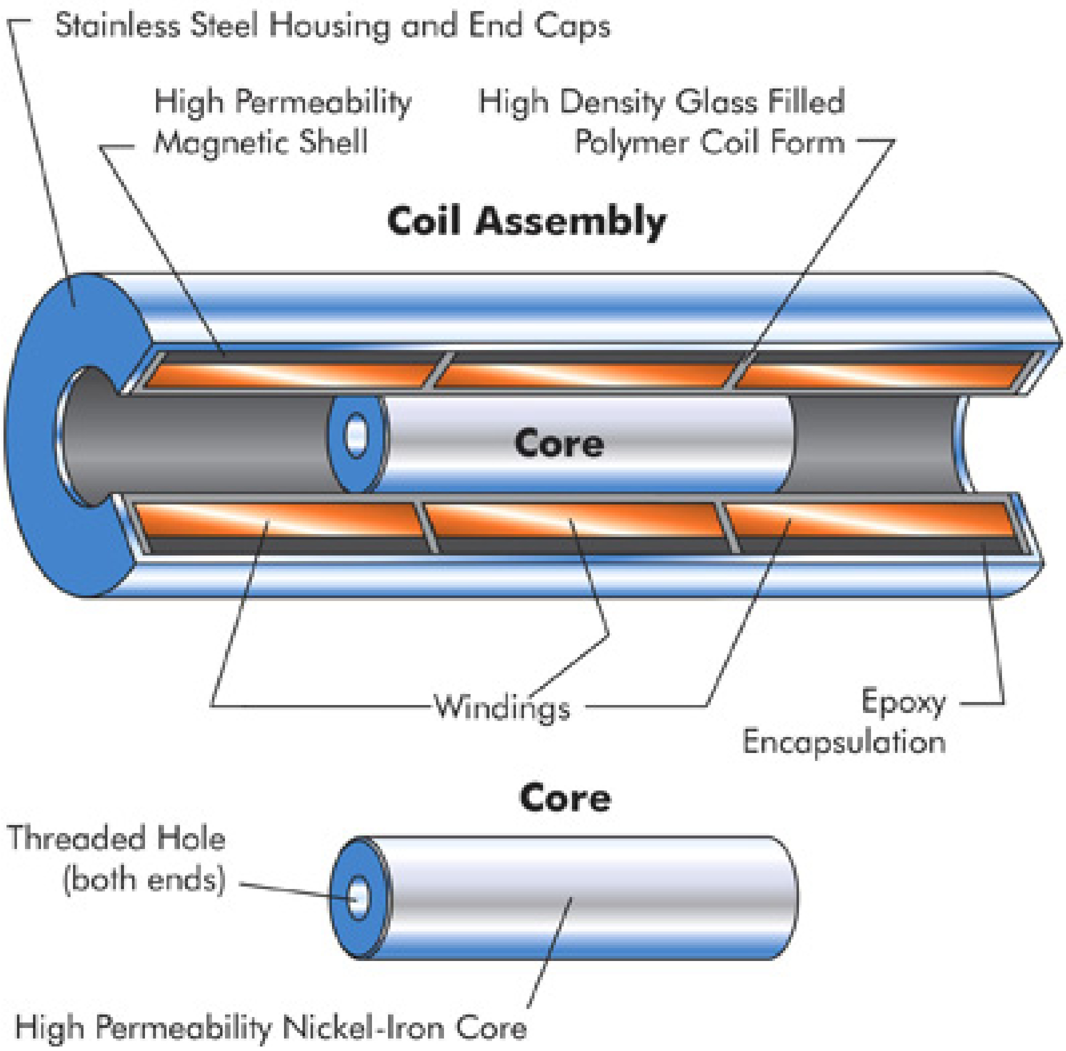
New construction materials and techniques enable LVDT linear position sensor operation in diverse environments

Lee Hudson, Applications Engineer, Macro Sensors, www.macrosensors.com

The LVDT Linear Position Sensor is a robust sensor adaptable to a variety of applications. A very reliable sensing device with no moving parts, LVDTs are often the best linear feedback technology when it comes to reliability and longevity. However, in the past, LVDTs were limited by its own sensitivity to the environment that caused errors in linear feedback. When exposed to elevated temperatures or extreme conditions such as high radiation environments, LVDTs must be produced with special materials or construction techniques.

For applications where sensors must operate in extreme environments, LVDTs now can be hermetically sealed, vented or constructed in a wide range of material such as stainless steel, Monel or Inconcel. These materials and construction techniques have extended the use of LVDT linear position sensors to new environments with temperature extremes, radiation exposure, seawater, corrosive acids, high pressures and even vacuum pressure conditions. As a result, Linear Position Sensors are becoming popular alternatives to less reliable technology, like linear potentiometers and magneto restrictive sensors, when it comes to position measurement in challenging environments.



Hermetically sealed LVDTs
In applications where LVDTs are surrounded by corrosive or pressurized media, high humidity or even slight levels of radiation, a hermetically sealed LVDT is recommended to ensure outside media does not enter the windings, making sensors impervious to dirt, water, steam, chemicals, and even extreme temperatures that can shorten sensor life or reliability.

These LVDTs feature a hermetically sealed assembly with a heavy-wall, metal housing and integral metal bore liner either made from 316 Stainless Steel or Super Nickel Alloys. (See Figure 1) This construction allows free movement of the core while sealing out the surrounding media from the windings.

In addition to its heavy-duty housing, bore liner and end washers are welded together to form a hermetic seal free from oxidation-producing faults that may cause leakage.

Sensor coils are wound on a one-piece hollow form of thermally stable glass reinforced polymer, encapsulated against moisture, wrapped in a highly permeable magnetic shield, and then secured in a cylindrical metal housing.

For severe applications involving extreme exposure to humidity, condensation, spray, salt atmospheres and similar environments, the coil windings may be further protected with special potting compounds or encapsulating resins. For high-temperature operation, vacuum-impregnation with moisture-resistant silicon varnish is possible.

Leads can be sealed with a glass-sealed header or compression bushing, sheathed in stainless steel sheathing or Teflon coated so connections don’t fail in extreme environments. Typical hermetically sealed LVDTs can withstand operating pressures up to 3000 psig. The hermetically sealed construction also lets the core withstand temperatures up to 400F.

Typical applications for hermetically sealed LVDTs include: machine tool positioning, hydraulic cylinder positioning, value position sensing, automatic assembly equipment. Hermetically sealed LVDTs typically operate properly with any conventional differential input LVDT signal conditioner so special LVDT instrumentation is not required.

Vented LVDTs
To accommodate extremely high pressures, the sensor case can be vented to equalize pressure inside and outside the LVDT linear position sensor. Since vent holes in the housing expose the coils inside, fluid must be electrically non-conductive and chemically benign. High temperature ratings are achieved by using internal materials rated for these temperatures.


Figure 2 shows how the coil assembly of miniature LVDT Linear Position Sensors is vented (pressure balanced) to the pressure of the non-conductive mediums to withstand extremely high pressures of the environment. As the sensor coil assembly can withstand a combination of high pressure, elevated temperatures, shock and vibration, the

LVDT is able to make measurements in down-hole drilling equipment possible where space is at a premium and the environment is hostile.

Optional material housings
While stainless steel construction with hermetically sealed electronics enables LVDTs to perform reliably in environments with high temperatures (400°F) or mild radiation exposure, other different material housings enable LVDTs to perform in more extreme operating environments including those with high and low temperatures, radiation exposure, seawater and vacuum pressure conditions often found in power generation, oil/gas and subsea applications.

• Inconel 718 provides greater pressure and chemical resistance so sensors can perform reliably under very hostile chemical conditions, even in seawater and corrosive acids. When designed Inconel 718 for pressure and corrosion resistance, an LVDT assembly can provide reliable operations for many years, even if the device is fully exposed to seawater.

• Monel 400, a special nickel-based alloy that provides excellent resistance against pitting and attack by micro organism, enabling sensors to perform in shallow and warm waters with high levels of oxygen. High pressure and seawater resistant LVDTs constructed from Monel or Inconel for pressure sensor corrosion resistance are incorporated into a variety of subsea measurement systems with seawater depths of 15,000 ft with external pressures of approximately 7500 psi. These materials enhance the already high reliability of the LVDT assembly, ensuring that it can meet service requirements of at least 20 years, even if the device is fully exposed to seawater.

• Titanium and hastelloy housings offer greater resistance to pressure and corrosion when measurements must be obtained in seawater depths down to 7500 ft. and with an external pressure of approximately 3800psi. Used in offshore drilling applications, LVDTs are typically designed with Inconel and Hastelloy to enhance sensor's high reliability so that it will continue to operate for at least 25 years, even if the device is fully exposed to seawater.

• Exotic alloys including cobalt, nickel and chromium allow the LVDT to perform in sulfidation environments in the presence of high levels H2-H2S concentrations and high temperatures up to 425 deg C. All these different material options open new doors for the use of LVDTs in different applications.

Offshore environments are one of the most difficult for LVDTs as sensors must survive for as 25 years or more. Figure 3 shows an example of an LVDT built for offshore applications. It is hermetically sealed with a welded subsea connector that is gold plated and rated up to 7500 psi. Dependent upon ocean temperature and depth levels, the LVDT casing is typically composed of special alloy that support long-term operation in difficult elements. As housing and core carrier made from Stainless Steel will not survive well in shallow warm waters, Monel is best rated for these conditions. Monel, due to its metal composition, resists sea life forming on it. At depths of 2000 feet or more where the temperature is around 5°C, Stainless Steel is acceptable.

Partitioning of LVDT with remote electronics
Another way to ensure Linear Position Sensors operate reliably in corrosive environments is to separate the LVDT core and coil structure into two different areas. For instance, the sensing element of an LVDT can be segregated from the electronic circuitry. Connected by long cables up to 100 meters (300 feet), these AC-operated LVDTs work with remotely-located electronics that power the sensors, amplify and demodulate their output. Output is, then, displayed on a suitable readout and/or inputted into a computer-based data acquisition system for statistical process control.