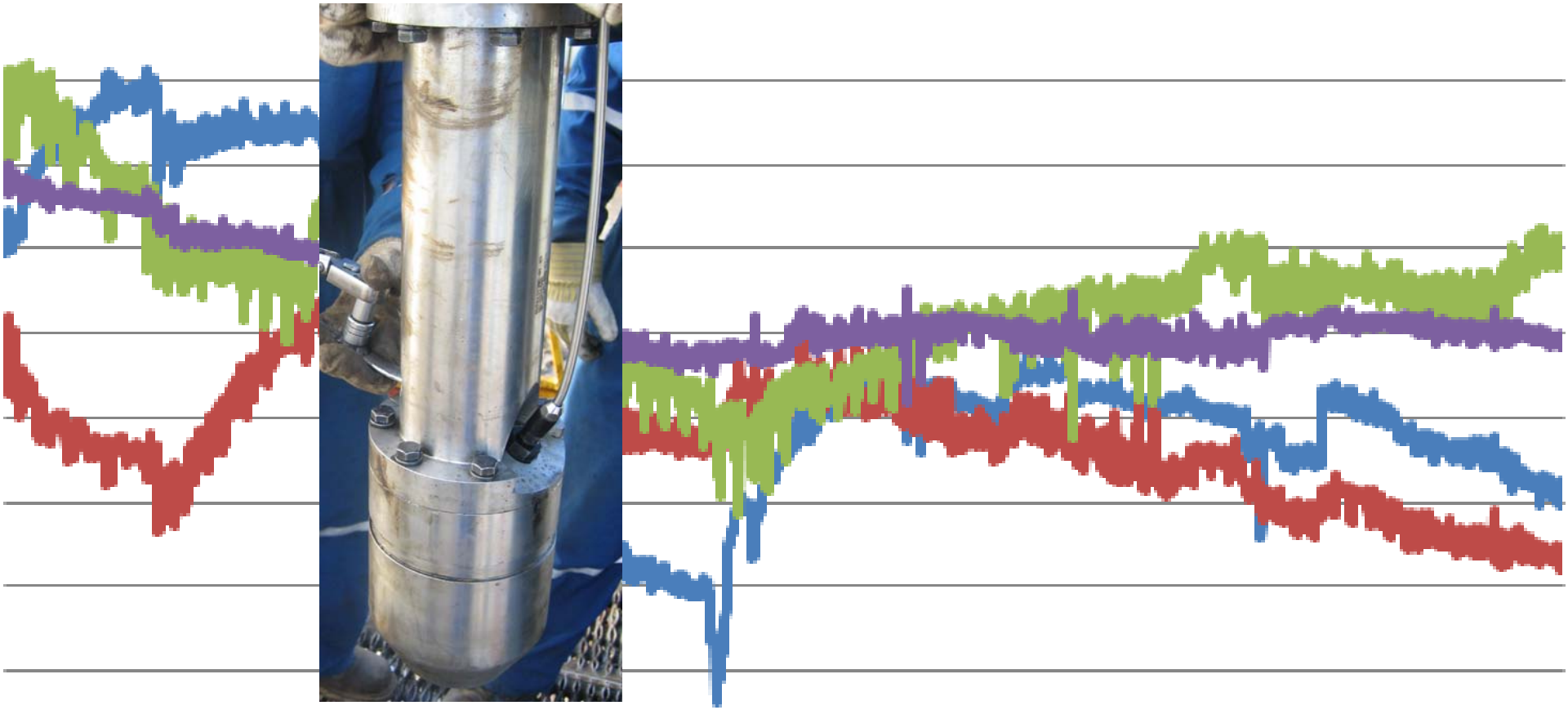


# High Temperature ESP Monitoring

May 18, 2010

**Brindesh Dhruva (principal Inv.)**
**Jack Booker (presenter)**
**Schlumberger**

Track Name

# Project Overview



- Timeline

| | Start | End | % Completion |
|---|---|---|---|
| – DOE Project | 30-Sep-2008 | 31-Dec-2010 | 100% |
| – Actual | 30-Sep-2008 | 31-Dec-2010 | 100% |

- Budget (Oct 2008 through Mar 2010)
  - Total project funding: $1.671M
    - DOE share: $1.254M (75%)
    - Cost share: $417K (25%)
  - Total project spend to date: $1.600M
    - DOE share: $1.212K (76%)
    - Cost share: $388K (24%)
  - Projected Total project spend end of 2010: $1.942M
    - DOE share: $1.254K (65%)
    - Cost share: $688K (35%)

# Relevance/Impact of Research



- The purpose of the High Temperature ESP Monitoring project is to develop a down-hole monitoring system to be used in wells with bottom hole temperature up to 300 ° C for measuring motor temperature, pump discharge pressure, and formation temperature and pressure.

- Monitoring the maximum motor temperature will greatly reduce the risk of over heating the motor and causing a motor failure.

- Measuring the well pressure and temperature can provide information of the well formation. Such as, monitoring the pressure draw down when the motor is started and pressure build up when the motor is stopped can assist in determining formation properties such as permeability and scale buildup.

# Scientific/Technical Approach

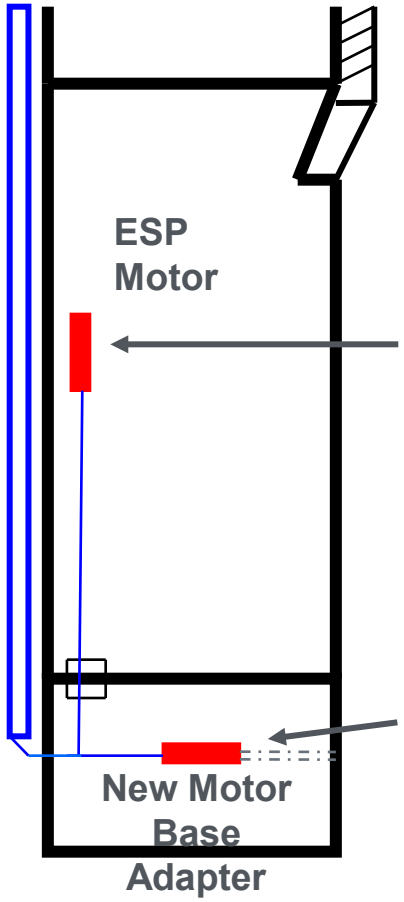


- Following the initial project award, it was determined that a substantial development would be required to modify the gauge design for it to survive unpowered at 300C for even a short amount of time. Therefore, a decision was made in March 2009 to stop the Free Piston Stirling Cooler development and concentrate on two other developments due to their high likelihood of success. These two new developments that do not include downhole electronics.

- The two projects are
  - Downhole Transducer with Surface Electronics
  - Fiber Optic Pressure System

# Downhole Architecture






7 - Conductor Cable Deployed to Surface

Motor Temperature Sensor

Sensor for Formation Pressure and Temperature

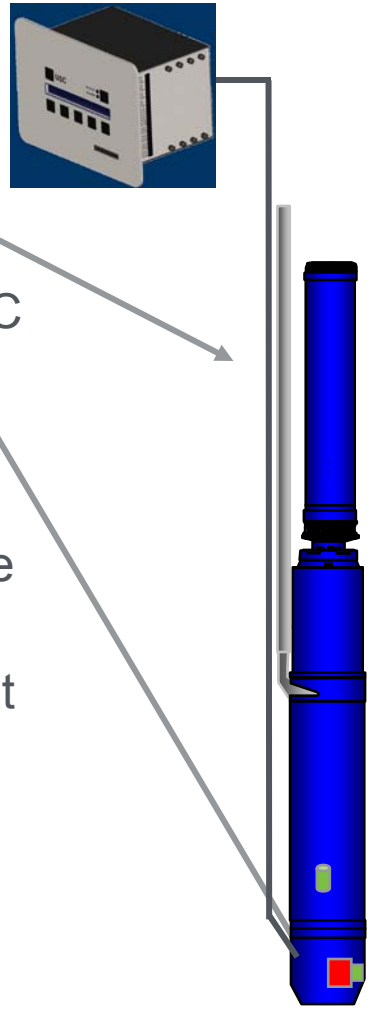
Use Fiber Pressure to measure Pump Discharge Pressure

# Downhole Transducer with Surface Electronics – Plan



- Development Risks
  - Change material of 7-conductor I-wire
    - Synergy with ESP Cable Development
  - Long term stability of pressure sensor at 300° C

- Development Plan:
  - Successfully test system with lower temperature sensor (220° C)
  - Complete characterization of pressure sensor at 300° C
  - Integrate new sensor into ESP motor
  - Ready for field test Q2 2010



# Fiber Optic Pressure - Plan

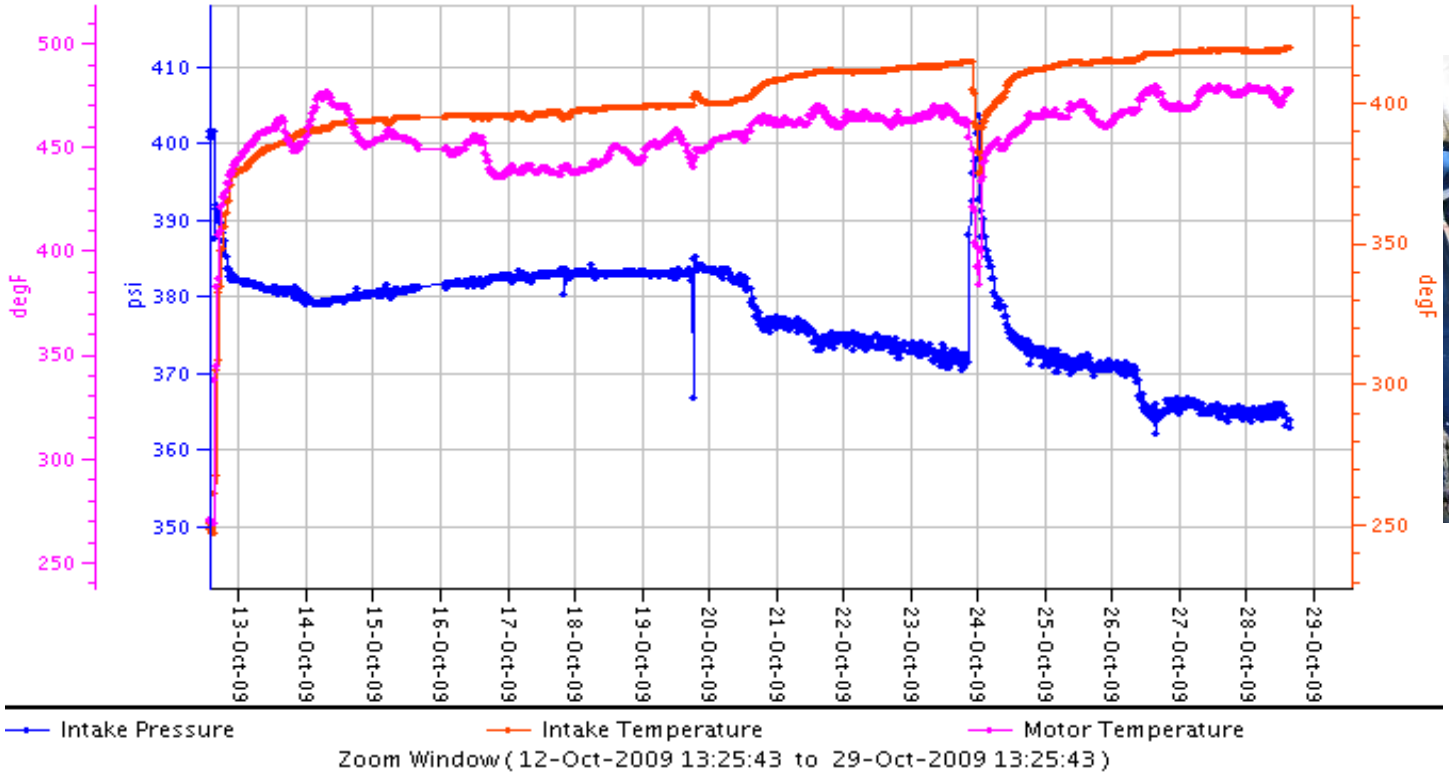


- Development Risks
  - High Temperature Optical Feed Through for Well Head
  - High temperature downhole feed through
  - Glass Fiber Life Span
    - Hydrogen Mitigation Could Require an Additional Development Phase

- Development Plan
  - Successfully test system with lower temperature sensor (250° C)
  - Complete Redesign of Downhole Gauge with New Feed Through
  - Long Term Fiber testing
  - Ready for field Q2 2010

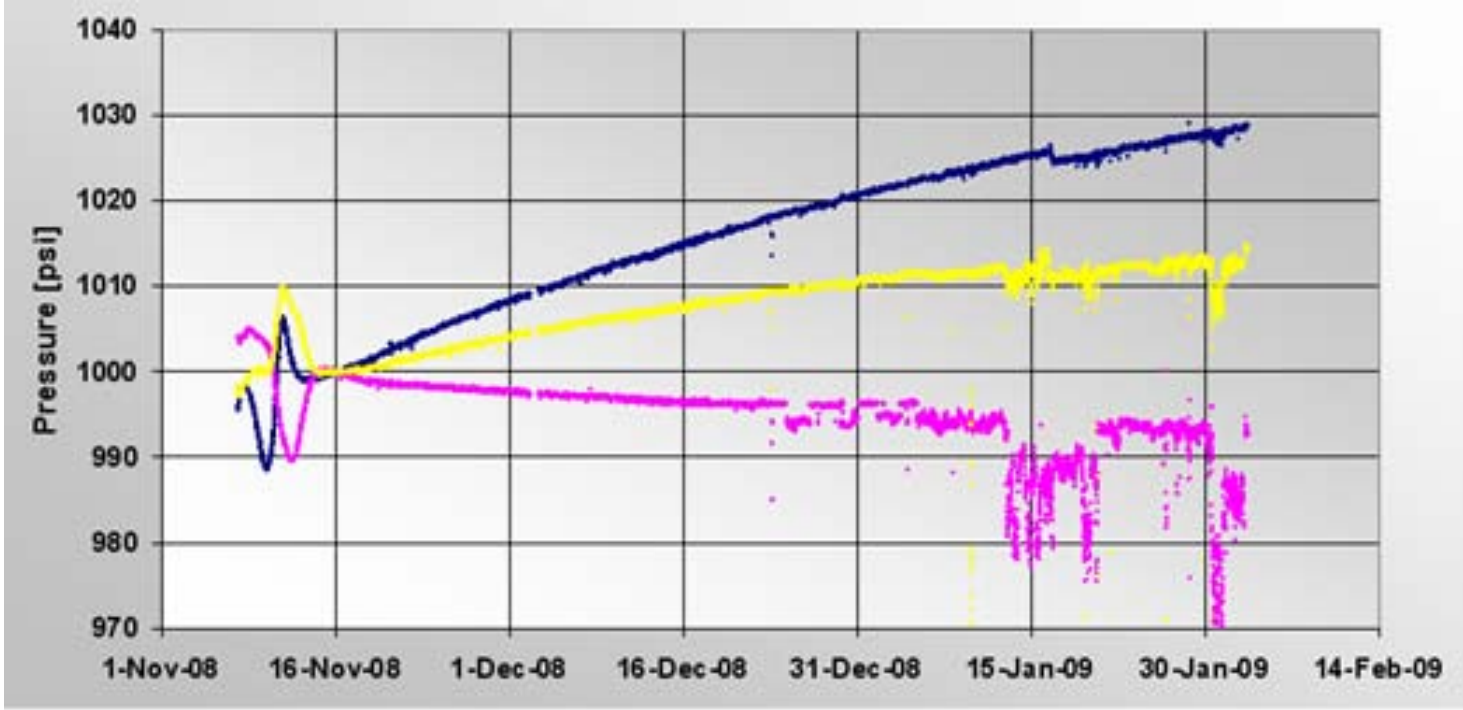
# Downhole Transducer with Surface Electronics

- Successfully installed ESP Monitoring System in a SAGD well September 2009 with 220C rated sensor (operated at 216C)



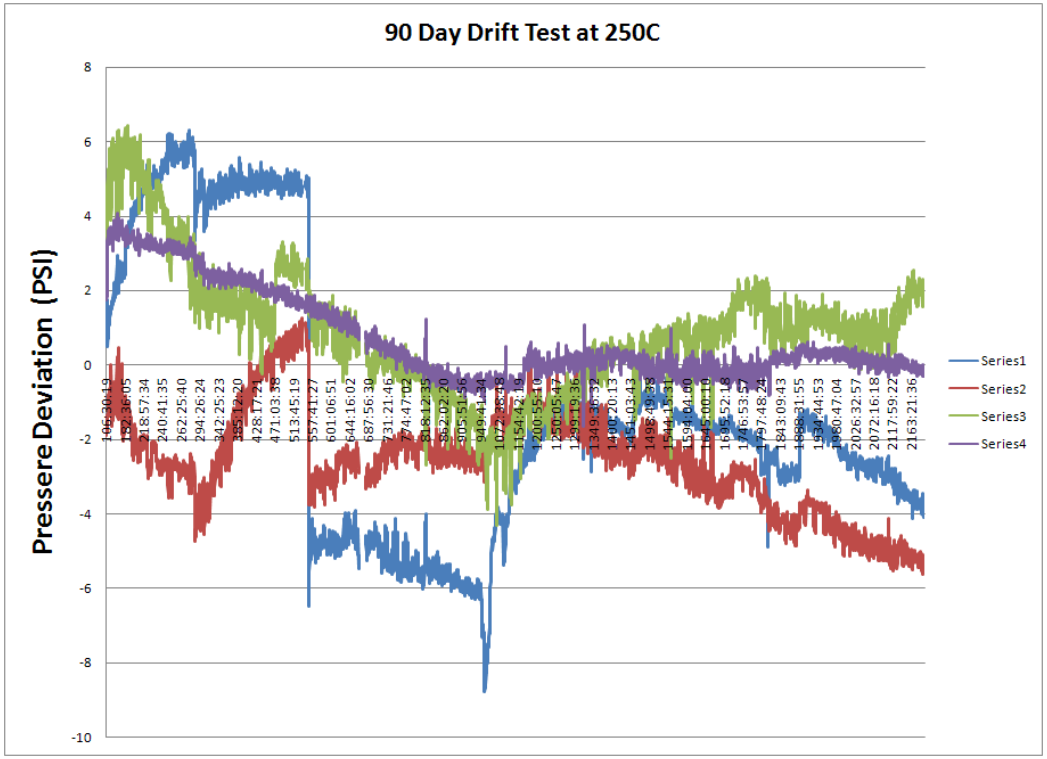

## Downhole Transducer with Surface Electronics

- Q4 2008/Q1 2009, performed 90 day drift characterization tests at 250C on new sensor
- 2 of 3 sensors drifted beyond the acceptance criteria of 15 PSI/year



# Downhole Transducer with Surface Electronics

- Identified material limitation and started second 90 day drift test at 250C in December 2010,
- 4 of 6 sensors were within beyond acceptance criteria of 15 PSI/year



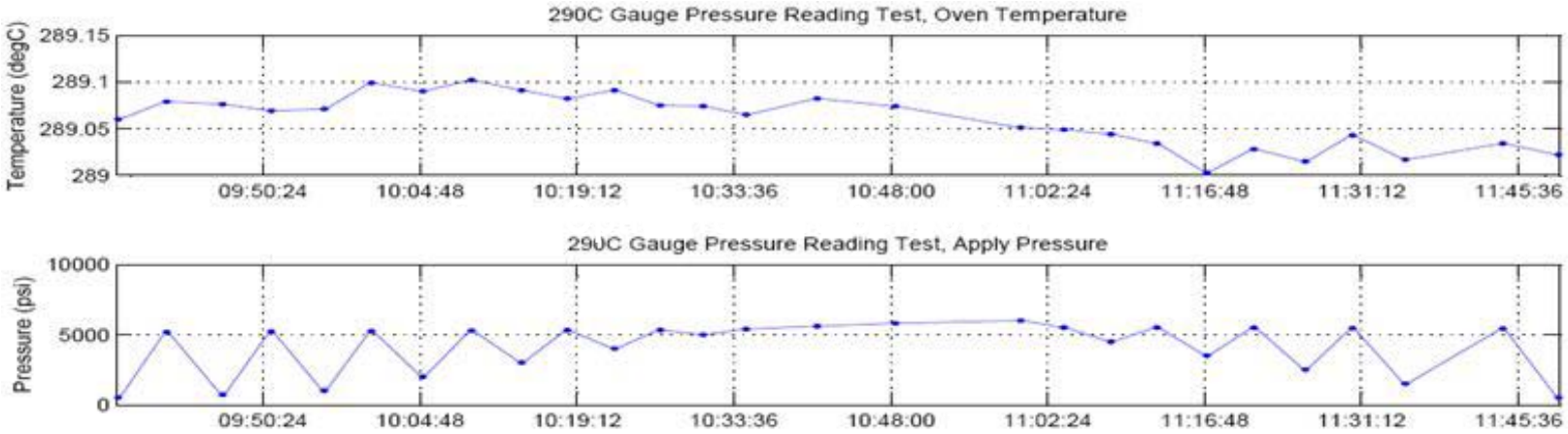
## Fiber Optic Pressure

- Completed qualification of 250C fiber pressure sensor and ready for field installations


- Successfully tested fiber Wellhead Outlet feed through at 250C and 20 KPSI

## Fiber Optic Pressure

- Optical Pressure Gauge Test Results at 290 C 6 KPSI




- Hydrogen tests on fiber completed
- Tests show HT fiber has very low degradation. Less than 2 db attenuation change over 2000 hours at 300 deg C.

# Future Directions



## Downhole Transducer with Surface Electronics

- Complete current characterization of new sensor at 250C and document manufacturing procedure.
- Characterize new sensor at 300C
- Qualify new 7 conductor signal cable and downhole connector for operation at 300C

## Fiber Optic Pressure

- Complete 300 C, 10 KPSI gauge assembly
- Conduct long term testing and qualification of fiber, and seal assemblies at 300 C, 10 KPSI
- Hydrogen test on gauge assembly in progress

# Project Management/Coordination



The EGS High Temperature ESP Monitoring project is one of a collection of developments to monitor ESPs for Schlumberger.

- Motor Winding Temperature, Intake Temperature, and Intake Pressure at 220 C for HotLine 550
- Motor Winding Temperature, Intake Temperature, and Intake Pressure at 250 C for HotLine 3
- **Motor Winding Temperature, Intake Temperature, and Intake Pressure at 300 C for DOE Enhanced Geothermal System**

# Project Management/Coordination



- Schlumberger engineering centers involved in project
  - Overall management and downhole mechanical design and integration
    - Schlumberger Reservoir Integration Center, Rosharon, Texas
  - Fibre Optic development
    - Schlumberger Fibre Optics Technology Center, Southampton, UK
  - Surface acquisition hardware and software
    - Edmonton Product Center, Edmonton, Alberta

- Monitoring system is an integral part of the motor being developed under the Hotline IV – High Temperature ESP EGC project (GO18182)

# Project Management/Coordination



- In 2010, the project funds awarded will be exhausted and Schlumberger will spend an additional $300K to complete the projects to the state that both systems will be designed and qualified for field installation.
  - End of Q2 2010, Downhole Transducer with Surface Electronics will be complete
  - End of Q4 2010, Fiber Optic Pressure will be complete
- The remaining funding does not cover the cost of any equipment to be installed and the supported required for a field installation.
- Addition funding and deployment specifics will be required in order to install a monitoring system in a demonstration well.

# Summary



## Downhole Transducer with Surface Electronics

- In 2009, successfully qualified and installed 220C High Temperature ESP monitor system in well, verified overall system operation
- In 2010, complete characterization of new sensor at 250C and 300C.
- In 2010, field test new sensor in ESP motor

## Fiber Optic Pressure

- In 2009, completed qualification of 250C gauge system and ready for field test installations
- In 2009, testing of hydrogen migration in fibre at 300C demonstrated good results
- In 2010, complete design and qualification of 300C gauge system. Ready for field test by end of year.

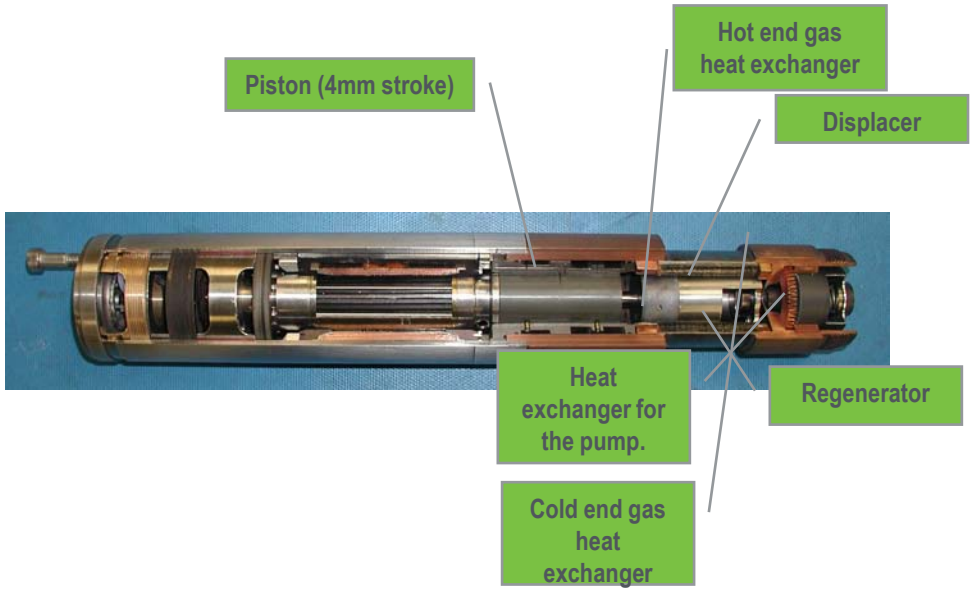
## No funds available to support installation of a system in a demonstration well.

# Supplemental Slides

# Stirling Cooler – Background & Status



- Original Proposal – Stirling Cooler
- Based on actively cooling a downhole sensor using a Free-piston Stirling Cooler.
- Completed initial feasibility study on Stirling Cooler and identified two issues
  - Piston Rotation
  - Clogging Gas Bearing Restrictors
- The highest risk item: Survivability of Electronics if Power is Lost to the Stirling Cooler



## Downhole Transducer with Surface Electronics

- Successful tested new sensor up to 260C in flow loop test
- Manufacturing of sensor requires condition at 280 C prior to applying coefficients