U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Hotline IV – High Temperature ESP

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Schlumberger

Track Name

Project Overview

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- Timeline

Timeline	Start	End	% Completion
– DOE Project	1-Sep-2008	31-Mar-2010	100%
– Actual	1-Jan-2007	31-Dec-2010	81%

- Budget (Sep 2008 through Mar 2010)
  - Total project spend: $2.459M
  - DOE share: $1.254M (51%)
  - Awardee share: $1.205M (49%)
  - 2009 DOE funding: $1.254M; 2010: $0, (funding received and/or available)
- Full Budget (Jan 2007 through Dec 2010)
  - Total project spend: $4.638M (through Mar 2010)
  - DOE share: $1.254M (27%)
  - Awardee share: $3.384M (73%)
- Partners: None

Relevance/Impact of Research

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	Fluid Temp	Internal Temp	Power	Runlife
Requirement	300C	?	2000HP	3-years
HT ESP	218C	288C	320HP	-
HP ESP	150C	205C	1500HP	-

- A submersible pump that meets the requirements is essential for EGS economics.
  - High temperature rating ensures maximum power per unit fluid
  - High Power ensures maximum fluid per well
  - Reliability ensures avg. pump replacement cost and downtime are acceptable
- Objective: Increase temperature rating of high temperature ESP’s
- Results
  - Designed and built system rated for 250C fluid temperature and 300C internal temperature
  - Tested up to 260C fluid temperature.
  - Significant Technology barrier to go to higher temperatures (still working on it!)

Scientific/Technical Approach

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- Management Process (SLB Generic Process)

Stage	End Checkpoint	Actual Date
Concept	Concept Closure	Aug 2007
Feasibility	Feasibility Closure	July 2008
Development	Commercialization	Dec 2010
Close-Out	Project Closed	Mar 2011

- Increasing Temperature Capability

- Improving Reliability

Increasing Temperature Ratings

- Complete re-evaluation of all non-metallic components
- Example: Elastomer Compound

	Fluid 1	Fluid 1	Fluid 1	Fluid 1	Fluid 2	Fluid 3	Fluid 4
	250°C	250°C	300°C	300°C	300°C	343°C	343°C
Compound	70 hours	7 days	70 hours	7 days	7 days	7 days	7 days
A	PASS	PASS	PASS	PASS	PASS	FAIL	FAIL
B	PASS	PASS	PASS	PASS	PASS	FAIL	FAIL
C	FAIL	FAIL	FAIL	FAIL			
D	FAIL	FAIL	FAIL	FAIL			
E	PASS	PASS	PASS	FAIL			
F	PASS	PASS	PASS	FAIL			
G	PASS	PASS	FAIL	FAIL			
H	FAIL	FAIL	FAIL	FAIL			
I	PASS	PASS	FAIL	FAIL			

Improving Reliability

- Balance between failed elements, failure modes, and root causes
  - Failed Elements: What failed on a system that stopped production
  - Failure Modes: What directly caused the element to fail
  - Root Causes: What originally allowed a failure mode to exist

- Project Focus
  - Increasing Redundancy of critical components
  - Mitigate effects of sand entry around critical and rotating components
  - Reduce potential service errors
  - Using internal motor temperature sensor for automated protection
  - Higher Temperature Materials

Scientific/Technical Approach

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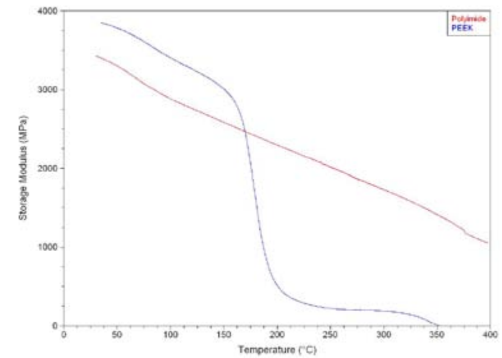
Management Process

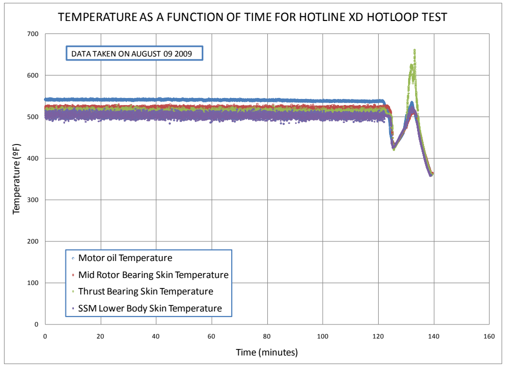
- Concept Phase Jan-2007 to July 2007
  - Checkpoint: Concept Closure
  - Look to accomplish: List of project requirements and economic value
- Feasibility Phase Aug 2007 to June 2008
  - Checkpoint: Feasibility Closure
  - Look to Accomplish:
    - Proof that project requirements are technically and economically feasible.
    - Identify important new characteristics and materials.
  - Milestones: Go/No-Go decision based on technical feasibility
- Development Phase July 2008 to Dec 2010
  - Checkpoint: Commercialization
  - Look to Accomplish: Design, build and test components, sub-assemblies, and assembly
  - Milestones: Functional Test of first prototype, Successful endurance test of prototype, field testing of design
- Close-Out Phase Jan 2011 to Mar 2011
  - Checkpoint: Project Closed
  - Look to Accomplish: Hand over project to sustaining engineering

Accomplishments, Expected Outcomes and Progress

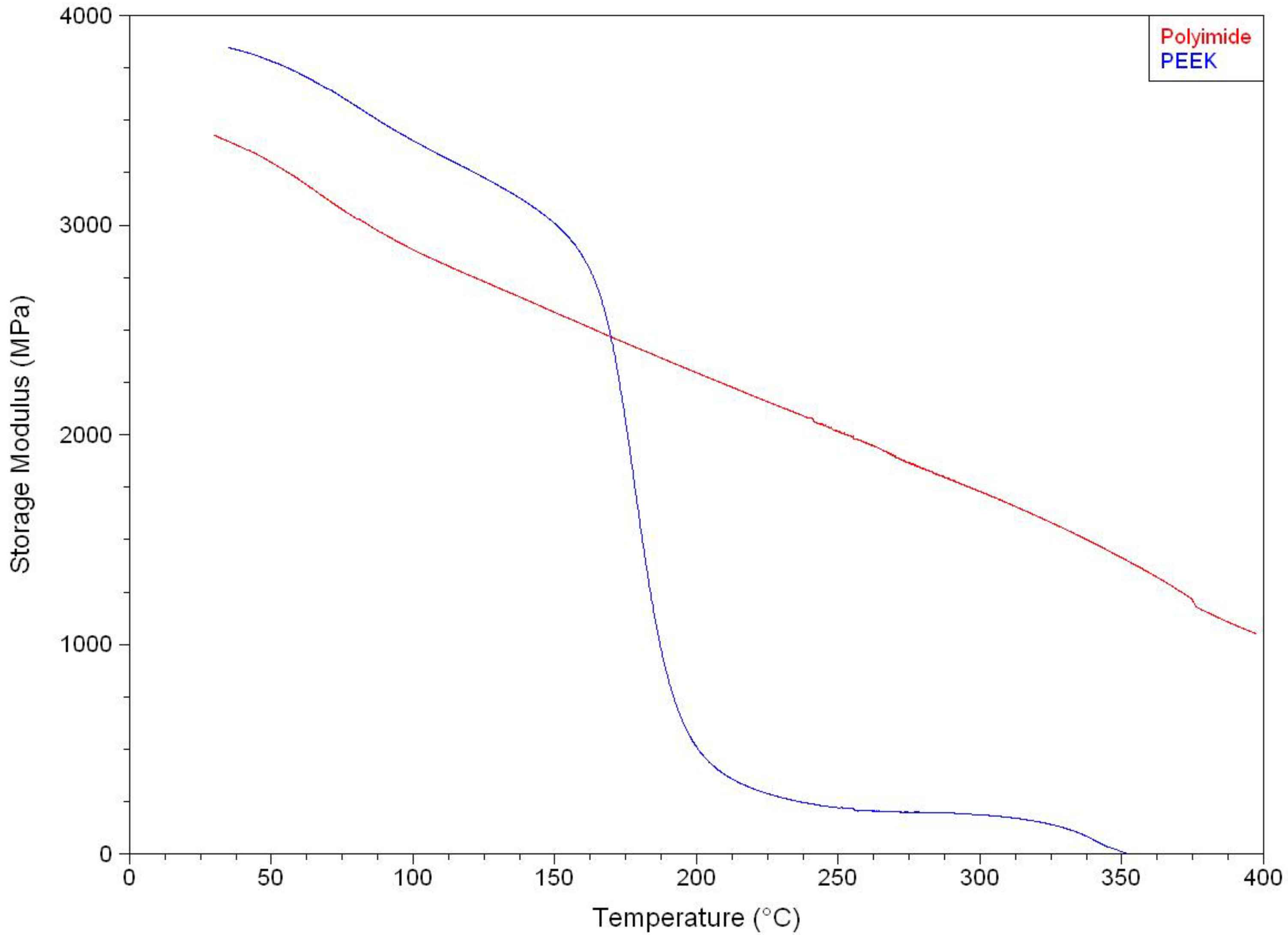
Accomplishments

- Identified Key Changes to improve reliability
- Selected material candidates and tested to determine best option for increasing temperature rating
- Designed, built, and tested three prototype units
- Internal endurance test for 300-hours
- External joint test with ConocoPhillips at C-FER Technologies
  - Temperature up to 260C fluid temp.

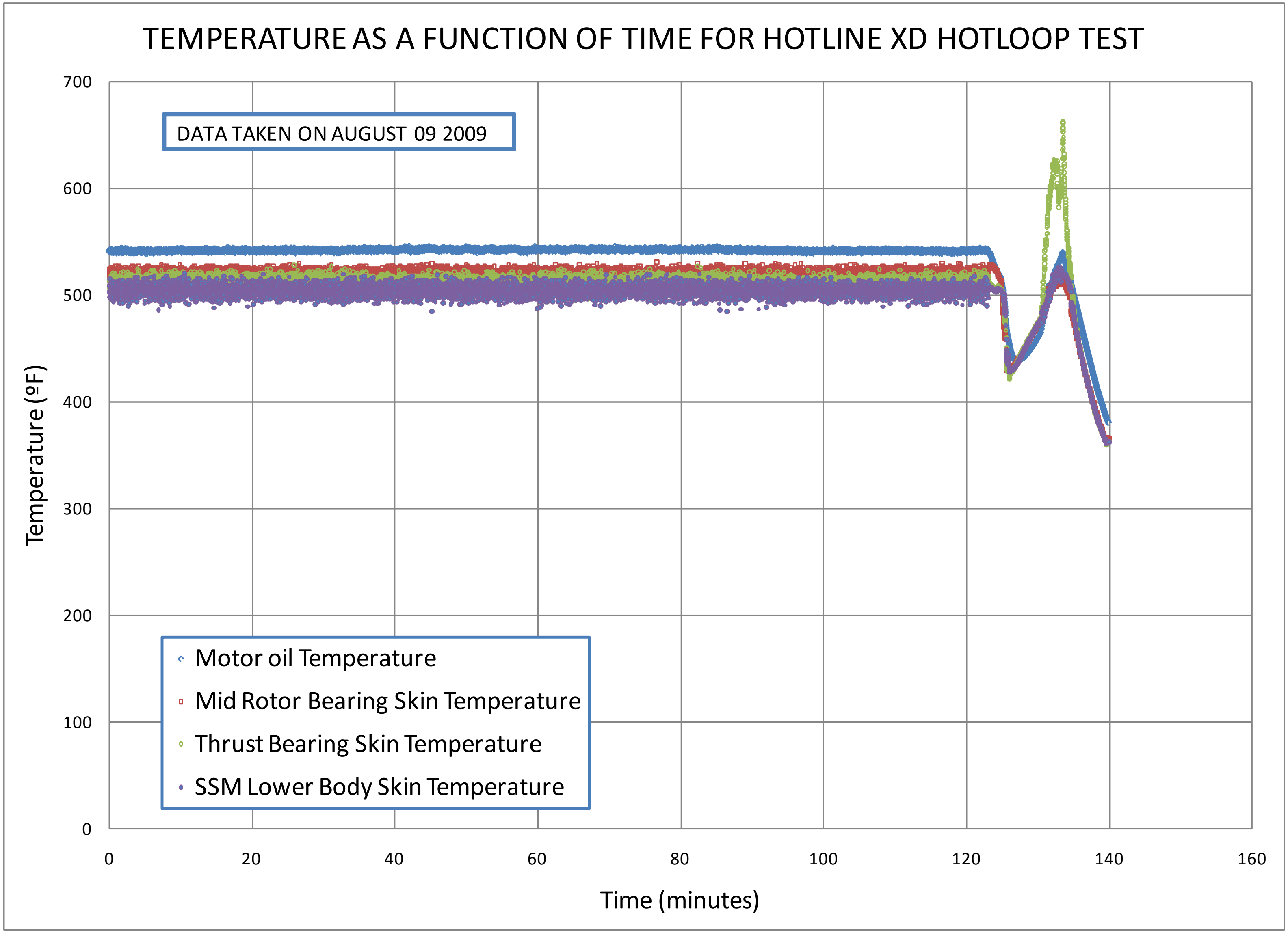




Accomplishments, Expected Outcomes and Progress



Accomplishments, Expected Outcomes and Progress



Accomplishments, Expected Outcomes and Progress

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Team

Member	Title	Loc	Yrs	Deg
Jose Caridad	Mechanical Engineer	SRC	8	MSc
Michael Dowling	Project Manager	SRC	14	BSc
Jason Kobersky	Designer	SRC	13	AAS
Albert Kyin	Electrical Engineer	SRC	6	BSc
Robert Philips	Designer	SRC	2	BSc
Arthur Watson	Project Team Leader	SRC	35	BSc
Chris Featherby	Designer	BPC	21	
Kevin Cox	Mechanical Engineer	LPC	2	MSc
Will Goertzen	Polymer Engineer	LPC	3	PhD
Sophie Govetto	Engineer	LPC	2	MSc
Greg Manke	Cable Eng. Manager	LPC	26	BSc
Melissa Vermeer	Polymer Engineer	LPC	11	PhD
Beng Chua	Manufacturing Eng.	SPE	6	MSc
Yohz Hendryanto	Manufacturing Eng.	SPE	6	BSc
Praveen Kakkan	Manufacturing Eng.	SPE	5	BSc/MBA
Haining Pan	Mechancial Eng.	SPE	2	PhD

Accomplishments, Expected Outcomes and Progress

Facilities

- Singapore
  ISO 9001 Certified (2008)
  – Worldwide Manufacturing Center

- Bartlesville, Oklahoma
  ISO 9001 and ISO/TS 29001 Certified (2007)
  API Q1 Certified (2008)
  – Original REDA Headquarters
  – Research and Manufacturing Center
  – High temperature motor test lab

- Lawrence, KS
  ISO 9001:2008 certified
  – Polymer Lab
  – Custom Elastomer Production
  – Cable Production (including electrical connectors)

Project Management/Coordination

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- Schedule
  - Parallel Development of Power Train and Monitoring System
  - Dealing with the unexpected
- Resources
  - Personnel
  - Test Facilities
  - Equipment
- Project Cooperation
  - High Temperature Monitoring System developed in parallel and integrated into motor.

Future Directions

- 300-HP, 250C System
  - Continued Development of new elastomer compounds
  - Field Trials approx. Aug 2010 through Dec 2010
  - Commercial Product End 2010
  - Continued monitoring for reliability improvement potential
- 300-HP 300C System
  - Development of components to enable system in 2010
  - Collaborative Work with industry partner on new materials
  - Testing and Field trials present a problem
- High Power System (250C)
  - Apply lessons learned to larger diameter motor
  - Present market in 'Hydrothermal' systems in Europe and Western U.S.
  - Target for preliminary design is mid 2011.

Summary

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- Successfully designed, built, and tested a new system that…
  - Is capable of permanent operation in 250C fluid.
  - Will improve on the reliability of the previous system
  - Is capable of 300-HP
- Field Trials will be Aug/Sep 2010 through end of 2010
- Product will be commercial in 2011
- Higher Temperature research will progress in 2010 toward 300C target.
- High power version is in the works

Year	Key Technical Results
2009	•Build Prototype •Internal Endurance Test •External Endurance Test
2010	•Release design for manufacturing •Field Trials

Supplemental Slides

Delivered

- None

Planned

- Global Petroleum Conference, 8-10 June 2010, Calgary Canada
- SPE Annual Technical Conference and Exhibition (ATCE), 19-22 Sep 2010, Tuscany Italy

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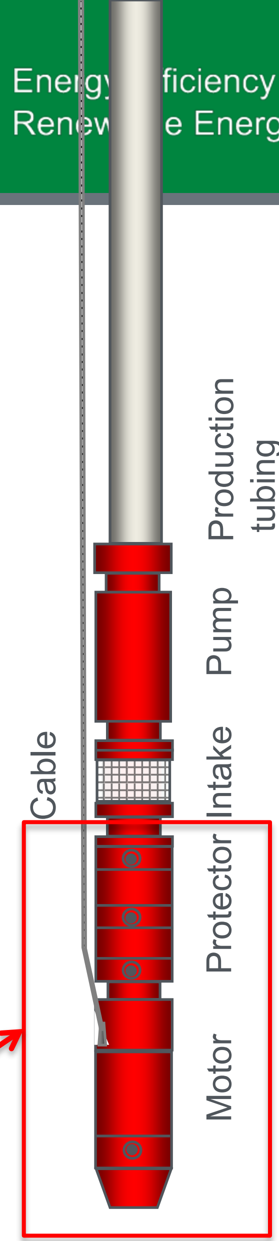
ESP Component Overview

- **Centrifugal Pump**
  Creates pressure to produce fluid to surface
- **Fluid Intake**
  Provides path for fluid into pump
- **Submersible Motor**
  Converts Electrical Energy to Rotational Motion
- **Cable and Electrical Connector**
  Delivers Electricity to Motor from Surface
- **Protector**
  Prevents Motor contamination



Hotline IV addresses the Motor, Protector, and Electrical Connector