

Unique Tracking Number Assigned by MORTS RTAR 1433
RESEARCH TOPIC ACCEPTANCE REQUEST (RTAR) FORM
(2 pages suggested, 3 pages maximum)
TC/TG: 10.5 Refrigerated Distribution and Storage Facilities

Title:

The Effect of Loss of Vapor Barrier Integrity on Insulation Performance for Facilities Operating Below 0°F

Applicability to ASHRAE Research Strategic Plan:

This directly meets the needs of:

A 6 • Develop integrated, best practice design methods that will allow energy consumption, life cycle cost and environmental impact to be minimized, and that will allow system life span and IEQ to be maximized.

A 8 • Establish benchmark data on energy use in industrial refrigeration.

D 3 • Improve performance and reliability and minimize the environmental impacts of working fluids and materials.

D 7 • Develop techniques that reduce the installed energy use of HVAC & R system auxiliary equipment by 50% by 2015.

See "Justification and Value to ASHRAE" for additional information.

Research Category:

Energy Conservation; Food Processing and Preservation; Refrigeration Systems

Research Classification:

Basic/Applied Research

TC/TG Priority:

1

TC Vote:

Reasons for Negative Votes and Abstentions:

For 10; Against 1; Abstentions 0; Absent 2; Total 13

*George Briley was one of the absent members. His is a senior member that has a hard time communicating. Please forgive our single absent vote.

Against reason

1.) If there is ice in the insulation system- it must be replaced, it will only get worst; 2) Manufacturers' vapor barriers publish their recommended practices to ensure completeness of vapor barrier. Having a Manufacturer's recommendation goes a long way if something goes wrong; 3) ASHRAE should recommend insulation vapor breaks every 50 feet. This way each 50 foot span is separated from the next 50 foot span. Refer to Dow's recommendations on practices. Research will be counterproductive if the above is utilized; 4) There are Manufacturer's of insulation drying systems, they have done the research for their own products; 5) Only approved insulations should be those following ASTM E96 and other standards; 6) Each Manufacturer of insulation has information on their product about moisture migration. Any questions – Client to contact their insulation Manufacturer Sales Rep; 7) If there is ice deposits, the concern should be to replace the insulation, and not, how bad it can be.; 8) All Owners of Refrigerated Facilities know they are losing efficiency when the insulation get wet. The issue is how/ when; where the Client can get the money to repair the issue.

Estimated Cost:
\$195,000

Estimated Duration:
(36 months duration)

Other Interested TC/TGs:

TC10.1 Custom Engineered Refrigeration Systems (not approached)
TC10.3 Refrigerant Piping, Controls and Accessories (not approached)
TC10.8 Refrigeration Load Calculations (not approached)
TC10.9 Refrigeration for Foods and Beverages (not approached)
TC4.4 Building Materials and Building Envelope Performance (Considering)

Possible Co-funding Organizations:

International Association of Refrigerated Warehouses (IARW) (Approached and considering)

Application of Results:

Refrigeration Handbook Chapters 12, 13, 32.
Fundamentals Handbook Chapters 23 to 25

State-of-the-Art (Background):

For many refrigerated facilities heat transmission through insulation represents between 10% and 50% of the total heat load. The effective thermal conductivity of the insulation once it is installed is higher than the nominal thermal conductivity of homogeneous surfaces of virgin insulation. Reasons include joints and jointing method, application conditions (Connolly, 1997), penetrations through the insulation, moisture migration and deposition (Waelti, 1987, Martin & Verchoor, 1994). There is also a deterioration of insulation quality over time due to insulation material ageing (Valenzuela, and Glicksman, 1981; Brandreth, 1986; Waelti, 1987; Tye, 1988). Western Insulfoam Corp. (1975) reported that at 4 °C polyurethane loses about 25% of its initial thermal resistance value during the first 3 years. It has been found that the increase in effective thermal conductivity with time for insulated containers is typically more than 4% per year for the first 10 years and between 2 to 4% per year thereafter (Boldrin *et al.*, 1993). For rail cars, the loss in the first year was 15 to 35% (Cioffi *et al.*, 1979).

For refrigerated facilities operating well below ambient temperature, it is well-known that provision of a highly impermeable and complete vapor barrier on the warm side of insulation is essential to prevent deterioration of the insulation quality due to condensation and/or freezing of water vapor (IIR, 2002). The thermal conductivity of ice and water are about 100 and 20 times higher than usual insulation materials respectively so their deposition greatly increase insulation effective thermal conductivity. In addition, condensate and ice formation can physically damage the integrity of the insulation system particularly due to the expansion of ice relative to water. Also the weight of the water/ice can lead to structural problems and, in extreme cases, collapse of ceilings or wall or floor surface damage.

It has been postulated that small localized imperfections in the vapor barrier can lead to major problems over time due to the migration of water vapor within the insulation to areas remote from the damage. While some research on the migration of water through vapor barrier and insulation has been conducted for standard building materials and envelopes (Martin and Verschoor, 1994; 496-RP), little research has been done on the heavily insulated envelope normally used for refrigerated facilities. Similar issues also arise for insulation of low temperature components of the refrigeration systems such as suction piping and vessels. Often insulation performance deterioration is worse in such situations because vapor barrier integrity is more difficult to achieve and maintain.

Some important aspects of this issue are:

- What is the rate of moisture transport through breaks in the vapor barrier of various types and size?
- What is the quantitative effect of the water/ice on insulation performance?
- How far from the break in the vapor barrier can the water vapor ingress significantly affect the insulation performance?
- Which construction techniques are more effective at ensuring completeness of the vapor barrier?
- Which methods to repair the inevitable damage to the vapor barrier are most effective?

How quickly will moisture and ice diffuse out of insulation after a vapor barrier is reinstated?
Are different types of insulation (e.g. open cell versus closed cell; polystyrene versus polyurethane) more resistant to moisture migration and damage due to water/ice deposition?

Advancement to the State-of-the-Art:

The research will enable the best-possible performance of insulated envelopes to be achieved and maintained for much longer periods by understanding the mechanisms for deterioration and therefore allowing definition of the best construction and maintenance practices. Currently a reported \$900 million worth of heavily insulated buildings are built annually in the US (about 10 million square feet built in 2004 as reported in industry magazines). Improved insulation performance by 10-20% over the life of these buildings is feasible through improved techniques and methods defined by this research. Assuming insulation is 30% of the total heat load on average, this improvement could reduce the total energy use by this sector by 3-6% over time. There would also be the economic return related to the increased time before replacement is necessary.

Justification and Value to ASHRAE:

This research will benefit two main groups:

The manufacturers, engineers and contractors that design and install refrigerated structures – they will be able to provide an improve service to their customers by using the best practices and better understanding the effect of poor vapor barrier installation on on-going insulation performance.
The owners and operators of the refrigerated facilities – they will have more cost-effective, long-lasting and energy efficient facilities and will understand how best to maintain the vapor barrier thereby reducing both the risk of failure and the rate of deterioration of their assets.

This research will contribute to the following ASHRAE strategic plan themes and goals:

- (a) Theme I – Energy and Resources
 - a. A6: Develop integrated, best practice design methods that will allow energy consumption, life cycle cost, and environmental impact to be minimized, and that will allow system life span and IEQ to be maximized.
 - b. A8: Establish benchmark data on energy use in industrial refrigeration
- (b) Theme IV – Equipment, Components and Materials
 - a. D3: Improve performance and reliability and minimize the environmental impacts of working fluids and materials
 - b. D7: Develop techniques that reduce the installed energy use of HVAC&R system auxiliary equipment 50% by 2015.

Objective:

While vapor barrier integrity is important for both piping and walls, unless bidders provide strong reasons otherwise, the scope of this project will be limited to wall insulation systems. Also, there are a large number of insulation systems in use. The project will focus on at least 3 of the most common types (probably including expanded polystyrene, polyisocyanurate and rock/mineral wool/fiber).

The objectives of this project are to:

1. Through the process of literature review, manufacturer contact and other research methods, the contractor shall identify commonly used construction practices for vapor barrier installation and repair.
2. Measure both the rate of moisture migration into different types and sizes of breaks in the vapor barrier and the movement of the moisture within the insulation away from the damaged area for different insulation types and construction methods identified in objective 1.
3. Quantify the rate of insulation performance deterioration as a function of water/ice content and distance from the vapor barrier damage.
4. Identify the most effective of at least 2 alternative methods to repair vapor barrier damage identified in objective 1.

5. Measure the rates that water/ice in insulation will be removed following vapor barrier repair.

Key References:

ASHRAE (2002) *Refrigeration Handbook*

ASHRAE (2001) *Fundamentals Handbook*

ASHRAE (2004) *HVAC Systems and Equipment Handbook*

Boldrin, B., Minotto, G., Panozzo, G., Toniolo, B., Lanza, J.W., Florio, G., Jacobini, A. and Sallusti, L. (1993) New data about ageing of insulated vehicles in service: a statistical analysis, *Proc. Refrig. Sci. & Technol.*, Vol. 1993-3, 555-564.

Brandreth, D.A. (1996) *Advances in Foam Aging – A Topic in Energy Conservation Series*, Caissa Edition, Torylyn, DE.

Cioffi, E., Padovan, G. and Panozzo, G. (1979) Theoretical and experimental researches about ageing of insulated structures of rail-cars for perishable foodstuffs transport, *Proc. XV Int. Congr. Refrig.*, Vol. IV, Venice, 337-347.

Connolly, B. (1998) ASHRAE refrigeration handbook addresses insulation for refrigeration systems, *Heating, Piping, Air-Conditioning Engng.*, Vol. 70 (9), 95-98.

IIR (2002) *Insulation and Air-Tightness of Cold Rooms*, ed. M. Duminil, International Institute of Refrigeration, Paris.

Martin, P. C. and Verschoor, J. D. (1994) *Investigation of Water Vapor Migration and Moisture Storage in an Insulated Wall Structure*, ASHRAE Research Project Report, 496-RP. Schuller International Mountain Technical Centre, USA.

Tye, R.P. (1988) Aging of cellular plastics: a comprehensive bibliography, *J. Thermal Insulation*, **11**, 196-222.

Valenzuela, J.A. and Glicksman, L.R. (1981) Thermal resistance and aging of rigid urethane foam insulation, in “*Thermal Insulation, Materials, and Systems for Energy Conservation in the '80s*”, Govan, F.A., Greason, D.M. and McAllister, J.D. (Editors), ASTM Publication, Philadelphia, Pa.

Waelti, H. (1987) Insulation and vapor barriers in potato storage buildings, A Pacific Northwest Extension Publication, PNW 295, Washington, 1-8.

Western Insulfoam Corporation (1975) Low temperature insulation, *General Technical Data*, Western Insulfoam Corporation, Kent, Washington.