Impact and Advantages of

Removable Insulation Protective Covers

By

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Introduction- General and Standard Care

Cost of energy has prompted all manufacturers, engineers, industry, and end users to evaluate every possible energy savings possible. One such area is the energy lost due to bad maintenance or natural decay of parts and pieces of equipment.

Equipment is procured with all of the energy concerns in response to a needed function. Once equipment is purchased, then how can one maintain the unit at the same level of original standard and specifications? The response to this question varies if the facility has full time maintenance crew. Standard care is higher in a facility with full time maintenance crew. Their continuously monitoring of equipment insures the operation of that equipment is nearly the same as the original installation. Maintenance crew also understand adjustments are made for decay, impact of the ambient weather (sun, snow, rain, …), age, entropy, friction, corrosion, erosion, fatigue, and other factors will be considered during the life expectancy of the equipment. In short, proper maintenance prolongs the life of the equipment and insures homogeneity in the specifications and operations of the equipment.

Lack of proper installation, and proper maintenance in a facility means the original installation will minimize the impact of the maintenance issues raised. This action can come at some cost. Then the argument of cost to benefit ratio is raised for every preventive maintenance action taken.

Proper maintenance extends life expectancy of equipment while insuring the homogeneity of the specification. If the unit is not operating at ideal condition, in order to compensate for its lack of performing, the components of the unit must work harder, longer duration, more stress to meet its demand specified.

Pipe Insulation- A passive component

One of the most passive components within any facility is **pipe insulation**. Transfer of energy from different components travels through pipes and insulation insures absolute minimum loss of this energy in the system. Air conditioning units, water heaters, or boilers use the thermostat to request the operation of the unit. The unit must deliver proper British Thermal Units' to the space as requested. The higher efficient units will satisfy the thermostat at a rapid rate as designed by original engineer. However, the less efficient unit will require more time to satisfy the heating or cooling of the space. This increase in time of operation can translate to:

- Longer operation of the unit
- Overstressing the unit beyond original manufacturer recommendation
- Higher personnel maintenance requirement
- Higher cost of electricity
- Higher maintenance annual budget for the facility
- Higher aggravation and occupant calls for heat or cool to the facility managers
- Faster replacement cost of the unit and
- budgetary constraints on the capital investment of the facility

Based on this discussion, maintenance becomes very important. Maintenance of piping insulation carrying and transporting the energy via the fluids (Freon, hot or cold water) becomes important. On the other side poor installation will cost financial damage to the facility.

Maintenance of pipes insulation is often non-existence. Aged insulation is generally brittle, poorly reinstalled, and subject to damage to the weather. A means and methods of maintaining and insuring the reinstallation is always basic goal of the facility energy

mangers. A well written protocol and guideline will satisfy many departments in a facility.

Primary Discussion- Correct Installation from beginning

Insulation materials cannot endure physical impact or are fragile to many elements, i.e. weather. Hence, proper protective covers are required for this protection. In addition, the insulations without protective covers are installed with use of adhesives, tapes and similar manners. In a maintenance circumstance, and during unwinding of the adhesives, the entire insulation is jeopardized or torn. Patching such system is nearly fatal to the entire system. This is when the repackaging of the insulation receives its highest importance. The repackaging must be easy and allow the least time or effort on the installers under any weather conditions.

Weather impact on insulation is very high. The sun enhances the transforms the insulation from thermoplast (soft) foam to thermoset (brittle) foam property. The property change also impacts the thermal conductivity of the material and consequently its performance. Protective covers become the sacrificial lamb and provide the stability in properties of the insulation.

Traditionally, insulations are installed with self adhesives or with adhesive tapes. These tapes do not last forever, and they do have consequences. There is several consequence of using traditional adhesive tapes over insulations.

The degree of reliable performance of adhesive tape over time depends on exterior conditions or gases (Ozone O3, Oxygen O2), UV lights, under direct exposure, yellowing or discoloration of the adhesive or backing, extreme temperatures, humidity, water, different kinds of chemicals. The effect of moisture content on the adhesive attacks the adhesive substrate interface, causing permanent adhesive failure rather than cohesive failure in the bulk. The internal condensation within pipes as well as exterior moisture attach within the rain condition. The continuous attack of the moisture degrades the adhesive components and reduces the age and effectiveness of the bonding of the tape. In addition, adhesive tapes are now known to accumulate bacteria beneath them. The degree

of the collection of bacteria depends on the exact environment or location. The indoor bacteria collection in an interior atmosphere will cause secondary concerns.

Protective Covers-

One can easily calculate the heat loss of any pipe with fluid with inside temperature of Ti and pipe wall temperature of Tw and the outside ambient temperature of To for various pipe sizes. This is seriously amplified when in a facility or in an apartment complex with 220 units with 5 ft Freon line sets all exposed to arid condition and weather. The dollar and energy lost of such units is significant. In the world of high energy cost, geo-political ramifications of energy, green and sustainable earth concerns, absolutely any energy savings achieved will be a blessing to the facility managers.

An insulation protective covers is easily removed and reinstalled becomes ideal in such circumstances. In addition, such covers will provide further insulation, and protection from the weather to the actual insulation within.

Sample Savings

One such examples is the maintenance issues of condensing units piping of the Freon lines exposed on
roof. The following rises the importance of maintenance of the refrigerant piping on the roof:

1. Refrigerant lines are little known even to engineers. Refrigeration leaks naturally by many means through the system. This translates to periodic maintenance on the units. The dryer unit which is generally on the roof near the unit must be changed for maintenance. LEED credit systems has identified this issue and addressed

   i. the leakage,
   ii. maintenance, and
   iii. life expectancy of the refrigeration system

2. As discussed earlier, plastic insulation on roof is subjected to the weather. With time, all thermoplast plastic material (soft/bendable) transform to thermoset plastics (brittle/rigid). The sun and heat become catalyst and expedite this process. This is why the dash port of old cars is torn and brittle/hard. This process modifies the insulation properties and with time they do not last simple contact, and if not replaced, the heat loss from the refrigerant lines increases.

3. All AC units require periodic maintenance. The frequency varies with how hard the unit operates, exterior temperature, preventive maintenance program, and many others. In every occasion, maintenance provides an excuse for the Freon line insulation to be touched and removed.

4. The Insulations are generally taped. Removal of tape damages the integrity of the original insulation into pieces, specially, if the insulation has reached thermoset state.

5. Basic construction industry standard and probability shows that as the building ages, the maintenance level reduces substantially and pipe insulation becomes none- existence.

Basic Heat Transfer Analysis

Assumption: Apartment Complex split system air conditioning unit-
Condensing unit on roof
Freon lines exposed 3 ft to 5 ft
0.15/kwhr cost of electricity (peak demand cost can be at 0.25$/kwhr)
10 hours operation
365 days
¾” Freon line
½” insulation property 0.020227 Btu/(hr F ft)

Steady-state, one dimensional heat flow through insulation systems is governed by Fourier's law:

$$q = - k \cdot A \cdot dT/dx \quad (1)$$

Where:

q = rate of heat flow, Btu/hr
A = cross sectional area normal to heat flow, ft^2
k = thermal conductivity of the insulation material, Btu-in/h ft^2°F
dT/dx = temperature gradient, °F/in

For cylindrical geometry, the equation becomes:

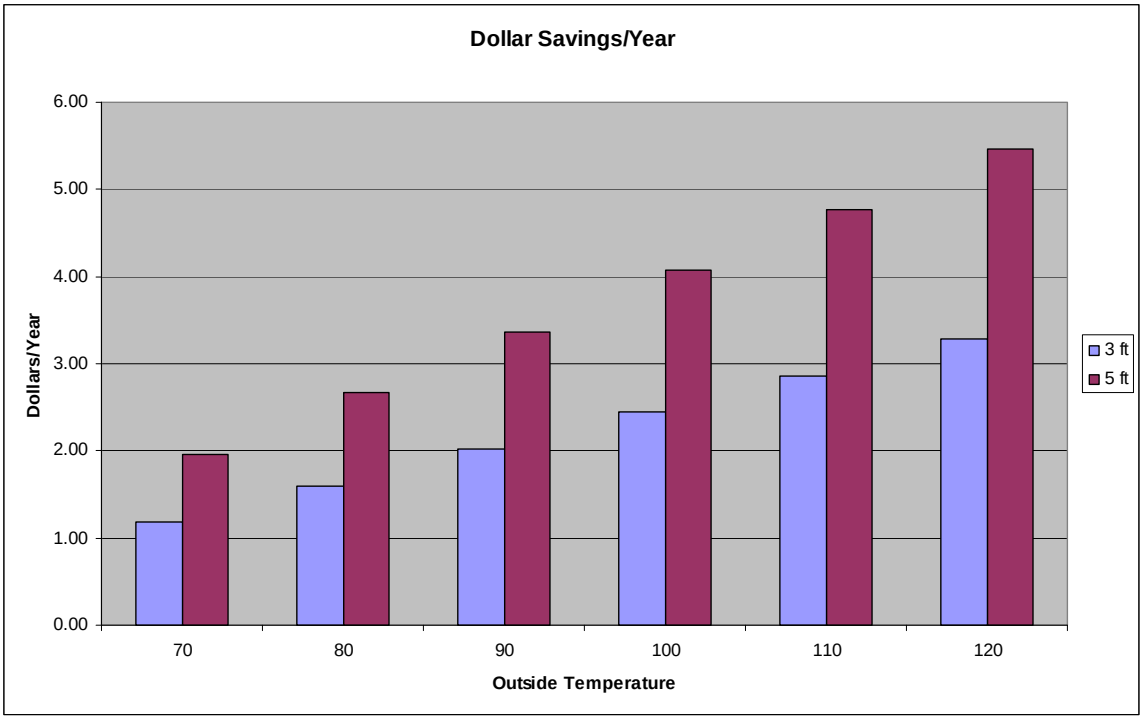
$$q = k \cdot A_2 \cdot (T_1 - T_2)/(r_2 \cdot \ln (r_2/r_1)) \quad (3)$$

Where:

r_2 = outer radius, in (Outer surface of the pipe, T1)
r_1 = inner radius, in (Outer surface of the insulation, T2)
A_2= area of outer surface of insulation, ft^2

The term $r_2 \ln (r_2/r_1)$ is sometimes called the "equivalent thickness" of the insulation layer. Equivalent thickness is that thickness of insulation, which, if installed on a flat surface, would yield a heat flux equal to that at the outer surface of the cylindrical geometry.

The resulting annual savings for 3 ft or 5 ft of Freon line set pipes bare shown for various climates in figure below:



Depending on the exterior temperature and assuming no wind on the roof, the energy saving varies. Note that the roof temperature due to roof reflection is higher than the ambient temperature. LEED recognizes this issue in multiple point systems as it impacts the environment and the earth. For arid zones such as Phoenix, the unit cost saving for each feet of pipe per year is 1 dollar worth of energy. There are many circumstances that the Freon pipe is near 10 ft on the roof. As stated, this energy savings is only the direct cost of savings. The other stated impact are immeasurable: reduction in life expectancy, longer operation of the unit, overstressing the unit beyond original manufacturer recommendation, higher personnel maintenance requirement, higher cost of electricity, higher maintenance annual budget for the facility, higher aggravation and occupant calls for heat or cool to the facility managers, faster replacement cost of the unit, and budgetary constraints on the capital investment of the facility.

Conclusion

Given our status of energy consumption and limited energy resources in United States, every measure of energy (btu's) worth savings cumulatively will reduce the energy demand of the country. Like the Olympic swimmers that thrive for one thousand of second for a gold medal, one btu savings from these insulation protective covers will be an excellent passive benefit to the facility as well as the country. This saving becomes significant in the case of 200 unit apartment in Palm Springs; Ca with average 5 ft of exposed Freon will save near $1000.00 per year in electricity. In addition, this cost does not reflect all secondary impact of heat loss or equipment inefficiencies. Overall, installation of insulation protective cover will save energy, reduce maintenance cost, and increases the asset capital of the building plus the favorable environmental impact on the building, the country, and the earth.