SPIRE METERING TECHNOLOGY

User's Manual

tPrime Series

280T Ultrasonic Heat Meter

Created July 12, 2012

Version Man280T-12071403_v15

WARNING!

(1) The 280T heat meter is not certified for use in hazardous environments. The local site safety codes and regulations must be observed.

(2) The 280T heat meter contains Lithium batteries. Please check to see if they're working before using the heat meter. The batteries must be recycled or disposed of properly.

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1. Introduction§1.1 Preface

A member of the tPrime Series, the 280T ultrasonic heat meter offers the most advanced BTU measurement in the market by using state-of-the-art ultrasonic flow measurement technology. The 280T does not have moving parts to wear out, thus it literally requires no maintenance. It is also very cost-effective, especially in the long run. This means both commercial and residential installations can profit from the advantages of wear-free heat measurement, such as precision, operating security, and long service life.

With its maximum operating temperature of 95°C (130°C version available upon request) and nominal pressure of 1.6MPa, the technical specifications meet the standard for residential meters. The high measurement dynamic allows a load of up to double the rating, thereby ensuring high operating security.

The 280T heat meter uses transit-time ultrasonic flow measurement principle to reliably measure the flow rate: sending and receiving transducers in opposition send ultrasonic signals alternately with and against the flow direction. The flow rate can be precisely calculated from the difference between the two transit times. There are no moving components in the sensor, and as a result, the measurement is wear-free and stable over a very long time period.

Suitable for both commercial and residential applications, this compact meter fits in even the smallest installation conditions and can be mounted separately from the electronics console. The meter includes an order option for remote read-out (pulse, M-Bus, or RS485 output). The large display can be set to display heat consumption, temperatures, flow total, working time, velocity, etc.

The 280T also offers tools for building energy management. When equipped with a M-Bus module, the heat meters can be networked through a two-wire bus to a central location for integrated resource management. An optional concentrator and data acquisition software make the whole system installation and integration easy. Spire Metering provides a complete AMR (automatic meter reading) solution as well.

Spire Metering's 280T Ultrasonic BTU meter stands out among its competitors due to its unique reflector-free sensor design and multipath technology. The 280T is able to work reliably even when the water is dirty, which is useful because the HVAC circuit could be like this after years of operation. Both commercial and residential installations can profit from the many advantages of wear-free heating/cooling energy measurement, such as precision, operation security and long service life.

§1.2 Features

- Wear-free ultrasonic measurement. No maintenance needed
- Proprietary robust sensor design. No reflector, thus works reliably for both clear water

and dirty water

- Excellent long-term stability. Accuracy does not degrade over time
- Not impacted by water impurity or magnetic interference
- Wide measurement range
- Low pressure drop
- For both hot and cold water
- Free positioning for mounting
- Battery supply for 6 or more years
- Nominal pressure up to 1.6MPa
- Pulse / M-Bus / RS485 for remote readout
- Optional BACnet or M-Bus concentrator
- Optional AMR and data management software, including meter reading software and utility billing software
- Simple and easy to install. Electronic box can be detached from the sensor body and installed separately
- Low cost over long run, low cost of ownership

§1.3 Typical Applications

The 280T is suitable for both commercial and residential applications, such as district heating and cooling, HVAC, green energy management, and AMR and billing. It meets the standards of industrial, utility, and submetering systems:

- Wider dynamic range allows for a load of up to double the rating, thereby ensuring high operational security
- Maximum operating temperature of 95 °C (up to 130 °C optional)
- Nominal pressure of 1.6MPa

This compact meter fits into even the smallest installation locations and can be mounted separately from the electronics console.
The large LCD screen can be set to display the heat consumption, temperature, flow total, working time, flow velocity, etc. The meter also has a remote readout which can be configured as pulse, M-Bus or RS485. An optional BACnet module is available upon request.

§1.4 Safety Instructions

- Never hold and transport the meter by the electronics box, but instead only by the flanged or threaded joint
- Assembling and dismantling should be carried out only when there is no pressure in the pipe
- Beware of sharp edges
- After installation, the tightness must be verified by pressurizing with cold water
- Use meter only under the specified operating conditions
  When conducting pressure test, make sure the pressure does not exceed 2.5MPa. Otherwise,

dangers may arise and will void the warranty
Make sure the flow rate range does not exceed the specifications

- Calibration, maintenance, replacement of components, and repairs must only be performed by a qualified person familiar with the hazards involved
- Calibration-related seals of the heat meter must not be damaged or removed! Otherwise, the warranty will be void
- Disposal of the Lithium battery must be in accordance to environmental regulations
- We regret that we do not provide lightning protection, however, lightning protection should still be ensured through other proper means

§1.5 Automatic Meter Reading (AMR)

AMR is a system for building energy management. When equipped with a connection module, multiple 280T heat meters can be networked through a two-wire bus to a central location for integrated resource management. Spire Metering Technology provides an entire system of AMR solutions, making the system installation and integration very easy.
Its SpireCapture™ system is a cutting-edge fixed AMR system which integrates both wired and wireless AMR/AMI technologies. It can accommodate a variety of metering networks, such as M-Bus, Pulse, RF wireless, GSM/GPRS, BACnet module, and TCP/IP. The data center software communicates with those networks through a standardized platform, which allows you to start with a simple AMR system and gradually expand to a large metering system.

For more information on AMR and serial communication, see Section §6.

§1.6 Built-in Time-Keeper

A time-keeper is integrated in the 280T heat meter. The time-keeper remains operating as long as the battery is alive. In case of battery failure, the time-keeper will not keep running, and the time data will be lost. The user must re-enter the proper time values after the battery failure is recovered. The user can also set the date and time as desired.

§1.7 Product Identification

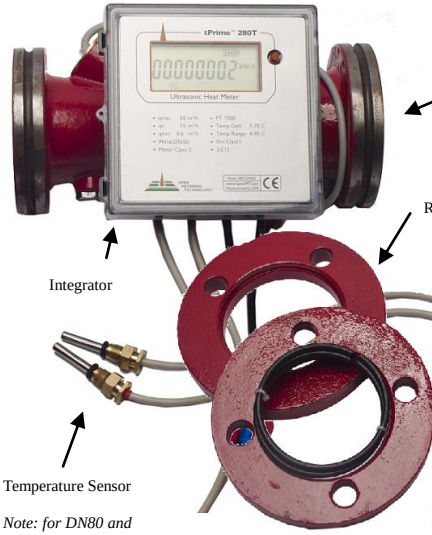
Each set of the 280T series heat meter has a unique product identification number or ESN written into the software that can only be modified with a special tool by the manufacturer. In case of any hardware failure, please provide this number.

2. Technical Information

§2.1 Parts Identification

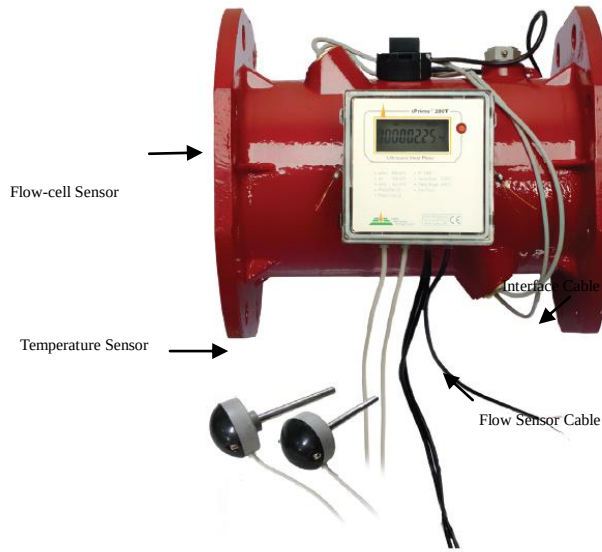
Small size BTU meter (DN15-40)

Medium size BTU meter (DN50-DN100)



Note: for DN80 and DN100, the temperature sensors are the same as those for DN125 and above.

Large size BTU meter (DN125-DN500)



§2.2 Packing List

DN 15-40

Item	Description	Quantity	Unit	Notes
1	Ultrasonic Heat Meter	1	set	
2	Tee with temperate sensor port (so-called thermal well)	1	piece	(optional)
3	Plumbing Adapters (extension connector, nut, gasket)	2	set	(optional)
4	Installation Guide	1	copy	

DN 50+

Item	Description	Quantity	Unit	Notes
1	Ultrasonic Heat Meter	1	set	
2	Thermal-well sleeve Mounting pocket	1	piece	2 pieces for DN250 and above
3	Thermal-well sleeve	1	piece	None for DN50, 65 2 pieces for DN250+
4	Installation Guide	1	copy	

§2.3 Battery Specifications

Lithium-Thionyl Chloride ER18505 type battery
Dimensions: 18.5mm diameter by 50.5mm height
Weight: average 28g
Nominal Capacity: 3.8 Ah
Nominal Voltage: 3.6V
Max Recommended Continuous Current: 100mA
Max Pulse Current Capability: 200mA
Operating Temperature Range: -55℃ to 85 ℃

§2.4 Specifications

Size mm	Flowrate (m^3/h)			Dimension (mm)			Weight[1]	Pipe Joint[2] (BSP/DIN)	
	Q_n	Q_{min}	Q_{max}	L	W	H	(kg)	Sensor	Ext.
15	1.5	0.03	3.0	110	120	86	0.7	G3/4B	G1/2B
20	2.5	0.05	5.0	130	120	86	0.8	G1B	G3/4B
25	3.5	0.07	7.0	160	128	89	0.9	G1 1/4B	G1B
32	6.0	0.12	12.0	180	130	96	1.3	G1 1/2B	G1 1/4B
40	10	0.2	20	200	134	98	1.8	G2B	G1 1/2B
50	15	0.6	30	200	165	190	5.8	Nut 4-M16	
65	25	1.0	50	200	185	204	6.8	Nut 4-M16	
80	40	1.6	80	225	192	220	9.0	Nut 8-M16	
100	60	2.4	120	250	220	240	11.6	Nut 8-M16	
125	100	4.0	200	250	230	235	16.2	Nut 8-M16	
150	150	6.0	300	300	265	270	18	Nut 8-M20	
200	250	10.0	500	350	350	320	22	12-M20	
250	400	16.0	800	450	405	405	60	12-M24	
300	600	25.0	1200	500	460	460	80	12-M24	
350	800	30.0	1600	500	520	520	105	16-M24	
400	1200	48.0	2400	500	580	580	123	16-M27	
450	1500	60.0	3000	500	640	640	157	20-M27	
500	2000	80.0	4000	500	715	715	208	20-M30	
(in.)	(qpm)	(qpm)	(qpm)	L (in.)	W (in.)	H (in.)	(lb)	Sensor	Ext.
1/2”	6.6	0.1	13.2	4.33	4.72	3.38	1.54	G3/4B	G1/2B
3/4”	11	0.2	22	5.11	4.72	3.38	1.76	G1B	G3/4B
1”	15.4	0.3	30.8	6.29	5.03	3.50	1.98	G1 1/4B	G1B
1 ¼”	26.4	0.5	52.8	7.08	5.11	3.77	2.86	G1 1/2B	G1 1/4B
1 ½”	44	0.9	88	7.87	5.27	3.85	3.96	G2B	G1 1/2B
2”	66	2.6	132	7.87	6.49	7.48	12.78	ANSI #150	
2 ½”	110	4.4	220	7.87	7.28	8.03	14.99	ANSI #150	
3”	176	7	352	8.85	7.55	8.66	19.84	ANSI #150	
4”	264	10	528	9.84	8.66	9.44	25.57	ANSI #150	

Notes: 1. Weight may differ depending on accessories.
2. Pipe joint could be NPT/ANSI flange upon request. For DN50-DN100, the flange is removable.

Electrical Data

Power Supply:	Battery, 3.6V, Lithium
Battery type:	Lithium, 3.6V
Battery life:	6 years. Optional 10 years
Backup Power Supply:	Internal SuperCap
Communication Interface:	M-Bus (default) Optional: RS485 with MODBUS support, Pulse, optical isolated, BACnet/MSTP, Radio, GSM
CE approval:	EN61326-1:2006
Pressure:	≤1.6 MPa
Press loss:	<0.025 MPa
Replacement Interval:	6 (optional 10) years at t_{BAT} <30°C (86°F)
Network Power Supply:	Automatically switch to M-Bus or RS485 power if available
Power Consumption:	<0.2W
Standby (Static) Current:	<10uA

Accuracy / MPE (Maximum Permissible Error)

Accuracy Class: Class 2

MPE according to OIML R75, the whole system error is the combination of the following:

- Calculator (Integrator): $E_c = \pm(0.5 + 2 / \Delta\Theta)$
- Temperature Sensor: $E_t = \pm(0.5 + 4 / \Delta\Theta)$
- Flow Sensor: $E_f = \pm(2 + 0.02\ q_n / q)$

Here $\Delta\Theta$ is the temperature difference between the flow and return of the heat exchange circuit. q is the flow rate and q_p is the nominal flow rate.

Calculator (Integrator)

Display:	LCD, 8 digits
Resolution:	999.99999 - 999999.99 - 99999999
Energy Unit:	KWh – MWh – GJ
Communication Protocol:	M-Bus (default). Optional: MODBUS, BACnet

Temperature Measurement

Sensor Type:	PT1000, 2-wire
Measurement Range:	0…150°C C (32…302°F)
Difference Range:	ΔΘ: 3K … 70K
Permissible Temperature:	Θ: 2°C…60°C (35…140°F) for long term and up to 95°C (203°F) for short term
High-temperature version:	up to 130°C (266°F)

Mechanical Data

Metrological Class:	2 (according to OIML R75)
Environmental Class:	B, optional C (outdoor)
Electromagnetic Class:	E1
Environmental Temp:	0…55°C (32…131°F)

Enclosure Protection:	IP65, optional IP68
Enclosure Material:	Plastic
Integrator Detachable:	Yes
Pressure:	PN16
Flow Sensor Body Material:	Brass
Flow Sensor Cable:	1.2m (10m upon request)
Temperature Sensor Cable:	1.2m (10m upon request)
Gasket for flow /temperature Sensors:	Silicon Rubber

Pressure Loss

The pressure loss of a flow sensor is proportional to the square of the flow:

$\Delta p = k \times q^2$

Here Δp is pressure loss, q is volume flow rate and k is the coefficient.

All meters have Δp less than 0.25bar at q_p.

§2.5 Units systems

Currently, the 280T device does not support additional unit systems, and so it measures everything in Celsius and kW h by default. However, one can use these simple equations to convert between units:

If you prefer to use BTU as the unit for energy, you may use the formula 1 kW h = 3412.3 BTU.

If you prefer to use °F as the unit for temperature, you may use the formula °F = °C * (9/5) + 32.

§2.6 How to protect the cables

When mounting the sensors, please be careful not to touch the meter wires. All cables must be properly protected so that no damage, short-circuit, or disconnection occurs to the device.

§2.7 Serial number

First, go to the A2 menu layer. Then cycle through the menus until you reach flow rate. The serial number is in the screen right after flow rate. You should have the serial number ready when you contact the manufacturer for support.

§2.8 Model Selection

280T - DN □□□ - □ - □ - □ - □

Size			
DN15 (1/2 ")	015	DN125 (5 ")	125
DN20 (3/4 ")	020	DN150 (6 ")	150
DN25 (1 ")	025	DN200 (8 ")	200
DN32 (1 1/4 ")	032	DN250 (10 ")	250
DN40 (1 1/2 ")	040	DN300 (12 ")	300
DN50 (2 ")	050	DN350 (14 ")	350
DN65 (2 1/2 ")	065	DN400 (16 ")	400
DN80 (3 ")	080	DN450 (18 ")	450
DN100 (4 ")	100	DN500 (20 ")	500

Output Interface	
Pulse	0
M-Bus	1
RS485/Modbus	2
BACnet	3
GSM wireless	4
RF wireless	5
Others	6

Pipe Joint	
BSP	A
NPT	B
DIN Flange	C
ANSI Flange	D

Accessory	
None	0
with extension piece (for size ≤ DN40)	1
with extension piece and T-connector / thermal well (for size ≤ DN40)	2

Temperature	
Standard Temperature	A
High Temperature	B

Example:
280T-DN025-1-A-2-A stands for the 280T tPrime series BTU meter for pipe DN25mm with M-Bus interface, BSP pipe joint, extension pieces and T-connector (thermal well), with standard temperature rating.

3. Operation

§3.1 Built-in Battery

The instrument operates from the built-in Lithium battery, which is long-lasting with 6 to 10 years of operating time. The static current of the battery is less than 10uA, and the terminal voltage reaches around 3.6V. If the 280T is connected to an outside power source, such as M-Bus, the meter will not use the battery but instead draw power directly from the M-Bus.

Due to transport regulations, the battery might be deactivated by an insulating strip, which must be removed completely in order to activate the meter. If a replacement battery is needed, please contact Spire Metering. If the meter needs to be sent by air freight, then the battery must be removed prior to shipping.

For safety precautions, the batteries should not be opened, come into contact with water, or be exposed to temperatures above 80 °C. Batteries should be disposed of at proper collection centers.

§3.2 Power On

First, make sure to activate the battery. Press and hold the red button until it turns on the power.

The 280T screen should display E0 when it is not connected to a water pipe (There is no water inside of the flow sensor). When the meter is connected to a water pipe, and the water is full in the pipe, the device will display the quantity of heat. If there is any abnormality, corresponding error messages will be displayed.

Generally, there should be no display of error messages, and the heat meter will go to the most commonly used window, which displays the total energy in kW h.

The heat measurement program always operates in the background of the user interface. This means that the heat measurement will keep running regardless of any user window browsing or viewing.

When the red button on the front panel is pressed, it cycles through different display windows such as supply water temperature (t1), return water temperature (t2), temperature difference (Δt), working time (hr), accumulated water quantity, water velocity, etc.

Once it is turned on, the 280T will keep on running until its long-lasting battery runs out. There is no need to turn off the device when not in use.

§3.3 Keypad

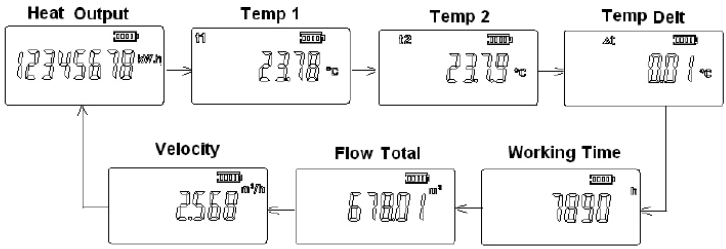
The keypad of the 280T heat meter has 1 key for all functions.

§3.4 Menu Windows

The user interface of this heat meter comprises of several results displays that can be viewed.

In order to get into a certain menu window, the user can press the red button to change the LCD display. The heat meter calculates the results and updates the display every 8 seconds. The following values can be displayed:

- Total Energy (kW h or MW h)
- Power (kW)
- Supply water temperature (t1)
- Return water temperature (t2)
- Delta (change) in temperature (Δt)
- Flowrate (m^3/h)
- Total Volume (m^3)
- Total Working Time (h)
- Current Date



Each short press of the red button switches the display screen to the next item. The menus are displayed in loop-fashion. After pressing the red button, the display may stay at an item for a short time and then return to the original display item. If you want the meter to display heat output all the time, first press the red button to switch to the heat output screen, then press and hold the button for 8 seconds. The display resolution is 0.001 kWh. If you want the meter to display water flow total all the time, first press the red button to switch to the flow total screen, then press and hold the button for 8 seconds. The display resolution is 0.00001m^3.

These are the top layer (A1-layer) of the menu display structure. On the second layer (A2-layer) of this structure, more information can be seen. To go from the A1-layer to the A2-layer, press the red button until it displays the flow rate. Then, press and hold the button for 8 seconds, and you should see "A2" on the LCD for a short time. This indicates that you are ready to view the menus on the A2-layer. On the A2-layer, the following menus are displayed:

- Total Volume with High Resolution (5 decimals)
- Total Energy with High Resolution (3 decimals)
- Current Date
- Error Code
  Factory Data 1
- Flowrate
- Serial Number
- Manufacturing Date
- Factory Data 2, followed by Meter Size
- Factory Data 3 (version)
- Factory Data 4 (Calibration Coefficient for Q1 and Q2, hex numbers)
- Factory Data 5 (Calibration Coefficient for Q3 and Q4, hex numbers)
- Supply water temperature (t1)
- Return water temperature (t2)
- Factor Data 6
- Special Number 110001400

To go back to the A1-layer, scroll to the Flowrate item of A2, then press and hold the button for 8 seconds until "A1" appears on the LCD. Or, simply leave the button alone for a certain time, and the meter will automatically switch to the top layer display.

Note: Factory Data 4 and Factory Data 5 are the calibration coefficients for Q1 (normal flowrate), Q2 (0.2 times normal flowrate), Q3 (0.1 times normal flowrate), and Q4 (minimum flowrate).

Example: If Menu Factory Data 4 shows 626C 63CE, then the coefficient for Q1 is626C (Hex) or 25196 (Dec), and the coefficient for Q2 is 63CE (Hex) or 25550 (Dec). Similarly, this applies to Factory Data 5.

§3.5 How to check if the instrument works properly

Generally speaking, when all the displayed data make sense and change accordingly to different conditions, the heat meter is functioning properly. However, be aware of these error messages:

If an 'E0' flashes, it means there is no water flowing through the heat meter. Check the pipe's water supply and try to get it so that the pipe is full of water.

If an 'E1' is displayed, it means that the flow rate is over the supported range of the instrument.

If an 'EA' is displayed, it means that the temperature sensor is short-circuited.

If an 'EB' is displayed, it means that the temperature sensor is disconnected or broken.

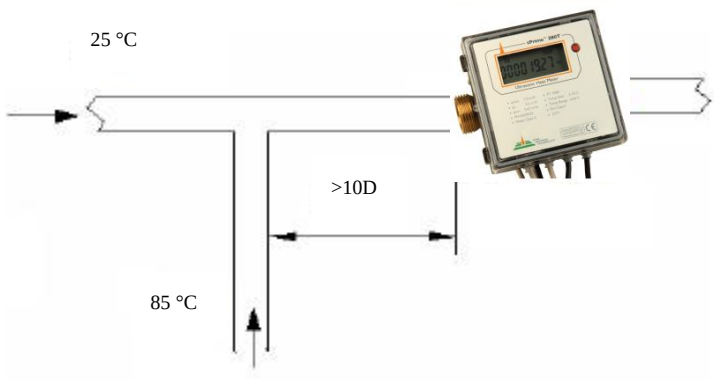
§3.6 Battery life

See the battery icon on the top right corner. Four bars signify almost full battery in the device.

4. Installation

§4.1 Location selection

- Find a suitable location for connecting the flow cell (the “tube” part of the device where water flows through) to the pipe line.
- Do not install the meter within 0.5m of an AC power line or a high-frequency radiation source.
- It is recommended to have a 5D straight pipe run upstream and 2D straight pipe run downstream, where D stands for pipe diameter.
- When two or more heat meters are installed closely, make sure they are distanced by 0.3m or more.
- If the flow meter is installed on the common return of two heating circuits (e.g. heating water and hot water), the mounting location must be at a sufficient distance, at least 10D, from the Tee, to ensure that different temperatures homogenize (refer to the figure on the bottom).
- For more information on optimal location, go to Appendix §8.4.

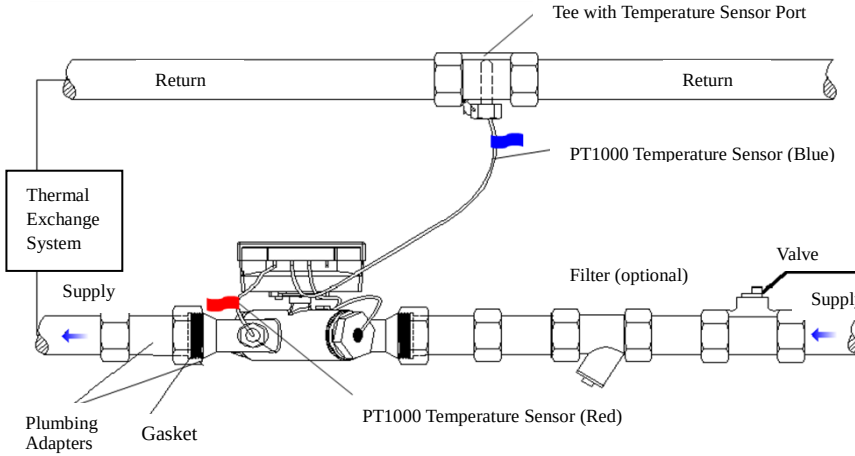


§4.2 Flow-cell installation

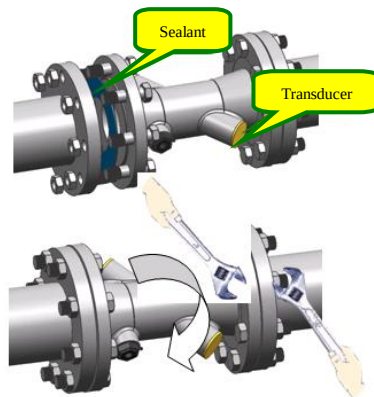
- When installing, make sure the arrow on the meter sensor points to the flow direction.
- When installing, do not turn the electronic box. When using a wrench to install, hold the metal part of the sensor rather than the electronics box.
- When the meter is used as cold meter, remove the meter’s main box and its mounting base and install the main box on a wall or other objects where the temperature is within 0~55°C. In addition, the meter box needs to be higher than the cold pipe, so that the condensed water on the cold pipe will not flow into the

meter box along the wires.

- The meter sensor can be installed vertically or horizontally:
  When it is installed vertically, make sure the flow goes upward.
  When it is installed horizontally, make sure the ultrasonic transducers of the flow-cell are on the side instead of the top or the bottom (please refer to the figure below)



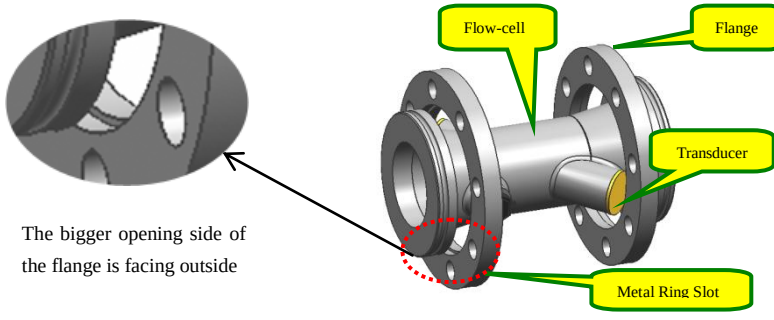
- Flange connection
  (1) Check the flow-cell dimension and reserve sufficient clearance for the flow-cell installation.
  (2) Install flexible flanges if applicable (DN50-100), see next section for details
  (3) Install the flow-cell between two shut-off valves.



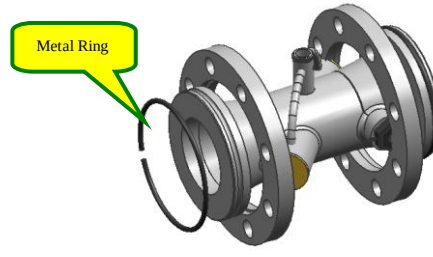
§4.3 Installation Guide for Flexible Flanges

Ultrasonic heat meters from sizes DN50 to DN100 normally use flexible flanges for pipe connection. Here shows how to assemble the flexible flanges with the flow-cell sensor and install them into a pipe line.

1. Each water meter or heat meter of size DN50-DN100 comes with a flow cell, a pair of flexible flanges, and two pieces of metal rings.
2. First, put the 2 pieces of flanges into the flow cell.



3. Put the metal ring into the metal ring slot. Do this for both sides of the flow cell.



4. Connect the flow cell to the pipe:
   Put the pipe sealant in place metal. Rotate the flange so that the two transducers are in the horizontal plane. Note that if your pipe is vertical, you may skip this step. Just make sure the flow in your vertical pipe is going upward, not downward. Put the bolts through the flange holes as shown below. Screw in the nuts with caution. Leave the nuts loose for this moment! Check whether the flow cell is in line with the pipe. If not, adjust the flow cell position. Tighten the bolts and nuts.

§4.4 Temperature Sensor Installation

For DN 10-40

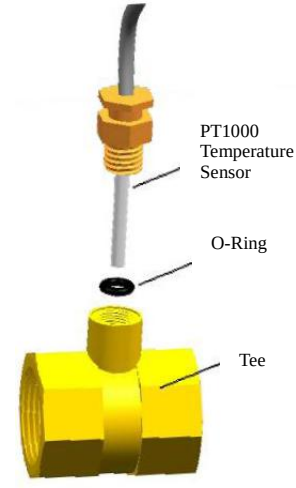
The red-labeled Temperature Sensor should be already pre-plugged into the flow cell. In order to install the blue-labeled Temperature Sensor on the return pipe, follow these steps:

(1) Insert the Tee into the desired location along the pipe line.

(2) Remove the Temperature Sensor Port plug from the Tee.

(3) Insert the O-Ring deep inside the Temperature Sensor Port.

(4) Gently insert the blue-labeled Temperature Sensor into the Tee's Temperature Sensor Port, being careful not to break the O-Ring, and then tighten it.



For DN 50-120

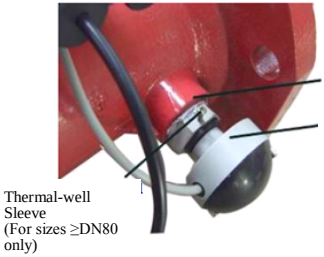
(1) Install the red-labeled temperature sensor into the temperature sensor mounting pocket on the flow-cell. Refer to the lower left figure for details.

(2) On the return pipe (assuming the heat meter is installed on the supply pipe), make a hole with size slightly bigger than the mounting pocket.

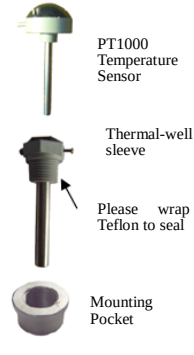
(3) Insert the mounting pocket into the hole and weld it onto the return pipe.

(4) Install the blue-labeled temperature sensor into the mounting pocket:

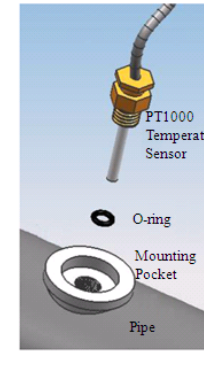
- For DN80 and larger meters, refer to the lower center figure.
- For DN50 and DN65 meters, refer to the lower right figure.



Temperature sensor
Installation on the flow-cell



For sizes ≥ DN80



For sizes DN50 and DN65

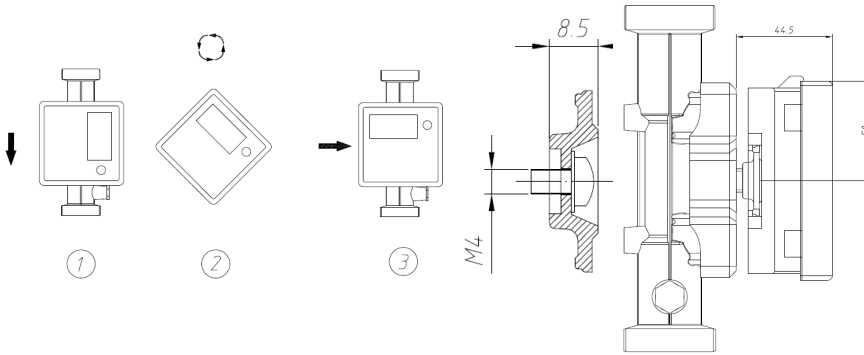
§4.5 Electronic Box Mounting Location

The electronic box can be mounted horizontally, vertically, or inclined on the meter mounting base of the flow sensor.

(1) Make sure the surrounding temperature is less than 55°C. If not, remove the meter mounting base and install it together with the electronic box on a wall that is at room temperature.

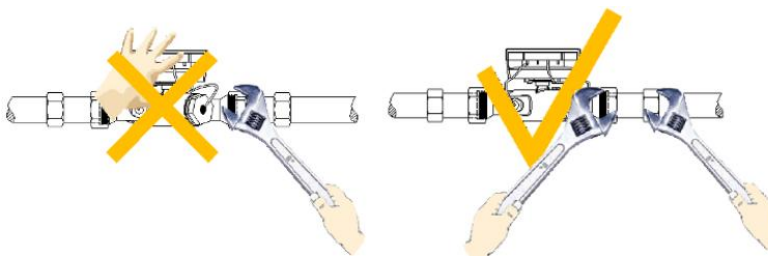
(2) If the water temperature is higher than 90°C, remove the meter mounting base and install it together with the electronic box on a wall.

(3) When used as a cold meter, remove the meter mounting base and install it together with the electronic box on a wall. In addition, the box should be above the pipe so that no condensed water will drop onto the box or run along the wire into the box.

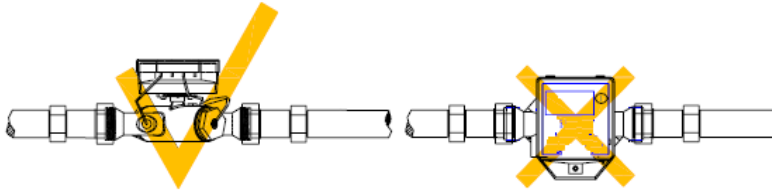


§4.6 Common installation mistakes

Use both wrenches when tightening the nuts

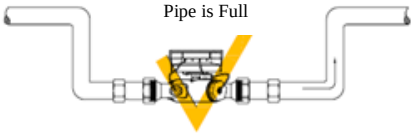


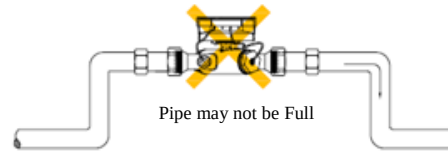
For horizontal pipes, the flow-cell should be installed in a way so that the meter box faces upward and the two ultrasonic transducers on the horizontal plane.



The pipe must be full of liquids.

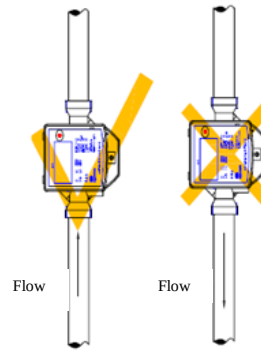
Pipe is Full





Pipe may not be Full

For vertical installation, the flow must go upward.



§4.7 Operations check

- After the installation is complete, the air in the pipe has to be purged out completely.
- Make sure the pressure in the system is normal.
- Make sure the red temperature sensor is installed in the temperature sensor port of the flow-cell, and the blue temperature sensor is installed in the temperature sensor port of the Tee. For pipe sizes DN65 or bigger, you may need to drill a hole to install the blue temperature sensor. Please contact the manufacturer for

instructions.

- Make sure the O-ring for the sealing is centered at the joining point. Otherwise, it could generate disturbance to the flow, thus, degrading the meter accuracy.
- Use meter only under the specified operating conditions. Make sure flow rate range is proper for the pipe.
- If the heating system is not running in winter, always empty the pipe. Otherwise, the pipe may burst when water freezes.
- Important: The pipe must be full of liquids during operation!

5. Troubleshooting

§5.1 Power-on Errors

When powered on, the 280T series ultrasonic heat meter automatically starts the self-diagnosis process to see if there are any hardware and software problems. If a problem is identified, an error message will be displayed. The following table shows the possible error messages, the corresponding causes, and their solutions.

Error message	**Causes**	**Solutions**
E0	No water in pipe detected	(1) Make sure water flow is turned on in pipe (2) Check the flow cell connection
E1	Flow rate is over the range supported by device.	Check flow source
EA	Temperature sensor was short-circuited.	(1) Reconfigure the temperature probe installation (2) Contact the manufacturer
EB	Temperature sensor is disconnected or broken.	Reconnect the temperature probes, or order new parts from the manufacturer
Reboot repetitively	Hardware problems	Contact the manufacturer

§5.2 Working Status Errors

Whenever something goes wrong while the device is on, the 280T heat meter will show an Error Code, just like with the power-on errors. When any abnormal Error Code shows, counter-measures should be taken.

§5.3 Other Problems and Solutions

(1) Q: Why does the instrument display 0.0000 flow rate while the liquid in the pipe is actually flowing?
A: There might not be enough water in the pipe. Try to get it so that water flow through the flow cell is almost full. Additionally, check the installation to see if it is in a desirable location.

(2) Q: The displayed flow rate is much lower or much higher than the actual flow rate in the pipe under normal working conditions. Why?
A:
(a) The flow cell and meter might have been installed incorrectly. Check the

connection.

(b) The amount of straight pipe run upstream and downstream may be too small. This can cause the data reading to be inaccurate.

(c) When the meter sensor is installed vertically, make sure the water flow goes upward. When it is installed horizontally, make sure the ultrasonic transducers of the flow cell are on the side instead of the top or bottom, as this may skew results.

(3) Q: Why is the temperature reading incorrect?

A:

(a) When 2 or more heat meters are installed closely, make sure they are separated by 0.3m or more, otherwise the measurements are affected.

(b) Make sure the temperature sensor is installed correctly in the temperature sensor port.

(c) Make sure the meter box is not in direct contact with the pipe if it's a used as a cold meter.

For more information, please refer to our technical support website:
http://www.spiremt.com/support

6. Interface/Communication

§6.1 General

The tPrime 280T series ultrasonic heat meter integrates a USB communication interface and a complete set of serial communication protocol. By using this serial communication link, one can configure the heat meter and acquire measurement results from a PC. Additionally, the 280T heat meter has multiple AMR/AMI integral options, including:

- Pulse
- M-Bus
- RS485 with Modbus
- RF
- TCP/IP
- BACnet modules

§6.2 Set up PC Software

To facilitate the use of and to fully explore the potential of 280T heat meter, Spire Metering has developed proprietary PC software, which is particularly useful for those who are not familiar with computer communication technology.

Please visit the following technical support website for more information on available PC software:
http://www.spiremt.com/support

§6.3 Communication Protocol

These are the main methods to read data from tPrime 280T heat meters: Infrared Meter Reading, RS485 Meter Reading, M-Bus Meter Reading, BACnet Meter Reading and RF Wireless Reading.
Infrared reading is a local meter reading method. The others are remote meter reading methods. The communication protocol discussed here is applicable to remote reading methods.

MODBUS Protocol:
Master-Slave communication architecture. The 280T meter is the slave.
Use RS485 serial communication. Default parameters are:

- Baud Rate: 9600 bps
- Checksum: None
- Data bit: 8 bits

- Stop bit: 1 bit

With the MODBUS module option, the 280T supports standard MODBUS protocol.

MODBUS REGISTER TABLE

Register Address	# reg.	Variable Name	Data Type	Notes
0001-0002	2	Flow Rate	LONG	*
0003-0003	1	Flow Rate Unit	INTEGER	*
0004-0005	2	Power	LONG	*
0006-0006	1	Power Unit	INTEGER	*
0007-0008	2	Flow Total	LONG	*
0009-0009	1	Flow Total Unit	INTEGER	*
0010-0011	2	Heat Energy Total	LONG	*
0012-0012	1	Heat Energy Total Unit	INTEGER	*
0013-0014	2	Cold Energy Total	LONG	*
0015-0015	1	Cold Energy Total Unit	INTEGER	*
0016-0017	2	T1 /Supply Temp	LONG	x0.01degC
0018-0019	2	T2 /Return Temp	LONG	x0.01degC
0020-0020	1	State	INTEGER	
0021-0022	2	Working Time	LONG	Unsigned. second
0023-0024	2	Clock	BCD	Writable. 3bytes BCD for second, minute and hour. Low on left
0025-0026	2	Date	BCD	Writable. 4bytes BCD for day, month and year. Low on left
0027-0027	1	4-20mA output current value	INTEGER	x0.01mA
0028-0029	2	Flowrate/Energy rate at 4mA	LONG	Unit similar to (0003)
0030-0031	2	Flowrate/Energy rate at 20mA	LONG	Unit similar to (0006)
0032-0032	1	Size	LONG	mm (saved in flash)
0033-0034	2	SN#	BCD	High on left
0035-0035	1	MODBUS ADDR	INTEGER	Writable (saved in flash)
0036-0036	1	Meter Type	INTEGER	BIT0=0:water meter BIT0=1:heat meter (saved in flash)
0037-0037	1	Comm Mode Select	INTEGER	Writable. 0 - 9600/MODBUS （Default）; 1- 2400/Mbus**
0038-0038	1	Firmware Version	INTEGER	Hex

Notes:

*Unit code:

05– KWH; 14 – Watt; 32 – Litre/H; 2C – Cubic Meter;

02– WH; 08 – GWH;

17– KW; 1A – GW; 29 – Litre; 35 – Cubic Meter/H.
Data Format:
For LONG data, it has 32bits. Thus, two registers are used to store a LONG. The first register (lower address) is for the lower 16bits of the data. The second register (higher address) is for the higher 16bits of the data.

** Use factory software to change the communication protocol. If you set the Communication Mode to 1, and set the duration to 6556, then the meter will switch to M-Bus protocol. Resetting the external power will switch the mode back to MODBUS protocol.

M-Bus Protocol:
Master-Slave communication architecture. The 280T meter is the slave.
Use M-Bus serial communication. Default parameters are:

- Baud Rate: 2400 bps
- Checksum: None
- Data bit: 8 bits
- Stop bit: 1 bit

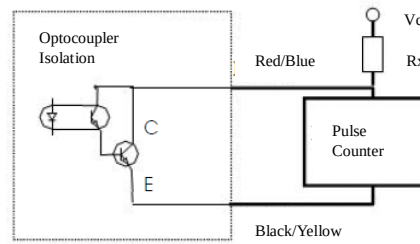
The 280T adapts the EN1434 / EN13757 M-Bus protocol. This allows it to communicate with any standard M-Bus master device.
Please note that only the major functions of the protocol have been implemented.

§6.4 Wiring Diagrams

Pulse Interface:

tPrime 280T (DN 10-40)		
Number	Wire Name	Color
1	Return Temperature Sensor	Blue Flag
2	Supply Temperature Sensor	Red Flag
3	Transducer Cable	Black
4	Pulse Output Wires	Red (Plus)
		Blue (Minus)
		Black (Ground)

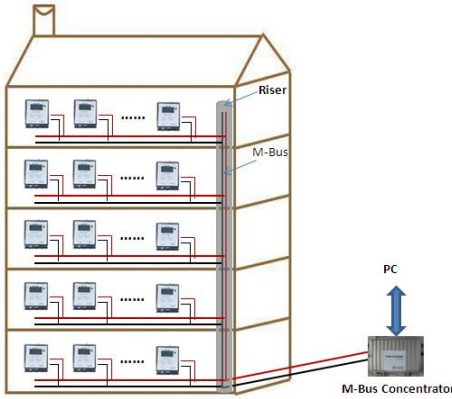
Specifications:
Vcc: 12~24 VDC power supply
Rx: 2kOhm
Pulse width: 15ms
Pulse frequency:
1 kWh/p (≤DN32),
10kWh/p (DN40~DN80),
100kWh/p (DN100~DN150),



1000kWh/p (≥DN200)

M-Bus Interface:

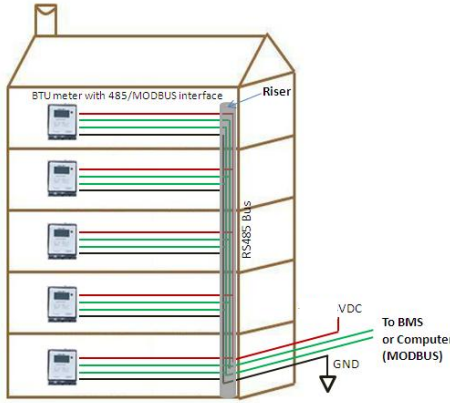
tPrime 280T (DN 10-40)		
Number	Wire Name	Color
1	Return Temperature Sensor	Blue Flag
2	Supply Temperature Sensor	Red Flag
3	Transducer Cable	Black
4	M-Bus Output Wires	Red (Plus)
		Black or White (Minus)



Two wires, no polarity.
Wire size: AWG26 or bigger, depending on distance.
Wire length: <1.2km
Twisted cable with shielding is better.
Once 280C-0 concentrator can support up to 250 M-Bus meters.
Refer to the figure on the left for details.

RS485/MODBUS Interface:

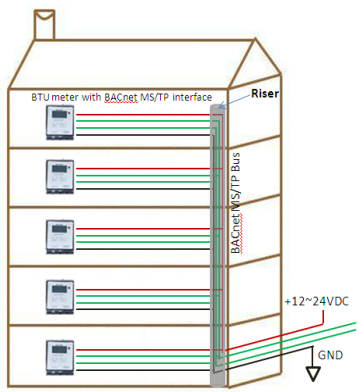
tPrime 280T (DN 10-40)		
Number	Wire Name	Color
1	Return Temperature Sensor	Blue Flag
2	Supply Temperature Sensor	Red Flag
3	Transducer Cable	Black
4	Modbus Output Wires	Red (Plus)
		Blue (Minus)
		Black (Ground)
		Yellow (B)



The RS485 output is an opto-isolated serial interface. It needs an external 5VDC/0.1A power supply.
This communication port setting is fixed at 9600,8,n,1.
This serial interface supports standard Modbus protocol.

BACnet Interface

tPrime 280T (DN 10-40)		
Number	Wire Name	Color
1	Return Temperature Sensor	Blue Flag
2	Supply Temperature Sensor	Red Flag
3	Transducer Cable	Black
4	Output Wires	Red (Plus)
		Blue (Minus)
		Black (Ground)
		Yellow (B)



Interface: Upper Link: BACnet MSTP
Downlink: RS485/MODBUS
Power Supply: 5VDC/0.5A

§6.5 Pulse Metering System

The pulse system is the easiest way to connect the 280T meter to an output source for serial communication. As shown in the wiring diagram in §6.5, be sure to include a black output wire for the ground.

The pulse output interface can be connected to a pulse wireless transmitter to send the meter data to a remote data center through a fixed wireless AMI infrastructure (refer to section $6.8 for details). It may also send data to a handheld meter reading device for mobile reading when AMI infrastructure is not available. Please contact solutions@spiremt.com for more information.

§6.6 M-Bus Metering System

M-Bus Cable

The M-Bus uses two wire cables which are going from the M-Bus Master / Repeater to each M-Bus device (bus structure). The M-Bus is polarity independent and needs no line termination resistors at the end of the cables.

Any cable type may be used as long as the cable is suitable for 42 V / 500 mA. Shielding is not necessary and not recommended since the capacity of the cable should be minimized.
In most cases a standard telephone cable is used which is a twisted-pair wire with a diameter of 0.8 mm each (2 x 0.8 mm). This type of cable should be used for the main wiring. For the wiring to the meters from the main wiring (last 1 … 5 m to the meter) a cable with smaller diameter may be used.

Please refer to the picture in section §6.4 for wiring details.

The M-Bus system is an European instrument “bus” standard designed for domestic metering devices, such as water meters, heat/water meters, gas meters, etc., to communicate with data centers. The “bus” simply uses two non-polarized wires to achieve a variety of options for reliable meter reading, remote diagnosis, remote control, incremental pricing, time-based pricing, batch service, prepaid billing, and more. This ‘bus’ system is both simple and economical to wire and implement.

A typical M-Bus AMR system consists of a number of M-Bus utility meters, several M-Bus concentrators, a GSM/GPRS Data Transmitter Unit (DTU) for each M-Bus concentrator, and a data center. The M-Bus Concentrator communicates with the data center computer through a GSM/GPRS network. The data center first issues a meter reading command and sends it to the network. The DTU receives the command and forwards it to the M-Bus concentrator. Then, the concentrator either replies to the command with requested data or passes the command to its submeters transparently.

Please note that you may not need the DTU unit if you can connect the M-Bus concentrator(s) to your computer directly. Alternatively, you may connect the concentrator(s) to your computer through TCP-IP network by using Ethernet-232 adapters. Similarly, you may connect the concentrator(s) to your BACnet or MODBUS network by using proper adapters.

The 280C Concentrators are used for an AMR system to facilitate the communication between the data center and the M-Bus utility meters of the AMR system. These concentrators support not only the 280T BTU meters, but also the 280W water meters and STE101C electricity energy meters. A wireless M-Bus concentrator is also available, where the M-Bus concentrator is affixed with a GSM/GPRS data transmitter unit (DTU).

A DTU (Data Transmitter Unit) is a GSM/GPRS modem which provides a wireless interface for the concentrator. Spire Metering's EP280 GSM modem and EP260 GPRS modem are specially designed for this application. Both EP280 and EP260 have the following features:

- Support GSM900/1800M dual band or GSM850/1900M dual band
- Transmitting power: 2W (900MHz) or 1W (1.8GHz)
- Receiving sensitivity: <-102dBm
- Frequency error: < +/- 0.1ppm
- Low power consumption
- International standard interface
- Standard RS-232 interface
- Provide SMS services，meet GSM07.05 standard
- DTU device for transparent communication
- Auto reset after power off or manual reset

§6.7 GSM Wireless Metering System

For remote locations where wired metering networks or RF networks are not suitable, Spire Metering offers GSM-enabled utility meters. This allows the utility meter to communicate with the data center directly.

One example is a 280T heat meter that has a built-in GSM modem (EP280). When the EP280 GSM modem is powered up, it starts to establish a wireless link with the GSM wireless network. On the data center side, another GSM modem (EP260) is connected to the computer. When this modem is powered up, it will also start to establish a wireless link with the GSM wireless network.

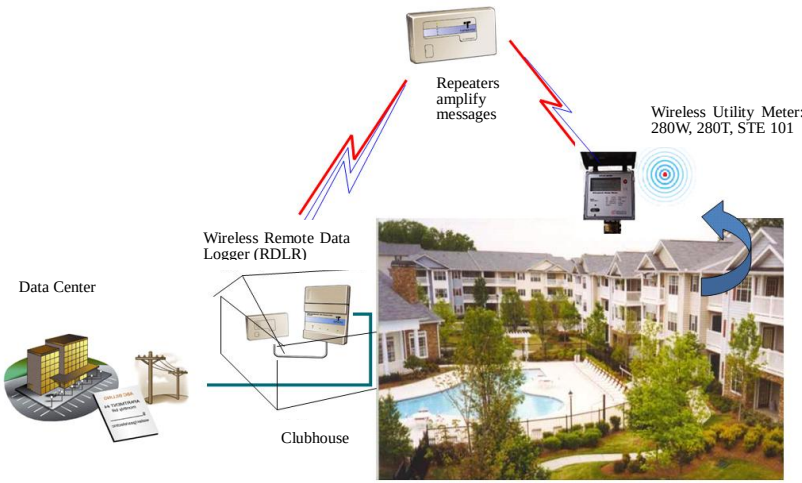
The data center software sends a query command together with the destination's phone number and address to its modem, EP260. EP260 then packs the command in SMS format and sends the SMS package to the GSM/GPRS cellular wireless network. The SMS service routes this package all the way to the destination modem EP280, whose phone number matches that of the command.

When the EP280 receives the SMS package, it strips off the SMS packing information and extracts the original command. Consequently, it sends the command to the meter whose address matches the one in the command. In this way, a number of utility meters, such as water meters, electricity meters, gas meters and valves, can be connected to the same EP280 GSM modem, as long as they have different addresses.

When the heat meter receives the command from its EP280 modem, it executes the command and responds with the requested data. The data will be sent to the GSM/GPRS cellular wireless network via SMS service. The SMS service routes this data all the way back to the data center computer. After receiving the response from the water meter, the Data Center Manager software will process the data, saving the data to SQL database.

§6.8 RF Wireless Metering System

This fixed network Advanced Metering Infrastructure (AMI) system utilizes a Remote Data Logger (RDLR) to receive and transfer meter data from transmitters located at each utility meter on to the utility computer. The SpireCapture data management software suite allows easy access to system information and a variety of customer service tools. In addition to providing meter data to the utility's billing system in a flexible and compatible file format, the meter data management software also monitors and controls system performance, manages data, and remotely reconfigures the RDLR as needed.



The RF system consists of 3 parts:

- RF transceiver: 433 MHz
- Repeater: an intelligent transceiver that identifies signals from the endnote transceiver and rebroadcasts those signals. The repeater transmits at a higher power than the endnote, so the endnote radio transmissions need only reach the repeater, not the Remote Data Logger (RDLR). This extends the life of the battery in the endnote and creates an accurate, reliable, and cost-effective wireless system.
- Remote Data Logger: interfaces to the wireless network for collection of utility consumption data, stores the collected data, and transfers the data to a remote billing server for bill generation.

§6.9 BACnet Metering System

The 280T meter can utilize a BACnet/MSTP adapter to provide the BACnet interface. It connects to the BACnet/MSTP adapter through RS485 and uses the MODBUS protocol to communicate. The BACnet adapter has passed the BTL certification test. It has proven to be robust, reliable, and flexible. The BACnet module has two banks of DIP switches, enabling the users to quickly configure the serial protocol settings without the need for any third party software. Settings available via the DIP Switches include

- MAC address
- Baud rate (including auto-baud setting for BACnet MSTP)
- Node ID

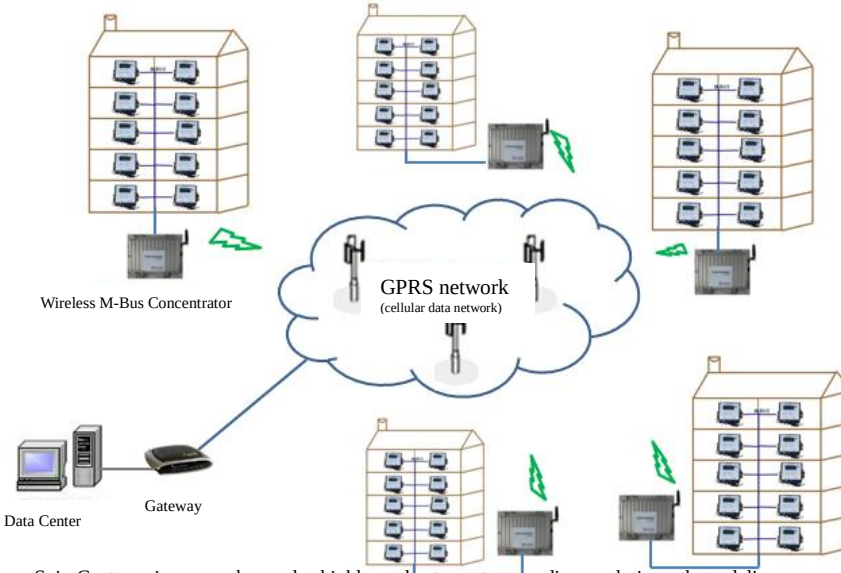
The BACnet module supports the following protocols:

- BACnet MSTP
- Metasys N2
- Modbus RTU
- Modbus ASCII
- Allen Bradley DF1

The data link layer options include BACnet IP (Annex J), MS/TP master (Clause 9), with a baud rate of up to 76.8 Kbps, and MS/TP slave (Clause 9). The networking options are BACnet/IP Broadcast Management Device (BBMD), as well as registrations by foreign devices.
The standard object types supported by BACnet interface are device object, analog input, analog output, analog value, binary input, binary output, binary value, multi state input, multi state output, multi state value, and notification class object.

§6.10 Automatic Meter Reading

Spire Metering's SpireCapture™ system is a cutting-edge fixed AMR system which integrates both wired and wireless AMR/AMI technologies. It provides a unified platform for meter reading and data management through M-Bus networks, RF wireless networks, GSM networks, GPRS networks as well as TCP/IP networks. In addition, the AMR system works seamlessly with Spire Metering's billing software to make data exchange easy, fast and reliable.



SpireCapture is an advanced, highly robust meter reading solution that delivers comprehensive usage information as well as timely, high-resolution meter reading. This data enables gas, water, heat and electric utilities to eliminate on-site visits and estimated reads, reduce theft and loss, implement time-of-use billing, and profit from all of the financial and operational benefits of a fixed-network AMI/AMR.

SpireCapture is based on a flexible, expandable, multi-tier architecture that can accommodate a variety of metering networks. The data center software communicates with those networks through a standardized platform, which allows you to start with a simple AMR system and gradually expand to a large metering system. SpireCapture communicates with utility meters using primarily the MBus protocol. It can also be extended to other protocols such as Modbus. This allows other brand utility meters to be integrated into the SpireCapture system.

7. Warranty and Service

§7.1 Warranty

The products manufactured by Spire Metering Technology are warranted to be free from defects in materials and workmanship for a period of two years from the date of shipment to the original purchaser. Spire Metering's obligation should be limited to restoring the meter to normal operating conditions or replacing the meter, at Spire Metering's choice, and shall be conditioned upon receiving written notice of any alleged defect within 10 days after its discovery. Spire Metering will determine if the return of the meter is necessary. If it is, the user should be responsible for the one-way shipping fee from the customer to the manufacturer.

Spire Metering is not liable to any defects or damage attributable to misusage, improper installation, out-of-spec operating conditions, replacement of unauthorized parts, and acts of nature. Additionally, fuses and batteries are not part of this warranty.

THE FOREGOING WARANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER EXPRESS OR IMPLIED WARRANTIES (INCLUDING BUT NOT LIMITED TO WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, AND WARRANTIES ARISING FROM DEALING, TRADE OR USAGE.)

§7.2 Service

The manufacturer provides instrument installation services for its customers, and the charge will depend on the complexity of the installation.

For operational problems, please contact the technical support department by telephone, fax, or email. In most cases, the problem can be resolved immediately.

For any hardware failure of the instrument, we recommend our customers to send back the instrument for service. Please contact the technical support department with the model number and serial number of the unit before sending the unit back to us. Both numbers can be found on the product label. For each service or calibration request, we will issue a Return Materials Authorization (RMA) number.
Take notice that the cost for repairing can only be determined after receipt and inspection of the instrument. A quotation will be sent to the customer before proceeding with the service.

Important Notice for Product Return

Before returning the instrument for warranty repair or service, please read the following carefully:
1. If the return item has been exposed to nuclear or other radioactive environments, or has been in contact with hazardous material which could pose any danger to our personnel, the unit cannot be serviced.

2. If the return item has been exposed to or in contact with dangerous materials, but has been certified as hazard-free device by a recognized organization, you are required to supply the certification for the service.
3. If the return item does not have a RMA# associated, it will be sent back without any service conducted.

8. Appendix

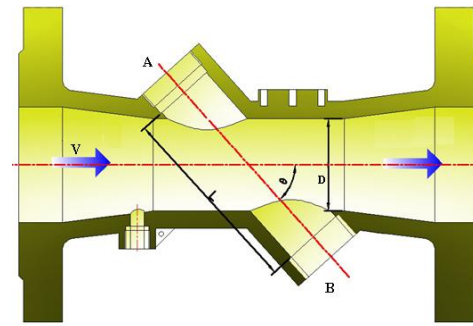
§8.1 Battery Maintenance and Replacement

The battery is a Lithium non-rechargeable battery. Therefore, one needs to replace the batteries once they run out of power (usually lasts 6 or 10 years). Please contact the manufacturer for purchasing new batteries. Dead batteries should be disposed of at proper collection centers.

§8.2 Principle of Measurement

The tPrime series 280T heat meter consists of an ultrasonic flow sensor, a pair of PT1000 temperature sensors, and a BTU unit. The microprocessor-based BTU unit controls the ultrasonic sensor to transmit and receive ultrasound in an orderly fashion in order to conduct precise flow measurement. The BTU unit also has electronics dedicated to measure the temperature in the supply pipe as well as the return pipe via PT1000 sensors. The BTU unit calculates the heat energy based on the flowrate and the temperature difference between the supply and the return.

The figure on the right illustrates how the ultrasonic flow sensor works. Two ultrasonic transducers (A and B) are mounted on a spool piece face-to-face; one is on the upstream and the other on the downstream. The electronic console (e.g., the BTU unit) operates by alternately transmitting and receiving a burst of sound energy between the two transducers and measuring the transit time it takes for sound to travel between the two transducers. The difference in the transit time measured corresponds directly to the velocity of the liquid in the pipe



§8.3 Heat Energy Calculation

In today's heat meter industry, there are two kinds of methods to calculate heat energy based on volume flow and temperature measurements. One method is to use the heat coefficient table, using this equation.

$$Q = \int_{v_0}^{v_1} k \, \Delta\Theta \, dV$$

where:
Q is the quantity of heat given up or absorbed
V is the volume of liquid passed
k is called the heat coefficient, a function of the properties of the energy-conveying liquid at the relevant temperatures and pressure
ΔΘ is the temperature difference between the flow and return of the heat exchange circuit

The true conventional value of the heat coefficient (*k*) for water, if it is used as the system's heat conveying liquid, can be obtained from a standard heat coefficient table.

Another method is to use the specific enthalpy table. Spire Metering Technology's BTU meter utilizes the second method to calculate the heat energy of a heat exchange circuit. The advantage of this method is that the flow sensor can be installed in either the supply or return line, as long as the Red-tagged temperature sensor is installed on the flow sensor side. The equation is below:

$$Q = \int_{\tau 0}^{\tau_1} \rho q_V \Delta h \, d\tau$$

where:
Q is the total heat given out or absorbed, from time τ_0 to τ_1, [J] or [Wh]
ρ(Ts, Tr) is the density of the liquid passed[kg/m^3]
Δh(Ts, Tr) is the specific enthalpy difference, calculated from the supply and the return line temperatures, in [J/kg].

To calculate heat (Q) accurately, both flow and temperature measurements must be accurate. Of the two, measuring flow rate is more challenging, as all of the values in the integral on the right side of the equation below must be correctly measured, determined, or pre-calibrated.

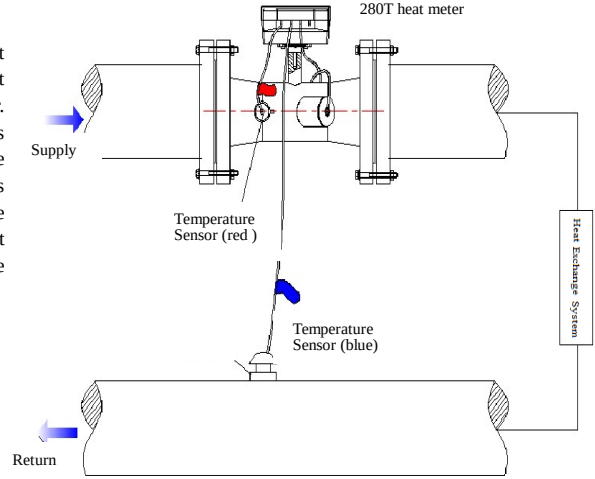
Here are the equations used to find q_v

$$T_{up} = L / (C - V \cos\theta) \qquad T_{down} = L / (C + V \cos\theta)$$

$$V = \frac{L}{2\cos\theta} \times \frac{\Delta T}{T_{up} \bullet T_{down}} \quad \text{and} \quad q_v = k\, S\, V$$

where:
Θ is the angle between the flow direction and the sound path
L is the transducer separation
T_{up} (T_{down}) is the transit time upstream (downstream), and $\Delta T = T_{up} - T_{down}$
k is a factory-calibrated scale factor, a function of the sensor structure and the fluid properties
S is the cross-sectional area of the flow at the sensor

The figure on the right illustrates a heat measurement system using the 280T meter. The temperature sensors measure the supply and the return lines, while flow rate is calculated as given above. The 280T calculates the heat transferred, Q, during a time interval, using the equations.



Depending on the pipe size, there are two kinds of transducer arrangements. For large pipes, a straight-through design is recommended. However, for small pipes, the straight-through does not provide enough sound path to obtain good accuracy. To increase the sound path, our competitors put a sound reflector in the pipe to get a V-shaped path or even put two sound reflectors to get a U-shaped path. The problem with the reflector occurs when the liquid in the pipe gets dirty, which is quite common in real heating/cooling loops. After many years in operation, the reflector surface is not smooth anymore, and its reflecting efficiency becomes very poor. This could cause the heat meter accuracy to be largely degraded, or even cause the meter to fail to register. With expertise on flow dynamics, Spire Metering Technology has designed a unique flow guide which allows the sound path to be more than 5 times longer than the straight-through design. This design significantly increases the measurement accuracy. Since there is no reflector, the sensor is very robust and reliable.

§8.4 Water Density and Specific Enthalpy Tables

A1 When pressure is less or equal 1.0MPa:

Table 1 P =0.6000MPa，Temperature 1℃～150℃

Temp (℃)	Density (kg/m^3)	Enthalpy (kJ/kg)	Temp (℃)	Density (kg/m^3)	Enthalpy (kJ/kg)	Temp (℃)	Density (kg/m^3)	Enthalpy (kJ/kg)
1	1000.2	4.7841	51	987.80	214.03	101	957.86	423.76
2	1000.2	8.9963	52	987.33	218.21	102	957.14	427.97
3	1000.2	13.206	53	986.87	222.39	103	956.41	432.19
4	1000.2	17.412	54	986.39	226.57	104	955.67	436.41
5	1000.2	21.616	55	985.91	230.75	105	954.93	440.63
6	1000.2	25.818	56	985.42	234.94	106	954.19	444.85
7	1000.1	30.018	57	984.93	239.12	107	953.44	449.07
8	1000.1	34.215	58	984.43	243.30	108	952.69	453.30
9	1000.0	38.411	59	983.93	247.48	109	951.93	457.52
10	999.94	42.605	60	983.41	251.67	110	951.17	461.75
11	999.84	46.798	61	982.90	255.85	111	950.40	465.98
12	999.74	50.989	62	982.37	260.04	112	949.63	470.20
13	999.61	55.178	63	981.84	264.22	113	948.86	474.44
14	999.48	59.367	64	981.31	268.41	114	948.08	478.67
15	999.34	63.554	65	980.77	272.59	115	947.29	482.90
16	999.18	67.740	66	980.22	276.78	116	946.51	487.14
17	999.01	71.926	67	979.67	280.97	117	945.71	491.37
18	998.83	76.110	68	979.12	285.15	118	944.92	195.61
19	998.64	80.294	69	978.55	289.34	119	944.11	499.85
20	998.44	84.476	70	977.98	293.53	120	943.31	504.09
21	998.22	88.659	71	977.41	297.72	121	942.50	508.34
22	998.00	92.840	72	976.83	301.91	122	941.68	512.58
23	997.77	97.021	73	976.25	306.10	123	940.86	516.83
24	997.52	101.20	74	975.66	310.29	124	940.04	521.08
25	997.27	105.38	75	975.06	314.48	125	939.21	525.33
26	997.01	109.56	76	974.46	318.68	126	938.38	529.58
27	996.74	113.74	77	973.86	322.87	127	937.54	533.83
28	996.46	117.92	78	973.25	327.06	128	936.70	538.09
29	996.17	122.10	79	972.63	331.26	129	935.86	542.35
30	995.87	126.28	80	972.01	335.45	130	935.01	546.61
31	995.56	130.46	81	971.39	339.65	131	934.15	550.87
32	995.25	134.63	82	970.76	343.85	132	933.29	555.13
33	994.93	138.81	83	970.12	348.04	133	932.43	559.40
34	994.59	142.99	84	969.48	352.24	134	931.56	563.67
35	994.25	147.17	85	968.84	356.44	135	930.69	567.93
36	993.91	151.35	86	968.19	360.64	136	929.81	572.21
37	993.55	155.52	87	967.53	364.84	137	928.93	576.48
38	993.19	159.70	88	966.87	369.04	138	928.05	580.76

39	992.81	163.88	89	966.21	373.25	139	927.16	585.04
40	992.44	168.06	90	965.54	377.45	140	926.26	589.32
41	992.05	172.24	91	964.86	381.65	141	925.37	593.60
42	991.65	176.41	92	964.18	385.86	142	924.46	597.88
43	991.25	180.59	93	963.50	390.07	143	923.56	602.17
44	990.85	184.77	94	962.81	394.27	144	922.64	606.46
45	990.43	188.95	95	962.12	398.48	145	921.73	610.76
46	990.01	193.13	96	961.42	402.69	146	920.81	615.05
47	989.58	197.31	97	960.72	406.90	147	919.88	619.35
48	989.14	201.49	98	960.01	411.11	148	918.95	623.65
49	988.70	205.67	99	959.30	415.33	149	918.02	627.95
50	988.25	209.85	100	958.58	419.54	150	917.08	632.26

A2 When pressure is higher than 1.0MPa but less than or equal to 2.5MPa:

Table 2 When P =1.6000MPa，temperature 1℃～150℃

Temp (℃)	Density (kg/m^3)	Enthalpy (kJ/kg)	Temp (℃)	Density (kg/m^3)	Enthalpy (kJ/kg)	Temp (℃)	Density (kg/m^3)	Enthalpy (kJ/kg)
1	1000.7	5.7964	51	988.23	214.89	101	958.33	424.51
2	1000.7	10.004	52	987.77	219.07	102	957.61	428.72
3	1000.7	14.209	53	987.30	223.25	103	956.88	432.93
4	1000.7	18.411	54	986.83	227.42	104	956.15	437.15
5	1000.7	22.611	55	986.35	231.60	105	955.41	441.37
6	1000.7	26.808	56	985.86	235.78	106	954.67	445.59
7	1000.6	31.004	57	985.37	239.96	107	953.92	449.81
8	1000.6	35.197	58	984.87	244.14	108	958.17	454.03
9	1000.5	39.389	59	984.36	248.33	109	952.41	458.25
10	1000.4	43.579	60	983.85	252.51	110	951.65	462.48
11	1000.3	47.768	61	983.33	256.69	111	950.89	466.70
12	1000.2	51.956	62	982.81	260.87	112	950.12	470.93
13	1000.1	56.142	63	982.28	265.05	113	949.34	475.16
14	999.95	60.327	64	981.75	269.24	114	948.57	479.39
15	999.80	64.511	65	981.21	273.42	115	947.78	483.62
16	999.64	68.693	66	980.66	277.61	116	947.00	487.85
17	999.47	72.875	67	980.11	281.79	117	946.21	492.08
18	999.29	77.057	68	979.55	285.98	118	945.41	496.32
19	999.10	81.237	69	978.99	290.16	119	944.61	500.56
20	998.89	85.417	70	978.43	294.35	120	943.81	504.80
21	998.68	89.596	71	977.85	298.54	121	943.00	509.04
22	998.45	93.774	72	977.27	302.72	122	942.19	513.28

23	998.22	97.952	73	976.69	306.91	123	941.37	517.52
24	997.98	102.13	74	976.10	311.10	124	940.55	521.77
25	997.72	106.31	75	975.51	315.29	125	939.72	526.02
26	997.46	110.48	76	974.91	319.48	126	938.89	530.27
27	997.19	114.66	77	974.30	323.67	127	938.06	534.52
28	996.91	118.84	78	973.70	327.86	128	937.22	538.77
29	996.62	123.01	79	973.08	332.06	129	936.37	543.03
30	996.32	127.19	80	972.46	336.25	130	935.52	547.28
31	996.01	131.36	81	971.84	340.44	131	934.67	551.54
32	995.69	135.54	82	971.76	344.64	132	933.82	555.80
33	995.37	139.72	83	970.21	348.83	133	932.95	560.07
34	995.04	143.89	84	969.93	353.03	134	932.09	564.33
35	994.69	148.07	85	969.29	357.23	135	931.22	568.60
36	994.35	152.24	86	968.64	361.42	136	930.35	572.87
37	993.99	156.42	87	967.99	365.62	137	929.47	577.14
38	993.62	160.59	88	967.33	369.82	138	928.58	581.41
39	993.25	164.77	89	966.66	374.02	139	927.50	585.69
40	992.87	168.94	90	965.99	378.22	140	926.81	589.96
41	992.49	173.12	91	965.32	382.43	141	925.91	594.24
42	992.09	177.30	92	964.64	386.63	142	925.01	598.53
43	991.69	181.47	93	963.96	390.83	143	924.10	602.81
44	991.28	185.65	94	963.27	395.04	144	923.19	607.10
45	990.87	189.82	95	962.58	399.24	145	922.28	611.39
46	990.44	194.00	96	961.88	403.45	146	921.36	615.68
47	990.02	198.18	97	961.18	407.66	147	920.44	619.97
48	989.58	202.36	98	960.48	411.87	148	919.51	624.27
49	989.14	206.53	99	959.77	416.08	149	918.58	628.57
50	988.69	210.71	100	959.05	420.29	150	917.65	632.87

§8.5 Heat Meter Mounting Location

The first step in the installation process is to select an optimal location for installing the device in order to make the measurement reliable and accurate. A basic knowledge about the piping and its plumbing system would be advisable.

An optimal location would be defined as a long straight pipe line full of liquid that is to be measured; it can be in a vertical or horizontal position. Principles to select an optimal location:

(1) The straight pipe should be long enough to eliminate irregular flow induced error. Typically, the length of the straight pipe should be 5 times of the pipe diameter (5D) straight pipe run upstream and 2D straight pipe run downstream, the longer the better.

(2) Make sure that the temperature of the mounting location does not exceed the range for the heat meter. When the meter is used as cold meter, remove the meter's main box and its mounting base and install the main box on a wall or other objects where the temperature is within 0~55°C. In addition, the meter box needs to be higher than the cold pipe, so that the condensed water on the cold pipe will not flow into the meter box along the wires. If the heating system is not running in winter, always empty the pipe. Otherwise, the pipe may burst when water freezes.

(3) Select a relatively new straight pipe line if possible. Old pipe tends to have corrosions and

depositions, which could affect the results.

(4) If the flow meter is installed on the common return of two heating circuits (e.g. heating water and hot water), the mounting location must be at a sufficient distance, at least 10D, from the Tee, to ensure that the different temperatures homogenize.

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