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PRE-INSULATED PIPING - THE STATE OF THE ART 1981

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EUROPEAN DISTRICT HEATING SYSTEMS

European District Heating experience differs from American in a number of ways. The absence of "cheap" energy reinforced accelerated acceptance of the district heating concept; they have been paying the true cost of energy for a much longer period of time so they have had to resort to the most economical methods of heating their homes, shops, businesses, office buildings, and plants. Today the market for district heating piping systems in Europe is roughly twenty times larger than that of the United States.

Secondly, the district heating boards in each country have been continually monitoring installations and setting standards for the various components of district heating systems, such as heat sources, heat exchangers, piping distribution systems, and installation techniques.

In addition to that the district heating boards of the various countries have been swaping information and technology between themselves. The close proximity of the countries has led to many district heating meetings on a Europe wide basis where the various countries exchange the experiences they've had with one another.

During the 70's the vast majority of district heating systems installed in Europe have been hot water (HW) operating in the 180° to 220° F. temperature range. These HW systems have evidenced a much lower installed cost as compared to steam systems. By far, the most common material specified for carrier pipes in European HW systems has been thin-wall steel approximately equal to Schedule 10 or 20 by U.S. standards. The insulation is polyurethane foam jacketed with either polyethylene or PVC, Polyethylene is used 90% of the time. Note, we find by studying the European manufacturers literature that although the steel pipes are of a lighter weight, the jacketing material is usually twice as thick as on a typical American system. The primary reason for this is that the urethane foam used is at least twice the usual U.S. standard of 2-1/2 pounds per cubic foot and with a 5 to 6 pound density the jacket must be thicker to avoid bursting during the foaming process. Copper tubing is sometimes used for run out lines to homes and smaller installations; and it is not unusual to find the main trunk lines coming from the power plant, or hot water generating station run in concrete trench systems. Very little fiberglass reinforced plastic (FRP) or asbestos cement (AC) pipe is presently used in Europe. Fully 80% of all district heating pipe installed in Europe in 1980 was steel pipe - urethane foam - and polyethylene jacket.

AMERICAN DISTRICT HEATING SYSTEMS

In the United States heating systems have developed in an environment characterized by cheap energy, drastic variations in geophysical and climatic conditions, local control of building codes, and a trial and error basis. Most heating systems provided in the U.S. have been and still remain individualized, self contained and rather small by European standards. However, certain kinds of typically American building structures and certain kinds of institutions lended themselves to a district heating approach, and U.S. specification authorities developed a large body of their own district heating expertise.

Because of the economies expected of "public sector" institutions, many colleges and military bases developed central heating sources using district distribution systems to provide heating.

In the U.S. three basic types of district heating systems developed: Steam, high temperature hot water (HTHW) and hot water (HW). The use of steam for district heating is wide-spread throughout the U.S., and although many people don't realize it, there are probably more central steam distribution systems in the U.S. than there are anywhere else in the world. They receive less publicity than European district systems because the vast majority of them are not large; some, in fact, encompass only several thousand feet, such as Olivet College in Olivet, MI. On the other hand, many are quite sizable by any standards, many of the military bases in the U.S. have steam distribution systems containing 20 to 30 thousand lineal feet of piping. These steam distribution systems usually operate above 300° F. and usually also incorporate a condensate return system.

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High temperature hot water systems (HTHW) are not as widely used as steam, and are usually found on military bases that do not have steam capability. HTHW systems utilize almost the same distribution systems as steam, therefore, the following description can be applied to both media.

Steam and high temperature hot water distribution systems operating at 300° F. and above are usually handled one of the following ways.

Older universities in the U.S. often have a series of underground concrete tunnels where all the utilities, including the steam lines, are run. These tunnels range in size from some large enough to drive a small car through to some large enough to handle only the utility piping systems. For some time now the trend has been away from these tunnels because of the obvious heavy expense of construction. When tunnels are required, owners tend to favor a shallow concrete trench large enough to contain only the steam and condensate pipe. In some cases the trench lid is raised above the ground and used as a sidewalk.

In the private sector a segment of the market is still using direct buried bare steel pipe and powder fill materials. These materials are holding their own market share and are mostly used where there is a low water table.

Certainly, however, the most common method of conveying steam and high temperature hot water for underground district heating systems have been the Class A type conduit; sometimes referred to as an air gap system, since the carrier pipe with the insulation around it is suspended in an oversized steel conduit with an air gap surrounding the insulated pipe. This system is factory fabricated and factory insulated, and its specifications have been standardized by the services construction authorities.

In the early fifties a number of problems with underground steam systems were experienced by the U.S. government. This resulted in the military Tri-Service Letter of Acceptability, which allowed only an air gap, drainable-dryable-air testable systems. High temperature applications have been dominated by this type of piping system since that time. Most private users, such as colleges, universities, and municipalities, have elected to rely upon this Federeal specification in lieu of designing their own systems and writing new specifications. The Class A type conduit system, therefore, dominates the market for high temperature applications in the United States.

Calcium silicate insulation is most often used since it retains its insulating characteristics after boiling and drying, fiberglass insulation is used at lower temperatures.

While this Class A system proves cost beneficial in environments where the conduit is subjected to periodic and severe flooding, it has some drawbacks in certain conditions.

Being steel, installation of the system requires highly skilled labor as well as detailed shop drawings and manufacturing processes which reduce field fabrication to a minimum. Steel casings require corrosion protection. This is usually achieved by use of coal tar or epoxy coatings as well as cathodic system in many cases. These features not only drive up installed first costs; but also present many instances where installation errors, hard to detect in the field, can result in serious deterioration of sections of the system. The chemical nature of condensate also has a tendency to deteriorate return lines more rapidly than the steam supply, even though specified in thicker walled Schedule 80 steel.

These features have led to increased use of inert materials such as FRP for condensate lines and casings. When the FRP pipe is used for condensate, it is most often insulated with urethanefoam and covered with a PVC jacket.

The combination of all these problems has led owners and specifying engineers in the U.S. to begin relying more upon at lower temperature hot water systems, just as their peers in Europe have been doing.

Hot water systems are fast becoming the method by which most people transmit heat below ground. The major reason for this is the fact that urethane foam insulation can be used with the lower temperatures, thereby cutting distribution system costs by at least 40%, as compared to the Class A system. Hot water heating systems are now found in virtually every area of the U.S., primarily

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in housing projects, college campuses, and most of the military bases. Not only are the vast majority of new systems being installed with hot water, but many replacement projects result in the switch from steam to hot water by means of installing a heat exchanger and converting the steam to low temperature hot water. These lower temperature hot water systems are almost always installed using factory insulated piping with a carrier pipe of either steel, copper, or fiberglass urethane foam insulation and a jacket of either polyethylene, PVC, or fiberglass. The vast majority of these piping systems are installed direct buried and the expansion is handled through either expansion loops or O-Ring mechanisms designed to handle the expansion and contraction, with the elimination of the expansion loops for steel and copper systems.

Unlike their European counterparts, American authorities have begun to rely on fiberglass reinforced plastic for new systems. Most fiberglass systems are installed straight line restrained without loops since the fiberglass is able to take up moderate expansion and contraction in the helically wound fibers of the pipe. Asbestos cement is also used as a carrier pipe with urethane foam and either an asbestos cement jacket or a thermo-plastic jacket, athough as in Europe this product continues to lose market share.

As you may have noted, I've described several different pipings systems here used for hot water. There are five major U.S. producers of these type systems and every manufacturer has their own basic concept of what they feel is best for these systems. Consequently, in order to market their products, each manufacturer is constantly upgrading the quality and the variety of their piping systems and tailoring the piping system to the application, the environment, the building code constraints, and the desires of the customer. This has resulted in a pool of expertise more wide ranging than the European but less well understood by the most important group, the user. This is where European experience may be most important to the American market.

DISTRICT HEATING BOARDS IN EUROPE

Most nations in Europe have developed a district heating board which disseminates authoritative information concerning district heating problems, solutions,

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and systems; and which, as a natural result of this initial function, ends up setting minimum systems standards through a materal standards board. These standards boards are usually not a government body. Most often they are organized as a division of the nation's district heating association. They include manufacturers, design A.Es, and users who oversee the operations of a technical staff.

Each national district heating board shares information with the others. In other words, the Norwegian District Heating Board can immediately receive considerable specific information about a particular district system located in Denmark from the Danish District Heating Board and vice versa. What this means is that the pool of technological experience developed by proprietary manufacturers is rapidly transmitted to designer, user, and owner authorities; both successes and failures are objectively documented and analyzed so the whole industry knows how and why a particular problem was caused as well as which system seems to function well in various environments.

It is interesting to note that this method has not led to a lessening of competition among system manufacturer; but has led instead to the reverse. A large number of indigenous firms compete for the European district heating piping market; and they do so effectively because the basic research and development necessary to create an effective system is provided by the District Heating Boards. This frees the manufacturer to concentrate on his "strong suit": producing a product in an increasingly cost effective way.

THE NEED FOR A U.S. BOARD

As mentioned above, there are only five firms engaged in manufacture of district heating distribution systems on a nation-wide basis, they have begun to rely on certain basic systems and material configurations. It is not usually the system wide and material issues which cause designers or owners problems subsequent to installation of a new system. It is either: (1) Installation of an otherwise acceptable system in an improper fashion; (2) Attempt to integrate an under-designed component into an otherwise acceptable system; or (3) Applicatio to an unacceptable environment of an otherwise acceptable system. And these three

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unfortunate things occur when we should be past that point, because there is a real body of historical experience available to designers, users, and owners, as well as manufacturers. It just isn't being gathered together and organized so people can use it when they need it.

It is instructive to note that anytime a particular system experiences a failure the manufacturer's competitors learn of it in a matter of weeks. They not only learn about it, they also attempt to discover what went wrong and why it went wrong so they can apply the experience to their own firm's systems and procedures and avoid problems of their own. The problem with this is that in America, in the absence of District Heating Boards, designers and owners often do not learn about the problem at all, and, when they do, generally have no authoritative explanation of what contributed to the system failure.

They are forced to rely upon their best supplier or vendor for indoctrination; and while this may be an acceptable process in many instances, it obviously leaves something to be desired when items as expensive as district distribution systems are the issue.

It seems to me that this organization has the wherewithal to develop its own standards board and should consider the following:

A. Some Standards are needed to avoid costly errors.

B. In eight years the ASTM committees have been unsuccessful in developing a specification for pre-insulated piping systems since they are more component or material oriented then systems.

C. The government with their attempts have taken 4 to 5 years to develop standards then 3 or 4 years to put them into practice. We don't have time for this lengthy process in this industry.

D. Our European friends have the basic knowledge that we need. A U.S. district heating standards Board could immediately converse with European counterparts and save countless thousands of manhours in developing systems.

E. The standard board could be made up of Engineers, manufacturers, large potential users as well as utility company personnel.

I'm not suggesting we adopt every concept product or method from the European "Carte Blanche", but I am suggesting that we as a body investigate and take that information that is so freely offered disseminate it and apply it to our industry for the benefit of our engineers, our consumers, manufacturers as well as our economy.