STATUS REPORT OF THE AMMONIA STORAGE COMMITTEE

In keeping with its policy of self-evaluation, and in recognization of need for safe practices, a guide for operation of ammonia storage facilities is soon to be published.

W. L. Ball
Air Products & Chemicals
Allentown, Pa.

The first installation designed to store a large quantity of anhydrous ammonia at essentially atmospheric pressure was installed in 1956. The storage of liquid ammonia at atmospheric pressure, generally less than one pound per square inch gauge, requires that the ammonia be refrigerated to maintain it at the corresponding saturation temperature, about 28° Fahrenheit below zero. This method of storing large quantities of ammonia is economically advantageous due to a significant reduction in fixed capital requirements as compared to a small increase in operating costs. The need to store large quantities of ammonia is due to the seasonal nature of the ammonia fertilizer market.

In recent years, both the number and size of atmospheric pressure ammonia storage tanks have increased at rapid rates which correspond to the growth and development of the ammonia industry.

A recent survey indicates that in the United States and Canada there are about 170 atmospheric pressure ammonia storage tanks, with a total capacity of about 3 million tons of liquid ammonia. It is not uncommon for a tank to be designed for a capacity of 30,000 tons, and even larger tanks have been built.

The first installation designed to store a large quantity of anhydrous ammonia at essentially atmospheric pressure was installed in 1956. Storage at this pressure level, generally less than 1 lb./sq.in.gauge, requires that the ammonia be refrigerated to maintain it at the corresponding saturation temperature of about minus 28°F. This method of storing large quantities is economically advantageous due to a significant reduction in fixed capital requirements as compared to a small increase in operating costs. The need to store large quantities of ammonia is due to the seasonal nature of the ammonia fertilizer market.

Start of the study committee

The ammonia industry has always been very safety conscious. Through an established policy of self-evaluation, the industry has maintained its remarkable safety record. An outstanding example of its self-evaluation continues to be the Air and Ammonia Plant Safety Symposium of the American Institute of Chemical Engineers. The symposium consists of an annual three-day meeting to freely discuss technical topics of mutual interest concerning safety in the ammonia industry.

A discussion of ammonia storage at the 1964 meeting indicated the desirability of obtaining more information about certain aspects of storing ammonia at low pressures in refrigerated tanks. There was specific concern for the thermal stability of a large quantity of refrigerated liquid ammonia, and for the hazards which might result from a large ammonia spill. With this in mind, the A.I.Ch.E. Symposium Subcommittee made a survey of the ammonia industry soliciting support for a research program to obtain information on these and related subjects.

The industry responded, and an initial meeting in April,1965, was attended by representatives of companies involved in the production, marketing, and shipping of ammonia as well as the engineering and construction of ammonia plants and storage tanks. Thirty-four companies representing a cross section of the ammonia industry agreed to form a committee and to contribute manpower and financial support to obtain information relative to safety in the storage of ammonia at atmospheric pressure. The committee is officially known as the Ammonia Storage Committee and is sponsored by the Compressed Gas Association. At the present time, 37 companies in five countries are members of the committee.

The Ammonia Storage Committee employed a research firm, University Engineers, Inc., Norman, Okla., to make a theoretical study involving the following subjects: (1) A literature survey and an analysis of industrial experience, (2) the effects of large spills, and (3) the possibility of roll-over and temperature stratification in refrigerated ammonia storage tanks. Subcommittees of the storage committee were appointed to work with the University Engineers in accomplishing the study.

Conclusions made from study

After consideration of the work done by the University Engineers, the storage committee has thus far reached the following main conclusions:

1. Concerning roll-over and temperature stratification of the storage tank contents, there does not appear to be a potential hazard. Calculations show that only an infinitesimal temperature gradient is needed to initiate and maintain natural circulation and prevent temperature stratification. Careful temperature profile measurements in a large atmospheric pressure ammonia storage tank substantiate these calculations.

Calculations also indicate, however, that there is a possibility of stratification for ammonia containing over 5,000 ppm. of water. Also, there can be bump-boiling in the area of localized tank insulation defects.

2. Concerning large spills of liquid ammonia, dangerous ammonia vapor concentrations could be expected at relatively long distances if the liquid were allowed to spread. This would be especially true during adverse weather conditions, such as thermal inversion combined with low wind velocity.

In spite of the theoretical nature of most of the work, the committee feels it is sufficiently indicative for them to write a guide of recommended practice for the operation of atmospheric pressure ammonia storage facilities. A sub-committee was recently formed for this purpose.

Scope of practices guide

At this time it is expected that the guide sub-committee will consider the following subjects:

1. Methods for minimizing the possibility of a concentration gradient in the storage tank.
2. Methods for controlling bump-boiling caused by a localized defect in tank insulation.
3. Methods for limiting the extent of surface area over which a liquid ammonia leak may spread.
4. Emergency plans and procedures for evacuation in the unlikely event of a serious spill.

It is also possible that the guide may discuss recommended practices on subjects such as nozzle locations, etc., to minimize the possibility of a major leak. The area of major concern here is the arrangement of tank bottom connections. Other areas may be considered as the committee continues its study.

The committee has also considered further research work to test the validity of the theoretical calculations and to evaluate possible methods for mitigating the effects of a major spill. At this time, however, further research work has been held in abeyance for the following reasons:

1. Large scale spill tests under a variety of weather conditions and topography are not considered practical.
2. There is some question whether wind tunnel experiments on ammonia vapor dispersion in the atmosphere could be scaled up to give a much greater degree of confidence than presently exists from the theoretical work.
3. Methods for mitigating the effects of a spill other than the method of confining the spilled liquid do not appear to hold much promise of success.

In summary, the Ammonia Storage Committee recognizes the need for safe industry practices for ammonia storage and is taking action to provide a guide of recommended practices for the operation of atmospheric pressure ammonia storage facilities. The guide is expected to be published sometime in 1968.

Discussion

Q. Is there any thought being given to what might be done to blanket a pool of ammonia to cut down on evaporation?

BALL: Various techniques were considered for cutting down evaporation rates. We have never gone into a detailed study of each of these ideas to see what could be done.

Q. This is not then going to be part of this guide?

BALL: It is not programmed into the guide at the moment, although as we work along something of that sort might be suggested and added. It is not part of the stated purpose of the committee to go into design detail.

C.L. HINDERAGER, Simplot Co.: We have a low pressure ammonia-storage tank. The piping out of the tank has been of some concern. It has a manual block valve out of the bottom of the tank and piping leading to a typical multistage ammonia pump. In the event of a piping failure, what is the practice of providing a way to close that valve?

BALL: What we have done is to install a manual block valve and then a remote controlled valve. In the event the remote controlled valve doesn't work, with appropriate safety precautions we can get to and close off the manual valve. In our lines into and out of the tank we have contain valving that will minimize the quantity of liquid that can be spilled at any one time.

Q. Do you provide anything against stress corrosion in these large tanks?

F.W.S. JONES: We have considered this quite carefully. There was work done after failures in the southern states some 10-12 years ago on nurse tanks, where stress corrosion in anhydrous ammonia was first noted as a serious situation. The stress corrosion cracking was confined to the knuckle radii of cold-worked ASME heads. In this region, because of heavy cold work, the stress level would be substantially above the level of residual welding stresses. In the large ammonia storage tank, in general, the material of construction is a mild steel of weldable grade and moderate yield strength. The residual stress, either due to the rather large radii of curvature or residual weldments would not be significantly above the yield value. This would be in the order of 45,000 lb/sq.in. This applies to the materials such as Lukens LT75N, Sheffield "Low Temp" and U.S. Steel "Charpact". These are standard weldable grades of material of superior notch toughness. The very high strength steels may provide residual fabrication stresses which would be above the threshold stress level required for stress corrosion cracking in ammonia. I'm not sure, but believe the majority of industry has taken the stand that they will use soft, low strength steels for major vessel and storage construction. The other factor, of course, is the ambient temperature. The probability is that stress corrosion cracking in anhydrous ammonia storage tanks will proceed more rapidly at ambient temperatures than it will at the -28°F atmospheric boiling point of anhydrous ammonia. This means that the upper part of the tank may occasionally be warm enough for this to be a consideration. Our view has been that providing one has built the tank in the conventional materials, rather than the high strength materials, one may safely use as-formed and as-welded conditions without significant risk of stress corrosion cracking.

Q. Is the committee giving consideration to the problems associated with underground ammonia storage which has been used so successfully for hydrocarbons?

BALL: This has not been specifically taken into consideration at this time. An underground storage system would certainly provide the ultimate in containment and minimize the dispersion of the ammonia into the atmosphere.

F.W.S. JONES: Norske Hydro is constructing underground ammonia storage in impervious rock, I believe granite. I also believe DuPont are looking into the situation in New Jersey. Others have it under consideration. It is rather difficult compared to the usual hydrocarbon underground storage facility, because of reactivity with salt. We do have a below grade storage ourselves containing liquid sulfur dioxide, some 3,000 tons. Here we have a steel membrane for containment.

JIM SHERMAN, DuPont Co: We understand we are the second in line in the underground storage of ammonia. We are constructing such storage at Gibbstown, N.J. This storage is 370 ft. below the surface measured from the bottom, the tunnels are about 30 ft. high and 20 ft. wide. The feasibility of this type of storage depends greatly on the composition of the underground rock. As you can well imagine in the Gulf Coast where there is pretty poor rock down to 3,000 ft., it is not practical. In our location, impervious rock starts at 150 ft. below ground. About 20 miles away the impervious rock starts at 500-600 ft. below ground. The storage excavation is begun by drilling a vertical bore hole about 55 inches in diameter. This is then lined with steel casing, with excavation taking place through the casing. The ammonia is brought out of the storage by means of deep well pumps. The main concern that we have had is the integrity of the rock formation and the real problem if appreciable water leakage is encountered. The attendant problem of combination with whatever salts are dissolved in the water also exists.

B.O. STROM, Central Farmers: We have many terminals in operation as well as many we plan to build. Our question at the moment is has the self-regulating aspect of the industry been sufficient to curtail any state regulating authority in codification of safety at these ammonia terminals? Have any ground rules been laid down for the building of these terminals?

BALL: I don't have sufficient data to comment specifically on that. One area which could affect us would be the state and federal programs controlling pollution. Certainly if there is a large spill of ammonia the possibility of both air and water pollution could be a concern.

Q. Is the question of humidity being considered and the level of non-lethal concentration which would nevertheless engender panic in the public at large?

BALL: Certainly the humidity of the atmosphere is one of the factors which adds confusion. A spill under high humidity conditions will cause a much greater problem than under dry conditions as the small droplets of aqueous ammonia that apparently result persist for a relatively long time.

The non-lethal concentration aspect is being taken under consideration by the group that is preparing a draft for the guide. It is easy to see that a certain concentration could cause panic without actually being a serious threat to the person's health. Looking at data available regarding ammonia concentration and physiological effect, 30-50 ppm is the odor threshold; 100 ppm is acceptable for an 8-hr. working day; at 300-700 ppm there is no lasting effect with exposures of ½-1 hrs. It may be difficult for people to stay in such an atmosphere depending on their individual tolerance, while there may be sufficient time for them to get away from the vapor.

Q. Will the guideline criteria which will eventually be issued have any criteria for changes in barometric pressure? What provision should be allowed for these changes in sizing, in refrigeration capacity, etc.?

BALL: If we get that specific we'd be getting into detail of design. What the guide will do will be to point out problem areas, suggest avenues of approach, and leave details to the people involved in the design and operation of the facilities.

Q. The toxic concern with large spills was noted. If the refrigeration compressors or significant insulation were lost, would the continuous venting resulting be considered a toxic problem?

BALL: I believe that something very akin to this was experienced with several tanks as a result of Hurricane Betsy a few years ago. To my recollection there was no serious problem reported as a result of this. This could be attributed to the specific location of those tanks. Such venting would have the advantage of venting at a higher elevation and would not be in the same order of magnitude as a large spill.