Urethane Foam Insulation Hazards

Although ammonia storage tank leaks can be effectively reduced by urethane foam insulation systems, care is needed due to combustibility of foam and some components.

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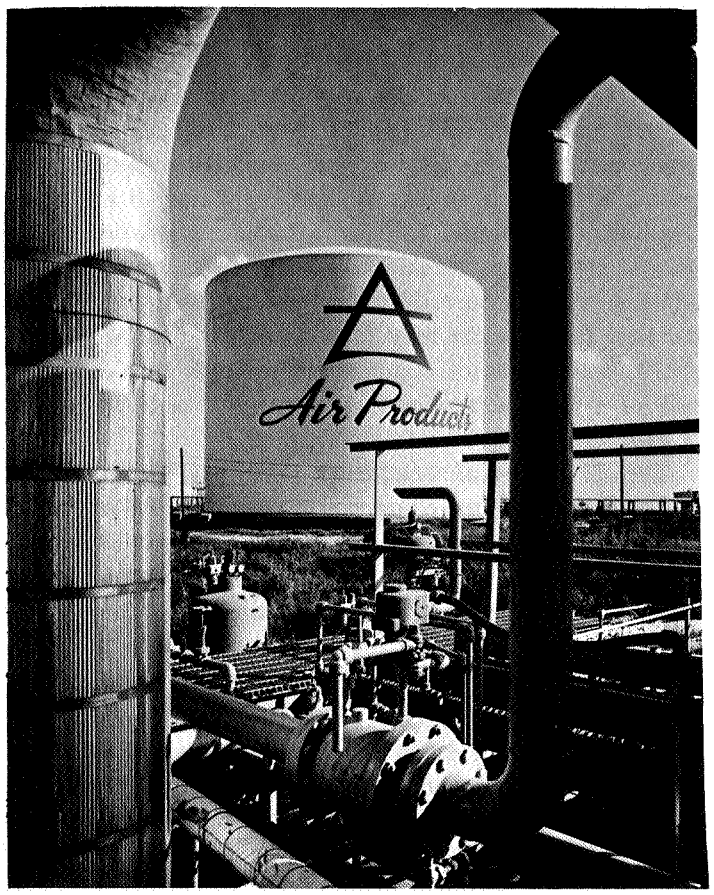


Figure 1. Air Products urethane foam insulated 30,000 ton atmospheric ammonia tank at New Orleans.

A survey of ammonia storage facilities in the United States and Canada, presented to the 1973 AIChE symposium on ammonia plant operations by C.C. Hale of Adtek, Inc., was devoted in part to the types of insulation used. With today's increase in energy costs, it is increasingly more important to decrease the heat leak into storage tanks to reduce compressor loads.

Of the types of insulation systems shown in Table 1, urethane foam is known to have the best insulative qualities. However, this benefit is not without its drawbacks. Polyurethane foam has come under criticism for its high flammability hazard. The ammonia industry is not unfamiliar with this problem. In 1966, H.L. Darling of Sherritt Gordon Mines, Ltd., reported a fire which consumed the entire insulation system of a 2,000-ton ammonia sphere.

Table 1. Insulation systems

	% of Total No. of Tanks	Thermal conductivity (Btu/hr.sq.ft. °F/in.)
Double wall tank with expanded Perlite and a blanket insulation	38	0.456
Foam-glass block with a moisture and weather outer seal coat	24	0.39
Polyurethane foam with an outer seal coating	17	0.16
Reflective aluminum in multi-layers with air spaces for insulation	9	0.23
Styrofoam with a moisture and weather coat	9	0.23
Fiberglass blanket with outer seal coat	3	0.23

A quick review of the incident is useful. This tank was insulated with 1-3/4-in. of sprayed-on urethane foam, sealed with a coat of Flincote C-29. One day after the contractor finished the insulation, a mechanic, who had been given a hot permit, attempted to thaw a nozzle with a propane torch. During this action, the bottom of the sphere ignited and fire soon engulfed the entire vessel. Investigation revealed that the sealer was the culprit. C-29 uses 100°F flashpt. petroleum solvent, which has a 30-day curing period. Thus, on exposure to the propane flame, the sealer easily ignited; and with this as the initiator, the foam readily caught on fire.

Entire system needs study as risk

The significance of this incident is that one cannot isolate the insulation from the total insulation system when investigating flammabilities. The entire insulation-adhesive-sealer system should be analyzed for risk.

The major components of urethane foam systems are the insulation, an adhesive, and the weather barrier. The flammability hazard of each will be discussed.

Urethane foams are used in construction in three forms: sprayed-on, poured-in-place, and in blocks. The methods of analyzing the hazards are the same in each case. Several laboratories are now involved in flammability studies of urethane foams; notably, Factory Mutual Research Corp. and Underwriter's Laboratories.

The traditional method of categorizing flammabilities is the Steiner Tunnel Test, also known as ASTM E84, UL 723, and NFPA 255. This test utilizes a 25-ft. sample of the insulation which is mounted on the top of a horizontal chamber. Test results are given as a flame spread index, the ratio of the flame velocity of the material tested to that of red oak (19.5 ft. in 5.5 min.). The flame spread index of red oak is set at 100 and asbestos board as 0. A flame spread value of 25 or less is generally recognized as desirable.

Another valuable source of information is the "Corner Test," developed by Factory Mutual Research Corp. This test uses a structure 25 ft. high with walls 40 and 50 ft. long. Specimens under test are attached to the walls and ceiling and subjected to a source of ignition, 750 lb. of burning wood (5 ft. high x 4 ft. wide x 4 ft. deep). The acceptability criteria for Factory Mutual is that "the material does not produce a self-propagating fire within the limits of the structure as evidenced by flaming or material damage."

Notable results from Factory Mutual's testing are:

1. Rigid polyurethane boards up to 4 in. thick with a flame spread rating of 25 or less are acceptable to Factory Mutual without sprinkler protection if they are faced with either steel or aluminum sheeting.

2. Metal-faced rigid polyurethane foam with flame spread of greater than 25 may be used; however, added protection will be necessary, e.g. a sprinkler system.

How can the results of these tests be applied to insulating ammonia tanks? When urethane foam has been chosen, flame spread ratings are helpful in comparing available products. The results of the "Corner Test" provide valuable information on fire protection and construction specifications. However, neither test is directly applicable to storage tanks. The tunnel test used a horizontal surface, which can be misleading for flame will spread much quicker vertically than horizontally. The "Corner Test" does not allow heat to dissipate to the atmosphere, unlike a storage tank where there is no enclosed environment. Therefore, these tests may serve as a basis for selecting material and protection but sound loss prevention experience must be added to this.

Another major point of concern when dealing with urethane is the large amounts of smoke evolved. Together with the obvious problem of hindering fire fighting procedures, there is the added danger of toxic gases emitted by burning urethane foam (hydrogen cyanide and carbon monoxide).

The Steiner Tunnel Test also measures smoke production. This is rated on the same scale as flame spread, i.e., red oak as a basis of 100. Smoke ratings of less than 50 are desirable.

Research into the development of fire retardant and low-smoking polyurethane foams has been greatly increased in the last few years. There are two basic means to decrease the flammability hazard:

1. Adding chemicals such as phosphorous, bromine or chlorine to the foam.

2. Changing the actual formulation of the foam to include more thermally stable materials in the compound.

Phosphorous and the halogens are excellent fire retardants; however, they increase the smoke hazard. Typical changes in the formulation of urethane leave the foam brittle and difficult to handle. Combinations of both methods are being attempted to reduce the flame spread to less than 25 and lower the smoking to tolerable limit levels with successful results.

Foam itself not always at fault

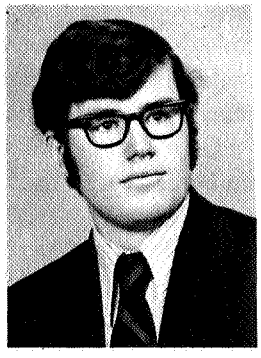
As evidenced by the Sherritt Gordon Mines incident, it is not always the urethane foam that initiates combustion. The entire insulation *system* must meet the flammability criteria.

Adhesives used in block-type foams should be non-flammable or self-extinguishing. An often applied test is the oxygen index test (ASTM D-2863) which indicates the oxygen content of a nitrogen-oxygen atmosphere necessary to sustain a flame. If an oxygen content greater than 21% is required, the material will not support combustion under normal conditions. However, this does not imply that the adhesive will not burn. If subjected to a flame or an external fire, the adhesive may join in combustion. Also desirable is a low heat of combustion; this will insure that in case of a fire the adhesive will contribute as little heat as possible.

Typical means of weather proofing an ammonia tank include: using a sprayed-on mastic, using an asphalt-based coating, or shielding the insulation with either stainless steel or aluminum sheeting. Care should be taken in choosing the vapor barrier. If a spray-on type is desired, prior knowledge of curing periods is necessary. The oxygen index test may be utilized to determine the vapor barrier's resistance to combustion.

When specifying a polyurethane foam insulation system it is extremely important that the individual parts be compatible. The entire unit will only be as fire-resistant as each individual part.

In summary, urethane foam insulation systems are excellent means of reducing heat leak into ammonia tanks. The merits are light weight, strength, and relative ease of installation. However, all urethane foams presently marketed, whether fire retardant or not, should be treated as combustible. With this in mind, an effective and safe system can be designed. #



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