Expansion Chambers for Fire Protection Systems

What They Are; How They Work

By Winston B. Young, P.E.

Introduction

Expansion chambers are primarily used in fire protection systems with backflow preventers to prevent over pressurization as a result of ambient temperature changes of the piping system. Pressure trapped in the sprinkler system piping can increase because of thermal expansion of the antifreeze liquid and can exceed the designed specifications for these systems. The liquid will grow volumetrically faster than the containing piping much like boiling water in a pressure cooker. Without a relieving device to release this liquid, the pressure can cause seals and gaskets to leak.

Description

An expansion chamber is a pressure vessel, which contains a gas charged bladder to absorb the excess liquid from thermal growth. It is normally fabricated from carbon steel and internally coated with a corrosion resistant epoxy. The function of the rubber bladder or diaphragm, which is typically manufactured from a flexible elastomer such as butyl, nitrile, and neoprene, is to separate the gas charge from the operating liquid. Without this separation, the gas would be absorbed into the fluid and eventually would be lost.

The Precharge

The initial gas charge of the bladder before the fluid pressure is introduced is calling the precharge (refer to Figure 1). The precharge should be a fraction of the operating pressure of the system (70%). If the precharge is too high – greater than the operating pressure – the bladder will not compress and the tank will not absorb any liquid. Should the

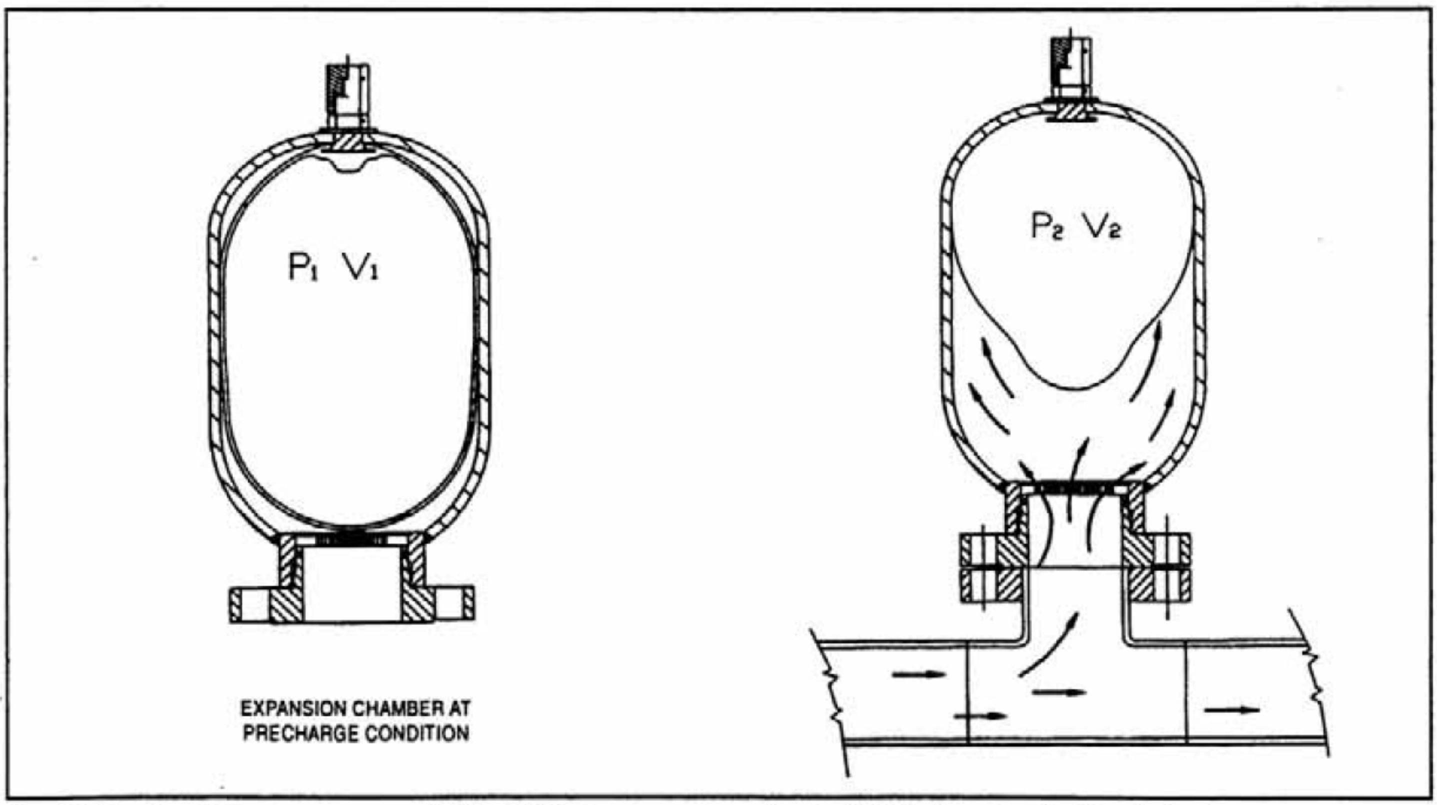

Figure 1: Expansion Chamber. The compress gas inside the bladder compresses and expands as the fluid in the pipe system is heated and cooled

precharge be too low, the amount of gas available to compress would be insufficient to provide the needed pressure range. This could allow pressures to still exceed design specifications.

Operation

The gas in the bladder compresses as the pressure builds, allowing the liquid to enter the chamber. As the fluid pressure increases as a result of expansion, the excess fluid discharges in the air chamber vessel and begins to compress the gas within the bladder or diaphragm. The more fluid that the chamber accepts, the greater the pressure becomes. The compression of this gas follows Boyle's Law of Gasses:

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Where
P_1 = precharge pressure (psia)
V_1 = volume of the expansion tank (gal)
T_1 = precharge temperature ($^{\circ}$R)
P_2 = compress pressure (psia)
V_2 = compress volume (gal)
T_2 = compress temperature ($^{\circ}$R)

Without the compression of this gas charge bladder, the piping pressure would develop extremely high pressure because the system is locked up hydraulically. The expanding fluid trapped by the back pressure valve has nowhere to go, thereby increasing the pressure.

The expansion chamber, to be effective, should be installed downstream of the backflow preventer in a location where thermal effects are minimal. This would be at the base of the piping where thermal effects are minimal. This would be at the base of the piping where temperature changes are kept to a minimum. Excessive heat will prevent the expansion chamber from absorbing its maximum capacity.

The total volume of the fluid, V, in gallons is:

$$V = \frac{\Delta V_s \left[\frac{P_2}{P_1}\right]}{1 - \left[\frac{P_2}{P_3}\right]}$$

Where
P_3 = Maximum operating pressure and the volumetric expansion of the liquid within the piping system (Vs) can be expressed as:

$\Delta V_S = \Delta T * V_S * \gamma$

Example

piping system – 6" ∅ pipe, 200 ft.
minimum temperature -10°F Pmax: 150 psig (165 psia)
maximum temperature 110°F P_2: 70 psig (85 psia)
P_1: 65 psig (80 psia)

$$\Delta T = 110 - (-10) = 120^{\circ}F$$

$$V_s = \left[\frac{\pi}{4}\right]\left[\frac{6}{12}\right]^2 (200)\left[\frac{7.481 gal}{1 ft^3}\right] = 294 \textit{ gallons total system volume}$$

$\Delta V_s = 120\,(294)\,3.210 \times 10^{-4} = 11.3$ gal. total volumetric expansion

$$V = 11.3\left[\frac{\left[\frac{85}{80}\right]}{\left[1 - \frac{85}{165}\right]}\right] = 24.76 \textit{ Gallons Expansion}$$

Chamber volume required

Maintenance

These devices are not explicitly addressed by NFPA 25, except under 25:1-4.2 (Responsibility of Owner), which requires maintenance in accordance with the manufacturer's instructions. Since these are simple devices with a high degree of reliability, there is little maintenance to be performed. An annual inspection of this is highly recommended to insure the proper pressure has been maintained. The gas precharge should be checked at least once a year as the gas will permeate through the rubber, comparable to the loss of air pressure in your car tires. The effect of low pressure was discussed under "Precharge." One should also check this device during the annual inspection for visual damage of other sprinkler devices.

About the Author:
Winston B. Young, P.E. is the founder and president of Young Engineering Manufacturing Inc., Monrovia, Calif., which designs and manufactures energy control products. He and the staff of engineers have over 40 years of experience in the field of hydraulic and mechanical design. A member of ASME and a Registered Professional Engineer in California, Young holds B.S. and M.S. degrees in Mechanical Engineering from California State University, Los Angeles