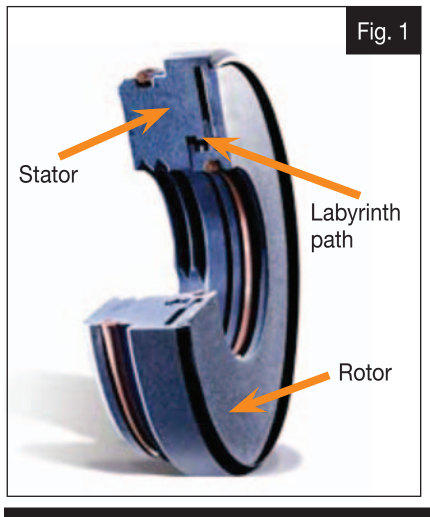
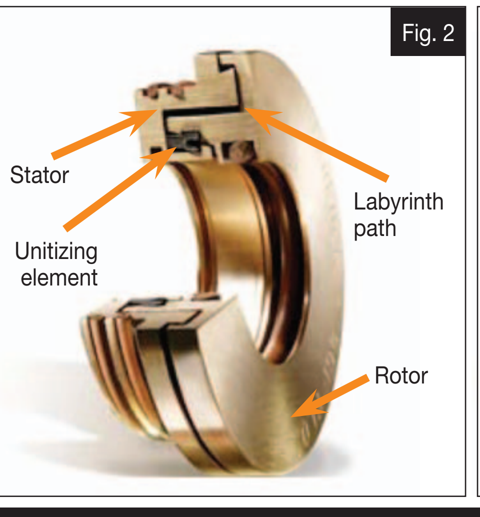
Seal of Approval

Hybrid bearing isolators, a.k.a. labyrinth seals, meet tough demands for sealing.

BY EARL ROGALSKI





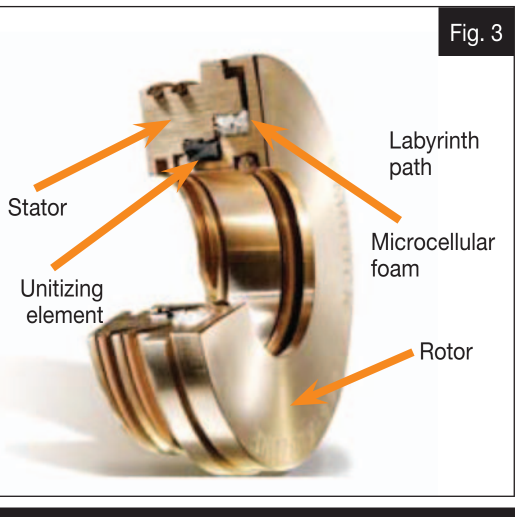


Fig. 1: Labyrinth bearing isolator. Fig. 2: Hybrid labyrinth bearing isolator with unitizing ring.
Fig. 3: Hybrid labyrinth bearing isolator with cellular foam material.

Dynamic sealing technology has continued to advance in recent years, changing from off-the-shelf radial lip seal commodities to high-tech engineered products. As asset uptime and governmental requirements become more and more demanding, the need for high-quality engineered sealing solutions increases.

Seal design advances include contact lip seals and non-contact labyrinth seals. For labyrinth seals, commonly known as bearing isolators, the intricate path and advanced design features are important factors to ensure consistent and reliable sealing. Understanding all of these factors will allow the user to make intelligent seal choices that will have a positive impact on equipment life, productivity and total maintenance costs.

Understanding labyrinth seals

Unlike elastomeric radial lip seals, labyrinth seals are relatively simple in theory. In standard designs, a labyrinth seal is nothing more than an intricate pathway with abrupt directional changes (see Figure 1). The intricate directional change creates a barrier that prevents ingress or egress of material, application lubrication, external fluids or airborne contamination.

However, new labyrinth seals, commonly referred to as hybrid labyrinths, are becoming popular. Hybrid labyrinth seals are essentially a combination of new sealing technologies with standard labyrinth technology. These new technologies consist of unique unitizing elements, hydrodynamic pumping features, cellular foams and/or liquid o-ring seals.

Hybrid labyrinth seals are typically chosen for technically challenging applications when standard labyrinth technology just won't work.

Figure 2 represents a hybrid labyrinth that uses a unitizing element to keep the assembly together while maintaining appropriate internal clearances. A common misnomer is that the unitizing element creates a seal barrier, but this is just not the case. The unitizing element simply prevents the rotor and stator from coming into contact with one another during operation, which prevents the potentially harmful generation of metallic particulates.

If contact between the rotor and stator were made during dynamic operation, the particulates generated would then contaminate the lubrication system and eventually lead to premature bearing failure, both of which are costly endeavours.

Figure 3 is yet another version of hybrid labyrinth seal technology. In this design, cellular foam is used in combination with standard labyrinth and unitizing technology to prevent contamination ingress.

The microcellular foam prevents ingress of airborne particulates or fluid by trapping the material into the outer surface of the cellular material. Airborne particulates are simply trapped, while liquid contamination is held via surface tension.

Although the cellular foam has limited capacity, once capacity is met, effective sealing will still occur as the foam will act as a permanent barrier.

Although this type of hybrid labyrinth is unique, it has been used successfully in highly c ontaminated environments when other sealing technologies simply will not work.

What defines the level of protection?

Many bearing isolator models conform to accepted standards for operation, including API, IEEE and NEMA. Understanding these standards, along with your requirements, is essential to ensure appropriate system protection.

API 610 is a standard for ANSI pumps commonly used in petroleum, heavy-duty chemical and gas industry services. API standards are published by the American Petroleum Institute body and are intended to provide fundamental standards for use by manufacturers and buyers alike.

Specific to labyrinth seals, API 610 indicates that bearing housings for rolling-element bearings must be designed to retain lubrication while preventing contamination ingress, all without additional facilities such as air purging. Acceptable sealing devices include replaceable labyrinth and magnetic face seals, while disallowing traditional contact radial lip seals. In addition, the materials used must be non-sparking should dynamic contact occur. The nature of this specification inherently limits the type of seal used and the selection of such.

IEEE 841, created and maintained by the Institute of Electrical and Electronics Engineers, defines the requirements for enclosures used in the petroleum and chemical industries.

Enclosures are defined as either Totally Enclosed Fan-Cooled (TEFC) or Totally Enclosed Non-Ventilated (TENV). Definitions are specified by ingress protection ratings as per NEMA MG 1, part 5.

NEMA, the National Electrical Manufacturers Association, designates the degree of protection provided by enclosures for rotating electrical machines. In addition, NEMA designates the test procedures used to determine if a machine meets the ingress protection requirements.

The IP rating designates two numeric identifiers for an enclosure's ability to protect against ingress. These characteristic numerals for the applicable ratings are, for example, IP55 or IP56. With the IP5 number, the number 5 specifies the ability to protect the machine from dust ingress.

To verify conformance, a labyrinth seal is installed in an enclosed environment. Talcum powder, sifted through a sieve with a nominal spacing of 75 µm, is agitated to create a talcum suspension replicating a dusty environment. Vacuum is generated to create air flow through the seal for a minimum of two hours. Ingress protection is determined if no accumulation of talcum occurs; i.e. there is no ingress of talcum through the labyrinth to the measurement side of the test fixture.

The second characteristic of the numeral 5 indicates a machine is protected against water jets. Conformance is verified by installing the labyrinth seal in an enclosed environment and subjecting the seal to a water spray from all practical directions. A water flow of 11.9 to 13.2 litres/min. (3.1 to 3.5 gpm) for three minutes with a minimum nozzle discharge pressure of 0.3 bar (4.4 psi) is used.

For the IP6 number, a characteristic of the numeral 6 indicates a machine is protected against heavy seas or powerful water jets. Again, conformance is verified by installing the labyrinth seal in an enclosed environment and subjecting the seal to a water spray from all practical directions. A water flow of 100 litres/min. (26.4 gpm) for three minutes at a minimum nozzle discharge pressure of 1.0 bar (14.5 psi) is used.

For either IP55 or IP56, the water must not limit the capability of the equipment.

Understanding how labyrinth seals function is imperative to ensure the appropriate seal technology is specified. Seal selection, when matched appropriately to the expected application and environment to which the equipment will be exposed, will directly have an impact on seal life, productivity and total maintenance costs.

Armed with this knowledge, users are encouraged to work with seal manufacturers to appropriately match seal technologies with application needs. **MRO**

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Case study: Harsh environment calls for upgraded seals

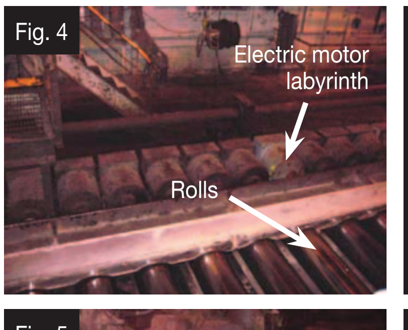
In the production of long steel products, it is often required to cool the newly rolled steel in an even and controlled method. A common solution is to allow the steel to roll through an open-air, liquid-cooling system on long run-out tables.

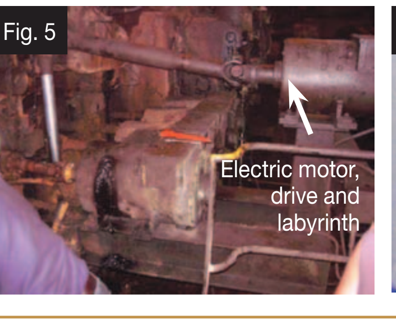
As the steel rolls across hundreds of rollers, a cooling solution is sprayed onto the steel (Fig. 4). The combination of controlled cooling and properly spaced rollers allows the steel to cool evenly and prevents physical distortion of the finished product.

During this cooling process, power transmission systems are often exposed to airborne contamination and oftentimes corrosive cooling solutions. The power transmission system, in this example, consisted of hundreds of rolling elements driven by variable-speed electric motors (Fig. 5). To control finished product quality, the electric motors were tuned to match the speed of the cooling steel. The electric motors were utilizing standard labyrinth seals but these were failing to provide adequate ingress protection — or they were failing prematurely.

Once it was determined that the original equipment labyrinth seals were not providing IP55 or better, a surface-mounted IP56 rated hybrid labyrinth seal was installed on each electric motor (Fig. 6). The upgrade of the original equipment labyrinth seal to an IP56-rated hybrid labyrinth seal solved the problem.

Once all the electric motors were upgraded, the run-out table was no longer a production issue, nor did it cause production downtime.





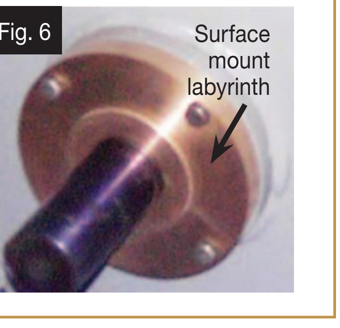


Fig. 4: Run-out table.
Fig. 5: Run-out table rolls.
Fig. 6: Run-out table rolls.