OXYGEN FIRES

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We have had a series of four oxygen fires because of failures at the mechanical seals in our high pressure oxygen pumps. The first fire resulted in considerable damage, and the operators were better prepared for the subsequent fires. They were able to valve in the pump so that less damage was done.

The pump is a Byron-Jackson 10-stage 10-in. design which has a Borg-Warner mechanical seal. This pump was originally secured from Air Products and Chemicals, Inc., and was put in service in our plant which was built by Flour, and the air plant part of which was a L'Air Liquide design. This pump has given us good service. However, we have had trouble with the mechanical seal life and had begun a program to improve the life of this mechanical seal.

Pump redesign

This pump pumps about 25 gal./min. at a suction pressure of 25 to 550 lb./sq. in gauge. It pumps a stream of 95% oxygen. The pump was redesigned on the job site about nine years ago, about March, 1956. The original pumps that were purchased for this service were not satisfactory, and that's how the Air Products and Chemicals, Inc., got into it. The Byron-Jackson chief engineer redesigned this pump on the job site so that it would take a mechanical seal. Air Products was using this pump with a packing at a lower suction pressure. The seals were lubricated originally with Fluorolube and after a period of time the operators started using a silicone-base lubricant which they thought was more effective.

The seal life did improve some. This lubricant was applied through a grease fitting with a grease gun. Our recent experience with lubricants was to use a liquid product that is made by the Halocarbon Corp. The seal life may or may not improve because we haven't had an occasion to run a very extended period of time without a failure. The first failure we had was July 30, 1965, and this resulted in a rather serious fire with flames leaping about 30 to 40 ft. up the side of the cold box.

Fire damage

Shortly after that we had a second fire, and the second fire didn't do nearly as much damage as the first. The first fire resulted in burning to molten metal the coupling where the motor joins to the pump shaft, a part of the stainless pump shaft, all of the seal top works. Part of the steel plate that is an 1-1/4-in. thick was damaged.

Upon the subsequent failures the operators were able to valve in the suction and discharge with very little damage except to the seal itself. The date, September 8th, brought about two fires in rapid order on the day shift. So it was decided then that we would shut the air plant down and completely derime and also blow out. Upon inspection of some of the pump seal parts we had found particles of silica gel and also some small particles that appeared to be a shiny metal, perhaps alumina or aluminum. These particles were not detectable by the naked eye. We had to use a 45 power microscope to find them; we suspected abrasive materials because on two of these failures the stationary face of the seal, which is carbon, had completely disintegrated or it had disappeared at least.

Inspection of rich liquid filters

This material perhaps came from the rich liquid filters and it had been our practice to inspect these rich liquid filters every two years. The last time they were inspected was in 1963 and they were scheduled for an inspection this year. They have been in service for 10 years and no doubt were contributing the dust. When we pulled the material and analyzed it for dust we found an average of 0.025%. The new silica gel that we installed contained a dust analysis of 0.006%. During our deriming and blowing procedure, we paid particular attention to the lines ahead of the pumps and at the suction of the pumps, and from the discharge of the rich liquid filter through the lower trays of the low pressure column.

The bleed points were sampled, using a clean gauze filter, which was then examined under the microscope. These particles were not detectable to the naked eye. They were very fine. The plant was blown until these tests indicated that no dust remained. While we were cleaning out out piping system Mr. T. Trones of the Byron-Jackson Co. worked with us in cleaning our pumps and improving the design.

I think the main improvement there was to notch out the carbon face to allow lubricant to enter the seal face. The metal part of the seal face is a stellited steel and this part was showing signs of wear also.

Vibration of mechanical parts

Another problem that we had had was vibration of the mechanical parts, so a systematic machining of the shaft sleeve, the top flange, and other parts that may have contacted upon vibration was accomplished to relieve the clearances, to reduce the possibility of metal to metal contact.

A lower tension spring was used so that less force was directed against the stationary face. Again we are trying the liquid Halocarbon lubricant, and we have an improved design for putting this in. We are using a sight glass and we have adjusted the level that we keep in this glass by studying the performance through a thermocouple. There is a thermocouple installed in the top flange of the seal and this is connected to a continuous recorder and it pretty well follows the trend of ambient temperature. If something goes wrong we can usually trace it to a head problem in the liquid lubricant sight glass. We've operated successfully for about two weeks with this liquid Halocarbon lubricant.

Preventing further problems

In summary we think that the seal failures resulted from abrasive materials in the process stream, lack of adequate lubrication, and mechanical vibration or misalignment. Deriming the plant and replacement of the silica gel in the rich liquid filters should prevent any further problems from abrasive materials. The redesign of the seal with the use of liquid lubricants should provide better lubrication for the seal faces. Mechanical vibration may have been caused by a crooked shaft, improperly balanced impellers or misalignment. The wear rings gave some indication that the pumps had been run dry perhaps on the occasion of a plant upset.

New impellers and shafts were not always checked for proper balance and straightness before assembly, but now it is a standard practice to purchase impellers and shafts separately, then check each piece before assembly to insure near perfect balance and straightness. In addition we feel that we have learned a great deal about assembly techniques and precautions that we should take in working with our pumps. We think perhaps we can eliminate the vibration problems and wear problems. We're hoping now for a safe operation. We have accumulated about two weeks safe operation to date.

DISCUSSION

BLACK—Foster Wheeler: Many years ago I recall seeing an experiment whereby some silicone grease was placed on a hot iron plate and a flow of oxygen directed against it from a welding torch. The silicone was oxidized very quickly. Is this a possible source of contamination of your seal? The heat of the seal and the grease forming small amounts of abrasive material?

COWLES: Needless to say, we have conducted several experiments that will show us what we might get in the way of abrasive from our lubricants, and also what we might expect from the possibility of combustion in oxygen. Our experiments don't indicate that we will get any abrasive material from the silicone lube. Now we have tried four types of lubricants. We have used a Halocarbon grease, a silicone grease, Fluorolube, and this Halocarbon liquid. Of the four, judging from the performances indicated by the thermocouple, the halocarbon liquid is superior, but we did not find any abrasive material formed by heating any of these four materials.

ROMANOWSKI—Canadian Industries: You mentioned that you have found an abrasive dust in the high pressure oxygen pumps, was it metallic aluminum or alumina dust?

COWLES: I believe it was aluminum dust.

ROMANOWSKI: Have you had a problem with alumina dust from activated alumina driers which prevails in many air plants? Alumina dust was found in one of our pumps and we believe it to be the cause of considerable wear. Our dust problem was corrected by a modification of the drier and filter arrangement.

COWLES: We have found alumina dust in our air plant, and at one time we didn't have a proper filter arrangement after our alumina driers.

BALL—Air Products and Chemicals: Could you clarify one other point? Did you have reactions only when you were using a silicone?

COWLES: We had seal failures with three of these lubricants, the silicone grease, the Halocarbon grease, and the Halocarbon liquid.

BALL: When you say seal failures, you mean the combustion reaction?

COWLES: Yes, that's right.

BALL: There is data available on all those materials, I think, as far as compatibility with oxygen is concerned. NASA for example, has quite voluminous reports on compatibility of various materials with liquid and gaseous oxygen, and there are several other sources. Have you had a chance to check that data?

COWLES: Yes, we have checked that.

MASON—Dow Chemical: I would like to call attention to one thing. You mentioned some aluminum as being present in this, together with this fluorolubes and Halocarbons, which are essentially the same thing. It might be well to call attention to the fact that aluminum in conjunction with these materials is itself a very distinct hazard. There is a chemical reaction between aluminum and the fluorocarbons at high temperatures. I think this is a Thermit-type reaction.