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EAD/RELIEF VALVE BLOWDOWN RING TESTING

MAY 14 - 22, 1984

ABERDEEN CHEMICAL PLANT

CONFIDENTIAL

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I. EAD TESTING

A. Background

BS & B Safety Systems was asked to develop a disc that would not lift the relief valve with premature rupture disc failure. As a result of this, a new type rupture disc referred to as an Energy Absorbing Disc (EAD) was developed. This new disc was intended for in series installation with a regular S-90 type disc. The EAD disc consists of two discs spot welded together. The first disc is a flat scored plate with holes. This plate absorbs the shock wave caused by a premature rupture failure. The second disc is a scored concave type that operates like a regular disc. Due to the permanent deforming of the flat disc, the energy absorbing characteristic of the EAD can only be utilized one time.

Testing has been done at BS & B facilities that showed the S-90/EAD disc combination works for 8" discs on a 100 gallon vessel. The EAD held a S-90 failure up to a pressure of 85% of the EAD set pressure. Testing of an EAD on a full size vessel was required before proceeding with any reactor installation.

B. General Procedures

The following are general items that apply to all the EAD tests:

1. Testing was performed in reactor D-600 on the condenser relief valve. The relief valve used was a Farris 6" x 8" with a nominal 185 PSIG set point. (Model number 26QA12-120, S/N 31670-A10).

2. Air was used as a medium for all tests. The reactor was pressured up to approximately 25-30 PSIG with air and then water was added with charge water pumps to increase the pressure in the reactor. The water volume at the S-90 burst pressure was very close to the normal running volume. The charge water pumps were left running even during the time the relief valve was discharging to simulate generation of vapor that can occur in a runaway VCM release. The agitator was also on for all the tests.

3. The pressure reported in these tests was obtained from a new and calibrated pressure gauge on the reactor. This gauge agreed closely to the pressure recorder in the control room.

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B. General Procedures (Cont.)

4. The EAD holders were pretorqued in the shop under the supervision of BS & B representatives Charlie Beir and Ron Jones. They also witnessed the installation of the holder in the reactor which was directly on the inlet of the relief valve.

5. The EAD discs used were all from the same lot (Lot #83006418A-1). These discs had a rated burst pressure of 192 PSIG at 72°F and 182 PSIG at 200°F.

6. There was a pressure gauge between the EAD disc and the relief valve to monitor if the EAD disc held when the S-90 disc burst.

C. Details of Testing

Table I gives a summary of the results of the EAD testing. Below is a description of the tests.

Burst Tests #1, #2 and #3

The objective of these first three tests was to show that the relief valve does lift when the disc fails prematurely. The discs used for these tests were rated at 160 PSIG at 72°F and 157 PSIG at 200°F (Lot # 63006418-2, S-90 MOC - Nickel). In the first test, the disc burst at 170 PSIG. The relief valve lifted and then reseated at 165 PSIG. 15,000 gallons of water were added to the reactor. In the 2nd test the rupture disc burst at 167 PSIG. The relief valve lifted and reseated at 164 PSIG. 14,790 gallons of water were added to the reactor. In burst test #3, the rupture disc burst at 170 PSIG. The relief valve lifted and reseated at 165 PSIG. 14,690 gallons of water were added to the reactor. In all of these tests, the relief valve blowdown ring setting was 18 notches.

At this point, we assumed that it had been proven that the relief valve would lift for a premature rupture disc of approximately 90% and were ready to move to the next test.

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I. EAD TESTING

C. Details of Testing (Cont.)

Burst Test #4

The EAD disc was installed in the reactor in conjunction with the S-90 disc which was from the same lot as was used in burst tests #1 - #3 (Lot #63006418-2). The pressure in the reactor was increased until at 168 PSIG, the S-90 disc burst. The EAD disc held as evidenced by the lack of pressure in the cavity between the EAD and the relief valve. The water pumps were stopped for a few minutes to verify the pressure. Then the pressure was increased until the EAD burst at 187 PSIG. The relief valve then lifted and reseated at 166 PSIG. A total of 15,370 gallons of water were added to the reactor.

On this test, the EAD held at 87.5% of its rated pressure (168/192). BS & B claims that it will hold up to 85%.

Burst Test #5

The same lot of S-90 and EAD discs were used on this test. (S-90 rated at 160 at 72°F and EAD at 192 at 72°F.) The S-90 disc burst at 173 PSIG, the EAD then burst and the relief valve lifted. The relief valve then reseated at 166 PSIG. 14,760 gallons of water were added to the reactor. This EAD did not hold at 90.1% of its rated burst pressure.

Burst Test #6

The S-90 disc (same lot as previous tests) burst at 128 PSIG and the EAD held. The pressure was then brought up to 192 PSIG and the EAD burst and the relief valve lifted. This valve reseated at 165 PSIG. The water added to the reactor was 15,270 gallons.

Burst Test #7

The S-90 disc (the same lot as in previous tests) burst at 174 PSIG. The EAD also burst at this time causing the relief valve to lift. The relief valve reseated at 165 PSIG. A total of 14,850 gallons of water were added to the reactor.

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Burst Test #8

At this point in the test, it was obvious that the lot of discs rated at 160 PSIG at 72° was failing out of tolerance. The BS & B representatives contacted the factory to get a new lot of discs made. While the new lot was coming, a hydrotest was performed. The EAD disc was installed on the reactor with a regular S-90 disc rated at 191 PSIG at 72°F. The reactor was filled with water until it flowed out of the atmospheric vent valve. The reactor was then drained for four seconds. Then the reactor was pressurized with one charge pump. Both the S-90 and the EAD disc blew at 190 PSIG and both air and water came out of the relief valve.

Burst Test #9

The new lot of S-90 discs was used on this test (Lot #83006418B-1). The rated burst pressure was 161 PSIG at 72°F. On this test the S-90 burst at 160 PSIG (83.3%) and the EAD held. The pressure was then increased and the EAD burst at 183 PSIG. The relief valve lifted at this point and reseated at 159 PSIG.

Testing of the blowdown ring occurred at this point. Please refer to that section for details.

Burst Test #10

For this test, the lot of S-90 discs that was used in test #9 was used again in conjunction with the EAD disc. The S-90 disc burst at 160 PSIG and the EAD held. At 168 PSIG, a "ping" was heard and pressure between the relief valve and the EAD as noted. This indicated there was leakage through the EAD and no differential pressure to cause the disc to burst. The pressure in the reactor was raised to 185 PSIG and the disc did not burst. The air in the reactor was leaking through the small holes in bottom disc through the small burst opening in the top disc and then leaking out the relief valve. The leakage out the relief valve could be heard. At this point the test was stopped and the EAD was taken from the reactor. There was a small crack along the score line of the top disc.

It is believed that the EAD disc would not have relieved no matter what pressure was built up in the reactor because there was no differential pressure to burst the disc. At this point, all testing on the EAD was essentially stopped as installation of a disc that can fail in this mode is unacceptable.

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I. EAD TESTING

C. Details of Testing (Cont.)

Burst Test #11

The S-90 and EAD discs were installed in the reactor before they could be told not to proceed with the testing of the EAD. These discs were burst in order to test the relief valve. The S-90 burst at 159 PSIG and the EAD held. Then the EAD burst at 187 PSIG. After this, relief valve testing was done.

II. BLOWDOWN RING TESTING

A. Background

In January of 1983, a premature rupture disc failure on reactor 744 condenser resulted in a relief valve discharge. The relief valve then remained open for about 3-5 minutes at a low flow rate even though the reactor pressure was about 142 PSIG (RV set point was 175 PSIG). At that time, it was thought that the premature failure causing the relief valve to lift was understood. However, we did not understand why the relief stayed open or why the "blowdown" was so great. At that time, the relief valve manufacturer was requested to study the problem and give recommendations. The manufacturer did so and responded that the blowdown ring setting was calculated and obtained from testing. The recommendation to test the blowdown ring setting on our reactors was made. Since this testing could easily be done in conjunction with the EAD test, it was decided to proceed with the test.

A description of how the blowdown ring causes changes in blowdown, pop action, simmer, etc. is given in the Appendix.

B. Details of Testing

Burst Test #9

On burst test #9, after the S-90 and EAD discs were burst, testing was done on the relief valve. The pressure in the reactor was lowered and then increased until the relief valve lifted. This was repeated several times to verify the set point (pop pressure). The blowdown ring was then checked and was found to be set at 18 notches

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B. Details of Testing

Burst Test #9 (Cont.)

as per Farris specifications. The blowdown ring set pin was still factory sealed. Listed below are results from this testing.

Blowdown Ring Setting	Simmer Pressure	Pop Pressure	Reseat Pressure	Comments
18	None Detected	176	158	
24	Slight Simmer At About 176	176	162	
30	172	177	171	Slight chatter on reseat

These results showed that the blowdown was decreased by lowering the blowdown ring setting. It was also evident that the amount of gas "leaking" through the valve (simmer) necessary to cause the "pop" action was greatly increased. The blowdown ring could not be lowered more without causing more severe chatter. Therefore, it was decided to leave the blowdown ring setting as it was. However, there was concern that the relief valve set point was not in tolerance. The setting on the relief valve was then changed for the next test.

Burst Test #11

After bursting the S-90 and EAD, testing of the relief valve was done. The relief valve started to simmer at 178 PSIG and lifted at 181 PSIG. The reseat pressure was 172 PSIG. There was also a slight chatter on reseat.

Burst Tests #12, #13 and #14

The objective of this test was to see if the relief valve would lift with the blowdown ring setting changed. It was discovered that the relief valves did not lift, but there was only leakage through the huddling chamber. Results are shown below:

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B. Details of Testing

Burst Tests #12, #13 and #14 (Cont.)

Test No.	RD Burst Pressure	Description
12	160	No Plastic Bag - nothing was seen or heard leaving relief valve.
13	159	Broke Plastic - nothing was seen or heard leaving relief valve.
14	160	Broke Plastic - nothing was seen or heard leaving relief valve.

744 Condenser Relief Valve Blowdown Ring

During the visit of Eugene C. Cullie, Engineering Manager for Teledyne Farris Engineering and Ron Butcher, Tri-State Valve and Equipment Company, the blowdown ring on the 744 condenser relief valve was checked. The blowdown ring setting bolt was factory sealed. Mr. Cullie broke the seal and checked the position of the blowdown ring. It was set at 9 notches and should have been set at 18 notches. Had the blowdown ring on this relief valve been set at 18 or 30 notches, perhaps the relief valve might not have "popped" when the rupture disc failed on January 14, 1983 and April 14, 1982.

TABLE I
EAD TESTING
S-90 DISC

Burst Test	Test Objective	Rated Burst Pressure At 72°F	Lot #	Burst Pressure (PSIG)	EAD Disc Burst Pressure	S - 90 / Relief Valve Ratio (%)	S - 90 / EAD Ratio (%)
#1	To confirm that RV will lift on premature failure.	160	63006418-2	170	—	91.8 (1)	—
#2	To confirm that RV will lift on premature failure.	160	63006418-2	167	—	90.2 (1)	—
#3	To confirm that RV will lift on premature failure.	160	63006418-2	170	—	91.8 (1)	—
#4	EAD will hold premature failure.	160	63006418-2	168	187	EAD HELD	87.5
#5	EAD will hold premature failure.	160	63006418-2	173	173	93.5 (1)	90.1
#6	EAD will hold premature failure.	160	63006418-2	128	192	EAD HELD	66.7
#7	EAD will hold premature failure.	160	63006418-2	174	174	94.1 (1)	90.6
#8	EAD will relieve in hydrotest.	191		190	190	—	99.0
#9	EAD will hold premature failure.	161	83006418B-1	160	183	EAD HELD	83.3
#10	EAD will hold premature failure.	161	83006418B-1	160	Did Not Burst Cracked At 168 PSIG	—	83.3
#11	EAD will hold premature failure.	161	83006418B-1	159	187	EAD HELD	82.8

Notes: (1) Later it was determined that the relief valve set point was actually 177 PSIG. See blowdown ring section for discussion.

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APPENDIX

Blowdown Ring Description

The purpose of the blowdown ring is two fold. First, it produces a sharp "pop" in the relief valve and second it controls the blowdown or the pressure at which the valve reseats. A diagram of a Farris 2600 series relief valve is shown on the following page. As the pressure increases in the vessel, the relief valve begins to lift very slightly, allowing the valve to leak between the "O" ring seat and the nozzle into the huddling chamber. Leakage out of the huddling chamber is controlled by the blowdown ring setting which creates an orifice. If the leakage rate into the huddling chamber is less than the leak- age rate out through the blowdown ring, the valve will simmer and not pop. Once the leakage into the huddling chamber exceeds the leakage out, the pressure builds and the effective area pushing up against spring is quickly enlarged. These unequal forces cause the relief valve to pop open allowing gas in the vessel to rapidly discharge. As the pressure decreases, the spring exerts force trying to close the valve, but movement of gas across the blow-down ring acts as an "air bearing" and causes the valve to discharge even below its set point. This difference between the valve popping pressure and reseat pressure is called blowdown.

If the blowdown ring is set too low (greater notches), the valve will not have a crisp pop point and will chatter. The spring then becomes the dominant force and the valve opens quickly, the pressure drops slightly and the valve immediately tries to reseat. Chattering can destroy the valve seat and disc seal and cause leakage.