FLARE LINE RUPTURE IN AN ETHYLENE PLANT

Trend towards large capacity plants emphasizes the need to adequately guard against brittle fracture risk

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In the original installation of the Lake Charles Petroleum Chemicals, Inc. ethylene plant, there were two flare systems installed -- one called the wet system and the other called the dry. This was necessary because our plant was what was known as a low temperature plant.

Each had a separate flare drum. The dry system originated in what we call our cold box and our low temperature tower and vessels. This dry flare line had branches that could put -225 F. gas or liquid into it. Over a period of seven years from the start-up of the plant until the explosion, we had four cracks occur in this low temperature or dry flare system. We recognized this as a bad hazard so we started a replacement program as time and conditions permitted. We did install a complete new stainless steel liquid collection line for low temperature chillers where 55 F. or colder liquids could be bled off from the bottom of these chillers. This minimized the possibility of cracking the flare line as at least some of the cracks that had occurred had been from liquid blown down into the line directly.

The demethanizer over-pressured

On July 13, 1965 at 4:25 pm the demethanizer tower over-pressured. It was vented to the flare system. The -200 °gas at elevated pressure was to go through a bundle with hot propylene vapor on the tube side to protect the carbon steel flare line. Due to the condition of the bundle and adjacent lines and controls after the fire and explosion, the true reasons for the break in the flare line has never been definitely determined.

As one man's opinion, I believe we had vented this tower enough times that the line above the heat exchanger which went straight up to a rigid flare line above it, which was held by the cross-members of the pipe rack, had contracted and expanded so many times over the years that it had work-hardened and this stretch was just one time too many.

We know the steel line above the exchanger connecting into the flare line parted circumferentially above the heat exchanger and large volumes of gas flowed out into the plant.

There must have been other problems occurring in the plant because I found out later that some of the pumps had tripped off and these either were or had caused the problem.

The operators called and the gas spill whistle was sounded. As I approached the main control room I could see by the refraction waves we had tremendous volumes of gas going northeastwardly. I dashed into the control room, and talked to A-operator to find out what was wrong. He said all the furnace fires were out and that snuffing steam was in them. He told me the best he knew of the situation and located generally where the operators were and what they were trying to do.

Boom! came next

At that time -- boom. We dug our way out of the rubble and dashed out of the building. We proceeded to set up fire teams with hoses all around the plant to minimize the spread of the fires. Obviously, with a fire like this you don't try and put it out. You just try and contain it where it is.

Specifically we wanted to protect our two oxygen and nitrogen plants and nitrogen scrub units on either side of this plant. There were many small fires throughout the ethylene plant. The operators as a group did a tremendous job both before and after the explosion. This was the first explosion -- there were a number of them.

One voluntarily went back into the plant because he couldn't find one of his fellow men. He reported that if he was where he was supposed to have been, there was no hope as the compressor control room had collapsed completely.

Figure 1 shows the only section of the panel board in that compressor control room that was still standing. The concrete walls had been blown against the panel board and the roof had fallen in. More details on the system damage are in the Feb. 14, 1966, Chemical Engineering article on this particular fire and explosion.

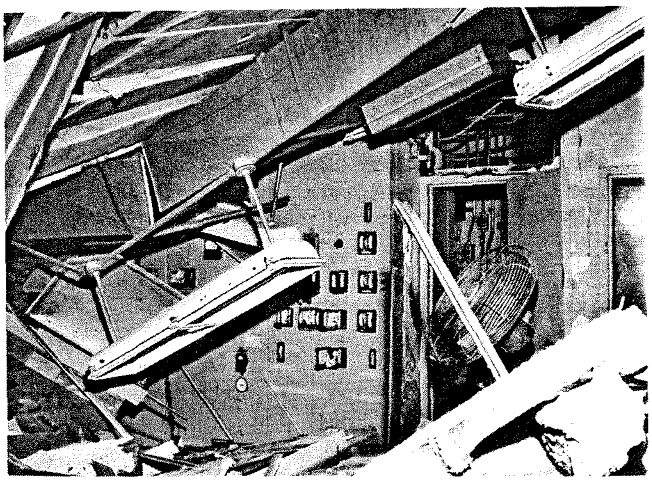

Figure 1. This was the only section of the panel board standing in the compressor control room.

Figure 2 shows the area where the exchanger broke or the line parted with the main gas flow coming from here. Observers from across the road said the fire seemingly originated in this area as one ball of flame. We were putting out fires several miles away for the next 4 to 8 hours.

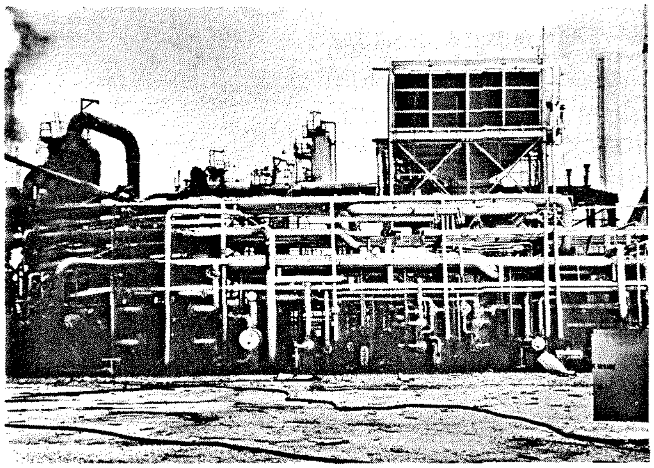

Figure 2. The exchanger broke or the line parted with the main gas flow coming from here.

At daylight next day the plant was burning fairly well. Figure 3 is looking from the southeast corner toward the fire, Figure 4, is another view of the damage. You can see all of the piping hanging down and everything just sort of hanging all over. This was over towards the control room. You can see here and here there are pieces of Corrulux. We had sections of Corrulux on our compressor buildings plus transit. I will talk about that but the Corrulux just sort of floated down (like a kite) to the ground. The little sharp pieces lying on the ground like little missiles were transite.

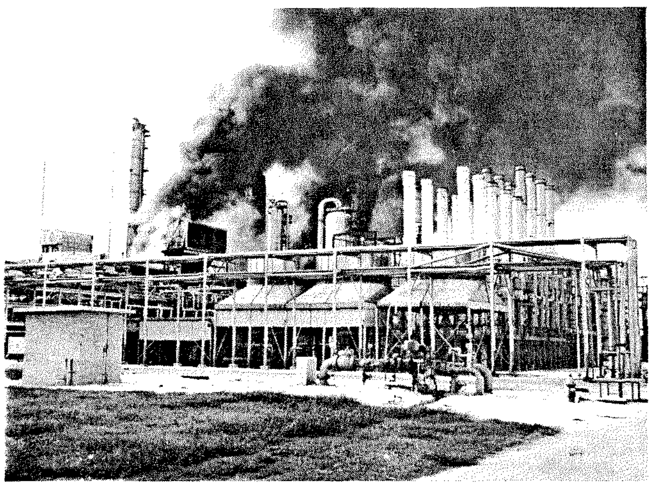

Figure 3. At daylight the next morning the fire was still raging; looking from southeast corner.

Figure 5 is the main control room with the rubble on the floor and every instrument in the main control room, which was on the far edge of the explosion and fire, had been blown out of its case. You could just see them hanging out.

Figure 6 is looking in the northerly direction. There is a gas turbine on either side. This is the compressor floor. It picked up grating, everything, just threw it around indiscriminately. Note evidence of small fires. There was no sprinkler system at this end.

Figure 7 the fartherest point from the fire. It was in the southeast corner, with instruments completely damaged, everything around it, the insulation, blown off. The one thing that happened and we found the most intense explosions had taken place on the periphery because of the lean gas there, whereas closer in, the richer gas didn't explode as much, it just burned fiercely.

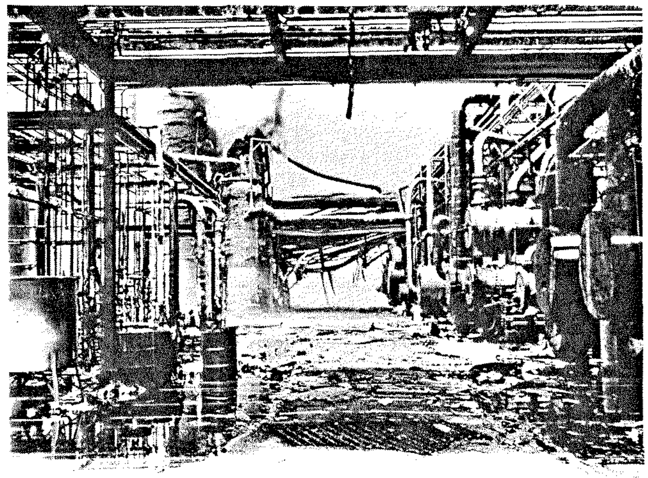

Figure 4. A closer view of the damage shows piping hanging down within process area.

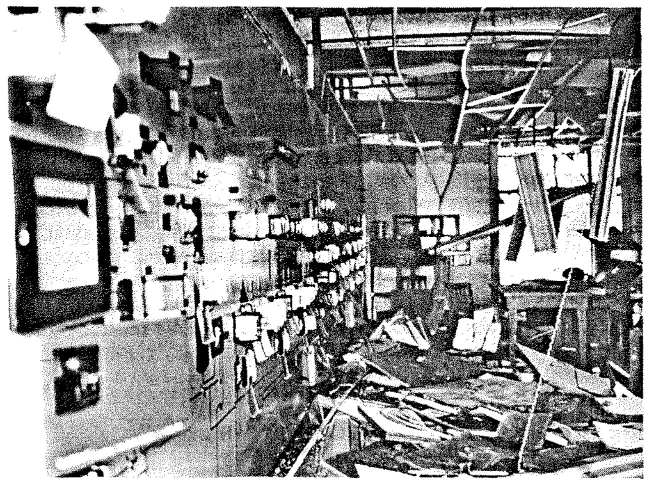

Figure 5. Every instrument in the main control room had been blown out of its case.

Figure 6. This is the compressor floor looking in a northerly direction.

Figure 8 is right next to the fire. The fire was over here and shows what was a 200 foot tower and what we called our cold box. We found several explosions had occurred in there. These are all our low temperature chillers and there was a small tower here which can't be seen because it was black at this point, behind the ethylene fractionator was the demethanizer which started all the trouble.

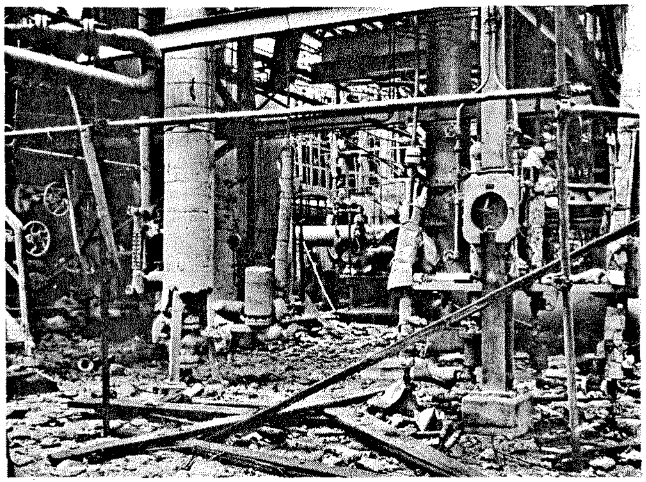

Figure 7. This was the farthest point from the fire; most intense explosions were on periphery.

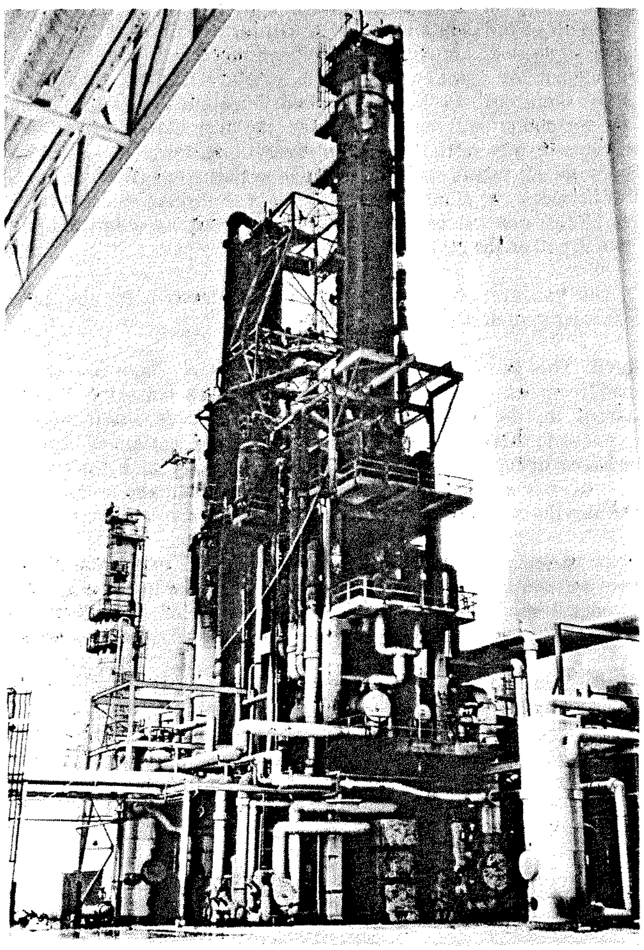

Figure 8. This was a 200 ft. tower right next to the fire with cold box adjacent to it.

The source of the gas was right behind the drums shown on Figure 9. Note the stainless steel bands were still on the foam glass on these drums and the foam glass was still on all three of the drums except the furtherest one and that one had to be replaced.

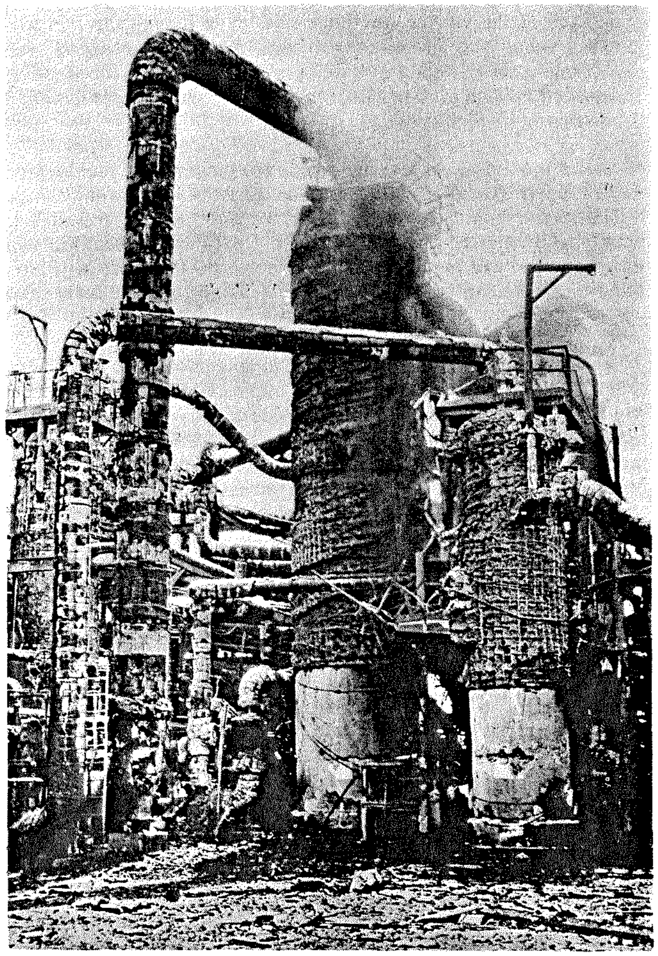

Figure 9. The source of the gas was right behind the drums shown in this view.

Four important points

There are four points I would like to discuss with you as important ways that we feel that we have improved this plant.

First, we would have been down for better than a year, I imagine, if it had not been for foam glass or equivalent nonflammable insulation on all our towers and drums.

This would have stood up better if it had been covered with thin stainless steel sheeting rather than aluminum jacketing. Aluminum jacketing melted off and allowed some of the foam glass to fail and fall off, thus damaging some of the drums and equipment that might not have been damaged otherwise. I am sure the aluminum people wouldn't like this, but this was the thing that struck me when they were talking earlier about aluminum as a low melting point and it was real obvious in this case.

I would be interested to have the Underwriters' Laboratory check the two methods of fireproofing -- the one that is standard that we used, and I think that most people use, and that is gunite on steel versus foam glass and stainless steel skin. Two drums were not replaced, we actually had to replace and repair the skirts, because the concrete had come off.

Never underestimate a sprinkler

Second, don't underestimate your sprinkler system and fire monitors. Our compressor building was completely covered by a sprinkler system. A 4,000 hp motor right behind those three drums was not even damaged. There wasn't any harm to any of the insulation, any of the wiring, anything else, even though the fire was intense enough and burned long enough that it forced us to keep the compressor building sprinkler system on for three days. There was evidence of fires throughout the compressor building but no fire damage to speak of.

On fire monitors, we learned a real good lesson. We had located them properly to be effective, we had aimed them as they should be, but we couldn't get to them. Put a remote valve on your fire monitors. Don't put the valve at the fire monitor because you may have the fire monitor too close to get to. It is sort of frustrating to have them there and no one dared go to try to turn them on.

Third, we went through our system to determine how and where to put in a stainless steel low temperature complete flare header. At the time our plant was built, it was standard to put in steel flare headers, even though everyone knew you couldn't put -255 F. methane or -155 F. ethylene liquids into a line without fear of cracking. Even today there are flare lines being installed in low temperature plants that are made of steel. Maybe you can get away with it in some cases if you don't have it tied down at various points with various entrances from other sources. Of course, in some cases heat exchangers are installed to heat up some of the cold gas or liquids before they hit the steel line. In many cases if you use something such as process gas from a compressor discharge to heat up the exchanger if you have an upset or a utility failure, you don't have the heat to heat up your gas. Also in that case, the plant would be pretty upset, and you probably would be putting out more hydrocarbon into the flare system than normal.

Cost: $3 million

The cost of the repairs to the plant alone were in excess of $3 million, not counting the value of products lost to ourselves and our customers. The incremental material cost of going from steel to stainless on the flare line, on a crash basis was less than $100,000. I think that is pretty cheap insurance.

Of course, you have a tremendous job of design of the stainless steel flare line versus the steel line. The co-efficient of contraction is better than three times. As a result, many expansion joints and rigid supports were needed.

They had quite a time putting that flare header in because we didn't want any stresses or strains in it, in any way, shape or form. We would argue with the foreman about what temperature he was going to put this section in, and how much to cut the opening and then put the bellows in, so we would have the right amount of expansion.

We had a national contractor figure the supports and expansion joints and loops and then we and another organization checked it. Of course, everybody has their own method so we all came out with something a committee builds, but we eventually ended up with what I think is an excellent installation. Even then, to keep things reasonable some field revisions were made.

Everyone had used lines coming off the relief valves to go to the flare lines and calculated the relief valve as a fixed point. When we went out in the field, we found a lot of the relief valves had goosenecks or various loops underneath them, so that the lines could be simplified.

This system had a severe test about six weeks after start-up when the diaphragm on the pressure relief valve on the ethylene tower overhead ruptured. It depressured the whole tower into the flare lines before the operators could get it on handjack. Long sections of the line had liquid ethylene boiling off at -155 F. With steel lines this should have been disastrous because of the probable cracking and volume of gases that would have been released in the area.

Furnace gas cut-off

The fourth major addition we had was to build a system of spring-loaded valves with a set of handles on a post so that as an operator left an area to go to a fire hydrant, all the gases to the furnaces would be cut off and snuffing steam put in them with just one pull. We have a by-pass on it so we can check this system monthly.

There are three minor items that we would recommend in installations of this sort. That is, replacement of transite with fire retardant fiberglass plastic panels. Transite is dangerous. The fragments become sharp pointed missiles and anybody could be hurt. It was a wonder someone wasn't.

We also put in a better located, more rugged compressor control room. We had none left so we just started over from scratch. It was cheaper that way.

A re-design of the propylene methane heater and piping was made so that there would be no further problem.

Discussion

Q. Did you have any disaster plans -- your own fire fighting team and all of the participation of the public authorities.

Kevil: In our area we have what is known as a mutual aid plan where all of the plants in the area will furnish fire fighting equipment as needed. Actually, the fires and there were many of them throughout the plant, were of such a nature that we didn't want to put them out. We had to let them burn out and it turned out that our equipment, our hose houses, the hose that was available, on the site was sufficient to cool everything down. Incidently, in our adjacent plants we had sprinkler systems too. We had cross-ties between our plant and another plant to furnish enough water. We almost ran out of water at one point, but we didn't actually have to call on the mutual aid.

Q. Did you ever determine the source of ignition for the gases that were vented that actually caused the fire?

Kevil: This is the $64 question. Hercules has a plant across the road from us. They say it started in, or at least the fireball started in, the northeast corner. We had three small heating furnaces in there. Now whether the snuffing steam in one of those furnaces didn't go on properly or what happened, I don't think we will ever know. There was just too much damage in that area and also the rest of the areas to actually determine.

Q. In re-designing your control room, did you make any allowance for the possibility of over-pressure on your walls with consequent design of your walls to have this type of strength necessary for an overpressure from an explosion external to the walls?

Kevil: Yes, it has a steel frame with steel braces in the walls now. It was designed with steel supports only but we have made it much larger and we have taken it out of the immediate area. It is actually situated almost at the edge of the plant, as the other control room is, so that there will not be the problems occurring. I think we have the structural strength in the walls in the re-design that they won't come in again as they did in this case.

Q. I understood that your wall facing was Corrulux.

Kevil: No. The wall facing was concrete block.

Q. Have you taken this into account in your over-pressure?

Kevil: Yes.

Q. You mentioned putting back in some walls of Corrulux. Is this right?

Kevil: Yes, the entire compressor building is Corrulux now.

Q. In this case, could you tell us a little bit just about how the Corrulux pieces themselves came off of the building in the explosion, relative to how the transite came off?

Kevil: They stayed together as one piece and just sort of went like gliders as best we can determine. Some of them we found hanging over pipe racks and the like, whereas the transite came as sharp flying missiles. We could see where it had hit the brick on buildings 150 feet away and actually gone into the brick, and made a hole in it. Incidentally, with respect to cost, everybody said that putting on Corrulux was the wrong approach. It is going to cost you an awful lot of money because the Corrulux is more expensive, they said; but it turns out that one man can pick up several sheets of Corrulux and walk along with it, whereas the labor costs on the transite was a lot higher than the Corrulux, so it almost balanced out.

Q. Did you consider using polyvinyl chloride panels instead of Corrulux?

Kevil: This was all that was available at the time. This was one of those things where we had to get what we could get as soon as we could get it, so we didn't quibble.

Q. Are there any combustible gas monitors in the plant so that you would actually know you had the condition existing before you would actually have the fire?

Kevil: In this particular case, we knew we had the condition existing because they heard the flare line snap like a loud report. Actually we have purchased and have installed fire detection devices. But this has only been this year that we have found something that we thought was satisfactory and would do the job and should be put in.

Anon: If you had a continuous combustible gas monitor throughout the plant to actually pick up the samples of air, you could locate these leaks before they got into a big problem. I am not saying this would have helped in this particular case, but in the plant for the smaller leaks which had the potential, this would seem that this would give a good indication that you had a problem possibly several hours before it could become critical.

Kevil: We are putting that in now but we are having a lot of difficulty. This plant covers quite an area and the location of where to put these is the thing that has us confused.

You start counting up the number of pumps you have, the number of potential leaks you have, the number of gauge glasses that you have, etc. -- we could put in 50 of them. I visited three ethylene plants in the last six months and only one of the three had these in. They had 12. We are trying to figure out some reasonable way of placing them, so that you don't end up having to put about 60 or 80 or 100 and get the cost just all out of proportion to what you could actually detect.