Safety in air and ammonia plants

. . . additional case studies and discussion developed at the Symposium

P. W. REYNOLDS—Imperial Chemical Industries, Billingham: A serious accident occurred on April 21, 1959, in a 240 tons/day oxygen plant which was being started up in England at Billingham. Without any warning, one corner of the coldbox was wrecked by an explosion. Although the actual explosive charge was small, the damage was quite extensive. The detonation was extremely violent. Three men were killed.

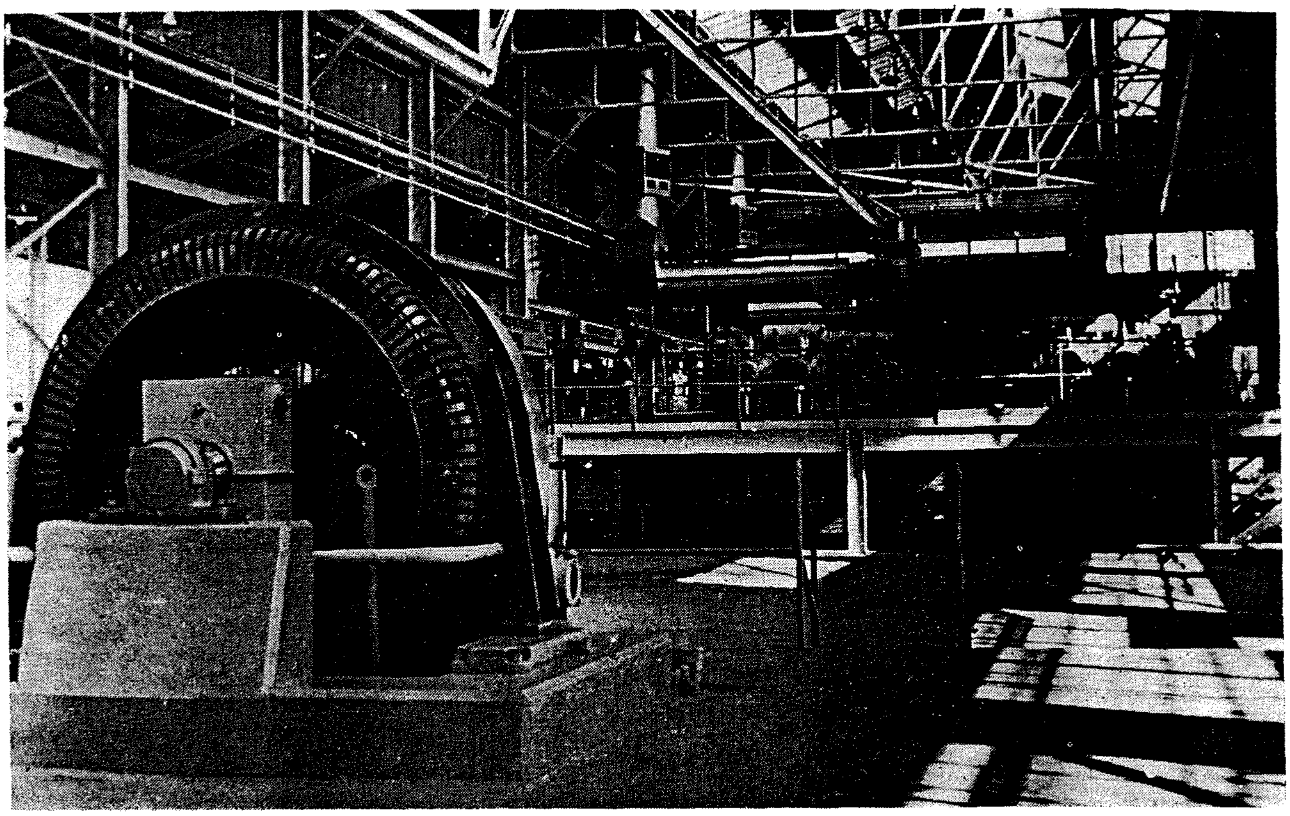
The accident was intensively investigated by a team of 40 chemists and engineers supplied by I.C.I., Air Products Inc., and Air Products (Great Britain) Ltd. Professor Newitt, head of the Chemical Engineering Department of the Imperial College of Science and Technology in London, acted as an independent consultant.

The plant was being commissioned when the accident occurred. It was quickly established that the whole plant was running under good conditions. There were no peculiar releases of hydrocarbon or acetylene from other plants. All the measurements had been properly taken. An additional hydrocarbon instrument had actually been installed on this very day and had shown repeatedly that the figures for total hydrocarbon were well within the specification. So far as anything inside the plant was concerned, everything had been in order. The only irregularity had been a liquid oxygen leak.

It was established by patient excavation of the debris that the explosion had occurred over a relatively small area, perhaps 3 sq. ft., near the floor in the corner of the coldbox. This area was close to the place where the liquid oxygen leak had occurred. A nitrogen line, which had originally been within 10 in. of the floor, was now pushed up to an apex about 10 ft. above it. This confirmed our conclusion that the explosion had been outside the plant's pipes and vessels. It occurred on the floor of the coldbox or very close to it. While it was obvious that the liquid oxygen was one component of the fuel, it was difficult to see how any combustible could have gotten into the position where the explosion occurred.

The damage caused was equivalent to the detonation of about a pint and a half of lubricating oil spread over rock wool and soaked in a slight excess of liquid oxygen. We think we know where this pint and a half of oil came from. But it was difficult to explain how it got to the site of the explosion.

This plant has turbo-expanders with gear assemblies mounted on bases just outside the coldbox wall in the compres-



Interior view of the anhydrous ammonia plant at American Cyanamid's Fortier plant near New Orleans. In the left foreground is one of the circulator compressors. The nitrogen and synthesis gas compressors are in the background.

sion plant. Oil had dripped occasionally from these gear assemblies on to their bed plates, but not in large quantities. The turbo-expanders themselves were faultless. These small leakages of oil were always meticulously cleaned up, but it is believed that some oil did get down off one of the bed plates and seep into a narrow crevice between the expander assembly mounting base and the coldbox wall. Although there was supposed to be, and probably had been originally before coolings-down and warmings-up had spoiled it, a proper joint between the wall and the concrete, we believe that oil from this source did seep into the position where the explosion occurred.

It seems useful to report this incident because there may be other plants where traces of oil have gotten into the coldbox or where oil exists just outside the coldbox. If there are, a leakage of liquid oxygen could lead to a similar disaster. It is to be remembered that mixtures of liquid oxygen and oil are so notoriously sensitive that even the vibration of the ground can be sufficient to set them off.

FRANK HIMMELBERGER — Air Products, Inc., Allentown, Pa.: What are some implications of the ICI explosion? First of all, the expander location should be spotted at least two feet away from the coldbox, so that there is a visible area between the coldbox and the expander pad. This will minimize the possibility of an unnoticeable crack occurring between the foundation and the coldbox panels, or in the foundation itself. This incident also emphasized the importance of a solid concrete pad, or at least solid construction under the box, so that no cracks are available for oil seepage.

Very rigid rules about oxygen concentration in wool and air plants must be established. We will not tolerate more than 40% oxygen in rock wool and, as a matter of fact, we try to hold it below 25% oxygen. Explosions in rock wool, with gaseous oxygen, are extremely unlikely because the rock wool itself is a diluent.

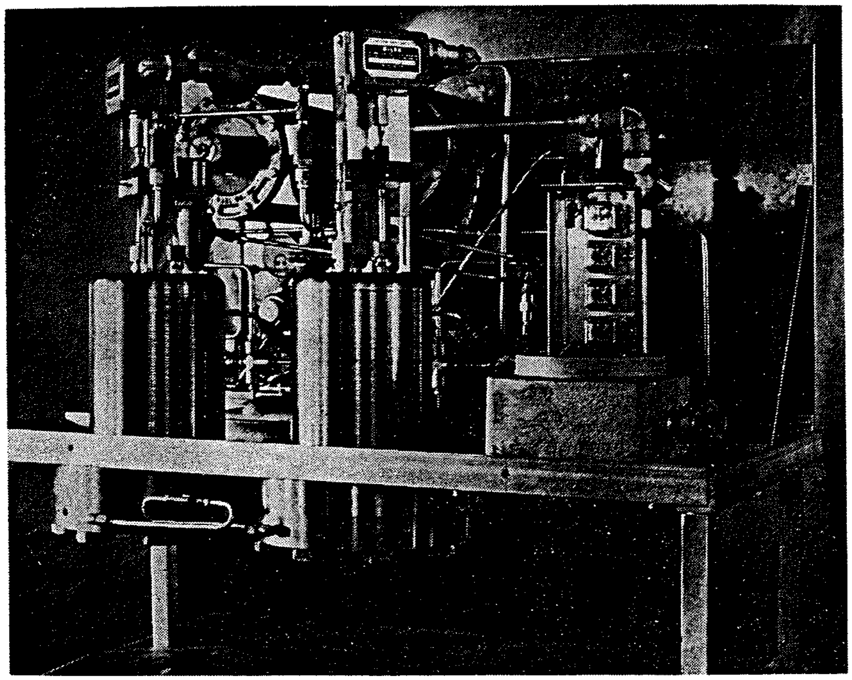
GORDON WEIGERS—American Cyanamid Co., New Orleans: I might point out that we were also very concerned about the possibility of getting oil into the area of the oxygen plant. We're fortunate in that our expanders are on separate pedestals and the oil would literally have to leap over a four-foot gap. However, one of our operators pointed out that we have a very large compression building adjacent to our oxygen plants and the surface drainage in the area was such that oil spill in the compression building would run right by and between the oxygen plants where, from time to time, it was conceivable that we could have a spill. So, we tore up (I don't know how many) cubic yards of concrete and relaid all our drainage ditches and regraded the area so that there is now a ridge between the coldboxes and the compression area; so that surface drainage cannot mingle between the two areas.

R. E. BUTIKOFER—Standard Oil Co. (Ind.), Whiting: It's common practice in the construction of coldboxes to use wood for bracing inside the box. Very likely everyone of us has some wood inside his air separation coldbox.

D. C. LAMOND — Canadian Industries, Ltd., Kingston, Ontario: Following the ICI explosion, we entered our coldbox first to determine if there was excess oil in our rock wool, or any type of leakage. Then we removed the floor-level wooden structures from the coldbox. We took a great many samples of rock wool, and could find no excess of oil. In our turbine and pump room, we graded the floor away from the coldbox so that oil could not run back into the box.

WALTER LINDE—Linde A G, Toronto, Ontario: We specify the oil content in the wool that is used in our plants to be less than 0.1%. The reason is we figure, that on deriming, we have a concentration of the oil. It evaporates where there is a hot pipe or vessel and it condenses where you have a cold spot. We feel it is better to be safe than sorry.

R. W. ROTZLER—Monsanto Chemical Co., Texas City: The only oxide of nitrogen that we have found is N_2O. We have tested for, but have not found,



Small-scale apparatus from Mine Safety Appliances Co. for vaporizing liquid oxygen.

either NO or NO_2 in any concentrations that we were able to measure. Now, on the basis of the tests that we have made, the N_2O itself, or even associated with acetylene is not dangerous. It's the acetylene that's dangerous. The N_2O apparently does nothing more than dilute it, and anchor it. In laboratory tests we ran on N_2O-acetylene crystals, we failed to get explosions of N_2O-acetylene crystals without liquid oxygen. With liquid oxygen, there are explosions which are just as violent as if the crystals were pure acetylene, but the N_2O apparently does not contribute much to the explosiveness of the mixture.

Accidents and analyses

WEIGERS—American Cyanamid: We had a most unusual mishap. We were operating our plant in a normal fashion and one day noticed that the pressure in the coldbox wall went up appreciably, and our heat-leak went up. We found ourselves running with more expansion turbines to maintain our liquid levels. We found that we had to cut production to maintain our liquid balance. A big ice spot appeared on one of the walls in the coldbox. At the first opportunity we shut the plant down to inspect it. We took the inspection plate off the coldbox wall in the area immediately adjacent to the ice spot, hoping that we would find a flange leak, or something of that sort. We found the source of the trouble but couldn't imagine how it occurred. A vertical run in the piping from the bottom of the regenerators to the high pressure column, had a dent in it as if someone whaled away at the pipe from the inside with a 100-pound ball-peen hammer. A little lump was formed like a golf ball sticking out of the pipe. Close to this, slightly below, the pipe was worked into a collar-like flange. The pipe was sheared off just across the top of the collar. It certainly looked like a detonation; it had all the indications of a very quick, very-high energy release although, fortunately, the amount of fuel there must have been very small. The thing that intrigued us is, how did it get up into a vertical run?

We're not sure we know the answer yet. There were stones from the regenerators lying in the pipe below, which were not the result of the accident. One possible theory is that during the previous run we could have gotten some solid acetylene on these stones, and that these stones bouncing up in the pipe caused the explosion. We're not at all satisfied with this explanation. It takes too many things for granted. The fact is that we had a minor detonation. The pipe failure was such that it could not be explained by high pressure. There was no evidence of corrosion on this pipe that would lead one to believe that the pipe may have been weakened by corrosion. This occurred at a time when we were running a recording acetylene analyzer on the intake air. We were running a recording total hydrocarbon analyzer on the liquid oxygen in the main condenser and, as is our routine, we were making acetylene analyses every hour-and-a-half. The wind for the previous 36 hr. had been from a direction where there is swamp for 75 miles. There were no diesel engines running near the air intake. We had been completely unable to find a possible source of acetylene during the previous 3 or 4 days. We don't know where the source of the detonation came from. We are assuming it was acetylene. But of course we can't substantiate it.

One thing I might add, the plant had been on stream for about three weeks following a total derime.

R. L. SWOPE—Southern Oxygen Co., Washington, D.C.: You mentioned that there were 75 miles of swamp. One principal product of the swamp is marsh gas, methane. Methane in our liquid oxygen, seems to stem largely from the existence of a sanitary land-fill located a half mile from our oxygen plant. When the wind is from that direction we invariably have an increase in the amount of methane in the liquid. I don't know whether methane in your case could have risen to such an extent as to be hazardous. Methane does stay behind in liquid oxygen as you boil off vapor. I don't know whether your plant involves boiling the liquid. If so, you may have a residual pool which might tend to retain the methane to a point where it might become hazardous.

WEIGERS—American Cyanamid: The point is an interesting one. However, the total hydrocarbon analyzer that was in operation during this time showed a very low reading—between 5 and 10 ppm. This is pretty much the "background noise" that we run into in our environment. I doubt that methane from the swamps was the source of our problem.

This concludes the published report on the Air-Ammonia Safety Symposium first-presented at St. Paul, with the first part appearing in the May issue of CEP. Readers interested in additional details may order reprints with supplemental material (see box). If you want to participate in the question-and-answer sessions, come to Tulsa, September 25-28, where another symposium is on the docket.