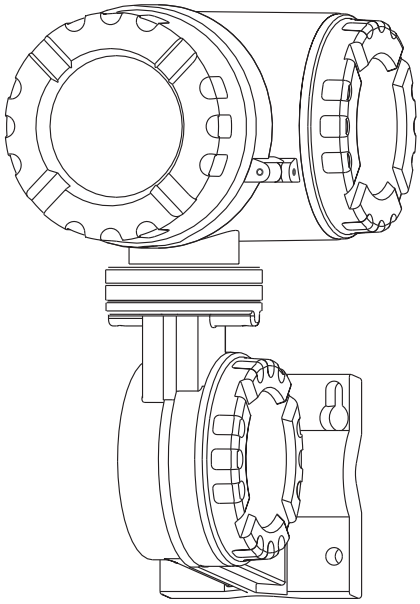
4590 Tank Side Monitor

Field device for tank sensor operation and monitoring and for integration into inventory control systems

Service Manual

Modbus Communication Protocol



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Contents

1 Introduction

This protocol guide explains the operation of the Modbus protocol per Modicon document PI-MBUS-300 Rev C (1991) implemented in the Varec 4590 Tank Side Monitor (TSM).

The Modbus protocol defines the format of data and the techniques used to control the flow of data. In Modbus, the flow of data between two devices uses a master/slave type arrangement. The 4590 TSM acts as a Modbus slave and runs on the EIA (RS)-485 version of the Modbus communications board.

2 Implementation

The implementation of Modbus protocol for the 4590 TSM provides a standard form of digital communication. Every effort has been made to parallel current implementations so that the 4590 TSM communicates with existing Modbus masters.

Check compatibility carefully to ensure that the 4590 TSM is properly configured for the data format expected by the host computer. Due to the unique application requirements of the 4590 TSM, exceptions have been made and noted.

Note! This is no guarantee, however, that the interpretation made here will be the same as that followed by the Modbus master.

The 4590 TSM implementation of Modbus protocol provides for the passing of measured and calculated variables, configuration information and diagnostics in data registers. Data is sent in these registers as floating-point values, word values, numeric codes related to configuration lists, status summary words (packed bits) or individual status flags (single bits).

One master and up to 31 4590 TSMs as Modbus slaves may be multidropped on a single EIA (RS) 485 communication bus.

The Modbus functions implemented in the 4590 TSM are listed in the following table.

Modbus functions

Function code	Function	Information type	Modbus nomenclature
03	Read	Word, code, status word, floating point	Read output registers
04	Read	Word, code, status word, floating point	Read input registers
06	Write	Word, code, status word	Preset single register
16	Write	Word, code, status word, floating point	Force multiple registers
65	Read	MFT 32bit floating point	Read floating point registers
66	Write	MFT 32bit floating point	Write floating point registers

3 Configuration

The Modbus port on the 4590 TSM must be configured to establish communications. The local display or Time-of-Flight (ToF) tool allows the user to set the 4590 TSM Modbus port to match the Modbus master.

4590 TSM addresses provide unique identification for the host. The 4590 TSM address is configurable through the local display or ToF tool. This address may range from 1 to 147 and must be unique for each Modbus device on a loop. Each 4590 TSM only responds when a query has been sent to its unique address by the host.

The Modbus protocol defines two modes of transmission, Remote Terminal Unit (RTU) or ASCII (American Standard Code for Information Interchange). The choice between these two modes is dependent on the preference of the host. RTU is often the preferred protocol because of its improved error detection capabilities and higher throughput. ASCII mode uses ASCII printable characters to represent hexadecimal values, this mode of transmission requires almost twice as many characters to pass information compared with the RTU transmission mode.

Note! The 4590 TSM only supports the RTU mode of communications.

3.1 Register Map

The 4590 TSM supports both input and output register and coil assignments.

- Function codes 03 and 04 apply to the same data registers.
- Function codes 01 and 02 are not supported by the 4590 TSM.

3.2 Parameters

The EIA485 port must be configured for a transmission speed (baud rate). Allowable values are 1200, 2400, 4800, 9600 bits per second. This item must be configured using the local display or ToF tool. A summary of the configuration information required by the 4590 TSM in order to implement Modbus is provided in the following table. Default values are highlighted.

Modbus configuration information

Configuration item	Valid entries	Modbus configurable	Local display or ToF Tool configurable
Modbus address	**1** ... 247	No	Yes
Baud rate	600 1200 2400 4800 **9600**	No	Yes
Parity	Odd Even None **One Stop Bit**	No	Yes
Mode	**Default no swap** Swap data WW swap[1]	No	Yes
Word type	**Unsigned** Signed	No	Yes

1. The mode value affects the format for the floating point data returned by the 4590 TSM

3.2.1 Parity Settings

The following table explains, how the data is sent when one of the available parity settings is selected in the 4590 TSM Modbus Menu. The column "RTU Settings" is important when the 4590 TSM is connected to a RTU8130, it shows how the RTU8130 has to be set up.

NRF parity	RTU Settings	Parity bit	Stop bits	Data bits	Startbits
Odd	ODD	odd	1	8	1
Even	EVEN	even	1	8	1
None	—	—	2	8	1
One Stop Bit[1)]	NONE[1)]	—	1	8	1

1. default Values

3.2.2 Description of the Basic Configuration Parameters ID (9211)

This Value set the ID of the 4590 TSM. Never setup two TSM with the same ID on the same loop.

3.2.2.1 Baud Rate (9212)

Setup the baud rate for communication speed (600, 1200, 2400, 4800, 9600).

3.2.2.2 Type (9213)

This is the setup for the parity bit (Odd, Even, None, One Stop Bit).

3.2.2.3 FP Mode (9214)

Set the format of the floating point value (no swap, swap data, WW swap).

3.2.3 Description of the Extended Configuration Parameters Word Type (9221)

Set Signed or Unsigned configuration for the integer registers. The 0% and 100% range has to be defined before otherwise a valid integer value could not be calculated.

3.2.3.1 Invalid Data (9222)

The data value that would be filled in, if an error occurred during transferring the data to the UART. (0xFF, 0x00).

3.2.3.2 Map Mode (9223) of 4590 TSM SW 1.x

Float Vals.:	all values in the TSM SW 1.x (see Section 7.1.4) register map is transferred as float values to the host
Integer Vals.:	all value in the TSM SW 1.x (see Section 7.1.5) register map is transferred as integer values to the host (signed or unsigned, based on the global settings – menu 9221)

3.2.3.3 Bus Termination (9224)

Activate bus termination. Termination resistors should be placed at each end of the communication bus to minimize reflections on the line.

Note! Bus termination is normally not needed at baud rates of 9600 or less.

Note! Do not use bus termination if the field communication is installed in a "star" configuration. Use bus termination only for daisy-chained field wiring.

3.2.3.4 CRC Mode (9225)

This section set the start value of the CRC register, default value is 0xFFFF but some Modbus Masters are working with 0x0000.

4 Functions and Data Formats

The Modbus data in the 4590 TSM is arranged in word registers, floating point registers and status bit registers. The assignment for these registers is found in “Modbus register assignments”.

The 4590 TSM also supports a two 16-bit register floating point data format. Function codes 03 and 04 are used to read these floating point register pairs while function code 16 is used to write the floating point register pairs.

A complete description of all the Modbus commands, can be found in the Modicon Modbus Protocol Reference Guide, document number PI-MBUS-300.

4.1 Word registers

Word registers holding 16 bits of data (sometimes referred to as integers) are the most commonly used type of Modbus data and are supported by most Modbus hosts. In the 4590 TSM implementation, the Modbus word registers are used to transfer one of the following four formats:

- Word Data (unsigned) – a scaled number from 0 to 65535.
- Integer Data (signed) – a scaled number form -32768 to 32767
- Coded Data – Multiple choice configuration data chosen from a coded list.
- Packed Bit Data – Registers form of 16 packed single bits.

The word and coded data registers contain all of the information needed to configure and read process data. Any word register may be read with function code 03 or function code 04. These same registers may be written one at a time with function code 06 or multiple registers can be written with function code 16.

4.1.1 Word data

The word data (unsigned) is a whole number between 0 and 65,535 stored as a 16 bit binary number.

4.1.2 Integer data

Integer data (signed) is a scaled number from -32768 to +32767.

4.1.3 Coded data

Coded data responds to a look-up table value. Data written to these registers must be a valid table entry or the value is rejected. For example, within the 4590 TSM the units of a value are represented by the HART standard value look-up table (see “Modbus register assignments”). Therefore, if the Units value read from a HART device was 45 (002D Hex), the units would be Meters.

4.1.4 Coded Discrete Values

State	Description
0	Unknown
1	Inactive
2	Active
3	Invalid

4.1.5 Packed bits

Packed bits represent 16 individual status bits packed into one register. The status bits have been packed this way for systems that prefer handling only register information. The bits within the packed registers are grouped by data or function type.

4.1.6 Varec Model 8130 RTU configuration

When configuring an Varec Model 8130 RTU to read these values (NOT using the default RTU "TSM" interface point), you should make sure the “Operational Mode” parameter of the MIREG point on the Model 8130 RTU is set to 1.

4.2 Floating-point registers

Although not part of the Modbus protocol specification, floating point numbers have been implemented using the IEEE 754 standard 32-bit representation [see the IEEE Computer Society (1985) "IEEE Standard for Binary Floating-Point Arithmetic, IEEE Std 754-1985" for complete technical information on this format]. Floating point numbers increase accuracy and reduce the complexity required in scaling word values and provide a means to transmit numbers used by the 4590 TSM that are not easily scaled.

4.2.1 Two 16-bit register format

The 4590 TSM makes these values available through a pair of 16-bit Modbus registers. Function code 03 or 04 are used to read a floating point register pair. Function code 16 is used to write floating point register pairs. The pair of registers holding the floating point MUST ALWAYS be read and written with a single command.

4.2.2 Varec Model 8130 RTU configuration

When configuring a Varec Model 8130 RTU to read these values (NOT using the default RTU "TSM" interface point), you should have the 4590 TSM Modbus Mode parameter set to 0 (default) and use a MFPREG point on the Model 8130 RTU with it's Mode parameter set to 1.

Modbus FP Mode compatibility

TSM modbus mode	Compatibility
Default no swap	Model 8130 RTU MFPREG point (operational mode = 1)
Swap data	Model 8130 RTU MFPREG point (operational mode = 0)
WW swap	Modicon format floating point

4.2.3 Convert to Word registers

When this mode was activated in software version 1.x, ALL floating point values in the Modbus map were converted into integer values using the same scaling factors. This means there were only two options:

1. read all registers as floating-point values
2. read all registers as integer values converted by the same scaling factor

Improvements:

1. in software version 2.x the floating-point and integer values using their own block of registers. This makes it possible to read for example the level as floating-point and temperature as integer value.
2. every group (like Level or Temperature) uses their own scaling factor (see Menu 9251 "Integer Scaling")

Group	0%	100%	Unit
Level Values	0	30000	mm
Temp. Values	0	100	°C
Press. Values	0	0,25	bar
Density Values	0	1000	kg/m^3
Flow Values	---	---	---
Vol. Flow. Val.	---	---	---
GP1 - 4 Values	---	---	---
User Map Values	---	---	---

4.3 Error values

When Invalid or Offline:	+ 99999999.999	0x4CBEBC20 (hex)
Maximum:	+ 99999999.999	0x4CBEBC20 (hex)
Minimum:	- 99999999.999	0xCCBEBC20 (hex)

5 Exception Responses

The exception responses returned by the 4590 TSM are listed below:

Modbus exception responses

Exception	Response	Reason
01	Illegal function	Try to use functions that are not supported
02	Illegal data address	Data address (bit or register) is not defined
03	Illegal data value	Data value being written is out of range
10 (0x0A)	Value read only	Data address being written is read only

In addition, messages that are received with a parity error, checksum error or message format error will be ignored.

6 Hardware Implementation

The 4590 TSM uses a 3-Wire EIA485 hardware interface to communicate with the Modbus master. EIA485 is a high speed differential communications network which allows up to 32 devices to operate on one network. The 4590 TSM and Modbus master share a twisted triad of wires to communicate.

The communication distance EIA485 can reliably travel is dependent on baud rate (communication speed), wire quality, environmental electrical noise, wiring configuration and the number of multi-dropped 4590 TSMs. The recommended wire for EIA485 systems is 18-gauge or larger, shielded, twisted triad. The shield should be grounded at the Modbus master (control system or computer) end.

6.1 Termination

Termination resistors should be placed at each end of the communication bus to minimize reflections on the line. If multiple 4590 TSM instruments are connected using Modbus communication, then an adjustment must be made on the Modbus communication board. For the last 4590 TSM connected on the Modbus, a resistor must be activated by setting it in the Modbus Extended Setup Menu (Menu 9224).

Note! Bus termination is normally not needed at baud rates of 9600 or less.

Note! Do not use bus termination if the field communication is installed in a "star" configuration. Use bus termination only for daisy-chained field wiring.

6.2 RS-485 Modbus Interface

There are various methods of interfacing a RS-485 Modbus loop to the control system, such as an Varec Model 8130 RTU or a PC RS-485 interface. The method used will depend on the system and software being installed. However, if a direct PC RS-485 interface is required, it is recommended that this be an internal industrial specification interface card (e.g. ISA, PCI, PCMCIA) providing galvanic isolation and lightning protection and not an external RS-232 to RS-485 converter.

7 Modbus Register Assignments

7.1 Tank parameters

7.1.1 Integer Values

Tank Parameters	Data Address	Modbus register	Data type	Access
User Assignable Register 8	2000	2001	Integer	Read Only (use function 03 and 04)
User Assignable Register 7	2001	2002		
User Assignable Register 6	2002	2003		
User Assignable Register 5	2003	2004		
User Assignable Register 4	2004	2005		
User Assignable Register 3	2005	2006		
User Assignable Register 2	2006	2007		
User Assignable Register 1	2007	2008		
Level	2009	2010		
Product Temperature	2010	2011		
Vapor Temperature	2011	2012		
Water Level	2012	2013		
Observed Density	2013	2014		
Pressure P1 (bottom)	2014	2015		
Pressure P2 (middle)	2015	2016		
Pressure P3 (top)	2016	2017		
General Purpose Value 1	2017	2018		
General Purpose Value 2	2018	2019		
General Purpose Value 3	2019	2020		
General Purpose Value 4	2020	2021		
Measured Level	2021	2022		
Level Percentage	2022	2023		
Level Flow	2023	2024		
Volume Flow	2024	2025		
Level Correction	2025	2026		

Tank Parameters	Data Address	Modbus register	Data type	Access
Temperature Element 1	2026	2027	Integer	Read Only (use function 03 and 04)
Temperature Element 2	2027	2028		
Temperature Element 3	2028	2029		
Temperature Element 4	2029	2030		
Temperature Element 5	2030	2031		
Temperature Element 6	2031	2032		
Temperature Element 7	2032	2033		
Temperature Element 8	2033	2034		
Temperature Element 9	2034	2035		
Temperature Element 10	2035	2036		
Temperature Element 11	2036	2037	Coded see section 4.1.4	Read Only (use function 03 and 04)
Temperature Element 12	2037	2038		
Temperature Element 13	2038	2039		
Temperature Element 14	2039	2040		
Temperature Element 15	2040	2041		
Temperature Element 16	2041	2042		
Discrete read Value 1	2042	2043		
Discrete read Value 2	2043	2044		
Discrete read Value 3	2044	2045		
Discrete read Value 4	2045	2046		
Discrete read Value 5	2046	2047		
Discrete read Value 6	2047	2048		
Discrete read Value 7	2048	2049		
Discrete read Value 8	2049	2050		
Discrete write Value 1	2090	2091	Integer only 0 and 1 is allowed	Read (function 03, 04) / Write (function 06, 16)
Discrete write Value 2	2091	2092		
Discrete write Value 3	2092	2093		
Discrete write Value 4	2093	2094		

Discrete Value:

Valid values are 0 (zero) or 1. Trying to write a value > 1 will set the current value automatically to 0 (zero).

7.1.2 Status Values

The following table describes the meaning of the bits in a status value.

bits	Value	not set (0)	set (1)
0	W&M Status	bad	good
1	Valid Value	invalid	valid
2	Error	none	yes
3..4	reserved	0	1
5	Data Status	live data	held data
6	Device Status	online	offline
7	Unit Error	none	yes
8..11	reserved	0	1
12	Initialized Value	unknown	initialized
13..15	reserved	0	1

7.1.3 Unit values

Tank Parameters	Data Address	Modbus register	Data type	Access
User Assignable Register 8	2200	2201	Coded	Read Only (use function 03 and 04)
User Assignable Register 7	2201	2202		
User Assignable Register 6	2202	2203		
User Assignable Register 5	2203	2204		
User Assignable Register 4	2204	2205		
User Assignable Register 3	2205	2206		
User Assignable Register 2	2206	2207		
User Assignable Register 1	2207	2208		
Level	2209	2210		
Product Temperature	2210	2211		
Vapor Temperature	2211	32212		
Water Level	2212	2213		
Observed Density	2213	2214		
Pressure P1 (bottom)	2214	2215		
Pressure P2 (middle)	2215	2216		
Pressure P3 (top)	2216	2217		
General Purpose Value 1	2217	2218		
General Purpose Value 2	2218	2219		
General Purpose Value 3	2219	2220		
General Purpose Value 4	2220	2221		
Measured Level	2221	2222		
Level Percentage	2222	2223		
Level Flow	2223	2224		
Volume Flow	2224	2225		
Level Correction	2225	2226		
Temperature Element 1	2226	2227		
Temperature Element 2	2227	2228		
Temperature Element 3	2228	2229		
Temperature Element 4	2229	2230		
Temperature Element 5	2230	2231		
Temperature Element 6	2231	2232		
Temperature Element 7	2232	2233		
Temperature Element 8	2233	2234		
Temperature Element 9	2234	2235		

Tank Parameters	Data Address	Modbus register	Data type	Access
Temperature Element 10	2235	2236	Coded	Read Only (use function 03 and 04)
Temperature Element 11	2236	2237		
Temperature Element 12	2237	2238		
Temperature Element 13	2238	2239		
Temperature Element 14	2239	2240		
Temperature Element 15	2240	2241		
Temperature Element 16	2241	2242		
User Write Value 1	2290	2291		Read (function 03, 04) / Write (function 06, 16)
User Write Value 2	2291	2292		
User Write Value 3	2292	2293		
User Write Value 4	2293	2294		

7.1.4 Float Values

Tank Parameters	Data Address	Modbus register	Data type	Access
User Assignable Register 8	2300	2301	Float	Read Only (use function 03 and 04)
User Assignable Register 7	2302	2303		
User Assignable Register 6	2304	2305	Coded	
User Assignable Register 5	2306	2307		
User Assignable Register 4	2308	2309		
User Assignable Register 3	2310	2311		
User Assignable Register 2	2312	2313		
User Assignable Register 1	2314	2315		
Level	2318	2319		
Product Temperature	2320	2321		
Vapor Temperature	2322	2323		
Water Level	2324	2325		
Observed Density	2326	2327		
Pressure P1 (bottom)	2328	2329		
Pressure P2 (middle)	2330	2331		
Pressure P3 (top)	2332	2333		
General Purpose Value 1	2334	2335		
General Purpose Value 2	2336	2337		
General Purpose Value 3	2338	2339		
General Purpose Value 4	2340	2341		
Measured Level	2342	2343		
Level Percentage	2344	2345		
Level Flow	2346	2347		
Volume Flow	2348	2349		
Level Correction	2350	2351		
Temperature Element 1	2352	2353		
Temperature Element 2	2354	2355		

Tank Parameters	Data Address	Modbus register	Data type	Access
Temperature Element 3	2356	2357	Coded	Read Only (use function 03 and 04)
Temperature Element 4	2358	2359		
Temperature Element 5	2360	2361		
Temperature Element 6	2362	2363		
Temperature Element 7	2364	2365		
Temperature Element 8	2366	2367		
Temperature Element 9	2368	2369		
Temperature Element 10	2370	2371		
Temperature Element 11	2372	2373		
Temperature Element 12	2374	2375		
Temperature Element 13	2376	2377		
Temperature Element 14	2378	2379		
Temperature Element 15	2380	2381		
Temperature Element 16	2382	2383		
User Write Value 1	2490	2491		Read (function 03, 04) / Write (function 06, 16)
User Write Value 2	2492	2493		
User Write Value 3	2494	2495		
User Write Value 4	2496	2497		

7.1.5 TSM SW 1.x parameters

Tank Parameters	Data Address	Modbus register	Data type	Access
Corrected Level	3000	3001	Float	Read Only (use function 03 and 04)
Tank Level	3002	3003		
Product Temperature	3004	3005		
Pressure P3 (top)	3006	3007		
Pressure P2 (middle)	3008	3009		
Pressure P3 (bottom)	3010	3011		
Observed Density	3012	3013		
Water Level	3014	3015		
Vapor Temperature	3016	3017		
Point Status Bit #0 – Invalid Level Bit #1 – Invalid Temp Bit #2 – Invalid Water Level Bit #3 – Invalid Density Bit #4 – Invalid Top Pressure Bit #5 – Invalid Middle Pressure Bit #6 – Invalid Bottom Pressure Bit #7 – Invalid Standard Density Bit #8 – Reserved Bit #9 – Level below minimum Bit #10 – Reserved Bit #11 – Reserved Bit #12 – Reserved Bit #13 – Invalid Air Temp Bit #14 – Invalid Vapor Temp Bit #15 – Invalid Flow	3018	3019	Coded	Read Only (use function 03 and 04)
Product Temperature	3030	3031	Float	
Vapor Temperature (453x ATC Average Temperature)	3032	3033		
Vapor Temperature (453x ATC Vapor Temperature)	3034	3035		
Temperature Element 1 (453x ATC Temperature 0)	3036	3037		
Temperature Element 2 (453x ATC Temperature 1)	3038	3039		
Temperature Element 3 (453x ATC Temperature 2)	3040	3041		
Temperature Element 4 (453x ATC Temperature 3)	3042	3043		
Temperature Element 5 (453x ATC Temperature 4)	3044	3045		

Tank Parameters	Data Address	Modbus register	Data type	Access
Temperature Element 6 (453x ATC Temperature 5)	3046	3047	Float	Read Only (use function 03 and 04)
Temperature Element 7 (453x ATC Temperature 6)	3048	3049		
Temperature Element 8 (453x ATC Temperature 7)	3050	3051		
Temperature Element 9 (453x ATC Temperature 8)	3052	3053		
Temperature Element 10 (453x ATC Temperature 9)	3054	3055		
Temperature Element 11 (453x ATC Temperature 10)	3056	3057		
Temperature Element 12 (453x ATC Temperature 11)	3058	3059		
Temperature Element 13 (453x ATC Temperature 12)	3060	3061		
Temperature Element 14 (453x ATC Temperature 13)	3062	3063		
Temperature Element 15 (453x ATC Temperature 14)	3064	3065		
Temperature Element 16 (453x ATC Temperature 15)	3064	3065		
Analog Output Point Status Bit #0 – Invalid source value reference Bit #1 – Source value is below offset value Bit #2 – Source value is above scale value Bit #3 – Not calibrated Bit #4 – Value has been forced to ZERO Bit #5 – Output is open circuit Bit #6 – Source value is offline Bit #7 ... #15 – Reserved	3114	3115	Coded	
W&M Lock	3115	3116		
Tank W&M Status Bit #0 – Level W&M Status valid Bit #1 – Temperature W&M valid Bit #2 ... #15 – Reserved	3176	3177		
Level Units	3179	3180		
Temp Units	3180	3181		
Pressure Units	3181	3182		
Density Units	3182	3183		
Level Percentage Range	3193	3194	Float	
Hydrostatic Level	3195	3196		

7.1.6 MFT parameters

The 4590 TSM Modbus map provides a compatible sub map to replace the Varec 4200 Multi-Function Transmitter without changing Modbus master settings, depending on parameters used.

Reference: 4200 Multi-Function Transmitter Installation and Operations Manual.

Tank Parameters	Data Address	Modbus register	Data type	Access
Effective Mass	0025	0026	MFT 32 bit[1)]	Read Only (use function 03 and 04)
True Mass	0026	0027		
Density	0027	0028		
Standard Density	0028	0029		
Level	0030	0031		
Water Level	0031	0032		
Product Volume	0032	0033		
Standard Product Volume	0033	0034		
Water Bottom Volume	0034	0035		
Remaining Volume	0035	0036		
Product Temp	0036	0037		
Ambient Temp	0037	0038		
Temp Bottom	0038	0039		
Temp Middle	0039	0040		
Temp Top	0040	0041		
Time To Fill	0041	0042		
Flow Rate	0042	0043		
Roof Mass	0043	0044		
Pressure P3 (top)	0044	0045		

Tank Parameters	Data Address	Modbus register	Data type	Access
Pressure P1 (bottom)	0045	0046	MFT 32 bit [1)]	Read Only (use function 03 and 04)
Pressure P2 (middle)	0046	0047		
Available Product	0047	0048		
User Assignable Reg. 1	0000	0001	Integer	
User Assignable Reg. 2	0001	0002		
User Assignable Reg. 3	0002	0003		
User Assignable Reg. 4	0003	0004		
User Assignable Reg. 5	0004	0005		
User Assignable Reg. 6	0005	0006		
User Assignable Reg. 7	0006	0007		
User Assignable Reg. 8	0007	0008		
Effective Mass	0051	0052		
True Mass	0052	0053		
Density	0053	0054		
Standard Density	0054	0055		
Level	0056	0057		
Water Level	0057	0058		
Product Volume	0058	0059		
Standard Product Volume	0059	0060		
Water Bottom Volume	0060	0061		
Remaining Volume	0061	0062		
Product Temp	0062	0063		
Ambient Temp	0063	0064		
Temp Bottom	0064	0065		
Temp Middle	0065	0066		
Temp Top	0066	0067		
Time To Fill	0067	0068		
Flow Rate	0068	0069		
Roof Mass	0069	0070		
Pressure P3 (top)	0070	0071		
Pressure P1 (bottom)	0071	0072		
Pressure P2 (middle)	0072	0073		
Available Product	0073	0074		

Tank Parameters	Data Address	Modbus register	Data type	Access
Alarm Status	0076	0077	Float	Read Only (use function 03 and 04)
User Assignable Reg. 1	0300	0301		
User Assignable Reg. 2	0302	0303		
User Assignable Reg. 3	0304	0305		
User Assignable Reg. 4	0306	0307		
User Assignable Reg. 5	0308	0309		
User Assignable Reg. 6	0310	0311		
User Assignable Reg. 7	0312	0313		
User Assignable Reg. 8	0314	0315		
Effective Mass	0350	0351		
True Mass	0352	0353	Float	Read Only (use function 03 and 04)
Density	0354	0355		
Standard Density	0356	0357		
Level	0360	0361		
Water Level	0362	0363		
Product Volume	0364	0365		
Standard Product Volume	0366	0367		
Water Bottom Volume	0368	0369		
Remaining Volume	0370	0371		
Product Temp	0372	0373		
Ambient Temp	0374	0375		
Temp Bottom	0376	0377		
Temp Middle	0378	0379		
Temp Top	0380	0381		
Time To Fill	0382	0383		
Flow Rate	0384	0385		
Roof Mass	0386	0387		
Pressure P3 (top)	0388	0389		
Pressure P1 (bottom)	0390	0391		
Pressure P2 (middle)	0392	0393		
Available Product	0394	0395		

1. IEEE 754 floating-point standard

7.2 Non-i.s. Analog output parameters

Non-i.s. analog output parameters	Data address	Modbus register	Data type	Access
Analog Output Point Status Bit #0 - Invalid source value reference Bit #1 - Source value is below offset value Bit #2 - Source value is above scale value Bit #3 - Not calibrated Bit #4 - Value has been forced to 0 Bit #5 - Output is open circuit Bit #6 - Source value is offline Bits #7 ... #15 - Reserved	3114	33115	Bits	Read Only

8 Modbus - Example Telegram

	Device ID	Function	Address	Number of registers	CRC
Rx	08	03	0B BC	00 02	07 52

	Device ID	Function	Byte Count	Value	CRC
Tx	08	03	04	41 93 33 30	93 C6

9 Tables and Reference Information

"The encoding of the units transmitted by the 4590 TSM follow the HART units coded table".

9.1 HART units coded table

As per HART Communications Foundation Document Number: HCF_SPEC-183 “HART - SMART Communications Protocol, Common Tables”

The **highlighted units** are supported by the 4590 TSM Tank parameters. Other generic HART devices may provide any of these values.

9.1.1 Temperature

HART unit code	Unit	Symbol
32	**Degrees Celsius**	**°C**
33	**Degrees Fahrenheit**	**°F**
34	Degrees Rankin	°R
35	Degrees Kelvin	Kelvin

9.1.2 Pressure

HART unit code	Unit	Symbol
1	**Inches of Water (68 °F)**	**InH^2O**
2	Inches of Mercury (0°C)	InHg
3	**Feet of Water (68 °F)**	**FtH^2O**
4	Millimeters of Water (68 °F)	mmH^2O
5	Millimeters of Mercury (0°C)	mmHg
6	**Pounds per Square Inch**	**PSI**
7	**Bars**	**bar**
8	**Millibars**	**mbar**
9	Grams per Square Centimeter	g/cm^2
10	Kilograms per Square Centimeter	kg/cm^2
11	**Pascals**	**PA**
12	**Kilopascals**	**kPA**
13	Torr	torr
14	Atmospheres	ATM
237	**Megapascals**	**MPA**
238	Inches of Water (4 °C)	inH^2O 4 °C
239	Millimeters of Water (4 °C)	mmH^2O 4°C

9.1.3 Volumetric flow

HART unit code	Unit	Symbol
15	Cubic Feet per Minute	ft^3/min
16	**Gallons per Minute (US)**	**gal/min**
17	**Liters per Minute**	**l/min**
18	Imperial Gallons per Minute	ImpGal/min
19	**Cubic Meters per Hour**	m^3/hr
22	Gallons per Second (US)	gal/sec
23	Million Gallons per Day	MilGal/day
24	**Liters per Second**	**lt/sec**
25	Million Liters per Day	MilL/day
26	Cubic Feet per Second	ft^3/sec
27	Cubic Feet per Day	ft^3/day
28	Cubic Meters per Second	m^3/sec
29	Cubic Meters per Day	m^3/day
30	Imperial Gallons per Hour	ImpGal/hr
31	Imperial Gallons per Day	ImpGal/day
121	Normal Cubic Meters per Hour "MKS System"	m^3/hr
122	Normal Liters per Hour "MKS System"	l/hr
123	Standard Cubic Feet per Minute "US System"	ft^3/min
130	Cubic Feet per Hour	ft^3/hr
131	**Cubic Meters per Minute**	m^3/min
132	Barrels per Second (1 barrel = 42 US gallons)	bbl/s
133	**Barrels per Minute (1 barrel = 42 US gallons)**	**bbl/min**
134	**Barrels per Hour (1 barrel = 42 US gallons)**	**bbl/hr**
135	Barrels per Day (1 barrel = 42 US gallons)	bbl/day
136	**Gallons per Hour (US)**	**gal/hr**
137	Imperial Gallons per Second	ImpGal/s
138	**Liters per Hour**	**l/hr**
235	Gallons per Day (US)	gal/day

9.1.4 Velocity

HART unit code	Unit	Symbol
20	Feet per Second	ft/s
21	Meters per Second	mtr/s
114	Inches per Second	in/s
115	Inches per Minute	in/min
116	**Feet per Minute**	**ft/min**
120	**Meters per Hour**	**mtr/hr**

9.1.5 Volume

HART unit code	Unit	Symbol
40	Gallons	gal
41	Liters	lt
42	Imperial Gallons	ImpGal
43	Cubic Meters	m^3
46	Barrels (1 barrel = 42 US gallons)	bbl
110	Bushels	bush
111	Cubic Yards	yd^3
112	Cubic Feet	ft^3
113	Cubic Inches	in^3
124	Liquid Barrel (= 31.5 US gallons)	bblLiq
166	Normal Cubic Meter "MKS System"	m^3
167	Normal Liter "MKS System"	lt
168	Standard Cubic Feet "US System"	ft^3
236	Hectoliters	hecto lt

9.1.6 Length

HART unit code	Unit	Symbol
44	**Feet**	**ft**
45	**Meters**	**m**
47	**Inches**	**in**
48	**Centimeters**	**cm**
49	**Millimeters**	**mm**

9.1.7 Time

HART unit code	Unit	Symbol
50	Minutes	min
51	Seconds	sec
52	Hours	hr
53	Days	day

9.1.8 Mass

HART unit code	Unit	Symbol
60	Grams	g
61	Kilograms	kg
62	Metric Tons	MetTon
63	Pounds	lb
64	Short Tons	ShTon
65	Long Ton	LTon
125	Ounce	ounce

9.1.9 Mass Flow

HART unit code	Unit	Symbol
70	Grams per Second	g/s
71	Grams per Minute	g/min
72	Grams per Hour	g/hr
73	Kilograms per Second	kg/s
74	Kilograms per Minute	kg/min
75	Kilograms per Hour	kg/hr
76	Kilograms per Day	kg/day
77	Metric Tons per Minute	MetTon/min
78	Metric Tons per Hour	MetTon/hr
79	Metric Tons per Day	MetTon/day
80	Pounds per Second	lb/s
81	Pounds per Minute	lb/min
82	Pounds per Hour	lb/hr
83	Pounds per Day	lb/day
84	Short Topns per Minute	ShTon/min
85	Short Tons per Hour	ShTon/hr
86	Short Tons per Day	ShTon/day
87	Long Tons per Hour	LTon/hr
88	Long Tons per Day	LTon/day

9.1.10 Mass per volume

HART unit code	Unit	Symbol
90	Specific Gravity Units	SGU
91	Grams per Cubic Centimeter	g/cm^3
92	**Kilograms per Cubic Meter**	**kg/m^3**
93	Pounds per Gallon (US)	lb/gal
94	**Pounds per Cubic Feet**	**lb/ft^3**
95	**Grams per Milliliter**	**g/ml**
96	Kilograms per Liter	kg/l
97	Grams per Liter	g/l
98	Pounds per Cubic inch	lb/CuIn
99	Short Topns per Cubic Yard	ShTon/CuYd
100	Degrees Twaddell	°Twad
102	Degrees Baume Heavy	°BaumHv
103	Degrees Baume Light	°BaumLt
104	**Degrees API**	**°API**

9.1.11 Viscosity

HART unit code	Unit	Symbol
54	Centistokes	centi stokes
55	Centipoise	cpoise

9.1.12 Electromagnetic Unit of Electric Potential

HART unit code	Unit	Symbol
36	Millivolts	mV
58	Volts	V

9.1.13 Electrostatic Unit of Current

HART unit code	Unit	Symbol
39	**Milliamperes**	**mA**

9.1.14 Electromagnetic Unit of Resistance

HART unit code	Unit	Symbol
37	Ohms	Ohm
163	Kiloohms	kOhm

9.1.15 Energy (includes Work)

HART unit code	Unit	Symbol
69	Newton Meter	NM
89	Deka Therm	
126	Foot Pounds Force	
128	Kilo Watt Hour	kWh
164	Mega Joule	MJ
165	British Thermal Unit	BTU
162	Mega Calorie	MCal

9.1.16 Power

HART unit code	Unit	Symbol
127	Kilo Watt	kW
129	Horsepower	HP
140	Mega Calories per Hour	
141	Mega Joule per Hour	kWh
142	British Thermal Unit per Hour	BTU/hr

9.1.17 Radial Velocity

HART unit code	Unit	Symbol
117	Degrees per Second	deg/s
118	Revolutions per Second	rev/s
119	Revolutions per Minute	rpm

9.1.18 Miscellaneous

HART unit code	Unit	Symbol
38	Herts	Hz
56	Microsiemens	uMho
57	Percent	%
59	pH	pH
66	Milli Siemens per Centimeter	mSiemen/cm
67	Micro Siemens per Centimeter	uSiemen/cm
68	Newton	N
101	Degree Brix	°Brix
105	Percent Solids per Weight	%Sol/wt
106	Percent Solids per Volume	%Sol/vol
107	Degrees Balling	°Ball

HART unit code	Unit	Symbol
108	Proof per Volume	proof/vol
109	Proof per Mass	proof/mass
139	Parts per Million	ppm
143	Degrees	°
150	Percent Steam Quality	%StmQual
151	Feet-Inch-1/16ths	Ftin16
152	Cubic Feet per Pound	ft^3/lb
153	Picofarads	pF
160	Percent Plato	%Plato

9.1.19 Special

HART unit code	Unit	Symbol
250	Not Used	
251	No Units	
252 & 0	Unknown Units	
253	Special	

9.1.20 Manufacturer Specific 4590 TSM Definitions

HART unit code	Unit	Symbol
240	**1/16th Inch**	**1/16in**
241	**Feet-Inch-1/16ths (stored as ft)**	**Ftin16**
242	Meters per second per second	m/s^2
243	Feet-Inch-1/8ths (stored as ft)	Ftin8
244	**Cubic decimeter**	**dm^3**
245	**Cubic decimeter**	**dm^3**
246		
247		
248		
249	**Ampere**	**A**

NOTES

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