INSULATION OF BELOW AMBIENT PIPING

SUMMARY

For VRV/VRF systems, all lines (liquid and suction for heat pump systems; liquid, suction, and discharge for heat recovery systems) are required to be insulated. It is important to understand the purpose of the insulation on these Piping Systems. One requirement is to thermally insulate the piping to provide unit capacity and efficiency. The other requirement is to prevent the formation of condensation on the piping and insulation. The thermal integrity and vapor integrity of the insulation must last for the life of the mechanical system. The following will discuss the materials and methods required for a proper piping insulation system.

UNIT CAPACITY AND EFFICIENCY

Each equipment manufacturer publishes insulation thickness required to maintain unit capacity and efficiency. Generally, one half inch (1/2”) or three-quarter inch (3/4”) wall thickness for elastomeric foam insulation is sufficient for thermal requirements.

PREVENTION OF CONDENSATION

VRV/VRF are below ambient piping systems. Depending on the ambient temperature and dew point, condensation potential may be significant. In some operation modes, the discharge gas line functions as a parallel suction line and the liquid line is mechanically sub-cooled. Prevention of condensation on both lines for heat pumps and all three lines for heat recovery systems is required. The first consideration is insulation thickness. Based on the weather conditions or special indoor conditions (locker rooms, kitchens, or other high humidity areas), the insulation thickness requirement may vary from 1/2 inch to 2 inches or more. The potential for condensation on below ambient piping depends on the moisture content of the air surrounding the piping and insulation system, and the temperature of the pipe or tube wall.

ASHRAE publishes design conditions in a variety of ways. The following statements are from ASHRAE Handbook of Fundamentals, Chapter 14.

“The 0.4, 1.0, and 2.0% dry-bulb temperatures and mean coincident wet-bulb temperatures often represent conditions on hot, mostly sunny days. These are often used in sizing cooling equipment such as chillers or air conditioning units.”

“Design conditions based on dew-point temperatures are directly related to extremes of humidity ratio, which represent peak moisture loads from the weather. Extreme dew-point conditions may occur on days with moderate dry-bulb temperatures, resulting in high relative humidity. These values are especially useful for humidity control applications…”

ASHRAE Handbook of Fundamentals, Chapter 14 Climate Design Information, Appendix: Design Conditions for Selected Locations, *column* Dehumidification DP/HR/MCDB is a good source for determining the desired “design dew point” temperature and coincident dry bulb for selection of insulation thickness. The design condition varies considerably from city to city. The calculation of insulation thickness to prevent condensation, based on this design dew point and coincident dry bulb requires a thorough understanding of the relationship between the insulation surface temperature and ambient dew point.

Insulation thickness is important, but correct and proper installation of the insulation system is also required for long-term condensation control. Condensation anywhere in the system promotes mold growth, structural damage and piping system corrosion.

BUILDING CODES AND ENERGY CODES

Building codes and energy codes are being adopted with additional emphasis on energy conservation and can have a significant impact on the insulation thickness required. The International Energy Compliance Code establishes insulation thickness based on the temperature of the fluid inside the tube. VRF/VRV systems, when used for heating and cooling can experience both low temperatures and relatively high temperatures depending on operating mode. Low-pressure gas temperatures can be below 40ºF and high-pressure gas temperatures can be greater than 200ºF or sometimes greater than 220ºF. These temperatures can require insulation thicknesses of 1-1/2" or 2-1/2". Check local code requirements carefully.

SELECTION OF INSULATION MATERIAL

Closed cell elastomeric foam pipe insulation is a proper material selection for below ambient refrigeration piping systems. It has very good thermal properties and is generally vapor resistant. This type of insulation is readily available in two material types.

A. NBR/PVC - nitrile butyl rubber with polyvinyl chloride blended into the rubber compound. There are two significant disadvantages to using this material on VRV/VRF or below ambient temperature piping systems.
   - The maximum temperature rating does not meet Daikin and LG requirements for piping service temperature. NBR/PVC has a maximum service temperature of 220F. Daikin, LG and other manufacturers require insulation rated for a maximum service temperature of 248F.
   - This rubber compound is not UV resistant. Installation instructions require insulation exposed to weather to be coated with a specific field applied coating that must be maintained and re-coated at specified intervals. From personal experience and observation of installed systems, NBR/PVC insulation will NOT stand up to outdoor exposure in most locations. Within one or two years, most insulation installations are not serviceable and need replaced.

B. EPDM (ethylene propylene diene monomer) is a type of closed cell elastomeric foam insulation that has a maximum service temperature of 257F. Additionally, this rubber compound is UV resistant. Published data indicates 20-year life when exposed to UV conditions.

There are other advantages to using EPDM pipe insulation, but the above points are reason enough to require the use of EPDM on all VRV/VRF piping systems, indoors and out.

INSULATION MANUFACTURERS INSTALLATION INSTRUCTIONS

To maintain the thermal properties of the insulation, to prevent water intrusion between the pipe and insulation, and to prevent condensation forming between the pipe and insulation, the insulation must be installed per the manufacturers' installation instructions.

- Use approved materials, methods, and sealants
- Use the appropriate size insulation. The ID of the insulation must match the OD of the tube or pipe.
- Do not clamp directly to the piping. The insulation must pass continuously through any support points.
- Use rigid insulated hanger inserts at ALL piping support points. Hangers and supports must not reduce the insulation thickness.
- Do not crush the insulation at any point (piping supports, beams, studs, structural penetrations). Do not attach cable ties to the insulation.
- Push the insulation onto the pipe, do not pull.
- All longitudinal seams, butt joints, insulation terminations, etc. must be completely sealed with the recommended glue/contact cement, or manufacturer recommended sealing method.
- Insulation must be sealed to the piping at all insulation terminations and every 12' to 18' (vapor dams), to prevent the entry of moisture or water and to prevent the migration of moisture along the length of the pipe system.
- Maintain clearance between insulated pipes to allow air circulation.
- Install field fabricated fitting jackets anywhere the insulation is crushed or stretched when conforming to the shape of fittings. Typically, insulation thickness of 3/4" or greater will require fabricated fitting jackets at 90-degree ells.
- If the piping is subject to physical damage (indoors or outdoors), provide proper protection.
- The piping system and insulation must be inspected and maintained on a regular basis. If any breach of the vapor barrier is found or the insulation is compromised in any way, the condition must be repaired immediately.

The insulation on VRV/VRF systems can cost as much as the piping. It is not reasonable to accept a sub-standard insulation installation. The insulation system is critical to the performance and life of the mechanical system.

FIELD APPLIED JACKETING

If Field jacketing of below ambient outdoor insulation is required due to a chance of severe mechanical abuse or for additional UV protection, a few cautions are in order.

- Aluminum Jackets will increase the required wall thickness of insulation. Depending on conditions this may be significant. This is due to the emissivity of the aluminum jacket. Refer to the insulation manufacturers installation instructions regarding aluminum or stainless-steel jackets.
- Installation of an insulation jacket requires the same care as installation of the insulation itself. The jacket MUST fit tight to the insulation to keep water from accumulating between the jacket and the insulation. All jacket terminations, overlap joints, and seams must be sealed watertight. If water gets under the jacket, it will compromise the insulation and allow the insulation to absorb water. When this happens, the insulation is ruined and must be replaced.

- Proper jacketing of fittings, multi-unit kits, etc. is difficult and must be done with utmost care.

ADDITIONAL PIPING INSTALLATION SUGGESTIONS

The sealing of piping insulation on the roof is extremely important to keep rainwater and condensation from ruining the insulation on the roof, but also prevent the insulation from channeling water to the interior of the building.

- Pay attention to the insulation termination at the outdoor unit. Condensation from the unit shut off valve can easily enter the insulation between the pipe and insulation and travel along the length of the pipe.
- Provide "top of riser" traps for piping installed on the roof. This creates an increase of piping height prior to entering the building (i.e. entering a shaft). This will prevent water that may have accumulated between the pipe insulation and pipe from entering the building by gravity. This inverted trap just prior to entering the building should be the high point of the rooftop piping.