

# TB-118: A Comparison of Size 25 Encoders

Size 25 shaft encoders (2.5" diameter), along with their 58 mm diameter European equivalents, are among the most popular encoders in the world. As a result, nearly every encoder manufacturer in the world makes them. This technical bulletin identifies and compares important features of Size 25 shaft encoders, including typical designs, and the Encoder Products Company (EPC) Accu-Coder™ Models 725N, 725I and the programmable Accu-CoderPro™ Model 25SP.

## The Basics

The typical construction for a Size 25 optical shaft encoder is shown at right (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". For resolutions over 1200 CPR, the air gap can be even narrower.

This narrow air gap presents 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 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.

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. For demanding industrial applications, preference should be given to encoders that feature:

1. Heavy duty bearings
2. Wide air gap between disk and sensor (0.004" or more)
3. Small diameter disk (1.65" or less)
4. Thick glass (0.039" 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

Manufacturers often do not publish all of these specifications in their product literature. This presents a challenge when specifying an encoder. For example,

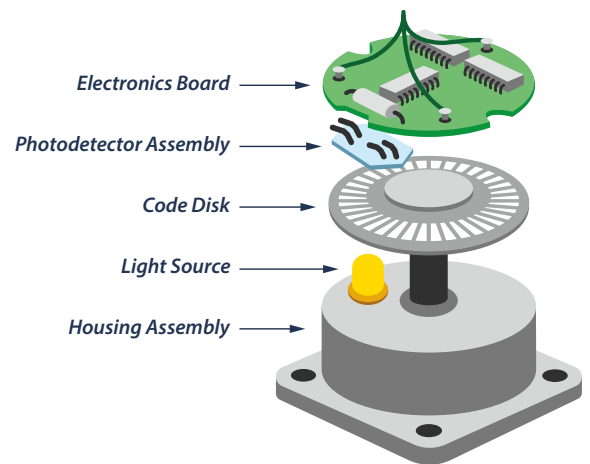


Figure 1

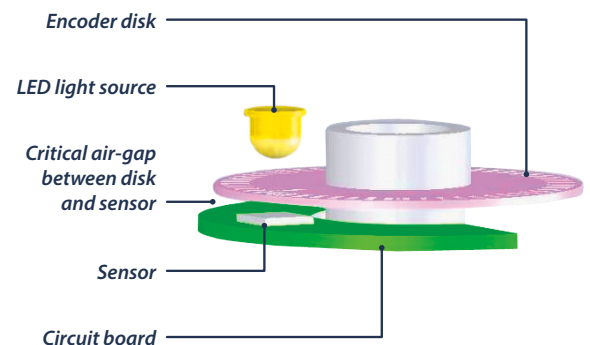


Figure 2

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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, however, do 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 rated 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.

### Improved Design: The Programmable Model 25SP

EPC's Model 725N was engineered to address the weak points that can affect a Size 25 shaft encoder's performance. This design was then used to develop the next generation Model 25SP, offering programmable features. With the Model 25SP, users may program the waveform, output type, and resolution to configure it to almost any application.

Two important considerations were part of the design process to develop the new, improved Size 25 shaft encoder. First, cost-prohibitive solutions were avoided. Second, the design was kept within the common Size 25 shaft encoder dimensions. The encoder would need to 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 needed to be a direct replacement for encoders already installed in the field, as well as a reliable option for OEM manufacturers that wouldn't require them to alter existing designs. The Model 25SP meets all these objectives.

The Model 25SP incorporates the following features to improve on typical designs:

1. **Increased glass thickness.** The glass used for the disk is 0.039", which is thicker than what is used in a 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 1.65" (rather than the common 2.00"), which minimizes the amount of deflection that can occur in the presence of radial shaft loading. Also, with the smaller disk, more than 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 Model 25SP can be programmed for any resolution from 1 to 65,536 CPR and offers frequencies up to 2.7 MHz, depending on the output type, which is also programmable.
3. **Increased air-gap.** The Model 25SP has a disk-to-sensor air gap of more than 0.005", almost double that of typical designs. This greatly

#### Model 25SP Accu-CoderPro vs. typical Size 25 shaft encoder 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

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increases the distance the edge of the disk would need to travel before it can possibly contact the sensor. With this air gap, 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 10 mm ID, size 6200 ABEC rated bearings 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 Model 25SP, 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 Model 25SP has an optional IP67 shaft seal with a novel double-lip design. In addition, a set of dual o-rings are installed between the cover and housing. With the Model 25SP, all three points of ingress are effectively sealed. All EPC connector options on the Model 25SP offer sealing to IP67.

**The design features of the Model 25SP are also incorporated into other EPC shaft encoder models, including:**

**Model 725N**

*Size 25 (2.50") incremental encoder*

**Model 702**

*Size 20 (2.00") incremental encoder*

**Model 802**

*Size 20 (2.00") incremental encoder with stainless steel housing*

**Model 758**

*58 mm incremental*

**Model 858S**

*58 mm incremental encoder with stainless steel housing*

### A Heavy Duty Solution: The Model 725I

While the design used for the Model 25SP 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) offers an extremely robust encoder, while still remaining within the target price category.

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 Model 25SP, 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.
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 1970s, has been almost universally adopted by encoder manufacturers for the application of hollow bore or thru-bore encoders to a rotating shaft. The 725I design is unique in that this concept is applied inside a shaft encoder.

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## Conclusion

While there are numerous choices for Size 25 shaft encoders, Encoder Products Company Model 25SP and Model 725I meet or exceed preferred specification ratings for encoders that go into the types of applications where a Size 25 Shaft Encoder is called for.

The following chart summarizes features of a typical design for Size 25 encoders, EPC’s Model 25SP, and EPC’s Model 725I:

Feature	Typical Design	25SP	725I
Disk diameter	2.00"	1.65"	1.30"
Disk thickness	0.030"	0.039"	0.062"
Disk surface area supported	15%	30%	30%
Bearings	2	ABEC rated, 2	ABEC rated, 4
Bearing load rating	10-20 lbs.	80 lbs.	80 lbs.
Disk/Sensor air gap	0.002"	0.005" minimum	0.004" typical
Internal encoder module	No	No	Yes
Vibration	Varies	20 g @ 5 to 2000 Hz	20 g @ 58 to 500 Hz
Shock	Varies	80 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

If you have additional questions, please contact EPC Technical Support at 800-366-5412 or email [techsupport@encoder.com](mailto:techsupport@encoder.com).