Case History

Experience with API Plan 53B

Pressurized Dual Seal Systems

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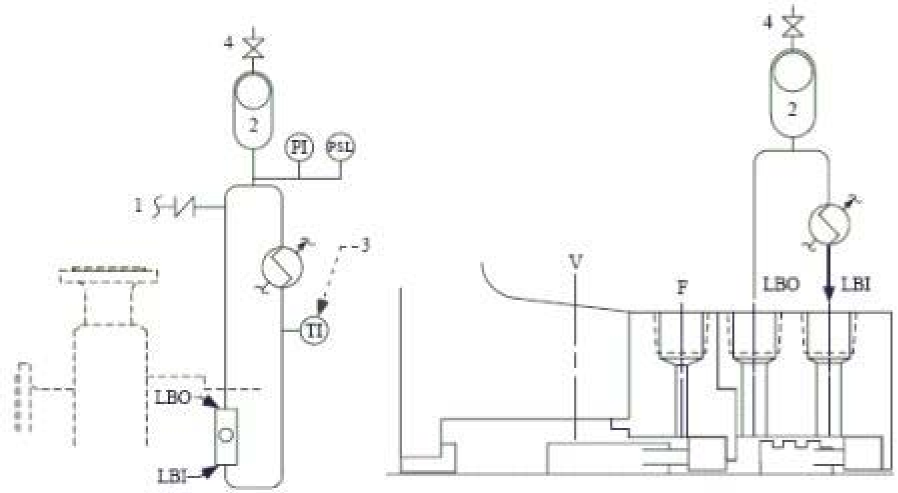
History

- Plan 53B is one of the newest API seal flush plans
- It first appeared in the second edition of API 682
- This case history is based on experience on a large project in China.
- This petrochemical complex is the first that the authors are aware of to apply this seal flush plan extensively (670 pumps with Plan 53B)
- This plan allows application of pressurized dual seals in plants with no nitrogen utility or at pressures above that of the nitrogen utility

The API 682 Schematic



SEAL CHAMBER FOR PLAN 53B

Notes:
1 Make up barrier fluid
2 Bladder accumulator
3 If specified
4 Bladder charge connection

LBI = liquid barrier inlet
LBO = liquid barrier outlet
F = flush
PI = pressure indicator
PSL = pressure switch low
V = vent (if required)

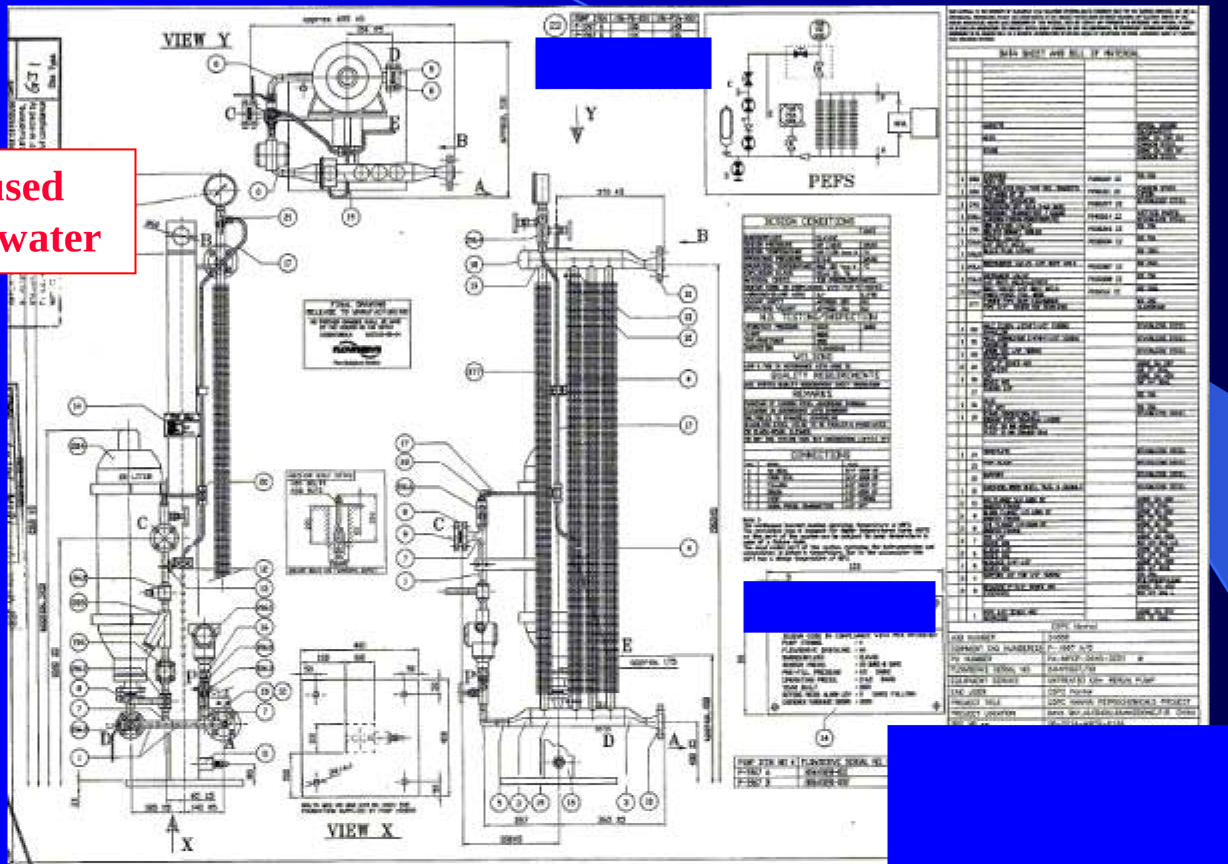
External piping provides fluid for the outer seal of a pressurized dual seal arrangement. Pre-pressurized bladder accumulator provides pressure to the circulation system. Flow is maintained by an internal pumping ring. Heat is removed from the circulation system by an air-cooled or water-cooled heat exchanger. This plan is used with an Arrangement 3 seal.

Figure D.16 — Standard seal flush Plan 53B

This API 682 Second Edition schematic is incomplete and it won't keep you out of trouble.

P&ID and GA for Plan 53B

Project mostly used air coolers; few water



All mechanical seals leak. It is the leakage across the faces that lubricates the seal. The manufacturer can tell you the leakage rate. The bladders were sized for a minimum of a months leakage.

Commissioning the System

- Assure the piping is clean
- Pour a small amount of barrier fluid into the accumulator to lubricate the surface of the bladder and shell

Not always done.

- Charge the bladder to the specified charge pressure (This project used maximum seal chamber pressure plus 1 bar.)
- Pump barrier fluid into the system
- Vent the system
- Pump more barrier fluid into the system until the desired system pressure is reached and repeat until all gas is vented
- The amount of working fluid specified for each installation resulted in system pressures 4 to 8 bar (60 to 120 psi) above the charge pressure

Some units were filled using a cart and hand pump; most units were equipped with a header system.

Operational Issues:

- Some pumps with high pressure systems become difficult to turn at 20 to 50 bar when the systems were pressurized.
- BB Pumps almost always become hard to turn at 40 bar Barrier Fluid Pressure
- SSOH pumps almost always become hard to turn at 50 bar BFP
- For these pumps a strap wrench (not a chain wrench) was used to turn the pump
- Several pumps could not be turned with a strap wrench and were simply started. No failures occurred when starting these pumps

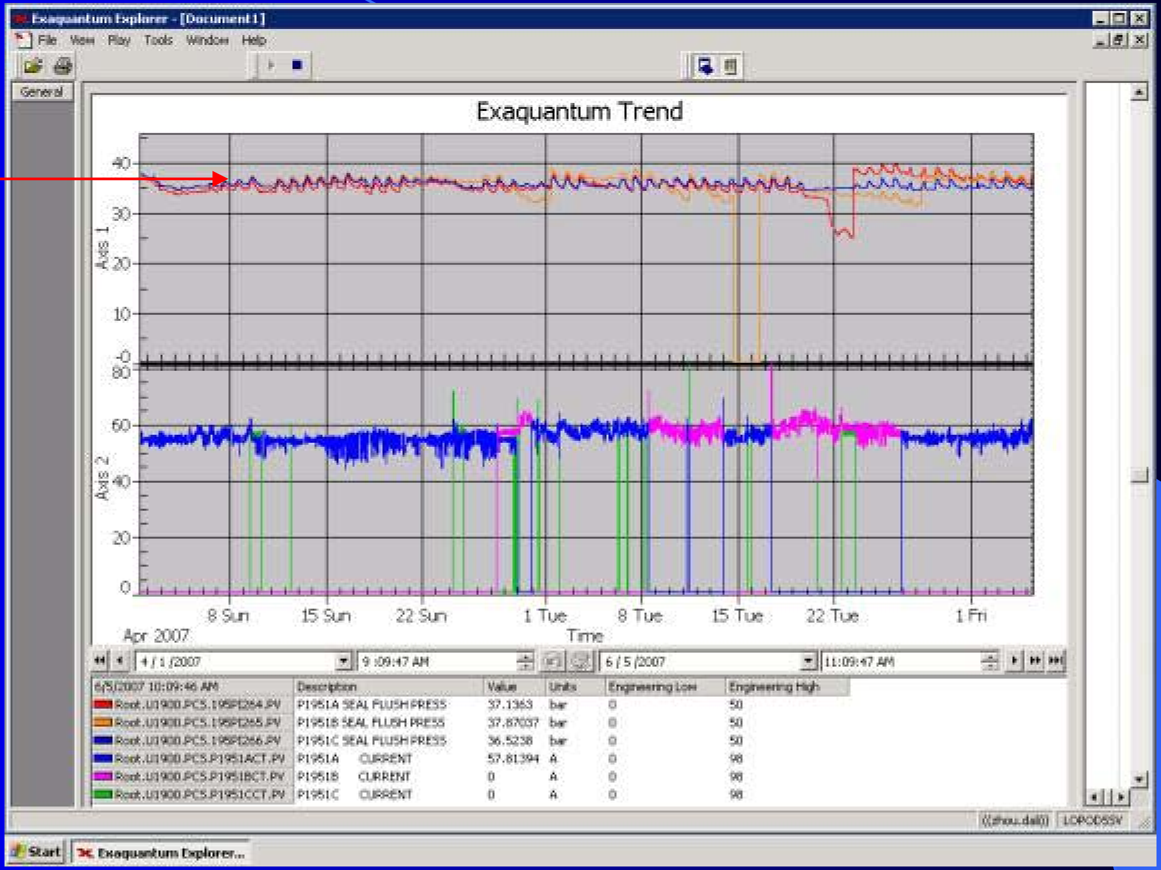
One liquid ring compressor needed a strap wrench at 9 bar.

Operational Issues:

- On several small pumps the extra seal drag at high barrier fluid pressure caused the motors to over-amp.
- System pressures must be monitored. On this project transmitters allowed the DCS to monitor the pressures

System Pressure Fluctuates

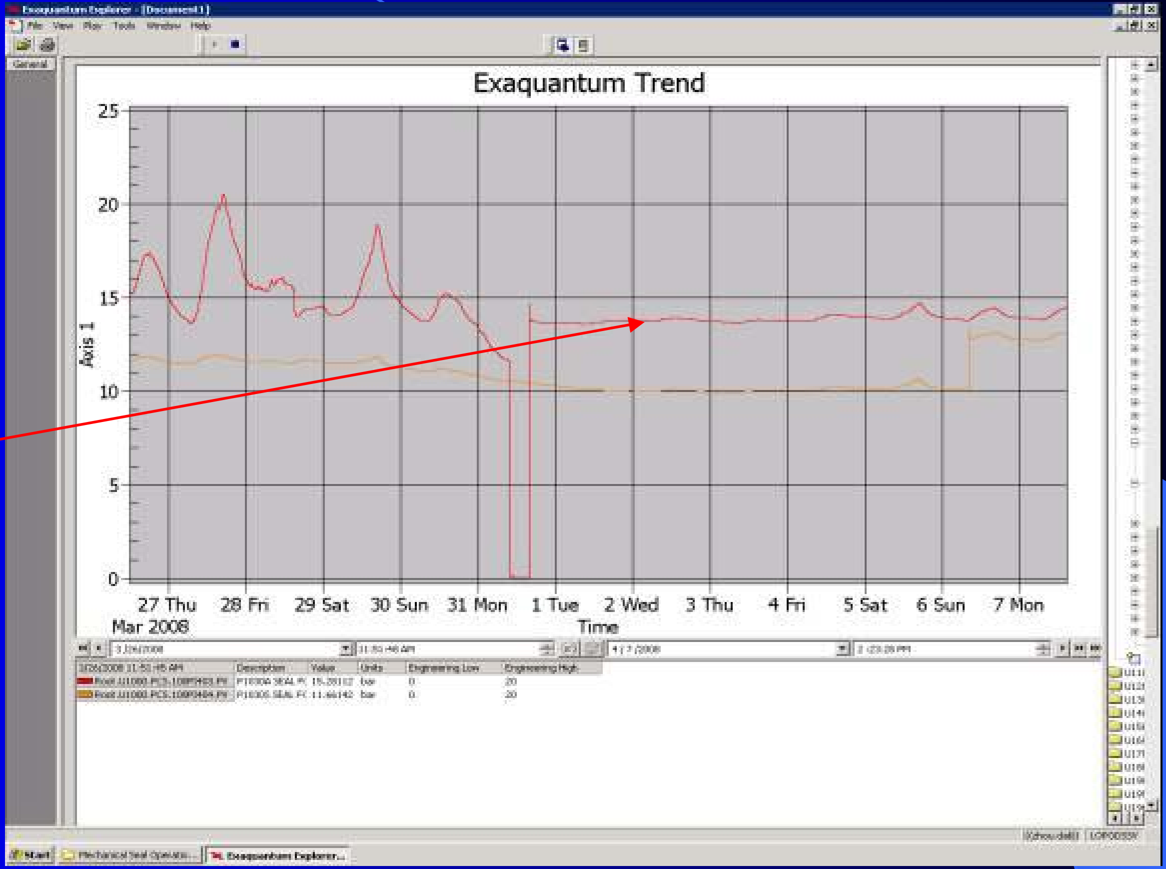
Daily fluctuations in pressure due to ambient temperature.



Bladder Charge Pressure Affects Pressure Fluctuations

Low bladder pressure makes for wider daily pressure fluctuations.

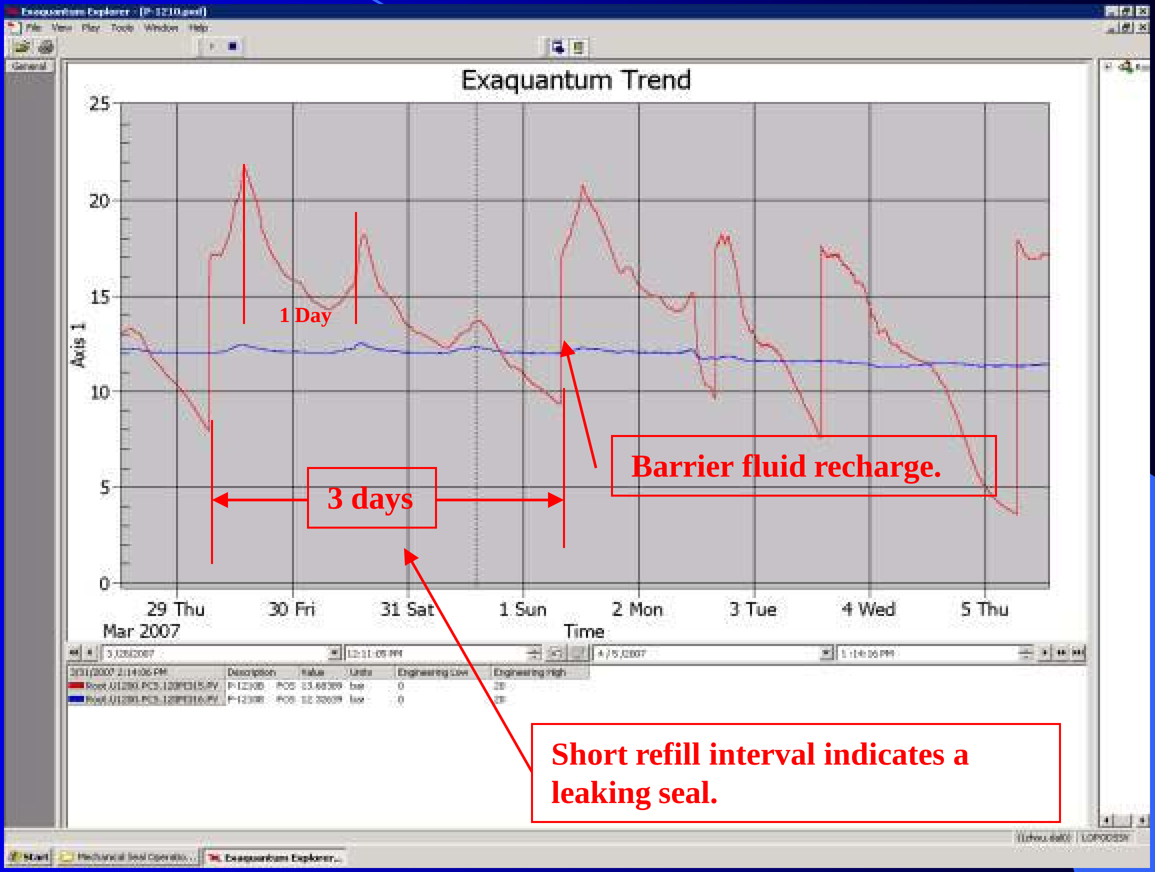
Pressure fluctuations reduced after recharging bladder.



Bladder and Seal Failure

Between Bearings Pump with 2 seals

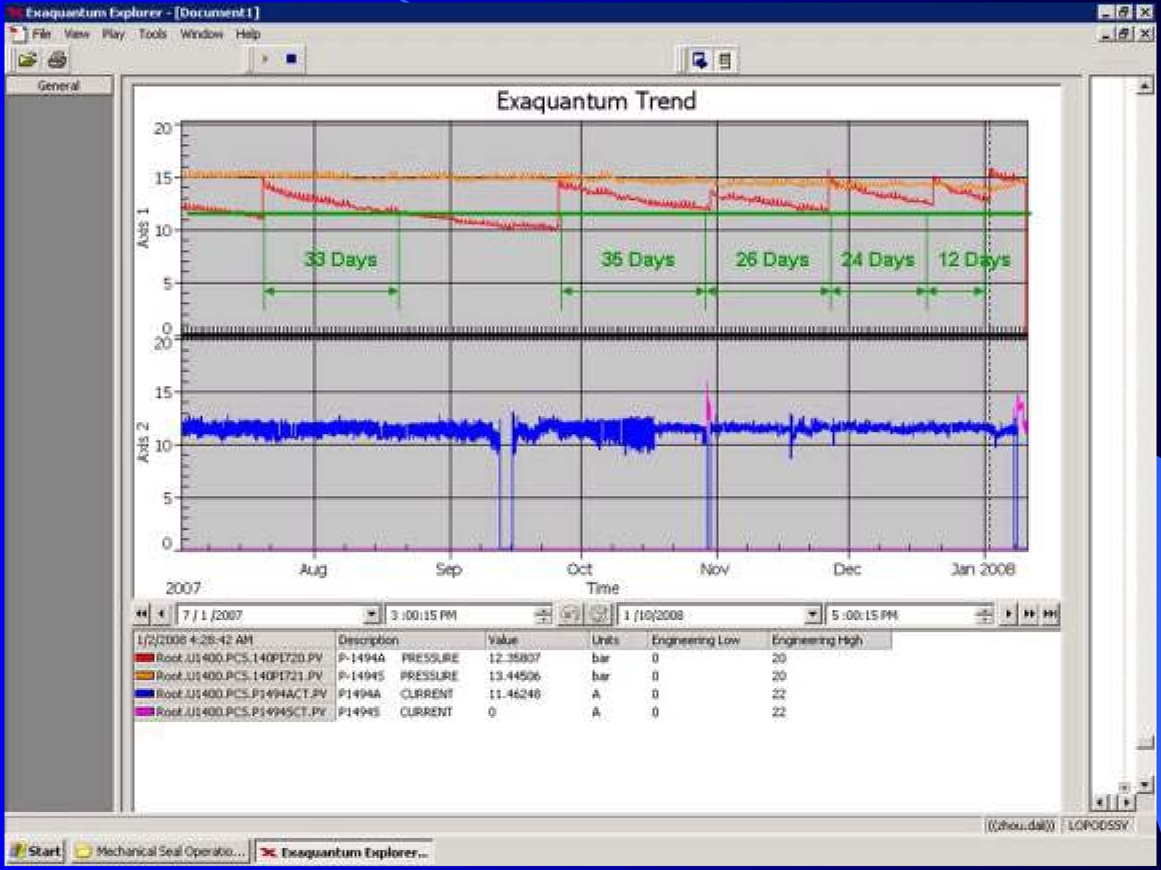
The barrier liquid system pressures fluctuate on the same daily period but one seal (red) fluctuates much more than the other (blue). This is clearly abnormal. Bladder (red line) was confirmed to have failed.



A typical rate of bladder pressure decline

When the system pressure reaches a preset limit the system must be refilled.

Declining refill interval is a sign of a deteriorating seal or other leak.



Fill Intervals

Barrier Fluid Pressure	Number of Pumps	Shortest average fill interval	Longest average fill interval	Average fill interval
< 10 bar	11	46 day	390 days	159 days
10 to 20 bar	22	19 days	163 days	61 days
> 20 bar	37	10 days	122 days	42 days

This data is typical of the whole plant but reflects only one process unit. This data must be gathered by hand due to IT limitations.

Higher barrier fluid pressure increases leakage through outer seal.

Reliability

	Number of Seals	Number of Failures	MTBR (years)
BP Pressure < 10 bar	277	10	13.2
BF Pressure 10 to 20 bar	288	24	7
BF Pressure 20 to 30 bar	49	6	4.7
BF Pressure >30 bar	56	7	4.6

Data collected for start up and the first 18 months of operation of the plant. This data includes all system 53B's in the plant.

Bladder Issues

- Bladder failures are not always easy to diagnose
- If the accumulator pressure increases more than can be explained by diurnal ambient temperature it is likely a sign of bladder failure

System becomes liquid full.

- If the accumulator had a separate drain to atmosphere valve, the operator could shut the accumulator in and drain it. In this case if the bladder pressure goes to zero the bladder has failed

Bladder Failure

- Bladder damage can occur if the precharge pressure falls below 35% of the working pressure
- With low pressure the bladder flexes excessively as system pressure fluctuates
- This crack at the bladder rim suggests this cause of failure.
- One must shut the pump down and depressure the system to detect bladder failure
- If "apparent bladder pressure" goes to zero bladder has failed

Bladder Costs

Bladder Capacity, l	Bladder Material	Cost
20	Nitrile	$740
20	Silicon	$5650
20	Viton	$5250
35	Nitrile	$1130
35	Viton	$9770
50	Nitrile	$1570
50	Viton	$13300

Pay attention to compatibility of bladder material to barrier fluid. Chose barrier fluids that allow less expensive bladders.

Have spare bladders on hand. You will fail a few as you learn to operate this plan. Project had half a dozen failures.

Where does one put this stuff?

- RLJ says on the baseplate
- On the baseplate gives the RE “control” over the design so he can optimize maintainability and operability working directly with the pump vendor
- This also makes the pump manufacturer responsible for the system circulating/working
- Many RE’s want the plan off the baseplate for operability and maintainability
- Off the baseplate (OTB) increases shipping and field costs
- OTB is difficult to control where the system will be mounted
- The systems must be within the equivalent length that the pumping device can overcome or they won’t circulate (most manufacturers want system within 1.5 m—this will likely not happen for OTB’s)

Other issues/Lessons Learned

- Use ¾" pipe or tubing between the plan 53B and the pump (30% of systems with ½ pipe had circulation problems)

Pipe elbows are a problem.

- One manufacturer supplied ½" pipe systems with poor reliability results
- Placing the fill valve at the high point of the system makes it difficult or impossible to vent the system. The more reliable systems placed a fill valve at the low point and a vent valve at the high point.
- The coolers shall be installed vertically. Horizontal placement makes it impossible to vent them or requires extra valves to vent

Conclusion

Plan 53B is a very reliable option for reaching near zero emissions.

Questions/Discussion?