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VCM RELEASES WHICH OCCURRED FEBRUARY 10, 1979,
APRIL 14, 1982 AND JANUARY 8, 1983 BECAUSE
OF THE PREMATURE FAILURE OF A
REACTOR RUPTURE DISC

Summary:

The premature failure of rupture discs which is defined as failure below the disc pressure rating is not new. Rupture disc technology has thus focused primarily on designs and manufacturing techniques to provide accurate burst pressures.

Conoco set up a program to study and prevent premature rupture disc failures in 1979 which Vista Polymers Inc. is still continuing. Application of the information which has been obtained in this program has greatly reduced the probability of a premature failure. However, it is now realized that complete elimination of premature failures is a difficult task because all of the causes are not known. The potential for large VCM releases has been reduced by replacing all of the double rupture disc assemblies with rupture disc and relief valve assemblies. A program has also been conducted to study the factors which may sometimes cause a relief valve to open when the rupture disc fails prematurely and which prevent the valve from quickly reseating. This study has resulted in some changes in the relief valve settings which are expected to both reduce the probability of a relief valve opening when a premature failure occurs and also to make the relief valves reseal more quickly. Thus the number and quantity of VCM releases due to premature rupture disc failures will be minimized.

Details on the results of the studies that have been conducted and the corrective steps that have been taken are provided in the answer to Question 2 below.

QUESTION 1: FOR EACH RELIEF VALVE OR MANUAL VENT VALVE DISCHARGE OF VINYL CHLORIDE ("VC") WHICH OCCURRED FOR THE PERIOD FROM JANUARY 1, 1979 TO JANUARY 1, 1985, A DESCRIPTION OF THE NATURE AND CAUSE OF THE DISCHARGE, INCLUDING PRIMARY AND/OR RELATED CAUSE(S).

Response:

Descriptions giving the nature and cause of the discharge, including primary and/or related cause(s) have been submitted to EPA. These are listed below.

February 10, 1979

1. This incident was reported in a letter to T. A. Gibbs, Chief Air Engineering Branch, on 2/19/79 which is attached as reference B-1, Appendix B.
2. More data was submitted 3/5/79 in a letter to T. A. Gibbs, Chief Air Engineering Branch. This letter included a copy of the plant emergency plan. This letter is attached as reference A-2, Appendix A.

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3. Region IV EPA and PEDCo ENVIRONMENTAL Inc., an EPA Contractor, made a field inspection of the Aberdeen plant on August 21, 1979. The report on this inspection which was prepared by PEDCo Inc. included some details on this incident. PEDCo concluded that this release was nonpreventable. A letter from Curry L. Miller (Plant Manager) to Wayne Aronson, EPA Region IV dated October 15, 1980, provided some additional information and corrected some misleading and incorrect statements in the PEDCo report. A copy of this letter is attached as reference A-3, Appendix A.

April 14, 1982

1. This incident was reported in a letter to Jerry B. Banks, Mississippi Department of Natural Resources, dated April 23, 1982 which is attached as reference B-2, Appendix B.
2. A report on this incident was also made to the National Response Center on April 15, 1982.

January 8, 1983

1. This incident was reported in a letter to Jerry B. Banks, Mississippi Department of Natural Resources, dated January 17, 1983 which is attached as reference B-3, Appendix B.
2. A report on this incident was also made to the National Response Center on January 8, 1983.

QUESTION 2:

FOR EACH DISCHARGE DESCRIBED IN RESPONSE TO III.A.1., A DETAILED DESCRIPTION OF ALL RELEVANT CORRECTIVE STEPS TAKEN BEFORE AND DURING EACH DISCHARGE TO PREVENT AND/OR MINIMIZE THE RELEASE OF VC TO THE ATMOSPHERE, INCLUDING, BUT NOT LIMITED TO, SUCH STEPS AS REROUTING VC EMISSION VENTS TO A COLLECTION VESSEL OR INCINERATOR.

Response:

The relevant corrective steps taken before and during the February 10, 1979 and April 14, 1982 discharges are discussed in the incident reports which are references B-1, Appendix B, A-2, Appendix A, and B-2, Appendix B.

Relevant corrective steps taken before and during the January 8, 1983 discharge are discussed in the incident report which is attached as reference B-3, Appendix B. In addition to the corrective steps discussed in reference B-3, Appendix B, the reactor was vented to the recovery system which helped to reduce the reactor pressure so that the relief valve could reseal. At the time of the January 8, 1983 release, the D-744 reactor was being heated up to normal reaction temperature with steam on the jacket. When the release occurred, the steam was shut off and full cooling water turned on. This helped to stop the release by reducing the reactor temperature and pressure.

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The information provided below and documented in the listed references is additional information relevant to corrective steps that were taken before and after the February 10, 1979, April 14, 1982 and January 8, 1983 incidents.

ADDITIONAL DETAILS ON CORRECTIVE STEPS TAKEN BEFORE THE
FEBRUARY 10, 1979 RELEASE

Stainless steel rupture discs were originally installed on the reactors. These discs were replaced with nickel discs because of concern that the stainless discs might be subject to chloride stress corrosion cracking and because of information which indicated that nickel would be less subject to polymer buildup. A release at Conoco's Oklahoma City PVC plant in August 1978 which was attributed at that time to chloride stress corrosion cracking reinforced this decision.

The Aberdeen polymerization reactors were equipped with 6" BS&B S-90 nickel discs in late 1976. These discs were a new design at that time and were chosen after an evaluation of the reverse buckling discs that were available from the major manufacturers. Only reverse buckling discs were considered in this evaluation since the older design tension loaded discs are not recommended for cyclic applications such as those experienced in the Aberdeen Plant PVC Process where the pressure on each batch ranges from a high vacuum to over 100 psig. All of the other reverse buckling discs available at that time including the BS&B RB-90 disc reversed against knife blades which cut the disc. The S-90 disc, however, is prescored so that the disc will open without cutting when it reverses. The S-90 disc thus does not require any knifeblades. Eliminating knife blades eliminated problems such as:

1. The knifeblades becoming dull and not providing a clean cut when the disc reverses.
2. The knifeblades plugging with polymer.
3. Disc reversal against the knifeblades without being cut open can occur. This may only happen occasionally but is a serious problem because the disc will then not burst until a pressure much higher than the design burst pressure is reached in the vessel. The disc thus no longer performs the intended function of protecting against vessel overpressure.

Another advantage of the S-90 disc for PVC reactors is that the pressure cycles do not fatigue the disc. Metallurgical studies of S-90 discs that have been removed from the reactors have confirmed that there is no evidence of metal fatigue. Further discussion of reverse buckling discs was provided in the reply to an EPA Region VI section 114 letter by the Oklahoma City PVC plant dated September 15, 1981.

BS&B did not manufacture 8" S-90 discs in 1976. The 8" reactor rupture discs were converted to S-90's in the second quarter of 1980 when they first became available from BS&B.

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Training of the mechanics in proper handling and installation procedures of the rupture discs was conducted by maintenance supervisors. A record of training on 1/31/77 is attached as reference B-4, Appendix B. Under normal plant procedures other training sessions would have been held but training records have not been located.

ADDITIONAL DETAILS ON CORRECTIVE STEPS TAKEN AFTER THE
FEBRUARY 10, 1979 RELEASE

Conoco initiated a study of the causes of premature rupture disc failures and methods of preventing such failures in 1979. This study included extensive discussions with BS&B and other rupture disc vendors, Conoco specialists and DuPont specialists. BS&B has also cooperated with this study by running burst tests on rupture discs and rupture disc/relief valve combinations. This study has led to a realization that improved handling and proper installation of the rupture discs will reduce the probability of premature failures. The first step taken to reduce premature failures was thus to provide the best available training for the plant mechanics.

Plant mechanics and supervisors were trained by BS&B representatives in the proper procedures for the inspection, installation and testing of rupture discs. Training sessions were held 3/13/80, 4/20/82, 4/28/82, 5/24/82, 5/25/82, 6/21/83 and 7/18/84. Additional training for plant mechanics was provided by the plant maintenance supervisors on 3/15/82, 1/17/83 1/19/83 and 7/16/84. Records of these training sessions are attached as references B-5 through B-14, Appendix B. Records of the 5/24 and 5/25/82 sessions are not included since they have not been located. However, plant personnel are sure that the sessions were held. Mechanics who are qualified to do rupture disc installations and testing are listed in memos which are updated as changes occur. Memo's which were issued March 7, 1983, August 22, 1983 and December 15, 1983 are attached as references B-15, B-16, and B-17, Appendix B respectively.

Rupture discs that were available from vendors other than BS&B were evaluated during the vendor discussions. The conclusion reached was that the BS&B S-90 discs were the best choice. Later discussions with DuPont confirmed this choice. DuPont based their conclusions on extensive tests which they conducted on rupture discs manufactured by BS&B and other vendors. During the first series of tests in 1977 the BS&B discs all burst within the proper range but the burst pressures of the other manufacturers discs were rather erratic. DuPont concluded that the BS&B discs exhibited remarkable burst accuracy. The burst pressures of the other manufacturers discs were greatly improved during a second series of tests in 1978 but they were still no better than BS&B.

Another step that was taken to improve rupture disc handling and installation procedures was to purchase new BS&B SRB-7RS holders and to mount all reactor rupture discs in them. This change was completed in the second quarter of 1979. The SRB-7RS holders were also purchased for the other S-90 discs in the plant and the installation was completed by late 1981. Use of the SRB-7RS holder permits rupture discs to be mounted in the holder in the shop where they can be carefully pretorqued to the proper value. Improper torque on the disc has been identified as one of the factors

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which can lead to premature failures. The mounted reactor discs are then tested in the shop to 90% of the rated burst pressure. This test confirms that the disc has not sustained any damage during shipment or mounting. BS&B believes and Conoco and Vista concur that proper mounting of rupture discs in the SRB-7RS holders is one of the most important steps in reducing premature failures. The SRB-7RS holder includes a bite ring to provide a tight metal to metal seal and hold the disc firmly in place to insure accurate burst pressures. This bite ring is four to five thousandths of an inch high when the holder is new. The rupture disc/relief practice manual which is attached as reference B-27, Appendix B contains a section on inspection of the bite ring. The manual states that a feeler gauge is to be used to measure the bite ring height and that the holder needs to be reconditioned when the bite ring is worn down to two thousandths of an inch. Since the manual was prepared, BS&B representatives in their annual training sessions at the plant have given new procedures for checking the bite ring. They now recommend that the holder be visually inspected to assure the bite ring is intact with no indentations or flat spots and then for the inspector to run his fingernail around the bite ring. If the bite ring is high enough to hold the fingernail all the way around, the holder is suitable for reuse. The holder is replaced and sent out for reconditioning if a flaw is found in the bite ring. Current practice at the plant is to visually inspect and use the fingernail test to determine if the bite rings are satisfactory rather than to use a feeler gauge. A letter from BS&B which includes a discussion of the bite ring is attached as reference B-19, Appendix B.

The performance of relief valves mounted over rupture discs was initially assumed to be the same as the relief valves alone. The opening of relief valves at pressures below the relief valve set point when rupture discs failed prematurely showed that this was not the case. Conoco, therefore, proposed a series of tests of rupture disc/relief valve systems to BS&B. BS&B agreed to conduct these tests and Consolidated Valve agreed to provide the relief valves for the tests. These tests were conducted in January 1980 and demonstrated that the relief valve would open even when the rupture disc burst at a pressure as low as 70% of the relief valve set pressure. Opening of the relief valve is attributed to the shock wave created when the rupture disc bursts. Two letters written by M. H. Lewis dated January 18, 1980 and February 5, 1980 which provide further details on these tests are attached as references B-20 and B-21, Appendix B.

A metallurgical examination was conducted of several intact rupture discs which were removed from the Oklahoma City reactors. A memorandum dated April 22, 1980, from J. Kirk Carnahan is attached as reference B-22, Appendix B. Some of these discs were burst by BS&B on the test bench. One of the discs burst at 135 psig which is well below the design pressure of 200 psig. The conclusion was that this low burst pressure was not caused by metallurgical factors.

The double disc assemblies on the reactors were replaced with rupture disc/relief valve assemblies. This change was made to reduce the amount of VCM released if a premature rupture disc failure occurs. All of the double rupture disc assemblies had been replaced by September 1981 and the EPA was notified in a letter dated September 29, 1981 which is attached as reference B-23, Appendix B.

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The rupture disc which failed April 14, 1982 was installed April 4, 1982 in a BS&B SRB-7RS holder and pressure tested in the shop by a maintenance supervisor. This supervisor had been trained by BS&B in proper installation procedures. The disc was then installed on the reactor by a qualified mechanic. Since all known precautions had been observed, this release illustrates the unpreventable nature of premature rupture disc failing and the difficulties that are faced in trying to completely eliminate premature rupture disc failures.

ADDITIONAL DETAILS ON CORRECTIVE STEPS TAKEN AFTER THE
APRIL 14, 1982 RELEASE

New procedures were established by C. R. Miller (Plant Superintendent) for the installation and testing of rupture discs in a memorandum dated April 26, 1982. A list of qualified mechanics and test observers was included with the procedures. A copy of this memorandum is attached as reference B-24, Appendix B. A copy of the operating instructions to the shift supervisors and operators to check all rupture discs before charging reactors which was dated April 28, 1982 is also attached as reference B-25, Appendix B.

A Rupture Disc/Relief Valve Practices manual was issued on May 6, 1982. This manual was revised and reissued on September 26, 1983. A copy of the revised manual is attached as reference B-27, Appendix B. This manual sets up detailed procedures for ordering, new rupture disc lot inspection and testing, rupture disc installation in holders, bench pressure testing, installation in the plant and removal after service. The procedure which has been set up to destructively test all discs removed from reactors is also described.

Since the Rupture Disc/Relief Valve Practices manual was issued, several of the items covered have been changed. On page 3 of the manual, item II.B.6. states that the maintenance department must notify the receiving department in writing that the lot of discs have either passed or failed the burst test. This notification is now done verbally. On page 7, item IV.A.3. states rupture discs on the reactors must be changed out at least every six months. Current practice is to change out the reactor rupture discs on an annual basis. This change is discussed in the answer to Question 5. On page 7, item IV.A.4. states that when a reactor is taken out of service for condenser drilling the condenser rupture disc guard(s) must be installed over the rupture disc nozzle(s). Current practice is to either remove the rupture disc and holder from the condenser when a condenser is drilled or to protect it with a guard. On page 10, item VII.B. covers in-place relief valve testing. Since changing the blowdown ring settings on the relief valves which is discussed on page 24, the stated procedure is no longer applicable. The plant is currently developing a method for in-place testing of relief valves with the new blowdown ring setting.

The procedure for the inspection and testing of new lots of rupture discs is described in detail in the rupture disc manual (reference B-27). The procedure calls for the discs to be inspected for flaws such as deep scratches or dents and then one disc from the lot is burst on the bench. Flawed discs are returned to the manufacturer. If the disc that is burst does not meet specifications, then the entire lot is rejected and returned to the manufacturer. One lot has been rejected at this time. This lot had five discs with deep scratches. One of these discs was burst on the bench.

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The rated burst pressure for the lot was 189 psig but the selected disc burst prematurely at 164 psig. The other four discs with deep scratches were then tested successfully at BS&B up to 90% of the rated pressure. The decision was then made to use this lot of discs to evaluate the effect of various types of damage to the discs on disc burst pressure. These tests were run at BS&B in August 1982. The conclusion from these tests was that damage to the top of dome is much more serious than damage at the outer radius. Scratches and small nicks did not seem to have any effect on burst pressure. Details on the tests are contained in a letter from Cindy Ziobro dated September 27, 1982 which is attached as reference B-28, Appendix B. BS&B suggested in a letter dated September 9, 1982 that a scratch depth over 50% of the disc thickness should be one of the criteria for disc rejection. This letter is attached as reference B-29, Appendix B. Because of the difficulty which the plant has experienced in measuring scratch depth, the plant rejects any disc that has a scratch or indentation that can be felt on the other side of the disc.

To reduce the possibility of leaks, the reactors are hydrotested to 90% of the pressure rating of the lowest rated disc each time that one of the major flanges on the reactor has been unbolted for any reason. There has been some concern that a rupture disc might be damaged during this hydrotest if the reactor became liquid full or if the test pressure were allowed to rise too rapidly. A revised procedure was thus established for pressure checking reactors after opening to reduce the possibility of damaging a disc during the hydrotest. This procedure included witnessing of all hydrotests by a process engineer or operations supervisor. A copy of this procedure dated August 2, 1982, is attached as reference B-30, Appendix B. The procedure was also documented in a memo dated November 15, 1982, which is attached as reference B-31, Appendix B. This memo set up a pressure check logbook.

ADDITIONAL DETAILS ON CORRECTIVE STEPS TAKEN AFTER THE
JANUARY 8, 1983 RELEASE

Standard rupture disc ordering criteria were established in a letter dated August 3, 1983, which is attached as reference B-32, Appendix B. These criteria were written after extensive discussions within Conoco and with BS&B to ensure that uniform high quality rupture discs would be purchased and installed on the PVC reactors. Most of the items specified are not new. The most significant new items are a requirement that the discs be ASME code stamped and that they be tested to 90% the rated burst pressure before shipping.

The long blowdown of the D-744 relief valve on January 8, 1983 after relieving at 19% below its set pressure because of the premature rupture disc failure raised serious questions about the reason why the valve did not reseal quickly. The plant discussed this problem extensively with Farris who manufactured the valve and found that there were several possible reasons why this could happen. The most likely reason being that the relief valve blowdown ring was set too close to the valve disc holder. This is called a high blowdown ring setting but it represents a low number of notches on the blowdown ring. The position of the blowdown ring is set by counting the number of notches away from the disc holder. The plant then decided to run a series of tests in one of the reactors using air.

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These tests were run in May 1984 and a Farris representative participated. The tests evaluated the effect of the blowdown ring setting on the reseating pressure of the valve. The amount of relief valve opening when a rupture disc beneath the valve was burst below the valve set pressure was also investigated. From the results of these tests, it was concluded that the possibility of a VCM release would be reduced if the blowdown rings were set further away from the disc holder. This change was completed in October 1984 when all of the blowdown rings were set at 30 notches which is almost double the normal 18 notches. This change was documented in a plant memorandum dated October 29, 1984 which is attached as reference B-33, Appendix B.

A discussion of how the blowdown ring affects safety relief valve operation will help to show why this change in blowdown ring setting will reduce the likelihood of VCM relief valve emissions. A diagram of the Farris 2600 safety relief valve which is used on most of the plant reactors is reproduced from the Farris catalog on the following page. An understanding of how the blowdown ring controls the relief valve reseating pressure at blowdown can be obtained by referring to the diagram. As the pressure increases in the protected vessel, the force against the disc begins to overcome the spring pressure. The disc then lifts slightly which allows some leakage past the valve O-ring seal into the huddling chamber. Leakage out of the huddling chamber (simmer) is controlled by the clearance between the blowdown ring and the disc holder. A setting of the blowdown ring close to the disc holder will thus reduce the clearance and the leakage rate out of the huddling chamber. When the leakage rate into the huddling chamber becomes greater than the leakage rate out then pressure will buildup in the huddling chamber. Pressure in the huddling chamber will lift the disc holder. The force on the disc holder added to the force on the disc overcomes the closing force of the spring and causes the valve to open quickly in the characteristic pop action. After the valve opens, it is kept open by the kinetic energy of the flowing gas as it changes direction in the huddling chamber. A gas flow of 25% or more of valve capacity is generally required to keep the valve open. When the relieving pressure drops below the valve set pressure, the spring force is able to overcome this kinetic energy and close the valve. However, if the blowdown ring is set close to the disc holder, pressure will again build in the huddling chamber as the disc holder approaches the blowdown ring and the force against the disc holder will prevent the valve from closing. Increasing the blowdown ring setting to a higher number of notches will increase the clearance between the blowdown ring and the disc holder and thus reduce the huddling chamber pressure and the force on the disc holder. This allows the spring to close the valve at a higher pressure. By positioning the blowdown ring further away from the disc holder, it should also be more difficult for the shock wave from a premature rupture disc failure to pop open the valve. This was confirmed by the plant tests. Thus a consideration of both the way the reactor safety relief valves are designed to operate and the results of the tests that were conducted leads to the conclusion that the new blowdown ring settings should reduce the possibility of VCM releases. Training in the changes that were to be made in the blowdown ring settings was provided to the plant engineers on July 13, 1984 which is documented in reference B-34, Appendix B.

Teledyne Ferris Safety-Relief Valves

Steel / Flanged

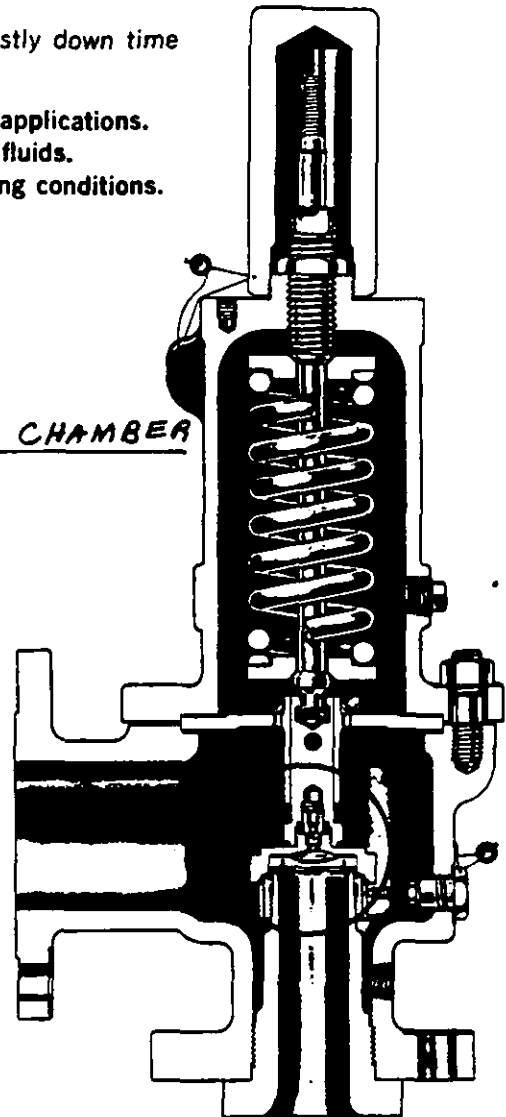
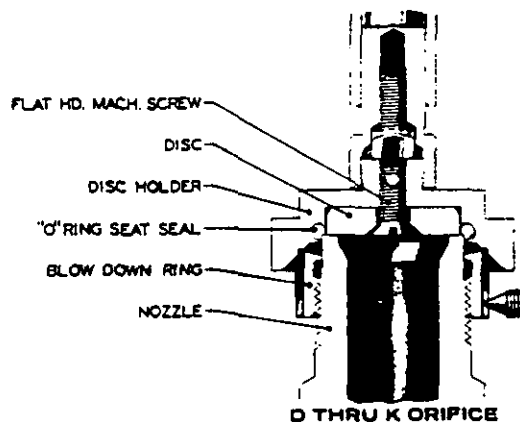
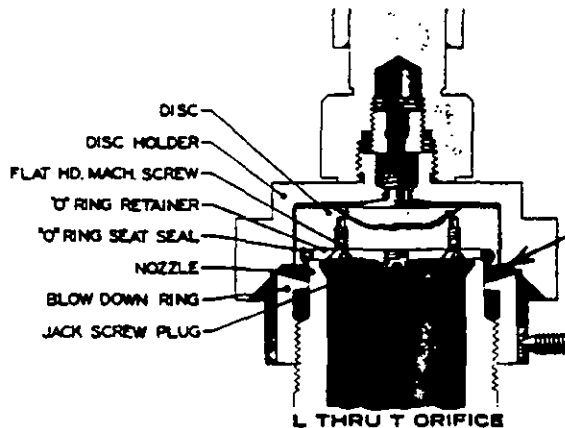
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2600 Series

Farris "O" Ring Seat Pressure Seal for Conventional or BalanSeal

Minimizes leakage and costly product loss as well as costly down time and maintenance on troublesome applications such as:

- Operation too close to set pressure.
- Light, hard to hold fluids.
- Entrained foreign particles and solids.
- Discharge piping strains.
- Vibratory applications.
- Corrosive fluids.
- Nozzle icing conditions.



Recognizing the need for a resilient seat in a safety-relief valve for extreme tightness, Teledyne Ferris Engineering first made available an "O" Ring seat seal in early 1950. Although limited in pressure, the "O" Ring design received phenomenal acceptance since it made possible complete tightness at pressures much closer to the valve set pressure than was ever possible with the standard metal to metal seats after service.

The present "O" Ring Seat Pressure Seal design is an improvement which allows the use of the "O" Ring Seat Seal to higher pressures and, equally important, the spring load is solely carried by the metal to metal portion of the seat with the "O" Ring becoming a pressure seal within its recessed chamber and the outer edge of the nozzle, assuring the ultimate in tightness.

The "O" Ring Seat Pressure Seal is available in our 2600 Series line of flanged safety-relief valves – conventional or BalanSeal construction – for pressures up to a maximum of 1500 PSIG.

Referring to the selection tables on pages 2.12 thru 2.39, substitute a "C" for the fourth digit "A" in the type number for the conventional valve and a "D" for the fourth digit "B" in the type number for the BalanSeal construction when an "O" Ring Seat Seal is required:

26FA10 becomes 26FC10 (Conventional)

26FB10 becomes 26FD10 (BalanSeal)

The pressure limit of the Conventional or BalanSeal valves covered in the selection tables is the same for the "O" Ring design in all type numbers and orifices with the 150 lb., 300 lb. and 600 lb. inlet flanges. On the "O" Ring design in all type numbers and orifices, 1500 lbs. is the limit for the "O" Ring design, not the conventional valve limit shown in the selection tables & charts. Refer to "O" Ring Material Selection Chart on page 2.11 for Temperature and Pressure ratings of the various elastomeric "O" Ring materials available.