Ending Encoder-Related Downtime in Oil & Gas Drilling Applications
Part 3 of a Series: Wireline Measuring Head Encoders

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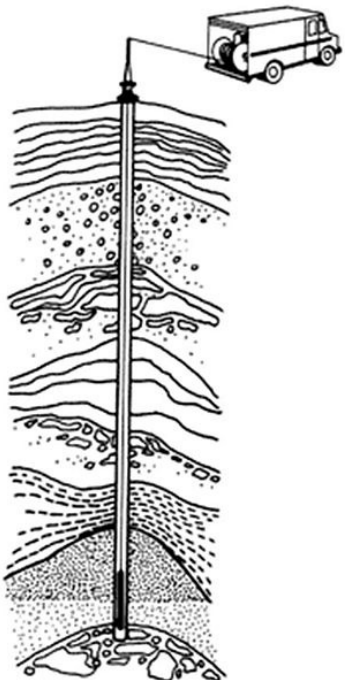
This series of white papers describes how to dramatically reduce encoder failures and encoder-related downtime in a range of applications for encoders in oil drilling and rework applications, from the top drive to coil tubing rigs. Encoders are an essential part of the control system yet cause serious downtime issues—these papers explore problems and practical solutions.

Wireline Measuring Head History

An overview of drilling equipment components:

From Wikipedia:
http://en.wikipedia.org/wiki/Wireline_(cabling)#Measuring_Head



The wireline truck is the central nervous system of a drilling operation. Without knowing the drill string position, the operator is drilling blind. To know the drill string position, the wireline truck uses a measuring head to exactly measure the amount of cable fed downhole.

The encoder is typically driven by contact wheels on each side of the cable **(Fig 1)**

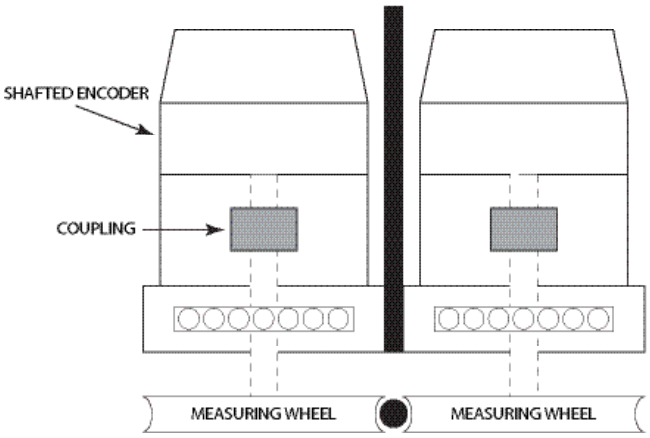


Fig 1

many vendors use two encoders due to the frequent failure of the encoder on the wireline head.

Fundamental Challenges

Vibration: The wireline head can see significant vibration during operation.

Physical Impacts: The threat of operation pales in comparison to transportation. If a truck operator neglects to secure the wireline head before driving the head swings violently from side to side and may even impact the truck working area. Since the encoder protrudes from the head it is usually one of the impact points.

Temperature Cycling: Wireline encoders don't see motor temperatures but they do see huge numbers of temperature cycles ranging from -40°C to +40°C. These temperature cycles cause direct electronic failures but even more commonly cause seal failures in standard encoders.

Environment: The drilling site can be 100% condensing humidity with salt water, ice, dirt, hydrocarbons and acids all present.

Safety Certifications: Approving insurers and drilling operators vary significantly in their safety certification requirements; wire line applications can be ATEX, IECX Zone 1 or 2 or UL Class 1 / Div 1 or Div 2 (US NEC 500) or UL Class 1 / Zone 1 or Zone 2 (US NEC 505) certification.

Failure Modes

Electrical failure: Encoders onsite are frequently exposed to voltage surges caused by vehicle power systems. Standard encoders can't withstand these overvoltage surges.

Optical electronic failure: Typical encoder construction uses optical sensors with a glass disk. Lines on the disk interrupt a light beam to a photoeye. **(Fig 2)**

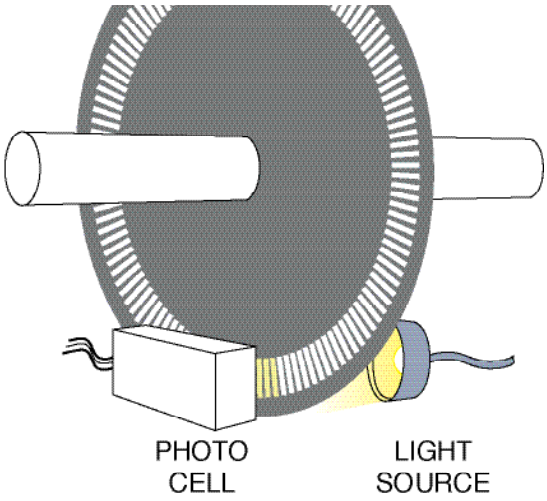


Fig 2

But this system can easily be disrupted by dirt and water that interrupt or distort the beam, and the glass disk is very prone to cracking or shattering.

Bearing failure: Typical encoders use a tiny ball bearing to support the solid shaft construction typically used on wireline heads. These bearings frequently fail when subjected to vibration and loads caused by the cable measuring drive wheels or misaligned couplings.

Coupling failure: To protect the tiny encoder bearings, most vendors use a separate bearing system for the measuring wheel, then couple the solid shaft encoder to the system. Unfortunately, couplings are even more unreliable than encoder bearings, and simply add another point of failure. Worse yet, since many encoder bearing failures are caused by vibration without rotation (when the truck is moving), the encoder's tiny bearings still fail!

Seal failure: The repeated temperature cycling causes pressure on the encoder seals which then give way. More temperature cycles draw dirt, dust, water and oil into the optics and bearings, causing optical system or bearing failure.

Practical Solutions

Mechanical issues. There's not much room for improvement of the shafted encoder system. The head has to be relatively light weight, so you can't add a 5 kg heavy duty encoder to a 7 kg measuring head. So bigger, stronger shafted encoders aren't very practical. The real key is to get rid of all the systems that fail in one fell swoop. Eliminate the optics, the tiny bearings, the inadequate seals and the coupling. By changing to a no-bearing modular magnetic encoder, the measuring head is made dramatically more reliable.

The system relies on the substantial bearings included in the measuring head itself; the no-bearing encoder uses the existing system for support.

A magnetic rotor mounts directly onto the shaft of the measuring wheel **(Fig 3)**

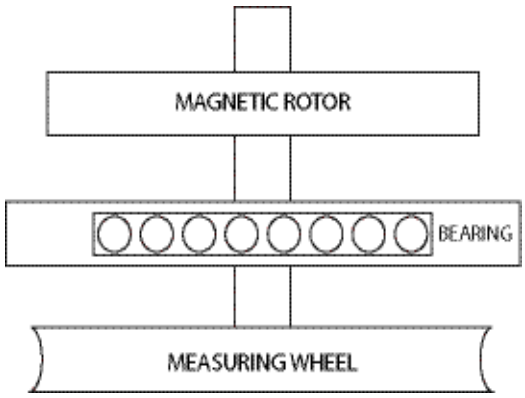


Fig 3

or can even be attached axially for even greater strength. **(Fig 4)**

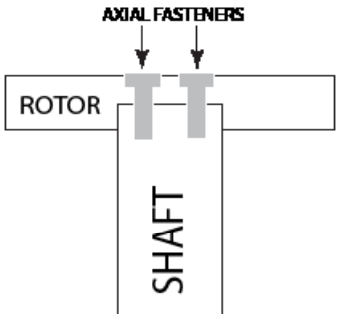


Fig 4

The stator electronics are fixed directly to the measuring head frame. With its solid metal construction and potted electronics, it is far better suited to withstand the occasional impact with the truck working area. Moreover, it's usually much lower profile than the encoder + coupling it replaces, further protecting the encoder from damage **(Fig 5)**.

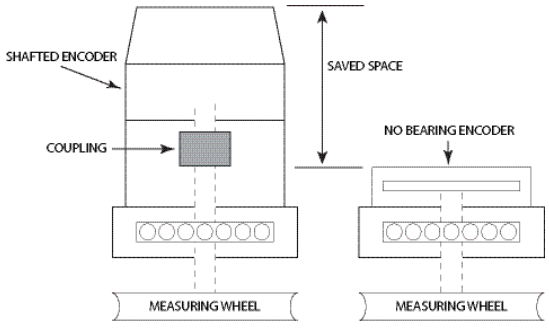


Fig 5

But modular encoders require a machined flange or face…you've got rigs in the field with existing shafted encoders.

The great news is that these can be retrofitted with no-bearing modular encoders, too. Vendors will supply flange adapters as needed to fit in the exact location where the previous solid shaft encoder previously fit the measuring head. The encoder will provide the same output, but with far greater reliability.
Bottom Line: Magnetic encoders don't require fragile glass disks or dust-free operation. Magnetism reaches through moisture, oil and dirt unaffected enabling the magnetic sensor to correctly and accurately detect rotation under all conditions.

Magnetic systems enable the encoder vendor to imbed the electronics in solid potting plastic compounds. This ensures the electronics ignore liquids and increases shock, impact, and vibration resistance. **(Fig 6)**

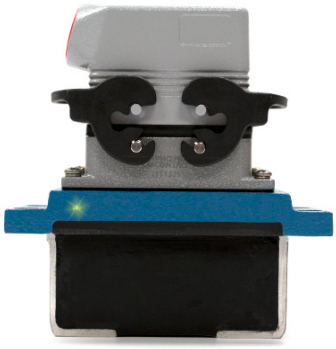


Fig 6

The encoder must protect itself. Insist on units with automotive or better grade input voltage regulators to protect against surges of at least 50v. Moreover, the outputs should be fully protected against all types of short circuits—line-to-line, line-to-ground, and line to V+ or higher. Wiring errors, such as wiring power to an incorrect pin, should not cause encoder failure.

Instead of wiring to a terminal box, consider premade cables using connectors certified for the safety standards. This will eliminate the time spent troubleshooting rewiring errors. Good connector systems are now widely available for ATEX, IECEX UL Class/Div and UL Class/Zone applications, and encoder vendors are adopting them.

Do you want to know about wire line measuring head encoder failures before they happen?

Get predictive diagnostics. These internal systems troubleshoot the encoder for you, and warn if the signal is drifting out of acceptable range. Often these systems warn of a problem before it causes a drive trip.

Also if there is a trip, the technician can check the local LED easily—if it's red, it's an encoder problem, if it's green, look elsewhere for the real problem. Some even include remote diagnostics that can be monitored by the wireline truck systems.

Older encoders had virtually no external diagnostics and required an oscilloscope to troubleshoot, or required the connection of a computer. The old method of troubleshooting was to immediately swap the encoder, then look for the real problem. Time consuming, especially when a spare isn't handy, the truck crew waits for the spare, then discovers replacing the encoder doesn't get them running again.

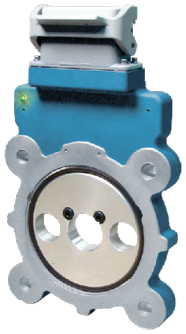
Summary:

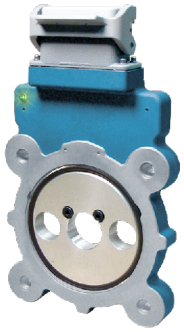
Wire line truck measuring heads are essential for drilling operations. If their encoders fail, whether due to vibration, impacts, or temperature swings the drilling operation is down until a replacement is found. By replacing solid shaft encoders on the wire line measuring head with no-bearing modular magnetic encoders, the OEM and wireline operator can dramatically improve uptime.

The appendix shows various Nidec-Avtron encoder models that have been proven to dramatically increase reliability of wireline truck measuring head applications. Models with safety certifications (ATEX, IECEX, UL, CE) are shown.

Appendix 1: Nidec-Avtron Encoder Models Suited for Wire Line Application in Oil and Gas Drilling:

XR56, XR115





Modular magnetic encoders for flange mount
No bearings
Potted electronics
Single or dual independent PPR outputs
Predictive diagnostics
Requires XRB1 Isolator for Zone 1 applications
ATEX Zone 1, 2, IECEX; UL Pending

For more information about this article or encoders & tachometers in general, contact:

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