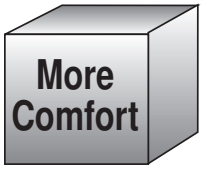
tekmar® - Essay

Control Functions and Benefits

E 005
07/01

A hydronic heating control system performs many complex and important functions. Each of these functions provide benefits that make the system comfortable, energy efficient, reliable and easy to operate. This essay provides a short description of these functions in order to assist in the selection of the appropriate control solution.



More comfort is achieved by:
- maintaining accurate system temperatures
- ensuring quiet system operation
- preventing excessive temperatures on heating surfaces
- providing the right amount of heat when and where you want it

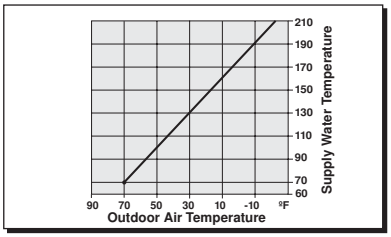
Energy savings is achieved by:
- minimizing boiler short cycling
- operating the boiler and the heat distribution system efficiently
- shutting down the system when no heat is required
- operating the system at the lowest practical water temperature

High quality is achieved by:
- protecting the boiler from corrosion and thermal shock
- preventing excessive temperatures in the heating system
- preventing corrosion and precipitate build up by exercising system components
- minimizing cycling of equipment
- providing high quality controls

Ease of use is achieved by:
- providing easy and consistent wiring and installation procedures
- providing feasible mounting options of enclosures
- providing automatic testing of wiring and detection of sensor faults
- minimizing manual settings through automatic functions
- providing visual readouts of system status

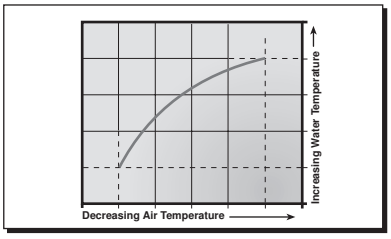
Functions

1 Outdoor Reset



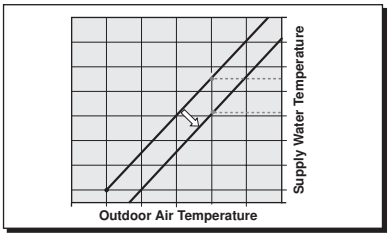
In order to properly control a hot water heating system, the heat supplied to a building must equal the heat loss from the building. The heat loss is dependent on the outdoor temperature. It is therefore necessary to reset the supply water temperature based on the outdoor temperature. The ratio at which the water temperature increases as the outdoor temperature decreases is the Heating Curve. Outdoor Reset improves comfort by limiting indoor temperature swings, and provides higher energy savings by minimizing distribution and boiler stack losses.

2 Characterized Heating Curve



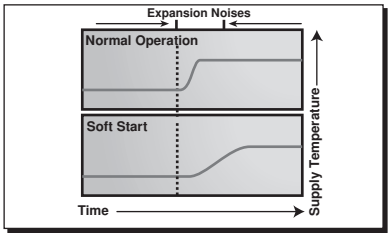
A Characterized Heating Curve is a more accurate method of outdoor reset. Each type of terminal unit delivers heat into a building with different proportions of radiation, natural convection and forced convection. With a Characterized Heating Curve, the control takes into account both the outdoor temperature and the type of terminal unit in order to determine the best water temperature for the system.

3 Water Temperature Setback



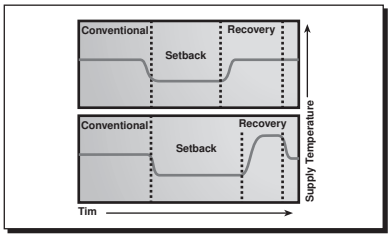
When setback is required, the water temperature to the system should be decreased to provide less heat into the space. tekmar Reset Controls shift the heating curve down in order to provide lower water temperatures when an UnOccupied signal is given to the control. The amount that the heating curve can be shifted is adjustable.

4 Soft Start



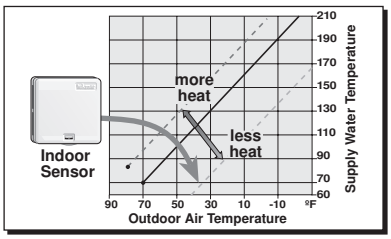
When a sudden change of supply water temperature occurs, the heating system is subjected to thermal stresses. This is evident in expansion and contraction noises. A change in supply water temperature results from a change in outdoor temperature or a change from a setback period to a recovery period. A soft start allows the control to slowly ramp up the supply water temperature to minimize expansion noises and thermal stresses.

5 Boost



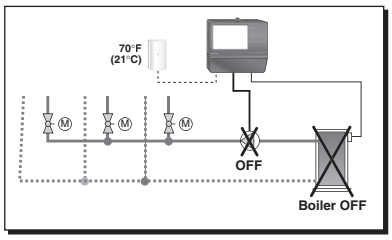
When combining setback with outdoor reset, the morning recovery period can be extremely long. By increasing the supply water temperature after the end of the setback period, a faster pick-up can be achieved. This allows for longer setback periods and therefore more energy savings can be obtained.

6 Indoor Temperature Feedback



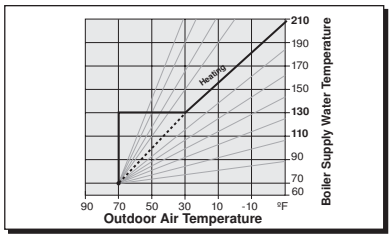
Most buildings have internal heat gains and losses due to people, passive solar heating, or opening of doors. If only the outdoor temperature is measured, the control cannot compensate for these heat gains/losses and overheating or underheating may occur. Indoor temperature feedback prevents this by shifting the heating curve up or down, in order to fine adjust the supply water temperature to the heating terminals. Single or multiple tekmar Indoor Sensors or Room Temperature Units (RTU) are required to provide the feedback to the Reset Controls. This function provides more comfort by preventing overheating or underheating.

7 Warm Weather Shut Down



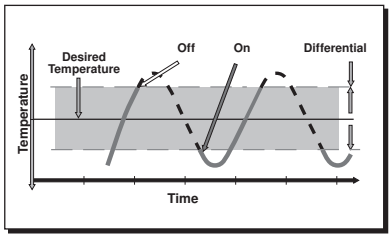
When the outdoor air temperature is warmer than the indoor temperature, no additional heat is required in the building and therefore the heating system can be shut down. Warm Weather Shut Down (WWSD) provides an adjustable temperature at which the heating system can be automatically turned off. This function increases system efficiency by preventing boiler operation when heat is not required.

8 Boiler Outdoor Reset



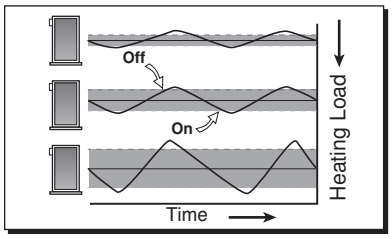
A boiler is controlled by turning it on and off. In applications where Outdoor Reset is used, the boiler temperature can be lowered based on the outdoor temperature. Resetting the boiler temperature is limited by the boiler manufacturer's minimum recommended operating temperature and allows water temperature reset for about 50% of the heating season. This function improves comfort by supplying the right amount of heat, and provides higher energy savings by minimizing distribution and boiler standby heat losses.

9 On / Off Differential



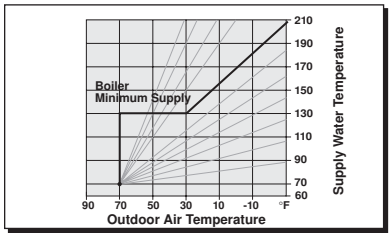
An on / off device, such as a boiler, must be operated with a differential in order to prevent short cycling. When the supply water temperature drops below the bottom rail of the differential, the device is turned on. The device is then kept on until the temperature reaches the upper rail of the differential. If the differential is set too wide, there can be large temperature swings, and if the differential is set too small the device short cycles and operates inefficiently.

10 Boiler Differential (Automatic)



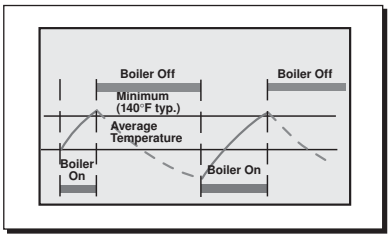
In order to decrease temperature swings and increase boiler efficiency, this function automatically changes the on / off differential of the boiler based on the heating load. As the load increase, the differential will decrease to minimize temperature swings. As the load decreases, the differential will increase to prevent short cycling. See item 9 for a description of on / off differential

11 Boiler Minimum Supply



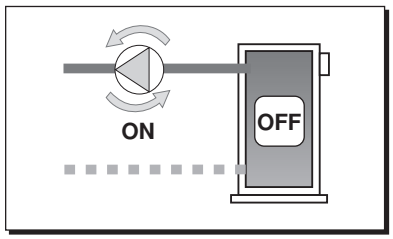
Most boilers require a minimum supply water temperature in order to prevent corrosion from flue gas condensation. The control should therefore only modulate the boiler supply water temperature down to the boiler manufacturer's minimum recommended operating temperature. This function allows the user to adjust the boiler minimum supply temperature based on the type of boiler being used.

12 Boiler Temperature Averaging



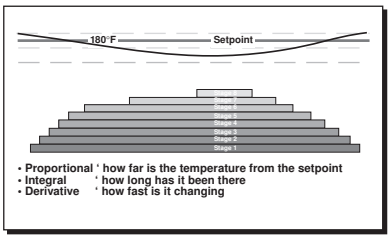
During mild outdoor temperatures, low supply water temperatures are desired in order to prevent overheating in the building. Most boilers must be operated at temperatures above the flue gas dew point to prevent condensation. This function operates the boiler at an average temperature below the boiler minimum supply in order to prevent indoor air temperature overshoot. However, the control ensures the boiler reaches the minimum boiler supply every time it is fired. This function provides more comfort by minimizing indoor temperature swings.

13 Boiler Post Purge



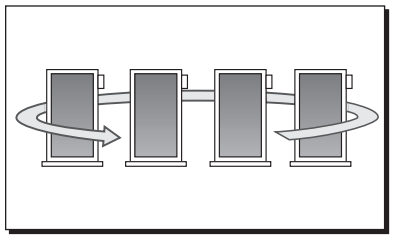
When a boiler is turned off some heat remains in the mass of the boiler. If the flow through the boiler is stopped at the same time the boiler is shut off, the residual heat is lost. Therefore, after operation of the boiler the residual heat in the boiler should be purged to the system in order to decrease standby losses. This is accomplished by turning the boiler off but keeping the system pump on for a period of time. This function increases system efficiency by minimizing standby losses.

14 PID Staging



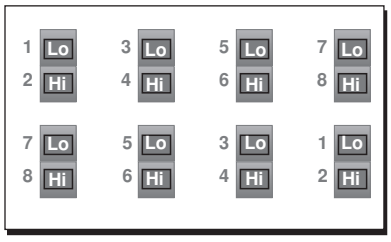
To provide proper boiler staging and accurate boiler supply temperatures, PID (Proportional, Integral, Derivative) control logic should be used. With PID control logic, the number of boilers fired depends on how far the boiler temperature is below the setpoint, how long the error has persisted, and how fast it is changing. This function provides greater boiler plant efficiency and also prevents water temperature droop that is commonly seen on proportional staged systems.

15 Equal Run Time Rotation



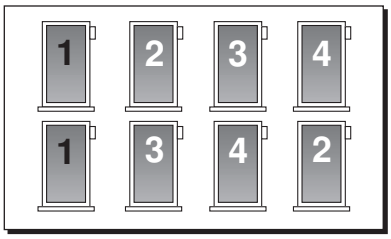
This function rotates the firing sequence of a group of staged boilers based on the accumulated running hours of each stage. When one stage has accumulated 48 hours more running time than any other stage, the operating sequence is rotated. The stage with the least running hours is rotated in the firing sequence to turn on first, while the one with the most running hours will be last. This function increases the quality and reliability of the boiler plant by ensuring equal running times of all boilers.

16 Lo / Hi Fire Boiler Rotation



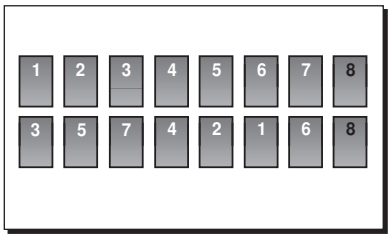
Many boilers or water heaters have two stage burners. The control must therefore stage the operation of the burner by first firing the lo fire and then the hi fire. If equal run time rotation is desired, the control must now rotate the two stages in sets of two. This ensures that the burner always fires in the proper sequence while still ensuring equal running times of all boilers.

17 Fixed Lead



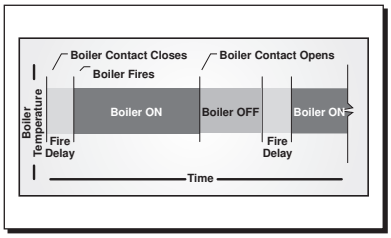
When multiple boilers are staged and rotated the first boiler can be fixed to be fired first at all times. This function allows the boiler nearest to the chimney to create sufficient draft to prime the chimney. This function can also be used to increase boiler plant efficiency by selecting a high efficiency boiler to be cycled first. This higher efficiency boiler takes the part load of the boiler plant which increases overall efficiency.

18 Fixed Last



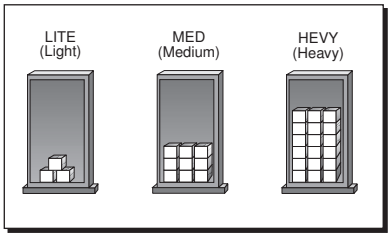
When multiple boilers are staged and rotated, the last stage can be fixed to fire last. A common application is to allow a second boiler plant, such as a DHW boiler plant, to assist with the heating when the DHW system is satisfied. Another common application is to front end load an older inefficient boiler with several higher efficiency boilers. Most of the heating load can be satisfied by the higher efficiency boilers and only during extreme conditions will the old boiler be allowed to fire. This function allows for added flexibility when designing or retrofitting a boiler plant.

19 Fire Delay



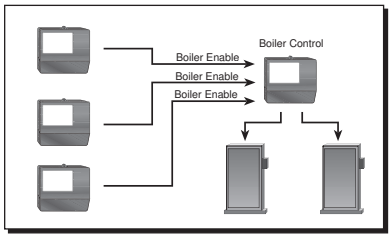
Most boilers have built in safety delays before the burner is allowed to fire. The Fire Delay function allows a boiler staging control to account for the delay between the time that the control signals the boiler to operate and the burner actually fires. By taking into account the delay time, the control can more accurately determine the required number of stages to turn on. This function improves the efficiency of the system by minimizing short cycling in a multiple boiler system.

20 Boiler Mass



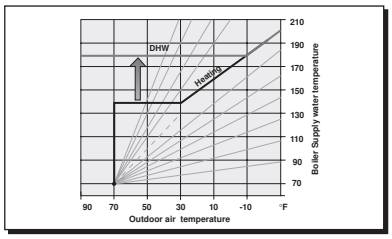
The heat up and cool down rate of a boiler depends on how much thermal mass the boiler contains. By knowing how fast the boiler heats up and cools down, the control can more accurately determine the required number of stages to turn on. The Boiler Mass function allows the multiple boiler control to intelligently stage the boiler plant. This function increases the efficiency of the system by reducing unnecessary staging.

21 Boiler Enable



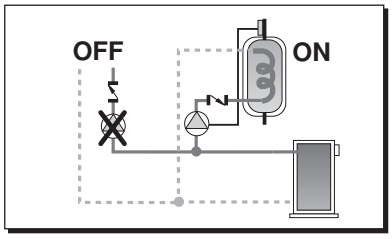
When multiple controls in a single system try to operate the boiler(s) simultaneously, short cycling can occur. For the most efficient boiler operation, only one control should operate the boiler(s). All of the remaining controls should send a simple on / off signal to the boiler control. This function when used with a proper boiler control improves the system operation by preventing short cycling of the boiler(s). This also allows for easy integration of controls into existing systems.

22 DHW Boiler Reset Override



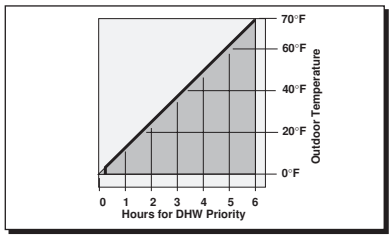
Most indirect fired DHW tanks require a boiler supply water temperature of at least 180°F (82°C) in order to transfer sufficient heat. If the boiler is also using a reset control for space heating, the water temperature may be below the temperature required for DHW operation due to the current heating curve or WWSD setting. Therefore the control must override the outdoor reset and increase the boiler temperature. This function allows for shorter DHW tank recovery times.

23 DHW Priority



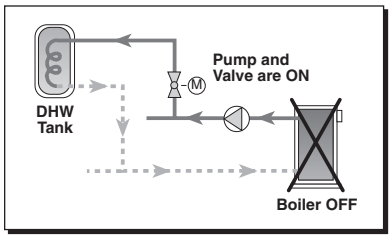
DHW priority allows the DHW tank to recover faster by temporarily suspending the heat supply to the heating system. All of the available heat is provided to the DHW tank for a period of time. This function provides more comfort by ensuring faster DHW pick up times and increases system efficiency by often allowing the use of a smaller heat source.

24 DHW Priority Override



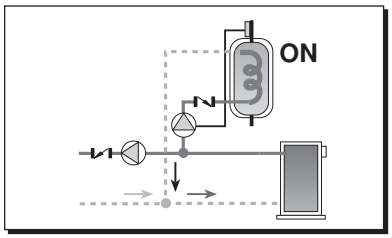
If DHW priority is selected then heat to the heating system is stopped during a call for DHW. At cold outdoor temperatures the building may freeze up when there is a long call for DHW. In order to prevent this, the control must be able to override the priority and simultaneously operate the heating system and the DHW. The maximum time allowed for DHW priority should decrease as the outdoor temperature drops. This function provides more comfort by preventing large temperature drops in the space during DHW operation.

25 DHW Post Purge



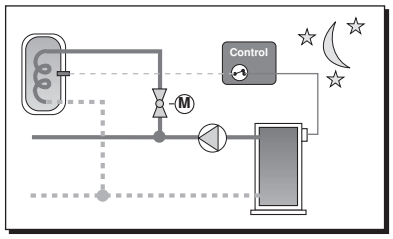
During DHW operation, the boiler temperature is normally raised above 180°F (82°C). Once the DHW tank is satisfied, the residual heat from the boiler may be wasted if there is no other call for heating. This residual heat from the boiler should be purged in order to reduce standby losses. This is accomplished by turning the boiler off but keeping the DHW pump or valve operating for a purging period. This function increases system efficiency by decreasing boiler losses.

26 DHW Mixing Purge



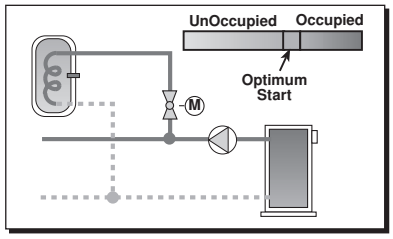
When DHW priority is used, the water temperature within the heating terminals may have cooled down significantly lower than the boiler operating temperature. When the DHW operation is complete the DHW pump will turn off and the system pump may turn on. This could cause a large temperature drop in the boiler return water, and therefore, may induce thermal shock. In order to provide a smooth transition between the DHW and heating loads the control briefly operates the two pumps simultaneously in order to mix the two returning water temperatures.

27 DHW Setback



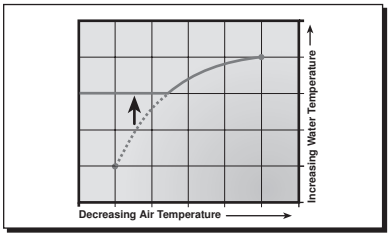
During the night, or when people are not within the building, energy can be saved by lowering the DHW tank temperature. This is achieved by ignoring the DHW call for heat during the setback period. Energy savings is obtained through lower heat losses from the tank as well as by preventing inefficient boiler operation during periods of low DHW demand.

28 DHW Optimum Start



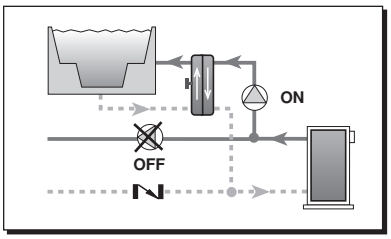
To ensure that the DHW tank is up to temperature after the DHW Setback period the control must raise the tank temperature before the setback period ends. This can be accomplished automatically by using a control that has an optimum start / stop function. This function increases comfort by ensuring the DHW tank is up to temperature at the beginning of the occupied period.

29 Setpoint Boiler Reset Override



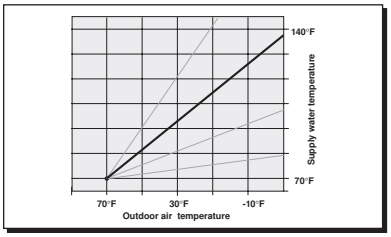
Most setpoint loads in a heating system operate year round and often at temperatures above the reset operating temperature. When the setpoint load requires heat, this overrides the Warm Weather Shut Down and Reset temperature of the control. This functions allows the heating system to operate only at the temperature required to satisfy the current load. This saves energy over a system that maintains a constant temperature sufficient to satisfy the highest load.

30 Setpoint Priority



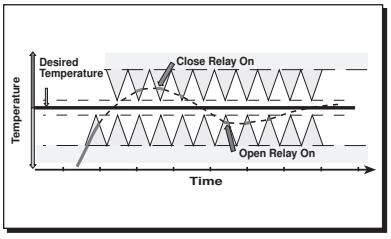
Setpoint Priority allows the setpoint load to recover faster by temporarily suspending the heat supply to the heating system. All of the available heat is provided to the setpoint load for a period of time. This function provides more comfort, by ensuring faster setpoint pick up times, and increases system efficiency by often allowing the use of a smaller heat source.

31 Mixing Outdoor Reset



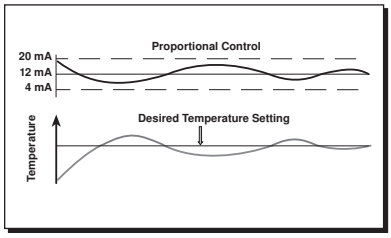
The full range of temperatures required through a heating season can be provided with a non-condensing boiler together with a mixing device. The mixing device provides different water temperatures based on the outdoor temperature throughout 100% of the heating season, and it is not limited by the boiler manufacturer's minimum recommended operating temperature. This function provides more comfort by reducing indoor temperature swings and increases system efficiency by reducing system distribution losses.

32 Floating Action Output



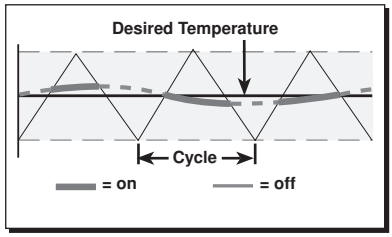
Floating action is an output used to modulate the position of an actuating motor and mixing valve. Floating Action either provides power to drive the motor further open or closed. If no power is supplied, the actuating motor remains at its present position. This is a simple and cost effective method for controlling the position of a mixing valve.

33 Modulating Output



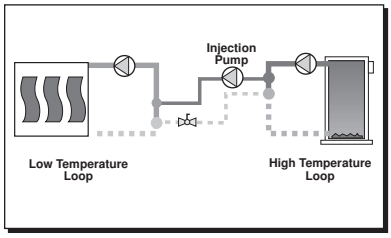
A modulating output provides a signal which is directly proportional to the actuator position required by the control. Common modulating output signals are a 4-20 mA, 0-135 Ω, or 2-10 V(dc). These signals can also be used to modulate the speed of an injection pump through a motor speed controller.

34 Pulse Width Modulation



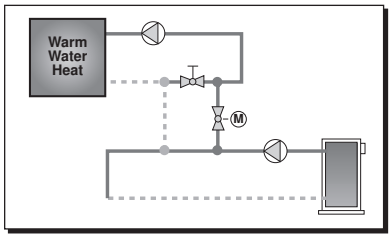
Pulse Width Modulation (PWM) is an on / off action that differs from an on / off differential by changing the length of the "on" time based on how much the actual temperature differs from the desired. The heating device is operated based on "how much" heat is required. This function prevents overshoots and undershoots in systems with large thermal mass such as pools or slabs.

35 Variable Speed Output



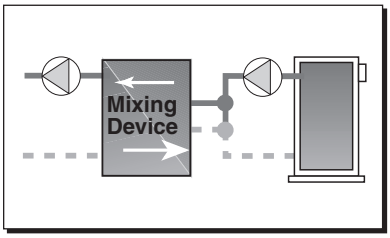
Variable Speed Output is used to vary the speed of a permanent capacitor, impedance protected pump motor of less than 1/6 hp. The pump is piped to inject hot water at different rates from a high temperature loop into a low temperature loop. Variable speed injection mixing provides fast and accurate temperature control and is especially suited for boiler return protection where a fast response is critical.

36 On / Off Injection Output



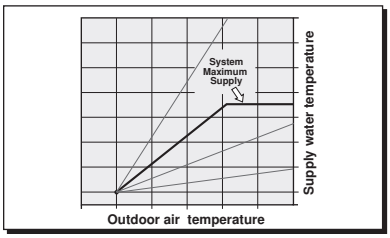
On / Off Injection output is used to operate an on / off device, such as a valve or a pump , in order to inject heat into a constant circulating low temperature loop. This type of mixing requires a differential in order to prevent short cycling of the injection device. This function provides a cost effective mixing system.

37 Boiler Protection



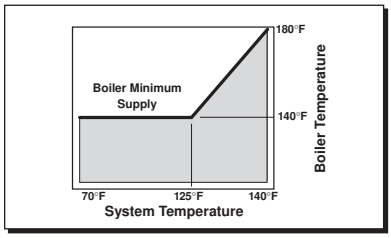
To protect the boiler against flue gas condensation and thermal shock, a mixing device should be used to control the load on the boiler. If the temperature of the boiler is below the condensation temperature or the return water temperature suddenly cools down, the mixing device can back off, allowing the boiler loop to come up to temperature. By protecting the boiler, this function provides longer boiler life.

38 System Protection



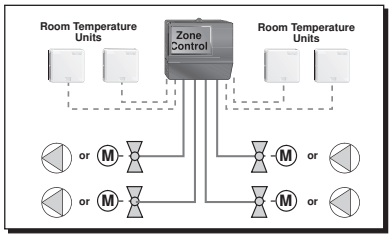
Some systems such as radiant floor heating must be maintained below an allowable maximum temperature in order to protect the tubing or flooring surface. System protection can be achieved by limiting the supply water temperature to the mixing loop. This function provides a high quality system by preventing potential damage from excessive temperatures.

39 Boiler Load Reset



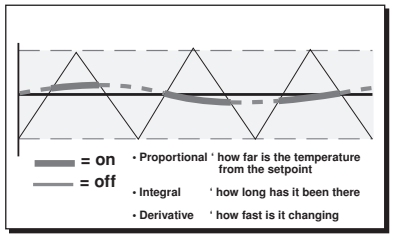
Many systems, such as radiant heating, use a mixing device to reduce the system supply water temperature. The boiler in these systems should be operated at the minimum allowable water temperature in order to reduce standby losses. As the heating load increases and the mixing device is fully open, the boiler temperature should be increased to satisfy the heat requirement. This function provides higher system efficiencies and better controllability by operating the boiler at the proper temperature.

40 Integrated Zoning



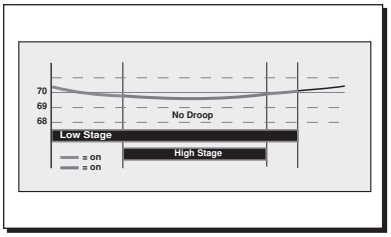
Integrated Zoning allows one central zone control to control multiple zones in a heating system using state of the art microprocessor technology. Sensors throughout the building are connected to the zone control and provide Indoor Temperature Feedback. Integrated Zoning provides Zone Load Coordination in order to minimize flow rate changes in the system and therefore, increase system efficiency. Integrated zoning also allows for pump and valve exercising as well as simpler cooling interlock wiring.

41 PID Zone Temperature Control



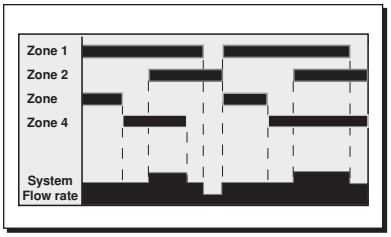
To prevent excessive room temperature swings and offset, PID (Proportional, Integral, Derivative) control logic should be used to control the zone temperature. With PID control logic, the control operates the zones based on how far the indoor temperature is below the desired temperature, how long it has been there, and how fast it is changing. This function provides more comfort by maintaining an accurate indoor temperature.

42 Two Stage Heating



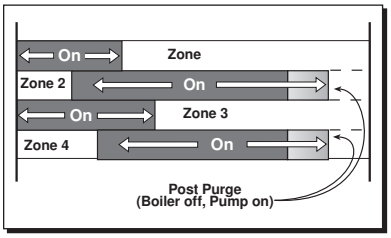
To provide proper two staging heating and an accurate room temperature, PID (Proportional, Integral, Derivative) control logic should be used. With PID control logic, the operation of the second stage depends on how far the room temperature is below the setpoint, how long the error has persisted, and how fast it is changing. This function prevents room temperature droop that is commonly seen with conventional two stage thermostats.

43 Zone Load Coordination



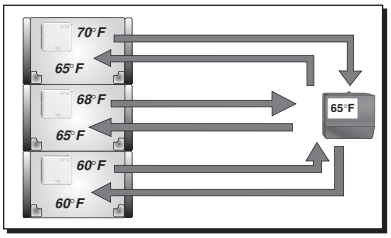
In a multiple zone system there can be sudden load changes due to multiple zones opening and closing. Zone load coordination staggers the operating times of each zone in order to maintain a relatively constant flow through the boiler and even out the load in the system. This function increases system efficiency and reliability by minimizing mechanical stresses and short firing cycles of the boiler.

44 Zone Post Purge



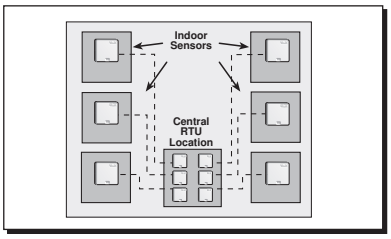
Since a Zone Control calculates all the on times of the zones, a Zone Post Purge can be performed. Before the last zone is turned off in a heating cycle, the boiler is turned off but the zone continues to draw heat from the boiler. This post purge decreases boiler standby losses and reduces overall energy consumption.

45 Adjustment Range Limit



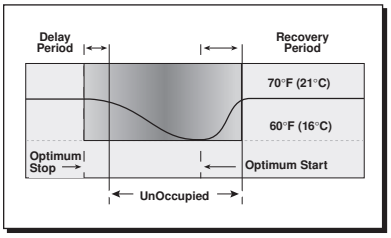
In systems where tenants have control of the space temperature, a central zone control with a temperature Adjustment Range Limit can allow the building owner to limit the maximum space temperature in the zones. This function saves energy by limiting the heat supply to the zones.

46 Remote Sensing



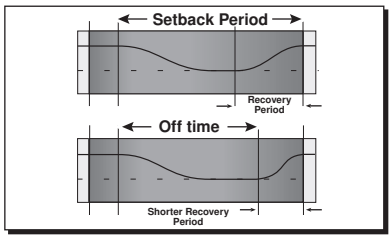
Remote sensing allows the end user to control the indoor temperature of several zones from one central location. Multiple indoor sensors located throughout the building measure the zone temperatures. Each sensor is connected to a Room Temperature Unit (RTU) which controls the desired zone indoor temperature.

47 Optimum Start / Stop



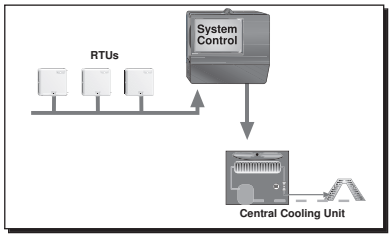
When a setback schedule is in effect, the building experiences delays in dropping down its temperature at the beginning of the setback period, and increasing its temperature at the end of the setback period. The Optimum Start / Stop function learns the response of the system in order to calculate a start time for the heating system so that the building is warmed up when the occupied period begins. The Optimum Start / Stop function increase the efficiency of the system and provides more comfort.

48 Water Temperature Boost



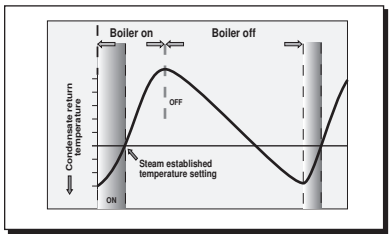
By increasing the supply water temperature during the recovery period before the end of the setback schedule, faster pick up times can be achieved. This allows for longer setback periods and therefore more energy savings can be obtained. This function works in conjunction with indoor temperature feedback in order to determine the correct amount of water temperature boost.

49 Heating / Cooling Interlock



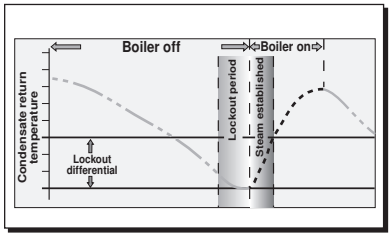
Heating / Cooling Interlock prevents the system from heating and cooling simultaneously. When the heating Room Temperature Units (RTU) have been satisfied for a period of time, the control allows for the cooling unit to operate. If a cooling RTU is used, the control operates the cooling unit to maintain space temperature. This function simplifies external wiring, and prevents inefficient system operation.

50 Steam Established



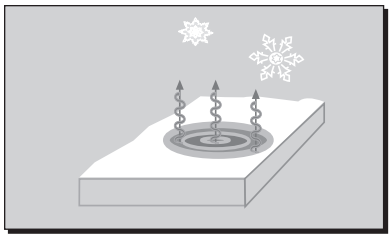
In steam systems the boiler is operated in heating cycles which are dependent on the outdoor temperature. Each heating cycle starts when the system is filled with steam. The Steam Established function delays the start of the heating cycle until steam is established throughout the system. The Steam Established function provides more accurate response by accounting for the time that the system takes to come up to temperature.

51 Lockout Differential



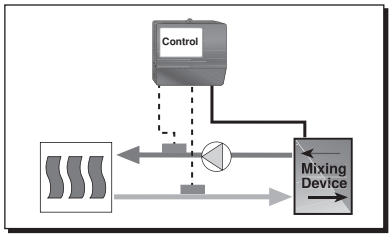
In order to increase the efficiency of a steam system, a Lockout or cool down period before each heating cycle can be used. The lockout differential ensures that the condensate temperature drops before turning the boiler on for the next cycle. This increases the efficiency of the system by removing the latent heat from the steam remaining in the heating system after the boiler shuts down.

52 Snow / Ice Detection



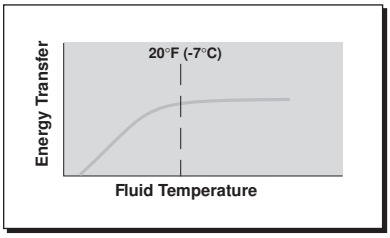
Snow / ice detection is used to automatically start and stop a snow melting system. When there is snow on the sensor, the sensor melts the snow / ice, detects the moisture and allows the control to start the melting process. This prevents accumulation of snow on the slab and provides a faster response. Automatic snow / ice detection is safer, more convenient and consumes less energy than manual systems.

53 Slab Protection



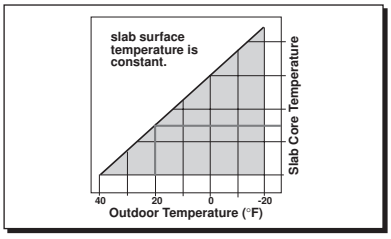
Snow melting system deal with extreme temperature differences. Slab protection is provided by limiting the rate of heat transfer into the slab. This is done by slowly ramping up the temperature difference (ΔT) across the slab and limiting the maximum temperature difference. This function prevents cracking of the slab due to thermal expansion caused by high heat inputs.

54 Viscosity Compensation



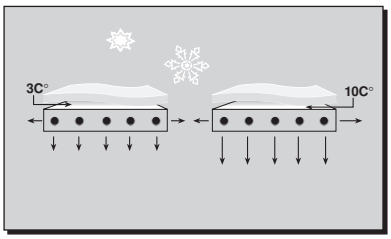
A glycol solution in snow melting systems increases viscosity at colder temperatures. This reduces the system flow rate and heat transfer. In order to compensate for these changes, the control automatically raises the maximum allowed temperature difference (ΔT) across the slab.

55 Slab Outdoor Reset



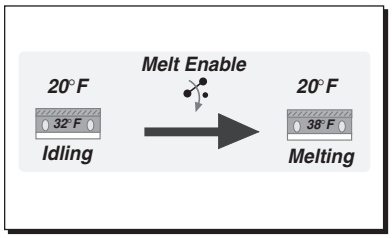
In snow melting systems the slab sensor is normally an inch below the slab surface. When the outdoor temperature suddenly drops, the sensor does not register this change immediately and surface freeze up could occur. The heat input to the slab must therefore increase as the outdoor temperature drops in order to provide a constant slab surface temperature.

56 Snow Melting Setpoint



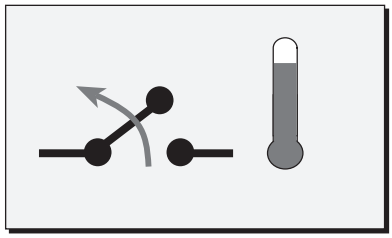
In snow melting systems accurate control of the slab surface temperature is required in order to provide an energy efficient system. When a snow melting slab operates at a higher temperature, the percentage of energy lost through the back and edge of the slab increase. This function saves energy by accurately controlling the slab temperature.

57 Snow Idling Setpoint



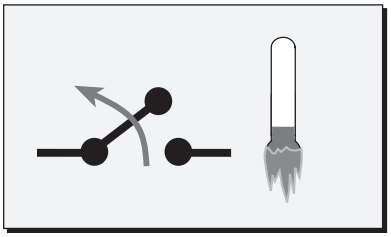
In systems where snow and ice removal is critical, such as hospital ramps, the pick up time for a snow melting slab can be reduced by maintaining the slab at an idling temperature. The idling temperature may be just below the freezing point. When snow melting is required, the slab temperature is increased.

58 Warm Weather Cut Off



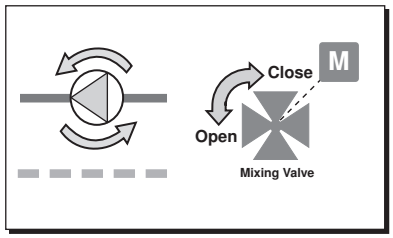
When the slab and outdoor temperatures are warm enough, the snow melting system should automatically turn off. The Warm Weather Cut Off (WWCO) function automatically shuts off the system when snow melting is not required. This saves energy by not allowing unnecessary slab warning.

59 Cold Weather Cut Off



At extreme cold outdoor temperature, considerable energy can be saved by turning the snow melting system off. With these extreme outdoor conditions, the snow may only be partially melted resulting in ice formation and a safety hazard. Cold Weather Cut Off (CWCO) prevents the system from turning on if there is insufficient capacity to fully melt the snow.

60 Pump / Integrated Exercising



The control operates the system components every three days for a few seconds to help prevent corrosion build up and the subsequent seizure. The control must ensure that during exercising no heat is supplied to the zones in order to prevent overheating in the summer.

tekmar® Control Systems

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All specifications are subject to change without notice.
Printed in Canada. E 005 - 07/01.