TB-118: A Comparison of Size 25 Encoders

Introduction

Size 25 shaft encoders (2.5” diameter), along with their size 58 (58mm diameter) European equivalents, are among the most popular encoders in the world. As a result, nearly every encoder manufacturer in the world makes them. That being the case, are there any compelling reasons to choose one over the other? This technical bulletin identifies and compares important features of Size 25 shaft encoders, including what we consider typical designs, and the EPC Models 725N and 725I.

Typical Size 25 Shaft Encoder

The typical construction for a Size 25 optical shaft encoder is shown below (Figure 1). In a rotary encoder, the disk is fastened to a rotating hub while the sensor is mounted to a fixed printed circuit board (PCB). Light passing through the disk pattern as it rotates past the sensor produces the signals that become the square wave output.

During design and manufacture, the air gap between the disk and sensor (Figure 2) is adjusted to calibrate the encoder in order to produce the optimal square wave. The air gap for typical Size 25 encoders can be as little as 0.002”, and for resolutions over 1200 CPR, the air gap can be even narrower.

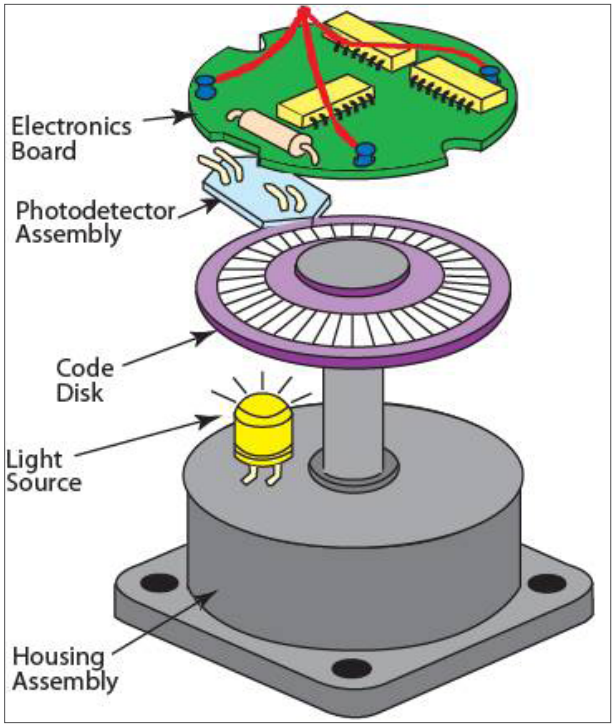


Figure 1

Weak Points of Typical Size 25 Shaft Encoder Design

- Narrow disk/sensor air-gap
- Thin glass disk
- Limited support of disk due to large diameter
- Vulnerability to shock, vibration, axial and radial shaft loads

This narrow air gap is a potential problem. Radial or axial loading can move the shaft in such a way that the attached disk can contact the sensor or other portion of the PCB. The resulting condition, known as disk-crash, usually renders the encoder inoperable or, at best, unreliable due to damage to the disk or sensor. In extreme situations, the disk can shatter.

The properties of the disk itself can also make it prone to failure. With typical sensor technology and manufacturing methods, the disk is made as large as possible and is a relatively thin 0.030” thick. The shaft hub that attaches to the disk supports just 15% of its total surface area, making it vulnerable to the slightest impact. These factors combine to increase the likelihood of disc fracture.

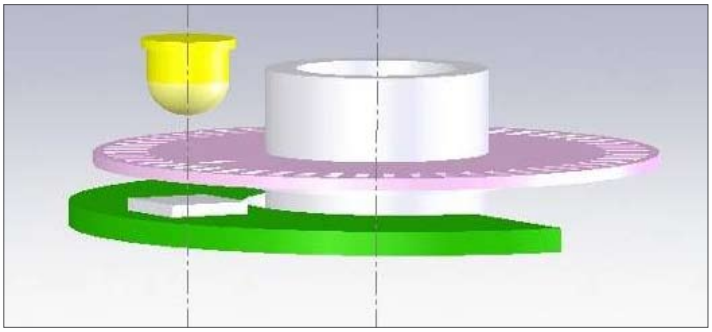


Figure 2

Improved Design: The 725N

The Encoder Products Company (EPC) Model 725N was engineered to address the weak points mentioned above. Two important constraints were part of the design process. First, solutions that would induce excessive costs were avoided. Second, the design needed to stay within the common Size 25 shaft encoder dimensions. The desired outcome was to be an encoder that would perform reliably in a wide range of operating conditions including heavy axial and radial shaft loads, shock, vibration, dust, dirt, moisture, and extreme temperatures. Also, the encoder should easily retrofit

encoders already installed in the field or be readily specified by OEM manufacturers without altering existing designs. The Model 725N meets all these objectives.

The 725N incorporates the following features to improve on typical designs:

1. *Increased Glass Thickness.* The glass used for the disk in the 725N is 0.062", more than double the thickness of what is used in the typical size 25 encoder. This fact alone dramatically reduces the chance of disk breakage. In addition, EPC uses a proprietary method of disk production that reduces the stress and propensity for chips in the glass. Both of these enhancements to the disk serve to increase performance and long term reliability.
2. *Smaller Disk Diameter.* The disk diameter is reduced from 2.00" to 1.30", minimizing the amount of deflection that can occur in the presence of radial shaft loading. Also, with the smaller disk, over 30% of its surface area is supported by the shaft hub, making it much more stable in the presence of shock and vibration. Even with this smaller disk, there is no compromise in encoder resolution or performance due to use of advanced disk manufacturing techniques and sensor technology. The 725N can be specified with a resolution up to 30,000 CPR and maximum frequency up to 1 MHz.
3. *Increased Air-Gap.* The 725N has a disk-to-sensor air gap of up to .004", almost double that of typical designs. This greatly increases the distance the edge of the disk would need to travel before it can possibly contact the sensor. Under most operating conditions, the risk of disk crash is extremely low.
4. *Heavy Duty Bearings.* Two large, rugged bearings carry the external shaft. The size 10 ABEC bearings are sealed and are rated for loads up to 80 lbs axial and 80 lbs radial. Due to the width of the bearings, a large portion of the shaft's length is supported, adding to the stability of the design. The bearings are secured in place by a mechanical lock.
5. *One-piece Housing.* The typical Size 25 shaft encoder often has a separate mounting flange that is bolted to the cylindrical housing. With the 725N, the flange and housing are machined from a single piece of aluminum stock. This design offers maximum strength and stability for the bearings and shaft.
6. *Sealing.* There are three potential points of ingress for contaminants to enter the encoder: the shaft, cover and connector. The 725N has an optional IP67 shaft seal with a novel double-lip design (Figure 3). In addition, a set of dual o-rings (Figure 4) are installed between the cover and housing. EPC connector options are all sealed to IP67. With the 725N, all three points of ingress are effectively sealed.

The design features of the 725N are also incorporated into a number of other EPC shaft encoder models including:

Model 702
Size 20 (2.0") incremental

Model 802
Size 20 (2.0") stainless steel incremental

Model 758
58mm incremental

Model 858
58mm incremental w/ stainless steel housing

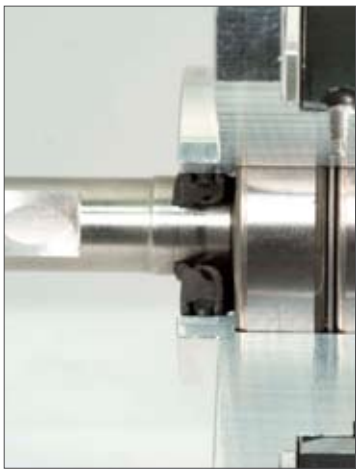


Figure 3

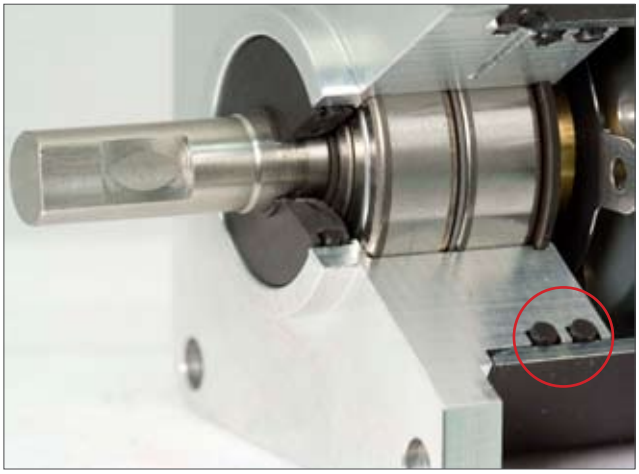


Figure 4

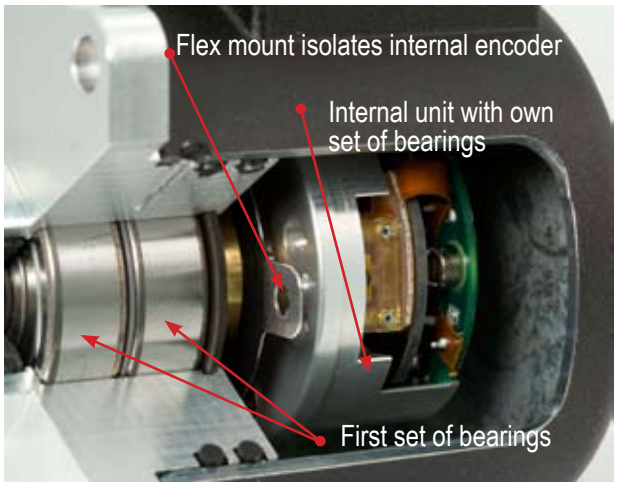
A Heavy Duty Solution: The Model 725I

While the 725N eliminated the weaknesses inherent in typical Size 25 designs, another alternative was developed that further enhances encoder performance and reliability. The Model 725I (the "I" stands for industrial) uses the 725N as a foundation upon which to build an extremely robust encoder, while still remaining within the target price category.

Model 725I shown with shaft seal.

The Model 725I has two primary and distinctive features that contribute to its ability to absorb shock, vibration and shaft loading with no adverse effects on function or performance:

1. *Internal Encoder Module.* The 725I employs an innovative "encoder-within-an-encoder" design. With this feature, the code-disk, sensor, and all signal processing electronics are enclosed in an internal module-- essentially a separate hollow-bore encoder nested inside. The external housing holds the same two heavy duty bearings as the 725N. However, the internal encoder also has another set of bearings, for a total of four. This additional level of isolation helps protect the disk, sensor and electronics from external hazards.



Model 725I close-up.

2. *Internal Flex Mount.* The internal encoder is mounted to the housing by means of a thin, flexible two-point tether. Thus, any damaging shaft loading is absorbed by the flexible tether and is not transmitted to the internal optics and electronics. This flexible tether feature, first developed by EPC in the 1970's, has been almost universally adopted by encoder manufacturers for the application of hollow bore or through-bore encoders to a rotating shaft. The 725I design is unique in that this concept is applied inside a shaft encoder.

Conclusion

When specifying a Size 25 shaft encoder, it's important to evaluate the potential hazards to the encoder. Heavy shaft loads, shock, vibration, dust and moisture can greatly reduce the operating life of ill-equipped encoders. Typical Size 25 shaft encoder designs are not adequate to provide long lasting, reliable feedback in such conditions. Thus, for demanding industrial applications, preference should be given to encoders that feature:

Improvements of the 725N vs. the Typical Design

- Wider disk/sensor air gap
- Thicker, stronger glass
- Greater support of disk area
- Heavy duty bearings
- Single piece flange/housing
- Sealing of all three ingress points
- Reduced vulnerability to shock and vibration

1. Heavy duty bearings
2. Wide air gap between disk and sensor (0.004" or more)
3. Small diameter disk (1.5" or less)
4. Thick glass (0.060" or better) or unbreakable disk material
5. Sealing for shaft, housing and connector
6. Adequate protection of internal optics, sensor and electronics from external hazards

For applications that present the most challenging operating conditions, consider using an encoder that completely isolates the disk, sensor and electronics such as the EPC Model 725I, which features an internal encoder module.

While the features listed above are desirable in an industrial duty Size 25 shaft encoder, manufacturers usually do not publish all of these specifications in their product literature. This can present a challenge when specifying an encoder. For example, short of physically examining a disassembled sample of the encoder, it may be difficult to determine the disk diameter or sensor/disk air gap.

Most manufacturers publish specifications for shock, vibration, shaft loading and environmental sealing. This information offers some measure of guidance for encoder specification. For industrial rotary shaft encoder applications, preferred ratings are:

1. Bearings: ABEC sealed bearings with load ratings of 40 lbs or better for radial and axial; 80 lbs preferred
2. Shock: Minimum 75 g @ 11 ms duration
3. Vibration: Minimum 20 g @ 58 to 500 Hz
4. IP Rating: Depends on application, but a minimum of IP65; IP67 preferred. Be sure to confirm that the published rating refers to the shaft and encoder housing, not just the connector.

While there are numerous choices for Size 25 shaft encoders, Encoder Products Company Model 725N and Model 725I meet or exceed the above preferred specification ratings.

The following chart summarizes features of the three designs discussed in this Technical Bulletin:

Feature	Typical Design	725N	725I
Disk diameter	2.00”	1.3”	1.3”
Disk thickness	0.030”	0.062”	0.062”
Disk surface area supported	15%	30%	30%
Bearings	2	ABEC, 2	ABEC, 4
Bearing load rating	10-20 lbs	80 lbs	80 lbs
Disk/sensor air-gap	0.002”	0.004”	0.004”
Internal encoder module	No	No	Yes
Vibration	Varies	20 g @ 58 to 500 Hz	20 g @ 58 to 500 Hz
Shock	Varies	75 g @ 11 ms duration	75 g @ 11 ms duration
Case/Housing Seal	None	Dual O-rings	Dual O-rings
Shaft seal	IP50	Up to IP67 Double-lip design	Up to IP67 Double-lip design

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