Failure Analysis: Anti-Foam Chemical Injection Pump MTBF Reliability Improvement

By Abdulrahman Alkhowaiter

This failure analysis and reliability study was completed in 2004. Natural Gas-Treating facilities at a Gas Processing Plant utilized two Anti-foam chemical injection pumps at each Gas Treat Facility, with a total of six units. The existing motor driven **Diaphragm type** chemical injection pumps rated at 350 PSIG and were installed in year 1982. The average MTBF of all pumps is only 4 months which required overhaul or replacement. This was an unacceptable failure rate occurring for the past 22 years.

A year 2004 study of the root causes of historical failures recognized that main root cause was unsuitable design of original diaphragm type pump, which was then changed to more robust Plunger type pumps at all gas treating facilities. Careful selection of new motor driven pumps with higher rating pressure and suitable materials, resulted in a very high increase of pump MTBO no less than 8.0 years as reported in 2012. The only preventive maintenance activity needed every 6 months is to grease the plunger packing and replace packing at every two to four years. So MTBF = 4.0 years and overhaul is every eight years.

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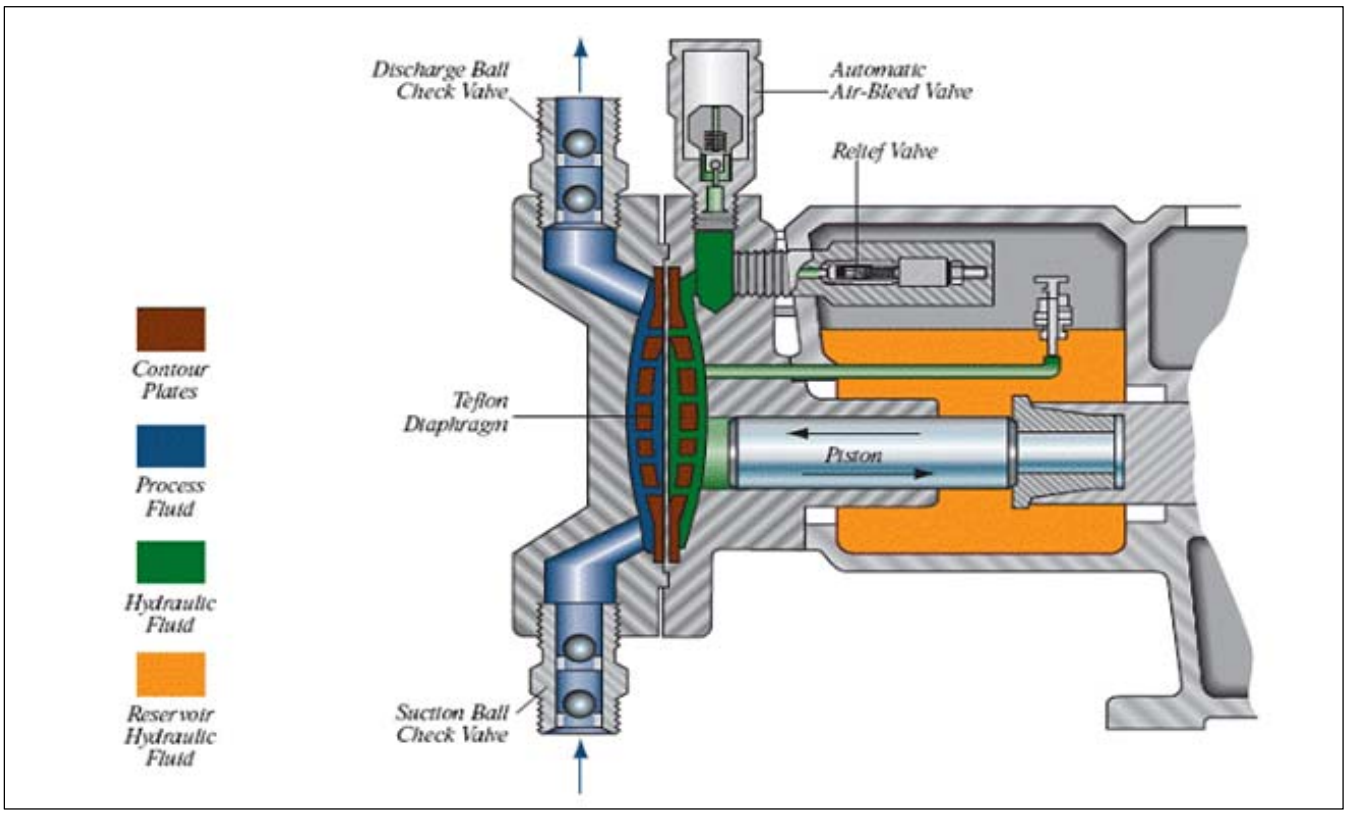

Original 1982 Pumps Were Diaphragm Injection Type

Improvement in Reliability: Eight yr. x 12 months/4 months= 2400% improvement

From: Khowaiter, Abdulrahman O
Sent: Tuesday, September 28, 2004 1:58 PM
To: Operation Foreman; Maintenance staff; Reliability
Cc: Engineering; Manager
Subject: Gas Treat R-32-G-112/312 Anti-Foam Injection Pumps Solution to Failures

We have investigated your complaint of poor reliability of the three existing Milton-Roy reciprocating diaphragm pumps at your facility; see data sheet below at the anti-foam skids of Gas Treat. We studied the issue with the maintenance technician who agrees that these have been bad actor machines. The field investigation shows that the existing pumps have the following Root Causes:

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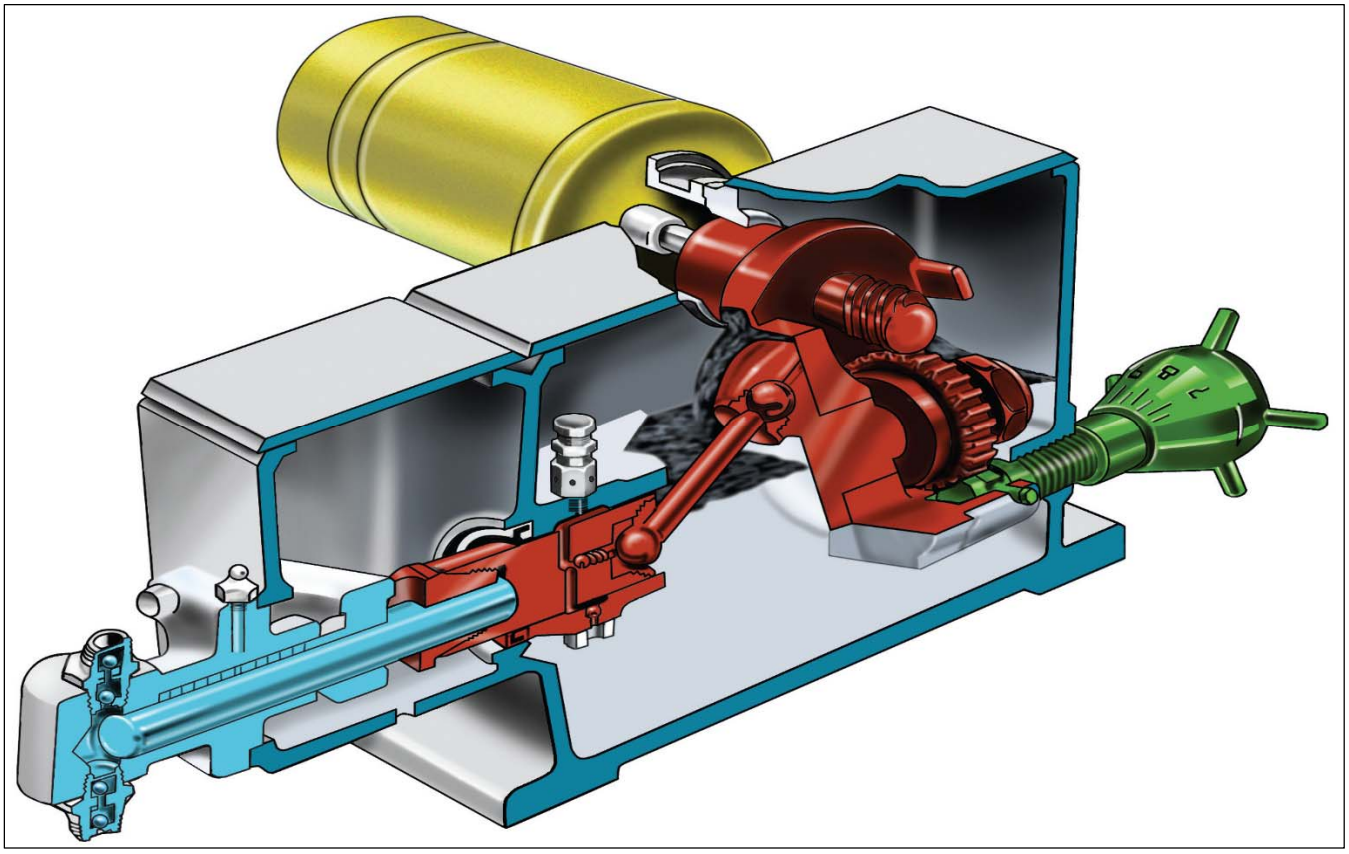

1. The Anti-Foam liquid is sometimes not mixed properly with the water in the Foam Tank, leading to a heavy concentration at the bottom of tank, with a very high viscosity.
2. The existing Diaphragm pump has complicated mechanical construction with multiple failure points. It has difficulty pumping the resulting thick, viscous liquids, leading to overloading of its gears and bearings, and early failure.

Initial Solution Proposed: Retrofit with air operated injection pumps. We searched the company stock for a suitable pump with **fewer mechanical parts, and more reliable operation.** We found an ideal candidate in the box below. This air operated injection pump will have no problem handling thick liquids, since it is direct pneumatic operated, and not motor driven.

From a flow rating point of view, this new pump can flow from 10% to 200 % of existing pump design flowrate, which is 10 GPH. It also has a pressure rating of 650 psig, which is well above the present discharge pressure of 350 psig.

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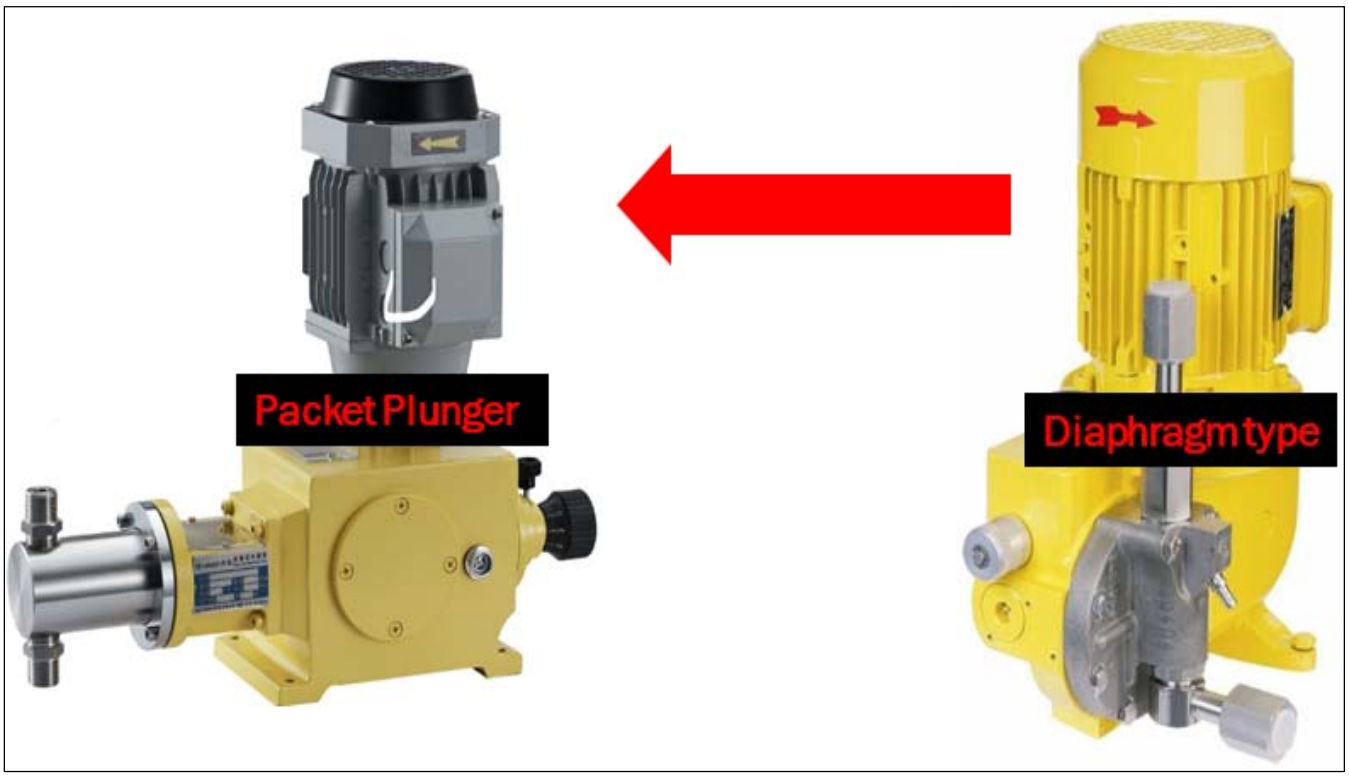

Foreman Prefers Motor Driven Plunger Type Injection Pump

From: Khowaiter, Abdulrahman O
Sent: Sunday, October 3, 2004 1:58 PM
To: Operation Foreman; Maintenance Staff; Reliability Unit
Cc: Engineering; Manager
Subject: Gas Treat R-32-G-112/312 Anti-Foam Injection Pumps Solution to Failures

In conversation with Gas Treat Unit Foreman, he prefers an electric driven injection pump instead of the pneumatic option due to their past experience with pneumatic pumps. In response, attached is the stock description for a **motor driven injection pump** to use for anti-Foam. Its design and reliability is superior to the existing Diaphragm pumps, because this new pump uses a piston plunger, so it has no diaphragms to fail. It is also rated to 70 Bar or 1000 psig, so it can easily handle this service. Notice that **the new plunger pump has more than double original rated discharge pressure giving high reliability** by the derating principle. Also, materials were checked for fluid compatibility. **Note:** This is an example where

the reliability specialist took non-specialists advice: Must keep an open mind to better ideas or solutions that improve his original solution. Flexibility in thinking is valuable. The motor driven option was the best selection.

Result after 8 Years: The new chemical metering pumps installed at the Gas Plant in December 2004, have so far in year 2012 achieved an MTBF exceeding 8.0 years for all six pumps, compared to maximum 3 to 6 months for the previous six diaphragm pumps. This means a reliability improvement of 2400%. The only maintenance required at first was simple plunger packing renewal every 12 months. Later, the maintenance staff discovered that the packing was not being greased, so packing life was extended to four years when a greasing PM was applied.

Chemical Injection Pumps Reliability Conclusion: If the metered liquid is non-hazardous: Always prefer plunger type metering pumps with hardened plunger instead of diaphragm type pumps. The reason is that diaphragm pumps have far more failure modes due to the additional mechanical components, and the higher level of stress on diaphragms compared to plungers.

How the injection pump reliability was improved through mechanical reliability methods:

1. **First step was discovering why the older design pump** was failing. The big failure mouse found was the realization that operators don't mix the anti-foam powder well with water in the suction tank. This leads to highly viscous clumps mixed with normal fluid. A Non reliability engineer would have said: Fix the personnel. That would not help much. This failure mechanism is obvious now, but not at the time.
2. **The second step in reliability analysis** was comparing the complicated construction of existing diaphragm pumps, with the simpler mechanical design of plunger pumps. This is the second major mouse found. So this means that the two mice working together reduced pump life to 4 months only.
3. **Third step was devising a solution,** realizing that a packed plunger type pump would find significantly reduced stress acting against viscous thick liquid because its force is high and plunger surface area small.
4. **Fourth step toward high reliability was purposely selecting a new pump with high stress rating** to be operated at lower rating, meaning a large safety factor in terms of mechanical stress. I searched for and selected an electric motor driven pump with 1000 psig rating while normal desired process load is only 350 psig. However, expected that pump will see up to double the 350 psig at worst case thick fluid viscosity.
5. **All the four steps above working together** led to the high reliability improvement of 2400%.