THERMAL STORAGE

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"Thermal Storage" is a term that describes a mechanical systems ability to sustain normal hvac operations through a thermal retention source. This system allows for the curtailment of operating major refrigeration equipment during periods of high kw demand which results in lower electrical costs. The effectiveness of this "Thermal Retention System" is determined by its design characteristics, its operational efficiency and comparative system analysis.

Today's computer technology has provided the ability to collect operational data for analysis resulting in more efficient designs. Since consistency of operation effects overall efficiency, equipment must provide for diversity and simplicity.

System Management is a vital component of a thermal retention system operations. The operational size of the system only indicates one characteristic of its operation and or its limits with sound strategies prevailing for safe and effective operations. The interface between the hvac equipment production mode and usage mode of operation is contingent upon system management.

Conducting system analysis is the paramount function required to sustain the operational transition from System Design to System Management. The Planned Maintenance System provides the foundation necessary to build a productive analysis program. Once evaluated, hvac equipment operating periods can be developed and or modified to correspond with levels of electrical demand and consumption.

SYSTEM DESIGN

The purpose of system design is to combine architectural, structural, electrical and mechanical designs in order to develop an economical Thermal Retention operation. A good thermal retention operation depicts a dynamic process by which **ideal** operating characteristics are developed into **real** operating conditions.

The new hvac requirement for maintaining critical environments has been extended outside the standard "9 to 5" operating window. Constant 24 hour conditioning of these areas reduces the chilled water production capabilities during the recharging cycle. Often during a project's design and development phase this reduction is not considered to be a major concern.

Historically, proper operation and maintenance of sophisticated hvac control systems is neglected. Effective operating manuals and adequate formal training should emphasize the essentials of proper operation and maintenance. The training of personnel should provide an understanding of the control system philosophy and intent so that the effect of any adjustments are realized. On-the-job training allows the knowledge gaps that periodic formal training and indoctrinal training would eliminate.

Realistic operating parameters must be implemented to achieve optimal results. For example: a chilled water thermal storage systems' concrete storage tanks were designed to retain both the water volume and maintain a neutral heat gain to the stored chilled water. The structural design did not allow for stress relief and structural faults ensued. The thermal integrity was drastically reduced.

In other concrete tank systems, insulation has been introduced with an elastic type liner to cover the walls and floor. The realistic operating parameters were accounted for in one design and not in the other. The differences were .25 to .5 degrees F (insulated) compared to 2.5 to 4.0 degrees F heat gain over a 24 hour period.

"Distribution Energy" is the energy required by the operating system to move cooling/heating to and from a conditioned space. High efficiency motors can reduce distribution energy and offer superior operating cost savings. The savings are virtually eliminated when operated under part-load conditions. Design engineers should consider the entire range of operating conditions when specifying equipment. As utility rate structures dictate kw demand and consumption cost levels, the system management design should have flexibility to make limited adjustments when necessary.

The overall efficiency of the Thermal Retention System is realized when attention is given to all system components and to their ability to compliment the operation of each other. There are various designed operating parameters which can effect a components efficiency. One area is Fig. #1, a comparison between the total building and the base building kw demand loads. This was achieved by subtracting the main chilling plant kw demand load from the total building load. This comparison can now be utilized to evaluate how the main chilling plant operation and the base building operation affects the total building kw demand levels. One method by which the efficiency may be evaluated is to compare the main chilling plant design kw/ton criteria to actual. It is imperative that some level of computerized monitoring capability be included with the design of the hvac operating system. In this case, the designed operating criteria was compared to the actual operating parameters. The net result is an inefficiency factor of approximately $200 each operating day because of the effect toward the total building profile. Fig. #2.

SYSTEM MANAGEMENT

The purpose of Thermal Retention System Management is to achieve effective comfort control at optimal energy cost. To achieve this goal, it is necessary to evaluate the thermal retention system components, implement effective personnel training and provide a detailed Planned Maintenance System.

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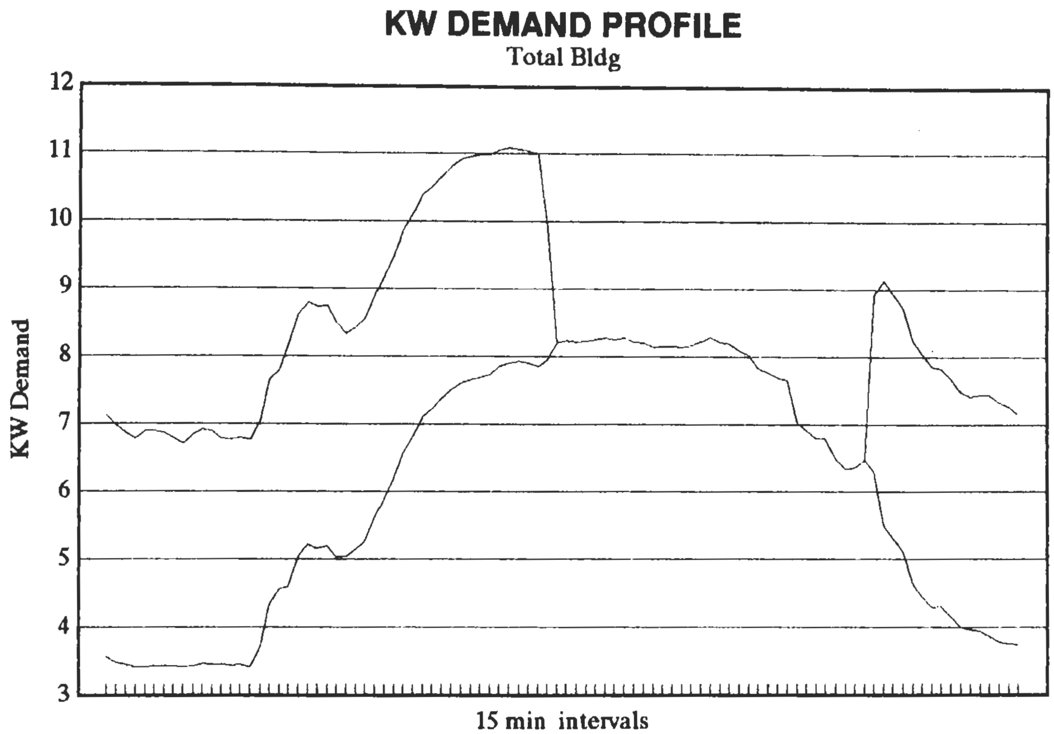
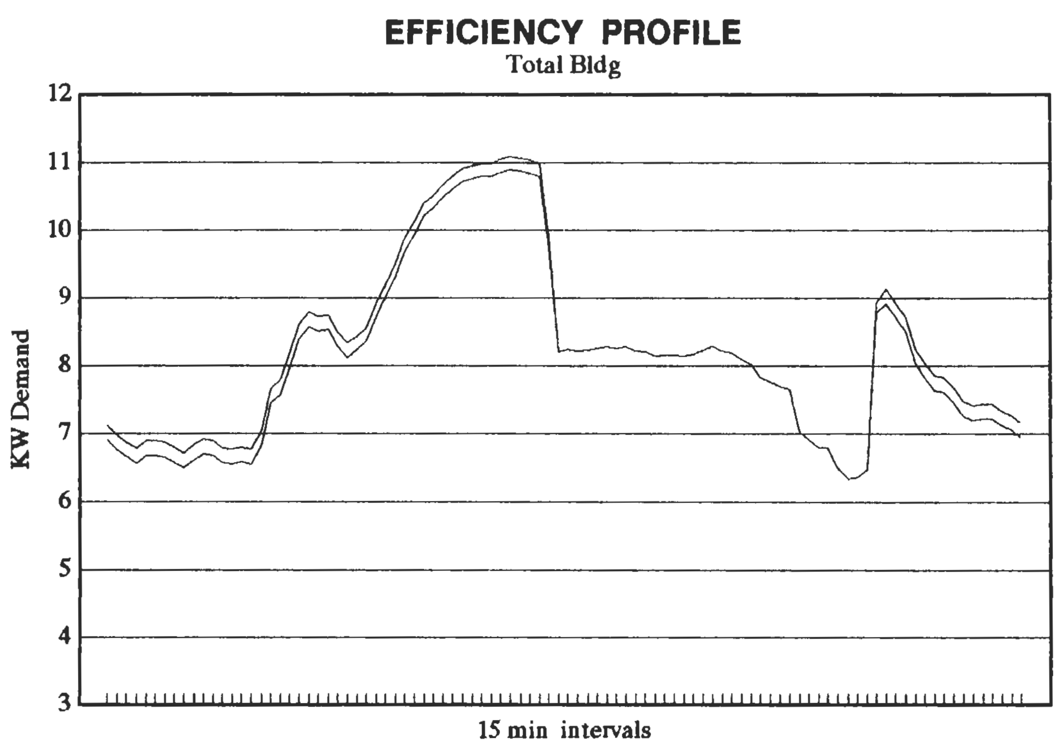


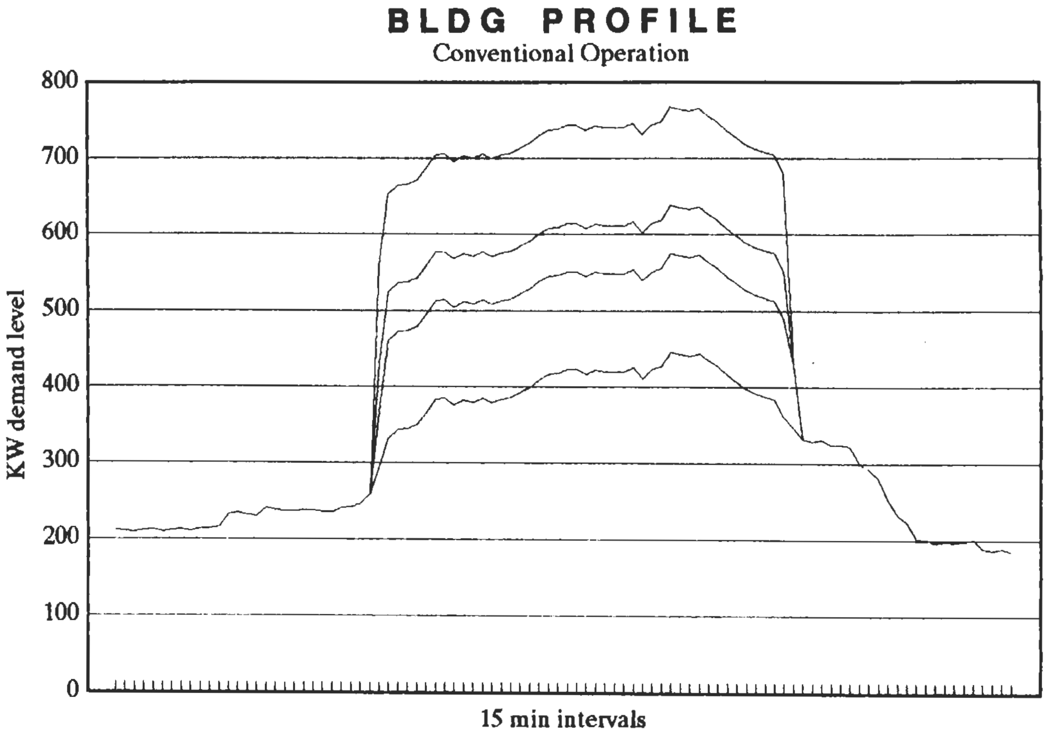
Base Bldg
Analysis

Fig. #1



Deficiency
6.14 %

Fig. #2



Component
KW demand analysis

Fig. #3

An evaluation of the hvac system components provides an understanding of their kw load values. This data resolves the effect combined component operations will have upon the total kwh consumed. Other results from this evaluation, when compared to a kw demand profile, show when and where operational strategies can be employed. Fig. #3. Typically, hvac components are started together. Each component's kw demand load is similar to stacking bricks; with each brick, the stack gets higher. Peak kw demand can be reduced by the staggering of demand load start-ups. This strategy results in a gradual buildup of total kw demand over a 15 minute window.

An hvac evaluation provides data for system management to develop strategies that optimize comfort control. This also determines at what point the load is under control and the variations from minimum to maximum throughout the day. Sound operational programs are capable of maintaining controlled space temperatures. The flexibility provided by chilled water storage accommodates supply air temperatures of 49° to 51° F. The lower temperatures remove additional amounts of heat ladened moisture from the conditioned space and increases the load shedding capabilities that will reduce the motors operating under part-load conditions.

The part-load operating condition of motors reduces their efficiency and increases the preventative maintenance required. The preventative maintenance actions to be performed on equipment motors often does not consider this condition. Planned maintenance and personnel training should include routine inspections to determine an optimal operating status. Conducting hvac evaluations, maintain sound operating strategies and conducting effective planned maintenance contours building systems operation to the seasonal weather variations and optimizes energy usage levels.

SYSTEM ANALYSIS

The purpose of a comparative system analysis is to provide the data required to sustain optimal system management and to allow a smooth transition from the construction of the initial system design. Planned maintenance, kw demand profiles and actual equipment operating data provides a basis from which operational strategies are formed and effective design philosophies can be implemented.

The kw demand profile is an effective tool from which system performance can be evaluated. There are various methods by which this information may be collected. Most local utilities provide exhaustive load reports, however, the daily transcription into usable graphs is tedious. "Data Star" is a kw demand collection meter now being utilized by TU Electric within their service area. This type meter allows the customer to purchase P.C. software with the capability to read and store this demand data via modem. One area that the kw demand profile can be utilized is in determining the kwh load factor. Load factor is the comparison of actual kwh consumed to the maximum kwh consumed over a period of time.

Equation (1)

$$Lf = \frac{U}{d \times (y \times c)}$$

Lf	=	load factor
U	=	actual kwh consumed
d	=	# of days to be evaluated
y	=	actual kw demand during the period of days to be evaluated
c	=	conversion of hours into days

As the load factor is increased, higher kwh consumption will follow and a lower kw peak demand will be the result. As the load factor is decreased, lower kwh consumption will follow and higher kw peak demand will be the result. Fig. #4. The comparison given here is not necessarily in direct proportion. By utilizing load management and daily demand monitoring, an increase in % load factor may constitute an increase in kwh consumed by 10% where the kw demand was decreased by 20%.

The result of this type of operation will be in the actual cost of energy. The utility rate structure can be broken down into terms that indicate which type of load factor strategy will result in a reduction of energy cost. A typical utility rate profile is shown in Fig. #5 with demand cost, indicating the highest 15 minute kw demand; energy cost, indicating a factored kw demand and kwh consumed; fuel cost, indicating the total kwh consumed and any applicable taxes. As a rate structure changes, Fig. #6, the rate by which the cost is increased may be deferred significantly when utilizing a load factor strategy. Fig. #7, the evaluation of the load factor from kw demand profiles can indicate areas where more effective operation. To achieve the levels required, thermal load design and operational data is necessary.

A thermal retention system can be utilized to achieve comfort control and can be an important part of energy load management. The thermal load of a structure must be evaluated and predicted to ensure optimal hvac operation. During the design and development phase of a project, intense thermal load models are created to provide the information from which materials and equipment are selected. The load parameters from these models can be utilized to form a thermal load monitoring system as well as a thermal load prediction profile.

The thermal load prediction profile consists of both fixed and variable parameters. Energy Management Systems are well equipped to handle such monitoring. The evaluation of the solar insolation load, radiant conduction load, supply air fan motor loads, equipment loads, lighting loads, ventilation loads, and people loads are all necessary to determine the total hvac load required. The ability exists to translate these loads into "real time" operating parameters.

Historical weather data must also be archived for evaluation with current data to form an experience factor. The precept here is to provide enough data to minimize major equipment operation and maximize their effective-

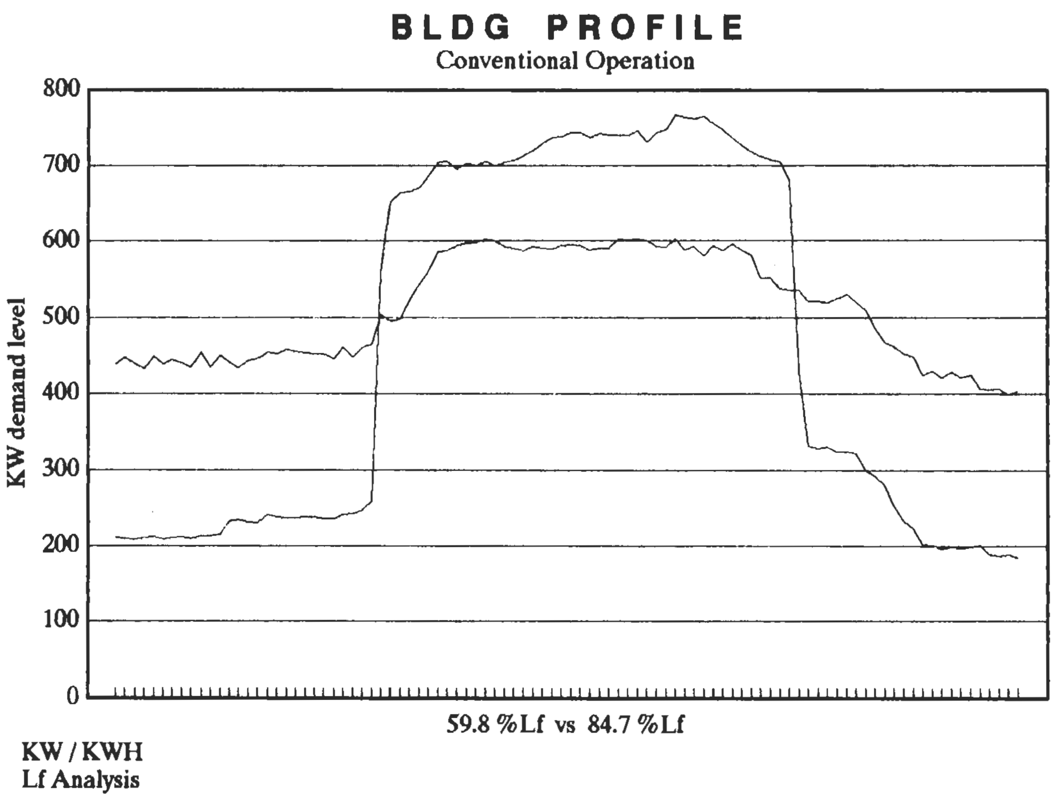


Fig. #4

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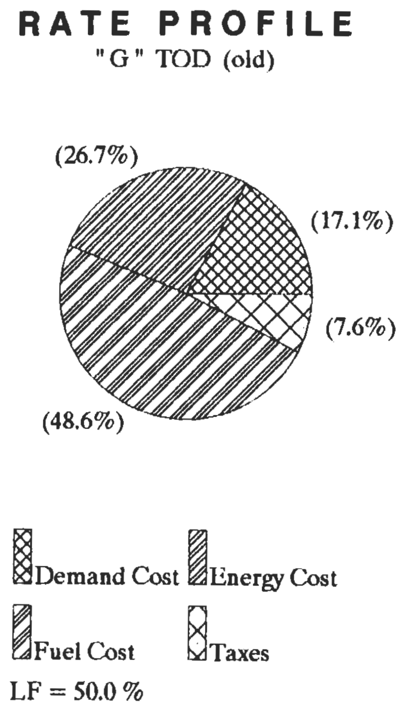


Fig. #5

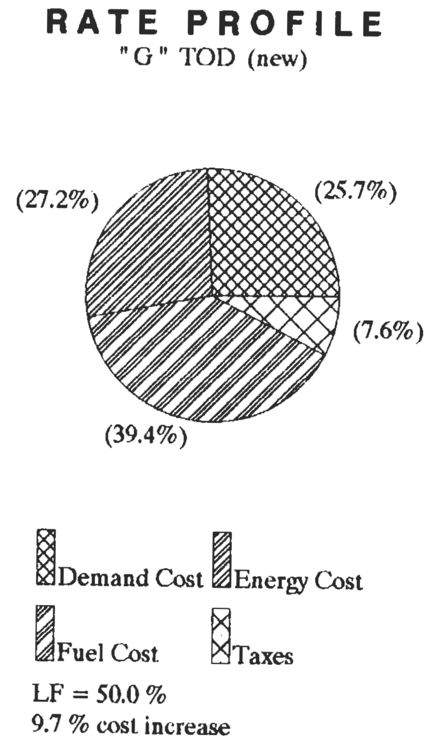


Fig. #6

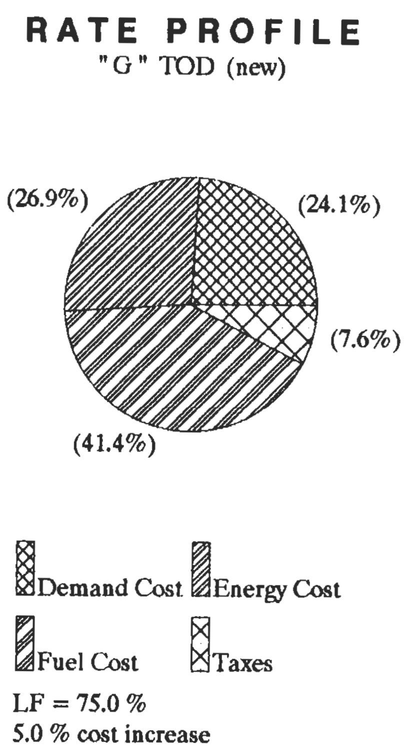


Fig. #7

ness. The thermal retention capacities of these structures and systems have limits, and fixed operating boundaries are set from these limits. An example of this would be the total # of gallons of chilled water within a thermal storage tank farm vs. the # of gallons required to satisfy the hvac load. Fig. #8. It is therefore necessary to maintain periodic monitoring of these loads for daily operation.

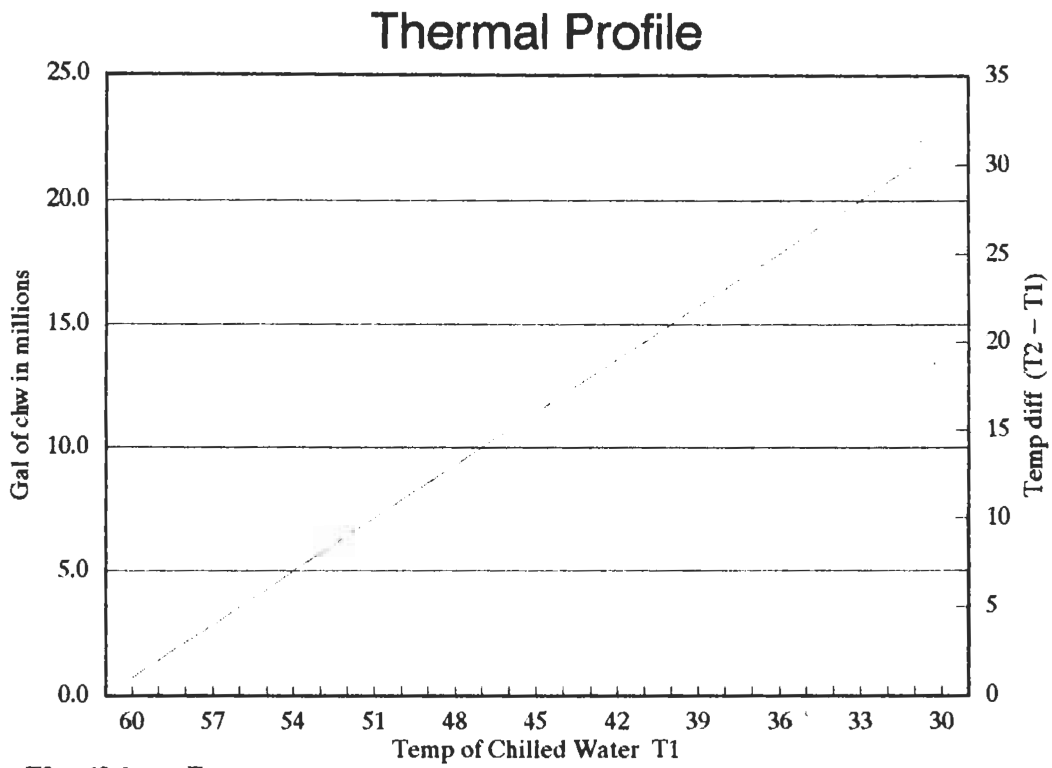
The thermal load monitoring system will utilize on-line operational data. Periods of load variations can be accounted for and necessary adjustments made to system controls to maintain maximum efficiency.

Equation (2)

$$\frac{(Ts2-Ts1) \times Gt}{(Ts2-Tu1) \times Gr \times C} = \text{Hours of capacity}$$

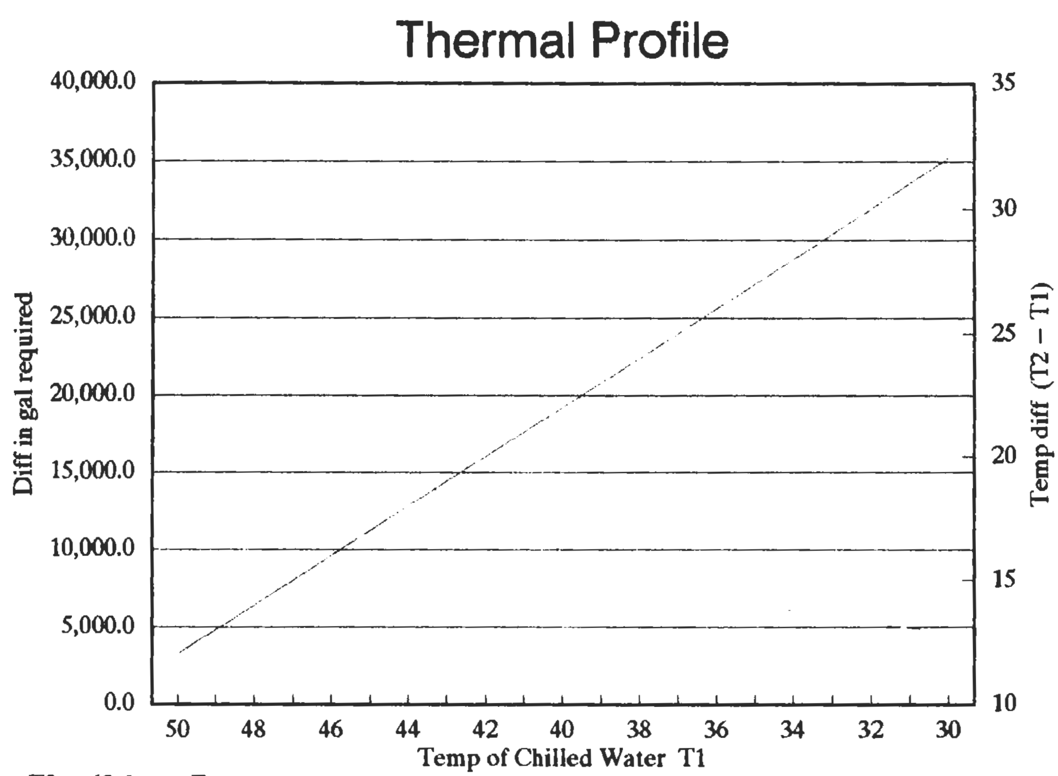
Ts2	=	return chw temp, deg. °F
Ts1	=	avg. tank temp, deg. °F
Tu1	=	actual tank temp, deg. °F
C	=	60 minutes/hour
Gt	=	total chilled, gal
Gr	=	total usage rate, gal/min

These variations in the operating load can have a significant result toward maintaining the thermal retention source till regeneration of the source can occur. Fig. #9. Heat gains from sources other than hvac loads necessitate the importance of a balanced operation.



T2 = 62 deg. – F

Fig. #8



T2 = 62 deg. – F

Fig. #9

Thermal load monitoring may also be done indirectly. HVAC start/stop optimization provides the conditioning of areas for both its sensible heat content and its latent heat content. From the point of sensible heat load containment, the solid materials within the conditioned areas begin to allow moisture evaporation. The dehydration of the solid material will then absorb heat ladened moisture once it has been introduced and therefore can assist the mechanical hvac system in maintaining the heat load. The time necessary to achieve sensible heat containment until additional mechanical cooling is required will be considered the monitored load area. Thermal vs. electrical load analysis will assist in identifying this load area. Fig. #10. Consistency in the operation of a thermal retention system is imperative. Equipment operating deficiencies and component failures should not necessarily be the cause of an inefficient operation.

Predictive maintenance is one area where equipment and system operation may require attention. Improper operation and maintenance will be evident upon the evaluation of load profile data. Equipment operational data can pinpoint a possible failure to major components thus resulting in the predictive maintenance being performed. System management can be better prepared to maintain all operating system integrities once predictive maintenance is coupled with preventative maintenance.

In conclusion, it is evident that some hvac systems can come in a pre-packaged chilled water thermal storage design or they can be the result of a conventional hvac system's effective operational strategies, or both. The utilization of the Thermal Retention Concept breeds flexibility, comfort control, energy cost savings, and operational integrity. The initial cost to retrofit a thermal retention for a project can be as little as a $30.00 monthly kw demand load report and the time dedicated to study the report. Thermal Retention design, management and analysis is an obligation, not a new type of mouse trap. This concept can utilize buildings that are within hot and humid climates to provide effective and efficient hvac operating systems.

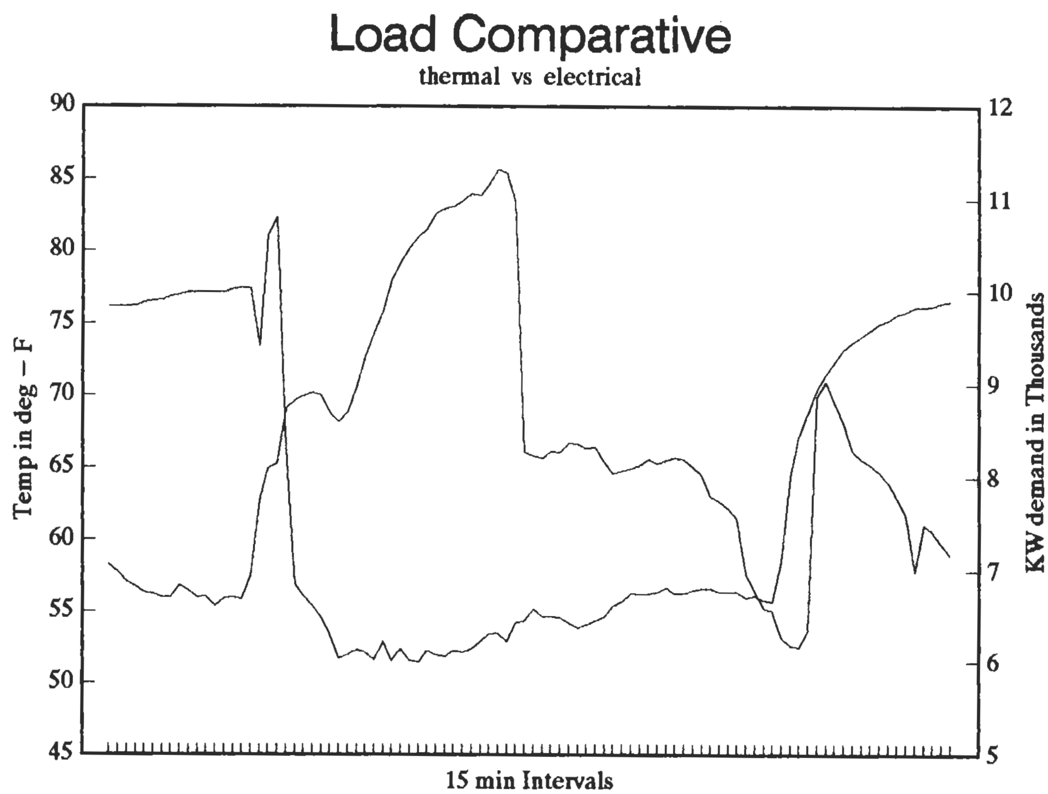


Fig. #10

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