Pumps

Problem:

-Pump Cavitation, Flow Separation, Vibration, Noise
-Frequent seal bearing or impeller replacement
-Non-uniform suction flow creating reduced flow
-Lack of space for proper pump installation

Since all centrifugal pumps require well-developed inlet flow to meet their potential, a pump may not perform or be as reliable as expected due to a faulty suction piping layout such as a close-coupled elbow on the inlet flange.

When poorly developed flow enters the pump impeller, it strikes the vanes and is unable to follow the impeller passage. The liquid then separates from the vanes causing mechanical problems due to cavitation, vibration and performance problems due to turbulence and poor filling of the impeller. This results in premature seal, bearing and impeller failure, high maintenance costs, high power consumption, and less-than-specified head and/or flow.

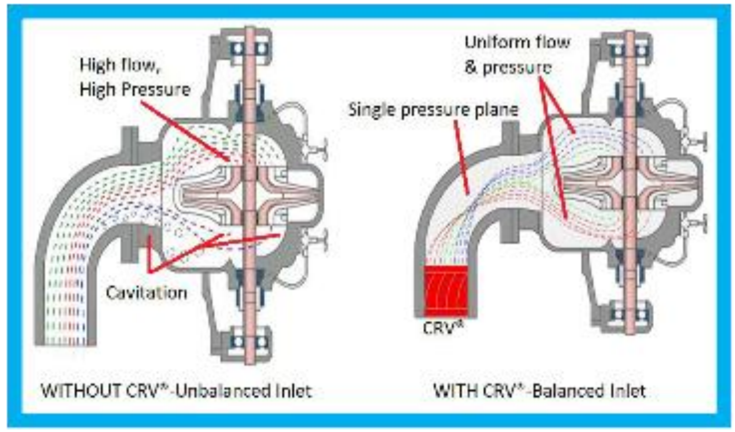
In many instances, pump purchasers buy the least expensive pump that will deliver the specified flow and head within the NPSH available. Such a pump with high suction specific speed operating at 3,600 rpm or greater requires a well developed, uniform flow pattern at a narrow flow rate range since the impeller inlet eye and vanes are optimized to not create turbulence at design flow. This pump design feature is very susceptible to non-uniform inlet flow because when liquid velocity varies and does not meet the pump design assumption of a uniform velocity striking the impeller eye, flow separation results which causes cavitation and associated problems.

To have a well-developed flow pattern, pump manufacturer's manuals recommend about 10 diameters of straight pipe run upstream of the pump inlet flange. Unfortunately, piping designers and plant personnel must contend with space and equipment layout constraints and usually cannot comply with this recommendation. Instead, it is common to use an elbow close-coupled to the pump suction which creates a poorly developed flow pattern at the pump suction.

Benefits:

-Reduced maintenance intervals & less downtime
-Reduced cavitation, vibration & noise
-Improved net positive suction head (NPSH)
-Safer work environment
- Higher reliability with less energy consumption
-Increased pump efficiency and head

Solution: The CRV®



With a double-suction pump tied to a close-coupled elbow, flow distribution to the impeller is poor and causes reliability and performance shortfalls. The elbow divides the flow unevenly with more channeled to the outside of the elbow. Consequently, one side of the double-suction impeller receives more flow at a higher velocity and pressure while the starved side receives a highly turbulent and potentially damaging flow. This degrades overall pump performance (delivered head, flow and power consumption) and causes axial imbalance which shortens seal, bearing and impeller life.

By imparting a swirl to the flow entering the elbow, the CRV® enables the liquid to negotiate the turn and be evenly distributed to each side of the impeller. With the CRV®, flow and characteristics will approach factory rated pump test performance, cavitation and noise will diminish seal, bearing, and impeller life will improve.

The CRV® compensates for specification and installation constraints and attacks the root cause of poor pump performance due to faulty suction piping layout. With CRV® installation, pump performance and reliability will be maintained despite close-couple elbows on pump suctions, even when applied in high suction specific speed and double suction pumps.

Compressors

Problem:

-Interstage hunting from non-uniform flow

-Inlet flow distortion causing less than factory rated flow, head and efficiency

Centrifugal and axial compressor operation and performance are sensitive to velocity and mass distribution at the suction, just as pumps and other rotating equipment. When a compressor's factory performance test is run, the ASME Power Test Code (PTC-10) requires a fully developed uniform velocity and mass flow profile entering the compressor. To accomplish this, PTC-10 states two requirements.

First, a minimum straight run of three pipes diameters is required between the last elbow and compressor inlet.

Second, a flow equalizer is required at the straight pipe inlet to produce a flat velocity profile and assure an even distribution of gas into the compressor inlet.

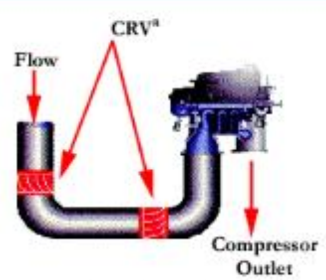


Figure 1 - CRV® in feed suction piping of a multistage compressor

Benefits:

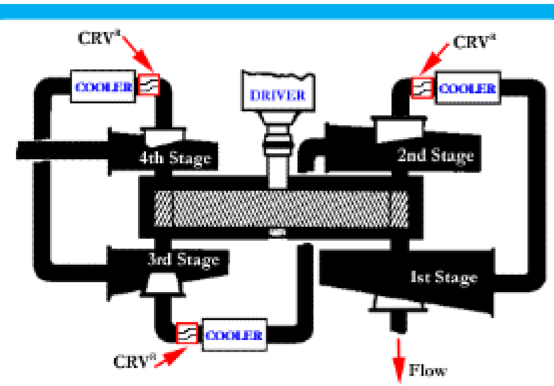
-Operate closer to factory rated flow, head & efficiency

-Reduced suction piping pressure drop and reduced energy costs

Solution: The CRV®

In field operations, however, compressors do not have this ideal suction piping configuration. Poor field suction piping includes single, double, and triple elbows immediately upstream of of the compressor, which create a considerable amount of distortion. For example, large multistage axial or centrifugal compressors that are used to supply air for refinery fluid catalytic cracking units, as shown above, have upstream turns in the air suction piping which results in non-uniform mass and flow profiles approaching the splitter in the compressor casing.

The CRV® when placed on the inlet side of an elbow produces a flat velocity profile and an even distribution of process gas at the elbow's exit. This allows the compressor to more closely approach its factory test inlet conditions and performance curves. Typical CRV® locations in compressor feed piping systems are shown below and for multistage externally-cooled compressors below.



CRV®'s in the feed suction piping of an interstage-cooled compressor

Flow Meter

Problem:

-Inaccurate flow measurements
-Long straight pipe meter runs required
-Lack of space for proper installation

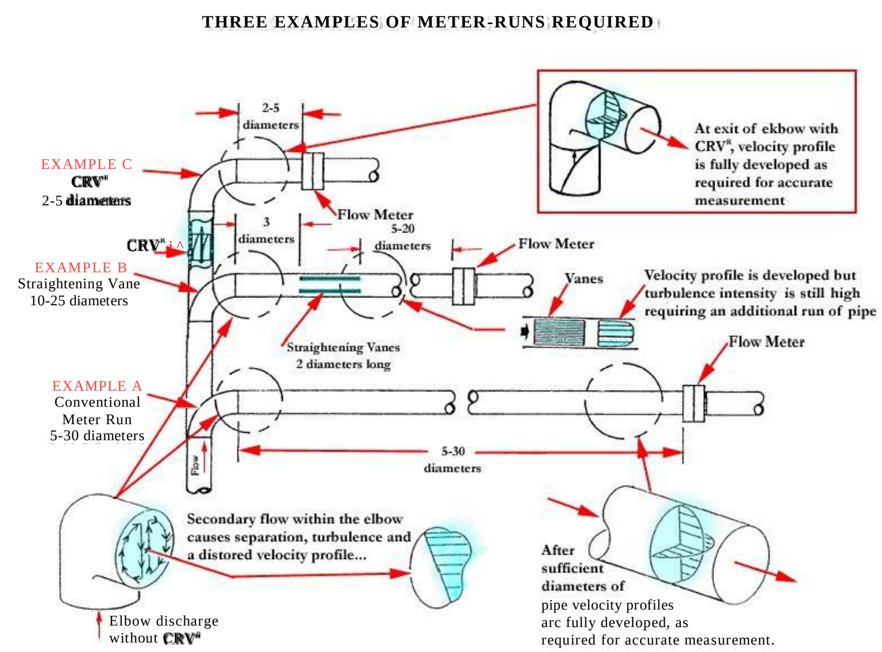
Flow metering devices cannot provide accurate measurement of the flow rate through a pipe when flow entering the measurement device is distorted. Consequently, flow meter manufactures and a number of independent organizations such as ASME, AGA and ANSI/API recommend that flow meters not be installed near and downstream of elbows.

Benefits:

-Accurate flow measurements
-More compact pipe layout
-Reduced piping costs

Solution: The CRV®

With the CRV® one can reduce the straight pipe run length for an orifice plate flow meter preceded by elbows as seen below.



For example, when an orifice meter with a Beta ratio of 0.7 is used and the flow meter is preceded by two elbows in one plane, example A shows that the American Gas Association (AGA) recommends a minimum of 19 pipe diameters of straight pipe be used between the last elbow and the flow meter. Conventional after-elbow-straightening vanes example B, only decrease the recommended straight pipe length between the last elbow and the flow meter to 12 pipe diameters. However, the use of CRV® upstream of the elbow in example C, decreases the recommended straight pipe length between the last elbow and the flow meter to 2 diameters.

In places where less than the recommended straight pipe meter run exists, installation of a CRV® will result in more accurate measurements. For example, dramatic improvements were witnessed in a 10”-diameter flow meter application where the installation of a CRV® decreased the meter error from 30% to less than 5%.

In new Installations, the CRV® allows the close coupling of flow meter to elbows, which results in space savings and reducing straight-run piping costs.

Elbow Erosion

Problem:

-Frequent elbow erosion due to particulate or two-phase flow
-Unsafe elbow erosion conditions
-Unscheduled maintenance shutdowns

Benefits:

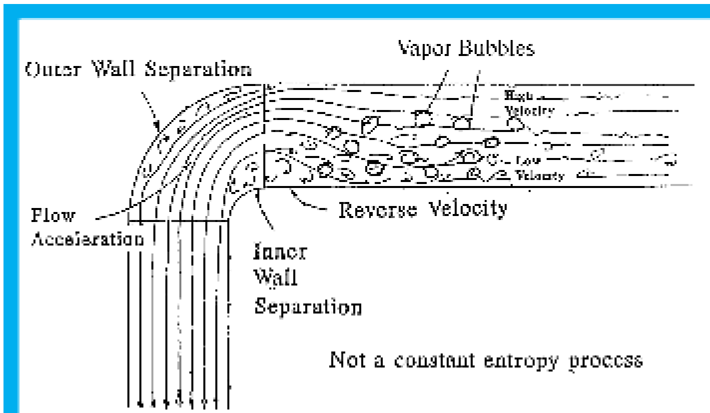
-Extended life of elbows
-Safer and better operating and maintenance conditions
-Safer work environment
-Less down-time

Erosion commonly occurs in elbows and turns within piping systems. Damage often occurs when the pipe line is carrying solid particulates, slurries, or two phase flow, such as wet steam. In a plain elbow, the flow is accelerated and directed toward the outer wall of the elbow, which focuses high speed particulates or droplets on a restricted region. Severe wear begins to occur at that point.

Installing a CRV® upstream of an elbow eliminates flow separation and creates a smooth aerodynamic flow with its vanes to ensure full rotation of all components in the fluid as a solid body around the turn. As a result, particulates and droplets are carried along with the flow much the same as in a straight piece of pipe, which shows little erosion in the same service. In addition, the entire cross-sectional area of the elbow is available for flow and the maximum fluid velocity reached is much lower than in a plain elbow.

The CRV® vanes aerodynamic design, as shown below, eliminates erosion of the CRV® itself in gas-liquid, two-phase flow applications. In slurry or gas-particulate applications, the CRV® can be hardened, surface treated or manufactured in an appropriate material whose hardness is greater than that of the particulates.

Solution: The CRV®



Case History 1: casehistoryinvolvingtheinstallationofatotalofsixCRV®s,oneupstreamofeachofsix2”extra heavy pipe elbows for wet steam service in a paper mill, prove successful operation for more than two years after installation. Previously, elbow replacement was required every 3 months.

Case History 2: Fluid catalytic cracking units (FCCU) in refineries have also successfully used the CRV® on spent catalystblowdownlines.Here,atotaloffourspeciallyhardenedCRV®swereinstalledintheFCCU12”diameter piping systems, one in front of each 90^{o} and 180^{o} turn, which eliminated the erosion experienced every 6 months in the sweep elbows .

Check Valves

Problem:

-Check valve chatter with close coupled upstream elbows
-Disc pin wear and breakage
-Poor sealing due to pin wear

Check valves, by the very nature of their design, respond to flow and pressure disturbances such as turbulence in the upstream piping system. This can result in the disc oscillating back and forth on the pin support. When a check valve is close-coupled to an upstream elbow, the turbulence becomes severe and the oscillations are of a large enough amplitude that the disc continually moves, may bang against the stop, and the pin eventually fails.

In check valve systems with upstream close-coupled elbows, one can eliminate harmful high amplitude pressure bursts (a) by installing a CRV® (b) upstream of the elbow.

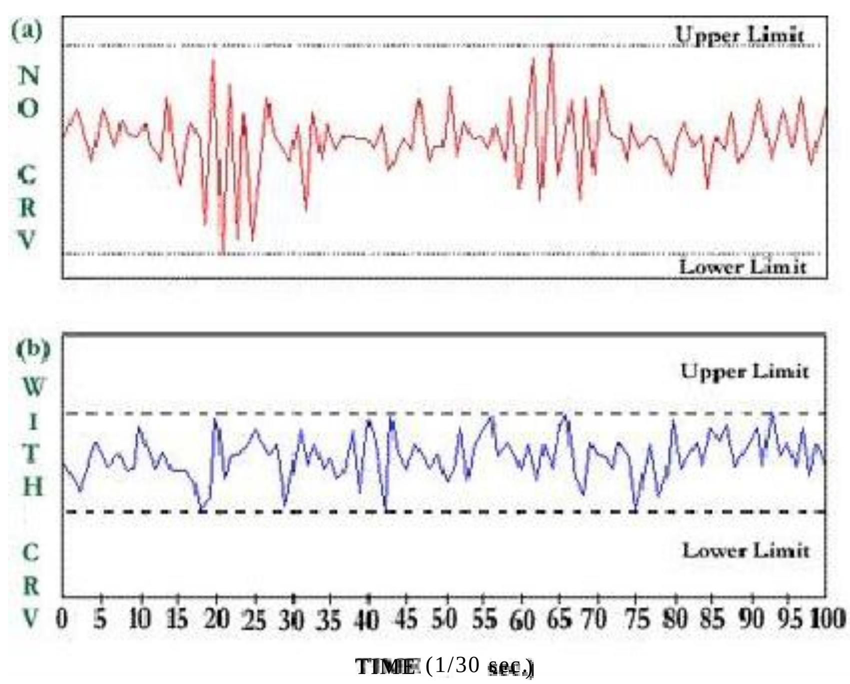
Benefits:

-Eliminate elbow induced flow turbulence
-Extend pin life
-Improve sealing life

Solution: The CRV®

Experimental results of check valve dynamics with and without a CRV® are shown. Figure (a) shows pressure measurements as a function of time with the elbow-check valve combination only (Without the CRV®). The high amplitude pressure bursts are damaging to the check valve and a result of the oscillating check valve disc and the turbulence generated by the elbow.

With a CRV® mounted in front of the elbow-check valve combination, turbulence generated by the elbow is eliminated. Figure (b) shows an absence of high amplitude pressure bursts. This results in minimized wear on check valve pins, extended life, reduced vibration and noise, and better sealing because or pin integrity.



Water Hammer

Problem:

-Travelling pressure wave reflecting back and forth in piping system
-Pipe and elbow breakage

Water hammer is actually a traveling pressure wave. It was initiated by the rapid stoppage of an incompressible flowing liquid. For example, the pounding of process piping usually occurs due to rapid valve closure or when large steam bubbles are introduced into water and the water rapidly collapses the steam bubbles. These pressure waves reflect back-and-forth between the interior walls of a piping system, reinforcing themselves as succeeding waves encounter the reflected waves. They can become so energetic that catastrophic structural damage could occur.

The CRV® proves extremely useful in controlling water hammer. Dramatic improvements were seen in a piping circuit with four elbows between the supply line and the shut-off valve where the wall static pressure with and without CRV®s was measured. The results indicate that with a CRV® in place upstream of each elbow, the amplitude of the peak pressure pulse was 49% of that without CRV®s.

The CRV®s geometric features prove extremely useful in controlling water hammer. When fluid is flowing in the forward direction, the CRV® is passive and offers little pressure drop, but when the fluid travels backwards, it will exhibit a high pressure drop and not remain attached to the CRV® vanes, as shown below in figure (a(. The high drag footprint for backward flowing fluid and pressure waves is shown below in figure (b), and acts as a passive damper for reverse flow pressure waves, thus controlling water hammer.

Benefits:

-Minimize pipe damage using CRV® as a passive damper for pressure waves
-Extended life of elbows and pipes

Solution: The CRV®