

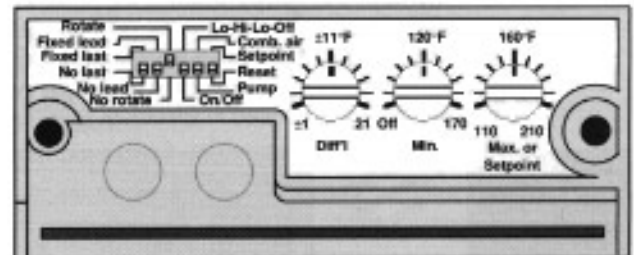
tekmar® - Data Brochure

D 32

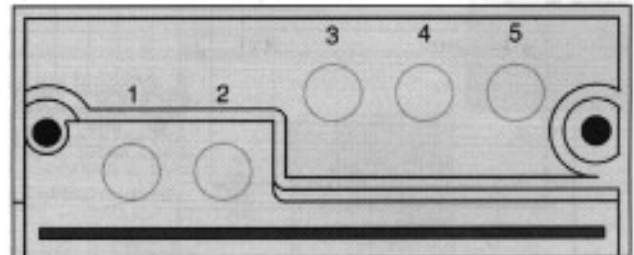
Multi-Stage Boiler Reset Control type 233, Six Relay Expansion Module type 235

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The tekmar® Multi-Stage Boiler Reset Control is a microprocessor-based control that determines the operation of up to four boiler modules or stages. With the addition of a Six Relay Expansion Module, as many as ten stages can be operated. The control efficiently operates the stages to maintain a desired supply water temperature from the heating plant. The desired supply water temperature is either set by a dial on the control (Setpoint function) or is calculated by the control as a function of the outdoor and indoor air temperatures (Outdoor Reset function). In addition to the two control functions (Setpoint or Reset) the control provides the installer with a choice of seven different patterns of staging and operation of the system pump or combustion/ventilation air dampers.



type 233 includes: 1 x Electronic Control, 1 x Plug-in Base, 1 x Boiler sensor (type 321) and strap, 1 x Outdoor sensor (type 317)



type 235 includes: 1 x Electronic Control, 1 x Plug-in Base
For application examples see brochure A 233

Technical Data

Technical Specifications

Power Supply	— 24 Vac $\pm 10\%$, 60 Hz, 4 VA per control. Class 2 transformer. When a Six Relay Expansion Module type 235 is added to a type 233, both controls must be powered by the same transformer.
Relay Capacity	— 6 Amp (SPST)
Operating Conditions	— 30°F to 120°F (0°C to 50°C), <95% relative humidity non-condensing.
Mechanical	— Overall dimensions of each control with base are 4-1/4" x 2-7/8" x 2-1/2" (108 x 73 x 64 mm). The control's base can be mounted on a DIN rail or attached to a flat surface.
Control method	— Proportional + Integral + Derivative (PID) control overcomes temperature offset (droop) between stages. The minimum time delay between stages turning on is 15 seconds and the minimum delay between stages turning off is 10 seconds.
Error Recovery method	— A watchdog timer protects the operating integrity of the control.

Installation

Caution:

Boiler Control type 233 is not intended for use as a primary limit control. Another control that is intended and certified as a limit control must be placed into the control circuit.

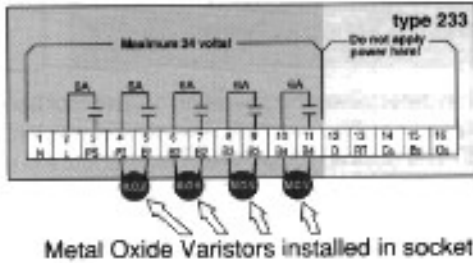
The location of this control must be within its specified temperature and humidity ranges. The control system installer must ensure that the control and its wiring are isolated and/or shielded from strong sources of electromagnetic noise

These electronic controls do not exceed the Class B limits for radio noise emissions from digital apparatus as set out in the Radio Interference Regulations of the Canadian Department of Communications. If this equipment does cause interference, the user is encouraged to try to correct the interference by reorienting the receiving antenna and/or relocating the receiver with respect to this equipment.

Les présents appareils numériques n'émettent pas de bruits radioélectriques dépassant les limites applicables aux appareils numériques de Classe B prescrites dans le règlement sur le brouillage radioélectrique édicté par le Ministère des Communications du Canada.

Electrical

The tekmar controls terminate the wires in a plug-in base; no wires are directly connected to the controls. This plug-in system simplifies installation and troubleshooting procedures.



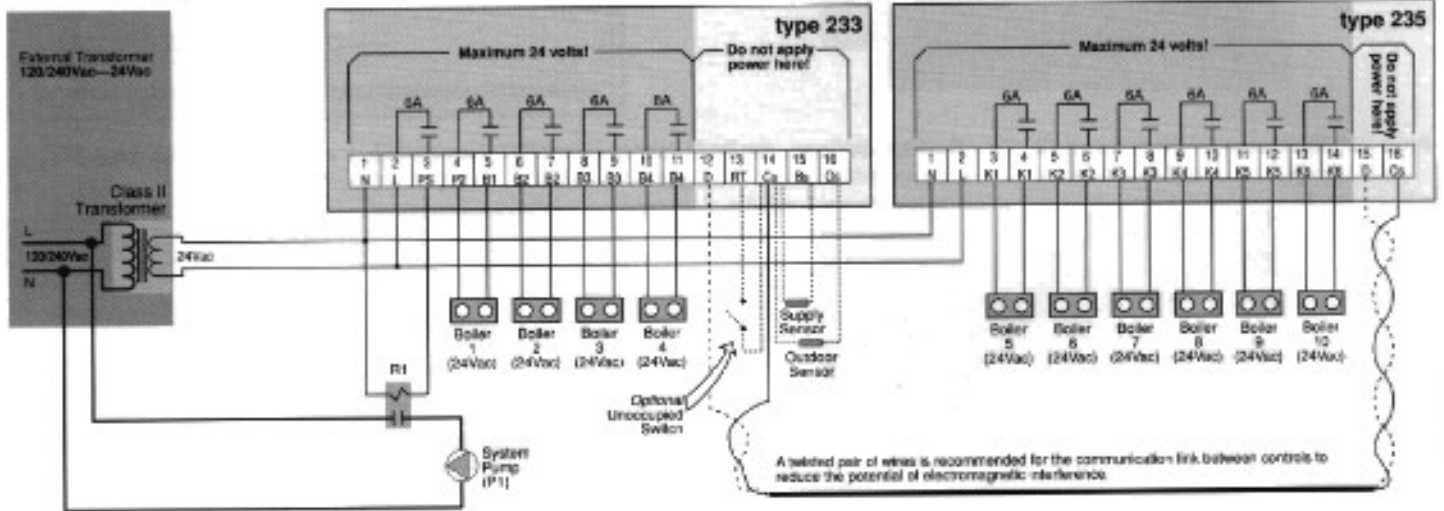
Important Notes:

To prevent problems of electromagnetic interference caused by the switching of pumps, relays and spark ignition systems, metal oxide varistors are installed across the control's output terminals (B1-B1, B2-B2, etc.) and should not be removed.

Installing a separate 24Vac class II transformer to power the control system will further reduce potential electromagnetic interference problems.

Continuous system pump operation

The system pump runs continuously, pumping water through the heating system main loop until the control turns the pump off at the WWSD (warm weather shut down) temperature. The boiler reset control will continuously monitor and adjust the system supply water temperature by cycling and staging the boilers. Control wiring for multiple boiler systems with continuous system pump operation is illustrated in Electrical schematic #1.

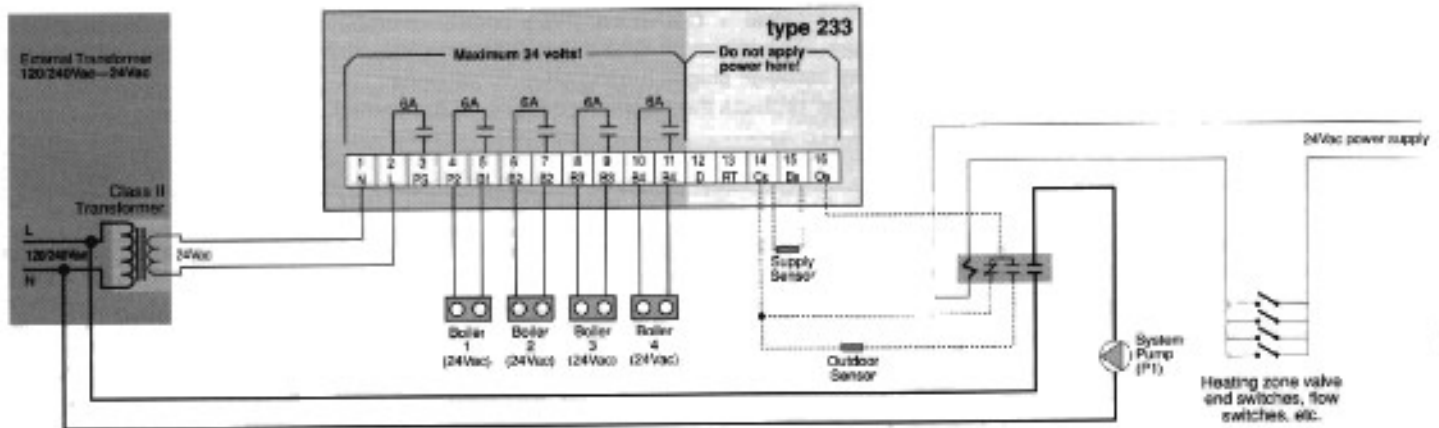


Electrical schematic #1, for 233/235 with *continuous* system pump operation.

Heat Enable function

In the reset mode the type 233 is heat enabled as long as its outdoor temperature sensor is connected. If the outdoor sensor is short circuited as shown in Electrical schematic #2, the control is not heat enabled. When the type 233 is heat enabled, it reads its temperature sensor inputs and processes the information to stage the boilers. When the control is not heat enabled it ignores its sensor readings and keeps the boilers turned off. Power and boiler running time information is maintained in both modes.

Continuous water flow across the supply sensor is very important to the type 233 whenever it is heat enabled so it can accurately measure the system supply water temperature. The staging and firing of the boilers is based on how much and how quickly the system water temperature is changing from the control's calculated setpoint, and if the supply water temperature cannot be accurately measured the control cannot properly stage the boilers.



Electrical schematic #2, for 233 with *intermittant* system pump operation.

Intermittent system pump operation

The system pump and boilers are turned off when none of the secondary heating zones call for heat. The boiler reset control monitors and adjusts the system supply water temperature only when the system pump is running. (Heat Enable)
When none of the zones call for heat (No Heat Enable), the control will ignore the system supply water temperature readings preventing misleading supply water temperature information from causing erratic operation.

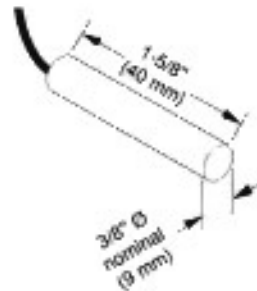
For detailed application drawings and additional applications, see Brochure A 233

Installation of the Sensors

The sensors and communication link are connected to the base using 2-conductor 18 AWG thermostat wire. The overall length of the wire can be 800 ft. (250 m) but it must not be run parallel to any power line or telephone cables.

Supply Sensor type 321

For accurate temperature readings the supply sensor should be inserted into a standard 3/8" well in the supply main. Optionally the sensor can be fastened to the pipe surface by the included strap; however, the sensor and pipe must then be wrapped in insulation. Do not immerse the sensor itself into a liquid. Connect this sensor's two conductor cable to terminals 14 & 15 of the socket. If the circuit to the supply sensor is shorted or disconnected the control will flash both the power and WWSD lights and leave the boilers and system pump operating as they were before the sensor or wiring was damaged.



Setback timer input

An optional setback timer can be connected between terminals 13 and 14. When the timer shorts these two terminals together, the control is switched into setback, its Sun dial (☀) is disabled and the Moon dial (☾) becomes the active setting. For a detailed description of the Sun and Moon dial settings and operation, see page 7.

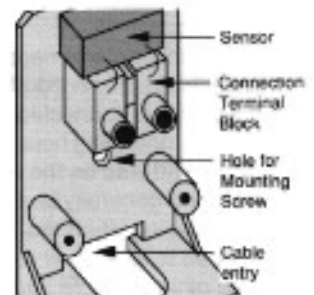
Outdoor Sensor type 317

The outdoor sensor should normally be mounted on the north side of the building. It should not be mounted immediately above a window or ventilation opening. With one round or pan head screw, attach the base of the sensor to the wall. **The hole for the cable entry must face downward** for proper moisture drainage. Connect a two conductor cable from the outdoor sensor terminals to terminals 14 & 16 of the control's base. Slide the cover of the Outdoor Sensor onto its base.

If the circuit to the outdoor sensor is disconnected while in the reset mode, the Boiler Control flashes its power light and switches to 'Setpoint' operation.

Important note:

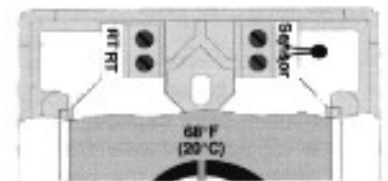
If you are using intermittent system pump operation, the 233 must be disabled any time the system pump is shut down. This is accomplished by shorting across the Outdoor Sensor leads with relay or flow switch dry contacts.



Room Temperature Unit (RTU) type 307 / type 308

To compensate for indoor heat gains/losses from solar radiation or wind infiltration, an optional Room Temperature Unit (RTU) may be wired to the control in terminals 13 & 14. RTU type 307 has an adjustable dial for the room temperature, a bimetal temperature indicator, and a thermistor sensing element. The setback RTU type 308 adds an adjustment dial for setback room temperature and a 7-day or 24 hr digital clock. See brochure D06 for further details.

Note: Only one device can be connected to terminals 13 and 14 at the same time and if an RTU is used, a setback timer cannot also be installed.



Communication Link

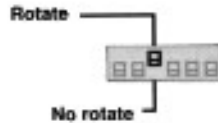
Connect the communication link D to D and Cs to Cs. The Six Relay Expansion module will turn off all its relays and flash its power light if the communications link to the Boiler Control is shorted, disconnected, or reversed. To reduce EMI/RFI emissions that may interfere with radio reception we recommend the communication link wires be twisted around one another such as unjacketed thermostat wire often is. There is a possibility that if the controls are connected to different 24V power supply transformers the data link may not work properly, therefore connect both controls to the same transformer.

Boiler Staging and Rotation Functions

The Multi-Stage Boiler Reset Control does not directly know how many stages are connected or operational, it only knows whether there are 4 or 10 stages potentially available. When the control determines that more heat is needed, it turns on a stage. If that stage doesn't increase the water temperature sufficiently, the control will turn on other stages until the required water temperature is achieved. During normal operation the time delay between stages may be quite long, but if a large error in temperature is introduced, the control will bring on additional stages faster. When the control is first powered up, it may stage the boilers on as fast as every 15 seconds, which is the minimum interstage time delay.

The following four DIP switches can be configured to select up to seven different boiler rotation modes as illustrated.

Rotate / No Rotate

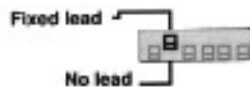


When the control is first started it assigns a ranking to each boiler with boiler #1 having rank 1, boiler #2 having rank 2, etc. As the heating load increases the control first turns on the boiler with the lowest rank, then the next lowest, etc. until the required water temperature is achieved. When boilers need to be turned off, the control first turns off the operating boiler of highest rank, then the one at the rank below that, etc. This staging procedure is called 'Last On - First Off' (LOFO).

When the Rotate function is turned on the Multi-Stage Boiler Reset Control automatically shifts the heating load between the boilers in order to equalize boiler firing time and allow the maintenance personell to establish documented service intervals for comprehensive system maintenance. The boilers are ranked according to their hours of use; the boiler with the least use has the lowest rank.

The staging procedure is 'Last On - First Off' (LOFO), however when a boiler needs to be turned off and there is more than 12 hours difference in use between the boiler with the least use and the boiler with the maximum use, then the ranks are reassigned and the operating boiler of highest rank will be turned off.

Fixed Lead / No Lead



Some boiler plants need to fire the boiler nearest the chimney first in order to develop sufficient draft up the chimney. The Fixed Lead function forces the boiler that is connected to B1-B1 to be the first boiler fired. In order to keep the total operating hours of this lead boiler as few as possible **the fixed lead boiler will also be the first one turned off**. Therefore, at part loads the lead boiler will generally be the one that is cycled off and on. If the Rotate function is turned on, then the ranks of the remaining boilers will be changed as needed to keep their operating hours all similar.

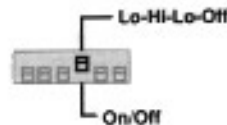
One other possible application of this function is with boilers of mixed size and/or efficiency. If the lead boiler is a high efficiency boiler or a smaller boiler than the others, then the average operating efficiency of the boiler plant can be markedly improved.

Fixed Last / No Last

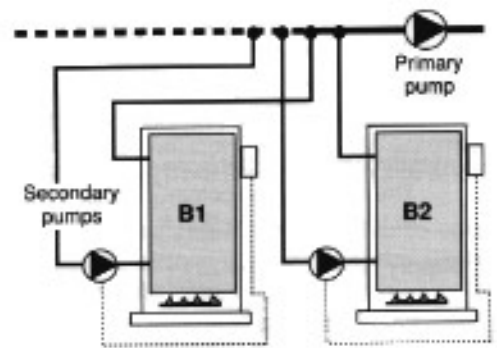


In some boiler plants which heat service water and the building, when full heating plant capacity has been reached the last stage operates a valve which adds hot water from the service water boilers to the heating system in order to assist the heating boilers. However, when 'Rotate' has been selected it is impossible to tell which stage is the last one switched on. With 'Fixed Last' selected, stage B4-B4 (or K6-K6 if a Six Stage Expansion Module is connected) will be the last stage switched on.

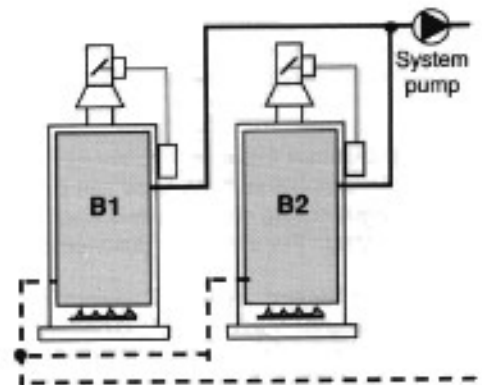
Lo-Hi-Lo-Off / On-Off



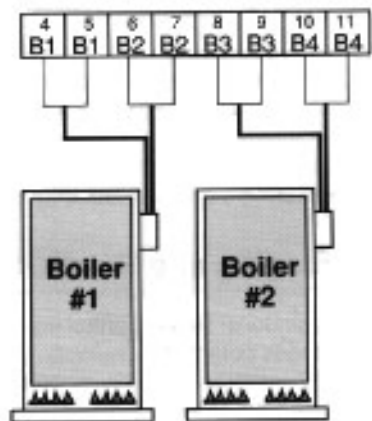
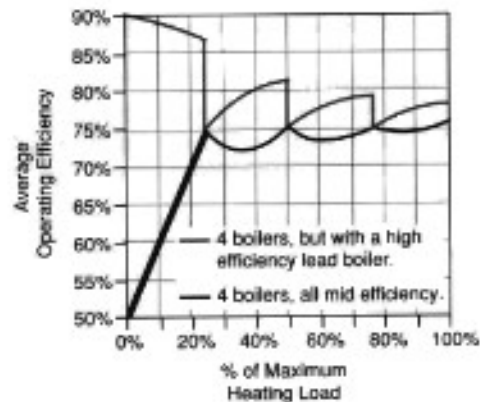
Enabling the Lo-Hi-Lo-Off function pairs the relays so that B1-B1 operates the low fire of boiler #1 and B2-B2 operates its high fire. Similarly, the low and high fire of boiler #2 are operated by B3-B3 and B4-B4 respectively. The staging sequence will first operate a boiler on its low fire, then, if more heat is required, both the low fire and high fire relays for that boiler will be on before the control will turn on the low fire of another boiler. If the Fixed Lead function is also selected then the boiler connected to B1-B1 and B2-B2 is the lead boiler. The Rotate function ranks the boilers based on hours of low fire use.



Primary/Secondary pumping



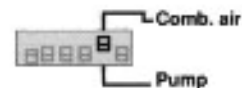
Motorized stack dampers



Lo-Hi-Lo-Off wiring

Pump or Combustion Air

The system pump is continually on when heating is required. During Warm Weather Shut Down the pump relay is cycled on for several minutes every 3 days to prevent seizure of the pump bearings. Alternatively, the pump relay can operate combustion/ventilation air dampers. With 'Comb. air' selected the relay will turn on when any stage is on and turn off when all stages are off.



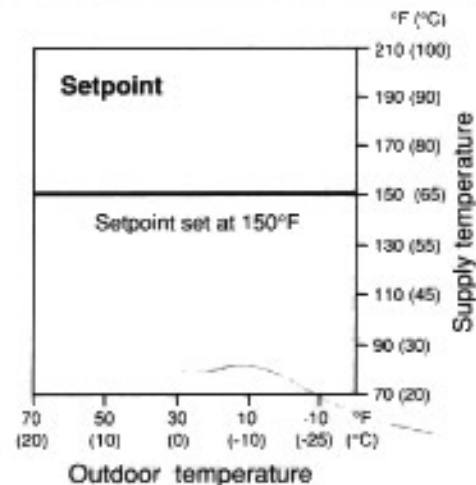
Setpoint Settings

Move the sixth function switch to the "Setpoint" position.



Setpoint, high range

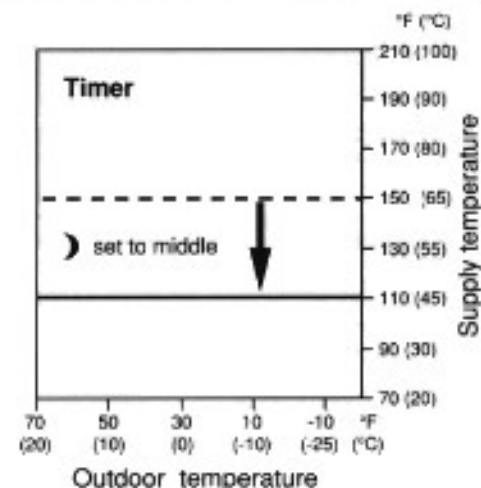
The Multi-Stage Boiler Reset Control can be configured to supply a constant supply water temperature at all outdoor temperatures. Move the sixth function switch to the 'Setpoint' position. The 'Max. or Setpoint' adjustment sets the desired supply water temperature from 110°F to 210°F (43°C to 99°C). The supply sensor is the only active sensor and is the one used to sense the supply water temperature; the outdoor sensor is ignored and does not need to be installed.



Setpoint, Timer Input (RT), low range

When RT is shorted to Cs then a second setpoint temperature is available. The moon (☾) adjustment shifts the operating water temperature 0 to 80°F (0 to 44°C) below the 'Max. or Setpoint' adjustment. The remaining adjustments on the front of the control are not used. In order to operate at a setpoint that is less than 110°F (43°C), short RT to Cs and turn the moon adjustment fully counter-clockwise to its '1' position. Now add 80°F (44°C) to the desired operating temperature to determine the setting of the 'Max or Setpoint' adjustment.

Example: Desired temperature = 45°F
 45°F + 80°F = 125°F is the 'Max or Setpoint' dial position.



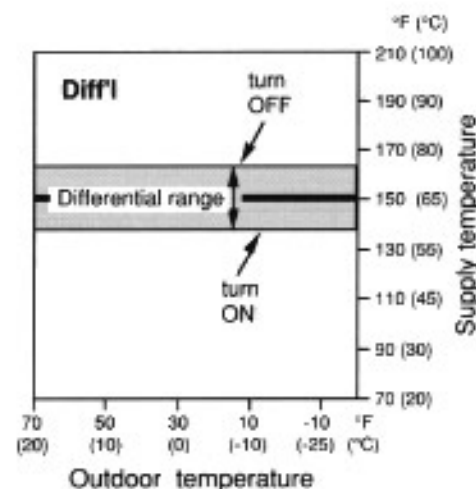
Differential (Diff'l)

The differential adjustment sets how much the actual supply water temperature may deviate from the desired temperature before a stage is turned on or off. The differential should be at least as large as the following equations indicate.

$$\text{Differential} \geq \pm \frac{\text{Btu/hr per stage}}{\text{US GPM} \times 1000} \quad \text{Eg: } \pm \frac{180,000 \text{ Btu/hr}}{30 \text{ US GPM} \times 1000} = \pm 6^\circ\text{F}$$

Water flow rate in the primary (mains) pipe where the supply sensor is installed.

$$\text{Differential} \geq \pm \frac{\text{Watts per stage}}{\text{litres/hr} \times 2.32} \quad \text{Eg: } \pm \frac{56,000 \text{ Watts}}{8000 \text{ l/hr} \times 2.32} = \pm 3^\circ\text{C}$$



Boiler Reset Settings

Move the sixth function switch to the 'Reset' position.



Heating Curve (Δ)

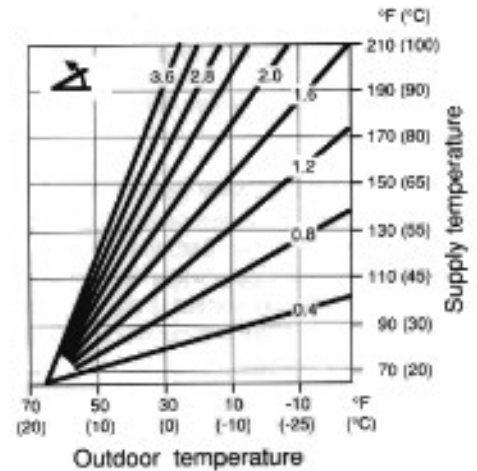
The heating curve is the ratio of increase in supply water temperature to a one degree decrease in the outdoor ambient temperature. The correct adjustment of the heating curve is defined by the following formula:

$$\text{Heating curve} = \frac{\text{design supply temp.} - \text{indoor temperature}}{\text{indoor temp.} - \text{design outdoor temperature}}$$

Example

- Design outdoor temperature = 5°F (-15°C)
- Design indoor temperature = 65°F (18°C)
- Design supply temperature = 155°F (68°C)

$$\text{Heating curve} = \frac{155^{\circ}\text{F} - 65^{\circ}\text{F}}{65^{\circ}\text{F} - 5^{\circ}\text{F}} = 1.5 \quad \text{OR} \quad \frac{68^{\circ}\text{C} - 18^{\circ}\text{C}}{18^{\circ}\text{C} - (-15^{\circ}\text{C})} = 1.5$$

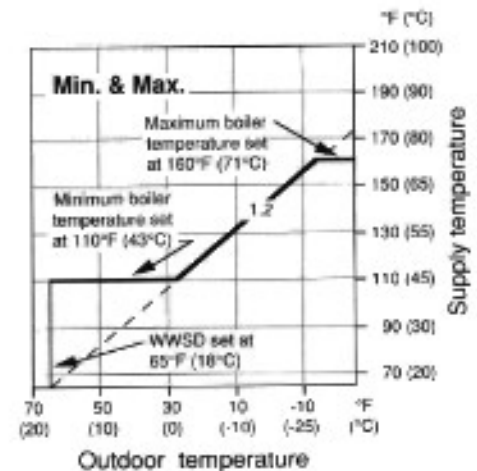


Minimum Boiler Operating Temperature (Min.)

This adjustment should be set to the boiler manufacturer's specification for the minimum allowable operating temperature of the boilers to prevent problems from condensation of the exhaust gases. If a minimum boiler operating temperature is not required, as with a condensing or electric boiler, then this adjustment should be set to 'Off'. Turning the dial slightly clockwise enters the operating range of the adjustment: 70°F to 170°F (21°C to 77°C).

Maximum Boiler Operating Temperature (Max.)

This adjustment should be set to the maximum expected operating temperature of the heating system. If the 'Min.' adjustment is set higher than the 'Max.' adjustment, then 'Max.' will take precedence and the control will operate similar to the 'Setpoint' mode except that the boilers and pump will be switched off whenever the outdoor air temperature becomes warmer than the Warm Weather Shut Down (WWSD) point.



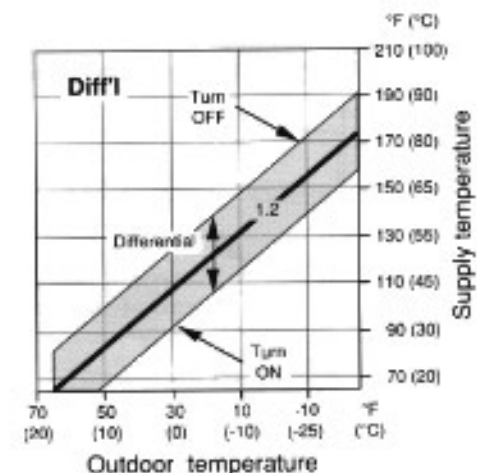
Differential (Diff'l)

The differential adjustment sets how much the actual supply water temperature may deviate from the desired temperature before a stage is turned on or off. The differential should be at least as large as the following equations indicate.

$$\text{Differential} \geq \pm \frac{\text{Btu/hr per stage}}{\text{US GPM} \times 1000} \quad \text{Eg: } \pm \frac{180,000 \text{ Btu/hr}}{30 \text{ US GPM} \times 1000} = \pm 6^{\circ}\text{F}$$

Water flow rate in the primary (mains) pipe where the supply sensor is installed.

$$\text{Differential} \geq \pm \frac{\text{Watts per stage}}{\text{litres/hr} \times 2.32} \quad \text{Eg: } \pm \frac{56,000 \text{ Watts}}{8000 \text{ l/hr} \times 2.32} = \pm 3^{\circ}\text{C}$$



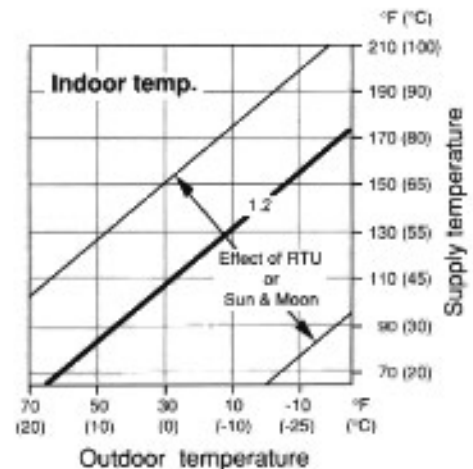
Indoor temperature adjustment (☀, ☾, RTU)

If the heating curve has been properly set then the indoor temperature which the hydronic heating system maintains can be adjusted by shifting the heating curve. The Multi-Stage Boiler Reset Control provides three methods of shifting the heating curve.

First, when nothing is connected to terminal RT then only the sun (☀) adjustment is in effect. With the sun adjustment in its centered position (|) the indoor air temperature should be 65°F (18°C) if there are no auxiliary heat sources. In this case the sun adjustment is also the Warm Weather Shut Down (WWSD) adjustment because whenever the outdoor air is warmer than the desired indoor air temperature, the boilers and pump will be kept off. The range of the sun adjustment is 65°F ± 20°F (7°C to 30°C).

Second, when terminal RT is connected to Cs then both the sun (☀) and moon (☾) adjustments are in effect. The moon adjustment causes the desired indoor temperature to be from 0°F to 40°F (0°C to 22°C) below the sun adjustment. The control will limit the desired indoor temperature to warmer than 32°F (0°C).

The third method of shifting the heating curve is to connect a Room Temperature Unit (RTU) or a tekmar Multi-Zone Control to terminals RT and Cs. The sun and moon adjustments become inoperative and RTU adjustments plus the actual room temperature determine shifting of the heating curve.



Warm Weather Shut Down (WWSD)

Whenever the outdoor air is warmer than the desired indoor air temperature, the boilers and pump are turn off and the WWSD light is turned on. If pump operation is selected then every three days the system pump is cycled on for four minutes to prevent seizure of its bearings during long periods of inactivity.

Testing and Troubleshooting

Do not plug the control into its base until the following tests have been performed. If any of these tests fail, check the wiring from the base to the sensor as well as the sensor itself.

Step 1 Test the sensors

- Install the sensors as in page 2. Using an ohmmeter, measure the resistance between terminals 14 & 15, 14 & 16, and if an RTU is connected, between 13 & 14.
- The following table lists the expected resistance values at various sensor temperatures. The resistance between ground (the pipes), and any of terminals 12 to 16 should be greater than 1,000,000 ohms, and the voltage (AC or DC) must be zero.
- If a Six Relay Expansion Module is also being installed, check that D on the Multi-Stage Boiler Reset Control is connected to D on the Expansion Module and similarly Cs is connected to Cs.

Step 2 Test the Power Supply

- Turn on power to the transformer. Using an AC voltmeter, measure the voltage between terminals 1 & 2. The voltage should be between 20 and 28 volts AC.

Step 3 Test the Boilers

- Ensure that the heating system pump or combustion/ventilation dampers operate when terminal 2 is shorted to 3. Shorting terminals 4 & 5 should turn on boiler stage 1, terminals 6 & 7 should turn on boiler stage 2, etc.

Sensor temperature		Resistance Ω	Sensor temperature		Resistance Ω	Sensor temperature		Resistance Ω
°F	°C		°F	°C		°F	°C	
-50	-45	59,000	50	10	3,700	150	65	500
-30	-35	33,000	70	20	2,400	170	76	360
-10	-23	17,000	90	32	1,500	190	88	250
10	-12	10,000	110	43	1,000	210	100	180
30	0	5,600	130	54	720	230	110	140

Step 4 Test the Control

Turn off the power. Set the function switch and adjustments on the control according to the instructions on pages 3 to 7. Plug the control into its base and turn on power to the base. The power light should turn on to indicate that the control is operating correctly. The following table lists the status of the control as indicated by the lights. If the power light of the Six Relay Expansion Module flashes then the module does not have proper communication with the Multi-Stage Boiler Reset Control.

Power light	WWSO light	Status
On	Off	Normal heating or setpoint operation.
On	On	Warm-Weather Shut Down operation.
On	Flashing	Watchdog timeout. Turn power off then on.
Flashing	On or Off	Outdoor sensor is shorted or disconnected.
Flashing	Flashing	Supply sensor is shorted or disconnected.
Off	On or Flashing	Internal error. Return for servicing.
Off	Off	Check power supply.

Manual Operation

The boilers and pump can be manually operated once the control is removed from its socket. To turn on the pump, short terminals 2 & 3. To turn on the boilers set the boiler aquastats to the required supply temperatures and short terminals 4 & 5 to turn on boiler stage 1, terminals 6 & 7 to turn on boiler stage 2, etc.

Limited Warranty and Product Return Procedure

Limited Warranty: tekmar warrants to the original purchaser each tekmar product against defects in workmanship and materials when the product is installed and used in compliance with tekmar's instructions. This limited warranty covers the cost of parts and labour provided by tekmar to correct defects in materials and/or workmanship. Returned products that are fully operational are not considered a warranty case. tekmar also does not cover parts or labour to remove, transport or reinstall a defective product. tekmar will not be liable for any damage other than repair or replacement of the defective part or parts and such repair or replacement shall be deemed to be the sole remedy from tekmar. This warranty shall not apply to any defects caused or repairs required as a result of unreasonable or negligent use, neglect, accident, improper installation, or unauthorized repair or alterations. In case of defect, malfunction or failure to conform to warranty, tekmar will, for a warranty period of 24 months from the date of invoice to the original purchaser or 12 months from the date of installation of the product, whichever occurs first, repair, exchange or give credit for the defective product. Any express or implied warranty which the purchaser may have, including merchantability and fitness for a particular purpose, shall not extend beyond 24 months from the date of invoice or 12 months from the date of installation of the product, whichever occurs first.

Replacements: tekmar can send replacement products if requested. All replacements are invoiced. Any possible credit for the replacement will only be issued once the replaced product has been returned to tekmar.

Product Return Procedure: Products that are believed to have failed must be returned to tekmar Control Systems Ltd, 4611-23rd Street, Vernon B.C. Canada V1T 4K7 when agreed to by tekmar. The installer or other qualified service person must, at the owner's expense, determine which component has failed. The product must be returned complete with

all of its components (sensors, base, etc.). Products must be returned together with the proof of purchase to the original purchaser who then returns the product to tekmar after receiving a Return Goods Authorization (RGA) number from tekmar.

Please include the following information with the product. The full address of the original purchaser, the RGA number and a description of the problem.

From the U.S.A., in order to avoid customs charges, products must be returned via US Post with the package clearly marked with the RGA number, product type and the statement "Canadian Product returned for repair". For shipping purposes the product can be valued at one half list price.

- 1) If returned during the warranty period and the product is defective, tekmar will issue full credit for the returned product less cost of missing parts.
- 2) If returned during the warranty period and the product is fully operational, tekmar will return the product to the original purchaser for a testing cost of \$30.00 plus postage.
- 3) If returned during the warranty period and the product is not damaged and is fully operational, tekmar can take back the product for a return charge of 40% of the product's net value. This request has to be specified otherwise the product will be returned with a testing cost of \$30.00 plus postage.
- 4) If returned after the warranty period and the product needs repair, tekmar will repair and return the product. Repair and postage costs will be invoiced. tekmar's repair costs are calculated at \$30.00 / hour plus the cost of parts. If the repair costs will be more than \$60.00 a repair estimate will be sent to the original purchaser.

In North America:	tekmar Control Systems Ltd., Canada tekmar Control Systems, Inc., U.S.A. Head Office: 4611 - 23rd Street Vernon, B.C. Canada V1T 4K7 Tel. (604) 545-7749 Fax. (604) 545-0850
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