

Leading Edge Powder Processing Technology

Gericke
RotaVal

ROTARY VALVES: AN INTRODUCTION TO SELECTION AND USE

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PREFACE

Bulk Solids Handling is the term used to describe the field of engineering involved in the mechanical management of powders and granular solids through transportation, storage and processing. Acknowledged as an industry in its own right, it is largely out of view from those who are not involved in supply and use, however, there is very little in modern life that does not rely on automated bulk solids handling systems somewhere in the supply chain.

Systems engineers, and component suppliers, are continually challenged to meeting the ever-expanding range of products being handled, user requirements, quality requirements, operating conditions and environmental needs. Final design and construction often change the parameters of the performance needed for successful efficient design. As it is hoped will be seen, successful system performance is often a matter of experience based judgement and not something easily managed through text books or computer algorithms alone.

At the heart of most systems is the seemingly simple and innocuous Rotary Valve, a machine that performs a vital part of the system function, being sited at the interface between two parts of the system equipment each operating under different conditions. And often also required to simultaneously meet other duty requirements.

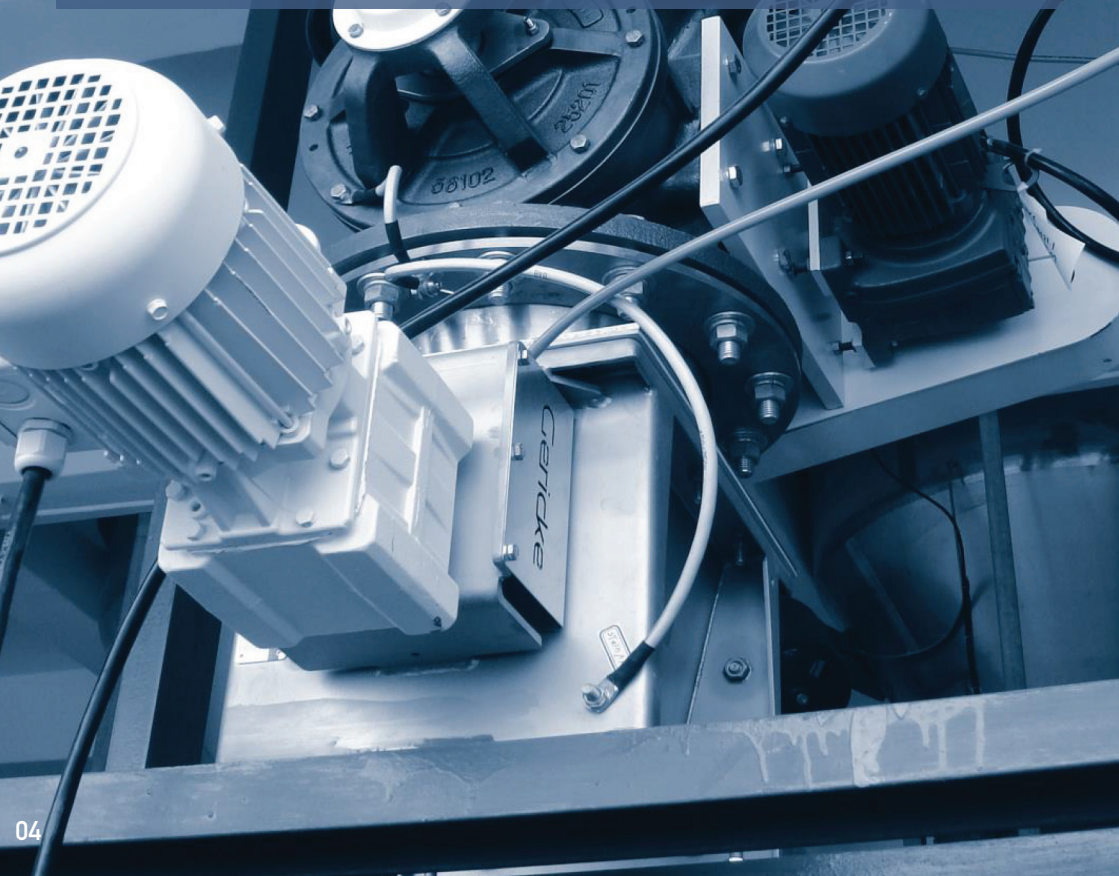
This booklet is primarily to provide a general insight into the subject of rotary valves, to help understanding in what is required in their design and supply.

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GLOSSARY OF TERMS

TERM	DEFINITION
Clearances	Operating gap(s) between rotor and housing.
Entrained	Product drawn in and transported by leakage air.
Gas	Predominately air but not exclusively.
Leakage	Upward passage of gas across the valve under operating conditions.
Notified Body	An organisation designated by a suitable authority to assess whether equipment meets the requirements set out in legislation.
Pressure Differential	Difference between gas pressure below and above the valve where the pressure below is the greater. (Note! Where the gas pressure above is the greater then this very rarely influences conditions).
Product(s)	The bulk solids being handled.
System(s)	Storage/conveying/processing installations in which rotary valves are used.
Throat	The transition area from valve inlet to the entry point into the Rotor pockets.
Venting	The physical partition of upward leakage from product flow into the valve.

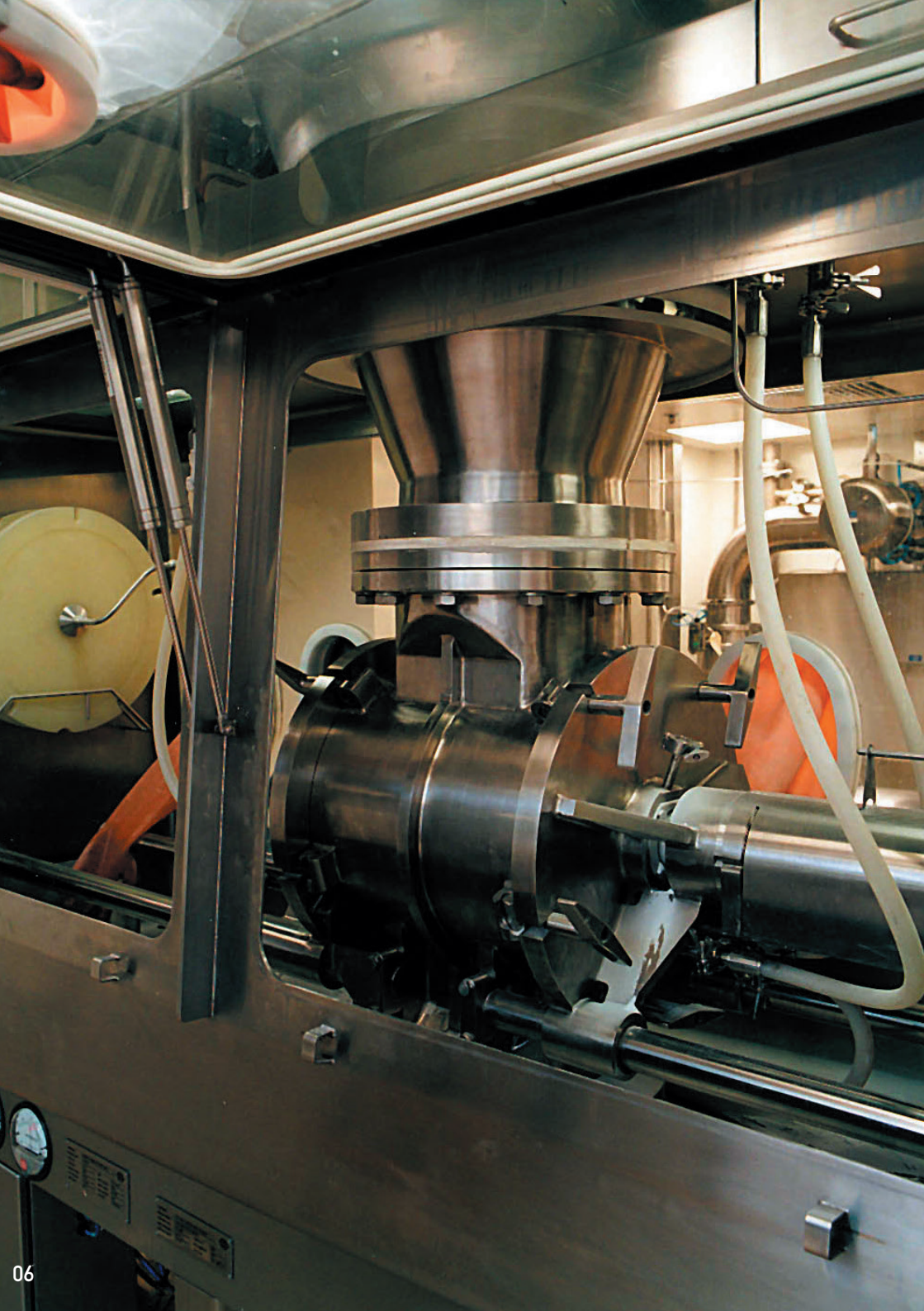


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1. INTRODUCTION

Rotary Valves are compact devices widely used in bulk handling systems to control the discharge of powders and granular solids, normally under gravity, between two parts of a system; usually when there is a gas pressure differential between the two parts.

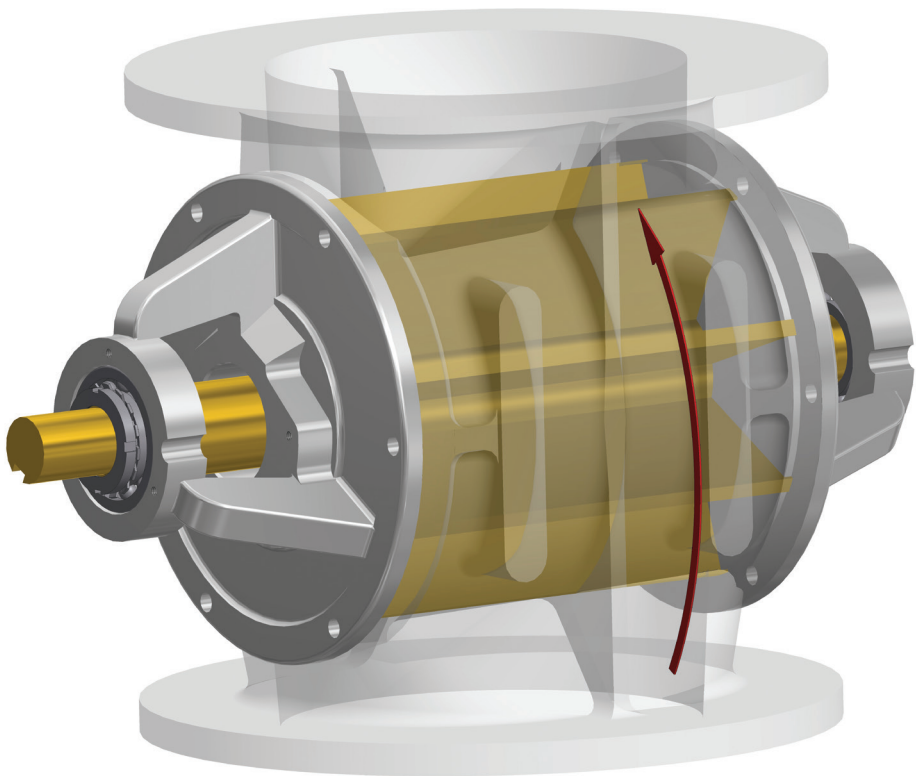
By definition, in their basic construction - ignoring any drive, they are the simplest of machines each incorporating just one moving element; a multi-vane rotor.

Yet until relatively recently rotary valves were often much maligned, due to customers often experiencing unreliable performance. As a result, many engineers actively sought alternative solutions or devices but with very limited success and only then in clearly defined applications.

Whereas the compact and economic simplicity of rotary valves provided for continuous development over time to become highly versatile devices, and are now established as important, reliable, and often vital components when correctly specified for the application.

That it can be a complex subject is reflected in the fact that **Gericke Rota Val** has a standard range of rotary valves supplemented by many thousands of standard options; as well as developing bespoke features or units when required.

ONE MOVING ELEMENT!



MANY THOUSANDS OF OPTIONS!



2. HISTORY

Bulk handling of particulate solids by automated control equipment is believed to have started at the beginning of the 20th century, and was initially based on handling cereals and other basic, easy to handle bulk foodstuffs. Initially development progress was slow as there was little understanding or experience on how to manage other products/system demands.

It is assumed that Rotary Valves may have come into existence being an obvious and simple solution for the controlled powered discharge of storage vessels.

For many decades there were various terms adopted to identify such valves for this purpose including: Rotary Airlock, Airlock, Star Valve, Rotary Seal, and Vaned Valve amongst others. Some remain in use today however; Rotary Valve is the most widely adopted generic term but not exclusively.

Wider development of systems engineering and valves was slow until around the 1950s when bulk handling started to develop into much more of a knowledge based, wide ranging, and accepted industry in its own right, and where operating needs were rapidly becoming much more widespread and demanding.

Despite the apparent simplicity, Rotary Valves have evolved to offer several functional uses:

1. **Control the product flow rate to the required value (fixed or variable).**
2. **Maintain a gas pressure differential between the inlet & outlet (airlock function).**
3. **Act as an explosion containment device.**
4. **Act as an 'Autonomous Safety Device' for explosion and flame containment.**
5. **Act as a process isolator / barrier.**

As well as satisfying any one, or combination of these requirements, the valve supplied often has to do so while overcoming adverse or difficult product characteristics, often affected by the duty, environmental and legislative requirements. Although now classed as a well-developed, mature industry; systems engineering continues to be faced with the challenges of new products, extended customer needs, and increasing legislation.

3. THE CHALLENGE

The generic description of a 'valve' is a device to control fluids i.e., gases, liquids, and slurries; including, when in a fluid condition, powders and particulate solids. However, unlike gases and liquids, bulk solids do not have stable physical handling characteristics, being vulnerable to different and sometimes variable environmental and production conditions, making predictable calculations for easy equipment design/selection difficult.

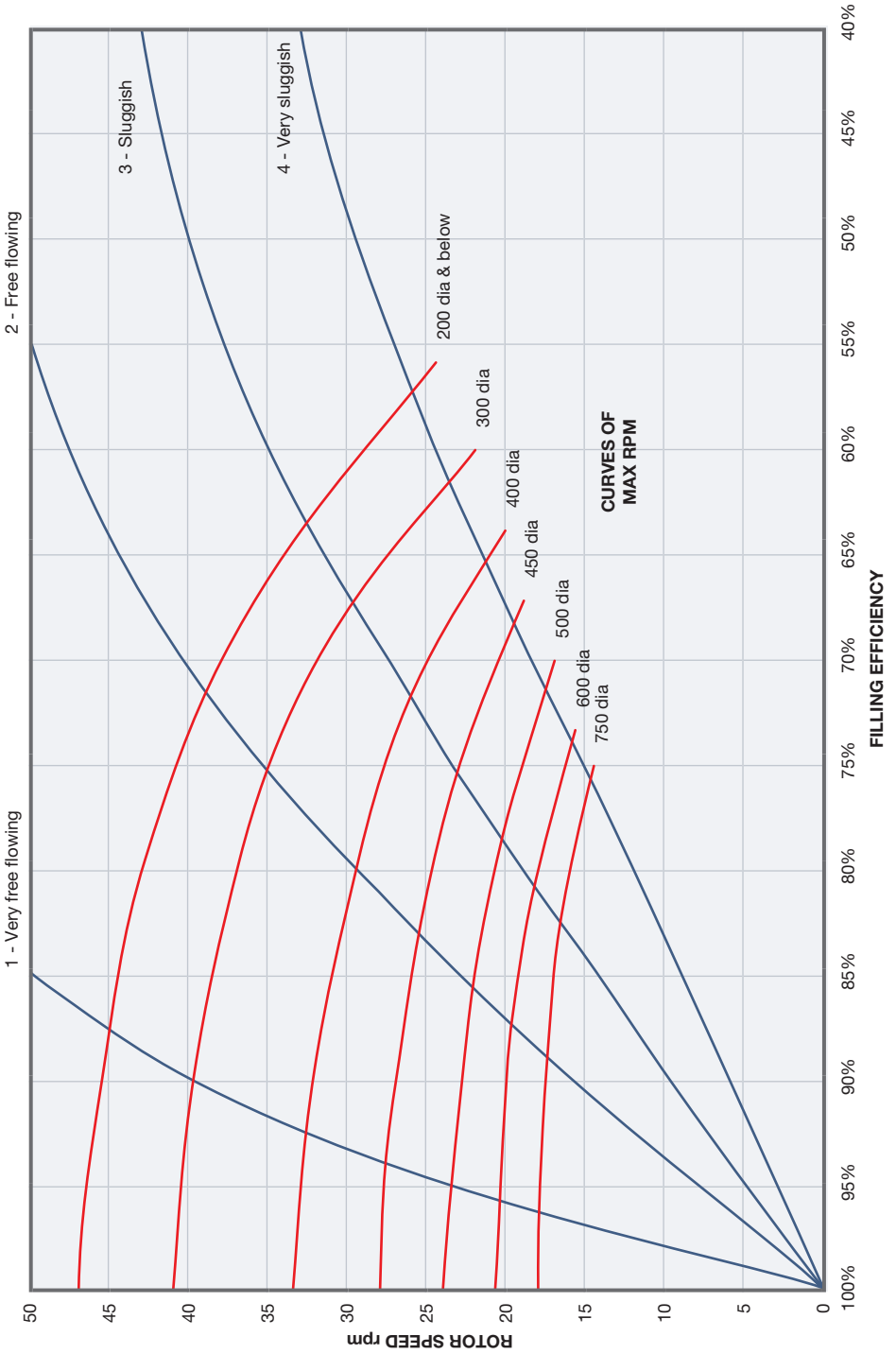
As is widely understood, handling characteristics of individual bulk solids at any given time, are heavily influenced by a range of factors and conditions. It has been suggested that bulk solids should be seen as being in the 'fourth state of matter' in that their physical values are defined by their immediate past history. With some applications operating conditions within the rotary valve can to a greater or lesser extent affect this state.

The challenge facing the applications engineer is to ensure that the valve supplied can operate effectively and reliably for an acceptable life span.

Notwithstanding the above, the greater majority of applications can be readily satisfied from a range of standard configurations and components and, where needed, a wide range of common developed features. The remainder tend to require bespoke engineering.



GRAPH 1 - Filling efficiencies



4. DETERMINING THE RIGHT CHOICE OF VALVE

The selection of final design and features is often not simple and evolves through five main areas of consideration which may need continuous reviewing until a final determination is arrived at.

4.1 Valve sizing / Speed

The selection of valve speed and size is not just a matter of mathematical calculation; it also takes into account the various factors that may negatively affect its performance from the theoretical maximum. Almost invariably, customers specify capacity required by weight/time e.g., tonnes/hour.

A Rotary Valve is a volumetric discharger, so valve size is calculated using:

- Throughput weight required
- Product bulk density
- Filling efficiency

Where Filling efficiency is affected by several factors:

- Rotor speed
- Flow characteristics of the product – See Graph 1 curves 1 to 4.
- The bulk density at the point of entry into the rotor pockets
- Effect of leakage
- Size of the valve
- Feeding conditions (system design)

Rotor Speed

It is important to select a size and rotor speed that ensures some of these factors are within manageable levels. As a very general rule a rotor tip speed of 40 m/min is around the maximum after which a decrease in throughput results; at or anywhere near this speed, erratic performance is inevitable. (40m/min equates to 85rpm for a 150mm dia rotor and 17rpm for a 750mm dia rotor).

To ensure reliable and stable throughput, most applications require selecting a valve size that gives rotor speeds below 25rpm for valves with rotor diameters up to 300mm; thereafter with larger valves it becomes progressively safer to run closer to the nominal 40 m/min tip speed due to the more accommodating larger throat sizes.

Final decision for suitable valve speed also takes into consideration the flow properties of the product being handled – Graph 1 offers general guidance.

4.2 Product Characteristics

These define the design and construction of the individual components. Knowledge of product handling characteristics and how they are affected by valve operation when under duty conditions is often essential for their final selection.

Caution is needed; for it is not uncommon for some products to act or be acted on adversely or be damaged when being handled within a Rotary Valve, and yet, not present a problem with other equipment.

Fine mildly abrasive product can become highly erosive when entrained in high velocity leakage that can occur within the valve operating clearances.

Some products are temperature sensitive and the inter-particle friction in the valve clearances can give rise to plasticising through particle fusion, undermining the product quality. Others, when under interface pressure or presence of moisture, can build up on the working surfaces and create unacceptable torque loads and / or distress noise. Whenever any potential challenging issues arise, the means to alleviate such problems will need to be incorporated. Sometimes customer liaison is needed to mitigate any influential conditions within a system that would otherwise be difficult or expensive to control by means of the valve alone.

Food and pharmaceutical products require sterile easy clean conditions as does any product that requires purity – See page 27 for more information.

Organic products can be explosive when airborne in dust form and requires special attention – See page 14.

4.3 Pressure Differential

When it exists, it is a critical factor when assessing valve suitability, due to its creation of leakage.

The greater the pressure differential, the greater the leakage – See page 23 – and the greater the effect it can have on the final choice of valve size and features. The particle size and handling characteristics of the product are also significant factors to be considered.

High leakage can significantly reduce material flow by reducing the bulk density through fluidisation and/or by physically opposing flow. Conversely, with some products and/or conditions it can aid product flow by creating agitation and/or fluidisation. Whatever the net effect allowance must be made when sizing the rotary valve, something that becomes progressively less of a problem with increased valve sizes, as the larger throats make for better dispersion of leakage air.

The potentially damaging effects of leakage will not only determine features to be included, but also whether leakage needs to be utilised or suppressed; the latter may need the involvement of the customer at the design stage of the planned installation.

Valves should also be fitted directly to the outlet of any hopper so that leakage air can disperse easily – See page 24. This is less of a problem when the valve is not operating in a flooded condition, i.e., when product enters the valve in a controlled cascade where leakage can naturally bypass the product flow.

See section 9 – page 21 for more information on clearances, leakage and venting.

4. DETERMINING THE RIGHT CHOICE OF VALVE - CONTINUED...

4.4 Temperature Conditions

Extreme low and high operating temperatures: from Dry Ice at -80°C to continuous discharge into a pneumatic conveying line of incinerator ash at 960°C , are two examples of successful applications that have challenged all aspects of engineering content and valve design.

It is not practical to go into detailed description and options in the context of this booklet, but it is important that there is understanding as to whether the valve

temperature will increase slowly during production or may be subject to shock temperature loading i.e., sudden influx of hot product. If the latter then the Rotor, being a lighter construction, will expand quicker than the Housing, which is also subject to external surface heat loss.

Clearances need to be set so that once operating temperature is reached they are at the optimum clearance for the duty. This means that leakage before the optimum has been reached will be much greater.

FIGURE 1. Some examples of valves designed for unusual applications



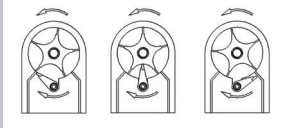
Stainless Steel valve designed to act as a process separator operating under Chlorine gas at an internal pressure of 7 bar pressure. Pressure Differential 100mbar.



'Hypergienic' Valve set as an 'Autonomous Safety Device' (See page 14) with extended features to satisfy requirements for handling highly toxic and sensitive pharmaceutical product.



Valve for handling light powder flowing products with extended inlet and inlet cone at precise angle required to meet product characteristics.



Valve with Rotor Pocket Scraper Option. Principle of Operation: The 'sweeping' lower component ensures removal of sticky products that would otherwise not discharge by gravity.



Tandem valve – available in two options:

1: With two sealing Rotors to minimise leakage when handling very light products that are easily windswept.

2: As a Metering Sealing assembly with upper Rotor having reduced capacity with increased clearances feeding the lower sealing Rotor at a reduced rate to eliminate jamming.



Heat resisting valve operating at 500°C continuously discharging ash and gravel from a fluid bed dryer. Incorporates auto reversing to release any product jamming.

4. DETERMINING THE RIGHT CHOICE OF VALVE - CONTINUED...

4.5 Customer / Industry Requirements

These can be challenging aspects of supply, requiring the ability to offer flexibility in both detail valve design, manufacturing and commercial capability in order to satisfy specific customer needs and/or their individual industry standards.

Many users are not concerned about most aspects of valve supply providing it performs to specification, is durable and requires very basic documentation.

Other customers / Industries are more demanding to a varying degree with regard to detail design and required manufacturing practices. As well as specifying industry approved design features, there is often a requirement to be supported by extensive validation and acceptance tests, certification, documentation, post-delivery tests etc.

Between the two extremes is a wide range of differing requirements – **Figure 1** shows examples of such valves.

Valves handling hazardous and/or toxic materials and/or operating in controlled environments will have further extended requirements.

4.6 Legislation Requirements

European Union Machinery Directive

A rotary valve is classed as a 'partly completed machine' which is intended to be incorporated into another machine or system. A certificate to this effect (declaration of incorporation) is provided for each valve.

Valves covered by other directives must also conform to the Machinery Directive.

European Union Pressure Equipment Directive (PED)

PED applies to equipment the design, manufacture and conformity of equipment with a maximum allowable pressure (PS) greater than 0.5 bar.

To assess whether the equipment falls within the scope of the regulation PS is multiplied by the internal volume (V) - having a maximum allowable pressure (PS) greater than 0.5 bar. PS is multiplied by the volume (V) to arrive at PS.V bar litres. In conjunction with the fluid type, PS.V is used to determine whether the equipment is covered by the directive. As the volume (valve size) increases then maximum allowable pressure (PS) decreases.

Smaller valves manufactured to Safe Engineering Practise (SEP) fall outside of this directive as can be seen in **Figure 2**.

FIGURE 2. Effect of PED on rotary valves

SIZE	GROUP 1 GASES										MAX Pressure allowed to remain Outside of PED	
	1	2	3	4	5	6	7	8	9	10		
50	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	10 bar (by design)	
100	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	10 bar (by design)	
125	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	10 bar (by design)	
150	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	1	1	1	10 bar (by design)
200	SEP	SEP	SEP	1	1	1	2	2	2	2	6.6 bar	
250	SEP	1	1	2	2	2	2	2	2	2	3.6 bar	
300	SEP	1	2	2	2	2	2	2	3	3	2.0 bar	
400	1	2	2	2	3	3	3	3	3	3	1.0 bar	
500	2	2	3	3	3	3	3	4	4	4	0.5 bar	
600	2	3	3	3	3	4	4	4	4	4	0.5 bar	
750	3	3	4	4	4	4	4	4	4	4	0.5 bar	

SIZE	GROUP 2 GASES										MAX Pressure allowed to remain Outside of PED	
	1	2	3	4	5	6	7	8	9	10		
50	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	10 bar (by design)	
100	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	10 bar (by design)	
125	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	10 bar (by design)	
150	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	SEP	10 bar (by design)	
200	SEP	SEP	SEP	SEP	SEP	SEP	SEP	1	1	1	1	10 bar (by design)
250	SEP	SEP	SEP	1	1	1	1	1	1	1	1	10 bar (by design)
300	SEP	SEP	1	1	1	1	1	1	2	2	8.2 bar	
400	SEP	1	1	1	2	2	2	2	2	2	4.1 bar	
500	1	2	2	2	2	2	2	3	3	3	1.5 bar	
600	1	2	2	2	2	3	3	3	3	3	1.0 bar	
750	2	2	3	3	3	3	3	3	4	4	0.59 bar	

KEY	SEP = Safe Engineering Practise (Machinery Directive applies, PED does not apply)									
	1 = Category 1 (Machinery Directive applies, PED does not apply)									
	2 = Category 2 (PED applies) 3 = Category 3 (PED applies) 4 = Category 4 (PED applies)									

4. DETERMINING THE RIGHT CHOICE OF VALVE - CONTINUED...

Where PED applies then actions ensuring compliance must be recorded in a technical manual and additional actions may be needed, possibly involving a Notified Body.

NOTE! If the valve is classed as an explosion containment device under the ATEX Directive, then this supersedes the PED Directive.

European Union ATEX Directive for potentially explosive atmospheres

ATEX applies to equipment provided for use in potentially explosive atmospheres, whether operating within or containing such atmosphere or both.

Equipment must not be a source of ignition either directly, or indirectly by means of other equipment fitted to it. While two metals making contact at speed can create a spark causing ignition, there is an accepted safe maximum of 1 metre/sec contact speed below which an ignition spark is not generated. Fortunately Rotor tip speed is invariably well below this value.

Subject to approved and tested detailed design and construction by external Notified Body, Rotary Valves can be installed in explosive atmospheres and where such atmosphere is within the valve then they must be able to contain any explosion event and usually also any flame (including hot embers) that might cause a secondary event downstream. Critical to meeting the flame containment is that operating clearances cannot exceed the maximum agreed with the Notified body in their certification at any time while in service.

When required to contain both explosion forces and flame containment the Valve is classified as an 'Autonomous Safety Device' and falls under those regulations including range certification by an appointed Notified body.

It is the responsibility of the end user to establish the ATEX zone classification and advise the valve manufacturer of their needs accordingly.

USDA (United States Department of Agriculture)

Valves intended for supply to food industries in the USA must conform to the relevant USDA regulations. The regulations specify design features, appropriate surface finish and manufacturing standards etc. and sample valves must be submitted for approval before certification can be issued.

EHEDG

(European Hygienic Engineering and Design Group)

EHEDG is a consortium of European equipment manufacturers and industries and is not a governmental mandatory requirement and only applies when requested by the customer. In practice the guidelines predominantly mirror USDA standards with relatively minor variations.

FDA – United States Food and Drug Administration

The FDA is responsible for protecting the public health by assuring the safety, efficacy, and security of human and veterinary drugs.

The FDA publish CFRs (Codes of Federal Regulations). From a rotary valve perspective these codes relate to approving materials of construction particularly those likely to be in contact with the products and cleaning materials.

They also approve complete production systems but not component machines such as Rotary Valves separately. Components and machines must be manufactured to GPMP (Good Pharmaceutical Manufacturing Practice).

Where high standards of sterility are required then traditional Valve construction incorporating castings may not be appropriate due to the risk of porosity and polishing difficulties; consequently controlled fabrication and or machined from solid has to be considered especially when electro-polishing is called for to minimise surface pathogens.

Extended requirements can include CIP (Clean-In Place) ability and features / testing to guarantee maintenance of minimum OEL (Operator exposure Levels) emissions when dealing with toxic pharmaceutical products.

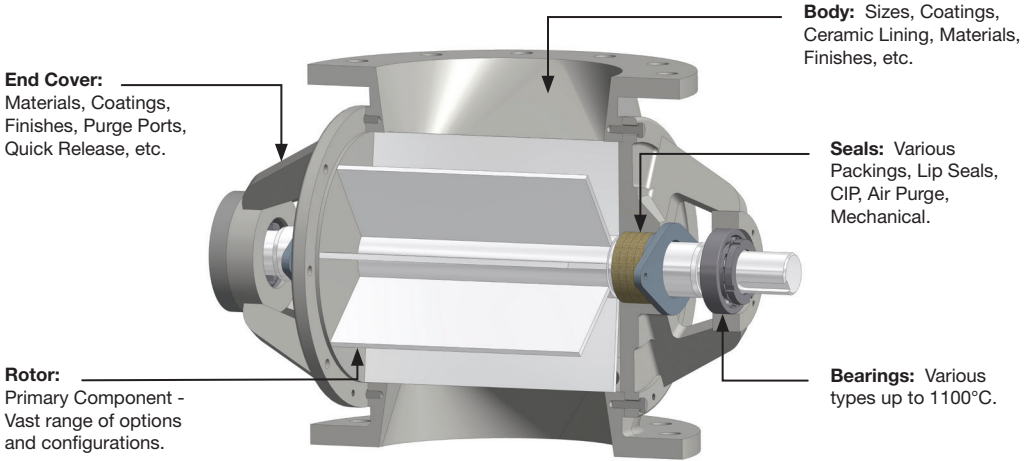
USDA and FDA standards are the most commonly adopted standards globally.



FIGURE 3. 600mm bore valve undergoing ATEX testing (For explosion/flame containment validation by Notified Body)

5. COMMON VALVE CONFIGURATIONS

FIGURE 4. Cross-section of basic valve



Standard Inline inlet & outlet



Blow Through – Blowing Seal
For direct connection in pneumatic conveying pipelines



Offset inlet & outlet
To minimise damage to granular solids



'Fast clean' type
For regular safe internal cleaning



'Hypergienic' type
Dedicated for 'High end' Pharmaceuticals

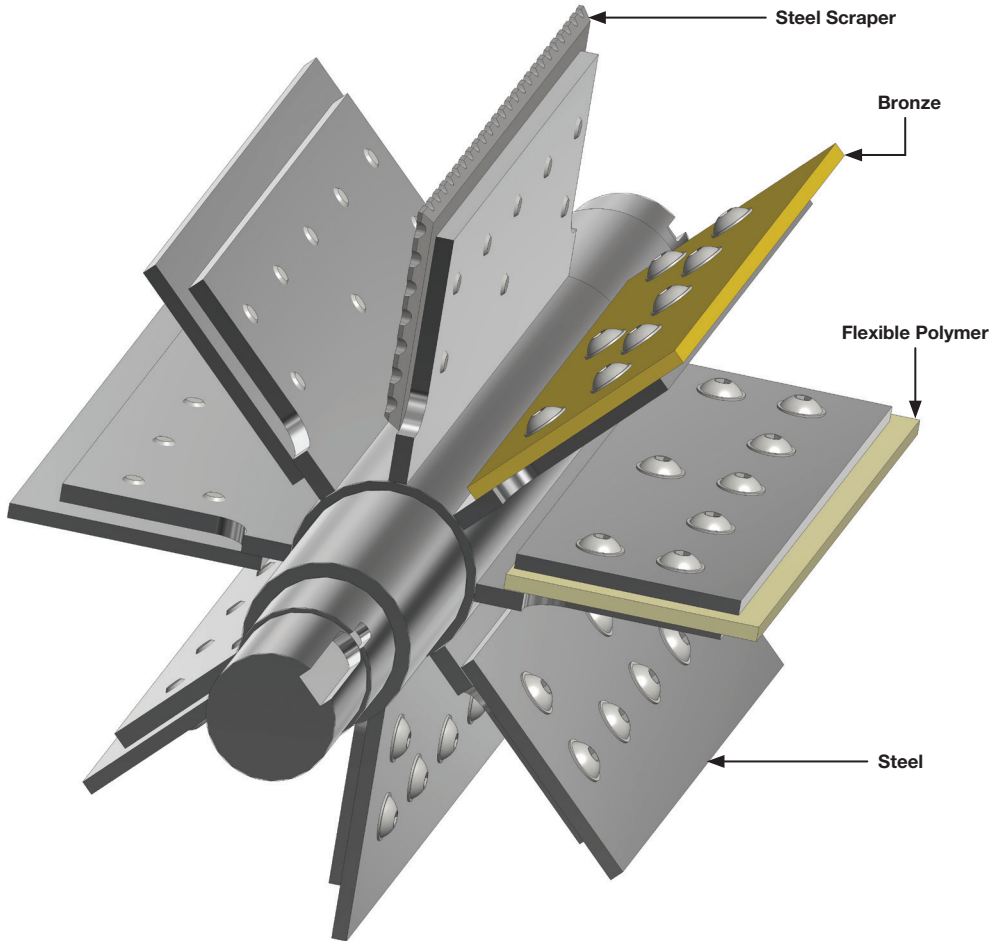


Fabrication examples

FIGURE 5. Replaceable Blade rotor sample options

Replaceable blades provide solutions for dealing with some difficult product characteristics. They also provide for in-situ adjustment to be able to run at minimum clearances and therefore leakage.

It is commonly assumed that they are included to provide adjustment to compensate for wear, however this is not the case as wear is never even.



Common Blade Types

Steel - For abrasion resistance – Hardened Steel up to around 160°C; Hard Alloy above.

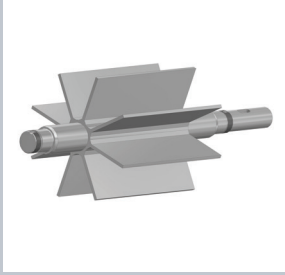
Stainless Steel - for corrosion resistance and sterility.

Phosphor Bronze - for close clearance operation for minimal leakage requirements.

Scraper - for products that compress and build-up on the swept surfaces to minimise torque loads. Predominately needed for food and plastic applications requiring Stainless Steel construction.

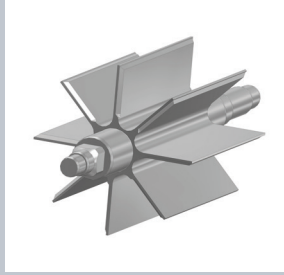
Flexible - (variable material options) low cost option for non-friable granular products. Generally confined to low pressure differential applications.

6. COMMON ROTOR DESIGNS



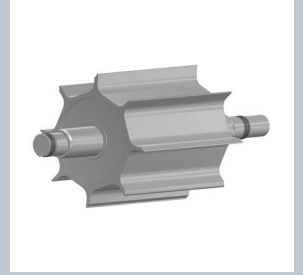
Open Fixed Vane

Basic component for products that do not exhibit difficult handling characteristics.



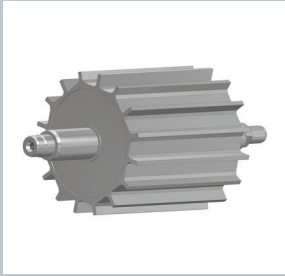
Open Fixed Chamfered

For product that tend to smear.



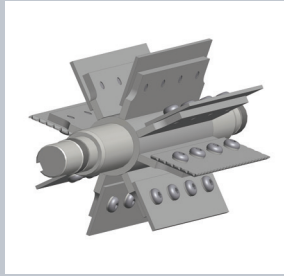
Reduced Capacity

For accurate control.

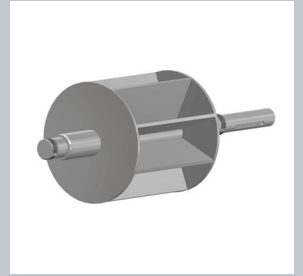


Reduced Capacity Multi-Vane

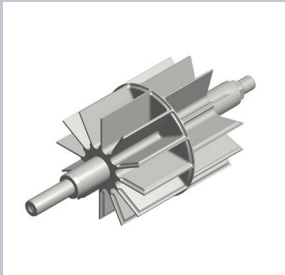
Where product have very poor flow characteristics requiring an abnormally large inlet throat.



Replaceable Blade – See page 16.

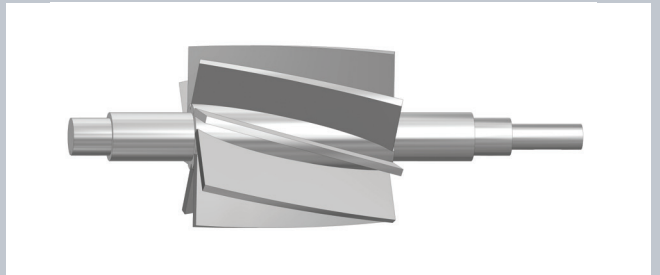


Closed



Staggered Pockets

For discharge into twin outlet.



Helical

Increased shear angle or reduced pulse discharge.

7. DRIVE ARRANGEMENTS

Normally rotary valves are driven via a geared motor unit either directly or via a chain and sprocket drive connection – See Figure 6 and Figure 7. The Chain drive is the most popular for two reasons:

1. It provides easy speed change on site to calibrate the throughput, although this is somewhat limited on the smaller sizes of blowing seals – See page 15, due to the limited space for the rotor sprocket.
2. By rating the chain size against its ultimate breaking strain it can be set to be used as a crude safety overload protection. (It is usual for customers not to fit a positive overload protection device due to cost and potential for abuse by operators).

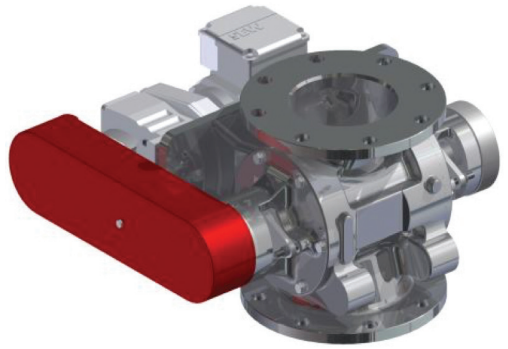


FIGURE 6. Valve complete with chain drive

Valves designed for regular dismantling for internal cleaning are normally fitted with direct drive units to facilitate easy withdrawal of end covers.



FIGURE 7. Valve fitted with direct drive unit (Helical type)

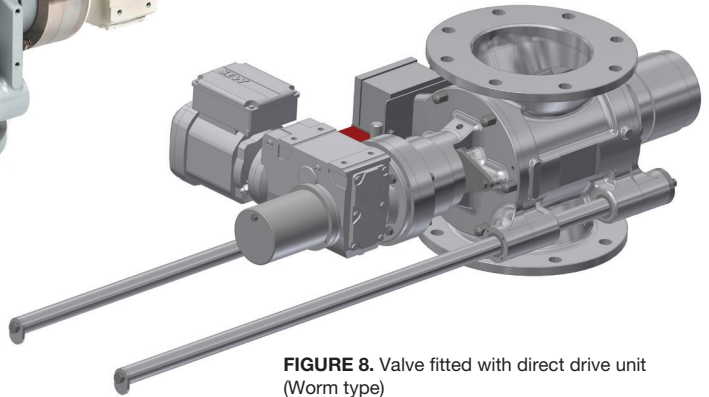
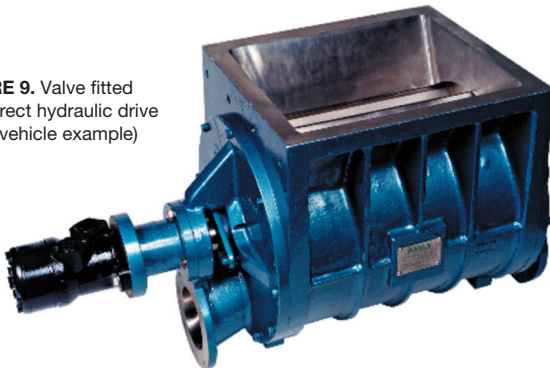


FIGURE 8. Valve fitted with direct drive unit (Worm type)

FIGURE 9. Valve fitted with direct hydraulic drive (Road vehicle example)



8. ACCESSORIES

Common accessories include:

- Non-rotation detection
- Speed monitors
- Safety switches on easy clean valves
- Variable speed control
- Pressure regulators and flow meters for air purge seals
- Seal leakage monitoring
- Rotor pocket purging equipment (to assist product discharge)
- Positive overload protection (shear pin or proprietary torque limiting devices)

An important development has been the introduction of rotor contact detection.

FIGURE 11. Some common sealing options

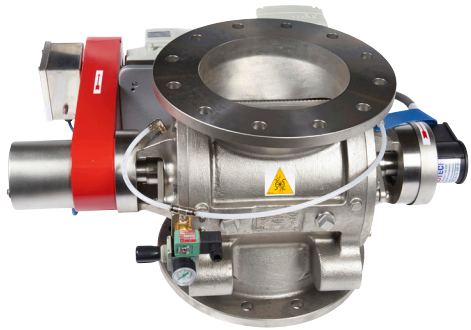
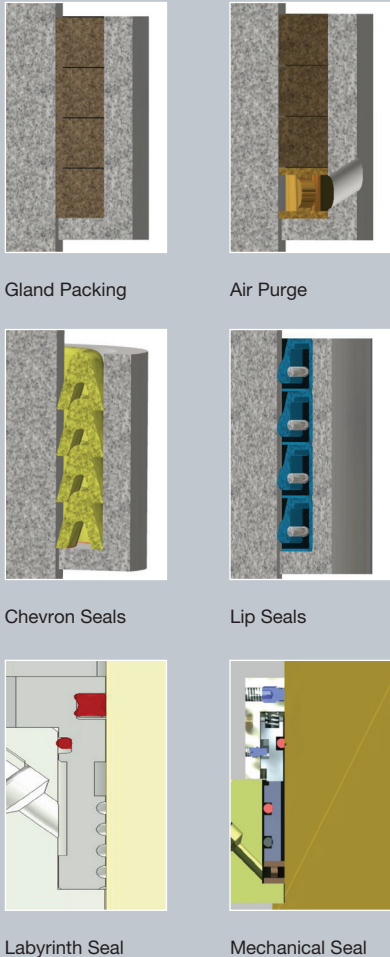


FIGURE 10. Valve fitted with RotaSafe RM2™, Air Purge Set, and Speed Monitor

The **RotaSafe RM2™** monitor is designed to instantly detect any contact between the rotor and housing and will isolate power to the drive motor, stopping the valve before serious damage can occur¹. It is also designed to detect circuit failure and power is also isolated should this fault occur.



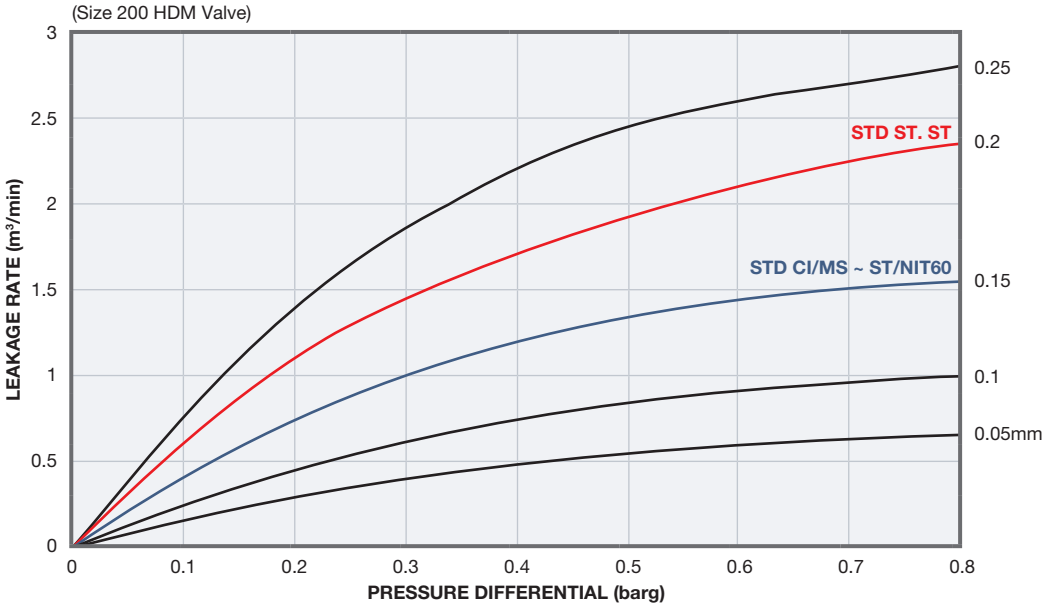
The **RM2™** is intrinsically safe, therefore, it can be used in hazardous areas when required.

Contact can occur due to:

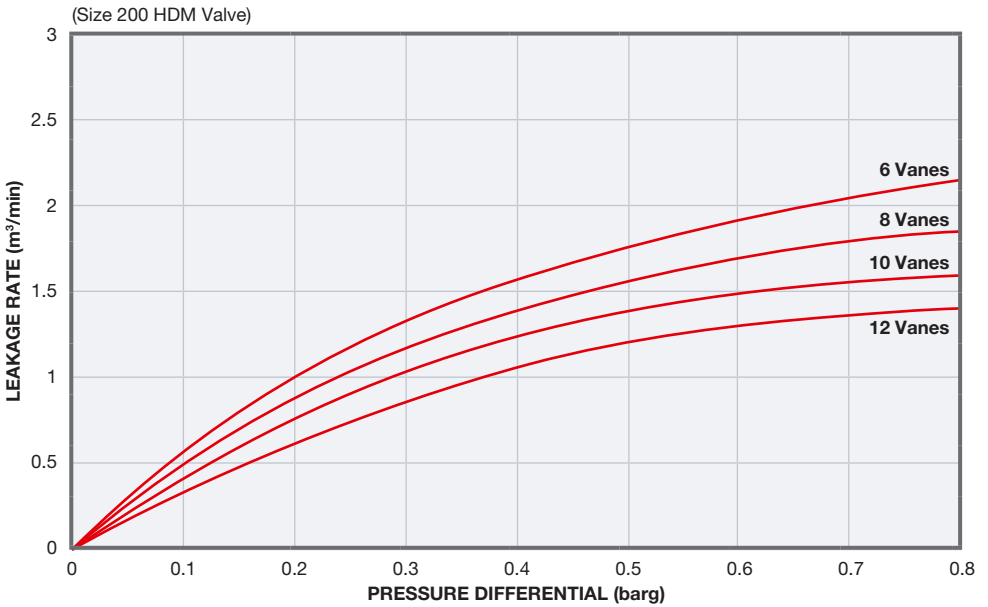
- Rotor deflection from overload due to particle entrapment or excessive system pressure.
- Metallic particle entrapment.
- Bearing failure.
- Incorrect valve reassembly following cleaning or maintenance.

1. If an Autonomous Safety Device – See page 14 has suffered damage, then this will very likely invalidate its status. Any contact with electro-polished working surfaces included to minimise the risk of attachment of pathogens would compromise the valve in meeting that requirement.

GRAPH 2. Effect of Clearances



GRAPH 3. Leakage Factors – Number of vanes (clearance 0.15mm)



9. PERFORMANCE FACTORS

9.1 Valve Clearances

The escape of gas through the operating clearances is the major component of leakage – See 9.2 page 23, consequently they need to be kept as small as practical.

Final clearances are a compromise between achieving minimal leakage yet wide enough to deal with:

- Presence of product.
- Avoiding contact between rotor and housing due to deflection from high loads caused by larger particle entrapment.
- Deflection due to high operating gas pressures.
- Operating temperatures.

Graph 2 shows leakage values at different clearances; it should be noted that changes in clearance does not produce a linear change in leakage values; another reason to keep clearances as small possible.

The graph also shows that the 'standard' clearance for a cast iron housing / steel rotor is set for 0.15mm and for stainless construction it is 0.2mm, the latter due to the greater risk of damaging contact should conditions give rise to it.

Graph 3 shows how leakage is reduced by fitting rotors having extra vanes. However extra vanes reduce the filling efficiency so needs to be applied with care.

Apart from the operational reasons listed above, there needs to be an allowance to provide for manufacturing tolerances.

Where there is minimal pressure differential then wider clearances can be provided to help avoid close clearance problems.

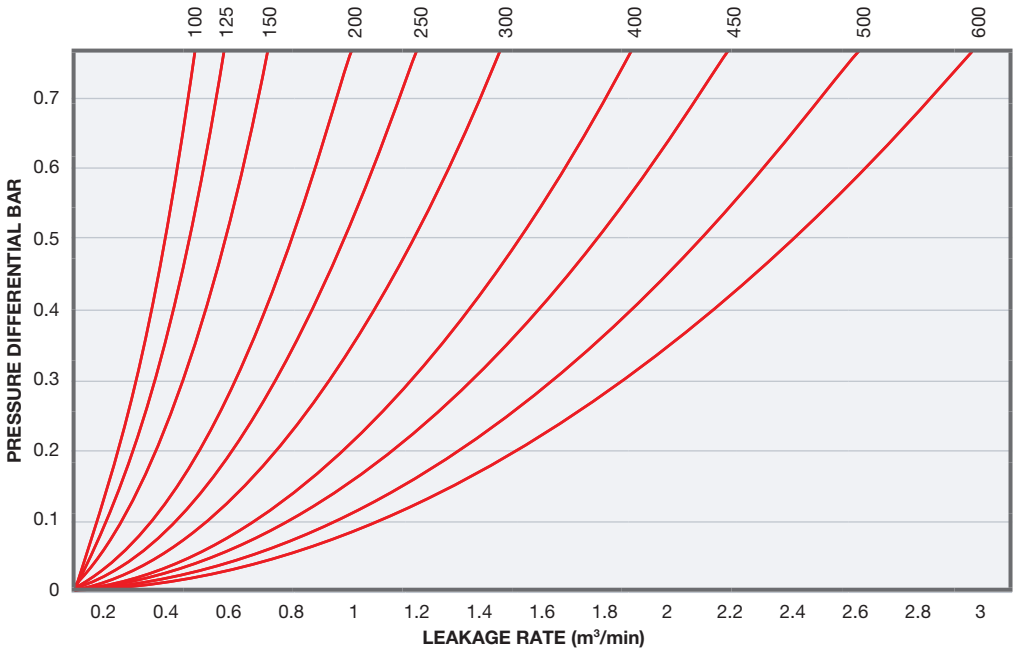
If faced with higher operating temperatures, initial clearances will need to be increased to allow for greater rotor expansion due to its lighter construction relative to the housing, such that they return to the preferred clearances when the valve has achieved a uniform temperature condition.

Where the rise is sudden e.g., the impact of hot product when first entering a valve at ambient temperature then further allowance needs to be applied.

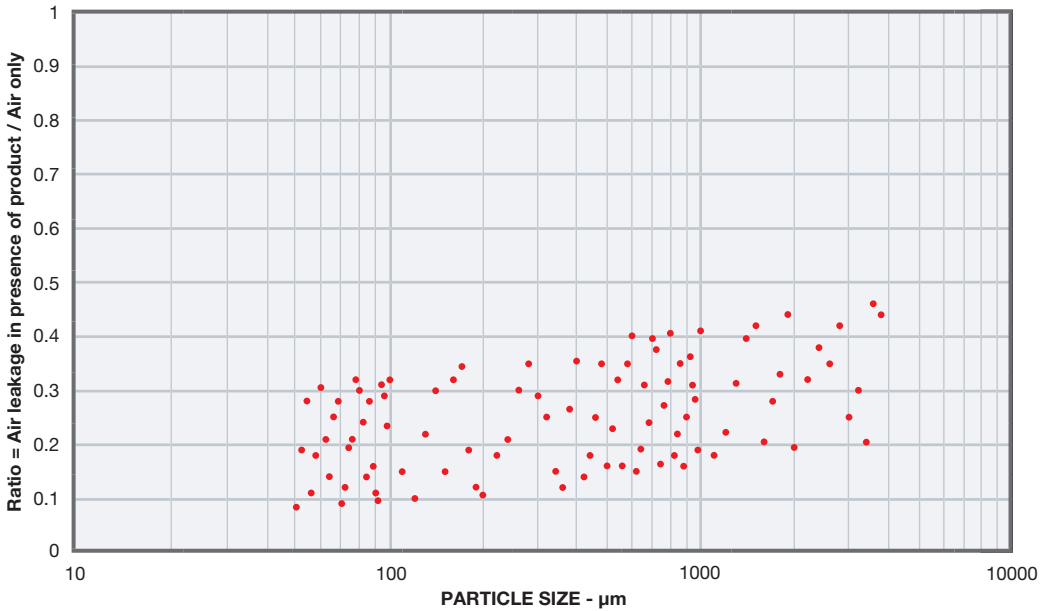
NOTE! If valve is an Autonomous Safety Device – See page 14, then the minimum number of vanes must be 8 and the maximum clearance must not exceed 0.3mm at any time.



GRAPH 4. Total leakage - air only



GRAPH 5. Effect of material present in and above the valve on reducing air leakage (As a function of particle size)



9. PERFORMANCE FACTORS - CONTINUED...

9.2 Leakage

Understanding leakage is an important part of the expertise in supplying rotary valves for any system.

Whenever a valve is discharging a product against a pressure differential, gas leakage will occur:

1. As displacement from product entering the empty rotor pockets
2. By transfer of higher pressure gas in the returning empty pockets
3. By escaping high pressure air through the operating clearances.

In operation, all factors combine to create a total leakage value as indicated in **Graph 4**. However, these values have been achieved by testing through a clean valve without product but in practice they will fluctuate due to operating variations in system pressures and conditions.

Nevertheless, these values are recommended to be used when specifying other related equipment e.g., compressors, exhausters, filtration units etc.; to ensure that they are adequately sized to provide a tolerance to meet any performance changes in the valve during operation and any wear and tear.

Most influential is the presence of product which has a significant mitigating effect on leakage, referred to as the 'Blocking Factor'; the effect of this is shown in **Graph 5**.

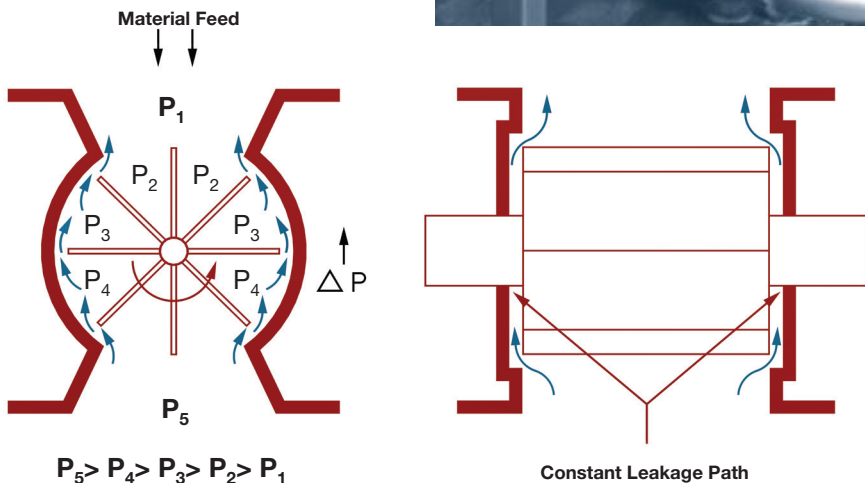
Feeding Pneumatic Conveying Systems

Feeding positive pressure pneumatic conveying systems represent around 50% of valve applications and are the most common for high pressure applications.

The previous arrangements are descriptive only as much will depend on the detailed construction of the feeding hopper. Leakage is relative to conveying line loading so ensuring reliable stable product flow through the valve is critical. Cyclic and erratic overall performance is likely if there are weaknesses in the selection of valve or design of the system as a whole.



FIGURE 12. Leakage paths



9.3 Venting

Understanding leakage is an important part of the expertise in supplying rotary valves for any system.

The lighter and finer the product, the greater will be the likely need for venting of leakage at the inlet throat so as not to impede product flow. Venting is primarily the responsibility of the system designers, as it will need to be provided for within their equipment.

As it is usually difficult to provide venting retrospectively, it must be determined whether to vent or not from the outset.

Whether to vent or not needs careful consideration!

Unvented leakage air can help some products to flow by means of fluidisation.

Venting adds a physical restriction in the throat. The consequence of this is that in some cases a larger than necessary valve will be needed or external means of creating product flow will have to be added.

Where the valve is handling potentially abrasive (erosive) products under flood conditions, the presence of a head of product above the valve will greatly suppress the leakage through the valve and therefore reduce the effect of the products erosive quality. The degree of suppression is a combination of the head of material, bulk density and permeability of the product, and the pressure differential. It is not unusual to set a low level control in a high position in the feed vessel to use this to minimise and possibly eliminate wear within the valve.

A badly designed vent will compromise system performance.

In many cases venting is simply unnecessary and only adds cost and aggravates the ability to clean equipment, particularly where hygiene or product contamination is an issue.

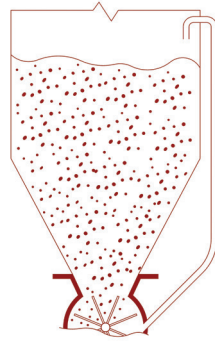


FIGURE 13. Active Vent

Normally used where the hopper is at the receiving end of a Vacuum conveying system. Pipe diameter must be just small enough to convey carryover product back into the Hopper.

FIGURE 14. Passive Vent

Plenum chamber and vent duct size must be large enough not to carryover product particles.

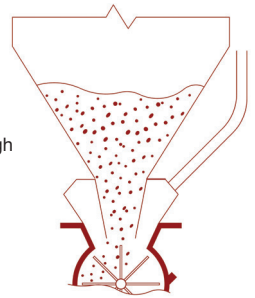


FIGURE 15. Integral vent - passive

Best to avoid back flooding due to product fluidisation.

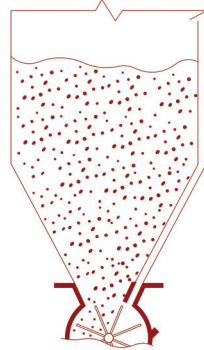
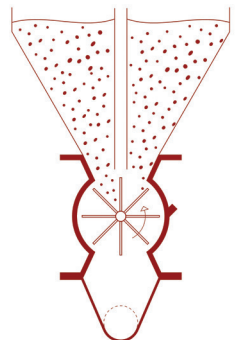


FIGURE 16. Pressure Relief Pipe

Suitable for both pressure relief and vacuum discharge Hoppers (also acts as a natural bridge-breaker).



10. DEALING WITH ABRASION

Valves can be affected by abrasion in two specific ways:-

- 1. Mechanical attrition** where product particles are sufficiently large to be drawn round within the valve clearances and are sufficiently hard to abrade the surfaces.

Provided the particles can 'roll' through and or are sufficiently friable then most often the life of the valve can be managed by wear resistant surface coatings and hard material components. The final construction chosen will depend on the character of the particles i.e., hardness, surface profile etc., and system conditions.

- 2. High Velocity Erosion** occurs when powder particles are entrained in the leakage air escaping through the clearances when operating under a high-pressure differential.

If unsuppressed, leakage velocities in the clearances can be as high as 140mtrs/sec so even some products that are not normally be classes as abrasive become so.

See Figure 17 and Figure 18.

Matters are further aggravated by much of the product arriving at the most abrasive approach angle of around 3° – See Figure 20

In such cases surface coatings are rarely offer much protection as once breached the conditions then rapidly erode the softer construction base.

If a Rotary Valve is the preferred choice for duty, then the requirement is for the working surfaces to be replaceable, wear resistant components that provide for both extended life and for on-site replacement when necessary – See Figure 19.

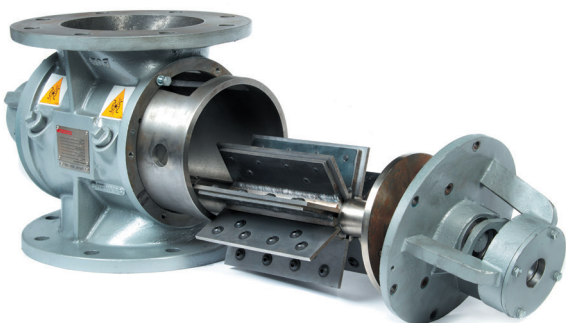


FIGURE 19. EHD showing sacrificial wear components

Providing extra life and on-site refurbishment.

Examples of wear components

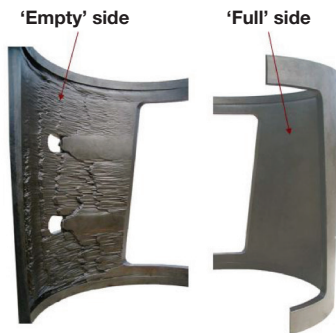


FIGURE 17. Wear pattern – Bore liner

Split to show wear pattern. Full side where product blocks leakage.

Empty side where residual carryover product has free passage through the clearances at high velocity.

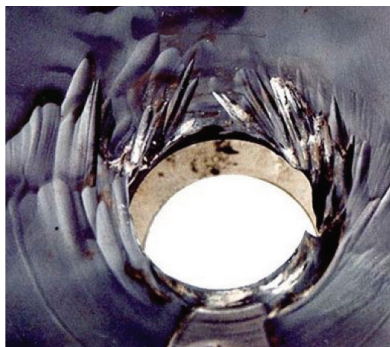


FIGURE 18. End Cover Wear

Velocity erosion at Shaft Seal area where leakage is constant.

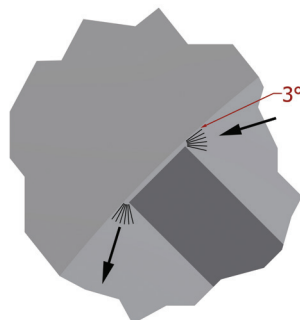
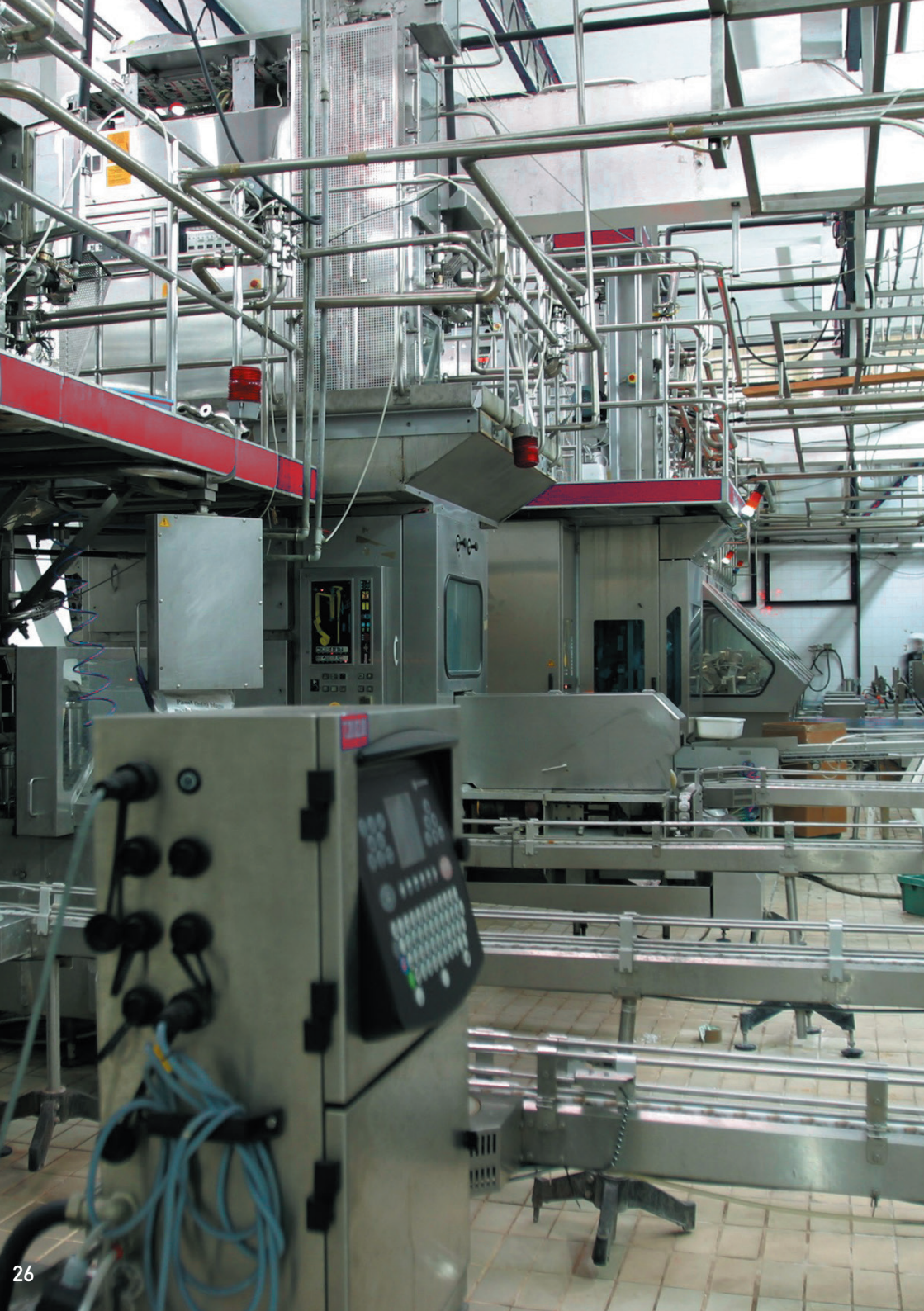


FIGURE 20. High velocity erosion



11. FOOD & PHARMACEUTICAL APPLICATIONS

Fortunately, most food and pharmaceutical products have physical characteristics that are easily managed and the basic internal construction of the valve in this regard can remain relatively simple, with the focus on high standards of hygiene and safety.

This can include:

- Very high standards of surface finish up to and including electro-polishing to significantly reduce the presence of pathogens.
- Guaranteed homogenous flaw free materials of construction.
- Detailed design to minimise difficult to clean areas.
- Easy, contact-free withdrawal and return of internal components for cleaning that ensures the safety of the operator and eliminates the risk of damage of the components and surface finish – **See Figure 21.**
- Clean-in-place (CIP) shaft seals.

While virtually all valves in the pharmaceutical industries are of stainless steel, in many cases the food industry can use standard valves and construction especially where the product has either self-sterilising or preserving qualities such as sugar or salt based products, or are subject to further processing by temperature.

Any such standard will normally be specified by the customer, however many users now require stainless steel, as a matter of good practice.

As abrasion is not normally an issue, relieved rotor vane tips are normally incorporated as standard; this minimises the drive torque requirements by reducing the tendency for some products to smear and build-up on the working surfaces.

Most food, pharmaceutical, and chemicals are organic and are potentially explosive in fine particle form and are therefore subject to the ATEX Directive requirements to act as an 'Autonomous Safety System' – **See page 14.**

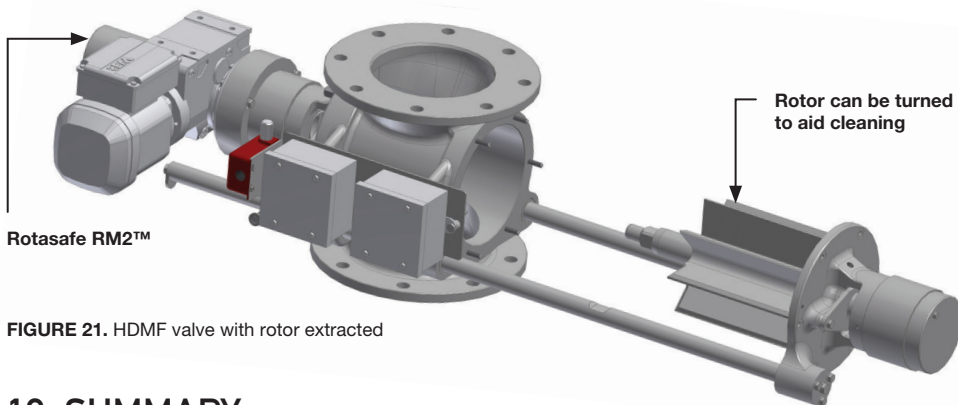


FIGURE 21. HDMF valve with rotor extracted

12. SUMMARY

- Rotary valves do not create product flow; but only pass such product that can fall into it and out of it under gravity.
- All rotary valves leak air (or gas) when the system is operating (regardless of whether there is a pressure differential or not) and this can affect product flow and system performance.
- The faster the rotor speed, the lower and more erratic the filling efficiency.
- The greater the air pressure differential across the rotor, the less predictable and less stable will be the filling efficiency.
- The performance of a rotary valve can be affected by the design and performance of the system in which it is incorporated, and vice versa.
- The selection of valve speed and size is not a precise science and takes into account the various factors that may negatively affect its performance from the theoretical maximum.

Notwithstanding the above the majority of applications are simple and needs well established however, unless prior experience dictates, all applications will be carefully vetted against the customers application details, and valve specification chosen accordingly. Given that this is done then there are very few products and applications that cannot now be satisfied.

FINALLY

Successful valve selection remains a combination of calculation, empirical data, and experience based keen judgement.



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