The industry speaks on . . .

Safely operating that low temperature plant

part 3 (Unpublished information from St. Paul)

Tanks, cars and trucks

MASON - Moderator: Our next subject is tank cars and trucks. Mr. L. B. Henderson, the superintendent of the ammonia and air separation plant of Dow Chemical and chairman of the Ammonia Committee of the Compressed Gas Association, will introduce this subject.

HENDERSON - Dow Chemical: The increasing demand for anhydrous ammonia dictated development of safe and efficient large-volume transportation facilities. Today these transportation facilities include cylinders, tank cars, tank trucks, portable skid tanks and barges. All of this transportation equipment is similar to that used for LPG except that valves, fittings, etc., are made of iron or steel rather than brass or bronze fittings commonly used on LPG equipment.

Requirements for these interstate transportation units are specified by the Interstate Commerce Commission. Any movement of anhydrous ammonia by water, barge, or portable tanks on vessels is regulated by the Coast Guard. Tank cars are regulated by ICC specifications 106-A-500, 105-A-300-W, and 112-A-400-W.

Tank cars included in specifications 106-A-500 are multi-unit cars consisting of a number of cylinder-type containers which are removed from the car for filling and emptying.

Tank cars regulated by specifications 105-A-300-W are single-unit tanks covered with insulation, which is protected by a steel jacket. These cars are practically identical with those in LPG service, except that valves and fittings are made of steel. Many of these cars are used for dual service, that is, they may be used for either anhydrous ammonia or LPG. The dual-service cars have fittings suitable for anhydrous ammonia and must be cleaned and inspected when interchanging service. These welded tank have no bottom outlet and are provided with an outlet at the top. All valves and fittings are attached to the outlet cover and protected by a dome housing. Fittings generally include two liquid lines extending to the bottom of the car, one line to the vapor space, and a safety relief valve. They also have a sampling line, a gauging device, and a thermometer well. On most cars the liquid and vapor lines are 2-in. pipe, and those in dual service are equipped with excess flow valves. The safety relief valve is set at 225 lb./sq. in. The filling density for these cars is 57% of water capacity.

Tank cars referred to in specifications 112-A-400-W are also single-unit cars, but are not insulated. These cars are similar to the insulated cars, but have relief valves set at 300 lb./sq. in. Filling density for these cars is 57% during the months of April to October and 58.8% during the months of November to March, provided the cars are loaded and shipped directly to consumers for unloading.

Tank trucks, or cargo tanks, meeting ICC specification MC-330 and portable tanks meeting ICC specification 51 are authorized for transportation of anhydrous ammonia. These units are similar to those in LPG service, except that ICC requires them to have a minimum design working pressure of 265 lb./sq. in. gauge as compared to 250 lb./sq. in. gauge in LPG equipment. All loading and unloading connections must be equipped with excess flow valves. The tanks must be protected from excessive pressure by a spring-loaded safety relief valve and all valves and fittings must be protected from physical damage by adequate steel guards or housings. Safety relief valves on cargo and portable tanks must be set to discharge at a pressure not in excess of 110% of the tank design pressure. The maximum permitted filling density for cargo and portable tanks is 56% by weight or 82% by volume. A filling density of 87.5% may be used, provided the temperature of the ammonia is not lower than 30° F, or if filling is stopped at the first indication of frost on the outside of the tank and not resumed until such frost has disappeared.

Three types of gauging devices are permissible for use on cargo and portable tanks: (1) the rotary-tube gauge (2) the slip-tube gauge and (3) the fixed-length dip tube. Since these gauges are subject to air when the tank is not level, it is desirable to weigh each load to avoid exceeding the allowable weight.

An excess flow valve or surge valve is a safety device which closes automatically against the outward flow of the contents of a tank such as may be encountered in case the external shut-off valve is broken, or upon failure of the connecting hose or pipe. There has been considerable discussion within the anhydrous ammonia industry concerning the need for excess flow valves on tank cars used for the transportation of anhydrous ammonia. The desirability of requiring excess flow valves in the interior liquid and vapor lines of tank cars used for chlorine and LPG has long been recognized and is required by ICC regulations. The greatest need for the use of these devices occurs during the loading and unloading operations when accidental moving of a car before the unloading lines are disconnected can result in the release of large amounts of gas. The desirability of providing some means of protection in these instances is generally recognized, although experience indicates that there is little hazard during transit. For this reason, the Ammonia Committee of the CGA did not recommend a change in the ICC regulations; however, it recommends the use of excess flow valves in the interior liquid and vapor lines of anhydrous ammonia tank cars. Excess flow valves should be checked periodically to be certain that they are in operating condition. An excess flow valve that fails to operate when the control valve is thrown wide open should be replaced, as it offers no protection. The rated closing flow for 2-in. excess flow valves is approximately 70 gal./min. of liquid ammonia. At this rate, an 11,000 gal. tank car can be unloaded in about 3 hr. One important feature is that control valves should be opened gradually to avoid a surge of liquid during the initial stage of unloading.

The term filling density was mentioned earlier. Filling density for liquefied gases is defined as the percent ratio of the weight of gas in the tank to the weight of water that the tank will hold at 60°F. The maximum filling densities have been established to prevent liquid-full containers in which tremendous pressures can be developed as the temperature of the liquid rises. Some indication of the pressure encountered in a liquid-full container can be seen from a test that we performed. A one-liter bomb, rated at 30,000 lb. working pressure, was filled with liquid ammonia at 35°F. When the temperature of the liquid reached 100°F, a pressure of 12,000 lb. was registered on the gauge. Difficulties that were encountered indicated that the bomb, the pressure gauge, etc., may not have been completely filled with liquid. However, it was an excellent demonstration that liquid-full containers should be avoided.

Recommended procedures for safe handling of ammonia published by several organizations such as the AAI, the CGA, the MCA, and the National Safety Council are available.

Intrastate ammonia transportation is not subject to the 265 lb./sq. in. ICC regulation, however several states have adopted the ICC regulations for intrastate transportation. Since there were no regulations against the use of 250 lb./sq. in. tanks in intrastate service, many 250 lb./sq. in. tanks have been operating in ammonia service within state limits for many years, with satisfactory results. In order to continue to operate these units and to permit interstate operations, it has been proposed that ICC regulations be revised. This has led to a controversy which has not been resolved at this time. Mr. Frank Fetherson, Secretary-Treasurer of the Compressed Gas Association, will discuss this question in greater detail.

FETHERSTON - Compressed Gas Association: I would like to review the history of the pressure design problem that exists in transportation of anhydrous ammonia.

Anhydrous ammonia, of course, has been transported by rail in tank cars for a great many years and there has never been any great problem. Transportation of anhydrous ammonia by tank truck is relatively new. It was probably the first of the liquefied gases to be carried - with the exception of carbon dioxide - over the highways in transport trucks. Prior to the use of tank trucks, ammonia was transported in cylinders and at that time the ICC regulations were written contemplating the container as an uninsulated vessel. The rules of the ICC said,, in effect, that the vapor pressure of the commodity in the container at 130 degrees shall not exceed by 120% the design pressure of the container. This laid the pattern for the first regulations of the ICC with respect to tank truck vessels. According to this the design pressure is approximately 263 lb., but it was rounded off at 265 lb. That's how we started out with 265-lb. vessels.

In the meantime, other industries developed a very potent use for 250-lb. vessels. You have to admit, there's not a great deal of difference between a design pressure of 265 and 250 lb. Sometimes, I feel that the mills in rolling their steel, or the fabricators in rolling the diameters of their containers, can hardly differentiate between the two.

The system in our country and Canada is more or less unique in packaging of compressed gases in that we do not necessarily dedicate a container to a commodity use. The container under ICC regulations is designed according to specifications, the service pressure is established according to the commodity. But the container, if the surface pressure is sufficiently high, and if properly cleaned and equipped with the necessary valves and other apertures, can be used for other commodities. The ammonia tank car is interchangeable between LPG and ammonia service. The ammonia container can be used for other liquefied gas services, providing that the pressure characteristics of the material and the outlets on the container are compatible and within the framework of the requirements of the ICC. It is quite logical for those who are interested in these commodities, LPG and anhydrous ammonia, to want to have their equipment interchangeable. This is the first reason for wanting to change the pressure regulations.

In the meantime, a great many things have changed. First, there was a demand for a portable tank from the LPG industry. The first, portable tanks were developed with the assistance of the Coast Guard and the limitations in size and gross weight that are now imposed by the ICC are in the regulations only because the Coast Guard set those limits as maximum for handling at the various ports.

When the portable tank was put into service, the question of whether 130 degrees as the temperature factor for loading density was proper. After all, you had a larger vessel and a larger volume of commodity, and the problem of heat transmission was different. The American Petroleum Institute at the time came up with some very interesting information about the effective temperatures on commodities and petroleum products shipped by water. It was agreed at the time that 115 degrees, rather than 130 degrees, the previously accepted was a more appropriate temperature for filling density considerations in the cargo tank. So, we moved from the 130 degree consideration to a change in the regulation which reduced the temperature to 115 degrees, which in itself made a difference in the end result.

Then, another change was made by setting a safety device on these containers. Originally, the industry recognized the ASME construction of pressure vessels and required that the safety devices be in accord with the ASME requirement. In other words, the start-to-discharge pressure would not be higher than the design pressure of the container. Experience of the industry proved the desirability of changing that rule. The ICC agreed, and regulations today state that the start-to-discharge of the safety device shall not exceed 110% of the design pressure of the vessel, and that the pressure in the vessel shall not exceed 125% of the design pressure when the device is open full.

The American Standards Association Committee has been trying to develop some installations standards for ammonia equipment for the last five years. We haven't progressed very far, mainly for the reasons that are before you now. Also, the Anhydrous Ammonia Committee of the CGA has a difference of opinion, both of which are supported by very strong views. There have been two reports made to our directors, one in favor of a recommendation to the ICC to change the present 265 requirement to 250, and the other report in support of the argument that is should not be changed. In our last directors' meeting, a committee of three consisting of the chairman of the two sub-committees and myself was appointed to resolve this problem. The Compressed Gas Association has been asked for its recommendation by the ICC, who has refused to move on the proposal to amend the regulation without the comment from this technical body. We are considering this particular subject, only from the point of view of safety to the public, as well as to the distributors of ammonia. We tried to rule out any consideration of economics or anything other than safety.

Our Executive Board, in being confronted with this problem, feels that they should have a broader opinion from those directly concerned with the problem. It is their intention to have a letter from the committee of three go to every producer of anhydrous ammonia to obtain company opinions on this subject. We've been told to get the letter out as soon as possible.

BUTIKOFER - Standard Oil: I'd like to discuss a problem which I believe that all of you have experienced. I'm speaking of the variety of fittings that you find on these trucks. We have trucks coming into our plant that have either male or female fittings, ranging from 1-1/4 to 2-1/2 inches. These fittings are changes that go from customer to customer. When they come into our place, it's necessary for us to put a pipe fitter on the truck to hook it up, rather than have the operator do it. This always involves extra delay and expense. We tried to do something about it in the Calumet region by calling the truckers together and discussing it with them. It looked as though we were making some progress; however, there was no agreement as to selecting a standard fitting.

I was wondering what the possibility might be to arrive at some standardization of these fittings on the trucks so that loading will be easier.

FETHERSTON: I do not think that there would be any difficulty in standardization of that particular item. I think that our Anhydrous Ammonia Committee in conjunction with our Valve Standards Committee could do a very good job on this problem. As a matter of fact, we have done many similar jobs for other industries.

BUTIKOFER: I would like to urge that we get started on this as soon as we can. Anything that we can do to help would certainly be in order.

ANONYMOUS: I would like to relate an incident that occurred recently at our plant when we were loading an MC-330 truck tank. In order to maintain a constant tare weight, we in the past have unhooked the tractor from the trailer and left the trailer with the brakes set on the scales during the loading operation. This particular loading operation was proceeding normally with the tractor unhooked and only the trailer on the scales.

After 1600 tons had been loaded, the trailer tipped over and lay on its side. What actually happened was the front dolly collapsed. The trailer went forward, down on its side, and tipped against the scale, displacing it about eight inches. The wheels skidded out from underneath, and the trailer rolled over. The hose was stretched, but did not break. The operators stopped the pump and we were able to vent the lines and unhook them from the trailer. We put a new set of hoses on and unloaded as much ammonia as we could from the trailer by pressuring back to our sphere. Since the trailer was in a rather odd position, we were only able to unload down to about six tons; however, we were able to right the trailer. This took about 16 hours.

I just wanted to throw this in as a possible precaution for other people in the future.

CHUBB - Atlantic Refining: We had an incident similar to the last one described. We were loading a cylindrical tank holding about 2-1/2 tons of anhydrous ammonia mounted on a stake-bodied truck. We had been assured before we started loading this trailer that it was equipped to comply with all regulations. We loaded this trailer in our normal manner; however, one day our loading hose ruptured after we started pumping into the trailer. This in itself, as you all know, was rather serious. We stopped the pump immediately, and closed the discharge valve on the pump. We thought that all we would lose would be the small amount of ammonia in the hose, figuring that the excess flow valve on the trailer would hold back the approximately 3/4 of a ton that was in the trailer at that time. However, there was no excess check valve on the trailer, and we proceeded to rapidly unload the ammonia in the trailer. That, in itself, taught us a lesson about double checking ICC approved slips.

The cause of the accident is what I really want to talk about. We had in the past used the conventional ammonia hose made of rubber with a braided steel covering covered by another layer of rubber. We had always used the boss-type fittings which fold over the end of this hose. About six months before this happened, we tried a brand new type fitting which was much lighter in weight and easier to handle than the original fittings. The new fitting was a compression fitting. This sounds like a good idea, however, in the flexing of the hose in hooking up the tank cars, the sharp edge of the compression fitting cut the outer covering. We thought that this hose was stainless steel grade; however, we found out later, much to our chagrin, that it was carbon steel grade. This carbon steel grade, exposed to the atmosphere after the outside rubber covering was cut, proceeded to deteriorate. While we were loading this trailer, the hose ruptured at the edge of the fitting. Needless to say, we do not use these anymore. We have gone back to the heavier boss-type fitting and we make sure that stainless steel is specified.

FETHERSTON: I mentioned earlier the problem of filling densities as being of importance to that of design pressure and safety device requirements. I'd like to ask Frank Heller, from Phillips Petroleum Company to give you a brief rundown on what is being done concerning filling densities.

HELLER - Phillips Petroleum: I think L. B. Henderson mentioned that the uninsulated tank cars were authorized for shipment of anhydrous ammonia some time ago. He mentioned the fact that they had both winter and summer filling densities authorized. When that went into the ICC regulations there was only one filling density for the 105-A-300-W insulated tank car. The question immediately entered our minds that if winter and summer filling densities are permissible for an uninsulated ammonia tank car, why shouldn't they also be permitted for insulated tank cars?

The practice of not having winter and summer filling densities goes way back and is a well-established custom. In order to advance any change in the regulation, we felt that we needed to substantiate any claims that we would make with some actual test data. So Phillips started, over a year ago, to conduct tests on four tank cars. We chose two insulated tank cars and two uninsulated tank cars for this test. We loaded anhydrous ammonia into one pair and LPG into the other and accumulated an abundant quantity of data. A computer was used to correlate the data. The computer has given us the best answer for all the data that we have accumulated, but then the question arose, "what are the maximum temperature conditions to which you are going to subject this best answer of the data?" Well, we didn't have the answer to that question. The CGA underwrote a program with the Weather Bureau in order to give us weather information that we could use in our analysis to come up with the answer as to whether or not filling densities for anhydrous ammonia tank cars can be changed.

The Weather Bureau had never received a request of the nature that we asked. We divided the country into six areas and told them that we would like to have the warmest ten consecutive days in summer and in winter. The Bureau said that was going to require quite a search and they estimated a cost of $5,000 which the CGA has underwritten. The CGA asked producers of ammonia to contribute to this problem, and they very generously have done so.

The weather data is just starting to come in now. We are estimating that our report will be completed in time to present at the January meeting of the CGA.

The weather data is going to be one of the most comprehensive weather reports ever compiled and it will be of interest not only to people interested in anhydrous ammonia, but to industry as a whole.

KNOX - St. Paul Ammonia Products: I was wondering if the safety regulations were also going to consider what happens to the cars at their destination? I think from a safety standpoint, we should also consider how the car is unloaded and the general practice of using cars as storage. This is both a safety and an economic problem.

HELLER: The ICC regulations only concerns themselves with safety in transportation. They do, however, consider safety at the destination when safe handling would conflict with the regulations.

WALTON: There's a few questions which some of us are curious about and perhaps Henderson may have the answers. One of them is the accident to a couple of LPG tank cars in Georgia that resulted in a high loss of life and which was not very well explained in the newspapers. I wondered if there was anything in that accident which might be of interest to us.

The second question concerns recent failures of springs and safety valves on some tank cars. I investigated two tank car lines and found that they used either cadmium-plated or nickel-plated safety valve springs. I was wondering whether that is being considered by the CGA.

FETHERSTON: I think I can answer both questions very rapidly. As far as the accident is concerned, the LPG tank car was near the tail end of a 100 car train that went over a very high tressel. It was unfortunate that this car was not at the front end, because it never would have been involved in the accident. No tank car, whether it is charged with LPG, ammonia, or any other commodity, would have withstood the abuse in falling from that tressel. It was inevitable under those circumstances that a commodity would be released. As far as the industry is concerned this could have happened to any commodity.

With respect to the second problem, the CGA has not done anything about this subject. We do know that fabricators of relief devices for tank cars have been quite concerned and have been doing something about it.

Repairs preparation

WEIGERS - Moderator: The next subject concerns preparation for repairs and will be discussed by George Odom, who is the operations manager of the Chemetron Corporation's Maine operations.

ODOM - Chemetron: It would be presumptuous of me to try to advise the members of this group on how to make preparations for a specific repair in his own plant, and I shall not attempt to do so. Neither would a detailed description of how we do these things in a relatively small plant located in a far corner of the country seem to be of any universal value. Nevertheless, because new plants arise and new faces appear in the industry, a consideration of a few fundamentals appears in order.

The first one I want to discuss is planning. In the case where the whole plant is to be shutdown no particular problems should appear. Most problems arise during the shutting down and starting up periods rather than in the periods of actual repair. Unfortunately, management is actually at fault more often than not because of insistence on getting back to production too quickly. Alleviation of this type of pain can only be through scrupulous planning and scheduling. Thought and preparation exerted during this phase of the problem will aid in the prevention of accidents during the actual shutdown in direct proportion to the effort exerted.

The second topic concerns the preparation of personnel. For repairs in an emergency or for unexpected breakdowns there is no advance preparation possible except thorough and complete training. Even as firemen have to be trained when there is no actual conflagration, personnel in a chemical plant have to be trained when there is no actual breakdown. Most of this training must be educational in character, but there is no text book. We must teach based upon experience. I am all too sure that many plants depend for such training only on the trial and error method. If you survive the lesson, it is assumed that you have learned it. Even for plant repairs it pays to take the people who will do the work into your confidence with thorough discussion of the problem, the method of approach, the hazards involved, and the special equipment to be used.

I might digress to say that it's my custom to have the day shift stay over for awhile every Thursday afternoon so that we can discuss matters pertaining to both safety and repairs. Management is indulgent to allow me a little overtime money to expend for this reason. I will hold up the safety record of my plant against any safety record, and I think that most of it is credited to this type of operator communication.

I might speak for a moment about preparation of the system. One of the most annoying of all repair problems is not being able to locate a leak which was so obvious before shutdown. Part of the preparation of the system for repair must therefore be made before the actual shutdown by marking or identifying the location of work. It is universal to do this by notes in the log book or by accumulation of shutdown items in a separate work book. In addition to this system, tagging of leaks, valves to be retrimmed or packed, pumps to be overhauled, and instruments to be reworked is a great help. We use tags which are red in color and have wire ties so they will not fall off. Prior to a shutdown the operators are all given a supply of these and are asked to tag the specific location and to write on the tag the nature of the trouble. When the trouble is repaired, the tag is removed.

For those who have an air separation plant, and thus have pure nitrogen available, the job of purging is much easier than for those who have only steam, CO_2, or inert gases and cylinders to rely upon or who have to use water for displacement. Even with pure nitrogen available, we still use these other methods in specific cases. Sloppy purging techniques is a prolific source of trouble, but proper planning will overcome most of the problems. Assuming the purging procedure to be safe, the modern plant has at its disposal many devices to see that the actual purge is completed properly. Explosometers, detectors for specific gases, laboratories equipped with chromatographs and infrared spectrophotometers leave little to chance. But one of the big problems is that these devices are only as good as the sample and the operator. Therefore, do not rely on one analysis, run at least a couple of checks, and preferably run samples by two different methods or by two different operators.

The next topic concerns preparation of equipment. All prime movers, valves, instruments, or other devices which could operate and produce a hazardous condition are tagged. If welding or cutting is involved another precaution is the requirement of a welding permit.

Taking all necessary personnel safety precautions is just as much a part of the repair job as any other phase. Gas masks, respirators, air or demand masks, and fire extinguishers must be attended to. These are all primary precautions. Finally, there is no substitute for close supervision of any job during its progress. The unexpected is almost always encountered. Supervision is needed most right on the job to see that the job is done properly and safely.

SWOPE - Southern Oxygen: I certainly go along with Mr. Odom with regards to preparation and testing. One thought that might escape some people concerns purging hydrogen lines. Everybody here has been talking about using nitrogen to do purge work; however, it is extremely difficult to tell when you are completely purged because nitrogen and hydrogen are both equally inert to the average Orsat type of testing equipment. If you use CO_2, it is very easy to tell when you are completely purged. It's also very easy to tell when you have gotten rid of the CO_2 when you're purging with hydrogen in going back on stream.

ODOM: The reason that we do not use CO_2 is because we had a couple of experiences with the formation of ammonium carbonate in pipes and we found that it causes more damage to our process. I do not think it has any safety aspect.

Personnel safety

LAWRENCE - U.S.I.: As an introduction to this subject, I will review some of the personnel safety problems involved. One thing we do is make sure we have an ammonia mask for every man in the plant and that he knows where his mask is, because one of the real deadly hazards is to have an ammonia line rupture and have somebody looking for a mask. We had a case in our plant a few months ago where we had a relief valve unseat on our refrigeration receiver and before the system was brought under control, we had dumped about eight tons of ammonia into the air. We were happy to have masks around and the valve was repaired with no serious harm.

A very interesting point was brought out recently at an Air Products safety meeting on oxygen. It concerns the fact that a man who is sampling oxygen and gets a lot of oxygen in his pants cuffs, on his shirt, etc. would take several hours to be decontaminated. I sat there and shuddered because we had an operator who sampled oxygen and a few moments later was working in a combustible area. We have changed this procedure. The fact that a man is pretty highly combustible after he takes an oxygen sample is something to think about.

Another thing that was brought up earlier in the meeting concerns noise, which is a strain and can actually be painful to personnel. We have Lee sonic ear valves for operators that work in noisy areas. These valves filter out all the high frequency noise, but do not inhibit you from hearing conversation. With these valves operators claim that they can have purges going all day and be around centrifugal compressors without any harm.

The last item concerns hazards caused by the operator himself. This is usually due to insufficient or improper training as discussed earlier by George Odom. To illustrate this point I might relate a little incident that happened at our plant. We had to send a bunch of our operators over to our acid plant because of our union contract and we got trapped in a short training program. Unfortunately, we had an emergency shutdown on a shift that was staffed with weak operators. As is standard in the industry, we have permament orders of what to do in all situations. We had everything very nicely covered, however the accident that occurred can be attributed to multiple operator failure due to improper training. One of the first things the operator does within the first 45 seconds is to shut the high pressure nitrogen valve between the 3000 pound nitrogen and the 400 pound hydrogen so that the nitrogen remains in the 3000 pound circuit. The next thing he does is blocks the nitrogen out and relieves the pressure in the hydrogen circuit.

In our particular plant we thought we'd be real smart. In cold weather, when we were having a little trouble with our derime system in the air plant, we would use nitrogen to reactivate the dryers. We had a pipe permanently connected between our two systems. This arrangement contributed to the accident.

On this particular night we had five orders violated on the same shutdown. The operator did not block the 3000 pound nitrogen to 400 pound hydrogen valve or the 3000 pound nitrogen to 3 pound nitrogen valve. The 3000 pound nitrogen was released, however the 400 pound hydrogen system was not released. The hydrogen in the 400 pound system went into the 3 pound nitrogen system. It went backwards to the nitrogen compressor suction lines and eventually it was headed for the hydrogen vent.

Meanwhile, we had a pump pulling that line through the air plant dryers and electric heaters. That was all right since hydrogen will dry in an air plant dryer pretty well without much problem. Everything was proceeding all right until we started the compressor and began pressurizing the plant. As soon as the pressure hit the boil up coil in the high pressure column, the oxygen in the low pressure column started to displace the hydrogen in the nitrogen lines. The mixture of oxygen and hydrogen hit that 900 degree heater element and the result was pretty spectacular. It blew the top out of the pre-exchanger and it split all the nitrogen pipes open. I immediately said that we would never reconnect the nitrogen line to the dryers as long as I was there.

First thing I did after the accident was to start looking the plant over to see if we had a normal shutdown and I found these valves open. I asked the operators and learned that they just forgot them. The main thing we attributed the whole thing to was the fact that we had three operators on the shift who had been there only a few days and they just forgot what to do in an emergency.

I'd like to close this discussion by saying that at Tuscola in the little over five years that the plant has been operating, we have never had a lost time accident and in the early days I was accused of being too safety conscious. Today, partly due to the work of this Committee, the people in the plant who do not understand ammonia and cold plants have read these articles and are starting to ask me if we're safe enough over there. I think that is a very great contribution.

MODERATOR: In our plant we have the explosimeters which are sensitized to hydrogen and acetylene, however, they will read a positive explosion atmosphere with steam. Certainly steam isn't explosive, so we decided to put a little dryer cartridge in the line to eliminate the false explosive reading with steam.

We test these explosimeters once a day using natural gas which is nearly everywhere. In certain areas there is no natural gas and so we use acetone. However, with these dryers you can have all the acetone you want and you get a zero explosion reading. Not only acetone, but all the solvents which are liquid at ambient temperatures. So we quickly had the instructions withdrawn to use the dryers so that explosive readings might be due to steam. I wanted to pass that on because it could have been a nasty situation in our plant.

BOLLEN - Dow Chemical: I'd like to relate a little accident that occurred in the early days of our air separation plant which emphasized the need for real tight control of low temperature products and good communication between supervisors and the people that handle these products. As soon as we started producing low temperature products, our maintenance department promptly approached us for aid in doing several jobs that they were having difficulty with, such as shrink fittings, repairing, and so on. On this particular occassion they wanted material to solidify some plastic. They sent one of the millwrights down to our plant where he contacted the operator there. We never did find out whether he asked for liquid oxygen or our operator, who was new on the job, was wrong. In any case, the lab technician was taking a sample of liquid oxygen at that time. The operator pointed to the sample and the millwright promptly took himself a container of liquid oxygen back to the plastic plant where he promptly used it to freeze the molten plastic around the equipment that they wanted to remove. The idea was to get the plastic hard so that they could chip it off with hammers. Well, they got it hard and the millwright promptly gave it a couple of smacks with a hammer and chisel. The thing exploded right in his face. Fortunately, he was wearing safety glasses and a mask so he wouldn't get hurt by flying particles. He did get a badly cut hand from it and a few cuts on his cheek, but he was very lucky. Since that time, we have instituted rigid controls concerning the use of our liquid oxygen and liquid nitrogen, the containers that we put it into, and the way that we sample it.

BATES - Foster Wheeler: Those of you who have been through your startup throws and have learned how to operate your plant for years have perhaps forgotten that the most critical period is when you are starting your plant for the first time. This is the time when personnel training is the most important. During these startup periods instruction comes in very frequently and we have the responsibility which provides some supervision. A well trained crew on the part of the customers is certainly a great help in getting the plant going. I think that most engineering construction companies take the position that if something can possibly happen, it will. Very often these things that happen during the start up phases will not happen after your operating staff is well acquainted with the problems of operation.

CHUBB - Atlantic Refining: I'd like to describe a method of safety which we started about a year ago. We were using four shifts and covering the plant 24 hr. a day. We designated one man in the shift as the safety representative. It is the responsibility of this operator to pass on to supervisionall safety suggestions which might come from any of the operators on the shift. It is also his duty to inspect once a month all of the safety equipment which we have in our plant. The inspections are acheduled so that all of the safety equipment is completely and thoroughly inspected once a week. The inspector submits a written report to the supervisor concerning the condition of the equipment.

We also have monthly safety meetings conducted by the shift foreman for each shift where safety problems are discussed. This has made an organization which in our minds is one of the most safety conscious anywhere in the Atlantic Refining Company. Certainly, this organization and these symposiums have helped.

WEIGERS - Moderator: I might mention something that we have started in our plant about a year ago which started off very quietly and turned out to be a success in terms of safety. We had become aware of the idea that familiarity breeds contempt. You see something every day and you begin to overlook the fact that you may have a safety hazard on your hand. So little inspection teams were formed of shift supervisors from foreign operating areas. They would descend on one particular operating unit and inspect it, looking specifically for unsafe conditions or unsafe acts on the part of the operating personnel. Well, the shift supervisor of the department that was being inspected felt bad when the inspection teams found something wrong. Now there is a very healthy competition between the shift supervisors to get their department in such good shape that the inspection team cannot find anything wrong. We have found that these have been the best, the most detailed, and the most productive inspections that we've had.

BOLLEN: I'd just like to remark that we have pretty much the same scheme. We have an inspection by a team of supervisors from other plants every three months which is completely unplanned. They go through the plant looking for safety hazards, unsafe conditions, and bad housekeeping.

ANONYMOUS: In our plant ammonia is considered one of the least toxic and least worrisome material that we have. Largely because of the other materials that we handle we adopted a plant-wide crisis procedure by which any operating supervisor or operator that sees a major spill develop can pick up the phone and call the operator. From there on it's automatic. The entire plant gets alerted by sirens and gas tests are automatically started. The operator tells the various departments where the crisis is taking place and what the weather conditions are. There is a regular evacuation procedure set up to clear out any area downstream of the major spill and take care of the shutdown on an emergency basis. The substances we are worried about are things like acetylene, hydrocyanic acid, acrylonitrile, and things of that sort.

MASON: We have a similar program at Dow and we have a trial test run about every three or four months. This is a comparatively new procedure at Dow.

ODOM: All of these schemes mentioned work, otherwise people would not adopt them. My philosophy is that it is up to the management to see that safe working conditions and rules are established and it is up to the hourly man to work safely. There is a difference. If you use hourly people to inspect your plant and tell you what is wrong with it, you must do two things; first, you must be prepared to accept that as a criticism of management and second, you must be prepared to do the greater part of the things that they suggest, otherwise what would be the point in having hourly people looking for things which are wrong. In my plant I insist that the supervisory people assume the inspection function and we keep it within the management group. We invite the hourly people to make voluntary suggestions and then it leaves it up to us as to whether we can do them.

Ammonia plant accident analysis

MASON: I'd like to call John Clapperton to discuss the description and analyses of accidents in ammonia plants.

CLAPPERTON - Columbia-Southern Chem.: The analysis of ammonia plant accidents is no different from the analysis of other types of industrial accidents. I will discuss here one approach to an organized analysis which is hoped can lead to a rational, logical solution to the problems, what caused them, and how we can prevent them. Accident investigation is of such prime importance in the safety program that both top management and the persons running the safety program must protect its integrity as a device for preventing accidents. Investigations must be objective, factual, and free from punishment motives. Otherwise, they may do more harm than good. This is not to say that responsibility may not be fixed if a personal failure has caused injury or that such persons should be excused from the consequences. However, the investigation itself is concerned only with the facts and investigating an individual or a group is best kept free from involvement with the consequences.

The principal purposes of an accident investigation are:

1. To learn accident causes so that similar accidents may be prevented by mechanical improvement, better supervision, or better employee instruction.

2. To publicize the particular hazard among the employees and their supervisors and to direct attention to accident prevention in general.

3. To determine facts bearing on legal liability.

An investigation undertaken solely for legal liability purposes will seldom give enough information for accident prevention purposes. On the other hand, an investigation for preventive purposes may disclose facts which are important in determining liability. Depending on the nature of the accident and other conditions, the investigation may be made by the foreman, safety engineer or inspector, the general safety committee, or an engineer from the insurance company or state labor department. If the accident involves special features, conferences with an assistant by the latter may be warranted. The foreman should make an immediate report of every accident since he is on the grounds, he probably knows more about the accident than anyone else, and it is up to him in most cases to put into effect whatever measures may be adopted to prevent similar accidents.

A representative of the safety department should make an investigation of every accident for his own information. In most cases he should make a written report to the proper officials or to the general safety committee. Nowhere is the safety engineer's value and ability better shown than in the investigation of an accident. His specialized training and analytical experience enable him to get all the facts, apparent and hidden, and to submit a report free from bias and prejudice. He has no interest in the investigation other than to get information that can be used to prevent a similar accident.

In many companies, especially those of small or moderate size, all safety activities are headed by a general safety committee whose activities include accident investigation. Ordinarily such investigations would be handled in routine manner, but in important cases the committee might conduct a special investigation. An accident causing death or serious injury obviously should be investigated. The near accident that might have caused death or serious injury is equally important from a safety standpoint and also should be investigated. Each investigation should be made as soon after the accident as possible. A delay of only a few hours may permit important evidence to be destroyed or removed, either intentionally or unintentionally. Results of the inquiry should also be made known quickly.

Within a relatively few years, accident prevention has progressed from a hit or miss proposition to a technology closely approaching the scientific method. In earlier years a reduction in accident rates was attempted primarily by humanitarian appeal to both management and workers. Today methods are employed which isolate and identify the causes of accidents and which permit direct and positive action to be taken to prevent their recurrence. Like other phases of modern business management, accident prevention must be based on facts which clearly identify the problems. An approach to the accident prevention problem on this basis not only will result in more effective control over accidents, but will permit this objective to be accomplished in saving time, effort, and money. Analysis of the circumstances of accidents according to the recommended standard procedures can produce these results:

1. Identify and locate the principal sources of accidents by determining from actual experience the materials, machines, and tools most frequently involved in accidents and the jobs most likely to produce injuries.

2. Disclose the nature and size of the accident problem in particular departments and among particular occupations.

3. Indicate the need for engineering revision by identifying the principal unsafe conditions of various equipment and materials.

4. Disclose inefficiencies in operating processes and procedures where poor layout or outdated methods might contribute to accidents. For example, procedures which overtax the physical capacities of the workers can be avoided by using mechanical handling methods.

5. Disclose the unsafe practices which need special attention in the training of employees.

6. Disclose improper placement of personnel in instances where inabilities or physical handicaps contribute to accidents.

7. Enable supervisors to use the time available for safety work to the greatest advantage by providing them with information about the principal hazards and unsafe practices in their departments.

8. Permit an objective evaluation of the progress of the safety program by noting the effect of different safety measures, educational techniques, and other methods adopted to prevent injuries.