ENGINEERING AMMONIA STORAGE TANK INSULATION FOR SAFETY

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There has been a tremendous increase in the use of ammonia in the United States over the last three years. As of January, 1962, the capacity was 16,500 ton/day; however, now it is approximately 30,000 ton/day, including plants that are currently being designed and constructed. With this growth in business has come an increase in demand for insulated storage tanks.

Importance of insulation

One of the most important items in the design of low pressure ammonia storage facilities is the insulation. Loose Perlite is used in double walled construction; however, this method has high initial cost. Single wall tanks have used Foamglas, polyurethane foam, spaced layers of aluminum foil and Styrofoam expanded polystyrene foam.

On single wall structures, it is very important to install the insulation properly. Good specifications and workmanship will result in low maintenance and a safe installation; however, poor specifications or workmanship could result in damage to the insulation and subsequent corrosion.

If a high percentage of insulation were lost, a severe safety hazard could exist. Temperature and pressure build-up would result in venting of ammonia vapors to the atmosphere. If this happened under extremely high ambient temperature conditions, the pressure build-up could cause the tank to rupture. Another factor which could contribute to this hazardous condition would be a simultaneous power loss which would result in additional pressure build-up. A power loss would be hazardous with any ammonia storage facility; however, it would be even more critical if it occurred with the insulation removed.

Tank tops

High winds will result in extremely high uplift pressures on tank roofs. To offset this pressure a secure fastening method is needed to keep the insulation in place.

Various methods have been used to attach insulations to steel roof decks. On flat surfaces, stud welds or adhesives will tie down the blocks or boards. Banding can be used on a dome top. This requires a floating ring at the center of the dome to attach the bands to.

When Styrofoam is used it is recommended to fasten the first layer with stud welds placed one per square foot. The board size should be 2 ft. × 4 ft. and the joints should be staggered. The Styrofoam is impaled over the stud weld and held in place with a metal clip.

To adhere the second layer of insulation to the first, it is recommended that latex modified cement adhesive be used in addition to wood skewers. The major portion of the bond comes from the cement. The wood skewers serve mainly to keep the insulation in contact with the adhesive during the set-up period.

Any insulation fastening device such as stud welds or banding should be a corrosion resistant material such as stainless steel. Experience has shown that galvanized banding will rust and break even though it is covered with a coating in corrosive atmospheres.

Vapor barrier requirements

There has been considerable past discussion on whether vapor barrier coatings are necessary over foam plastic insulations. It is advisable to prevent moisture from contacting the tank wall. Eliminating the water will prevent ice formation which may melt when the tank is warm and cause corrosion. Field experience where block-type insulations were used without a vapor barrier and sealed joints have shown ice build-up in the joints; however, with Styrofoam this icing stops after the joint is full. Ice build-up that has heaved the Styrofoam insulation away from the tank has not been experienced. This has, however, occurred with some insulations.

Foam plastic insulations such as polyurethanes and polystyrenes have a higher coefficient of thermal expansion (3 to 5 $\times 10^{-5}$ in./in./°F) than steel (0.6 $\times 10^{-5}$ in./in./°F). When the storage tank is brought down to temperature, the insulation contracts and the vertical and horizontal joints will open up. There are several precautions necessary to eliminate this problem. First, the insulation should be applied in a minimum of two layers with all joints staggered. Since there is a smaller temperature gradient across the outer layer, the thermal contraction will be decreased. The joints will not open up as much as they will with single layer construction. This also eliminates a direct opening from outside the insulation to the tank surface.

Sealant characteristics

A heavy bead of sealant should be applied inside the joints of the outer layer of insulation. It is important to use a product that remains flexible and maintains good elongation characteristics, so it can absorb any movement at the joints. It should also have a low moisture vapor transmission rate.

Theoretically, a good vapor seal can be obtained between blocks of insulation; however, this is not practical in the field on all joints with any block- or board-type system. For this reason a vapor barrier coating is recommended over the exterior insulation surface. These coatings or films should have a moisture vapor transmission rate of less than 0.05 perms (grains per hour through 1 sq. ft., under a partial vapor pressure differential of 1 in. of mercury), excellent weathering properties, and be adequately protected from mechanical damage.

Banding procedures

It is important to use proper banding practice to tie the insulation to the side walls. Poor band spacing and bands not properly tightened can cause problems during high wind conditions.

With large diameter tanks there is considerable friction build-up between the bands and the insulation during the tightening process. If tensioning is done in one location, that side may be tight and the other side loose. Since the side walls contract when brought down in temperature, the bands can become loose at that time. To eliminate the above problems, steel banding should be tied to vertical tie rods placed on a maximum of 60-ft. centers. Tensioning should take place half way between these bars. This divides the insulation into small segments that come and go with expansion and contraction of the tank. Figure 1 shows these tie rods which can be insulated with foam-in-place polyurethane foam.

Styrofoam should be installed with bands on a maximum of 12-in. centers and a maximum of 4 in. away from horizontal joints.

Past experience

It was reported in a paper entitled, "Safety and Low Pressure Ammonia Storage," (1) that Styrofoam had popped off a tank due to sudden atmospheric pressure changes or high wind conditions. This report has been fully investigated and it was found that the Styrofoam was not securely fastened down.

The specification on the tanks in question called for stud welds to hold the roof insulation in place. Only four stud welds were used per 2 ft. × 8 ft. board. The second layer of insulation was adhered to the first with wooden skewers. No adhesive was used. These fastening methods are not adequate to properly tie down insulation under severe winds. Figure 2 compares good and bad stud weld patterns for Styrofoam.

Any insulation not properly adhered to a single wall tank could be blown off during the severe wind conditions which existed when these problems occurred.

Existing installations

In 1956, the Southern Nitrogen Co. of Savannah, Ga., built a 140-ft. diameter × 40-ft. high ammonia storage tank and insulated the walls and roof with Styrofoam. It has been in service since early 1957 and has performed extremely well which is good evi-

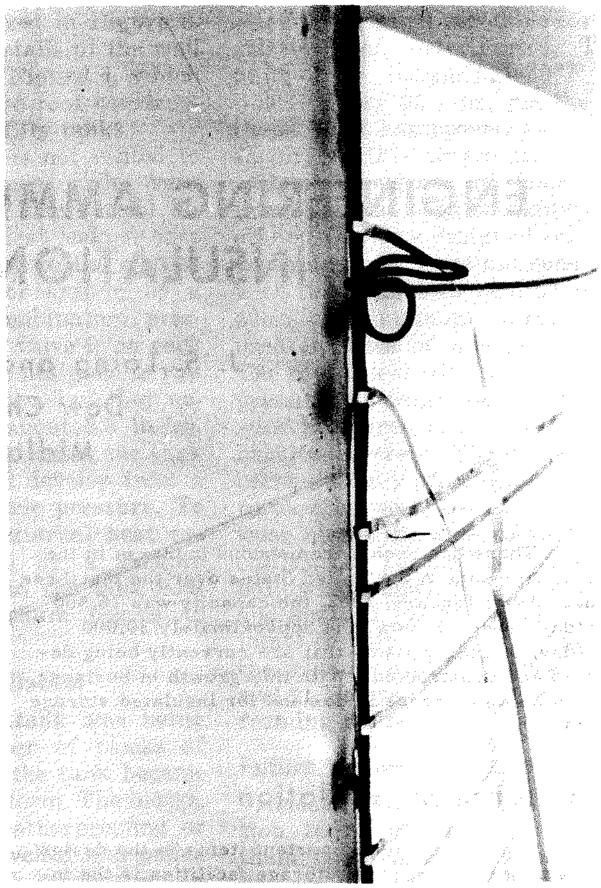
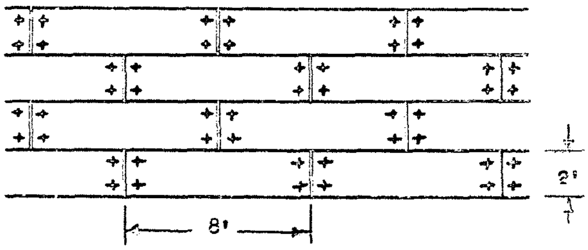
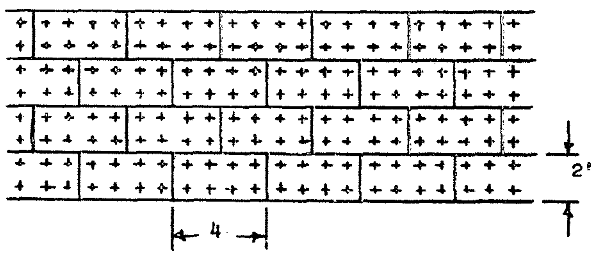


Figure 1. Vertical bars used to attach banding to the tank wall.



Poor - 2' x 8' Insulation boards with four Studwelds per board.



Good - 2' x 4' Insulation Boards with one Studweld Per Sq. Ft.

+ Indicates Studweld Position

Figure 2. Comparison of insulation and stud weld patterns on steel tank roofs.

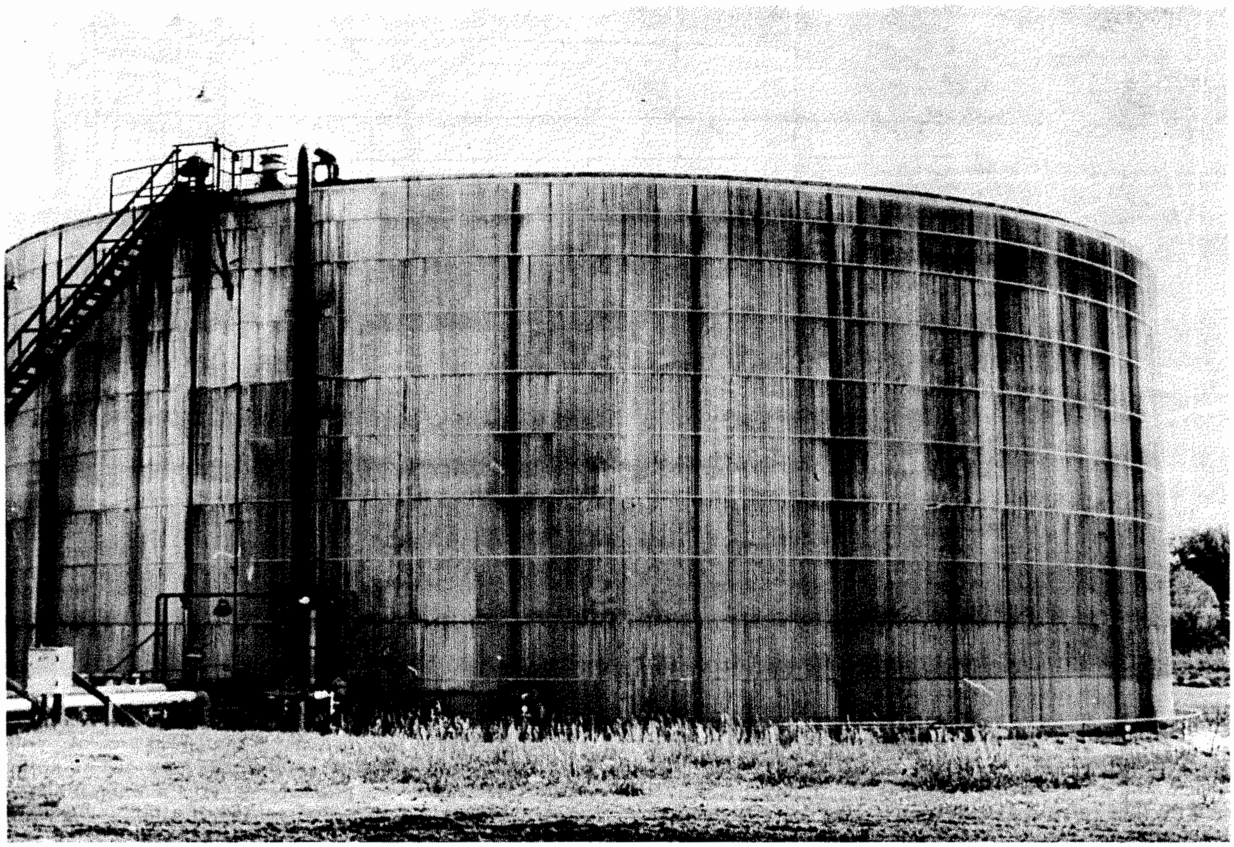


Figure 3. Styrofoam insulated ammonia storage tank built in 1956; photograph taken April, 1964.

Figure 4. Method of attaching stud welds to the roof with a stud gun.

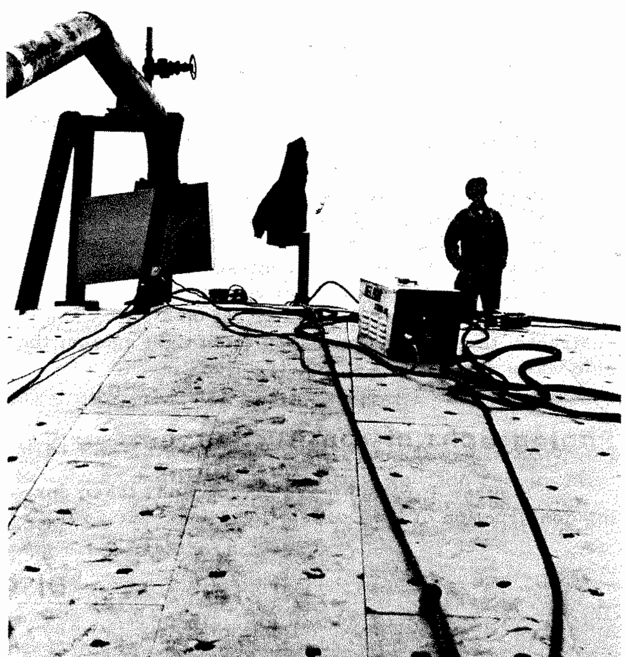


Figure 5. First layer of Styrofoam, impaled on the studs, in place on the roof.

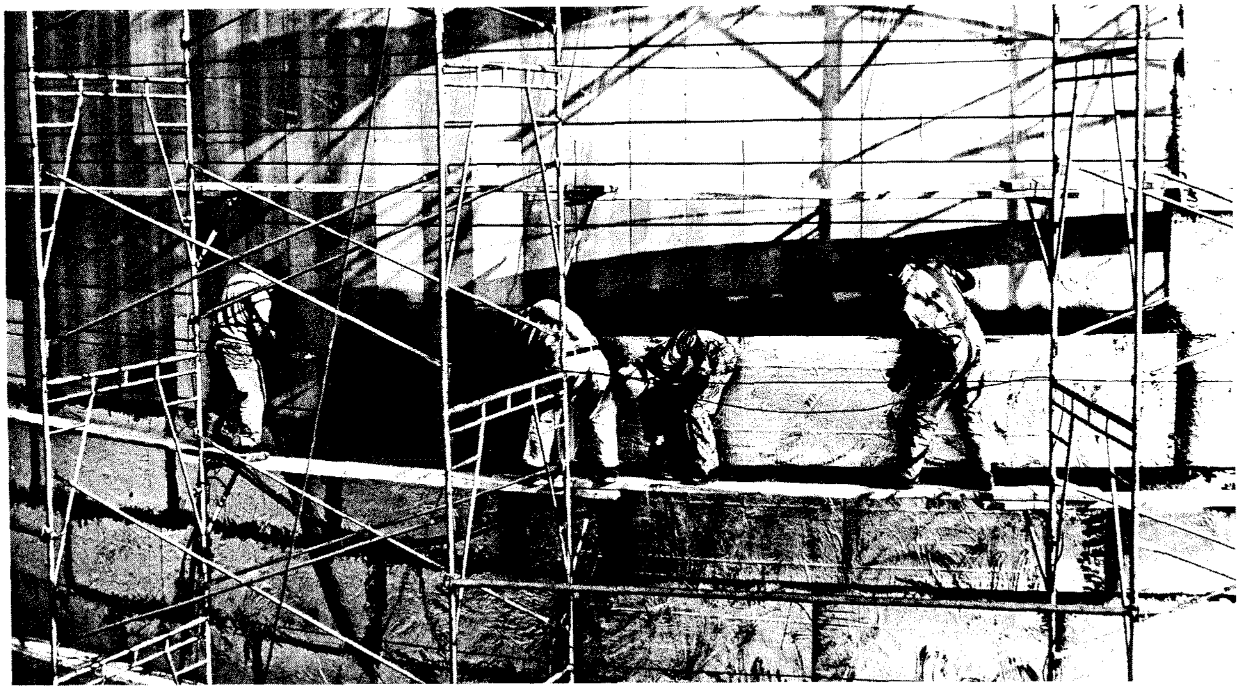


Figure 6. Adhesive being sprayed on the surface of the Styrofoam and vapor barrier film being rolled into the adhesive.

dence that Styrofoam properly installed will function satisfactorily. Figure 3 shows a recent photograph of this job. This insulation was applied in two layers with a vapor barrier over the outer surface.

Several other installations have used Styrofoam including a recently completed storage facility for Best Fertilizer Co. of Texas, Plainview, Texas, and a job currently being erected by Ammonia, Inc., Bonnie, Fla.

An ammonia storage tank is currently being constructed by Dow in Midland, Mich., using the same general construction previously outlined, except for the banding technique. A new banding concept is being used on the Dow tank. The vertical tie bars are eliminated and the individual straps will be tightened simultaneously by several tensioners located around the tank circumference. A nonmetallic nylon band is used in place of metal straps. It is called Dymax and is distributed by the Signode Steel Strapping Co., Chicago, Ill. Dymax has the ability to contract more than 5% after tensioning. The practical result of this resiliency is that the bands will stay tight on a tank when it contracts, thus, keeping the insulation tight against the side walls at all times of construction.

Photographs of construction

Figures 4, 5, and 6 are photographs taken during construction of the Dow storage tank.

Figure 4 shows the method of attaching the stud welds to the roof with a studweld gun.

Figure 5 shows the first layer of Styrofoam, impaled on the studs, in place on the roof. Note that clips have been driven down on the studs and driven into the Styrofoam 1/2 in. The pattern of stud welds spaced at 1-ft. intervals provides secure fastening. The transformer for the stud welder is also shown in this photograph. Figure 6 shows adhesive being sprayed on the surface of the Styrofoam and vapor barrier film being rolled into the adhesive. Styrofoam is held in place by tensioned nylon bands spaced at 18-in. intervals and at both ends of each 9-ft. board.

Safe and economical job

The successful past experience with Styrofoam as a low temperature tank insulation indicates that a safe and economical job can be obtained when proper installation procedures are used.

Literature Cited

1. Jenkins, W., "Safety and Low Pressure Ammonia Storage," in "Safety in air and ammonia plants," Vol. 4, p. 30-34 (June, 1962).

DISCUSSION

Pertaining to papers by L. B. Henderson and M. S. Crowley.

SWANBURG—Collier Carbon & Chemical: I'd like to direct two questions to either gentleman. One, do you have comparable heat loss data for the various types of installations, and two, would you care to comment on the safety philosophy of double-wall and single-wall tanks?

CROWLEY: I don't have any data on the heat loss. I have read various things, but I do not have any experimental data as such. With regard to your second question, I don't have any information that I can recall at this time on the relative safety.

WALTON—SunOlin: We have about six ethylene oxide tanks which operate at about 30°F. These were insulated with magnesia insulation and it's now in the process of falling off. We have to reinsulate them and I had suggested that we used sprayed polyurethane foam. The reaction I got from our maintenance superintendent was no—it's flammable. Any comments on this?

CROWLEY: We've checked this matter of flammability and all I can say is that some foams are and some aren't self extinguishing. Physical characteristics of polyurethane are rather subtle so I'd really rather have a heavy foam producer answer the question.

WALTON: Dr. Crowley, you suggested that Bob Butikofer comment on his recent installation. I wonder if he'll let us know how he feels about this, and also at the risk of being commercial, who did it, because it's kind of hard to find people who are, at least in our part of the country, willing to say that they can do a spray job.

BUTIKOFER—American Oil: We recently sprayed polyurethane on a 65 ft. diameter anhydrous ammonia storage sphere. This was done with our own forces using a Binks two-component spray gun-Model 18FM. A minimum thickness of 3/4 of an inch was applied, however, in some areas the application was about 2-in. thick. Polyurethane was sprayed on top of a red lead primer and then sealed with three coats of paint.

In this instance, we were seeking surface protection rather than insulation. Paints are unsatisfactory on a sphere surface which is wet about 90% of the time. There is no evidence of sweating on the polyurethane surface and the application appears good.

Polyurethane was also used in one other application and found satisfactory. Those of you who operate nitrogen wash boxes know that a problem exists in trying to avoid air leakage into the insulation, particularly where process piping extends through the wall of the cold box. A portion of our nitrogen wash box was sprayed with polyurethane and a satisfactory job of sealing was achieved.

BRADFORD—Manufacturer's Mutual Fire Insurance Co.: I think you'll find that most of the polyurethanes are combustible. Some of them are very highly flammable. They can be treated with additives to cut down the flammability, but I don't know of any of them, with one exception, that won't be seriously decomposed by relatively low temperatures in a fire, and to insulate ethylene oxide storage tank or a tank of ammonia that has any fire exposure to it, would in my opinion be very hazardous.

MASON—Dow Chemical: Isn't the problem in general of fire exposure—not from the standpoint of any fire danger to the contents of the tank, but merely a question of the subsistence of the insulation at the point of the fire? I think that as you indicated, the urethanes in general will not continue to burn after a fire source has been removed, and this is also true of the Styrofoam materials that would be used in a case like this. That is, these so-called self-extinguishing foams are not a source of fire, but as you indicated, they are not resistant to heat from a fire.

BRADFORD: For an ethylene oxide storage tank that has a reactive flammable liquid in it, in the event of a leak the fire which results would be very dramatic.

JONES—Canadian Industries, Ltd.: One gentleman brought up the question of relative safety of the polyurethane coating versus double-wall construction. It would seem to me that perhaps one might include missiles and ask which wall would be the most successful in defending against a local accident in which the ammonia tank was not primarily involved but had become secondarily involved. We hear from year to year of unfortunate accidents in which substantial pieces of metal are cast considerable distances and unless one takes the defense of removing the tanks a good distance from the plant, one might consider the physical defense of the tank part of the duty of the insulation. I'm wondering if there are any comments in this area.

The second thing I'd like to say is that we are presently constructing a tank to contain liquid sulfur dioxide and this is being constructed below grade in rock. It is a steel tank, bonded with concrete, to the excavated hole in the granite. The bottom of the tank is also bonded to the rock. I believe that this is a new and perhaps somewhat expensive approach. We compare the cost above grade and below grade and perhaps it is 25% more expensive below grade using this type of approach.

However, we make explosives, so there is some small compensation in this, and also this particular tank is located in a situation in which we elected to bend over backwards, as the saying goes, to see to it that there was no real risk of a spill. Perhaps we will be able to tell you more about that when we have some operating experience.

ELLIS—DuPont: I would just like to inquire on how these studs are placed onto the tank and whether they are harmful for the low temperature storage?

HENDERSON—Dow Chemical: The studs are welded to the tank by means of a Studweld gun. The stud is inserted in the gun and pressed against the steel surface. Squeezing the trigger of the gun retracts the stud producing a momentary arc and the stud is pressed into the pool of molten metal. The studs used on the tank roof were about 1/8 in. diameter. The tank is not damaged by welding the studs to the surface.

Anonymous: This type of approach is satisfactory to Dow Chemical then, from the aspect of notches and arcs and a few other things as they are put on?

HENDERSON: I doubt if there would be any notches or arcs—it's just a shop weld.

Anonymous: Just those that are not fastened were the ones I was worried about. I don't think you'll get 100% —maybe you will—100% contact of each stud placed in position.

HENDERSON: I don't believe so.

MILLER—DuPont: I wonder if I could ask Dr. Crowley to discuss a little bit more thoroughly the results he gained from the settling of perlite in the double-wall tank. Do you feel that 7 to 8 lb./sq.in. is limiting or just economically not attractive.

CROWLEY: I said that a pressure increase of 7 to 8 lb./sq.in. might be expected from 70-ft. tall perlite-insulated tanks. The number could go higher, in which case the economics of construction might be changed significantly.