EXPLOSIONS AND SAFETY PROBLEMS IN HANDLING UREA-AMMONIUM NITRATE SOLUTIONS

Leaks into insulation contributed to hazardous conditions; insulation has been replaced

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Two of the incidents to be discussed occurred within 10 ft. of each other. A short description of the facility will help to better understand what happened.

This particular area is a urea nitrate solution loading system. At our facilities at Lawrence we have four large aluminum storage tanks that will hold approximately 40,000 tons of urea nitrate solution. Normally this is stored as 32% UAN. It has an approximate composition of 35% urea, 45% nitrate, balance water with small amounts of free ammonia; a tenth of a percent, sometimes two tenths of a percent.

The loading lines are 4 in. and 6 in. aluminum piping. These lines are steam traced and insulated. The loading facilities include two truck loading spots and six tank car loading spots.

The first incident occurred on the afternoon of March 31, 1966. The time was approximately 4:15 in the afternoon. This was about fifteen minutes after shift change.

On the afternoon shift, six cars had been loaded. The operators had stopped loading. The train crew had moved out the cars and pushed in some empties to be loaded on the evening shift. The operator on duty at the time was on the loading rack which was located about 200 ft. from the pump. He was preparing the cars for loading. The suction valves and discharge valves at the pump were open and only the block valve at the tank car rack itself was closed. The pump was not running.

Flame from the suction line

The operator heard a noise like a low pressure relief valve discharging. He turned and looked towards the tank, and he saw a spurt of flame from the suction line near the pump rise about 8 to 10 feet in the air. This was followed by a sharp explosion, and about two seconds later a large gush of urea solution started coming out of the line.

The operator immediately ran to the tank and shut the valve at the tank to stop the flow of urea nitrate solution. He also shut off the steam **tracing** . We were loading from the No. 3 tank at the time. It had approximately 12 ft. of material in it. There is a riser in this line due to some obstruction in this area. This is about a 4 ft. riser, and then into the suction of the pump on out to loading.

The first explosion occurred right at this point, here. The insulation is an inch thick and is wrapped with aluminum, except the elbows which were covered with glass fabric and had a mastic sealer on the outside. When we inspected these pieces, this elbow was completely blown apart. The fragments were all within an area of about 20 ft., the main force going in this direction. They were in pieces the size of a dime up to size of your hand. It opened the elbow up and split the pipe on the side of the elbow. This piping, down a bit wasn't affected at all.

Picking up the pieces

When we picked up the pieces and got them all back together, we observed the area of the weld between the elbow and the horizontal piece of pipe, and found some inclusions in this particular weld, and it looked like there had been some pinhole leaks at that particular point. The outer surface of the metal had been quite hot and some of the insulation was partly blackened. On this particular failure we felt that we had had a small leak and got the insulation saturated and possibly the heat from the steam tracing line had caused ignition that started the train of events. It appeared to us that this particular riser was full of gas at the time even though we had been loading only an hour or so prior to this explosion. There definitely was a pressure surge and a flame prior to the major portion of the explosion, and we feel this started on the outside.

At the time we inspected some of the other elbows on the suction side, particularly where we had risers, unfortunately, we did not look at the riser on the discharge side of the pump. On May 25, about 3:20 pm, we were transferring material from one tank to another. We use the same lines except instead of going into loading we block in the loading line and use it for transfer.

At this particular time we had emptied one tank and to the best of our knowledge the pump had lost suction and been running 20 minutes prior to the time of the second explosion.

An eyewitness account

This incident was a little bit different from the earlier one. We had two eyewitnesses who happened to be looking at the pipe when it happened. The first was a maintenance man who was in an elevated position about 30 ft. off the ground and about 150 ft. away. He said: "I was working on a conveyor to the bagging hopper at the No. 2 bulk warehouse. I looked across to the urea tanks. I heard a noise and saw a cloud of yellow-orange mixed with white smoke forming above the line at the loading pump. This cloud rose into the air about 8 to 10 ft. and trailed off into a white stream. About 30 seconds later material started coming out of the hole in the line." The material, he was talking about was UAN solution.

There was another employee who was about 90 degrees from this fellow. He was at ground level and about 150 ft. away. He said: "I was on the north dock of the No. 2 plant looking north as a trash truck approached the dock. I heard a noise like a relief valve whistling to my left. I looked in the direction of the urea tanks, saw steam and greenish grey ball, like a Roman candle go up west of the UAN loading line. It rose 5 to 10 ft. in the air and disappeared. About a half a minute later, UAN solution gushed out of the line."

They agreed on the 30 second period before UAN appeared but had a considerable difference of opinion in the color of the gas which came out.

This explosion was much less intense. It did not blow the insulation away from the elbow or the piping. The first one blew the insulation away and broke the band holding the aluminum jacket on the insulation. In this case we had to pull the insulation off and it was difficult to remove. Once we got it off, the elbow was in 25 pieces, but it didn't have enough force to part the the insulation.

We didn't find any indications of pinholes in this piece of metal. The solution that had been transferred was about 110 F. We did note that the steam tracing was tied to the line with iron wire--normally we use stainless steel. Where the iron wire was around the aluminum pipe, it had cut a groove in the latter.

Since the explosions, we have stripped all insulation off this loading system, inspected all the piping, and reinsulated it. There has been approximately 600,000 tons of solution loaded through this system. We are still uncertain of the exact cause of the explosions.

Discussion

Q. In making your UAN solution you said it had some traces of ammonia. I assume the ammonia comes from urea.

Anderson: Right.

Q. I have been wondering about the possibility of having nitrate urea present, or something like that. Would it have been possible that you had your ammonium nitrate a little bit on the acid side when you add it to the urea when you made it up.

Anderson: We didn't have any indication of that. We took a sample from the tanks and they were on spec. Of course, with a little bit of free-ammonia in the solution, the pH is always high on our UAN solutions. As far as we know, we didn't have any nitrate on the acid side going in.

Q. I was thinking of - when you first started, when you mixed it originally with the nitrate ammonium.

Anderson: Our mixing is all done in a mixed tank prior to coming to the large tanks. We mix as we come off our day tanks. We have a proportional type blending system, mix it all up, cool it, and then transfer it out to the large storage tanks. It is pretty well monitored.

Q. What was your thought on the iron wire on aluminum pipe?

Anderson: We normally use stainless wire. I just made that remark because it had cut a groove in the pipe, but we didn't have any evidence that linked it to the explosion.

Q. Was it your thought that it was an explosion, or was it a pressure release?

Anderson: No, there was an explosion.

Q. What was the construction material of this pipeline, and were the fractures apprantly brittle ones?

Anderson: It is aluminum, but I am at a loss as to what particular alloy of aluminum. It looked pretty brittle. We had had some analysis made of it, and the people at Kansas University said it was strictly a stress break from pressure: not necessarily corrosion.

Q. In the second case was the steam tracing off?

Anderson: Yes, it was off.

Q. Now in these explosions, could you, or is there any way you could, establish from the position of the fragments or the way they fractured, whether the explosion was on the inside or the outside?

Anderson: The first explosion was definitely on the inside, although we were pretty sure there had been some fire on the outside before the explosion. The second one was on the inside, but it didn't throw any pieces. It just kind of puffed and the insulation actually contained the explosion.

Q. Were the ells used in this line aluminum ells. Were they sand cast, permanent mold cast, what were they?

Anderson: I am pretty sure they are cast ells. I don't know what alloy.

Q. Were there possibilities of hydraulic surges in this line or valve slamming shut on you?

Anderson: No.

Q. Are you sure you have an effective ground connection to the piping system.

Anderson: Yes, we checked our ground systems and it appeared to be satisfactory.

Q. Sometimes just as a hint, you have a ground connection, if your ground is dry, particularly in certain times of the year, you are lulled into a false sense of security and in some places it is necessary to go down into a deep well or something like that to get what is called an effective ground.

Anderson: This particular area is fairly wet. We have an open sewer that comes by this point, in fact, that is one reason that loop is in there. We prefer not to have the loop but we did have an obstruction to cross over.

Problems in urea plants

Our facilities at Lawrence, Kan., include two urea plants. They are both fairly small units. Our first unit was a Chemico design partial recycle plant. The original design was for 30 tons day. It was installed in 1959 and in 1960 it was converted to a full recycle plant, with capacity increased to 50 tons day. The second unit was installed in 1961. It is a once-through type urea plant. It had an original capacity of 50 tons day, and in 1963 we increased the capacity to 120 tons day.

The majority of our problems have centered around the original plant which was partial recycle and converted to full recycle. One of our major problems in the early days centered around the carbamate pump. This was a plunger type pump with a suction of 200 lb. sq.in. and discharge of 3,000 lb. sq.in.

To give you example of the extent of some of our problems, our maintenance on this pump amounted to about $33,000 in 1962. This was primarily due to replacing plungers, packing, and such things as this. We felt fortunate when we got a 3-week run without having to change packing or having leaks.

Tried many materials

We went through a series of materials for plungers and packing. To give you a short list, on the plungers we tried 304 stainless, Hastelloy D, titanium and 329-S. Currently we are using 316 stainless overlaid with Colmoloy No. 6. Our current packing is a Teflon asbestos pre-compressed ring. Our major problem was solved by the addition of an injection pump. We installed a small three plunger condensate pump which was timed to inject water during the stroke of each of the main pumping plungers. After the installation of this pump our maintenance expense dropped to $4,200 a year.

On this pump, the block houses the suction and discharge manifold and is made of titanium, the barrels are 329 stainless. The lantern rings, land rings, and coil lantern rings are 316 stainless. They have a Babbitt lining to keep them from seizing to the

plunger. The original rings had a silver lining. We tried aluminum linings on these particular lantern rings, but the Babbitt has worked out very well. The valves are 329 stainless and we are now using titanium disc in the particular pump.

Another spot that we watched particularly close in the unit is the reactor inlet piping. This is a section of pipe about 3 ft. long. It is 3 in. O.D. and has ⅝ in. wall. This particular pipe is 316 ELC material.

We X-ray this line about twice a year. As we see it getting thinner we replace it. The welding procedure we use in replacin it is to nitrogen purge the line during welding and then passivate the metal with a weak nitric acid solution. We would like to try 329 stainless at this particular spot, but have been unable to procure material as yet.

Other spots that we have paid particular attention to are in the letdown valves on both units. On both plants, the valves have 316 stainless bodies. On the recycle plant we have replaced the valve bodies twice over a seven year period. The inner valves are normally 329. We have also used titanium. The valves in the once-through plant are of different manufacture. They are the same material and they have titanium inner valves. These have held up much better than the ones in the recycle plant.

Block valve a problem

We have had a problem with a particular type of block valve that has a plug in its bottom. It is a screwed-in type plug, seal-welded. On several occasions we have had this plug blow out. It is probably due to crevice type corrosion. Of course, the seal-weld isn't strong enough to hold the 3,000 lb. pressure at that point. We are now cutting them out and going to full welded plugs. So far we haven't had any failures with this method of installing the plug, although it requires more work to repair the valve.

We use a Chevron valve packing of virgin Teflon. It has worked very satisfactorily. We like most other people, have had considerable trouble with check valves. Our CO_2 compressor is located about 3/4 mi. away. When the compressor shuts down fluid starts backing up and plugs the transfer line. One of our engineers designed a check valve that has worked very satisfactorily for the past year. It is a blank lens ring made of 316 stainless steel with holes drilled and fitted with a spring loaded device and flat plate that had been well lapped. It is installed between a pair of flanges. We have had three quick shutdowns on this unit in the last year and haven't had any leakage through this type check valve.

Another area where we have a problem is with pressure transmitters. We have capillary seal units which I imagine some of you have. Ours have a 316 stainless diaphragm with a Teflon coating. We have numerous diaphragm failures. We have had some relief valve problems on the second stage decomposer in particular. This vessel operates normally at about 30 lb. and 220 F.

One of the most notable occasions occurred during an upset the vessel was overpressured and the relief valve didn't blow but the sight glass failed.

It acted as a rupture disc. It pretty well alarmed everybody around the area. We inspected the relief valve and found the same thing that Norton did. It was filled with solid urea. This valve had a ruptured disc under it. The ruptured disc had broken but apparently the valve had been seeping prior to this time and plugged off the line.

Right after this incident we put a steam connection in the line to keep it open, and since that time we have replaced the valve, with a steam jacketed valve. It also is equipped with bellows to protect the guiding surfaces and we have a steam line that washes inside as well as the outlet of the valve. This has been in about six months now, and as far as we know, it appears to be satisfactory. We hope to have a look at it in the near future.

Our major problem with process lines is in the off-gas system. We take our off-gas through our neutralizers where we neutralize ammonia and nitric acid. These lines were made of aluminum. Here again I'm not sure what the alloy was, but over a period of time they have been pretty well shot. We have been replacing these lines with 316-L. This also applied to the rundown lines from the decomposer separator to our urea day tanks. The lines are now pratically all replaced with 316-L.

Discussion

Walton (SunOlin Chemical): I might mention that we have had success on plungers of carbamate pumps with chrome plating. We tried Colmonoy and wasn't as successful as with 100% chrome plating.

I am interested particularly in your success with 329 which is something we haven't tried very much. The suction valves on our carbamate pumps had 6 in. Teflon-lined cocks. We have had a great deal of trouble with these Teflon liners failing. In the past year we changed to ball valves and these appear to be more satisfactory although we have had to rework them. We think the cause of it has been that broken pieces of valve plate have gotten into them. The other possibility is that when we put these in we did not fully equip them with wash connections such as we had on our Teflon-lined cocks. That, perhaps, is the problem in that we have had some solid carbamate in there which scored the ball and the seals. We have since added some wash connections.