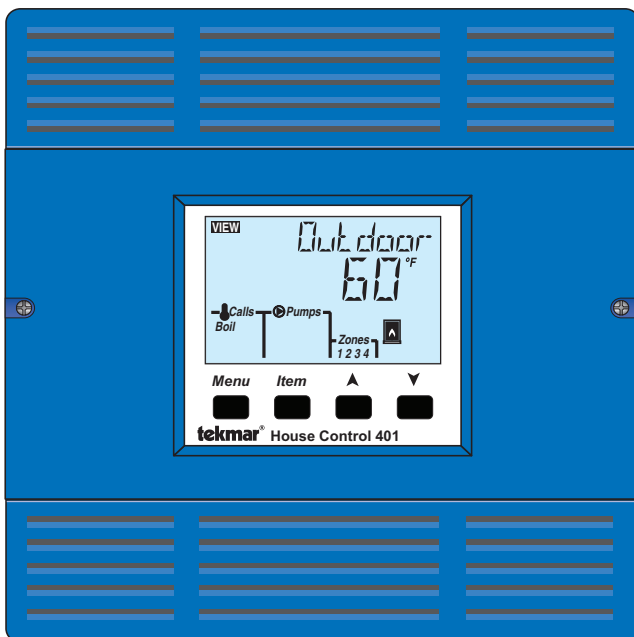


## Introduction

The House Control 401 is designed to operate as part of a complete hydronic heating system with tekmarNet®2 (tN2) thermostats. It can provide operation of a single outdoor reset water temperature, Domestic Hot Water and Setpoint capabilities. It is easy to add more zones, add schedules or other convenient accessories through the use of the tekmarNet®4 (tN4) Expansion terminals.



## Features

- Single on-off, two-stage or modulating boiler
- Boiler outdoor reset temperature
- Domestic Hot Water tank operation
- Setpoint operation
- For use with tekmarNet®2 Thermostats
- Four 115 V (ac) powered zone pump outputs
- Expand to 24 zones using tekmarNet®4 expansion ports
- CSA C US Certified for use in USA and Canada

## Benefits

- Energy efficiency through Outdoor Temperature Reset with Indoor Feedback
- Indoor Feedback minimizes the water temperature (increasing energy savings), and the efficiency of your mechanical equipment through integrated tekmarNet® Thermostats
- Zone Synchronization reduces equipment cycling
- Auto Differential - Reduces boiler cycling
- Compact enclosure for flexible installation
- Simple zone expansion using Wiring Centers

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### WARNING



It is your responsibility to ensure that this control is safely installed according to all applicable codes and standards. tekmar is not responsible for damages resulting from improper installation and/or maintenance.

### To avoid serious personal injury and damage to the equipment:



- Read Manual and all product labels BEFORE using the equipment. Do not use unless you know the safe and proper operation of this equipment.
- Keep this Manual available for easy access by all users.
- Replacement Manuals are available at [tekmarControls.com](http://tekmarControls.com)



- Disconnect all power before opening the control.

- It is the installers responsibility to ensure that this control is safely installed according to all applicable codes and standards.
- Improper installation and operation of this control could result in damage to the equipment and possibly even personal injury or death.
- This electronic control is not intended for use as a primary limit control. Other controls that are intended and certified as safety limits must be placed into the control circuit.
- Do not attempt to service the control. There are no user serviceable parts inside the control. Attempting to do so voids warranty.

## Radio Frequency Interference

The installer must ensure that this control and its wiring are isolated and/or shielded from strong sources of electromagnetic noise. Conversely, this Class B digital apparatus complies with Part 15 of the FCC Rules and meets all requirements of the Canadian Interference-Causing Equipment Regulations. However, if this control does cause harmful interference to radio or television reception, which is determined by turning the control off and on, the user is encouraged to try to

correct the interference by re-orientating or relocating the receiving antenna, relocating the receiver with respect to this control, and/or connecting the control to a different circuit from that to which the receiver is connected.

Cet appareil numérique de la classe B respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

## Installation

### Preparation

#### Tools Required

- tekmar or jeweller screwdriver
- Phillips head screwdriver
- Needle-nose Pliers
- Wire Stripper

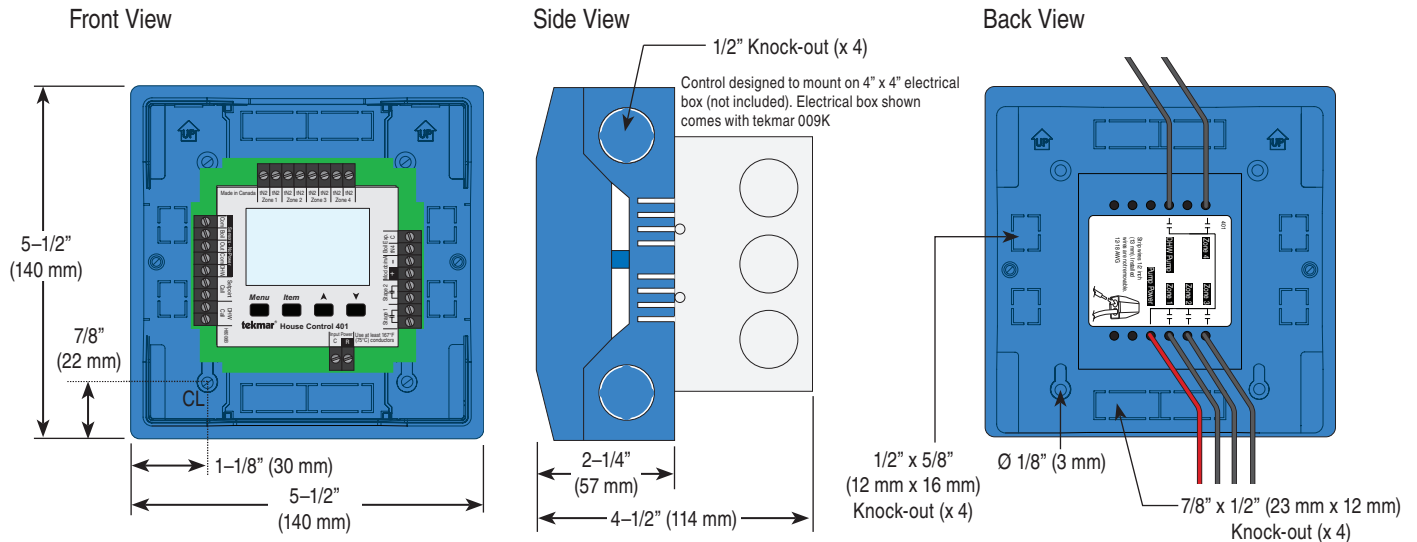
## Materials Required

- (2) #10 x 1" Wood Screws
- (3) Wire Nuts
- 18 AWG LVT Solid Wire (Low Voltage Connections)
- 14 AWG Solid Wire (Line Voltage Connections)
- tekmar 009K (24 V (ac) transformer with 4" x 4" junction box)
- Cable or Conduit Connectors

## Power Required

- 115 V (ac), 1-phase, 15 A service from circuit breaker panel
- Power disconnect (optional)

## Physical Dimensions



## Installation Location

- When choosing the location for the control, consider the following:
- Keep dry. Avoid potential leakage onto the control.  
RH ≤ 90% to 104°F (40°C).  
Non-condensing environment.
- Do not expose to operating temperatures beyond 32-104°F (0-40°C)
- Provide adequate ventilation.
- Keep away from equipment, appliances or other sources of electrical interference.
- Locate the control near the pumps if possible.
- Provide easy access for wiring, viewing and adjusting the control.
- Mount approximately 5 ft. (1.5 m) off the finished floor.
- Install the electrical junction box to a wall using #10 x 1" wood screws. Wall anchors are recommended when mounting to sheet rock wallboard or masonry.

## Rough-In Wiring

### Line Voltage Wiring

The control operates a number of pumps through wiring on the back of the control. The control must be mounted to a 4" x 4" electrical junction box so that these electrical connections are safely contained.

For ease of service, the circuit breaker or power disconnect should be located in reasonably close proximity to the equipment.

All line voltage wire connections are recommended to be pulled inside a flexible or solid conduit. Always follow proper wiring practices, building and electrical codes for your jurisdiction.

Each cable must be pulled from the equipment to the electrical junction box. It is recommended to label each cable for easy identification. All line voltage wires should be stripped to a length of 1/2" (13 mm).

**Pull a three conductor 14 AWG cable for the following equipment:**

- Circuit Breaker or Power Disconnect
- DHW Tank Pump (if applicable)
- Four Zone Pumps

## Low Voltage Wiring

Each cable must be pulled from the equipment to the control's plastic enclosure. All low voltage wiring connections enter the enclosure through conduit knockouts on the sides, or through the square knockouts on the rear. It is recommended to label each cable for easy identification. All low voltage wires are to be stripped to a length of 3/8" (9 mm) to ensure proper connection to the control.

**Pull two conductor 18 AWG LVT cable, up to 500 feet (150 m) for the following equipment:**

- tekmarNet®2 Thermostats
- Boiler Stage 1 T-T

- Boiler Stage 2 T-T (if applicable)
- Modulating Boiler 0-10 V (dc) or 4-20 mA (if applicable)
- Outdoor Temperature Sensor
- Boiler Supply Temperature Sensor
- DHW Tank Temperature Sensor (if applicable)
- DHW Tank Aquastat (if applicable)
- Setpoint Device (if applicable)

**Pull three conductor 18 AWG LVT cable for the following equipment:**

- tekmarNet®4 Accessories (User Switch, Timer)

## Sizing the Transformer

The control requires an external transformer with 20 VA capacity or greater. A tekmar Transformer 009 (or 009K which includes a 4" x 4" electrical box) can supply up to 40

VA, and includes an in-line fuse to protect the transformer and control.

## Control Wiring

### Line Voltage Wiring

**CAUTION: TURN ALL POWER OFF BEFORE PERFORMING ANY WIRING.**

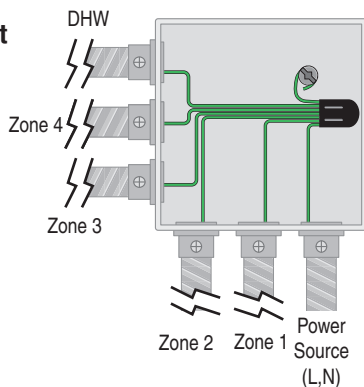
#### Ground the Pumps

- Connect the pump grounds to the power supply ground as shown in Figure 1. The ground wire must also be grounded to the electrical box.

#### Wire the Pump Neutrals

- Connect the Neutral (N) wires from each pump and wire to the 115 V (ac) Neutral (N) wire. If the transformer has been mounted to this electrical box, connect its neutral wire with this group. This is shown in Figure 2.

**Figure 1 - Connect Ground Wires**



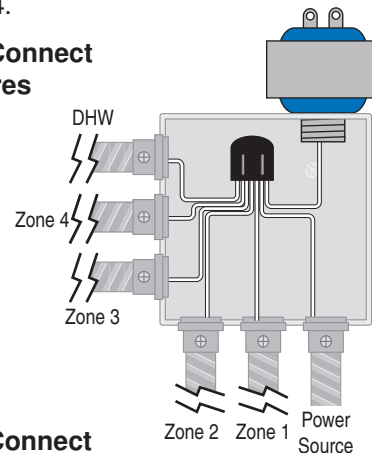
#### Wire the Pump Power (L)

- Connect the 115 V (ac) line voltage (L) wire to the red Pump Power (L) wire on the back of the House Control and to the 115 V (ac) side of the transformer. Use a wire nut or approved connector. See Figure 3.

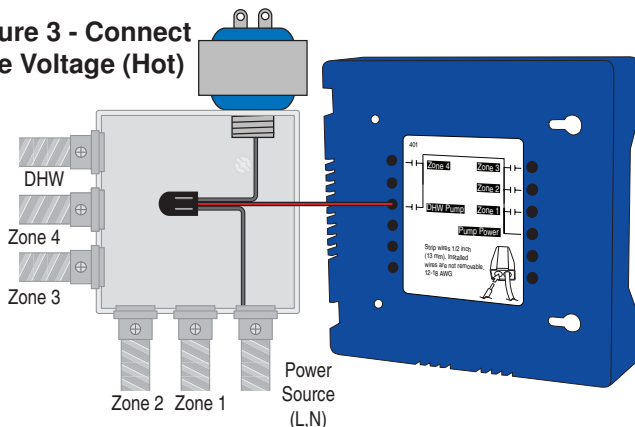
#### Wire the Pumps

- Wire each remaining line voltage pump wire into the push-in wire connector of the corresponding pump lead on the back of the House Control. This is shown in Figure 4.

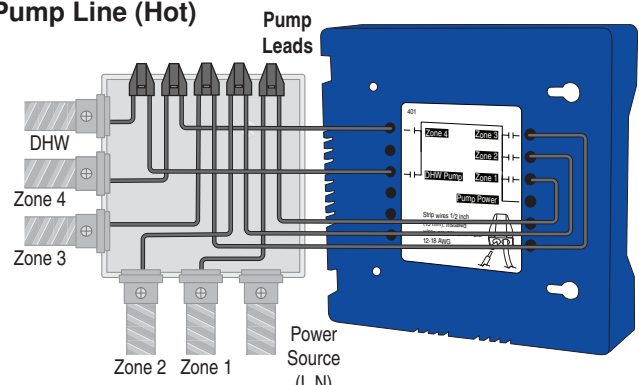
**Figure 2 - Connect Neutral Wires**



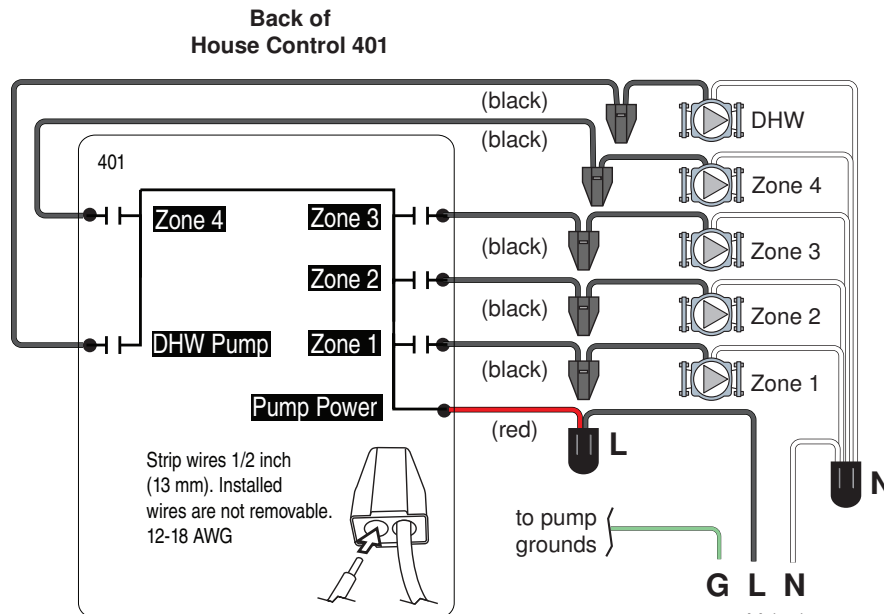
**Figure 3 - Connect Line Voltage (Hot)**



**Figure 4 - Connect Pump Line (Hot)**

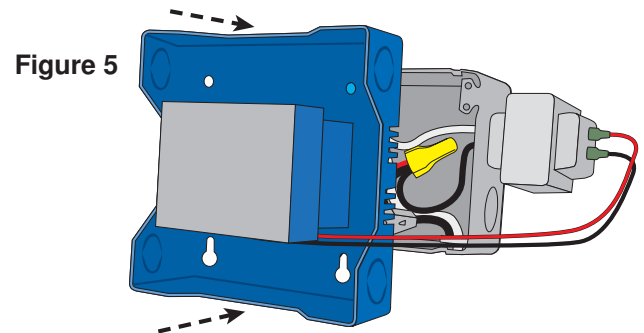


## Rear Line Voltage Wiring Diagram



## Install The Enclosure

- Ensure that the pump wires are neatly tucked inside the electrical box.
- Using 2 of the 4 holes in the back of the enclosure, securely fasten it to the electrical junction box with 2 #10 screws as shown in Figure 5.



## Low Voltage Wiring

### External Power Supply

It is strongly recommended that a transformer with an in-line fuse be used in order to protect the transformer from high currents. The tekmar Transformer 009 includes a fuse.

- Connect the 24 V (ac) leads from the transformer to the C and R terminals marked "Input Power" on the 401.

### tN2 Thermostats

The 401 is designed to operate with tekmarNet®2 Thermostats. They provide the heating and cooling control for each zone, and communicate with any other tekmarNet® device on the system.

- Connect the tN2 terminals from each thermostat to the corresponding tN2 terminals for each zone on the 401.

### tN4 Boiler Expansion Terminals

The 401 uses the Expansion tN4 and C terminals to communicate with additional thermostats, setpoint controls, wiring centers, and other tekmarNet® devices.

- Connect the tN4 and C Boil Exp. terminals on the 401 to the corresponding tN4 and C Expansion terminals of the additional external device.

### Domestic Hot Water (DHW) or Setpoint Call

When the control receives a DHW Call or Setpoint Call for heat it will override Outdoor Reset and Indoor Feedback

and operate the boiler to heat the DHW tank or the Setpoint equipment.

- To create a DHW call, wire a dry contact OR apply 24 V (ac) to the DHW call terminals.
- To create a Setpoint call, wire a dry contact OR apply 24 V (ac) to the Setpoint call terminals.

### Wiring the Boiler

The 401 can operate a single modulating boiler, single on-off, or a single two-stage on-off boiler.

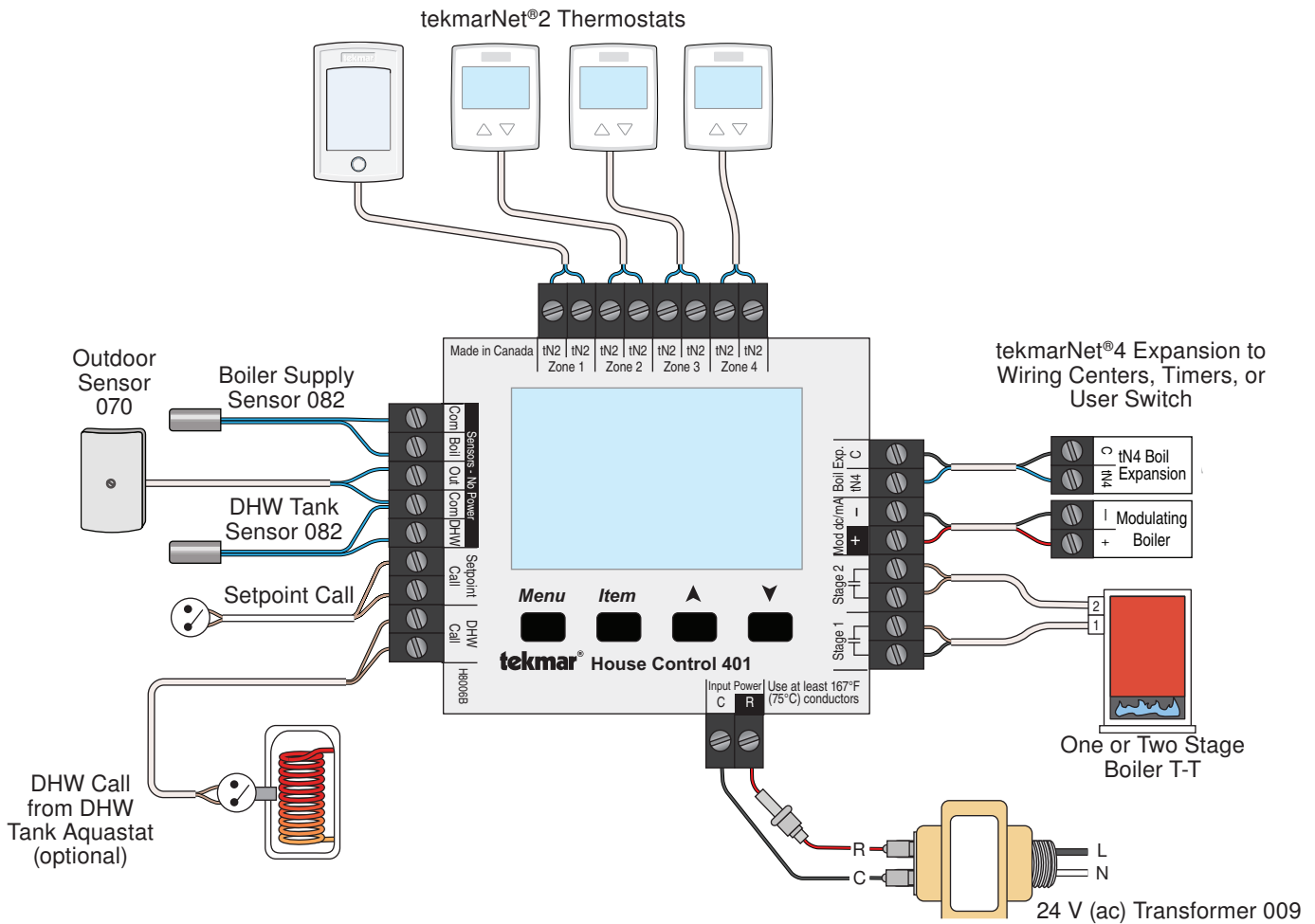
#### On/Off Boiler

- Connect the Boiler Stage 1 terminals on the 401 to the T-T (or R-W) terminals on the boiler.
- If required, connect the Boiler Stage 2 terminals on the 401 to the second stage T-T (or R-W) terminals on the boiler.

#### Modulating Boiler

- Wire the Mod (dc/mA) positive (+) and negative (-) terminals on the 401 to the input signal terminals on the boiler. Correct polarity of the wires is important.
- In some cases, the modulating boiler also requires contact closure on the T-T terminals to fire the boiler. If required, connect the Boiler Stage 1 terminals on the 401 to the T-T (or R-W) terminals on the boiler.

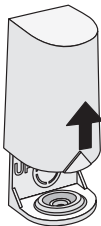
# Front Low Voltage Wiring Diagram



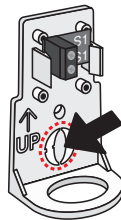
## Sensor Wiring

### Mounting the Outdoor Sensor

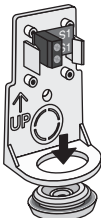
- The 070 can be mounted directly onto a wall with the wiring entering through the back or bottom of the enclosure. Do not mount the 070 with the conduit knock-out facing upwards as rain could enter the enclosure and damage the sensor.
- In order to prevent heat transmitted through the wall from affecting the sensor reading, it may be necessary to install an insulating barrier behind the enclosure.
- The 070 should be mounted on a wall which best represents the heat load on the building (a northern wall for most buildings and a southern facing wall for buildings with large south facing glass areas). The 070 should not be exposed to heat sources such as ventilation or window openings.
- The 070 should be installed at an elevation above the ground that will prevent accidental damage or tampering.



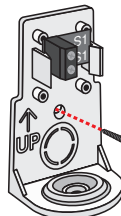
Remove cover by sliding upwards away from the base.



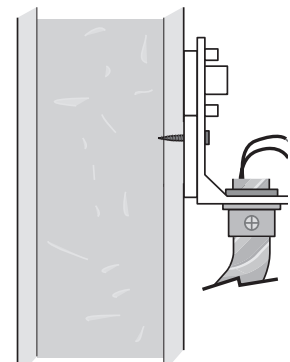
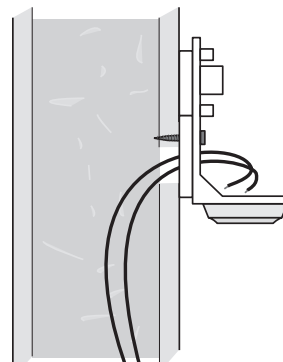
To wire from the back, remove the knock-out in the sensor base.



If using conduit, remove the flexible plug from the base bottom.

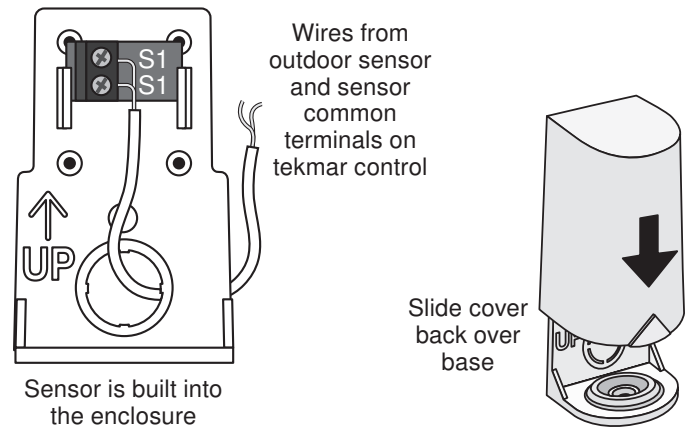


Attach the base to the wall, soffit or electrical box.



## Wiring the Outdoor Sensor

- Connect 18 AWG or similar wire to the two terminals provided in the enclosure and run the wires from the sensor to the control. Do not run the wires parallel to telephone or power cables. If the sensor wires are located in an area with strong sources of electromagnetic interference (EMI), shielded cable or twisted pair should be used or the wires can be run in a grounded metal conduit. If using shielded cable, the shield wire should be connected to the Com or Com Sen terminal on the control and not to earth ground.
- Follow the sensor testing instructions in this brochure and connect the wires to the control.
- Replace the cover of the sensor enclosure.



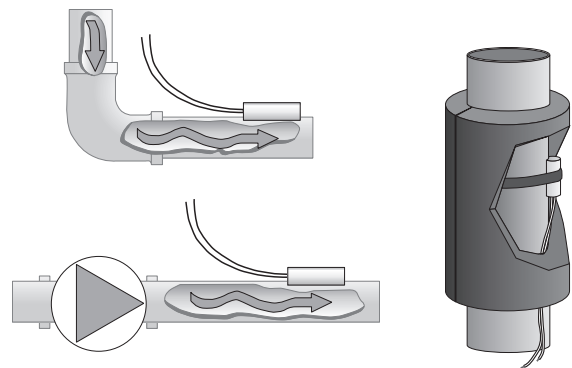
## Mounting the Universal Sensor

Note: These sensors are designed to mount on a pipe or in a temperature immersion well.

The Universal Sensor should be placed downstream of a pump or after an elbow or similar fitting. This is especially important if large diameter pipes are used as the thermal stratification within the pipe can result in erroneous sensor readings. Proper sensor location requires that the fluid is thoroughly mixed within the pipe before it reaches the sensor.

### Strapped to Pipe

The Universal Sensor can be strapped directly to the pipe using the cable tie provided. Insulation should be placed around the sensor to reduce the effect of air currents on the sensor measurement.

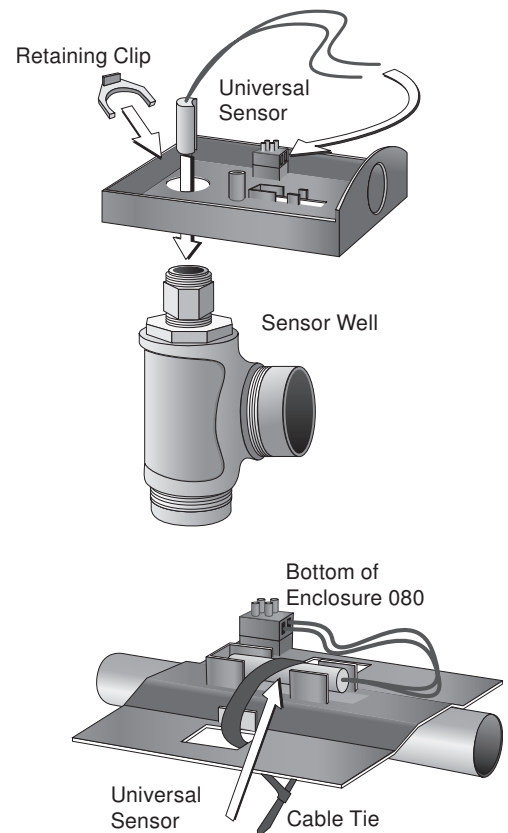


### Immersion Well

If a Universal Sensor is mounted onto 1" (25 mm) diameter L type copper pipe, there is approximately an 8 second delay between a sudden change in water temperature and the time the sensor measures the temperature change. This delay increases considerably when mild steel (black iron) pipe is used. In general, it is recommended that a temperature well be used for steel pipe of diameter greater than 1-1/4" (32 mm). Temperature wells are also recommended when large diameter pipes are used and fluid stratification is present.

### Conduit Connection

The Universal Sensor and Universal Sensor Enclosure 080 (sold separately) are specifically designed to mount onto a 3/8" (10 mm) ID temperature well that is supplied with an end groove. To install the well, plumb a 'T' into the pipe and fix the well into the 'T'. The 080 enclosure has a 7/8" (22 mm) back knockout that must be removed and fitted over the temperature well. The Universal Sensor is then inserted into the well and the retaining clip supplied with the enclosure is snapped onto the well end groove. If the well has a threaded end, the installer must supply a standard threaded conduit retaining ring. The two wires from the sensor are connected to the terminal block provided in the enclosure. The other side of the terminal block is used to connect wires from the control.



## Testing the Sensor Wiring

A good quality test meter capable of measuring up to 5,000 k $\Omega$  (1 k $\Omega$  = 1000  $\Omega$ ) is required to measure the sensor resistance. In addition to this, the actual temperature must be measured with either a good quality digital thermometer, or if a thermometer is not available, a second sensor can be placed alongside the one to be tested and the readings compared.

First measure the temperature using the thermometer and then measure the resistance of the sensor at the control. The wires from the sensor must not be connected to the control while the test is performed. Using the chart below,

Temperature		Resistance	Temperature		Resistance	Temperature		Resistance	Temperature		Resistance
$^{\circ}\text{F}$	$^{\circ}\text{C}$	$\Omega$	$^{\circ}\text{F}$	$^{\circ}\text{C}$	$\Omega$	$^{\circ}\text{F}$	$^{\circ}\text{C}$	$\Omega$	$^{\circ}\text{F}$	$^{\circ}\text{C}$	$\Omega$
-50	-46	490,813	20	-7	46,218	90	32	7,334	160	71	1,689
-45	-43	405,710	25	-4	39,913	95	35	6,532	165	74	1,538
-40	-40	336,606	30	-1	34,558	100	38	5,828	170	77	1,401
-35	-37	280,279	35	2	29,996	105	41	5,210	175	79	1,281
-30	-34	234,196	40	4	26,099	110	43	4,665	180	82	1,172
-25	-32	196,358	45	7	22,763	115	46	4,184	185	85	1,073
-20	-29	165,180	50	10	19,900	120	49	3,760	190	88	983
-15	-26	139,401	55	13	17,436	125	52	3,383	195	91	903
-10	-23	118,018	60	16	15,311	130	54	3,050	200	93	829
-5	-21	100,221	65	18	13,474	135	57	2,754	205	96	763
0	-18	85,362	70	21	11,883	140	60	2,490	210	99	703
5	-15	72,918	75	24	10,501	145	63	2,255	215	102	648
10	-12	62,465	80	27	9,299	150	66	2,045	220	104	598
15	-9	53,658	85	29	8,250	155	68	1,857	225	107	553

estimate the temperature measured by the sensor. The sensor and thermometer readings should be close. If the test meter reads a very high resistance, there may be a broken wire, a poor wiring connection or a defective sensor. If the resistance is very low, the wiring may be shorted, there may be moisture in the sensor or the sensor may be defective. To test for a defective sensor, measure the resistance directly at the sensor location.

**Do not apply voltage to a sensor at any time as damage to the sensor may result.**

## Testing the Control Wiring

### Testing the Power

If the control display does not turn on, check the Input Power wiring terminals using an electrical multimeter. The voltage should measure between 21.6 to 26.4 V (ac). If the voltage is below this range, measure the line voltage side of the transformer. The voltage should measure between 103.5 to 126.5 V (ac).

### Testing the Thermostats

If the thermostat display turns on, this indicates that the thermostat is operating correctly and there are no electrical issues. In the event that the display is off, or the display is cycling on and off, follow this procedure.

1. Remove the tN2 wires from the thermostat.
2. Use an electrical meter to measure DC voltage between the tN2 terminals.

If the DC voltage is 0 V (dc) for 20 seconds, then there is an open or short circuit in the tN2 wires. If the DC voltage is 0 V (dc) for 10 seconds and then is 23 to 24 V (dc) for 5 seconds, this indicates the wiring is correct.

3. Connect the thermostat to the tN2 wires from a zone on a House Control, Wiring Center, or Zone Manager.
4. If the thermostat display is off, or is cycling on and off, move the thermostat to the next available zone on the House Control, Wiring Center, or Zone Manager.

If the thermostat display remains permanently on, there may be a fault with the previously tried zone on the House Control, Wiring Center, or Zone Manager.

If the thermostat display continues to be off, or is cycling on and off, there may be a fault on the thermostat. If a fault is suspected, contact your tekmar sales representative for assistance.

### User Test

The User Test is found in the Toolbox menu of the control. Press the Menu button to access the Toolbox Menu. Press the Item button to locate the User Test.

Start the test sequence by going to the User Test item and pressing the 'Up' arrow button.

Pause the test sequence by pressing the Item button. To advance to the next step, press the Item button again.

If the test sequence is paused for more than five minutes, the control exits the entire test routine and returns to normal operation.

To advance to a particular step, repeatedly press and release the Item button to display the appropriate device.

### User Test Sequence

- Step 1 Zone 1 turns on for 10 seconds.
- Step 2 Zone 2 turns on for 10 seconds.
- Step 3 Zone 3 turns on for 10 seconds.
- Step 4 Zone 4 turns on for 10 seconds.
- Step 5 The DHW pump turns on for 10 seconds.
- Step 6 During the boiler test step, zone relays 1 through 4 turn on.



- If the Boil Type is 1 Stage, the boiler stage 1 relay is closed for 10 seconds and then opened.
- If the Boil Type is 2 Stage, the boiler stage 1 relay is closed for 10 seconds, then the boiler stage 2 relay is closed for 10 seconds and then both relays are opened.
- If Boiler Type is modulating 0 - 10, the boiler stage 1 relay is closed for 10 seconds and the modulating output operates at 50 % [5 V (dc)].
- If Boiler Type is modulating 4 - 20, the boiler stage 1 relay is closed for 10 seconds and the modulating output operates at 50 % (12 mA).

Step 7 Control returns to normal operation.

### Testing the Zone Output

Activate the User Test sequence and pause at Step 1 by pressing the Item button once Zone 1 turns on. Using an electrical meter, measure the voltage between the zone 1 pump and terminals. The voltage should measure between 103.5 V (ac) and 126.5 V (ac). Repeat for Zones 2, 3, and 4.

### Testing the DHW Pump

Activate the User Test sequence and pause at Step 5 by pressing the Item button once the DHW pump turns on. Using an electrical meter, measure the voltage between the DHW pump and a neutral. The voltage should measure between 103.5 V (ac) and 126.5 V (ac).

### Testing the Boiler Stage 1 Contact

Activate the User Test sequence and pause at Step 6 by pressing the Item button once the boiler stage 1 turns on. Using an electrical meter, measure for continuity over the boiler stage 1 terminals.

### Testing the Boiler Stage 2 Contact

This test applies for 2 stage on-off boilers only.

Activate the User Test sequence and pause at Step 6 by pressing the Item button once the boiler stage 2 turns on. Using an electrical meter, measure for continuity over the boiler stage 2 terminals.

### Testing the Boiler Modulating Output

This test applies for modulating boilers only.

Active the User Test sequence and pause at Step 6 by pressing the Item button once the boiler stage 1 turns on. Using an electrical meter, measure for either a 5 V (dc) or 12 mA signal. The Boil Type setting selects whether the signal is V (dc) or mA.

### Testing the DHW Call

Remove all wires from the DHW Call terminals. The control display should show no DHW Call. Reconnect wires. Then apply either a short circuit or 24 V (ac) over the DHW Call terminals. The control should now show a DHW Call.

### Testing the Setpoint Call

Remove all wires from the Setpoint Call terminals. The control display should show no Setpoint Call. Reconnect wires. Then apply either a short circuit or 24 V (ac) over the Setpoint Call terminals. The control should now show a Setpoint Call.

## Max Heat

The control has a function called Max Heat. In this mode, the control turns on and operates the system up to the maximum set temperatures as long as there is a call for heat. Use this mode to run the circulators during system start-up and commissioning, and purging air from the piping. This function is useful when drying sheet rock and paint in the building.

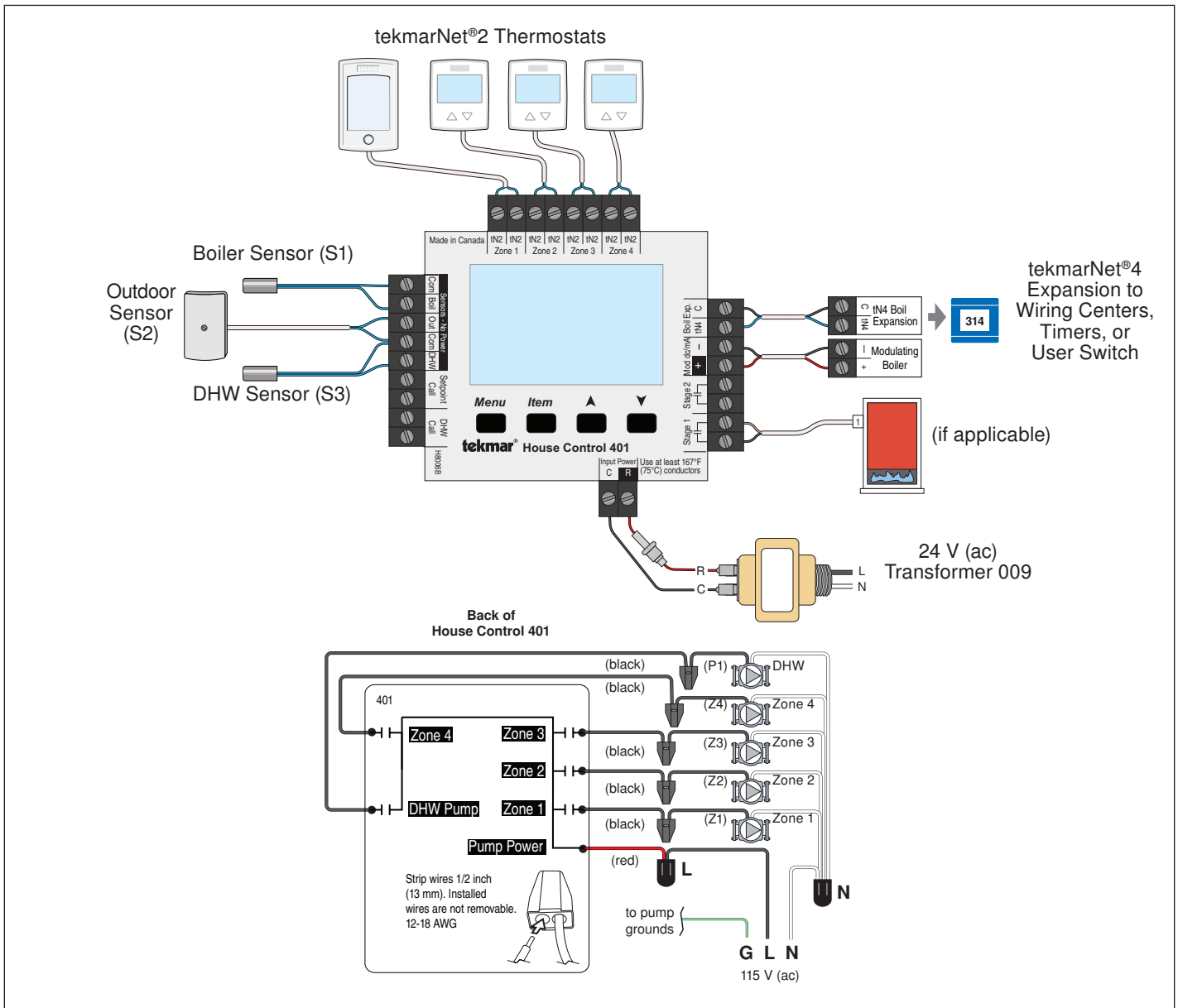
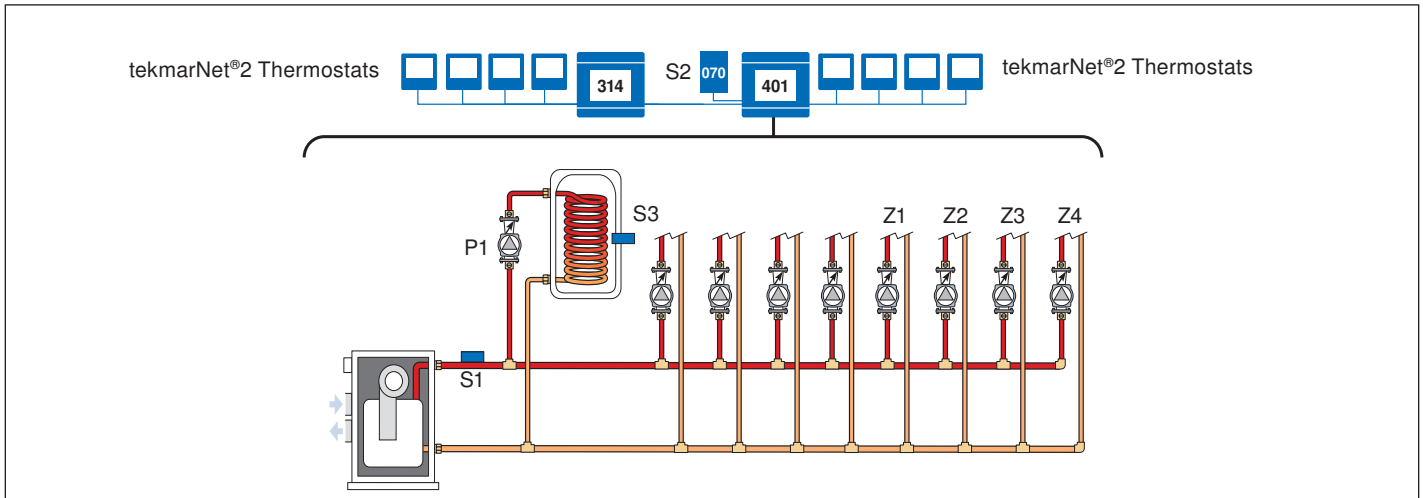
To enable Max Heat, enter the Toolbox Menu and find Max Heat. Use the up arrow to select 'On'.

- When a space heating call is present, the boiler will run to maintain a target of Boil Design + 10°F (+ 6°C). (One can purge the system using this test and leave the boiler un-powered. This will prevent heat from entering the system during the purge.)

- When a DHW Call or Setpoint Call is present, the boiler will operate at the DHW exchange or Setpoint temperature settings.
  - WWSD and DHW Priority is disabled during Max Heat mode.
  - When Max Heat is on the display will show 'Max Heat Test'.
  - Max Heat will automatically turn off after 24 hours.
- To Cancel Max Heat, go to Max Heat in the Toolbox menu and use the down arrow to select 'Off'.

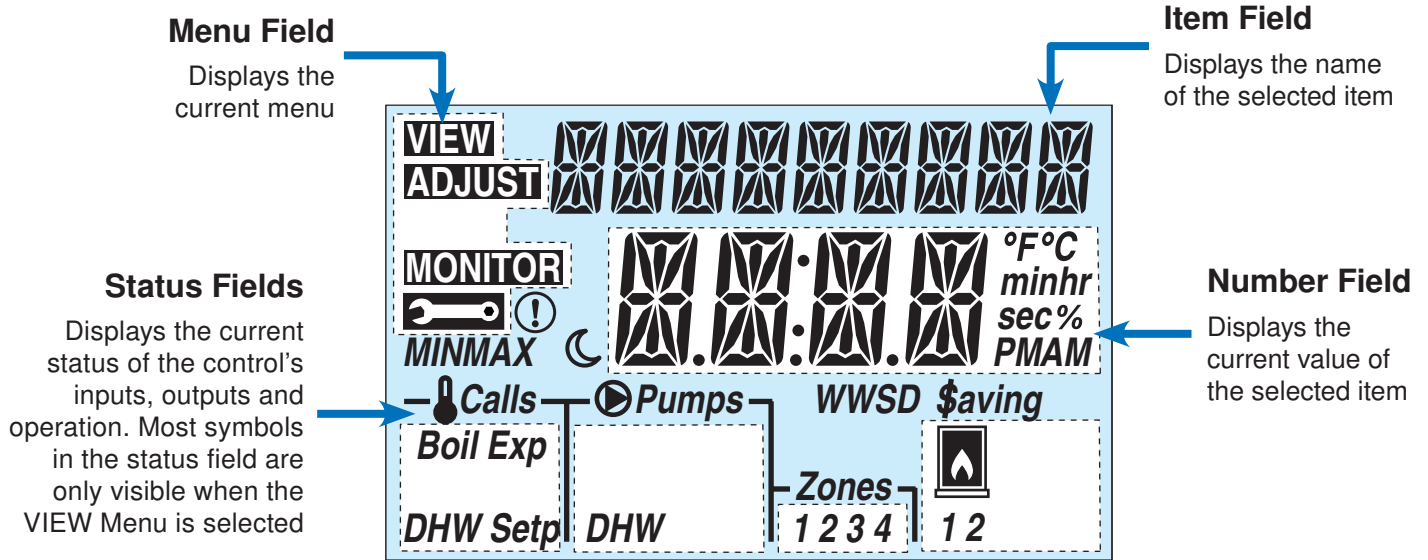


**Description:** The House Control 401 operates a modulating boiler, and indirect Domestic Hot Water tank and four onboard hydronic zones. The boiler is operated using Outdoor Reset with Indoor Feedback. Four additional boiler water temperature zones shown are operated by a Wiring Center through the tN4 Boil Expansion terminals.








# User Interface

## Display



## Symbols

 <b>Calls</b>	<b>CALLS</b> Displays any call for heat the control is receiving.	<b>WWS</b>	<b>WWS</b> Displays when the system is in Warm Weather Shut Down.
 <b>Pumps</b>	<b>PUMPS</b> Displays any pump currently operating.	<b>°F°C</b> <b>minhr</b> <b>sec%</b>	<b>°F, °C, %, HOURS, MINUTES, SECOND</b> Units of measurement for current number.
<b>Zones</b> <b>1 2 3 4</b>	<b>ZONES</b> Displays if an on-board zone is operating.		<b>UNOCCUPIED</b> Indicates that a User Switch or Timer has put the system into UnOccupied.
	<b>WARNING</b> Displays if an error exists on the system.		<b>BOILER</b> Indicates that the boiler should be heating.
<b>\$aving</b>	<b>ENERGY SAVING INDICATOR</b> Displays when the system is saving energy. See Energy Saving Features section.	<b>MINMAX</b>	<b>MIN / MAX</b> Displays when an operating temperature reaches a minimum or maximum value.

## Navigating The Display

The 401 uses a simple user interface to accomplish a variety of functions. The four buttons beneath the display

are used to change the menu, sort through Items, and adjust each setting as required.

### Menu Button

The menus display in the Menu Field at the top left side of the LCD. Four menus are available: View, Adjust, Monitor and Toolbox (identified by the wrench symbol).

- The View menu allows the user to view the current status of various system parameters.
- The Adjust menu allows the installer to adjust settings to ensure control operation matches requirements of the mechanical system.

- The Monitor menu keeps track of run times and other important data that is collected during system operation.
- The Toolbox menu is a source of system information and includes useful tools for commissioning and testing the system.

### Item Button

Each menu contains a list of Items that can be viewed and, in some cases, adjusted. Press the item button to scroll through the list in each Menu.

- To view the next available item, press and release the Item button.
- To view the previous item, hold down the Item button, and press and release the Up button.

### Up and Down Buttons

The Up and Down buttons are primarily used for adjusting settings.

To adjust a setting:

- Select the appropriate menu using the Menu button.
- Select the item using the Item button.
- Use the Up or Down button to make the adjustment.

### Default Item

When navigating menus, the display reverts back to the default item (View Menu) after 60 seconds of button inactivity.

- To set the default item in the View menu, display the item for more than five seconds.

## Access Levels and Thermostat Lock

The 401 is shipped pre-programmed with common settings. The 401 has an 'Installer' access level that allows full access to all settings and a 'User' access level that restricts the number of settings to only the Warm Weather Shut Down and the temperature units. The 401 defaults to the 'User' access level after 12 hours of operation.

All thermostats are locked while the 401 is in the 'User' access level. Certain settings on the thermostat will be unavailable while the thermostat is locked.

To change to the 'Installer' access level and Unlock the thermostats:

- In the Toolbox menu, locate Access
- Adjust the access level to 'Installer' by pressing the up or down button. This will permit setting changes to the control.

## Programming and Settings

The 401 settings can be found in the 'Adjust' menu. When changing the item's value, the setting is saved to the control's memory once the Item button is pressed to advance to the next item, or after 60 seconds, the control times out and reverts back to the 'View' menu.

All settings are stored in permanent memory and will be kept correctly during any loss of power.

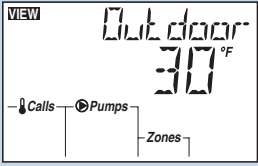
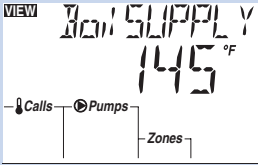
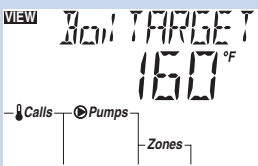
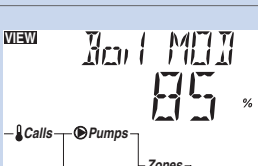
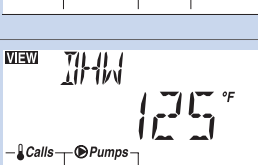
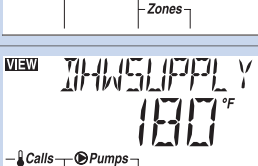
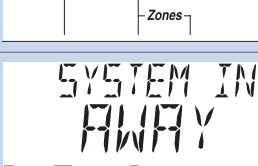
## View Menu (1 of 1)

Menu

Item

The View menu items display the current operating temperatures and status information of the system.

VIEW MENU

Item Field	Range	Description
	-76 to 149 °F (-60.0 to 65.0 °C)	<b>OUTDOOR</b> <span style="float: right;"><a href="#">SECTION B</a></span> Current outdoor air temperature as measured by the outdoor sensor. The outdoor air temperature is shared to all thermostats in the tekmarNet® system.
	-22 to 266 °F (-30.0 to 130.0 °C)	<b>BOILER SUPPLY</b> <span style="float: right;"><a href="#">SECTION B</a></span> Current boiler supply water temperature as measured by the boiler sensor. The control operates the boiler so that the boiler supply is within the boiler differential of the boiler target. 'MIN' is shown when the control is providing boiler minimum protection to the boiler.
	---, 35 to 200 °F (1.5 to 93.0 °C)	<b>BOILER TARGET</b> <span style="float: right;"><a href="#">SECTION B</a></span> The boiler target is the temperature the control is currently trying to maintain at the boiler supply sensor. The boiler target is calculated based on the outdoor design, boiler design, and boiler minimum settings. "---" is displayed when no heat is required. 'MIN' is shown when the control is providing boiler minimum protection to the boiler.
	0-100%	<b>BOILER MODULATION</b> <span style="float: right;"><a href="#">SECTION E</a></span> Current percent modulation of the boiler's burner. The boiler modulation increases when the boiler supply is less than the boiler target. The boiler modulation decreases when the boiler supply is greater than the boiler target. <b>Note:</b> This item is only available when the Boil Type setting is set to 0-10 or 4-20.
	-22 to 266 °F (-30.0 to 130.0 °C)	<b>DHW TANK</b> <span style="float: right;"><a href="#">SECTION C</a></span> Current Domestic Hot Water tank temperature as measured by the optional DHW sensor. If the DHW tank temperature falls 6°F (3.0°C) below the DHW Occ setting, a DHW call is created and the tank is heated. <b>Note:</b> This item is only available when a DHW sensor is installed and DHW Mode is set to 1 or 2.
	-22 to 266 °F (-30.0 to 130.0 °C)	<b>DHW SUPPLY</b> <span style="float: right;"><a href="#">SECTION C</a></span> Current supply water temperature to the indirect DHW tank heat exchanger as measured by the DHW sensor. <b>Note:</b> This item is only available when a DHW sensor is installed and DHW Mode is set to 5.
	--	<b>SYSTEM IN AWAY</b> <span style="float: right;"><a href="#">SECTION G</a></span> The heating system is in the Away scene. The DHW tank will not be heated. Setpoint calls are still responded to. Use the User Switch to change scene out of Away.

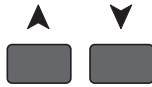
After the last item, the control returns to the first item in the menu.

## Adjust Menu (1 of 2)

Menu



Item



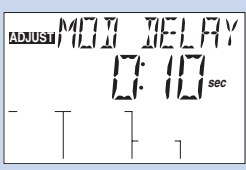
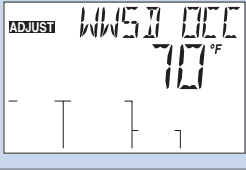
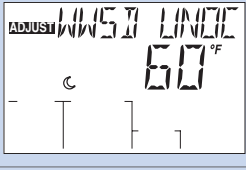
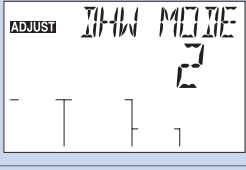
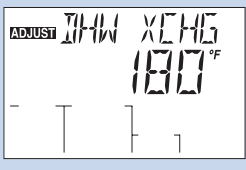
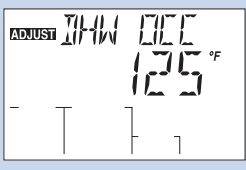
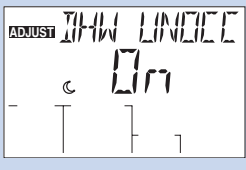
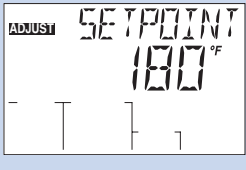
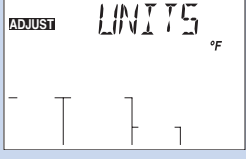
The Adjust menu items are the programmable settings used to operate the mechanical equipment.

ADJUST MENU

Item Field	Range	Access	Description	Set to
	-60 to 45°F (-51.0 to 7.0°C) Default = 10°F (-12.0°C)	Installer	<b>OUTDOOR DESIGN</b> <i>SECTION B</i> Typically set to the temperature of the coldest day of the year. The outdoor air temperature is used by the boiler heating curve to determine the boiler target temperature.	
	EMS2, EMS1, 4-20 0-10, 2STG, 1STG Default = 1STG	Installer	<b>BOILER TYPE</b> <i>SECTION E</i> The type of boiler connected to the control. 1STG = single one-stage on-off boiler 2STG = single two-stage on-off boiler 0-10 = 0-10 V (dc) modulating boiler 4-20 = 4-20 mA modulating boiler EMS1 = tekmar boiler staging controls EMS2 = Viessmann modulating boilers with OpenTherm	
	70 to 200°F (21.0 to 93.5°C) Default = 180°F (82.0°C)	Installer	<b>BOILER DESIGN</b> <i>SECTION B</i> The supply water temperature required for the boiler zones to heat the building on the typical coldest day of the year. Recommendations: High mass radiant floor = 120°F (50°C) Low mass radiant floor = 140°F (60°C) Fancoil or air handling unit = 190°F (90°C) Copper fin-tube convactor = 180°F (80°C) Radiators = 160°F (70°C) Low profile baseboard = 150°F (65°C)	
	OFF, 80 to 180°F (26.5 to 82.0°C) Default = 140°F (60.0°C)	Installer	<b>BOILER MINIMUM</b> <i>SECTION B</i> The minimum allowed boiler target temperature. Recommendations: Condensing gas or electric boiler = OFF Non-condensing gas and oil boilers = 140°F (60°C) <b>Note:</b> If Boiler Type is 0-10 V (dc), 4-20 mA, EMS1 or EMS2, this setting is defaulted to Off.	
	10 to 230 seconds Default = 30 seconds	Installer	<b>BOILER MOTOR</b> <i>SECTION E</i> The time required for the modulating actuating motor to fully open the gas valve or ramp the burner fan from off to full speed on a modulating boiler. Set to 30 seconds unless otherwise recommended by the boiler manufacturer. <b>Note:</b> This item is only available when the Boiler Type is 0-10 V (dc) or 4-20 mA.	
	0 to 50% Default = 0%	Installer	<b>MINIMUM MODULATION</b> <i>SECTION E</i> The minimum percent modulation of the boiler burner. <b>Note:</b> This item is only available when the Boiler Type is 0-10 V (dc) or 4-20 mA.	

Continued on next page.

## Adjust Menu (2 of 2)

Item Field	Range	Access	Description	Set to
	0 to 3:00 minutes Default = 10 seconds	Installer	<b>MODULATION DELAY</b> <a href="#">SECTION E</a> Delay time between the burner firing and the boiler releasing to modulation. <b>Note:</b> This item is only available when the Boiler Type is 0-10 V (dc) or 4-20 mA.	
	40 to 100°F (4.5 to 38.0°C) Default = 70°F (21.0°C)	Installer User	<b>WWSO OCCUPIED</b> <a href="#">SECTION G</a> The system's Warm Weather Shut Down temperature during Occupied periods or when a schedule is not used.	
	40 to 100°F (4.5 to 38.0°C) Default = 60°F (15.5°C)	Installer	<b>WWSO UNOCCUPIED</b> <a href="#">SECTION G</a> The system's Warm Weather Shut Down temperature during Unoccupied periods. <b>Note:</b> Item is only available when a schedule or User Switch is present on the system.	
	Off, 1, 2, 5 Default = 2	Installer	<b>DHW MODE</b> <a href="#">SECTION C</a> Selects the DHW mode of operation. The mode determines the zone pumps operation whenever the DHW pump is in operation. Note: DHW Mode 3 and 4 are not available.	
	100 to 200°F (38.0 to 93.5°C) Default = 180°F (82°C)	Installer	<b>DHW EXCHANGE</b> <a href="#">SECTION C</a> Selects the minimum boiler target to the DHW heat exchanger. <b>Note:</b> Item is only available when DHW Mode is set to 1 or 2 when a DHW sensor is not connected. It is available in DHW Mode 5 when a DHW sensor is connected.	
	70 to 180°F (21.0 to 82.0°C) Default = 125°F (51.5°C)	Installer	<b>DHW OCCUPIED</b> <a href="#">SECTION C</a> Selects the temperature of the indirect DHW tank. <b>Note:</b> Item is only available when an optional DHW sensor is installed and the DHW Mode is 1 or 2.	
	Off or On Default = On	Installer	<b>DHW UNOCCUPIED</b> <a href="#">SECTION G</a> Selects whether or not the indirect DHW tank should be heated to during Unoccupied time periods. <b>Note:</b> Item is only available when Schedule #1 is available or a User Switch is present on the system.	
	60 to 200°F (15.5 to 93.5°C) Default = 180°F (82.0°C)	Installer	<b>SETPOINT</b> <a href="#">SECTION D</a> The minimum boiler target temperature when a Setpoint Call is present.	
	°F or °C Default = °F	Installer User	<b>UNITS</b> Selects units for temperature display.	

ADJUST MENU

After the last item, the control returns to the first item in the menu.



## Monitor Menu (1 of 1)

Menu



Item



The Monitor menu items provide information about the system's operation and performance. To clear any item back to default, press and hold the Up and Down buttons while viewing that item.

MONITOR MENU

Item Field	Range	Description
	-76 to 149°F (-60.0 to 65.0°C)	<b>OUTDOOR HIGH</b> Records the highest outdoor temperature since the item was last cleared. Press and hold the Up and Down buttons while viewing to reset.
	-76 to 149°F (-60.0 to 65.0°C)	<b>OUTDOOR LOW</b> Records the lowest outdoor temperature since the item was last cleared. Press and hold the Up and Down buttons while viewing to reset.
	0 to 9999 Hours Default = 0 hr	<b>RUN TIME (BOILER)</b> The total 'on' time of the boiler relay since the item was last cleared. Press and hold the Up and Down buttons while viewing to reset.
	0 to 9999 Hours Default = 0 hr	<b>RUN TIME (DHW PUMP)</b> The total running time of the DHW Pump since this item was last cleared. Press and hold the Up and Down buttons while viewing to reset.
	0 to 9999 Hours Default = 0 hr	<b>RUN TIME (\$AVING)</b> Maintains a record of the total length of time the \$aving icon has been active. Press and hold the Up and Down buttons while viewing to reset.
	0 to 9999 Hours Default = 0 hr	<b>BOILER ENERGY USE</b> Multiply this value by the BTU rating (input BTU/hr) of the boiler to get an approximate energy consumption (in BTU's) for the boiler. Press and hold the Up and Down buttons while viewing to reset. Not available when Boiler Type is EMS1 or EMS2.

- After the last item, the control returns to the first item in the menu.

## Toolbox Menu (1 of 1)

Menu

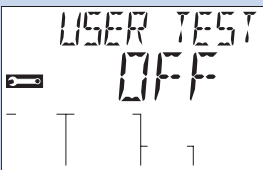
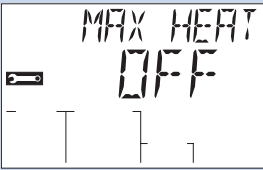
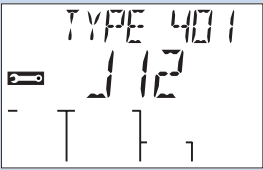
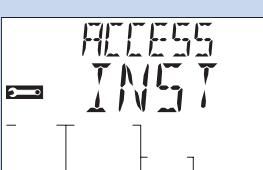

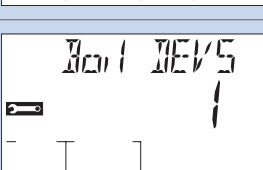
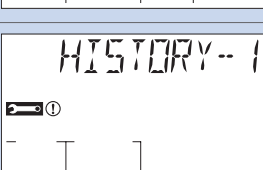


Item



The Toolbox Menu is a location for system information and Test functions. If any errors are present on the system, they will be located at the beginning of this menu.

TOOLBOX MENU

Item Field	Range	Description
	On or Off Default = Off	<b>USER TEST</b> <span style="float: right;"><i>TESTING</i></span> Begins the test routine which tests the main control's functions. See the Testing the Control section for more details. Use the up button to turn the User Test On.
	On or Off Default = Off	<b>MAX HEAT</b> <span style="float: right;"><i>TESTING</i></span> When selected, control operates the system up to maximum set temperatures. Will operate up to 24 hours, or can be manually turned Off. See Max Heat in the Testing the Control section for more details.
	401 J12 05C	<b>TYPE AND SOFTWARE VERSION</b> Displays the type number of the product, followed by the current software version beneath.
	INST (Installer) or USER Default = INST	<b>ACCESS LEVEL</b> Selects the Access Level of the control, which determines the Menu items available. USER provides the most limited level of access and shows the fewest possible items. When set to USER, all thermostats are locked and the number of thermostat settings available are reduced.
	OFF, SEL Default = Off	<b>FACTORY DEFAULTS</b> Loads the factory default settings. Hold the Up and Down buttons for 1 second until SEL is shown.
	0 to 24 devices	<b>BOIL DEVICES</b> Displays the number of devices on the Boiler bus (Water Temperature). This is made up of thermostats connected to the House Control and Boil Expansion terminals.
	See Troubleshooting Guide	<b>HISTORY - 1 THROUGH 5</b> Displays a history of any past errors that have occurred on the system. Will clear after 30 days, or press Up and Down buttons for 1 second to manually clear. The last 5 history items will display if present.

• After the last item, the control returns to the first item in the menu.

# Sequence of Operation

## tekmarNet® System

## Section A

tekmarNet® is a family of products that use communication to operate the HVAC system in a comfortable and efficient manner. The House Control is the central component in a tekmarNet® system and requires tekmarNet®2 (tN2) Thermostats to be directly connected to the control.

The tekmarNet®4 (tN4) Expansion terminals can link the House Control with other tekmarNet® components:

- Wiring Centers 313, 314, 315, 316 - Add additional zones
- tN2 and tN4 Thermostats - Add thermostats
- tN4 Timer 033 - Adds 4 programmable schedules
- tN4 User Switch 479 - Provides a system override for vacations and holidays
- tN4 Setpoint Control 161 - Control hot tubs, pools and more

## Boiler Temperature Reset Operation

## Section B

### Boiler Call

When a device connected to the House Control calls for heat, the House Control registers a Boil call for hydronic heating on the boiler loop.

When a device connected to the tN4 Boil Expansion terminals calls for heat, the House Control registers a Boil Expansion call for hydronic heating on the boiler loop.



### Boiler Target

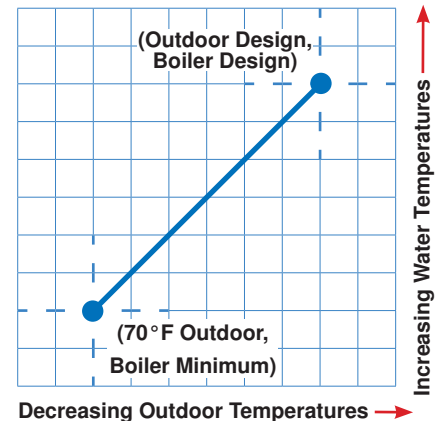
When there are no Boiler calls, the boiler target in the View menu on the display will show '— —' to indicate there is no requirement for boiler operation.

Once a Boiler Call is present, a boiler target is determined by the control using the boiler heating curve (boiler minimum, boiler design and outdoor design settings) together with indoor temperature feedback from the thermostats. The heating curve operates based on the principle that a buildings heat loss increases with colder outdoor temperatures. The calculated Boiler Target will be shown in the View menu on the display.

### Boiler Minimum

The House Control protects non-condensing boilers from sustained flue gas condensation through the Boiler Minimum setting. The boiler minimum is the lowest temperature that the control is allowed to use as a boiler target temperature. If the boiler is operating at the boiler minimum temperature, the "MIN" segment is turned on in the display when viewing either the boiler supply temperature or the boiler target temperature.

Boiler Heating Curve



### Boiler Maximum

The control has a fixed boiler maximum temperature of +10°F (+5.5°C) higher than the Boiler Design setting for the Boiler Heating Curve. When this occurs, the "MAX" segment will display when viewing the boiler target or boiler supply temperature in the view menu. The control will operate the boiler so that the boiler supply temperature will never exceed 210°F (99.0°C).

**DHW Call**

A DHW Call is required in order for the control to provide heat to a DHW tank. Once the control registers a DHW Call, it will display the “DHW” icon under Calls in the display. This can be done in three ways:

**DHW Tank Aquastat**

- If a DHW aquastat (mechanical switch) is used to apply a DHW Call, the tank is heated to the aquastat temperature setting. A dry contact or 24 V (ac) signal is applied across the DHW Call terminals on the House Control.

**DHW Tank Sensor**

- A DHW tank sensor provides superior temperature control of the tank compared to an aquastat. The House Control automatically detects whether a DHW sensor is installed. The upper limit of the DHW temperature is set by the DHW setting. The DHW tank differential is fixed to 6°F (3°C).

**DHW - Boiler Target**

When a DHW Call is present, a boiler target is determined.

- When using a DHW Tank Aquastat, the boiler target is set to the DHW Exchange setting.
- When using a DHW Tank Sensor, the boiler target is set to the DHW Occupied setting plus 40°F (22°C).

**DHW Mode**

The control has three different settings available for DHW Mode that affect pump operation. The required DHW Mode setting will depend on the piping arrangement of the DHW tank and whether or not priority for the DHW tank is necessary. DHW Priority stops or limits the delivery of heat to the building heating system while the DHW tank calls for heat. This allows for quick DHW tank temperature recovery.

**DHW MODE 1 - DHW in Parallel no Priority**

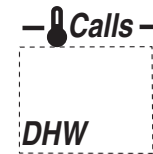
When a DHW Call is present, the DHW pump is activated. The zone pumps may operate if there is a Boiler call.

It is assumed that the DHW pump will provide adequate flow through the heat exchanger and the boiler.

**DHW MODE 2 - DHW in Parallel with Priority**

When a DHW Call is present, the DHW pump is activated. All boiler temperature zone pumps are shut off through tekmarNet® communication to achieve DHW priority.

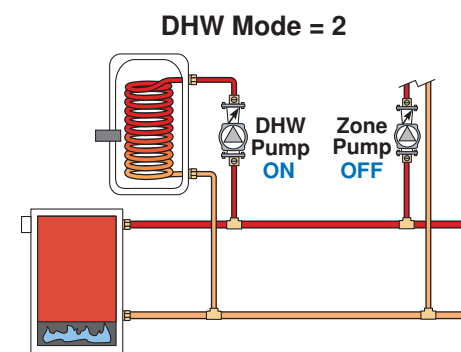
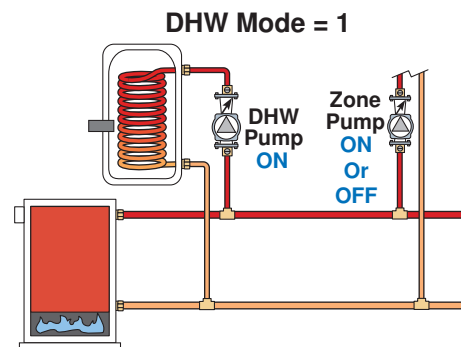
It is assumed that the DHW pump will provide adequate flow through the heat exchanger and the boiler.



**tekmarNet® Setpoint Control with Sensor**

- A DHW Call is provided through the tekmarNet® system. This can be done through the Boil Expansion tN4 terminals with a tekmarNet® setpoint device such as a Setpoint Control 161.

- When using a tekmarNet® Setpoint Control, the boiler target is set to the devices Exchange Supply setting. If there are multiple devices calling for heat, the boiler target is set to the highest temperature requirement.

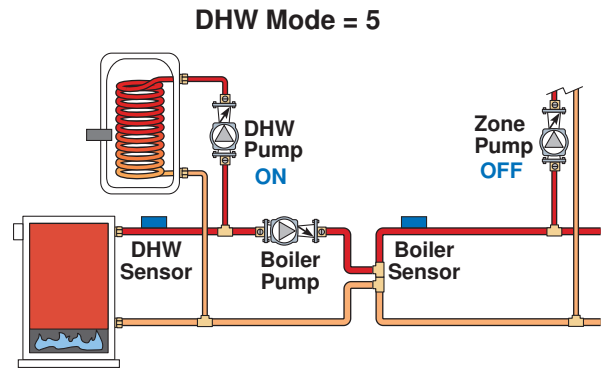


## DHW Mode 5 - DHW in Near Boiler Piping with Priority

DHW Mode 5 requires that a DHW sensor be located on the boiler outlet pipe and a DHW call from an aquastat inside the DHW tank. The aquastat operates the DHW tank temperature while the DHW sensor is used to control the boiler temperature delivered to the DHW indirect heat exchanger.

When a DHW Call is present, the DHW pump is activated. All boiler temperature zones are shut off through tekmarNet® communication to achieve DHW priority.

It is assumed that the DHW pump will provide adequate flow through the heat exchanger and the boiler.



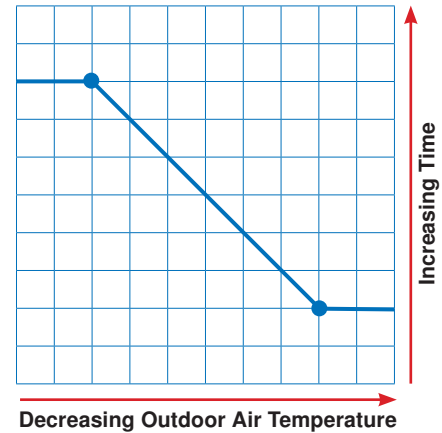
## DHW Priority Override

To prevent the building from cooling off too much or the possibility of a potential freeze up during DHW priority, the control limits the amount of time for DHW priority during cold weather. During warm weather the DHW priority is 120 minutes. During cold weather the DHW priority is 15 minutes. Once the allowed time for priority has elapsed, the control overrides the DHW priority and resumes space heating for 15 minutes. It will then revert back to DHW Priority and repeat.

## DHW Post Purge

After the DHW Call is removed, the control performs a purge on the boiler. The control shuts off the boiler and continues to operate the DHW pump. This purges the residual heat from the boiler into the DHW tank. The control continues this purge for a maximum of two minutes. The control also stops the purge if the boiler supply temperature drops below the current boiler target temperature.

## DHW Priority Override Time



A Setpoint Call is required in order for the control to provide heat to a setpoint load, such as a spa, pool, or snowmelt load. This can be done in two ways:

**Contact Closure**

A dry contact or 24 V (ac) signal is applied across the Setpoint Call terminals on the 401.

**tekmarNet® Setpoint Control with Sensor**

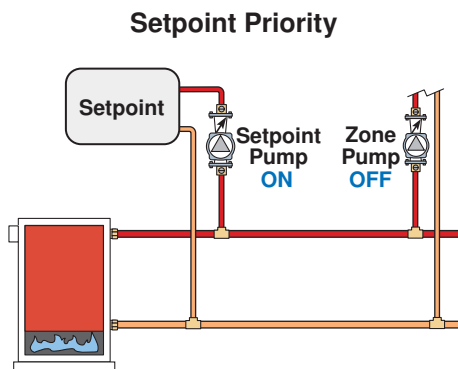
A Setpoint Call is provided through the tekmarNet® system. This can be done through the tN4 Expansion terminals with a setpoint device such as a Setpoint Control 161.

Once the control registers a Setpoint Call, it will display the “Setp” icon under Calls in the display.

**Note:** Setpoint operation has a fixed priority of on.

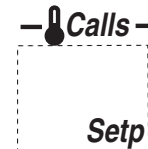
**Setpoint Operation**

The control can operate to satisfy the requirements of a setpoint load in addition to a space heating load and a DHW load. A setpoint load overrides the current outdoor reset temperature and WWSD setting in order to provide heat to the setpoint load.



When the control receives a Setpoint Call:

- All boiler temperature zones are turned off.
- The boiler will operate to maintain the Setpoint temperature as set in the Adjust menu, or as set on the tekmarNet® Setpoint control if one is being used.



It is assumed that the Setpoint pump will provide adequate flow through the heat exchanger and the boiler.

Setpoint calls will also be responded to when the system is in *Away*, which can be set using a 479 User Switch.

**Setpoint Priority Override**

To prevent the building from cooling off too much or the possibility of a potential freeze up during setpoint priority, the control attempts to limit the amount of time for setpoint priority.

As the outdoor air temperature becomes colder, the length of time the control provides setpoint priority is reduced. Once the allowed time for priority has elapsed, the control will check the space heating target.

- If there is a space heating target, the boiler operates at that target for 15 minutes.
- If after 15 minutes there is still a Setpoint Call, the control will shut off all boiler heating zones and target the Setpoint temperature.
- Note: It is possible to disable Setpoint Priority by using a tekmarNet® Setpoint control and turning the priority to Off in the Setpoint control.

The 401 is able to operate a single 1-stage or 2-stage on-off boiler or a single modulating boiler as a heat source. For proper operation of the boiler, the 401 must be the only control that determines when the boiler is to fire.

**\*Important note:** The operating control in the boiler, also known as an aquastat, remains in the burner circuit and acts as a secondary upper limit on the boiler temperature. The boiler operator temperature setting can be adjusted above 210°F, which is the fixed Boiler Maximum on the 401.

**Boiler Target Temperature**

The boiler target temperature is the temperature which the control is trying to operate the boiler at. There are three items that determine the boiler target temperature:

- Boiler or Boiler Expansion Call
- DHW Call
- Setpoint Call

If the control receives more than one call for heat at the same time, it will operate the boiler at the highest of the three calls.

The control displays the temperature that it is currently trying to maintain as the boiler supply temperature in the View menu. If the control does not presently have a call for heat, it does not show a boiler target temperature. Instead, ‘— —’ is displayed on the LCD.

**Boiler Minimum**

When operating non-condensing boilers, it is important to prevent cool water from returning to the boiler. Cold return temperatures create flue gas condensation, which if left too long, can severely damage the boiler.

The 401 protects the boiler through the Boiler Minimum setting. The boiler minimum is the lowest temperature that the control is allowed to use as a boiler target temperature. If the boiler is operating at the boiler minimum temperature, the “MIN” segment is turned on in the display when viewing either the boiler supply temperature or the boiler target temperature.

## Boiler Maximum

The 401 will operate the boiler so that the boiler supply temperature will never exceed 210°F (99.0°C). The highest allowed boiler target is the boiler design temperature + 10°F (5.5°C).

## Boiler Type

The 401 can operate either of the following types of boilers:

- One single-stage on-off boiler
- One two-stage on-off boiler
- Modulating boiler using a 0-10 V (dc) signal
- Modulating boiler using a 4-20 mA signal
- tekmar EMS signal (for use with multiple boiler stagers)
- EMS signal for Viessmann modulating boilers

## On-Off Operation

The 401 operates a single hot-water on-off boiler to maintain the boiler target within a differential. The boiler target is the average temperature and the boiler supply temperature can fluctuate by 1/2 of the differential above and below of the boiler target.

## Modulation Boiler Operation

The 401 can operate a single hot-water modulating boiler using the Mod dc/mA output and the Boiler Stage contact. Not all boilers require the use of the Boiler Stage contact.

The control operates the boiler by first switching the boiler stage contact to allow the modulating boiler to go through the ignition sequence (the boiler stage contact may not be required on all modulating boilers). A 0-10 V (dc) or 4-20 mA analog signal is then used to modulate the boiler firing rate starting from 50% (5 V (dc) or 12 mA signal) for 30 seconds.

After the 30 second delay has elapsed, the control will then allow the boiler to modulate down to the minimum modulation setting and hold it there for the Modulation Delay time setting. The Modulation Delay setting is determined by the boiler manufacturer. It is the amount of time that the burner must operate before the internal boiler control allows an external signal to operate the burner.

After the Modulation Delay has elapsed, the control uses PID logic to change the boiler firing rate signal in order to satisfy the boiler target temperature. When the firing rate signal is reduced down to the Minimum Modulating setting and the boiler supply temperature exceeds the boiler target by 1/2 of the differential, the control will shut off the burner.

## Minimum Modulation

The Minimum Modulation is the lowest signal the control can send to modulate the boiler. This operates the boiler at low fire.

- Refer to the boiler manufacturer's literature to determine the minimum output voltage V (dc) or current (mA) that the boiler will successfully operate at.

### For 0-10 V (dc):

$$\text{Minimum Modulation} = \frac{\text{Boiler's Minimum Input Signal}}{10 \text{ V (dc)}} \times 100\%$$

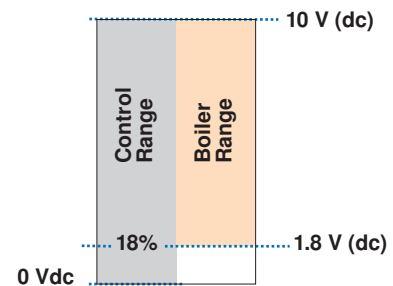
### For 4-20 mA:

$$\text{Minimum Modulation} = \frac{\text{Boiler's Minimum Input Signal} - 4\text{mA}}{16 \text{ mA}} \times 100\%$$

### Example:

A boiler requires a 1.8 V (dc) signal to fire the boiler at low fire. The boiler can be modulated to 10 V (dc) where it reaches high fire.

$$\text{Minimum Modulation} = \frac{1.8 \text{ V}}{10 \text{ V}} \times 100\% = 18\%$$



## tekmar EMS Signal Operation

The 401 can provide a 0-10 V (dc) signal proportional to the boiler target which is compatible with tekmar Boiler Staging controls that accept an EMS input.

- To use the tekmar EMS signal operation, the Boil Type setting in the Adjust menu must be set to EMS1.

## Viessmann EMS Signal

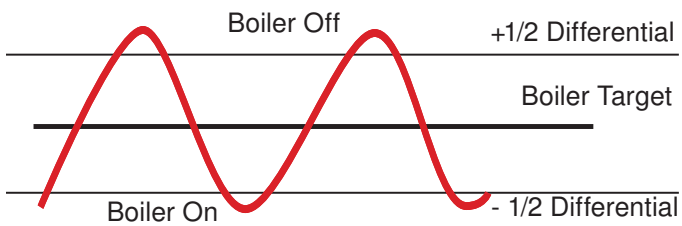
The 401 has a special 0-10 V (dc) signal proportional to the boiler target that is designed to be compatible with Viessmann Open Therm 0-10 V (dc) inputs.

- To use the Viessmann EMS signal operation, the Boil Type setting in the Adjust menu must be set to EMS2. The signal is 0 V (dc) when the boiler is off. The voltage is 2.2 V (dc) to provide a boiler target of 81°F (27°C), up to maximum of 10 V (dc) to provide a boiler target of 176°F (80°C).

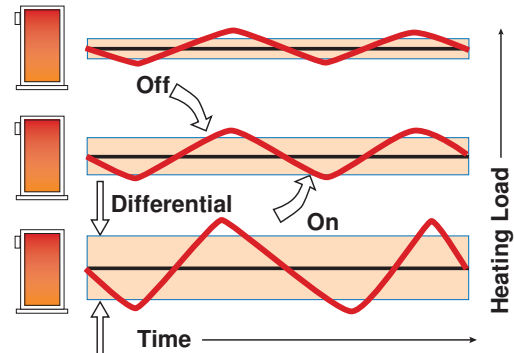
## Auto Differential

Both on-off and modulating boilers are operated with a differential. In some cases, a modulating boiler must be operated with a differential while operating at low fire because this indicates the load is smaller than the minimum modulation of the boiler. For modulating boilers, the differential no longer applies once operating the boiler above low fire.

The differential operates by closing the boiler contact when the boiler supply water temperature is 1/2 of the differential below the boiler target temperature. As the supply temperature reaches 1/2 of the differential above the boiler target temperature, the boiler is shut off.



In order to decrease temperature swings and increase boiler efficiency, the Auto Differential feature automatically adjusts the operating differential of the boiler based on the heating load. As the load increases, the differential will decrease to minimize temperature swings. As the load decreases, the differential will increase to prevent short cycling. This can significantly improve operating efficiency and prevent equipment failures through excessive cycling.



## Pump Operation

## Section F

### Pump Exercising

The control operates each pump every three days for 10 seconds to help prevent corrosion and / or precipitate build up on the pump components that can lead to pump seizure.

The control ensures that no heat is supplied to the zones during exercising.

## Energy Saving Features

## Section G

The "\$aving" icon is displayed when energy is being saved. The following features reduce energy consumption.

### Network Schedules

Adding a schedule to a tekmarNet® system is both easy and valuable. A Timer 033 provides scheduling with up to 4 events per day for every tekmarNet® Thermostat. Turning down the room temperatures when they are unoccupied reduces boiler on-time and energy consumption which helps save money and the environment.

### One-Touch Economy

A User Switch 479 allows for one-touch overrides of the system. For example, if leaving the building for vacation, simply press the "Away" button and all the thermostats will immediately operate at a lower temperature, instead of having to walk around the building lowering the heating temperature setting and raising the cooling temperature setting on each thermostat.

### DHW Tank During Away

In addition to the One-Touch setback, a User Switch 479 also allows the user to press the 'Away' button and tell the House Control 401 to ignore DHW Calls, preventing the DHW tank from unnecessarily heating up when no one is living in the building.

### Warm Weather Shut Down (WWSD)

During warmer weather, heating of the rooms is typically no longer required. To prevent energy waste from unnecessary boiler operation, the control goes into Warm Weather Shut

Down (WWSD) when the outdoor temperature rises above the WWSD temperature set in the Adjust menu.

### Further Savings!

Use a Timer 033 with programmable schedule #1 to gain the WWSD Unoccupied setting. This provides an additional WWSD temperature that can be set even lower for Unoccupied and Sleep time periods.

- This setting will appear after WWSD in the Adjust menu if a Timer 033 or User Switch is present on the system.

### Zone Synchronization

Another feature of the House Control is Zone Synchronization. In typical zoned systems, the thermostats operate on a stand-alone basis. This means that a zone turns on and off as required without any regard for other zones. The net effect is random operation of the zones causing short cycling of the heat source. tekmarNet® thermostats communicate to ensure that their cycles are synchronized. Energy is saved by ensuring zones requiring heat operate on the same cycle, therefore reducing short cycling of the boiler.

### Zone Post Purge

When the last zone is nearly satisfied for heating, the boiler is shut off and the zone pump continues to operate. This purges the residual heat from the boiler into this zone. The control continues this purge for a maximum of two minutes. The control will stop the purge if the boiler supply temperature drops below the boiler minimum setting.

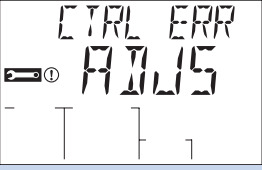
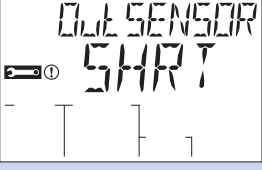
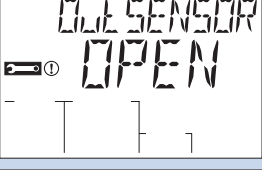
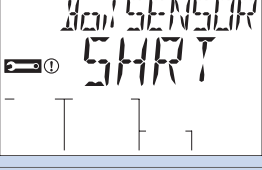
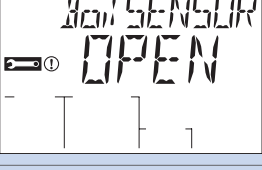
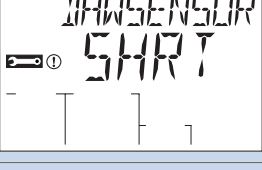
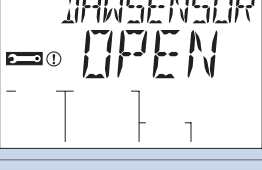
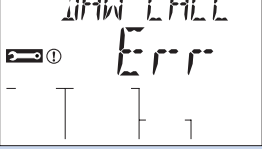


## Troubleshooting

It is recommended to complete all wiring to ensure trouble free operation. Should an error occur, simply follow these steps:

- 1. Find:** If the House Control or tekmarNet® Thermostat flashes ① on the screen, it is indicating a problem on the system.
- 2. Identify:** Use the Menu button to locate the Toolbox Menu. The Error code should appear as the first item.
- 3. Solve:** Using the lookup chart below, match the Error code to the one on the control. Use the Description in the chart to solve the problem.

### Error Messages (1 of 2)

Error Message	Description
	<p><b>ADJUST ERROR</b></p> <p>The control failed to read the Adjust menu settings, and reloaded the factory default settings. Operation stops until all the Adjust menu settings are checked.</p> <p><b>Note:</b> To clear the error, the access level must be set to Installer and each setting in the Adjust menu must be checked.</p>
	<p><b>OUTDOOR SENSOR SHORT CIRCUIT</b></p> <p>Due to a short circuit, the control failed to read the outdoor sensor. As a result, the control assumes an outdoor temperature of 32°F (0°C) and continues operation. Locate and repair the problem as described in the “Test the Sensor Wiring” section.</p>
	<p><b>OUTDOOR SENSOR OPEN CIRCUIT</b></p> <p>Due to an open circuit (disconnected or broken wire), the control failed to read the outdoor sensor. As a result, the control assumes an outdoor temperature of 32°F (0.0°C) and continues operation. Locate and repair the problem as described in the “Test the Sensor Wiring” section.</p>
	<p><b>BOILER SENSOR SHORT CIRCUIT</b></p> <p>Due to a short circuit, the control failed to read the boiler sensor. When there is a call for heat, the control no longer controls the boiler. Instead, the control provides a boiler enable and the boiler operates on its aquastat/limit until the sensor is repaired. The control will not operate the boiler contact if the Boil Minimum setting is set to Off. Locate and repair the problem as described in the “Test the Sensor Wiring” section.</p>
	<p><b>BOILER SENSOR OPEN CIRCUIT</b></p> <p>Due to an open circuit, the control failed to read the boiler sensor. The control no longer controls the boiler. Instead, the control provides a boiler enable and the boiler operates on its aquastat/limit until the sensor is repaired. The control will not operate the boiler contact if the Boil Minimum setting is set to Off. Locate and repair the problem as described in the “Test the Sensor Wiring” section.</p>
	<p><b>DOMESTIC HOT WATER SENSOR SHORT CIRCUIT</b></p> <p>Due to a short circuit, the control failed to read the DHW sensor. As a result, the control no longer heats the DHW tank. Locate and repair the problem as described in the “Test the Sensor Wiring” section. DHW tank heating will resume once the sensor problem is corrected. The error message self clears once the error condition is corrected.</p>
	<p><b>DOMESTIC HOT WATER SENSOR OPEN CIRCUIT</b></p> <p>Due to an open circuit, the control failed to read the DHW sensor. As a result, the control no longer heats the DHW tank. Locate and repair the problem as described in the “Test the Sensor Wiring” section. DHW tank heating will resume once the sensor problem is corrected. The error message self clears once the error condition is corrected.</p>
	<p><b>DOMESTIC HOT WATER CALL ERROR</b></p> <p>A DHW sensor and a DHW call have been applied at the same time. The DHW tank will not be heated until the DHW call signal is removed. The error message self clears once the error condition is corrected.</p>

## Error Messages (2 of 2)

Error Message	Description
	<p><b>BOILER DEVICE LOST (b:01 TO b:24)</b></p> <p>Each tekmarNet® device (thermostat, setpoint control, timer) has an address. The device with this address on the boiler water temperature is no longer reporting back to the 401. The device can be located by either the address, or by going to each device in the building, checking that the LCD is on, and the tekmarNet® communication symbol is on. Trace the wires from the control to the lost device looking for loose or damaged wires.</p> <p><b>Note:</b> If you deliberately remove a tekmarNet® device, hold the Up and Down buttons to clear this error.</p>
	<p><b>MASTER DEVICE ERROR</b></p> <p>More than one master has been detected on the tekmarNet®4 expansion terminals. The 401 is a “Master Device” and no other tekmarNet® reset controls can be added to the tekmarNet®4 expansion terminals. If one has been added, remove it from the system.</p>
	<p><b>DEVICE ERROR AT ADDRESS b:01 to b:24</b></p> <p>Each tekmarNet® device (thermostat, setpoint control, timer) has an address. One of the devices on the boiler water temperature has an error. If there is a record of the device address together with the room name, go to that device to correct the error. Otherwise, go to each device in the building, checking for the flashing Warning symbol. Once the error on the device is corrected, the error message will clear.</p>
	<p><b>MIX MODULE ERROR</b></p> <p>A Mixing Module has been connected to the Boiler Exp. tN4 terminals. The 401 control cannot operate tekmarNet® mixing expansion modules. Once the mixing expansion module is removed, the error message will clear.</p>

## Frequently Asked Questions (1 of 2)

Symptom	Look For...	Corrective Action
LCD display is off	Fuse holder	Control power supply has a 24 V (ac) fuse which if blown, requires replacement.
	Power to control	Use electrical meter to measure 24 V (ac) voltage on input power R and C terminals.
No DHW tank heating	DHW Call on LCD	If a DHW call is present, the control is aware that the DHW tank requires heat.
	DHW tank reading	Ensure the DHW tank temperature is accurate and replace if necessary.
	Burner symbol on LCD	If the burner symbol is on the LCD, there is a problem with the boiler. Ensure the boiler aquastat manual limit is reset to the on position.
	DHW pump symbol on LCD	If the DHW pump symbol is on, check to ensure the DHW pump is in operation by checking for pump vibration or voltage on the pump wiring terminals.
	DHW pump in operation	If DHW pump and boiler are operating, the system may require the boiler system pump to operate to heat the DHW tank. Ensure the DHW Mode setting is set correctly.
No DHW tank heating	DHW Call on LCD	If a DHW call is present, the control is aware that the DHW tank requires heat.
	DHW tank reading	Ensure the DHW tank temperature is accurate and replace if necessary.
	Burner symbol on LCD	If the burner symbol is on the LCD, there is a problem with the boiler. Ensure the boiler aquastat manual limit is reset to the on position.
	DHW pump symbol on LCD	If the DHW pump symbol is on, check to ensure the DHW pump is in operation by checking for pump vibration or voltage on the pump wiring terminals.
	DHW pump in operation	If DHW pump and boiler are operating, the system may require the boiler system pump to operate to heat the DHW tank. Ensure the DHW Mode setting is set correctly.

## Frequently Asked Questions (2 of 2)

Symptom	Look For...	Corrective Action
LCD display is off	Fuse holder	Control power supply has a 24 V (ac) fuse which if blown, requires replacement.
	Power to control	Use electrical meter to measure 24 V (ac) voltage on input power R and C terminals.
No central heating	Burner symbol on LCD	If the burner symbol is on the LCD, there is a problem with the boiler. Ensure the boiler aquastat manual limit is reset to the on position.
	WWSD symbol on LCD	Warm Weather Shut Down (WWSD) is an energy saving feature that prevents central heating during the summer. Ensure the outdoor temperature reading is accurate and replace outdoor sensor if necessary. WWSD setting can be increased if heating is required.
	Boil Calls on LCD	If there are no Boil Calls, there are no thermostats calling for heat.
	DHW Call on LCD	During DHW tank heating, the central heating may not be heated.
	System in AWAY	During AWAY, the thermostats operate at a lower temperature. Locate a 'User Switch' and set to Normal to resume heating.
Single zone over heating	LCD shows zone on	Thermostats have a differential of +/- 1.5°F of the temperature setting. Due to the display rounding numbers up, heating can appear on when the temperature is 2°F above the setting. This is normal operation.
	LCD shows zone off	Ensure zone pump terminals measure 0 V (ac). Measuring 0 V (ac) indicates the control relay is functioning correctly and the problem may be related to the mechanical piping. Measuring 115 V (ac) indicates control relay may have failed.
Single zone under heating	LCD shows zone on	Ensure zone pump terminals measure 115 V (ac). Measuring 115 V (ac) indicates the control relay is functioning correctly and the problem may be related to the mechanical piping. Measuring 0 V (ac) indicates control relay may have failed.
	LCD shows zone off	Check for Boiler Call

## Job Record

Item	Setting	Item	Setting
OUTDOOR DESIGN		DHW MODE	
BOILER TYPE		DHW EXCHANGE	
BOILER DESIGN		DHW OCCUPIED	
BOILER MINIMUM		DHW UNOCCUPIED	
BOILER MOTOR		SETPOINT	
MINIMUM MODULATION		UNITS	
MODULATION DELAY			
WWSD OCCUPIED			
WWSD UNOCCUPIED			

**WARNING:** This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.  
**For more information: [Watts.com/prop65](http://Watts.com/prop65)**

# Technical Data

<b>tN2 House Control 401 Boiler, DHW &amp; Setpoint, Four Zone Pumps</b>	
Literature	D401, Q401
Control	Microprocessor control. This is not a safety (limit) control.
Packaged weight	1.4 lbs (640 g)
Dimensions	5.5" H x 5.5" W x 2.25" D (140 x 140 x 57 mm)
Enclosure	NEMA 1 rated, blue PC+ABS plastic
Approvals	CSA C US, meets class B: ICES & FCC Part 15
Ambient conditions	Indoor use only, 32 to 104°F (0 to 40°C), RH ≤ 90% Non-condensing
Power supply	24 V (ac) ±10% 60 Hz, 100 VA max, Class 2
Control load	2 VA
Boiler stage 1, 2 relays	24 V (ac) 5 A
Zone 1 to 4 pump relays	115 V (ac) 5 A, 1/6 hp
DHW pump relay	115 V (ac) 5 A, 1/6 hp
Pump power	115 V (ac) 12 A max
Setpoint and DHW calls	Short, 0 - 32 V (ac)
Boiler modulating output	0 - 10 V (dc) 500 Ω min load impedance, 4 - 20 mA 1 kΩ max load impedance
Sensors	NTC thermistor, 10k Ω @ 77°F (25°C ± 0.2°C) β=3892
- Included	Outdoor Sensor 070 and Universal Sensor 082
Warranty	Limited 3 Year

## Limited Warranty and Product Return Procedure

**Limited Warranty** *The liability of tekmar under this warranty is limited. The Purchaser, by taking receipt of any tekmar product ("Product"), acknowledges the terms of the Limited Warranty in effect at the time of such Product sale & acknowledges that it has read & understands same.*

The tekmar Limited Warranty to the Purchaser on the Products sold hereunder is a manufacturer's pass-through warranty which the Purchaser is authorized to pass through to its customers. Under the Limited Warranty, each tekmar Product is warranted against defects in workmanship & materials if the Product is installed & used in compliance with tekmar's instructions, ordinary wear & tear excepted. The pass-through warranty period is for a period of twenty-four (24) months from the production date if the Product is not installed during that period, or twelve (12) months from the documented date of installation if installed within twenty-four (24) months from the production date.

The liability of tekmar under the Limited Warranty shall be limited to, at tekmar's sole discretion: the cost of parts & labor provided by tekmar to repair defects in materials &/or workmanship of the defective product; or to the exchange of the defective product for a warranty replacement product; or to the granting of credit limited to the original cost of the defective product, & such repair, exchange or credit shall be the sole remedy available from tekmar, &, without limiting the foregoing in any way, tekmar is not responsible, in contract, tort or strict product liability, for any other losses, costs, expenses, inconveniences, or damages, whether direct, indirect, special, secondary, incidental or consequential, arising from ownership or use of the product, or from defects in workmanship or materials, including any liability for fundamental breach of contract.

The pass-through Limited Warranty applies only to those defective Products returned to tekmar during the warranty period. This Limited Warranty does not cover the cost of the parts or labor to remove or transport the defective Product, or to reinstall the repaired or replacement Product, all such costs & expenses being subject to Purchaser's agreement & warranty with its customers.

Any representations or warranties about the Products made by Purchaser to its customers which are different from or in excess of the tekmar Limited Warranty are the Purchaser's sole responsibility & obligation. Purchaser shall indemnify & hold tekmar harmless from & against any & all claims, liabilities & damages of any kind or nature which arise out of or are related to any such representations or warranties by Purchaser to its customers.

The pass-through Limited Warranty does not apply if the returned Product has been damaged by negligence by persons other than tekmar, accident, fire, Act of God, abuse or misuse; or has been damaged by modifications, alterations or attachments made subsequent to purchase which have not been authorized by tekmar; or if the Product was not installed in compliance with tekmar's instructions &/or the local codes & ordinances; or if due to defective installation of the Product; or if the Product was not used in compliance with tekmar's instructions.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, WHICH THE GOVERNING LAW ALLOWS PARTIES TO CONTRACTUALLY EXCLUDE, INCLUDING, WITHOUT LIMITATION, IMPLIED WARRANTIES OF MERCHANTABILITY & FITNESS FOR A PARTICULAR PURPOSE, DURABILITY OR DESCRIPTION OF THE PRODUCT, ITS NON-INFRINGEMENT OF ANY RELEVANT PATENTS OR TRADEMARKS, & ITS COMPLIANCE WITH OR NON-VIOLATION OF ANY APPLICABLE ENVIRONMENTAL, HEALTH OR SAFETY LEGISLATION; THE TERM OF ANY OTHER WARRANTY NOT HEREBY CONTRACTUALLY EXCLUDED IS LIMITED SUCH THAT IT SHALL NOT EXTEND BEYOND TWENTY-FOUR (24) MONTHS FROM THE PRODUCTION DATE, TO THE EXTENT THAT SUCH LIMITATION IS ALLOWED BY THE GOVERNING LAW.

**Product Warranty Return Procedure** All Products that are believed to have defects in workmanship or materials must be returned, together with a written description of the defect, to the tekmar Representative assigned to the territory in which such Product is located. If tekmar receives an inquiry from someone other than a tekmar Representative, including an inquiry from Purchaser (if not a tekmar Representative) or Purchaser's customers, regarding a potential warranty claim, tekmar's sole obligation shall be to provide the address & other contact information regarding the appropriate Representative.



tekmar Control Systems Ltd., A Watts Water Technologies Company. Head Office: 5100 Silver Star Road, Vernon, B.C. Canada V1B 3K4, 250-545-7749, Fax. 250-984-0815 Web Site: tekmarControls.com

