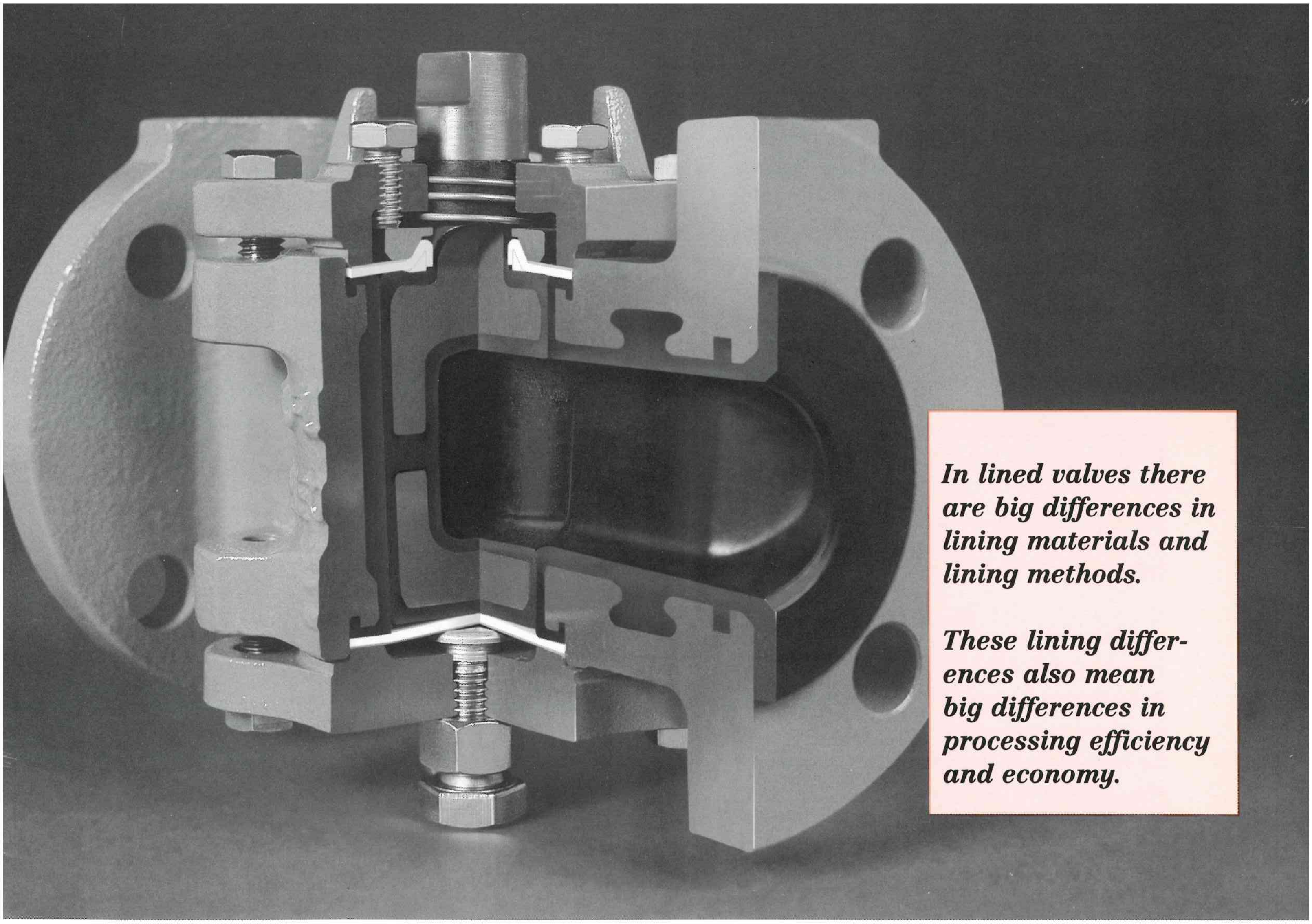


PFA and FEP linings overcome the valve failure problems associated with PTFE linings.

By M. R. Ramakrishnan

What is a lined valve?

In a lined valve, all wetted surfaces are a plastic material, typically a fluorocarbon. A lined valve's metallic parts are manufactured from relatively inexpensive materials such as ductile iron. In a fully lined valve, no media comes in contact with any metal parts.

Lining materials.

The primary valve lining materials are PFA (perfluoroalkoxy) and FEP (fluorinated ethylene-propylene). They are used because of their chemical inertness. While FEP is less expensive, PFA can handle higher temperatures. PTFE has some inherent limitations that may make it less appropriate as a lining material.

Inside . . . an evaluation of the relative strengths and weaknesses of various lining materials →

The problems with PTFE valve linings.

PTFE is sometimes used for valve linings, but there are two serious factors that adversely affect its performance as a valve lining material:

- Micro-fissures that develop during the blow molding process.
- Blow-out and collapse.

Problem 1

PTFE blow molded linings are permeable.

Microscopic pores are present in PTFE due to imperfect particle fusion during PTFE processing. During the blow-molding process, these pores develop into micro-fissures or micro-cracks due to the high stress that develops. This makes the blow-molded PTFE valve lining vulnerable to permeation and absorption.

Where the PTFE is blow-molded around an edge or curve in the valve body, the PTFE is both thinned and put under greater stress. These areas are especially vulnerable to media seepage through the lining to the body metal.

The proof is in the pictures.

These scanning electron microscope fractographs speak for themselves. The microscopic fissures (Figures 1. and 2.) are large enough to easily allow a wide variety of media to migrate into and through the PTFE.

The technician at the independent laboratory preparing the S.E.M. fractographs stated,

> ***"Even at only 2000x, PTFE's micro-cracks were pervasive and easy to find. It was evident all the way through the samples of PTFE lining we evaluated."***

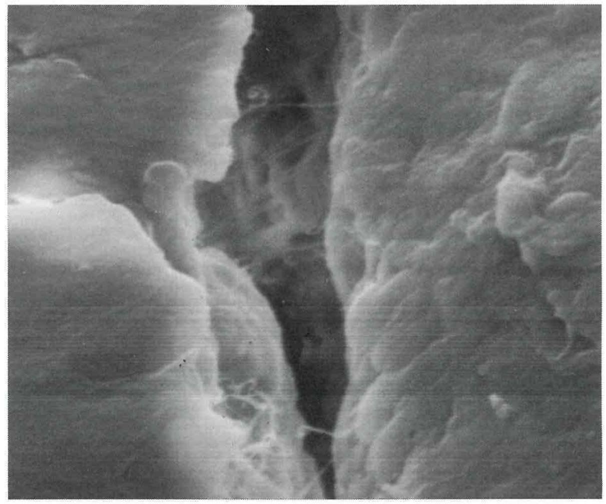


Figure 1.
PTFE valve lining magnified only 2,000 times.

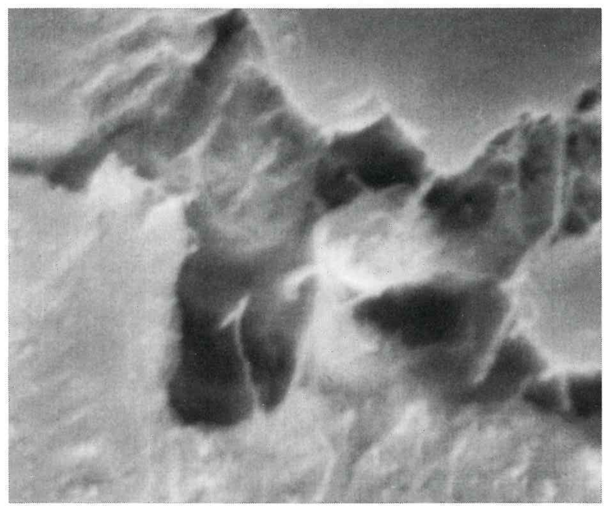


Figure 2.
PTFE valve lining magnified 10,000 times.

Sampling procedures.

An independent laboratory was employed to evaluate lining porosity.

At the laboratory small, random samples of lining material were removed from valves lined with PTFE, PFA, and FEP (Figure 7).

The samples were examined with a scanning electron microscope at various magnifications (Figure 8).

Figure 3.
PFA valve lining magnified 10,000 times.

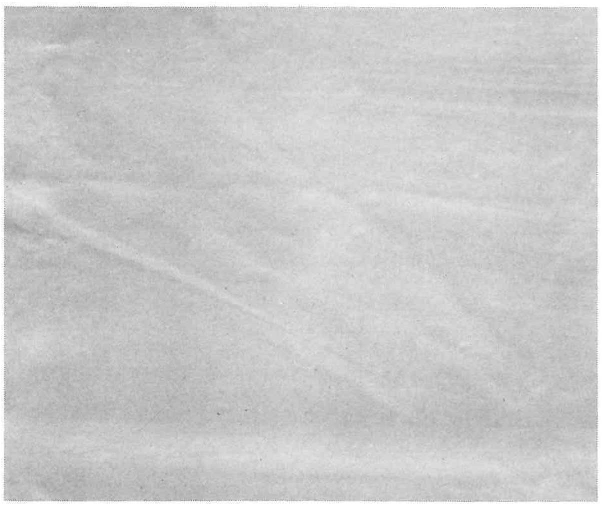


Figure 4.
FEP valve lining magnified 10,000 times.

PFA and FEP transfer molded linings are virtually impermeable!

Figures 3. and 4. show typical sections of PFA and FEP magnified 10,000 times.

The S.E.M. technician stated,

> ***"After rigorous scanning of the PFA and FEP lining samples I could find no significant porosity."***

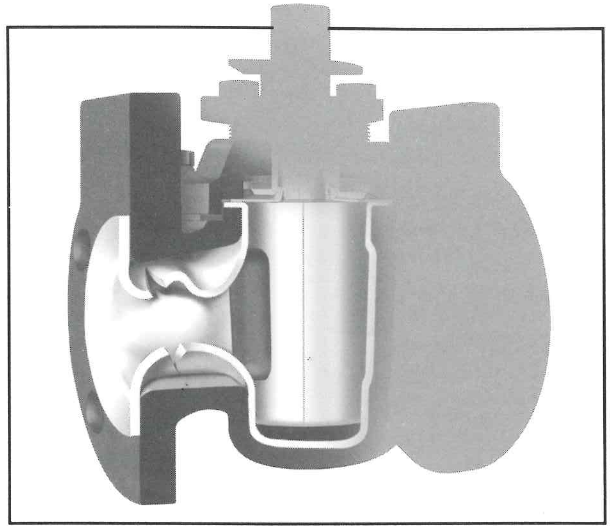


Figure 5.
A PTFE valve lining can collapse and split.
It cannot be locked to the body.

Problem 2

PTFE is vulnerable to blow-out, collapse, and creep.

Because of the limitations involved in conforming PTFE to the shape of the valve passage way, it is more vulnerable to failure (Figure 5.).

Two lining methods.

There are two ways to line valves, molding and forming. The lining method depends upon the lining material.

FEP and PFA are melt-processible. This means that they can be precisely molded to the valve body and locked into place. Locking is accomplished by molding the lining into dovetails machined into the valve body (Figure 6). This dovetailing prevents liner collapse.

PTFE is not melt processible. It does not become molten at elevated temperatures. Consequently, it cannot be molded in the same way as PFA and FEP. PTFE is limited to the blow-molding method.

With blow-molding, PTFE cannot be "locked" into the valve body as FEP and PFA can. Therefore, PTFE is more susceptible to separation from the valve body in several ways including blow-out, collapse, and creep.

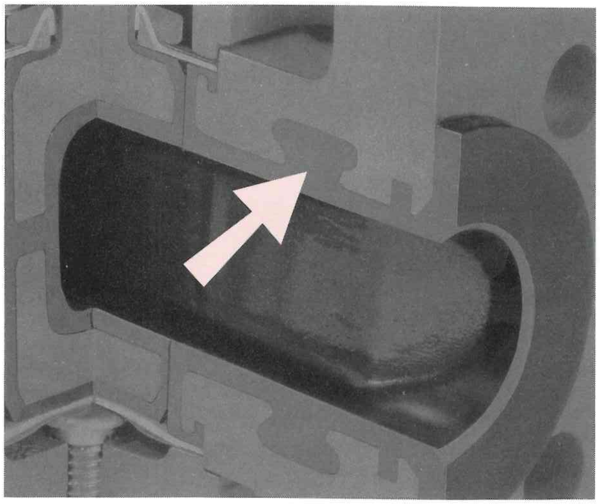


Figure 6.
PFA and FEP linings can be locked into the valve body with dovetail recesses. The lining cannot blow out or collapse.

PTFE requires blow molding. Blow molded linings cannot be locked to the valve body so PTFE linings are susceptible to collapse.

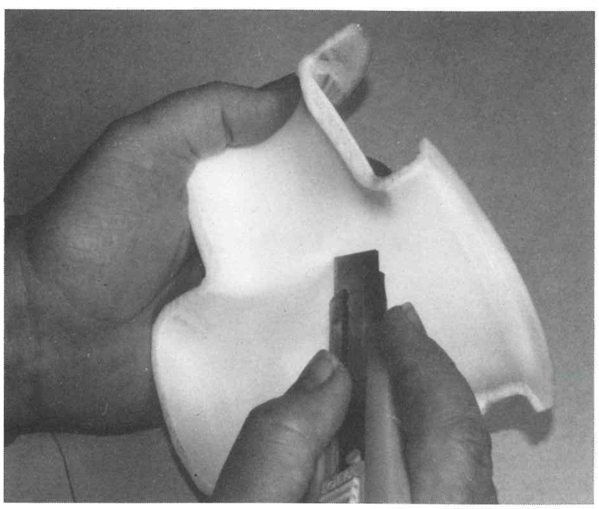


Figure 7.
At an independent laboratory, small random samples of PFA, FEP, and PTFE were removed from valve linings.

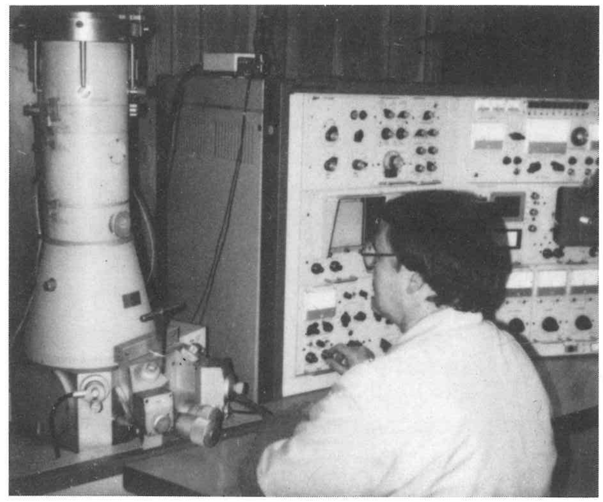


Figure 8.
Samples were examined with a scanning electron microscope. Micro-fissures were immediately evident throughout the PTFE sample.

After extensive searching at five times the initial PTFE magnification, no significant porosity was found in the PFA or FEP.

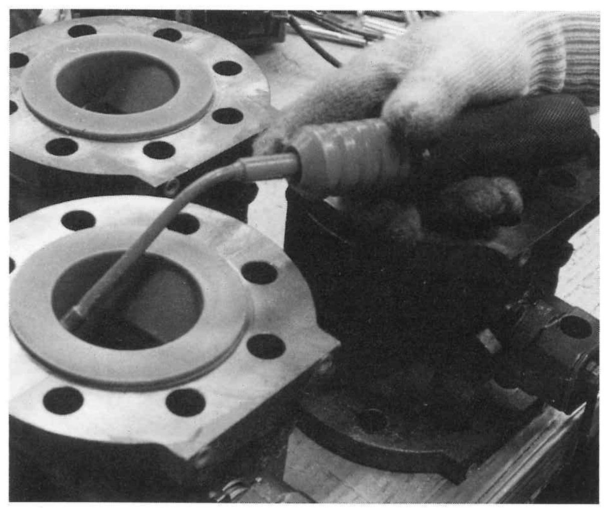


Figure 9.
Even the smallest lining defect is pinpointed by this "spark" test. At Xomox, comprehensive quality control and continued testing assure the liner integrity of Tufline Valves.

The lurking potential for PTFE failure.

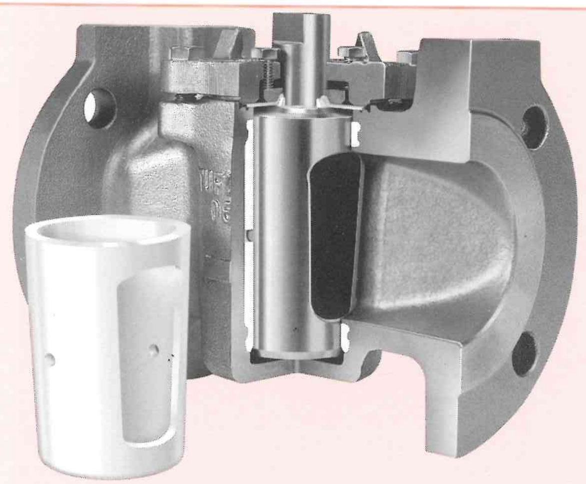
Though PTFE lined valves may perform adequately for extended periods of time, disaster can strike suddenly.

Minute changes in processing temperature or minor changes in the molecular structure of the processed media may allow the media to easily flow through micro-fissures in the PTFE even though it previously resisted permeation.

With changes in media temperature and chemistry, the media may become more "seeking". It finds its way from fissure to fissure through the PTFE and attacks the body metal.

Many processors who have been content with their PTFE lined valves for extended periods of time have suddenly found that they have massive leaks developing through valve bodies.

Often this sudden and unexpected problem can be traced to subtle changes in processing procedures, temperature, or media formulation that would not have affected PFA or FEP.



While PTFE makes a poor lining material, it is appropriate for the sleeve in sleeved plug valves.

PTFE is appropriate for certain other applications.

While blow molded PTFE is inappropriate for lining plug valves, PTFE performs well as the sleeve material in a sleeved plug valve.

In this application the PTFE acts as lubricant and seal. Its function is not to protect the metal. In addition the sleeve is compression molded, not blow molded.

In this application, the PTFE sleeve is also under compressive stress. This actually increases density and keeps micro-fissures from developing.

In Brief:

Valves lined with PFA or FEP generally provide reliable, economical, long-term service.

Valves lined with PTFE may perform adequately. However, with minute changes in processing parameters, PTFE lined valves have failed suddenly and catastrophically.

Lined valve advantages.

Lined ball, butterfly, and plug valves work well in most corrosive applications. They often outperform more expensive alloy valves.

Lined valves are also more versatile than alloy valves. Unlike alloy valves, corrosion resistance in lined valves is virtually unaffected by changes in process fluid, chemical concentration, and processing temperatures. With the versatility of lined valves, they can be used with almost all corrosive fluids, so there is no need to stock and carefully match different alloy valves for every application. The mismatch of an inappropriate alloy valve and a corrosive media can be both costly and dangerous.

This versatility also means that lined valves are especially appropriate for multiple-product processing lines where different fluids or differing concentrations of fluids flow through the valves.

Effluent and recycle processing is becoming more important and more difficult because of more stringent environmental regulations. Lined valves offer a number of advantages in these applications. Downstream and reprocessed fluids tend to vary greatly in concentration. An alloy valve may meet the nominal specifications for handling a corrosive fluid. However, small changes in processing conditions can significantly change the fluid's affect on valve material and cause failure due to corrosion. Unlike alloy valves, fully-lined valves are seldom affected by changes in chemical concentrations or processing temperature variations within their operating range.

Lined valve limitations.

Temperature is the main limiting factor for lined valves. FEP has a service temperature rating of 300°F. PFA lined valves are rated to approximately 400°F. With a porous lining such as blow molded PTFE, elevated temperatures increase the likelihood of leakage through the lining to the body, causing the body material to quickly corrode.

Erosion resistance.

Linings are more susceptible to erosion than alloys. However, PFA and FEP lined valves handle a broad range of erosive fluids and slurries very well. Erosion resistance depends on the nature of the entrained solids, the flow rate, and other factors. Consult the valve supplier for lined valve performance data in erosive applications.

Assured lining integrity.

As stated previously, lining integrity is critical. Even very small micro-cracks or defects can allow flow media to reach the body material. At Xomox, all Tufline Valve liners are dielectrically tested for defects with a "spark test" at a minimum of 20,000 Volts DC (Figure 9.). It is a positive check for the smallest liner defects. In this test, the lining acts as an insulator. If there is any defect in the lining, the electrical charge seeks the defect and passes through to the base metal.

Lined valve types.

Plug, ball, and butterfly valves work well as lined valves. This is because the wetted parts of these valves are relatively few and simple in shape.

Gate, globe, and other rising stem valves are not easily adapted to the lining process. This is because these valves have so many exposed, separate, and intricate pieces that require lining. To take advantage of the benefits of lined valves, high-alloy rising stem valves can sometimes be replaced by fully lined quarter turn valves, even in control applications.

About the author:

M. R. Ramakrishnan earned his M.S. in Materials Engineering at Rensselaer Polytechnic Institute, Troy, New York. His particular work experience makes him uniquely qualified in the area of valve lining materials. He is employed by Xomox Corporation, a leading manufacturer of lined valves. He has also worked for The Center For Composite Materials & Structures at the Rensselaer Polytechnic Institute.

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