EXPLOSION DURING BREAKING IN OF A COMPRESSOR

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A storage tank containing ten tons of liquid anhydrous ammonia broke into two sections in Belgium in 1929. In the accident, 35 men died from asphyxiation by ammonia fumes and over 250 men were hospitalized, some of them for several years. Prior to the accident, this tank had been in operation for over one year. Several sulfuric acid storage tanks were being built next to the ammonia storage facilities. In Belgium such tanks are built with conical bottoms. The construction people were inside these tanks placing rivets. They could not get out in time and the ammonia gas enveloped the tanks trapping the men and causing the death of practically all of them by asphyxiation.

Recently in Terre Haute, Indiana, under a similar set of circumstances, one man was killed. A preliminary report submitted by the project engineer who was in charge, reported the following facts:

Project engineer's report

"The events leading up to this explosion on the fourth-stage synthesis gas discharge of the west compressor were as follows:

The compressor was started at 8:45 A.M. on September 17th with air as the compression medium on the synthesis gas service. At approximately 8:55 P.M. a light load was placed on the machine with the intention of not exceeding 500 lb./sq. in. gauge pressure. The fourth-stage discharge pressure was brought up until the gauge on the panel board indicated about 200 lb./sq. in. gauge. This was brought about by manually throttling the 4:1 bypass valve which was located under the operating floor. A pipefitter was stationed at this valve since it was still under construction supervision.

It was noticed that the third-stage discharge pressure was coming up while the fourth-stage pressure remained stationary. At this point the pressure gauge block valve, located behind the panel board, was found to be practically closed. The valve was then opened and the gauge then indicated about 3,000 lb./sq. in. gauge. The pipefitter at the 4:1 valve was instructed to open the valve immediately and the gauge was further checked. It indicated about 2,800 lb./sq. in. gauge at this time. The pipe fitter was about to be advised to hasten his action when the explosion occurred at 9:01 A.M. as indicated by a stopped electric clock. Two millwrights were stationed at the fourth-stage packing housings. These men were injured and hospitalized. A third man, a pipefitter, who apparently had no direct connection with the compression operation and, therefore, was not supposed to be there, was killed.

The fourth-stage discharge snubber bottle was turned loose at the snubber inlet pipeweld. The upper portion of snubber was bulged and the inspection plugs were blown out. The snubber turned about 180° and bent the outlet nozzle of the snubber.

The 4:1 bypass valve outlet line was broken loose and some steel adjacent to the fourth-stage discharge pipe was bent when it was hit by the loose pipe. Transite and translucent sheets on the building were broken as a result of the blast. The question of damage to the fourth-stage cylinder, rods, valves, crosshead, and the extension crankshaft deflection will be determined after thoroughly checking these parts. Any pipe that will be reused (adjacent to the blast) will be checked by X-ray of the welds."

Is it safe to use air?

The compressor was checked and found undamaged and is already back in operation. It was never learned exactly what caused the gauge valve to be closed when it should have been opened. There were construction men on the job; sometimes they do not listen to all of the instructions and sometimes they think they know better.

A question, concerning the operation, arose immediately: Was it safe to use air in order to lubricate the compressor? However, it has always been done in this way. At 500 lb./sq. in. gauge one does not get a high temperature. Use of air has actually begun again. "Why not use nitrogen?" To some extent, the answer is that some people do not like to spend money when they will not get an immediate return on their investment. In this particular instance, the nitrogen would have to be brought to the plant in bottles. This would be a costly proposition, therefore, the practice in such cases is to use air. It will probably remain in use provided that people pay a little more attention to instruction regarding the opening of gauges.

DISCUSSION

MASON—Dow Chemical: Was the valve, that was partly shut off, between the third and the fourth stage?

STRELZOFF: That's right, sir.

MASON: What was the reason for having a valve in that location?

STRELZOFF: Actually there were valves in all these locations just to monitor performance.

MASON: This was at the third stage pressure. What was the normal pressure at this point?

STRELZOFF: I don't know exactly. In general this plant has a reformer section to operate at 300 lb. So I would guess that when you come to this point it's probably over 2,000 lb.

MASON: Wasn't there a safety valve on this line between the two stages?

STRELZOFF: I don't know.

MASON: I would think this would be necessary.

SIMMS: Mr. Strelzoff hasn't actually physically been in the plant since the piping was completed.

The valves are to the pressure gauge, it wasn't in the piping, and there were relief valves there but the relief valves pressure had not been exceeded as far as normal synthesis gas goes. It's a 5,000 lb. discharge.

Anonymous: One other question I'd like to ask. I gather that the people who were running the compressor, that is, starting it and testing it, were not the normal plant operating personnel?

STRELZOFF: You are right. Just the construction people.

Anonymous: Of course it's always difficult under these circumstances to discuss policy or what have you, but for ourselves, let me say that we would always use our own operating personnel. I don't mean to be critical but we feel that our people would be in a better position to say whether the valves were open, closed, etc.

STRELZOFF: The construction union keeps the machinery under their jurisdiction so it's a complete turnover of operating personnel. We reached this kind of program in time. Some companies will manage to have their own operators run the machine and pay the construction man to stand by just to look at it and not to be responsible for handling the valves. In some cases it can be done, in some cases it cannot.

JACKS—M. W. Kellogg: I'm still not clear on one point with respect to the valve. I believe you mentioned that the piping man was at a valve and was told to open it quickly. He was opening it at the time of the explosion. I am wondering if that is the same valve we were talking about with reference to the gauge or was that another valve. If it was just the gauge, I don't see why you would care too much about his opening the valve very quickly.

STRELZOFF: Well, actually—don't misunderstand—the valve that was closed was the valve to the gauge. This means that there was improper reading of the pressure. The valve that had to be opened quickly was the bypass valve. The man was mainly trying to slow it and maybe did not realize exactly how quickly it should be done.

JACKS: Did you determine where the explosion actually originated, and if so, can you tell us that?

STRELZOFF: Well, there are some theories—it might be it just took place right on either the compressor or snubber, and maybe the piping. We don't know exactly where it started. A metallurgical examination might be able to determine it exactly. We don't have the complete story—where the exact ignition took place and how that affected the rest of the piping.

DOYLE—Factory Insurance Association: It seems to me that this might be similar to the accident at a plant with a demand for large volumes of high pressure air. Air was admitted into the pipe very fast; it carried an oil mist and there was an explosion as a result of static. Much of this oil was picked up from the lining of the pipe. Would that have been possible? Maybe the man was opening the valve fast and that was what got him into trouble.

STRELZOFF: I don't think I can go on and theorize right now because this is still subject to complete investigation. The only thing I can do is present the facts; the facts at least as are reported by the people of the plant. We don't have the final analysis.

WALTON—Sun Olin: One thing that we're trying to develop here is safe practices. We have broken in many compressors and it's always been my practice to remove all the valves, the suction valves and the discharge valves, and run the compressor to break in the rings, the liner, the bearings, and other rubbing surfaces, and so on, without making it do any work.

This has always seemed to me to be satisfactory as a method of break in. It doesn't have the problems of getting a gas other than air which may be difficult or expensive to do, so that you can make it actually do work under compression. Does anybody feel that there is any great advantage in breaking in a compressor by making it operate doing some work, or can breaking it under no load be considered a satisfactory and normal operating practice?

RENDOS—Air Reduction: We agree that removing compressor valves is good practice. However, the compressor manufacturer's representative complains that this practice introduces foreign material (dust) into the compressor which can score the cylinder walls. We always insist upon removing the valves and operating the compressor under no load. We also use nitrogen gas for break-in. The nitrogen is fed into the suction of the compressor and is bypassed from the discharge into the suction side. The temperatures and pressures are monitored for design conditions.

HEPP—Sun Oil: I have two comments. In breaking in our air compressors, we've always taken a line off the discharge and let it go out on a once through basis and throttle the discharge valve if we want any load on the compressor; we would not recycle it. Secondly, I would like to know the type and size of this recycle valve that they were trying to open?

STRELZOFF: I'm not in a position to say. I did not communicate with this project engineer. I don't know the details.

SIMMS—Phillips Petroleum: It was the normal block valve on the suction of the discharge; discharge to the suction bypass.

HEPP: Was it a cock valve?

SIMMS: No, it was a regular seated valve. I might comment that we of course have had air compressor explosions in the discharge piping, though not frequently. Any of you perhaps have operated the old style nitric acid units, compressing air at a much lower pressure, have had explosions in your discharge

piping or the aftercooler unless you were injecting water or direct cooling immediately down stage or immediately following the compressor. In breaking in our compressors, we follow the practice recommended by Air Reduction, removing both suction and discharge valves because we're well aware that the compressor will be under several hundred percent normal lubrication. This is considered essential by the mechanical experts. To cope with the problem of dust, which we have lots of in Texas, we provide an inlet filter at the first stage.

HENDERSON—Dow Chemical: We have broken in eight compressors somewhat similar to the method mentioned by Mr. Hepp. The compressor is operated for a 24-hr. period with all valves removed, then operated for 6-hr. periods with valves in the first stage, then the second stage, etc. Pressure is built up periodically until the compressor is fully loaded on air. This is always a once through proposition with no recycle. No attempt is made to filter out dust.

STRELZOFF: Chemico has built a considerable number of ammonia plants in the last 25 years. It has been the practice to run these compressors the way it was done at Central Nitrogen except they kept the gauge valve open. This is the only thing that we can point to now. Everything else was done as a matter of routine.

SOMMERS—Pennsalt Chemicals: It seems to me that there must have been some very extraordinary circumstances surrounding this particular happening. I'll venture to say that everyone here who has been in the ammonia, CO_2 or similar business and has started up, that is, broken in new compressors, would adhere to the same practice of running in the unit for at least 24-hr. or maybe as much as a week if you want to be very conservative—with many times the normal quantity of oil to the various parts. During this time, the pressure is normally slowly built up to the operating level—usually with all lubricator pumps wide open. This is a once through operation with no recycling.

SNIPES—W. R. Grace & Co.: What were you trying to do in this compressor? Were you running in the bearings or were you running in the packing?

STRELZOFF: What we call breaking in the compressor is running the compressor just to have it operating and checking conditions.

SIMMS: I wanted to clarify a couple of points. I'm speaking strictly from my daily reports from Chemico. The compressor had been run with the valves off to check the bearings. This was a check, I think, of side deflection and other things on the compressor under slight loads.

MASON: I'd like to suggest that it's possible that this sudden opening of the valve may have caused the explosion. If the valve were opened very suddenly, a very sudden adiabatic compression could raise the temperature of the mixture that had some oil in the air. It may have picked up oil due to the extremely high velocity and the adiabatic compression of a sudden flow of the air into the line. It may have raised that temperature high enough to ignite this material. Of course, it is necessary to have both fuel and oxygen and a source of ignition. This sudden compression may have been the source of ignition.

STRELZOFF: I would like to point out, as I mentioned, two pressures: one was the 3,000 lb. reading before the gate valves was opened, the other was around 2,800 lb. pressure when the explosion took place. I don't know if there was time for an adiabatic expansion to take place, it was too quick.

COWLES—Armour & Co.: I'd like to report briefly on the break in of the compressors at the Cherokee, Alabama plant, which was constructed by M. W. Kellogg. We also had a plant that did not have a source of nitrogen, so we, as has been mentioned, broke in a compressor at no pressure with the valves out at first. And then after this period of time which was about 24 hr., we introduced a stream of natural gas which is much closer to the molecular weight of syn gas than air is, and I'd like to hear any further comments on the use of natural gas. We did recycle this gas so that we didn't lose a large quantity. We blocked the compressor in and used the bypass valve.

STRELZOFF: I'd like to point out that when we started on the compressors, of course, we didn't start immediately with 500 lb. It is taken gradually up to 500 lb. and we stay at 500 lb. I presume if you start with natural gas, if compressed to 3,000 lb., you would have terrific explosions. I don't think that's safer than what we have done. It's just a matter of a human mistake. Instructions were probably not properly followed. The gauge valve was not opened, people were running the compressor without knowing what they were doing.

GIBSON—Atlantic Refining: Did you have a corresponding temperature with the 3,000 lb. discharge?

STRELZOFF: I don't know whether they had that at the log sheets.

GIBSON: 500 to 3,000 is about 6 to 1 compression ratio. That wouldn't give you much of a temperature increase.

STRELZOFF: I pointed out that the breaking in had just started in the morning. The explosion actually took place only 10 or 15 minutes after it started. I don't think there was a proper reading done on anything.

HEPP: As Walton said, our purpose in these meetings is to try to learn from accidents and to develop some conclusions and good practices. I'd like to submit that this incident even though the compressor manufacturer differs and the type of compressor is different is, in fact, very similar to the Ingersoll-Rand centrifugal explosion reported in Volume 2 of these meeting transcripts. I believe the key to each is the recycling of the air upon itself, where with oil present an explosive oil mist-air system can build up. In the Ingersoll-Rand explosion, the investigating committee decided that it was probable that the ignition of an oil-air mixture occurred in the compressor. They found no evidence of either over pressure or temperature; something unknown just set it off.

Several people have spoken from the floor today saying they have broken compressors in for years on air with complete safety. However, when I ask them if they are talking about air-on-a-once-through basis or recycled, they all say once through. I would like to suggest that recycling air through a compressor is poor practice.