# BUTTERFLY VALVES IN THE PETROLEUM INDUSTRY

*BRAD BERTREM*
*Dover Corporation/Norris Division*

## INTRODUCTION

Early applications for butterfly valves were restricted to throttling control in many types of fluid flow systems. These early throttling-type butterfly valves were very similar to the disc in an automobile carburetor and did not provide positive shutoff.

In the early part of this century, however, semipositive low-pressure shutoff butterfly valves were developed, using natural rubber for seating materials. These valves received only limited acceptance because of natural rubber's limited resistance to media and its undesirable characteristic of deteriorating physical properties when exposed to temperature over a period of time. This water-works type valve was unsuitable for petroleum services due to the use of natural rubber seats.

However, the development of these semipositive low-pressure valves coupled with the emergence of many synthetic rubbers during World War II led to the leak-free high-pressure butterfly valves we know today. The new elastomers also allowed the valve designer to obtain improved resistance to media, while providing positive shutoff.

The primary function of a butterfly valve today is to achieve positive shutoff. They can be fully opened and closed in a quarter turn. Their ease of operation permits them to be used for throttling and on-off automatic applications in various fluid flow systems.

Butterflies will handle many different types of media, including vapor (steam), gases, liquid, slurry and solids.

Butterfly valves provide positive shutoff up to 250 psi and have far greater life than the early natural rubber-seated valves.

A variety of unique design advantages are offered in butterfly valves, including weight, economy, simplicity of design, ease of installation and maintenance, compactness, simple quick operation, reliability, and versatility.

The light weight of butterflies allows installation without the necessity of a hoist up to the 10-in. or 12-in. sizes.

Weight economy is also a cost advantage because a minimum amount of materials are used in manufacturing and the valve design is simple, providing economical prices.

A minimum amount of premium material is required in handling corrosive media since many butterfly valve designs prohibit the medium from reaching the valve body. This, of course, is not true in gate, ball, plug, or globe valves since they must have high alloy bodies as well as high alloy trims (such as titanium, hastelloy, stainless steel) if they are to be compatible with highly corrosive flow streams.

In addition to economy, the simplicity of design of the butterfly allows on-site repair without special tools or equipment. Elastomers can be replaced right at the job site.

Compactness of the butterfly valves, particularly the wafer design, minimizes the amount of wasted space necessary for piping systems.

Little or no maintenance is required on butterfly valves. If properly selected, butterflies will provide leak-free service with a minimum of maintenance. Most butterfly valves are permanently lubricated and require no special attention once installed.

Due to the many trims available in butterfly valves they are one of the most versatile valve types available today. Depending upon the proper selection of metals and elastomers, butterflies are capable of operating from -65° to +450°F and can handle media from low vacuum pressures up to and including 250 psig working pressures.

Among the limitations of butterfly valves is temperature. The range previously mentioned for butterflies is determined by the elastomer seals. Resilient or rubber-lined butterflies are generally available from moderate vacuum up to and including 250 psig with valves containing a limited elastomer in their seals capable of handling up to 720 psig in special designs.

Butterfly valves should be closed slowly to prevent "water hammer". When butterfly valves are closed too rapidly, hydraulic shock will occur. When a valve disc is closed quickly the disc must absorb the energy that is stored in the movement of liquid it is suddenly stopping. This hydraulic shock can be avoided by the use of a gear operator or other device on top of the valve which prevents quick closing.

A major criterion for maximum valve life is selection of the proper valve. Various media, valve use, cycle rate, temperatures and pressures affect the proper selection of valve style and trim.

Prior to installation, valves should be carefully handled to prevent disc edge damage. Valve flanges should be welded to pipe prior to inserting the valve body. Piping must be properly supported and flanges accurately aligned to prevent unnecessary loads on valve bodies.

Valve assemblies, pipeline and mating flanges should be cleaned prior to valve installation. These basic steps before installation combined with periodic checks and cycling during operation will prolong the life of any valve.

Butterfly valves have emerged as a strong competitor to other types of valves in a variety of applications. Specific petroleum industry applications are listed later, but generally butterfly valves are found in all areas of the petroleum industry.

## BASIC TYPES

The three basic types of butterfly valves are the metal-to-metal throttling type where positive shutoff is not required, the resilient-lined type which is positive shutoff but may also be used for throttling service, and the metal-seated elastomer sealed type which is positive shutoff with limited throttling capabilities. (Fig. 1).

The metal-to-metal "D" series valve is primarily used for throttling control and is designed to have low-leakage in the closed position. This is done to eliminate any rubber torque, to minimize seating torque, and to provide improved throttling control via automated actuators.

The butterfly valve has a linear throttling characteristic between 20 and 75 degrees open and the user can capitalize on this linearity from a control standpoint by use of a linear actuator. (Fig. 2)

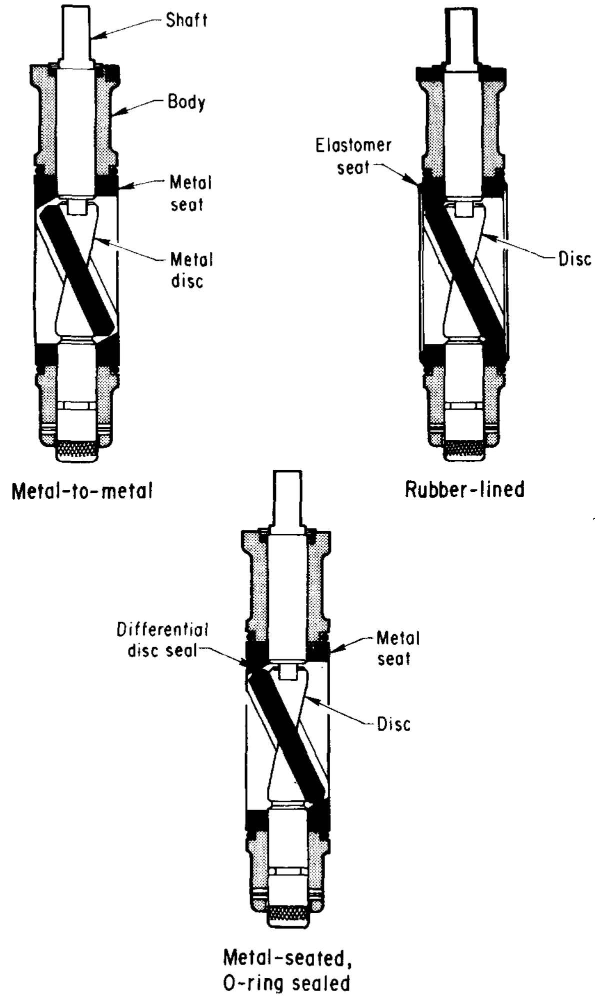


FIG. 1—Butterfly Valves are available for throttling control or modulating service which do not give positive shut-off. Rubber lined valves are positive shut-off with throttling capabilities up to 30 feet per second. Metal seated, O-ring sealed, valves are positive shut-off with limited throttling capabilities.

The metal-to-metal valve is generally used on those applications where a large variation of flow or pressure drop is anticipated.

The engineer selects the proper valve size by using the values of the flow coefficient published by the manufacturer.

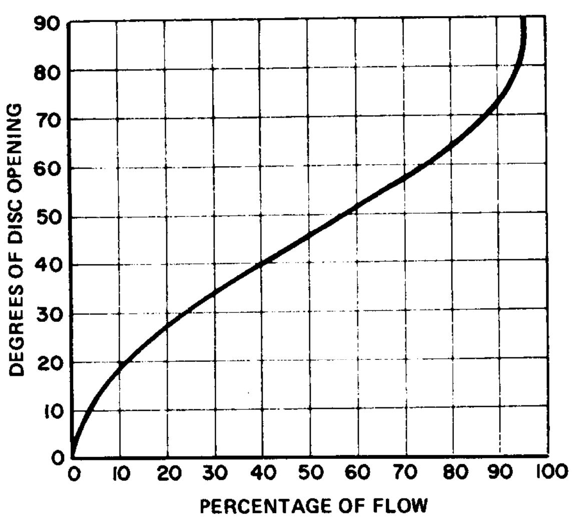


FIG. 2—BUTTERFLY VALVES HAVE EXCELLENT THROTTLING CHARACTERISTICS WHICH ARE NEAR LINEAR FROM APPROXIMATELY 20 DEGREES TO 75 DEGREES OPEN.

Butterflies are a more efficient valve than most other valve types because the approach velocity of fluid is not lost as the fluid passes through the valve bore.

Because of this advantage, the butterfly valve is ideally suited for those systems requiring a valve that can be operated to produce a minimum pressure loss in the system.

The quality of control obtained from a valve is dependent upon the ratio of the pressure drop across the valve to that of the entire system.

It should be noted that fittings and pipe configuration adjacent to the valve affect the valve's performance characteristics and care should be exercised when selecting precision control butterfly valves to consider the adjacent piping effect.

Resilient-lined or rubber-lined butterfly valves are the most popular style and are available in three basic configurations: vertical disc, offset disc, and the angle disc. (Fig. 3)

The vertical disc style valves usually have lower cycle life due to the scrubbing and compression set of the elastomer that takes place in the disc boss area.

Offset discs eliminate this problem; but they have a reduced port diameter, resulting in a less efficient valve.

The angle disc configuration effectively eliminates or at least minimizes both of these problems.

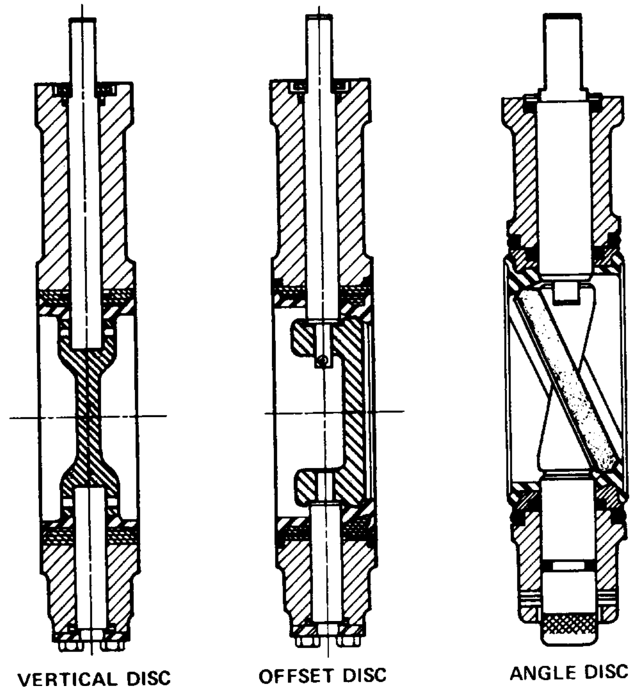


FIG. 3—COMPARISON OF THE THREE MOST POPULAR STYLES OF RESILIENT-LINED BUTTERFLY VALVES. BASIC DISC CONFIGURATION DETERMINES VALVE GEOMETRY.

The metal-seated type butterfly valve gives positive shutoff. As opposed to the resilient-lined type, the metal-seated valve minimizes the amount of expensive elastomer required to obtain the seal. This minimal amount of elastomer enhances the valve design because it can handle a wider temperature range and has less volume to be attacked or swollen by the medium handled. (Fig. 4)

Butterfly valves are also available from 1-1/2 to 4-in. size in body configurations having threaded ends. The body configurations are also available with grooved or welded ends for use with quick disconnect couplings and/or for welding in the pipeline.

The original butterfly valves were designed with flanges on each end and are often referred to as "full body" valves. Like gate, plug, and ball valves, there is considerable waste of material in this type valve as compared to wafer or single flange lug-type valves. Flanged valves also require installation of two complete sets of flange bolts, when one set will suffice with the wafer style. (Fig. 5)

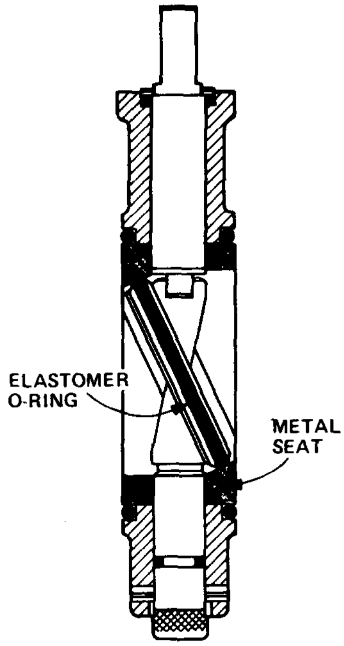


FIG. 4—LIMITED ELASTOMER SEAL POSITIVE SHUTOFF VALVES MINIMIZE EFFECTS DUE TO ELASTOMER DETERIORATION IN SERVICE.

The slip-in wafer style valve is available in a span, lug or single flange, and double flange configuration.

The most popular configuration is the span, followed closely by the lug style. The span is most popular partly due to its ease of installation, which involves slipping it between flanges in a cradle of bolts and bolting it up with no special alignment.

There are two basic families of butterfly valves which are often referred to as industrial or narrow face-to-face valves and AWWA or wide face valves. The two types of valves perform essentially the same functions; however, the industrial valve requires less material and is therefore much more competitively priced.

The wafer-style narrow industrial valve is the most popular type for petroleum applications since it offers many advantages to the engineer designing a piping system. Advantages include less space requirements, lighter weight, fewer pipe hangers and supports are required, extra economy, reliability, and a broader variety of trim materials are available.

Metal seated elastomer "M" series valves offer a high degree of fire resistance while resilient-lined type "R" series offer moderate fire resistance.

Proper valve selection has become more difficult in recent years because of new valve types and new material technology.

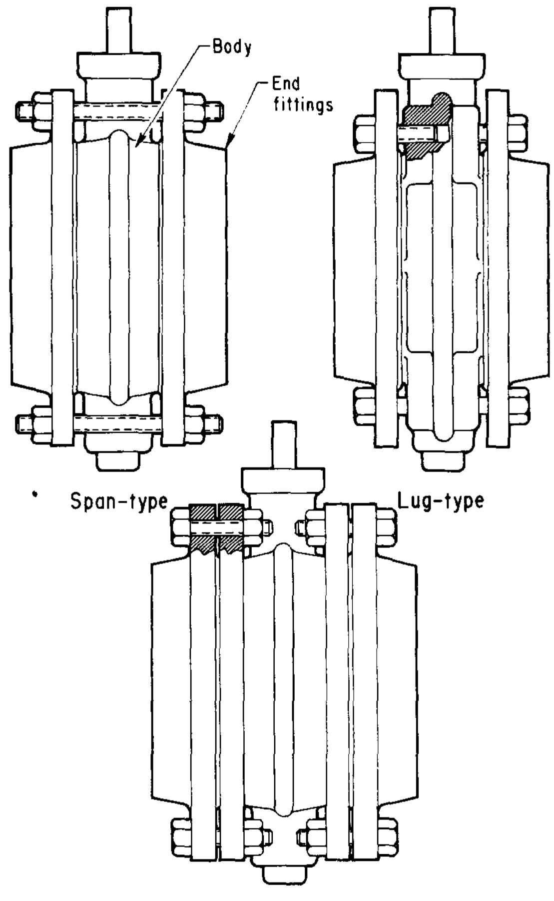


FIG. 5—DIFFERENT BODY CONFIGURATIONS ARE REQUIRED DEPENDING ON PIPING DESIGN NEEDS. LUG TYPE, SINGLE FLANGE AND DOUBLE FLANGE TYPE BOTH PROVIDE FOR END OF LINE CONNECTIONS.

Following are considerations the engineer-user should make as he selects butterfly valves.

SELECTION AND SIZING OF VALVES

1. Determine the system requirements for flow and pressure drop to calculate the probable line size.
2. Calculate the correct valve size based on pressure drop and flow capacity requirements.
3. Determine the system temperature, pressure, and surface exposure to permit selection of the proper seat, stem and disc materials.
4. Check the line velocity and pressure drop against the maximum allowable for the particular valve selected.
5. Check the temperature rating of the resilient

materials used for valve liners and seals, either or both should have been selected to be compatible with the medium at operating temperature.

6. Check the system for possible conditions that could lead to water hammer or cavitation. Make necessary adjustments to valve placement, sizing, and speed of closing to prevent this from occurring.
7. Determine the fluid-dynamic torque, compare it with the seating torque to assure that the operation is properly sized to handle the dynamic conditions of the valve.
8. Select the proper material of construction to assure that it is compatible with the environment of the piping system. Also check the rating of the valve to assure that it complies with the maximum pressure the system will be handling.
9. Select the proper valve flanges to mate with the valve selected. Determine if it is necessary to provide seals between the valve face and the flange or if the flange seals are integral in the design of the valve. Flange ID must allow the disc to move without interference as the valve is opened.

## TYPICAL APPLICATIONS

*Drilling*

Typical drilling uses of butterfly valves include: mud tanks, mud suction lines, mud hoppers, centrifugal separators, and desanders.

Butterfly valves were originally designed to operate under the severe conditions encountered in mud systems on rotary drilling rigs where a self-cleaning valve is necessary. The wiping action of the disc sweeps away accumulation and sedimentation to permit the disc to form a bubble-tight seal with the seat. Butterfly valves' resilient seats are designed for resistance to abrasive action by drilling mud. (Fig. 6)

*Production*

Production applications include: water flooding, tank batteries, lact units, production manifolds, gathering systems, storage facilities, and salt water disposal systems.

The many points in the production of petroleum products where differential pressures do not exceed 200 psi wp are ideally suited to the use of butterfly valves. (Figs. 7, 8 and 9)

These valves are compact and lightweight, yet rugged. They are easily automated, require little maintenance and are fully field repairable.

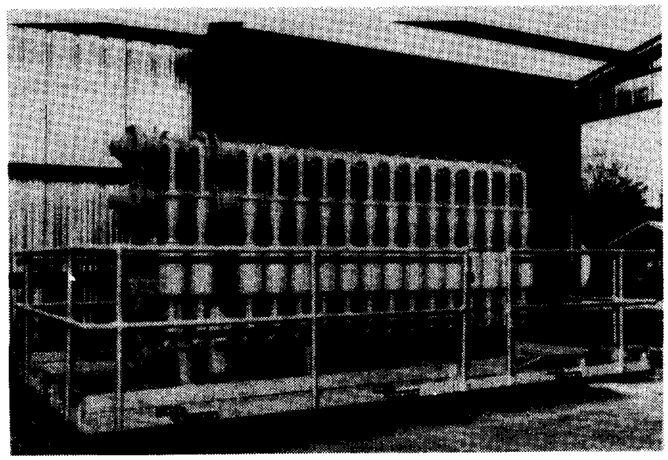

FIG. 6—DRILLING - LARGE SKID-MOUNTED DESANDER

Butterfly valves have fewer parts to wear out. Should a valve require servicing, replacement of parts can be made at the job site without special tools.

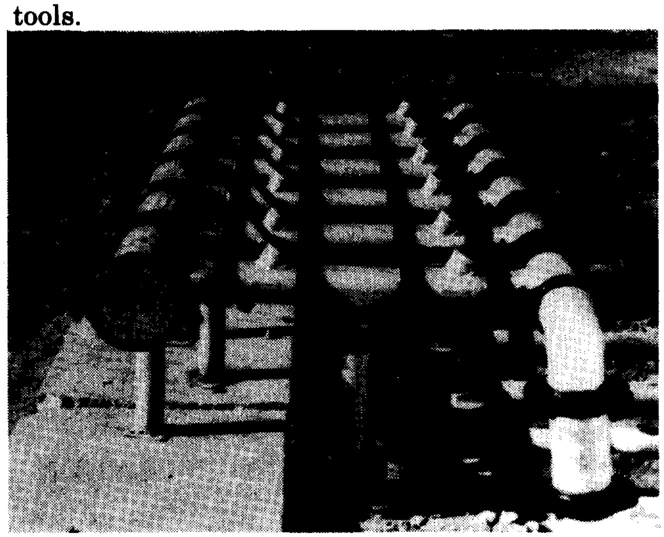

FIG. 7—PRODUCTION - STANDARD PRODUCTION HEADER

Because they are manufactured in a wide variety of materials, there is a butterfly valve to overcome virtually any corrosive condition which might be encountered in petroleum production. Materials used in the construction of valves are selected after extensive research, experimentation, and experience. Most valve designs assure dry back construction, making use of premium body materials unnecessary. Only the internal wetted parts need to be corrosion resistant to the medium.

Some butterfly valves allow removal of the lever and operation of the valve with an ordinary wrench. Several valves may be operated with a single handle. Removal of the lever prevents undesired tampering; padlocking devices are also available for maximum security.

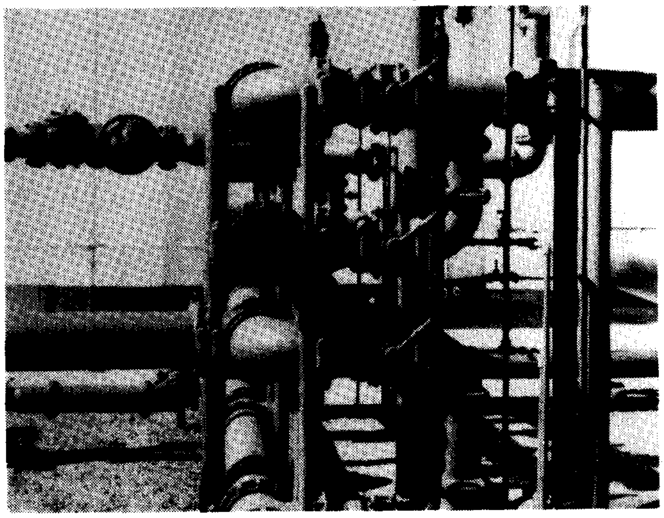

FIG. 8—WATERFLOODING - VERTICAL FILTER BACKWASH UNIT

FIG. 9—WATERFLOODING - ISOLATION VALVES FOR FILTERS

*Pipelines*

Butterfly valves are used in: pump stations, compressor stations, meter runs, cooling towers and jacket water cooling systems, suction manifolds, tank valving and gathering systems.

The compact size and light weight of butterfly valves make them especially adaptable to both block and throttling services in support systems for oil and gas transmission lines. Butterfly valves have provided many years of trouble-free service handling cooling water, air, lubrication oil and other utilities around pump or compressor stations. Since they are available in a variety of trims, the applications are numerous where working pressures of 200 psi or less are being

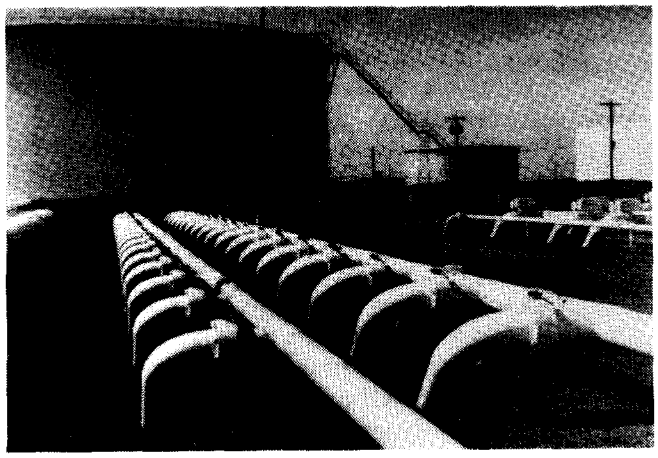

FIG. 10—PIPELINES - SUCTION MANIFOLD AND STORAGE TANK

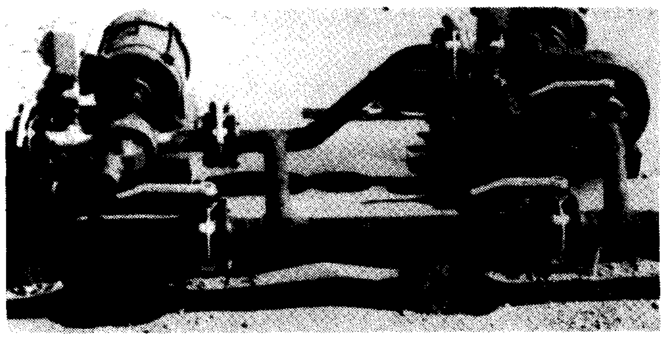

FIG. 11—PRODUCT BLENDING OPERATION

handled. (Figs. 10 and 11)

On cooling towers, EPDM has proved to be the most dependable elastomer for hot and cold water services where hydrocarbons are not present.

Because of their high efficiency (low pressure drop) and near linear throttling characteristics, butterfly valves are ideal for use in fluid or gas handling services.

*Refineries, Gasoline and Petrochemical Plants*

Butterfly valves are used in: cooling water lines, steam lines, fire protection equipment, scrubbers, absorption units, separators, and alkylation units.

Applications for butterfly valves in refining and processing petroleum products are limited only by the pressures and temperatures involved. High efficiency, flow characteristics, block and throttling capabilities plus compact size and light weight make butterfly valves a valuable tool in the complex network of petroleum products processing. (Fig. 12)

For many years, valve manufacturers' application engineers have been working with the process industry to define the most extreme

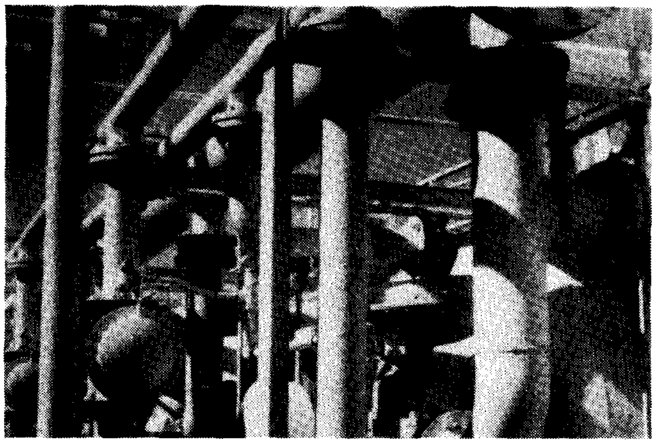

FIG. 12—REFINING - COOLING WATER

conditions under which butterfly valves can be used safely. Extensive research is currently being done in the steam handling capabilities of butterfly valves. The nature of the system, whether the steam is saturated or super heated, will determine trim materials required and limitations to the use of butterfly valves in a particular application.

Development of a positive shut-off, metal-lined wafer valve has extended the potential for butterfly valves. Limited use of elastomers in this type valve breaks down the barriers to use of butterfly valves where temperatures exceed 275°F, one of the factors limiting use of the more conventional resilient-lined valves. Selection of the proper elastomer allows application of valves in temperatures up to 400°F, even when bubble-tight closure is required.

Butterfly valves were first used in refineries for fire protection. The quick opening characteristic makes wafer valves ideal for dispersal of foams and other media for fire control.

Butterfly valves are especially well-suited to controlling the liquids, gases, slurries or solids in catalyst and product lines, alkylation units, heat exchangers and sulphur-recovery systems. The temperatures, pressures and possible corrosive or abrasive properties of the medium determine selection of trim material and limitations.

Butterfly valves are solving some of the most complex valving problems associated with refineries, gasoline and petrochemical plants.

*Petroleum Marketing*

Typical applications are found in: bulk stations, loading racks, tank valves, transfer manifolds, hydrant valves, and transport trucks.

These valves have replaced many gate and plug valves in petroleum marketing service because they are quick-opening, lightweight, provide position shut-off, require no lubrication and the initial cost is lower. Many petroleum marketing companies have standardized on reliable butterfly valves because of their excellent compatibility with refined petroleum products. (Fig. 13)

Most butterfly valves require no lubricant which could affect product purity. Double O-ring shaft seals prevent outside contamination from entering the valve bore. Metal-seated valves are particularly well-suited for handling petroleum products which tend to swell elastomers. These positive shut-off, metal-seated valves are also more compatible with extremes in temperature and have been used successfully at temperatures from -65°F to 400°F for long periods of time.

Single-flange lug body valves can be used as block valves to isolate pumps, compressors, flow meters, and other process equipment which require periodic maintenance. Since metal-seated valves are capable of holding pressures to drain a system when repairing adjacent equipment.

If a system is to be operated for a long period of time with downstream piping removed, it is recommended that a flange be temporarily installed downstream.

The many valve types and trims available today plus numerous design improvements have made the butterfly valve the most versatile valve for throttling and blocking applications within its pressure-temperature limitations.

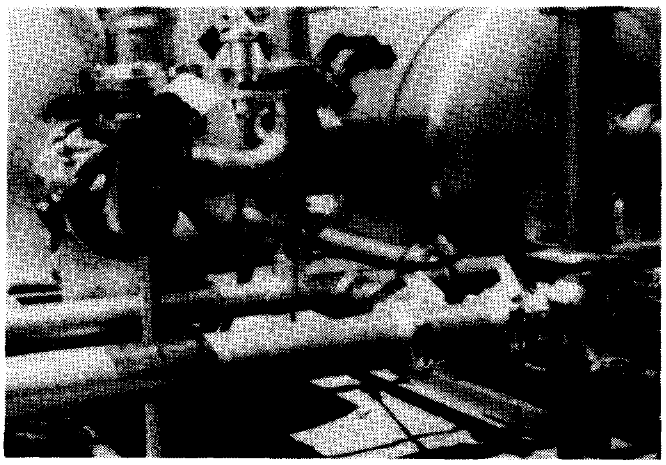

FIG. 13—MARKETING - TANK STORAGE MANIFOLD