EXPLANATION OF A ROTARY AIRLOCK VALVE

Rotary airlocks are referred to by many different names. Some are appropriate, and some are not. There are three appropriate names which are universally accepted when referring to this product. Technically, they all refer to a similar device in terms of design and appearance. These are:

1. Rotary Feeder
2. Rotary Valve
3. Rotary Airlock

Most suppliers and users are familiar with all these terms. We will focus on the term ‘rotary airlock’ for the purpose of this discussion. To further identify the name ‘rotary airlock’, we will define the two separate terms.

ROTARY---Refer to Illustration 1B and locate the vanes and pockets. The word ‘rotary’ refers to the fact that during operation of a rotary airlock, the vanes turn or rotate. As they turn, the pockets, which are formed between the vanes, become rotating pockets. The material being handled enters the pockets at the top, through the Inlet port, travels around in a rotating motion, and exits at the bottom, or through the Outlet port. As the vanes and pockets continue to turn, material continues to be moved from top to bottom, or from Inlet port to Outlet port, in a rotating motion.

AIRLOCK

Refer to Illustration 1C. The word ‘airlock’ means that this device is to act as a seal, or lock to the air, between the Inlet and Outlet ports, while moving material in a continuous rotating motion through its pockets. Material travels downward from Inlet port to Outlet port, but airflow is restricted. To provide a reference in discussing airflow through the rotary airlock, we have notated a 10 PSI air pressure on the Outlet port side. The air pressure, in this example, is trying to push airflow up through the rotary airlock. If the air were allowed to flow upwards, the material...
entering the Inlet port would be restricted and less material would be moved.

Not all rotary valves or rotary feeders can be classified as ‘rotary airlocks’. But almost all rotary airlocks can be classified as both rotary valves and rotary feeders, depending on the interpretation. The term ‘airlock’ is very significant when used as a classification. The requirement of a rotary airlock to move material continually, and maintain a constant air pressure or vacuum difference between the Inlet and Outlet ports efficiently, presents one of the greatest challenges to most rotary airlocks.

Consider the complications involved. A rotary airlock must be capable of moving various materials when there is an air pressure or vacuum on either the Inlet port or Outlet port, or both. The airlock application considerations are not to be taken lightly. While simple by design, airlocks are a very important element in material conveying and processing systems. An improperly applied airlock can lead to poor efficiency, extra maintenance and operator manpower, product degradation, equipment wear and replacement, and lost production due to process shutdowns. The annual cost of any of the deficiencies could easily exceed the cost of the equipment. To properly apply a rotary airlock, it’s important to know and understand all of the variables related to rotary airlock performance.

6, 8, & 10 VANE ROTORS
A rotary airlock ‘rotor’ has been called by many names, such as paddle wheel, impeller, flipper, blades, pockets, etc. For clarification and reference, it’s important to establish some common terminology when discussing rotary airlocks and related components. The rotor is the part of the airlock that turns. It can be called the rotor assembly, because it is a combination of blades and shaft welded together. Refer to Illustration 2A

The vanes are the metal plates, or blades, that are welded to the shaft to form the pockets. If the rotor assembly is a ‘6 vane rotor’, then 6 vanes, or blades, are welded to the shaft. An ‘8 vane rotor’ has 8 vanes and a ‘10 vane rotor’ has 10 vanes. Illustrations 2C, 2D, & 2E represent cross-sectional end views of 6, 8, and 10 vane rotors.

The pockets between the vanes carry the material that the rotary airlock is to handle. As the rotor turns, the pockets fill at the Inlet port, travel around
and down the body, or housing, and dump at the Outlet port. They travel back up to the Inlet port, where they are filled and start the cycle over again. Refer to Illustration 2F, 2G, 2H, & 2I

Illustration 2F

Illustration 2G

Illustration 2H and 2I

It’s important to note that when the vanes and pockets rotate from the Inlet port to the Outlet port, they are said to be on the ‘load side’ of rotation. As they travel from the Outlet port to the Inlet port, they are said to be on the ‘return side’ of rotation. The body of the airlock, or area surrounding the rotor, is called the housing. The housing is made with the same contour as the rotor vanes. It’s the quality and consistency of the fit, or relationship, between the housing and the vanes that determine the rotary airlock’s ability to perform properly.

Refer to Illustrations 2C, 2D, & 2E. Consider the positions of the 6, 8, and 10 vanes, as they relate to the housing. The 6 vane rotor has two vanes in close contact with the housing at any point during its rotation. The 8 vane rotor has 4 vanes in close contact with the housing, and the 10 vane rotor has 6 vanes contacting the housing at any one point during the rotation.

Generally speaking, the more vanes the rotor has, the better its ability to seal pressure differences between the Inlet and Outlet ports. When comparing the 6 vane rotor to the 10 vane rotor, it could be said that the 10 vane rotor has three times the sealing potential, since it has triple the number of vanes in contact with the housing at all times. An 8 vane rotor offers greater sealing potential than the 6, but less than the 10 vane rotor.

The other big difference resulting from the number of vanes on the rotor, is the size or capacity of each pocket. The pockets are largest on the 6 vane rotor, and decrease in size as more vanes are added. When pressure differences between the Inlet and Outlet ports are low, or not critical to the function of the airlock, the wider pocket openings on the 6 vane rotor can offer advantages over the 10 vane, depending on the material being processed. For example, larger sized items, such as peaches, potatoes, carrots, etc. processed in the food industry, are best handled with wider pocket openings. Additionally, materials that tend to pack together, or are slightly tacky in nature, tend to release easier from a larger pocket opening.

At a given RPM of the rotor assembly, a 6 vane rotor pocket will typically fill at a greater percentage rate than a pocket on a 10 vane, providing the pressure differences between the Inlet and Outlet ports are low or insignificant during operation. Materials that tend to be ‘free flowing’ will be less affected by the number of vanes, as to pocket fill percentage, than a material that is ‘slow flowing’. Another factor affecting the flow rate percentage comparison is the weight density of the material measured in pounds per cubic foot. Heavier materials will be affected less
by the number of vanes than lighter materials. With these two combinations, it could be said that the heavier, faster flowing materials will maintain greater pocket fill rates whether a 6 vane or 10 vane rotor is used. However, regardless of the weight and flow characteristics of any material, a greater percentage of pocket fill will usually be realized with a 6 vane rotor compared to a 10 vane rotor at a given RPM of the rotor assembly.

An 8 vane rotor offers compromises between 6 vane and 10 vane rotor designs in all of the above examples and comparisons. There are applications where the nature of the material is best handled with either a 6 vane or 10 vane, but with few exceptions, an 8 vane rotor provides the greatest compromise of features and benefits.

In summary, the applications and circumstances will dictate the preferred number of rotor vanes. Most rotary airlock manufacturers offer some form of 6, 8, or 10 vane rotor construction. While all three designs have their own unique characteristics, the most common design available for a broad range of material applications is the 8 vane rotor design.

OPEN-END AND CLOSED-END ROTORS
Illustration 3A represents an open-end rotor assembly. Illustration 3B represents a closed-end rotor assembly. Most rotary airlock manufacturers offer both styles, and there are few minor differences from one manufacturer to another. To understand the operations of these rotors, one must imagine the rotor mounted inside an airlock housing. The relationship of the vanes to the housing surface dictates many variables, including wear and performance. The most common rotor assembly design is the open-end style which refers to the open pocket at each end of the rotor. When this style is used, the pockets developed between any two vanes is contained on both ends by the rotor assembly of the end plates of the airlock housing. Material processed through an open-end rotor design comes in contact with the housing bore and the inside surfaces of both end plates of the housing assembly. As the material travels through the rotary airlock, it rubs against these three surfaces. As a result, the vanes develop three tip areas – the vane tips adjacent to the housing bore, and the vane tips on each end of the open ends of the rotor assembly. Therefore, when referring to the rotor tips on an open-end rotor assembly, it's important to note all three tip areas as being rotor vane tips.

The tolerances of clearance on an open-end rotor between its tips and adjacent surfaces are applicable to all three areas. In other words, if the tips of the rotor vanes adjacent to the inside of the housing bore should have .004" clearance, then the tips on
each end of the rotor vanes adjacent to the housing end plates should also have .004” clearance.

On an open-end rotor, wear occurs where material processed comes in contact with the tips and adjacent surfaces. The wear to these three tip areas may not be of the same severity by comparison, but all three will wear.

With the pockets of an open-end rotor being open to each of the two end plates of the housing, the rotor assembly shaft seals touch the material being processed. As the material within each pocket is directed around the inside of the airlock housing, it tends to migrate towards the rotor shaft seal area. Depending on the particle size, abrasive nature of the material and pressure differences between the Inlet and Outlet ports, the end plate seals become subject to failure. On most open-end rotors, there is nothing to restrict the material being processed from migrating to and through the seal, except the seal itself. Thus, the ability of the airlock to contain the material without leakage depends on the performance of the seal. Material is continuously being wiped against the seal by the rotor vane tips, making it exceptionally vulnerable to wear.

Refer to Illustration 3B for a closed-end rotor assembly. In contrast to the open-end design, the closed-end rotor has plates attached to each end and closes the pocket areas on those ends. On a fabricated rotor assembly, the plates are usually welded to each end of the vanes. In the case of a molded or cast rotor construction, the plates are molded or cast as part of the rotor assembly. In either case, these two plates are referred to as shrouds.

By enclosing the ends of the pockets rotating in the airlock, the wear surfaces are reduced from three to one. This one wear surface is the housing bore, thus eliminating the two housing end plates as rotor tip wear surfaces.

This design also isolates the material being processed from the rotor shaft seal, eliminating that as a source of wear and failure.

In summary, in its simplest form, a closed-end rotor assembly offers improved performance capabilities over open-end rotors when wear and pressure differentials are likely to create problems to the flow of the material being processed. While open-end rotors should be considered when the material is not abrasive, flows easily, and there are very slight pressure differentials, any circumstances beyond these criteria could easily require the use of a closed-end rotor.

**CAUSES OF WEAR AND ABRASION TO ROTARY AIRLOCK VALVES**

Among the leading causes of rotary airlock valve failures is wear to either rotor, or housing, or both. Wear of these components occurs during use. Since a rotary airlock valve is primarily a material handling device, it is subject to erosion and abrasion created by the material being processed. The proper selection of one rotary airlock valve for an application depends, to a large extent, on the nature and characteristics of the material being processed; and how the material is being processed.

From an overview, rotary airlock valves are used in material processing applications ranging from flour to rocks, plastics to potatoes, dust to detergents, peanut hulls to cotton seed, carrot tops to salt, coal to rice, wood chips to aluminum shavings, and many, many more materials too numerous to mention. Some of these materials are abrasive, some are not. Those that are abrasive are not necessarily equally abrasive by comparison. There are, of course, other considerations for each material other than abrasion, but our focus for this discussion is going to be on the abrasive characteristics and their effect on the airlock components.

Wear, due to abrasion, from a material being...
processed through a rotary airlock valve can be divided into two types:
1. Surface drag abrasion
2. Pneumatic assisted abrasion

SURFACE DRAG ABRASION
This term refers to abrasion created by materials being ‘dragged’ and/or ‘trapped’ between two surfaces moving in opposite directions. Or, abrasion created by moving or pushing an abrasive material using one surface against another. In a rotary airlock valve, it is a mechanical type of abrasion created as the rotor assembly rotates around the housing wall, dragging the material against the housing wall surface and trapping the material between the rotor assembly tips and the housing wall, thus trying to ‘crush’, or overpower, the resistance of the material to move smoothly.

Refer to Illustration 1
This illustration shows a cut-away view of a rotary airlock valve with a hopper type feeder attached to the Inlet port a non-pressurized container provided under the Outlet port of the airlock. The shaded area shown in the hopper, airlock valves, and container represent material processed through these pieces of equipment.

In this example, it’s easy to see that any wear to the airlock housing wall would occur on the load side. The load side refers to that area of the housing where the material passes from the Inlet port, around the inside surface of the housing wall, and exits out of the Outlet port. The vanes of the rotor assembly would be loaded during this portion of the rotation, thus developing the load side of the airlock housing. As the rotor assembly continues to rotate, the rotor pockets ‘dump’ into the Outlet port and continue around toward the Inlet port of the return side.

If the material in this example were abrasive, there would be potential for surface drag abrasion to the housing wall on the load side only.

The rotor assembly in this example would have potential for surface drag abrasion against all surfaces, particularly the ‘land’ area of the rotor vane tips.

Since the rotor assembly is in constant rotation, each rotor vane tip will come in contact with the processed material on the load side of the airlock housing wall for each complete revolution. If an open-end rotor assembly were provided in this example, each of the two end plates would be subject to surface drag abrasion as well. Material would be dragged and/or trapped between the rotor vane ends and each end plate. There would be little, if any, abrasion on the return side of the end plates.

If a closed-end rotor assembly were provided in this example, the ‘shrouds’, or vane plates provided on each end of the rotor assembly, would eliminate rotor vane ends. Consequently, with a closed-end rotor, only the ‘shroud’ or vane plate’s edges are considered abrasion surfaces.

It’s important to get a clear understanding of the potential wear surfaces subject to surface drag abrasion in both open-end and closed-end style rotor assemblies. Doing so will help in determining when to use either style of rotor assembly on a given application. As a rule, a closed-end rotor generally provides advantages over an open-end rotor on abrasive material applications. However, an
open-end rotor will suffice if the particle size of the material being processed is larger than the clearance tolerance between the rotor and housing and end plates. But, an open-end rotor airlock will still be subject to more wear than a closed-end rotor airlock by comparison.

**PNEUMATIC ASSISTED ABRASION**

Refer to Illustration 1B

One of the most destructive causes of the rotary airlock valve wear is due to abrasion created by ‘blow-by’ or ‘turbulent’ air developed at the Outlet port of the airlock valve when used on a pressure style pneumatic conveying system. Whether the airlock valve body is a ‘blow-thru’ style airlock, or an airlock valve has a ‘blow-thru’ adaptor attached to the Outlet port flange, conveying air traveling through either of these areas create undesirable turbulence and misdirected conveying air energy. The misdirected air is that which tries to force itself up through the rotary airlock valve rotor and housing toward the Inlet port area. This is commonly referred to as ‘blow-by’ air, or ‘air leakage’. By itself, this misdirected air can create material flow problems and blower efficiency loss. It also becomes a vehicle for abrasion, and as such, it provides the force behind ‘pneumatic assisted abrasion.’

In general, pneumatic assisted abrasion only occurs when the conveying air is a pressure style system. The greater the pressure within the airlock Outlet port area, the greater the available force to air turbulence.

As the pockets of an open-end style rotor rotate from Inlet port to Outlet port, the material within the pockets acts as a seal between the rotor, housing, and end plates. This being the ‘load side’ of the airlock’s rotation, little, if any, ‘blow-by’ occurs from the conveying air. But as the rotor rotates from the Outlet port to the Inlet port on the ‘return side’, the rotor pockets are empty. The clearance gaps between the rotor tips, housing wall, and end plates are the only seals to potential ‘blow-by’ air.

As the conveying air is trying to blow up through the airlock between the ‘return side’ clearance gaps, it will carry fugitive particles of processed material, thus creating a high speed ‘sandblasting’ effect across the rotor tips and around the housing wall. If the fugitive particulate is abrasive in nature, severe abrasion can occur over a short period of time. Even if the processed material is considered non-abrasive, it can develop abrasive conditions when traveling at a high rate of speed. Over a period of time, even non-abrasive materials can abrade and erode rotor tips, housing walls, and end plates. The result of the abrasion and erosion generally wears wider tolerances between rotor tips and housing surfaces, thus providing more area for ‘blow-by’ to occur and self-perpetuating additional wear.

This same development can occur with a closed-end rotor airlock valve. However, with a closed-end rotor design, ‘blow-by’ air can be greatly reduced between the rotor shrouds (vane end plates) and housing end plates using a well designed system of end plate air purging components. This approach uses air...
pressure piped through each of both end plates to offset or counteract the conveying air from blowing into these two areas. This method can restrict or reduce much of the ‘blow-by’ air and fugitive material from traveling through the airlock valve in these two areas. This ‘blow-by’ abrasion and erosion is then focused only on the rotor tips and housing wall. While these surface areas will eventually erode and result in greater clearance gaps between rotor tips and housing wall, the amount of ‘blow-by’ air allowed to pass through this area is less than what would be allowed through an open-end rotor assembly. The result would be less self-perpetuating wear with a closed-end rotor.

An additional wear area created by abrasion from ‘blow-by’ is that which can occur to rotor assembly shaft seals. Since ‘blow-by’ air seeks a ‘path of least resistance’, it will take a path of least restriction. Again, other than the loss of potential conveying air for the efficiency of the pneumatic system, ‘blow-by’ air through the rotor shaft seals creates little, if any, problems. But when accompanied with fugitive material particles, abrasion and eventual erosion to the rotor shaft seals can occur. This ‘blow-by’ through rotor shaft seals is self-perpetuating. As the ‘blow-by’ containing material particles develops a ‘path’ of travel through the seal assemblies, material particles traveling at a high speed can abrade the seal or become embedded into the seal components, eroding the seal away over a short period of time. Once rotor shaft seals begin to leak due to ‘blow-by’, or pneumatic-assisted abrasion, they can deteriorate very quickly.

Rotor shaft seals are usually more subject to ‘blow-by’ air abrasion with an open-end rotor than with a closed-end rotor because of the direct access to the seal area. A closed-end rotor, with end plate air purging, isolates the rotor shaft seals from most of the potential ‘blow-by’ and subsequent abrasion. Rotor shaft seal leakage can create mechanical failure to the airlock valve, by providing a path of fugitive material loss through the seals and into the rotor shaft bearings. Depending on the design of the valve rotor shaft bearings are said to be either INBOARD or OUTBOARD.

Regardless of the type or style of seal, the INBOARD style bearing design places the bearing assembly adjacent to the housing. With this design, fugitive material can be forced into the bearing assembly components when there is air leakage. There is nothing to keep this fugitive material out of the bearing assembly other than the bearing seals. If the seals fail, due to abrasion or erosion, the bearing assemblies can become contaminated and fail to operate. This results in downtime, major repair or replacement of the valve, and production loss.

In contrast, regardless of the type or style of seal, the OUTBOARD style bearing is separated from the housing and provides a ‘gap’ or path for fugitive material to escape to the surrounding area without passing into or through the bearing assembly. That’s not to say that this totally eliminates the possibility of bearing contamination. Given the specific style of bearing assembly and rate of fugitive material leakage, failure can still occur. However, the potential for contamination and failure of the bearing assembly is greatly reduced.

As a result, the OUTBOARD bearing designed valves are highly recommended for applications where potential for ‘blow-by’ exists. If the seal assembly fails, the material passing through the seal will generally travel through the relief ‘gap’ or ‘path’ separating the seal and bearing assembly, and migrate to the surrounding area without damaging the bearings components. The cost to replace only the seals is much less than replacing the seals and bearing, or the entire airlock valve, as could be the case with an INBOARD bearing designed airlock valve. Rotor shaft seal failure usually results in product loss,
efficiency losses to both available conveying air and blower pressure, rotor shaft bearing failures, and ultimately the failure of the airlock valve completely. This results in downtime, repair or replacement costs, and production losses.

SUMMARY
In summary, wear due to abrasion can be divided into two types – surface drag abrasion and pneumatic assisted abrasion. Surface drag abrasion is that which is caused by the moving, rubbing, pushing, or dragging of abrasive materials along and/or between surfaces, creating erosion to these surfaces. Pneumatic assisted abrasion is that which is created by either abrasive or non-abrasive material being mixed or entrained within a turbulent air stream and then passing by, or against, surfaces at high speed to create a ‘sandblasting’ type of surface erosion. Typically, this air stream is referred to as ‘blow-by’ and only exists when a pressure style pneumatic conveying system is attached to the Outlet port (or Inlet port in some cases) of the rotary airlock valve.

Surface drag abrasion usually only occurs on the ‘load side’ or Inlet-to-Outlet port side of the rotor assembly rotation. Pneumatic assisted abrasion usually only occurs on the ‘return side’ or Outlet-to-Inlet side of the rotor assembly rotation.

The potential causes of wear due to abrasion should always be considered carefully when airlock valves are applied to a product flow system. Failure to consider these causes of wear is to invite premature failure of any rotary airlock valve and related production problems.

SPECIAL BLOW-THRU ADAPTOR CAN SOLVE ‘BLOW-BY’ AIR
Rotary airlock valves have been a primary component in pneumatic conveying systems for many years. Whether in a pressure or vacuum style system, rotary airlock valves serve as a barrier or ‘lock’ to pneumatic conveying air loss while, at the same time, provide a material handling function.

In many of today’s industries, greater demands are being placed on pneumatic conveying systems. Consequently, there are increased demands being placed on the various rotary airlock valves used within these systems. Since the rotary airlock valve is an important and primary component to a pneumatic conveying system, its performance is critical to the overall efficiency of the system.

A pressure style pneumatic conveying system is potentially more abusive to its interconnected components and rotary airlock valves than a vacuum style system. A common problem which is encountered is ‘blow-by’ air through the airlock valve. The requirements of an airlock valve, in this type of application, are:
1. To meter and/or feed product from a hopper or bin into a pneumatic conveying line
2. To restrict or prevent conveying air from blowing up into the hopper or bin
While most rotary airlock valves are expected to perform both of these requirements, it’s the prevention of conveying air blowing through the airlock valve that is the most difficult. However, if the ‘blow-by’ air can be restricted or eliminated, efficiencies in three areas usually develop:
1. Improvement in product flow increases capacity
2. Improvement to available conveying air improves production with less blower loss
3. Wear to the rotary airlock valve rotor and housing is reduced. Refer to Illustrations 2A and 2B.

IAC has been supplying systems that utilize a more effective ‘baffle style’ blow-thru adaptor which addresses this ‘blow-by’ problem. By design, it creates a negative pressure on the Outlet side of the airlock valve, thus eliminating ‘blow-by.’ We have found this style of adaptor to be compatible with varied applications, and it provides a higher degree of protection against abrasion, than the typical ‘blow-thru’ adapter. This design is critical to the efficiency of a conveying air system, and prevents the ‘blow-by’ air before it becomes a problem or element to overcome.

When coupled with the properly designed airlock valve, our adapter creates a venturi type vacuum within the ‘blow-thru’ adaptor pocket. This specially-designed, pressure differential baffle eliminates the potential for ‘blow-by’ air to develop. In fact, the vacuum negates the ‘blow-by’ and helps draw the product out of the airlock rotor vanes, channeling it into the conveying piping. The product material is then blown away from the airlock valve body and rotor vanes. Refer to Illustration 2D.
When a rotor assembly is manufactured, the machining of the vane tips is accomplished with a lathe turning operation. The rotor assembly is turned at a high rate of speed and the surface finish of each tip is produced. The tip width has a slight convex or radius surface equal to the overall diameter of the rotor vanes.

Refer to Illustration 3A

The width of the surface area of the tip is equal to the thickness of the vane material. A vane that is ¼” thick is said to have a ¼” plain tip, a 5/16” thick vane is said to have a 5/16” plain tip, and so on. Because a plain tip is as wide as the vane material, it has the greatest surface area adjacent to the housing wall surface. This surface area provides the greatest potential sealing area for each vane tip. With the vane tip being uniform, the rotor assembly can turn in either direction – CW or CCW. If a plain tip rotor vane is manufactured as an open-end rotor assembly, both ends of each vane are machined with flat surfaces equal in width to the thickness of the vane material. On a closed-end rotor assembly, the edge surface of each shroud is flat and as wide as the thickness of each shroud plate.

Refer to Illustrations 3C & 3D

The trade off of positive conveying air, to develop this vacuum energy, is a slight pressure drop across the ‘blow-thru’ adaptor. While this drop does exist, it is very minimal. With a 2” diameter conveying line, and an air velocity of approximately 3200 FPM, there is a 1/3 PSI drop across the ‘blow-thru’ adaptor – a very small price to pay for the benefits gained. Tests of this product support increased production, increased conveying air available, and less wear to the valve components – all desirable benefits to any system.

ROTOR TIPS
One of the most significant features of a rotary airlock valve is the selection of a rotor assembly vane tip design. Following is the varied selection of vane tip designs which IAC offers.

PLAIN TIP
Refer to Illustration 3A
The most common of all rotor vane tips is the plain tip. This has been a standard tip design for many years. The plain tip offers three primary advantages:
1. It is the lowest in cost to produce
2. It offers the greatest sealing potential of pressure differential between the rotor vane tip and the housing
3. It’s rotor assembly can rotate in either direction – CW or CCW
or compress it tight enough to cause excessive wear to the rotary valve and/or cause the rotor assembly to lock tight and become inoperable. Materials such as plastic resins, powders, chemicals, processed grain products, rock dust, coal dust, and many other similar materials may not process well through a rotary airlock valve utilizing plain tipped rotor vanes.

**FIXED-RELIEVED TIP**
As shown in Illustration 3E, the fixed-relieved vane tip provides a narrower width of tip area than a plain tip. This narrower tip is produced by relieving part of the vane tip area with a beveling procedure. The fixed-relieved vane tip offers three primary advantages.

1. Good sealing potential when there is a pressure differential between the Inlet and Outlet ports of the airlock valve
2. Less material entrapment between rotor tips and housing wall surface
3. Less friction and heat caused by entrapped material, which can cause product deterioration

Illustration 3E shows a 1/8” fixed-relieved tip. The flat or ‘land’ area of the vane tip is produced using the same manufacturing procedure as the full width plain tip. The ‘relieved’ portion is produced using a secondary technique which creates the bevel on the edge. The combination of these two surfaces

A plain tip can work well with dry products, such as flour, grain dust, etc. It can offer advantages in sealing potential when handling the materials where pressure differentials between the Inlet and Outlet ports of the rotary airlock valve exceed 10 PSI.

The biggest drawback to the plain tip is its use in applications where the material being processed is sticky or can develop an adhering quality due to friction, or heat from friction. As the rotor vane tip rotates, material can become trapped between vane tips and housing and momentarily develop enough pressure or heat to break down the material.
is typical of fixed-relieved tip designs. The pitch of the beveled surface is not critical, as long as it is significant enough to provide a good relief area.

Illustration 3F shows a 1/16” fixed-relieved tip. The only difference between it and the 1/8” fixed-relieved tip is the width of the ‘land’ or flat area.

When an open-end rotor is produced with a fixed-relieved rotor vane tip, both ends of each rotor vane are machined with fixed-relieved surfaces to match the vane tip’s design. On a closed-end rotor assembly, the edge surface of each shroud is machined with the same fixed-relieved design to match the vane lip’s design, with the ‘relief’ or bevel to the outside of each shroud edge. Refer to Illustration 3G

A fixed-relieved rotor vane tip will work well with a wide variety of materials. Even with higher pressure differentials between the Inlet and Outlet ports of the airlock, it offers a good sealing capability. This sealing capability is slightly less than the plain tip, but the added advantage of a wider range of material applications, reduction of product degradation, and the reduced friction heat generation makes it an excellent choice. It works well with grain products, dust, fly ash, coal dust, as well as a wide variety of plastic powders, resins, food products, and many, many more applications – too numerous to mention.

The one drawback to the fixed-relieved rotor vane tip design is the tolerance clearance considerations between the rotor vane tips and the airlock housing wall surface. The clearances allowed require a slightly closer machining tolerance than does the plain tip design, for equal sealing capability. Where a plain tip gap tolerance might be .005”, a fixed-relieved tip gap tolerance might require .001” to .0035” to provide comparable sealing with higher pressure differentials. This tighter gap tolerance, however, also has the added advantage of improving product processing, creating no product breakdown due to frictional heat build-up.

**ADJUSTABLE TIP**

Refer to Illustration 3H

An adjustable tip is an add-on vane tip usually bolted onto the vane and designed to be adjustable closer to or away from the airlock housing. This allows for an opening or closing the gap between the tip surface and the housing wall surface.

Since this adjustable tip is an add-on component, it can be made from a wide selection of materials. These include carbon steel, stainless steel, tool steel, brass, aluminum, and other similar materials. Usually
ferrous or non-ferrous metals are used, but nylon, UHMW, Delrin, and other similar polymers have been used as well.

The adjustable tips are available in plain tip, fixed-relieved, or knife edge design designs. This results in many useful options, but there are a few limitations. For example, when an adjustable tip is provided on an open-end style rotor assembly, they are mounted on the vane tip adjacent to the housing only. The vane tips on both ends of the rotor assembly are fixed. Consequently only one of the three rotor tips is equipped with the adjustable add-on.

Another drawback to adjustable tips is their potential to become ‘out of adjustment’. Setting the tip clearances can be very time consuming and requires accuracy if the tip is to perform efficiently. In short, there is no easy or simple procedure for maintaining adjustable tips. Also, these tips are generally more expensive, but are sometimes the only option for an efficiently working system.

FLEXIBLE TIP
Refer to Illustrations 3I & 3J

There are probably as many different designs of flexible tips as there are manufacturers of rotary airlock valves. Most designs are simpler and less costly to produce than a machined rotor assembly. A flexible tip rotor could have 4, 6, or 8 vanes. A 10 vane assembly is a rarity.

IAC offers several different flexible tip designs. Refer to Illustration 3I

The ‘fabricated’ rotor design utilizes a flexible material, usually ¼” thick, that is ‘sandwiched’ between formed metal plates that are then bolted together to form the vane portions of the assembly. In this design, a type of open-end rotor is developed with the flexible material extending on all three vane tip areas, adjacent to the housing wall and both ends. This design is utilized in applications where little or no pressure differential exists across the Inlet and Outlet ports, and when temperatures are in the ambient range.

This ‘fabricated’ rotor assembly design is also utilized in various machined housing rotary airlocks where the normal machined tipped rotor assemblies will not suffice, due to specific problems.

Refer to Illustration 3J
The second type of flexible tip mounts the tip material, usually 1/8” or ¼” thick to a modified machined type rotor assembly along the vane tip
area adjacent to the housing wall surface. Using a rigid back-up plate, the flexible tip is attached to one of the vanes using threaded fasteners. This is considered to be a high pressure flexible tip. High pressure in this case refers to air pressures from 0-15 PSI. Therefore, when a flexible tip airlock is required and the pressure differential across the Inlet and Outlet ports exceeds the acceptable limits of the fabricated rotor assembly flexible tip shown in Illustration 3I, this style is required. It is applicable on both open-end and closed-end rotor assembly designs.

**FLEXIBLE WIPER-SEAL TIP**

Refer to Illustration 3K

This is a slightly more flexible tip that is attached to the leading edge of a machined fixed-tip rotor assembly. It seals the tolerance, or gap, between the fixed-tip vane and the housing wall. It is generally used with a closed-end rotor, but can be used with an open-end rotor, if necessary.

This tip provides an excellent seal that closes the normal tip clearance of Class I .003”-.007” and Class II .008”-.011”. It wipes across the housing surface, moving the material, while at the same time forming a seal against air leakage. This design is particularly effective when higher pressure pneumatic conveying systems are utilized and the potential for excessive ‘blow-by’ exists. This wiper-seal tip is made from special polymers, with a temperature range up to 450 degrees, and is attached to the vane tip using a back-up metal plate.

**SUMMARY**

A rotary airlock valve can be equipped with a variety of rotor assembly tip designs. Each tip design addresses a particular problem or requirement of the application. Some are good for a wide range of applications, while others have limited applications.

Knowing which tip to use is more of an art, than a science. Many times experience with a specific product material, or similar material, is the only guide. Sometimes, with all the variables to consider within a system, this experience may not be enough to accurately determine the proper tip design. It is, however, a good place to start. These descriptions and illustrations are to help clarify various terms and applications, but can not completely cover the endless variety of configurations which are possible in the manufacture of rotor assemblies.