Guide for the Selection, Installation and Maintenance of Silent Check Valves

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Contents

PREFACE

Experience has proven the need for check valves in piping where reverse flow could be detrimental to the system.

A valve which closes quietly and eliminates water hammer is obviously desirable. A need for basic information on how to specify and utilize these check valves does exist and it is the purpose of this article to shed light in this area.

The Check Valve Section of the Fluid Controls Institute has undertaken the task of preparing this article and it gratefully appreciates the assistance of those members who have made it possible.

A silent check valve allows flow in one direction only and closes silently. Silent closure is usually accomplished by spring loading the disc so that it closes prior to reversal of flow. This can also be accomplished by means of an elastomeric diaphragm.

Silent check valves were developed to eliminate water hammer problems connected with the use of conventional swing check valves. The most common type of installation includes the use of a pump and a swing check valve installed in the pump discharge piping. In theory, the swing check valve closes quickly when the pump shuts down - it does, but not quickly enough. Reversal of flow in the piping will slam the clapper shut against its seat and cause noise, vibration and piping stresses, which can be easily controlled by the use of a spring loaded silent check valve.

There are many recorded cases of water hammer so severe they have ruptured pump casings, expanded and ruptured piping and even vibrated buildings on the foundations.

In short, swing check valves depend upon reversal of flow to close. Silent, spring loaded check valves are designed so that the disc returns to its seat at zero velocity before the reversal of flow occurs.

TABLE I — TYPES OF CHECK VALVES

There are several basic types of conventional silent check valves:

1. Insert type - consists of a seat, disc and spring and fits inside of a fitting or between flanges. See Figure 1.
2. Threaded type - similar to insert type except supplied with its own body. See Figure 2.
3. Compact wafer - consists of a body, disc, seat and spring and fits inside of the bolting in a flanged connection. See Figure 3.
4. Standard wafer type - similar to compact wafer except body is the same outside diameter as the flanges and bolts pass through the body. See Figure 4.
5. Globe type - spherical shaped body with flanges. See Figure 5.
6. Cone type - features an elastomeric conical unit inside of a perforated cone. The elastomeric cone collapses to allow normal flow and seals off perforated cone to eliminate back flow. See Figure 6.
7. Special purpose valves - for air and gas service see Figures 6 and 7.

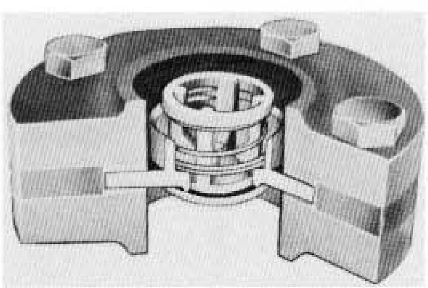
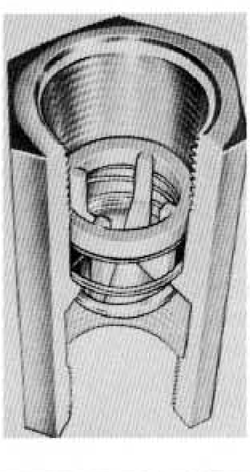


Figure 1



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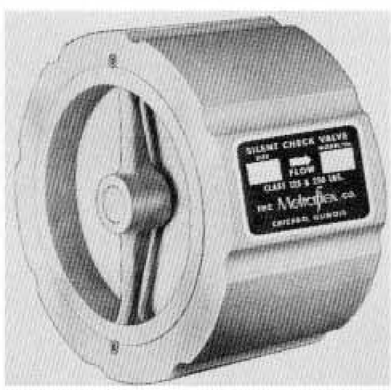

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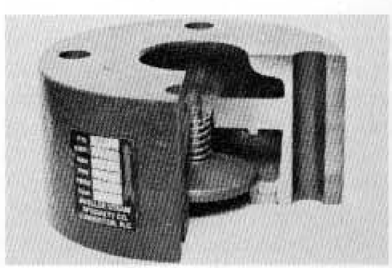

Figure 4

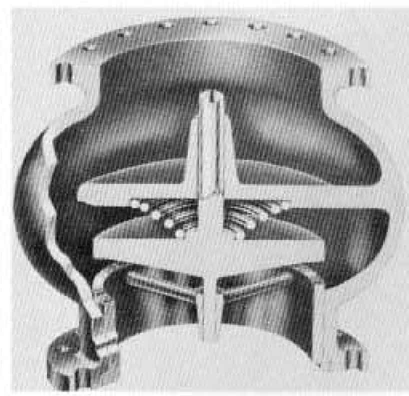

Figure 5

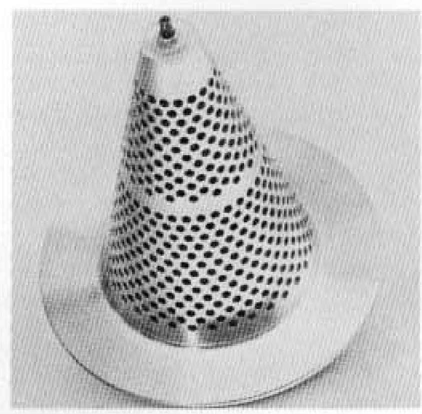

Figure 6

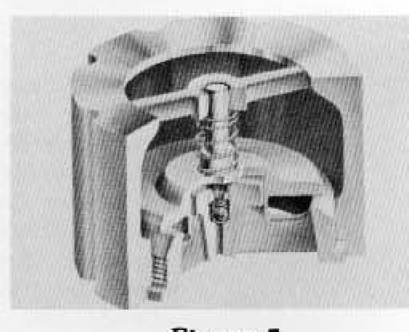

Figure 7

OPERATION AND APPLICATIONS

All check valves are intended to allow flow in one direction and stop reverse flow. A check valve is expected to operate automatically whenever normal flow ceases and if properly selected it will do this year after year.

A major problem associated with some swing check valves is that of slamming due to reversal of flow accompanied by water hammer and its momentary overpressure.

Silent check valves were designed to eliminate this problem. Loading the disc with a properly designed spring returns the disc to its seat, closing the valve, prior to reversal of flow. Most commonly, springs are designed to allow the valve to start opening with a 1/2 psi differential pressure. Generally, silent check valves are designed so that their flow area exceeds that of the connecting pipe in order to keep pressure loss at a minimum.

Silent check valves can be used in horizontal or vertical piping. They may also be used in vertical downward flow provided the manufacturer is advised. In this case, a spring strong enough to support the weight of the disc and any head differential and hold it to the seat must be provided.

The most common application for silent check valves is in pump discharge piping such as shown in Figure 8.

Another common usage for these valves is in pump suction piping where the valve closes upon pump shutdown keeping the suction piping filled. When installed at the inlet of the suction piping, they are referred to as "foot valves" and usually their inlet is protected by a screen to prevent the entrance of sediment.

Silent check valves can take the place of any swing or lift check in most applications. Generally, they are lower in weight and cost, while performing the same function and providing silent closure.

APPLICATION LIMITATIONS

The following describes those applications where caution should be used and only after the manufacturer has an opportunity to evaluate the operating conditions.

Raw Sewage

Silent checks usually have ribs which support or guide the disc. Sewage could collect on these areas, preventing the valve from closing.

Reciprocating Air Compressors

Pulsating flow frequently attributed to reciprocating compressors can make any normal check valve disc operate like a high speed yo-yo. Service life under these conditions is usually brief. Special check valves such as the cone type (Fig. 6), one with lightweight disc arrangement or one having an internal dashpot to effect pulsations dampening (Fig. 7) may be satisfactorily used for this service.

Steam

Although silent check valves may be used on steam service, the manufacturer should be provided with design conditions to eliminate the possibility of erosion of seats and discs due to oversizing of the valve. Pressure, temperature and flow rate in pounds per hour should be provided to the manufacturer when ordering.

Boiler Feed - Hot Water

Under certain conditions, hot water can flash into steam when passing between the seat and disc of any valve, causing instability and or erosion. Again, oversizing is usually the culprit. Provide the manufacturer with pressure, temperature and flow rate (pounds per hour or GPM) when ordering. A good rule of thumb is to select a valve which produces at least a 3 psi loss at normal flow. This allows the disc to open more fully, avoiding "flashing" and "wire drawing".

Although silent checks may be installed directly on, or a short distance from pump discharge and

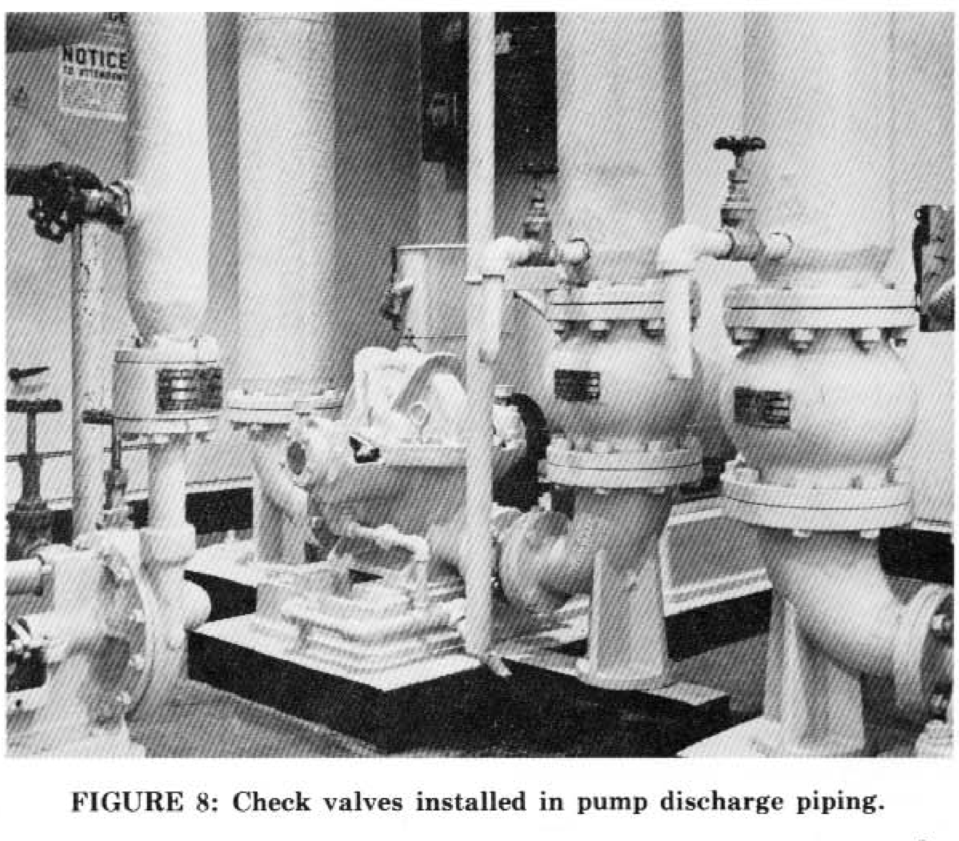

FIGURE 8: Check valves installed in pump discharge piping.

elbows, longer life results when the valve is exposed to non-turbulent flow. For this reason, it is desirable to separate the valve from turbulence producing items by 4 or 5 pipe diameters.

END CONNECTIONS AND PRESSURE RATINGS

Wafer, globe and many screwed silent check valves are provided with only inlet and outlet ports and the trim is usually serviced from the inlet end. For this reason, welded or soldered ends are usually not available.

Wafer, globe, compact wafer valves and cone valves are furnished for use with ANSI flanges, in most cases 125lb through 2500lb.

Threaded valves are basically provided in three styles. A one piece valve (Figure 2) having a cylindrical body with inlet and outlet tappings. A two piece body (Figure 9) held together at the center having an inlet and outlet tapping. A check valve insert (Figures 10, 11) which fits into unions, bushings or pipe fittings.

Some valves are available in sweat or silbraze ends, usually in sizes 2″ and smaller. In addition, some manufacturers have available special valves with ring-type joint flanges and Victaulic ends.

CORROSION RESISTANCE AND MATERIAL SELECTION

Silent check valves are available in a variety of materials. Cost and corrosion resistance must be considered in making a practical choice.

There are many corrosion resistance charts available from which to determine the best choice of materials. In some cases, stainless may be given an "A" (best resistance) and iron may be given a "B" (good resistance). Economics may then be the determining factor.

Table II contains a list of materials which are available from various manufacturers. Some of these materials are considered special and deliveries can be extended. Various coatings are available for corrosion and abrasion resistance such as asphalt, Kynar, Teflon, epoxy, etc. Contact manufacturers for recommendations.

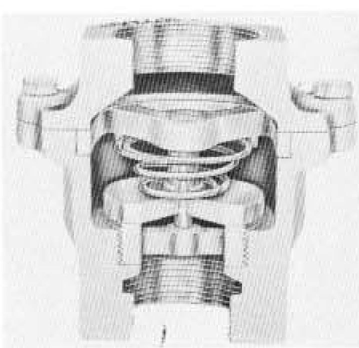

FIGURE 9: Example of a two piece body.

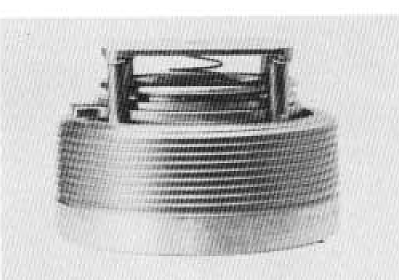

FIGURE 11: Check valve insert.

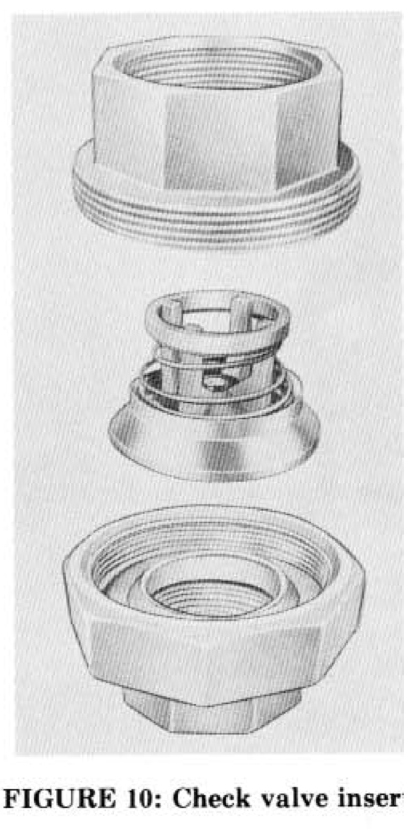

FIGURE 10: Check valve insert.

SPECIAL PURPOSES

Silent check valves have been used extensively as vacuum breakers. When pumping fluid from a tank, it is often necessary to allow air into the tank to prevent the formation of a vacuum. A silent check valve installed on the top of the tank with the *outlet* attached to the tank will open and allow air into the tank breaking the vacuum created by the removal of the fluid. Most silent checks will open at 1/2 psi (1 inch of mercury) which will prevent collapse of the tank.

When pipe lines cross hilly terrain and pumping ceases, the fluid can split at the high points of the line, creating a vacuum at these points. A silent check valve installed as previously described can eliminate this problem.

Under certain conditions, a silent check valve can be used as a relief valve. Dependent on size, heavier springs can be installed in the valve which will resist opening pressure until the desired cracking pressure is reached. Springs having up to a 10 psi cracking pressure are generally available. Consult appropriate safety codes.

PRESSURE LOSS

Any flow of fluid or gas through a piping system results in a loss of pressure due to friction and check valves are no exception.

Spring loaded silent check valves will have a slightly higher pressure loss than swing check, one reason is that the spring pressure must be overcome by fluid pressure. This small difference however, is more than offset by their silent operation and the avoidance of water hammer problems.

Although pressure losses will vary from one manufacturer to another, it is generally true that the globe style will have a lower loss than wafer style valves.

Most manufacturers publish pressure loss charts which will be expressed in any one of the following ways:

1-Pounds per square inch (psi) loss at various flow rates (GPM).
2-Feet of water loss at various flow rates (GPM).
3-Pounds per square inch or feet of water loss for various velocities.
4-As a C_v factor. C_v is defined as the quantity of 60°F. water, in gallons per minute, which will pass through a specific valve at maximum lift, at 1 psi pressure drop.

C_v is experimentally determined by dividing the water flow through the valve by the square root of the pressure drop produced by that flow. Conversely, given the C_v, the water flow through the valve at any given pressure drop may be calculated by multiplying the C_v by the square root of the pressure drop. Therefore, for a given pressure drop, the higher the C_v, the higher the rate of flow.

For most piping installations a 1.0 psi loss through a silent check valve should not be considered excessive.

Avoid selecting a valve larger than necessary as this could result in the disc being too close to the seat at minimum flow. Vibration and chattering could be the result.

For a valve to operate satisfactorily, it is not necessary for it to be fully open. A liquid velocity in excess of 10-12 feet per second will result in the typical valve being full open. Four to eight feet per second velocities are quite common for process and heating/air conditioning systems. In general, silent check valves work well over a wide variety of velocities and require little or no maintenance.

DRAIN CONNECTION

Drain connections in check valves are normally not supplied as a standard procedure. If a drain connection is desired, the purchaser should indicate this fact on his purchase order.

In the absence of any instructions to the contrary, when a drain connection is specified on the order, the manufacturer will follow the instructions as contained in a recognized standard. The accepted standards are American National Standard, B16.1 and Manufacturers Standardization Society of the Valve and Fittings Industry Standard MSS SP-45-1976.

In the case of globe check valves the drain connection is usually placed on the largest diameter of the globe section. For wafer type check valves the drain connection is placed in the body so that it is downstream from the disc and half-way between any two adjacent flange bolts.

WATER HAMMER

When a liquid is flowing through a pipe there is a definite amount of energy in the liquid (mass times velocity). If the energy is stopped, it must be used in some way. If the liquid is relatively incompressible and if the flow is stopped suddenly, the energy of the liquid is used expanding and increasing the diameter of the pipe and equipment.

The increase of pressure energy under this condition is known as water hammer, which is often accompanied by a sound or clank like that of a hammer striking a pipe, followed by vibration of the piping. In some cases, this vibration or pressure wave is transferred to the building structure in which the pump is operating or to municipal piping systems far removed from its source. These pressure waves can greatly exceed the rating of the piping system, including the pump casing. When this occurs, the pump or other units can literally explode from the shock.

Water hammer is a phase of hydraulics about which little is known, but tests have brought interesting facts to light. These are of great importance because water hammer has been a real problem due to the use of centrifugal pumps producing high velocities.

Tests were made to determine the intensity of the water hammer effect, the action of the pressure wave, and its origin. Experiments were also made regarding methods of control.

These tests revealed that water hammer is caused by the sudden stopping of a column of water and that its intensity is governed by the velocity with which the water is traveling at the moment of stoppage. The energy exerted by stop-

TABLE II — STANDARD MATERIALS

BODY	ASTM
Iron (Semi-steel)	A-126-B or A-278-30
Ductile Iron	A-536
Carbon Steel	A-216-WCB
Bronze	B-62
Stainless Steel	A-296-CF8M
TRIM*	
Bronze	B-62
Stainless Steel	A-296-CF8

SPECIAL MATERIALS

High Strength Iron (40,000 tensile and higher)
Iron Austenitic (Ni Resist)
Steel - Chrome Moly
Stainless - 304, 304L, 316L, 317, 347
Alloy 20 Stainless
Aluminum
Bronze
Monel
Nickel
Hastelloy B & C
Titanium

*Resilient seated and hard faced materials available.

ping the flow is taken up in the piping and equipment. If great enough, the action causes damage and is very likely to cause disagreeable noises. However, water hammer is not necessarily accompanied by noise.

It has been proved that the theoretical figure of 54 psi for each foot per second of velocity that is stopped by the valve is essentially correct, and with the instantaneous closure of the valve a pressure of 540 psi above system pressure is possible with a flow velocity of 10 ft. per. sec.

When a pump shuts off, the column of water has a certain momentum, which continues until it has spent itself in overcoming friction and gravity. A check valve to operate without noise must close prior to the reversal of flow. It is the sudden stoppage of the reversal of flow which causes water hammer, and the longer this reversed flow continues, the greater the hammer when stopped. Since water is relatively incompressible, it can be compared to a solid column and its action on the disc of a check valve is the same as dropping the weight in a pile driver. The farther the weight falls, the greater the force exerted when stopped.

To prove the correctness of theories regarding check valve water hammer, a series of tests have been conducted in which a conventional swing check valve was used, and results compared with a center-guided silent check valve.

In addition to proving that water hammer is caused by the sudden stoppage of the reversal of flow, it was desired to ascertain the directional distribution of pressure surge. Specifically, to determine if distribution of pressure surge was the same on the system side of a check valve as it is on the pump side upon closure of the check valve.

Figure 12 shows comparative results of water hammer caused by check valves installed on the discharge or system side of pump operating under identical operating conditions.

Conditions: Figure 12 - a metal faced swing check valve and Figure 13 - a metal faced silent check valve. Size: 6". Flow: 500 GPM. Velocity of outflow: 6 ft. per second. Both check valves installed in horizontal position. Recording instrument was placed on discharge side of check valves under test. Metal faced swing check valve (Figure 12) experienced a pressure surge of 380 PSI loud water hammer with vibration of the piping system.

Metal faced silent check (Figure 13) registered a pressure surge of 130 PSI with no water hammer and or piping vibrations evident and closure was silent.

Metal faced swing check valve (Figure 14) registered a pressure surge of 75 psi. Metal faced silent check valve (Figure 15) registered a pressure surge of 10 psi. Figure 13 clearly indicates that a silent check valve on the discharge side of a pump, by eliminating or substantially reducing water hammer will protect pumps, recording instruments, and other components from the damaging effects of water hammer due to check valve closure.

Objectionable noises can also be reduced. Silent check valves operate satisfactorily in vertical or horizontal lines with no effect on their ability to prevent water

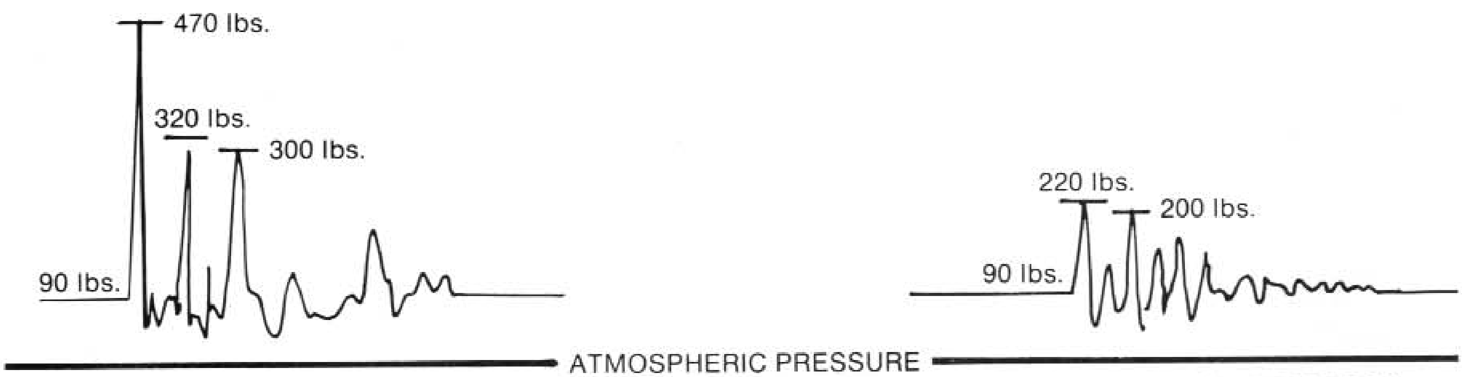

FIGURE 12 SWING CHECK Indicator on System Side

FIGURE 13 SILENT CHECK Indicator on System Side

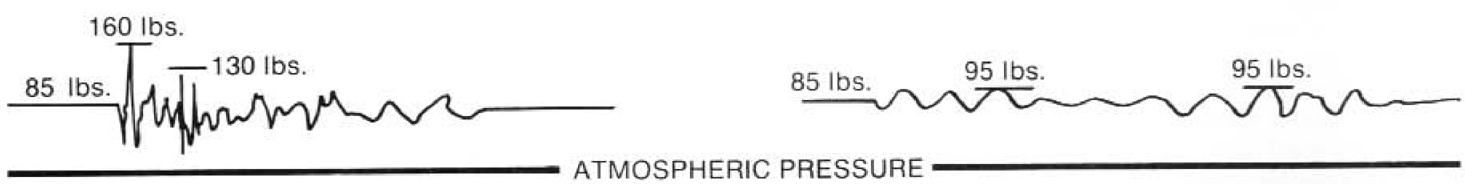

FIGURE 14 SWING CHECK Indicator on Pump Side

FIGURE 15 SILENT CHECK Indicator on Pump Side hammer.

Silent operation was unaffected by operating working pressure or temperature of the liquid. Among the liquids observed were cold water, condensate, boiler feed, petroleum products etc.

Working pressure from vacuum to 5000 psi and temperature to 700°F were tested.

It is better engineering to select the proper type check valves so that water hammer will not take place, than it is to allow water hammer to take place and then try to control it with surge suppressors, dash pots, bypasses or other devices.

Engineers have made rapid strides in water hammer prevention by using silent check valves which overcome previous inadequacies of conventional check valve designs. Experience has proven that their operation is automatic and dependable. Reverse flow is stopped before it can start. Water hammer and its accompanying ill-effects are reduced and use of these valves is recommended wherever fluids flow for the safest and quietest piping systems possible.

TESTING

During the initial design stage, each new line of check valves is tested by the manufacturer to meet proof or burst pressures in accordance with established standards or codes. Manufacturers use hydrostatic shell and seat leakage tests conducted in accordance with ANSI/FCI 74.1-1979. The hydrostatic shell tests are done to verify the integrity of the shell or body and to check for porosity. The seat leakage tests are conducted in accordance with applicable standards. Manufacturers publish pressure loss data which has to be determined by actual testing.

SPECIFICATIONS

To allow a manufacturer to make a selection or recommendation for a particular silent check valve, as much as possible of the following information should be provided:

A. PHYSICAL CHARACTERISTICS
   1. Pipe size
   2. Style
   3. End connections
   4. Material (body and trim)
   5. Pressure rating (design/operating)
   6. Temperature rating (design/operating)
   7. Capacity - GPM, SCFM or lbs/hr
   8. Special requirements - heavy spring, drain tapping, etc.
   9. Applicable specifications (military specs, special non destructive tests or other)

B. FLOW DATA
   1. Liquid
      a. Description of liquid
      b. Rate of flow - gallons per minute (GPM)
      c. Viscosity - SSU
      d. Specific gravity
      e. Temperature
      f. Concentration - if acid or other corrosive.
   2. Gas
      a. Rate of flow - standard cubic feet per minute (SCFM)
      b. Specific gravity
      c. Temperature
      d. Pressure
   3. Steam
      a. Flow - pounds per hour
      b. Pressure
      c. Temperature

Although the foregoing information is desirable it will only be required in very few instances. A standard silent check valve will satisfy most requirements.

CONCLUSION

A check valve is expected to do its job year after year without receiving any outside help. There are many different types of check valves currently available. The purpose of this guide is to describe a type of valve which can economically perform at least 90% of those jobs that need a check valve. As a bonus, they do their job silently and reduce water hammer.

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