A Whitepaper On The Kennedy Controls '**Kentrol Energy Miser**' Building Energy Control System

What The System Is –

The Kennedy Controls Corporation '**Kentrol Energy Miser**' system uses the laws of physics and sophisticated software running on a Windows PC to control the heating or cooling of a building. The system provides maximum fuel savings consistent with the building being at the desired temperature for its function all of the time. It is applicable to nearly any building that is heated or cooled using purchased energy of significant value, and has additional valuable functions as well. The system is designed to work with common types of heating and cooling equipment – steam, hot water, forced air, etc. – and will work with any type of heat or cooling source – natural gas, fuel oil, coal, geo-thermal, propane, electricity, etc. It is a control system. . . it does not replace the heating or cooling equipment. The actual control is accomplished through the use of two types of special 'black boxes' installed in the building.

What The System Has To Deal With –

The energy consumed for heating and cooling, and therefore the cost of heating and cooling, is proportional to the difference between inside and outside temperatures. When the inside of the building and the outside of the building are the same temperature, no energy flows in or out of the building. The greater the difference there is between the building's inside and outside temperatures, the more energy flows. Heat energy flowing out of the building in the heating season and heat energy flowing into the building during the cooling season require purchased energy to offset the flow so the desired building interior temperatures can be maintained.

Although it is difficult to manage, one can see from the above information that if one could somehow allow the building temperatures to be as close to the outside temperatures as possible during times of the building's non use (nights, weekends, holidays, vacation periods, etc.), the heat transfer would be minimized. If the heat transfer were minimized, the energy cost would be minimized as well.

The difficulty in a management scheme to achieve the above goal is complicated by a number of factors. Consider heating a school building in the winter, for example. If a given class room has a thermostat, its function is to maintain the same temperature in the classroom all the time. Therefore heat loss during the non-use period of the room is much greater than it would be if the temperature in the room was allowed to lower somewhat.

The simplest attempt at a solution would be the use of a timed thermostat or other timing device connected to the thermostat. For instance, one could lower the classroom's desired temperature from 72 to 62 for the period of 5 PM to 6AM. Definite savings would result, but there are four complications.

First, the selection of 62 degrees for the non-use period desired temperature was arbitrary. Could it have been 52, for instance? More savings would have resulted. Could it have been allowed to leave the temperature 'down' for a longer period. . . say until 7AM, for instance?

Second, what about weekends or school holidays? And perhaps more important, what about returning the temperature back to normal for special events or meetings held at night or weekends?

Thirdly, since the outdoor temperature is always changing, doesn't all of the above have to change to match the outdoor conditions – in other words, if it isn't so cold (or windy) out on a given night could the setback

period be longer than if it was colder? Of course, the answer to that one is yes – but how much longer could it have been?

Fourth, if the setback was for a longer period it could be 'deeper'. For instance, consider the difference between an overnight setback and a weekend or holiday setback. If an overnight setback is too deep, the heating equipment may not be able to bring the temperature back up in time. On the other hand, a deep setback can be used when the setback period is for several days, as the setback wouldn't be 'undone' by the requirement of an early return that took a large percentage of the setback time.

All of the above is for one room. The thermal characteristics of a given room are unique to that room. Every other room in that building has a different set of characteristics based on its makeup, its location with respect to other rooms, the direction it faces, capability of the heating system in it, and a host of other factors.

As you can see, the optimization of any set back program is based on a number of conditions as explained above. . . but the most significant conditions are ones that have to do with the variability of the weather, or the 'weather pressure' on the building. Weather pressure as used here is a term used to identify a plurality of characteristics. The most obvious is the temperature outside. Another factor is the wind outside. Higher wind causes more effect on the building through both degradation of the stationary or boundary layer of air on the outside of the building and by increasing infiltration loss through increased leakage around doors, windows, ventilator openings, etc. A third factor is the effect of the sun on the building, and there are other factors in weather pressure as well.

The Solution –

Dealing with all of the above in order to calculate the optimum setback in temperature for the optimum time for every room in the building under all possible weather conditions is simple for the **Kentrol Energy Miser**. The system does everything for you. From day one of the installation, it collects the data, it analyzes the data and it files the data for future use. It gets smarter the longer it is installed. The **Kentrol Energy Miser** solution is in two parts, getting the data, and then making the best decisions possible.

Through the use of the 'black boxes', the **Kentrol Energy Miser** easily, quickly and continuously gathers the pertinent data – the thermal characteristics of the room versus the weather outside. The powerful software handles the data and makes the decisions for the setback amount and duration. Additionally, the computer automatically updates its decision making process in response to changing outside conditions. And it does all this without any operator input or attention!

Many natural phenomena of the 'Newtonian laws of physics' can be predicted with a combined calculus function called proportional integral derivative, or PID. PID has been around for a long time, and it is the basis for the complex algorithm used by the software. While this is completely transparent to the user, the **Kentrol Energy Miser** quickly and easily makes 'impossible' calculations and determinations to generate the utmost in energy savings.

Implementation –

Both implementation and installation are simple. Kennedy Controls is experienced in the design and manufacture of electronic control systems, so we have created two unique hardware devices that connect the data gathering and the controlling functions – the 'black boxes' mentioned above. One is called a WatchDog, and the other a BusMaster. Each room to be monitored has a WatchDog. Connected to the WatchDog are

both the room temperature sensor and the control for the heating and/or air-conditioning equipment for that room. Each WatchDog is typically connected to the next for a wing of a building, for instance. At the end of the series of WatchDogs is another device called a BusMaster. The BusMaster converts the WatchDog signals to an ordinary computer Ethernet (TCP/IP) LAN, which could be the one that is likely already in the building for use with 'office' computers. Connection of the WatchDogs to each other and to the BusMaster is by simple RJ-11 telephone type connectors. The BusMaster connects to the building's LAN with the customary RJ-45 telephone type connector used in conventional LAN cables. The BusMaster simply plugs into a LAN hub or switcher.

If desired, multiple BusMasters can be installed in the same building and connected to the same LAN at different locations. This is helpful in some layouts where the 'chains' of WatchDogs are physically separated by significant distances. As an example, consider a school like building with three wings of classrooms and a central hub containing a gymnasium, offices, a cafeteria, the mechanical plant, and a library. Each wing could have the WatchDogs in its rooms connected to a BusMaster, and that BusMaster connected to the LAN in that wing. The central hub could have its various rooms connected to an additional BusMaster that is also connected to the LAN. With such a scheme, wiring is simplified as the building's LAN is exploited to accomplish the connections.

The building's Ethernet LAN allows the computer that is running the **Kentrol Energy Miser** to be anywhere on the LAN, or if it is desired, anywhere in the world via the Internet. The computer could be a dedicated unit (usually recommended), or could have other duties. The ability to contact this computer via the LAN in the building, a WAN of a school or multi building corporate computer system, or the Internet is particularly significant, as it goes a long way to making the system practical to install and maintain. Incidentally, the WatchDogs continue with their last instruction set should the connection to the computer be broken. The system is therefore at least partially immune to LAN or computer outages.

Of course, if the building doesn't have any existing computers or LAN in it, a simple CAT 5 cable can be run from the BusMaster(s) to the computer or Internet connection.

Software Features –

The main features of the software are two fold. The first part is related to setting up the system and allows things like the assignment of building room numbers to WatchDogs, etc. The second part contains the actual daily operation of the system, which includes a number of helpful features.

Since the setup is done only once and is fairly simple, most of the interaction with the user is with the operation portion of the software. One of the most frequently used parts of the operation is a Calendar where each room's control can be set up or altered if desired. For instance, if the gymnasium in a school is normally only required to be up to temperature during school hours, but it is known months in advance when night functions of the gym are to be held, this information can be input to the calendar. Similarly, impromptu changes can be made if night use of a classroom or office is desired at a time that would normally be 'set back'.

Access to control of the system is broken into two levels. System Administrator Control is necessary for setup and some information readout functions. System Administrator Control is accessed by password to only those that are in charge of the system as it contains the WatchDog and BusMaster setup functions, etc. Local Administrator Control is accessed by a different password and allows access to make setup changes related to the building's use. In a school, for instance, the building chief administrator or his assistant may make alterations to the 'normal' programmed function because of a classroom being used at night for a meeting, for instance. This is normally done by accessing the Calendar mentioned above. Access to setup functions is not allowed in the Local Administrator Control mode.

In either mode, historical data can be viewed. An example would be to view the temperatures in a given room over time. Typically, the recorded temperature and the calculated target temperature are simultaneously plotted against time. The performance of the system and a historical record of the room's temperature are available easily and, of course, the current temperature of any location can be similarly viewed.

Boiler Control –

It has been said that aside from setback, the greatest savings possible occur from control of unneeded boiler operation. Holding a boiler at steam or hydronic water temperature when the building is not calling for heat is pure waste. Hence if a control system could anticipate when heat would be needed next, and shut down the boiler until a time only prior to that point such that the heating load would be met, economies could be achieved.

The **Kentrol Energy Miser** has a special function that does just that. It monitors the building state, the state the building will be required to go to in the future, and the outside conditions. From this information it can make an intelligent decision as to when the boiler could be shut down, and when it will need to fire again in order to meet the building demand.

In order to provide this function, a WatchDog is simply connected to the boiler. Then when the boiler is not needed for heating, it is shut down. . . but will be restarted in time to meet future heating loads. This particular WatchDog is controlled by a special section of the software that is dedicated to boiler control. Additionally, multiple boilers can be similarly controlled; with the **Kentrol Energy Miser** software staging the boilers as required if that is desired. This staging can add significant economies in multiple boiler systems through 'seasonal efficiency'.

Other Features –

In addition to the above features, the system is capable of a great range of additional tasks. The most significant of these is perhaps the steam trap monitoring function which is capable of monitoring the function of steam traps used in the common two pipe steam heating system. Each WatchDog of the type used to monitor and control a room's temperature actually has two inputs. The second input can be connected to a temperature sensor just downstream of the trap. If the trap malfunctions, the sensor will detect steam temperature in the condensate piping. The WatchDog will then report the malfunctioning trap to the computer. An additional source of significant energy savings is eliminating the malfunction of traps. The trap monitoring function of the WatchDog not only detects this problem when it happens, but it also completely removes the requirement for trap maintenance. With the WatchDog monitoring the traps, they can normally be left in service without attention until they fail. In some buildings this is a tremendous benefit as well as a significant energy saving function. It is possible that this feature can change a steam heating system from being the most labor-intensive system to the least.

Similarly, devices connected to a WatchDog – with the computer being advised by the WatchDog if the system malfunctions -- can monitor boiler pressure or hydronic water temperature or pressure. As an example, consider the installation of a simple pressure switch downstream of the hydronic circulating pump in a building. If an expansion joint develops a leak or the pump stops or other malfunction occurs, the operator can be notified in seconds. The same would be true of a pressure switch on a steam boiler. If the burner failed and the steam pressure got down the operator could be notified before the building even started to get cold. Other important functions could be monitored as well – things like high water in the condensate well, low boiler water, etc.

Other functions outside the control of 'normal' heating or cooling systems can also be connected to the computer via various WatchDogs. Common examples are inputs from existing intrusion or fire alarms. In fact, the system has an optional software module that can be used to create a complete stand-alone intrusion and fire alarm system if desired.

Two other examples are 'enthalpy' control of the admission of outside air based on the air's ability to help with the conditioning of the building, and CO2 based control of outside air admission to limit the quantity of fresh air tempering required in a building. Additionally a special WatchDog is available to continuously check the sanity of the control computer. It is typically connected to a separate and isolated dialer that can call a number to advise that something is likely wrong with the computer.

That makes a total of five 'special' WatchDogs – other than the standard unit used to replace a thermostat and gather data from a conditioned space. To recap. . . the five are 1) boiler control, 2) alarm [fire, intrusion, low pressure, high water, low temperature, etc.], 3) CO2 control of fresh air, 4) enthalpy control for the use of outside air to more economically condition the controlled space, and 5) the computer sanity WatchDog.

Alarm Emergency Reporting –

In the event of a serious system malfunction – anything from a building room that won't stay at temperature and therefore might freeze, to the building being on fire can be setup to be reported to the responsible manager via an intelligent call out system. The optional **Kentrol Energy Miser** alarm software module includes the ability to dial a list of numbers until it reaches a person and then will verbally announce the appropriate emergency message.

As an example, consider a steam pressure switch connected to the boiler that closes its contacts in the event the boiler pressure drops to less than 1 PSI, indicating a boiler firing or other problem. The software can be programmed to start down a list of telephone numbers, and play a detailed message about exactly what caused the alarm condition. In this case, the message could say "The steam pressure in boiler number 3 at the North West High School has fallen below one PSI. There is no heat available from this boiler. A burner-firing problem is assumed. Please take immediate action. Further, use the prescribed method to acknowledge the receipt of this message", followed by a repeat of the message for a reasonable length of time.

During the message, the computer listens for specific touch-tones as a code that someone has heard the message that knows the acknowledgement code. If the computer hears the required acknowledgement, it will stop dialing. If it does not hear the acknowledgement, it will proceed to the next number on its list. If it comes to the end of the list and still has not heard the acknowledgement, it will start at the top of the list again. Of course, any type of number can be input, including pagers, etc.

Notice that two courses of action are available to the people on the list. If the first person on the list hears the message and knows he needs to immediately go to the site and will need help, he can simply hang up the phone (without acknowledging the message to the computer). The computer will then call the next person on the list, etc. If set up logically, this system can be of great value in cases of emergency where several people need to be notified. A very good example would be the report of low hydronic pressure in a building. The reported condition may be indicative of the building being flooded by the heating system – not to mention losing its source of heat. Or, of course, the called party can acknowledge the computer and he can take appropriate action by himself.

Video Surveillance –

Building physical management in today's world is really three fold. First (from a cost perspective) is the energy the building consumes. Second is fire and intrusion detection. Third is video surveillance.

The optional **Kentrol Energy Miser** video module and Video BusMaster are designed to provide the third function in a fashion somewhat different than typical video systems. First and most importantly, it uses the building LAN to provide the communication required by the cameras. . . just as the WatchDogs do. This goes a long way to making a video installation practical as both cable installation and allowable video cable length are frequently problematic. Second, the software has been developed specifically for building and plant site monitoring. It has very nice features such as automatic maintenance of as much previously recorded video as the drive can hold, recording only images where motion is actually present (thus both preserving drive space and making 'overnight or weekend review' very quick and practical), various real time video observation modes, such as full screen, split screen of multiple cameras, continuous rotating images, etc., live on screen video control of PTZ (pan tilt zoom) cameras, etc.

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