Downhole ESP Gauge with Motor Diagnostics

*New Downhole electrical measurements optimising efficiency & output*

EuALF 2018 European Artificial Lift Forum
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Gauge history

DOWNHOLE GAUGE DEVELOPMENT

First downhole pressure and temperature gauge

1994
First multi-parameter ESP gauge

2007
Distributed pressure, temperature, vibration measurements across the ESP

2012
First ground fault immune ESP gauge

2016
First downhole ESP gauge with MD system

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ESP gauges are typically “Comms on Power”

- Gauge connected to the motor WYE point
- Gauge power and data superimposed onto the 3phase ESP electrical circuit
- Extracted at surface via a electrical choke
- No separate TEC lines to surface
The latest ESP gauge parameters

**MEASURED PARAMETERS**

**Primary Parameters:** for essential pump and well surveillance and protection

**Predictive Parameters:** for preventative maintenance and effective workover management

**Intelligent Parameters:** for advanced well and pump analysis, diagnosis and optimisation

* calculated parameter
ESP gauge with motor diagnostics

PACKAGING
Looks like a regular ESP comms on power gauge

• Connects to the motor windings in the same way as a conventional ESP gauge
• New electrical measurements added to the standard pressure, temperature and vibration parameters
• All data transferred via ESP cable to surface
• Conventional surface logger displays/logs parameters
# Zenith E-Series ESP gauge with motor diagnostics

## MEASURED PARAMETERS

Along with Pi, Pd, Ti, Tm, Vx and Vz, the gauge provides:

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Impact</th>
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<tbody>
<tr>
<td>Shaft RPM</td>
<td>Lift Performance / power / production</td>
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<tr>
<td>Slip rate</td>
<td>Lift Performance / power / production</td>
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<tr>
<td>True power factor</td>
<td>Power</td>
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<tr>
<td>Torque</td>
<td>Lift Performance</td>
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<tr>
<td>Motor HP</td>
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<td>Real-time cable insulation</td>
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<tr>
<td>Imbalance indicator</td>
<td>Lift Diagnostics</td>
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<tr>
<td>Motor efficiency</td>
<td>Lift Performance / power</td>
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<tr>
<td>Shaft rotation direction</td>
<td>Lift Diagnostics / production</td>
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</tbody>
</table>
FIRST TO MARKET

OPTIMISING POWER USAGE
## Power optimisation

<table>
<thead>
<tr>
<th>Traditional Parameters</th>
<th>New Electrical Data</th>
<th>Output Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressures</td>
<td>Downhole wye-point</td>
<td>Slip rate</td>
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<tr>
<td>Temperatures</td>
<td>Waveform analysis</td>
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<td>Vibration</td>
<td>Surface wye-point</td>
<td>True motor horse power</td>
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<tr>
<td></td>
<td>Waveform analysis</td>
<td>Efficiency</td>
</tr>
<tr>
<td></td>
<td>Volts, Amps, Hz</td>
<td>Torque</td>
</tr>
</tbody>
</table>

Replaces calculated parameters with real time measured data
➔ allowing more accurate and confident ESP optimisation

Fully compatible with intelligent well and field optimisation software
➔ optimise power vs barrels produced considering both production and ESP power usage
Customer power quality challenges

SOURCES OF POWER QUALITY ISSUES

- Voltage Dips: 28%
- Short Interruptions: 19%
- Long Interruptions: 11%
- Transients & Surges: 13%
- Harmonics: 5%
- Other PQ Problems: 11%

Effect of power quality on ESP operations:

- Operating Expense
- Downtime
- Equipment Run Life

Source: ResearchGate
The impact of insight into true power factor

BENEFITS OF KNOWING YOUR TRUE SURFACE AND DOWNHOLE POWER FACTOR

- Reduction of electricity bills
- Extra KVA available from existing supply
- Reduction of losses and voltage drops
- Extended equipment life
- Environmental
  - Reduced consumption / improved efficiency
  - Less emissions / fossil fuel depletion
Motor load – why is measured torque and horsepower useful?

THE RELATION BETWEEN FULL LOAD AND TORQUE / HP

- Ideally you can vary motor load from 0 – 100% by changing the frequency from 0 – 60Hz, this is in an ideal motor and ideal design.
- To run a motor efficiently it is beneficial to know torque, HP and load.
- A VSD does not have a direct measurement of downhole torque, HP or load at the motor (a VSD calculates these parameters based on correct input of motor vs surface electrical data)
- The motor diagnostics gauge is agnostic of input data and highlights when 100% load is achieved in real time
- Load and torque can be used to protect the motor and run at optimum power consumption
CASE STUDY: Motor load optimization

- The ESP was designed to reach 100% load and 100% HP at 60Hz.
- However the gauge identified that the motor reached 100% load at around 48Hz.
- It was (later) advised that at this point the motor was re-rated to 150% by adjusting tappings and “adjusting” VSD nameplate value settings
- Full load was detected again by the gauge at ~57Hz.
- The motor diagnostics gauge advises exactly when 100% HP is achieved so user can correct tappings to operate at best motor efficiency vs load.

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Motor Monitoring: Torque & HP

- Full load/ Saturation detected
- Nameplate reference detected

Downhole Amps (ESP Drive)

- Current drawn by the motor increasing
- But power is wasted

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At ~120% of motor rated load (~120% of original nameplate) extra power supplied from increasing frequency is wasted

SAME PRODUCTION @ LESS POWER COST
CASE STUDY: Motor load

MEASURED MOTOR LOAD (GAUGE) VS. CALCULATED MOTOR AMPS (VSD)

Load measured by the MD DHG

Current draw

Max load

Power wasted
CASE STUDY: Motor load

MOTOR EFFICIENCY VS VSD CALCULATED DOWNHOLE AMPS

Max load measured by the MD DHG

0
10
20
30
40
50
60
70
80
90%

45
47
49
51
53
55
57
59
61
63
Hz

76%
78%
80%
82%
84%
86%
88%
90%

Downhole Amps
eff

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CASE STUDY: Available power saving

• Motor data suggests that by changing Volt/Hz ratio from current settings to 60 Hz (e.g. volts which are supplied at 63Hz now to be supplied at 58 – 60Hz) should deliver

  Potential saving of 9% - 13% on power cost with the same production

• In this case the VSD tripped many times after exceeding the suggested maximum operating point of 57Hz.

• Due to long log rate of VSD data — poor user input — trips were not always detected in VSD amperage log leading to extended downtime
CASE STUDY: Motor performance diagnostics

~150% SUDDEN INCREASE IN LOAD DETECTED

Exceeding maximum motor torque, in this case 350%, may shear the shaft or cause permanent damage – if not controlled or rectified.

Within 1 minute, frequency drops from 60Hz to 35Hz & returns to 60

Caused huge steps of motor load and torque
CASE STUDY: Motor failure prediction

Increased stress indicated by the DHG, while ΔP and DH amps did not change. The ESP tripped for electrical motor failure.

![Graph showing stress over time with an arrow indicating where Coms lost/ESP tripped at over 13 hours]
Optimising production

- Motor diagnostics gauge immediately shows motor direction without having to wait for fluid to surface
- Detects stuck pumps
- Forward/reverse configurable for pump manufacturer
Case study data: Backspin

MEASURING TRUE BACKSPIN DOWNHOLE

- Zenith gauge is capable of detecting backspin, ruling out risk involved in measuring voltage manually & perhaps eliminating need for a backspin relay.

- Backspin info can be vital during RIH ensuring kill fluid rate is within safe range to the ESP stages.

- Pi, Pd readings will not necessarily indicate backspin in all cases.

- Graph is an example of backspin logs taken at intervals during RIH.
Conclusion
Zenith E-Series ESP gauge with motor diagnostics

BENEFITS

- Replaces inaccurate surface calculations
- Enables accurate electrical performance monitoring
- Run equipment at actual optimum points against load

System adjustments are made based on measured not estimated values ensuring truly efficient, safeguarded ESP operations.
CONCLUSION

The Zenith E-Series Gauge with Motor Diagnostics provides **real-time power analysis** enabling operator to:

- Monitor motor performance for informed decision-making
- Operate ESP at the best efficiency and lowest cost
- Place less strain on equipment to enhance runlife
- Quickly know pump is spinning the correct way at start up
- Optimize production vs power consumption