-----------|------------|----------------------------------------------------------|
| 7131 | Read Only | AP mid calibration |
| 7132 | Read Only | AP high calibration |
| 7133 | Read Only | DP lo calibration |
| 7134 | Read Only | DP mid calibration |
| 7135 | Read Only | DP high calibration |
| 7136 | Read Only | Current Unfiltered Temp |
| 7137 | Read Only | Current Unfiltered AP |
| 7138 | Read Only | Current Unfiltered DP (GO only) |
| 7140 | Read/Write | Test Mode Fixed RTD |
| 7141 | Read/Write | Test Mode Fixed AP |
| 7142 | Read/Write | Test Mode Fixed DP (Test Pulse Counts PI Meter) |
| 7143 | Read | Volume calculation period pulse count (PI) |
| 7144 | Read | Current instantaneous flow rate in ACF/Hour (PI) |
| 7145 | Read | Uncorrected volume accumulator in ACF (PI) |
| 7146 | Read | Previuos day period uncorrected volume in MACF (PI) |
| 7147 | Read | Last calculation period uncorrected volume in ACF (PI) |
| 7148 | Read | Last calculation period Fpv (PI) |
| 7149 | Read | Last calculation period Fpb (PI) |
| 7150 | Read | Last calcaultion period Ftb (PI) |
| 7151 | Read/Write | Fixed Ap (PI) |
| 7152 | Read/Write | ACF low limit (PI) |
| 7153 | Read/Write | ACF high limit (PI) |
| 7154 | Read | Pulse input meter factor |
| 7155-7204 | Read/Write | General Purpose User Registers |
| 7205 | Read/Write | Valve Control AP Bias |
| 7206 | Read/Write | Valve Control DP High Limit |
| 7207 | Read/Write | Valve Control DP Low Limit |
| 7208 | Read/Write | Valve Control DP Setpoint |
| 7209 | Read/Write | Valve Control DP Dead Band |
| 7210 | Read/Write | Valve Control Pipe Length |
| 7211 | Read/Write | Valve Control AP High Limit |
| 7212 | Read/Write | Valve Control AP Low Limit |
| 7213 | Read/Write | Valve Control AP Setpoint |
| 7214 | Read/Write | Valve Control AP Dead Band |
| 7215 | Read/Write | Valve Control Pipe ID |
| 7216 | Read/Write | Valve Control FR High |
| 7217 | Read/Write | Valve Control FR Low |
| 7218 | Read/Write | Valve Control FR Setpoint |
| 7219 | Read/Write | ValveControl FR Dead Band |
| 7220 | Read/Write | Valve Control Battery Voltage |
| 7221 | Read/Write | Valve Control AP Override |
| 7222 | Read/Write | Valve Control AP Restart |

Table 5.6 AGA 3 Archive Flow Records

Access to daily and hourly archive records is an extension of the Gould Modbus ASCII protocol. Enron daily and hourly period flow records are read using Modbus function code 03.

Register numbers 701 and 702 are used to indicate Enron daily and hourly flow data. The record number is passed in the quantity field of the read request. One daily or hourly record may be read per request.

| Field | Size | Type | Description |
|-----------|------|-------|-----------------------------------------------|
| Date | 4 | FLOAT | Log Date: MMDDYY.0 |
| Time | 4 | FLOAT | Log Time: HHMM.SS |
| Dp_avg | 4 | FLOAT | Average Dp during flow (inches H2O) |
| AP_avg | 4 | FLOAT | Average Ap during flow (psig) |
| TF_avg | 4 | FLOAT | Average temperature (degrees F) |
| Extension | 4 | FLOAT | Uncorrected volume MACF |
| Volume | 4 | FLOAT | Volume for the day (MCF) |
| Energy | 4 | FLOAT | Energy for the day (MMBTU) |
| Flow Time | 4 | FLOAT | Number of minutes of flow in period (MMMM.SS) |
| | 36 | | Daily Flow Record Length |

Table 5.7 AGA7 Archive Flow Records

Access to daily and hourly archive records is an extension of the Gould Modbus ASCII protocol. Enron daily and hourly period flow records are read using Modbus function code 03.

Register numbers 701 and 702 are used to indicate Enron daily and hourly flow data. The record number is passed in the quantity field of the read request. One daily or hourly record may be read per request.

| Field | Size | Type | Description |
|-----------|------|-------|-----------------------------------------------|
| Date | 4 | FLOAT | Log Date: MMDDYY.0 |
| Time | 4 | FLOAT | Log Time: HHMM.SS |
| AP_avg | 4 | FLOAT | Average Ap during flow (psig) |
| TF_avg | 4 | FLOAT | Average temperature (degrees F) |
| Extension | 4 | FLOAT | Uncorrected volume MACF |
| Volume | 4 | FLOAT | Volume for the day (MCF) |
| Energy | 4 | FLOAT | Energy for the day (MMBTU) |
| Flow Time | 4 | FLOAT | Number of minutes of flow in period (MMMM.SS) |
| | 32 | | Daily Flow Record Length |

Table 5.8 Event Log Record

Access to Event Log archive records is an extension of the Gould Modbus ASCII protocol. Enron Event records are read using Modbus function code 03.

Register number 32 is used to indicate Enron Event data.

| Field | Size | Type | Description |
|------------|------|---------|--------------------------------------|
| Event Type | 2 | INTEGER | 16 BIT mask for describes event type |
| Register # | 2 | INTEGER | 16 BIT Register # of affected value |
| DATE | 4 | FLOAT | Date of this log record: MMDDYY.0 |
| TIME | 4 | FLOAT | Time of this log record: HHMMSS.0 |
| OLD VALUE | 4 | FLOAT | Value changed from... |
| NEW VALUE | 4 | FLOAT | Value changed to... |
| | 20 | | Event Record Size |

Enron Event collection acknowledge is performed using function code 05 and register number 32. After Events have been collected, the host sends an acknowledge to the FCU which then resets the Events collected pointer so that the host collects new Events only.

Table 5.9 Totalflow Event Code / Register Cross Reference

| Event Code | Register | Description |
|------------|----------|-----------------------------|
| 1 | 7004 | New date and time |
| 5 | 7006 | Contract day starting hour |
| 8 | 5007 | AIU Stream ID |
| 9 | 1039 | Use fixed anlysis on error? |
| 10 | 1025 | Reset volume |
| 11 | 1041 | Wakeup from sleep |
| 14 | 7136 | Accumulated volume rollover |
| 16 | 1037 | Attached to AIU stream? |
| 20 | 1023 | RTD installed |
| 21 | 1024 | Use fixed temperature |
| 24 | 1014 | SS/Monel orifice plate |
| 25 | 1012 | Use Fb |
| 26 | 1007 | Use Fr |
| 27 | 1008 | Use Y |
| 28 | 1003 | Use Ftb |
| 29 | 1002 | Use Fpb |
| 30 | 1004 | Use Ftf |
| 31 | 1005 | Use Fg |
| 32 | 1010 | Use Fpv |
| 33 | 1006 | Use Fa |
| 34 | 1027 | Use contact on charger low |
| 35 | 1028 | Contact on dp lo |
| 36 | 1029 | Contact on dp hi |
| 37 | 1030 | Contact on ap lo |
| 38 | 1031 | Contact on ap hi |
| 39 | 1032 | Contact on remote sense |
| 40 | 1034 | Auto re-open |
| 41 | 1033 | Contact on vol set point |
| 42 | 1009 | Use Fw |
| 43 | 1011 | Use Faux |
| 50 | 7137 | well log code (Site Code) |
| 51 | 1025 | Accumulated volume reset |
| 60 | 7065 | Fb |
| 61 | 7071 | Orifice diameter |
| 62 | 7073 | Pipe diameter |
| 63 | 7037 | Specific gravity |
| 64 | 7127 | DP lo limit |
| 65 | 7128 | DP hi limit |
| 66 | 7129 | AP lo limit |
| 67 | 7130 | AP hi limit |
| 68 | 7038 | CO2 mole percent |
| 69 | 7039 | N2 mole percent |
| 70 | 7138 | AP lo calibration |
| 71 | 7139 | AP mid calibration |
| 72 | 7140 | AP hi calibration |
| 73 | 7141 | DP lo calibration |
| 74 | 7142 | DP mid calibration |
| 75 | 7143 | DP hi calibration |
| 76 | 7126 | DP zero cutoff |
| 77 | 7061 | Temperature base |
| 78 | 7062 | Pressure base |

| Register | Access | Description |
|----------|--------|------------------------------------|
| 79 | 7059 | Fixed temperature |
| 80 | 7060 | Temperature bias |
| 81 | 7064 | Viscosity |
| 82 | 7063 | Ratio of specific heats |
| 83 | 7068 | Ft - gravity adjusted temp |
| 84 | 7069 | Fp - gravity adjusted press |
| 85 | 7036 | BTU/SCF |
| 86 | 7013 | AP pressure marker |
| 87 | 7014 | DP pressure marker |
| 100 | 7067 | Faux |
| 102 | 1038 | Initial analys. OK? |
| 108 | 3007 | Z method |
| 111 | 3005 | AGA calculation type |
| 112 | 7066 | Fixed cd |
| 115 | 7070 | Zba |
| 116 | 7003 | Software revision change |
| 117 | 3010 | Volume calculation period |
| 118 | 5002 | Log Period |
| 119 | 7051 | H2S content |
| 120 | 7058 | H2O content |
| 121 | 7053 | Helium content |
| 122 | 7040 | Methane content |
| 123 | 7041 | Ethane content |
| 124 | 7042 | Propane content |
| 125 | 7044 | N-Butane content |
| 126 | 7043 | I-Butane content |
| 127 | 7046 | N-Bentane content |
| 128 | 7045 | I-Pentane content |
| 129 | 7047 | N-Hexane content |
| 130 | 7048 | N-Heptane content |
| 131 | 7049 | N-Octane content |
| 132 | 7050 | N-Nonane content |
| 133 | 7057 | N-Decane content |
| 134 | 7054 | Oxygen content |
| 135 | 7055 | Carbon Monoxide content |
| 136 | 7072 | Orif coef of expansion |
| 137 | 7074 | Pipe coef of expansion |
| 138 | 7075 | barometric pressure |
| 143 | 1020 | Calculated or Fixed Cd in vol calc |
| 144 | 7056 | Fixed Argon mole percent |
| 145 | 7052 | Fixed hydrogen mole percent |
| 146 | 7136 | Accumulated volume rollover |
| 157 | 1018 | Use Faux |
| 158 | 1019 | static pressure tap up/downstream |
| 159 | 1015 | Use Y expansion factor |
| 160 | 1016 | Use Fpv factor |
| 161 | 1017 | Use Fw water vapor factor |
| 162 | 1026 | Reset Log Period |
| 164 | 1001 | Use Linear/Sqrt Averaging |

| Register | Access | Description |
|----------|--------|--------------------------------------------|
| 165 | 1036 | Hold last read analog values (AP, DP, TF) |
| 166 | 3021 | Maximum number of events log records |
| 167 | 3028 | Maximum number of day period records |
| 168 | 3026 | Maximum number of log period records |
| 171 | 5013 | Partition memory free space |
| 172 | 1040 | Use fixed water content in wet gas calcs |
| 173 | 7076 | Water content (LBS/MMSCF) |
| 174 | 7077 | Water content bias |
| 175 | 1029 | Use Fixed Test Mode AP, DP, and RTD values |

Table 5.10 FCU System Status Byte

Modbus function code 07 returns an 8 bit system status byte.

| Bit # | Description |
|-------|-----------------------|
| Bit 7 | Cold Start |
| Bit 6 | Warm Start |
| Bit 5 | Running |
| Bit 4 | Spare |
| Bit 3 | Unacknowledged Alarms |
| Bit 2 | Spare |
| Bit 1 | Spare |
| Bit 0 | Spare |