

NITRIC ACID PLANT EXPLOSION

An accumulation of ammonium nitrite probably in solution during a prolonged startup was pinpointed as the probable source of the explosion

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About a year ago an explosion occurred in one of our nitric acid plants at Billingham, England. Following the investigation, some modifications were made and plant operating procedures altered. You may be interested in the details. The information herein is taken from the original report.

The plant was built in 1964 to produce 275 tons of HNO_3 per day, (90,000 tons yr.) in the form of 60% acid. It was commissioned in August, 1964. Mixed gas containing around 12% ammonia is filtered and burned in four burner units at slightly less than atmospheric pressures and 830 C. to produce nitrous fume.

This, after raising steam, is cooled first by a spray of weak 3% nitric acid and then by water in a gas cooler which I will refer to as No. 1 gas cooler. The condensate from this cooler runs into the 3% acid tank and forms the major part of the make up to the absorption system.

Secondary air joins the gas stream at the suction of the compressor which raises the pressure to 45 lb. sq.in. gauge. The hot gas passes through the tail gas preheater and is further cooled by water in a second cooler which I will refer to as No. 2 gas cooler, before passing to the absorption section. The condensate from No. 2 gas cooler flows to a tank of 1 cubic meter capacity. This is the 35% acid tank and is then pumped to the appropriate point in the absorption towers. Condensate from the tail gas preheater drains to the 3% acid tank.

The plant ran without major difficulty for a year. About a week before the explosion, following a light up after a minor shut down, the foreman reported that there was something unusual in the spread of No. 4 burner which was lit without preheat. It is worth mentioning that since initial startup of the plant, the use of steam on the preheater had not been found necessary. Water has been injected in the main between No. 1 gas cooler and the secondary air branch only at times of start-up.

Just before the explosion

I am now going to describe the plant operation immediately preceding the explosion! A heavy acid leak in a level controller necessitated a shutdown of the plant and because of the nature of the leak there was only 5 minutes sweep through of the plant after shutting off the ammonia.

After the leak was repaired, several abortive attempts were made to start the plant up, each one failing due to one cause or another. I do not propose to go into details of these startups.

The plant was finally started up shortly after the night shift came on at 10 o'clock. The oncoming shift found the 35% acid tank full almost to the top level connection, and the tank was hot

to the touch. I mention this because I think it may be significant. It was emptied to the absorption system leaving a normal level in it. By 10:15 the plant was ready to start; an ammonia rate of 2,000 cu.m./hr. was set and lighting up of the burners commenced. Three of the burners lit without incident but No. 4 blacked out in areas when the hydrogen torch was withdrawn. During these operations trouble was experienced with the level in No. 1 boiler and the ammonia rate was shut off at 11:05 pm. This had also occurred on a previous shift. The ammonia rate was shut off by the boiler extra-low-level trip coming into operation.

The explosion occurred at 12:30

Normal conditions were quickly restored and by 11:15 a starting rate of 2,000 cu.m./hr. was set. Nos. 1, 2 and 3 burners lit without the use of the torch but again No. 4 would not spread when the torch was withdrawn. At 11:30 the assistant foreman reported that he was not satisfied with No. 4 burner. Further attempts were made to light it and at 12:20 the pre-heater was brought on line. No. 4 burner then started to spread, but not with the usual random spread of lit areas. The explosion occurred at 12:30 am.

Damage was quite considerable. The flying debris caused minor injury to two men. The 35% acid tank was completely destroyed, large pieces of it going through the roof, being found many yards from the building. There was little fragmentation. The adjacent 3% acid tank was distorted by the blast. A few mains and lines were ripped apart. There was considerable damage to the building. A brick wall was bulged and cracked; roof sheets were broken at a distance of 50 yards. The compressor was found badly out of alignment. This was the largest single factor in delaying the restart of the plant.

Leaks were found

The explosion, of course, was investigated. Analysis of samples showed ammonium nitrite to be present at various points in the plant. Leaks were found in the economizer coils on Nos. 1 and 4 boilers. The leak on No. 4 was probably the primary cause of the burner failing to light normally. The gauzes on No. 4 burner looked patchy, the patches presumably corresponding with the lit and unlit areas. The gauzes from the other burners were unmarked.

Calculations show that during unsuccessful attempts to light No. 4 burner prior to the explosion, 0.8 tons of ammonia had gone to this particular burner. The amount of ammonia present in the absorption towers estimated from analyses was approximately 0.6 tons. Ammonium nitrite would be formed from the mixture of ammonia and nitrous fumes leaving the burner system under startup conditions. Further ammonium nitrite could form from

the ammonia already in solution in various cool parts of the plant. Confirmation is found in the analysis of condensate trapped in No. 2 gas cooler drain line, and from the tail gas preheater drain line.

The evidence of the night shift that the 35% acid tank contained very hot liquor may be significant. Under normal conditions the acid in this tank is about 35 to 40 C. Higher temperatures could arise from the heat of neutralization of ammonia passing forward from earlier lightups and from the decomposition of ammonium nitrite. A calculation showed that the amount of ammonia from one unlit burner, about 500 cu.m. hr. is more than sufficient to neutralize the amount of acid formed during established running conditions.

It is concluded that the explosion was caused by the accumulation of ammonium nitrite, probably in solution during the prolonged start-up. When normal running conditions were restored, the conditions in No. 2 gas cooler condensate tank changed from alkaline, in which ammonium nitrite is relatively stable, to acid, causing violent evolution of gas. The rapid build up of pressure achieved detonation velocity in places. It has not been possible to make any reliable estimate of the total quantity of ammonium nitrite involved.

Modifications were made

Following this investigation, the following modifications to the plant and start-up procedures were made.

In order to minimize the time taken over lighting up, the pre-heater is used on each occasion. The number of lighting torches is increased from one to two. Two people light two gauzes simultaneously.

The maximum time for lighting a burner has been fixed at 10 minutes. If lighting is not satisfactorily completed within this time, the ammonia flow is stopped and the gauze reactivated by thoroughly flaming it with the hydrogen torch. Should this prove unsuccessful the plant manager must be contacted and consider-

ation given to opening the burner for examination and changing the gauze.

The formation of ammonium nitrite in small quantities is inevitable at every light-up and both gas cooler condensates are therefore put to drain during the start-up. When this is completed, as judged by the condensates becoming acid, they are then returned to the plant. The tail gas pre-heater and no. 2 gas cooler is flushed with water continuously during the start-up from new injection points. An additional flushing line has been added to No. 1 gas cooler for startup purposes.

Steam is injected after the compressor until lighting up is complete. Hitherto the drain lines from the tail pre-heater joined and went to No. 1 gas cooler condensate tank. The first pass drain has now been joined to the drain from No. 2 gas cooler. The second pass drain has been left to No. 1 gas cooler tank since this condensate is considered relatively free from risk.

The incident emphasizes the ease with which ammonium nitrite is formed at startup and the dangers resulting from such formation. Conditions favorable to the accumulation of ammonium nitrite are particularly likely to occur in pressure absorption plants with efficient heat exchangers and condensate catchpots.

We conclude that under normal running conditions sudden damage to gauzes will not necessarily lead to formation of ammonium nitrite in quantity since ammonia passing through relatively small areas may be decomposed by nitric oxide to form nitrogen.

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