New Concepts in Zonal Isolation for EGS

Existing borehole packers are incapable of handling temperatures above 175 ° C

High Temperature, High Pressure Devices for Zonal Isolation in Geothermal Wells

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Project Overview

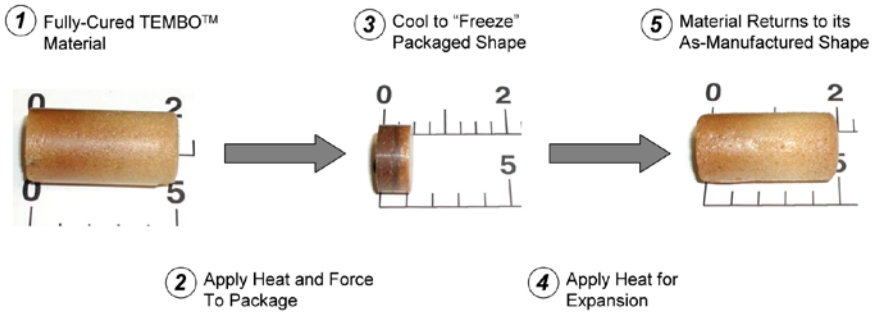
- **Goal:** Design, demonstrate, and qualify high-temperature high pressure zonal isolation devices compatible with the high temperature downhole Enhanced Geothermal Systems (EGS) environment
- **Timeline**
  - Start date: January 29, 2010
  - End date: December 31, 2012
- **Budget**
  - Total budget: $1,180,546
  - DOE share: $940,546, awardee share: $240,000
- **Barriers:**
  - Sealing materials capable of withstanding high temperatures (300° C) and high pressures up to 10,000 psi
- **Partners:**
  - Brontosaurus Technologies, Inc. (geothermal well design)
  - A-Power (testing in simulated downhole conditions)
  - Sandia National Laboratories (design and testing)

Relevance/Impact of Research

- **Program Objective: Develop HTHP EGS zonal isolation devices**
  - 10,000 psi differential pressure at 300° C
  - Primary barrier is poor stability of elastomeric seal above 175° C
  - Precise stimulation location
  - Increased fraccing speed and efficiency
  - Increased flow rates
  - Compatible with downhole environment
  - Reusable
- **HTHP Zonal Isolation will enable**
  - Seal off unwanted flow regions
  - Enable stimulation (fraccing)
  - Eliminate fluid loss
  - Identify and mitigate short circuiting
  - Target individual fractures for testing
  - Validating reservoir models

Scientific/Technical Approach

- **New zonal isolation at HTHP achieved by**
  - Use of shape memory polymer materials (SMP)
  - Thermally triggered actuation
  - SMP becomes a structural seal as it fills the well bore cross-section
  - Controlled flow through SMP increases differential pressure to form a high pressure seal
- **Utilize CTD's expertise in**
  - Shape memory polymers
  - Deployment mechanisms
  - High temperature materials



Deployable Solar Array

TEMBO® Shape Memory Foam for industrial application

Scientific/Technical Approach

- **Challenges**
  - Development of SMP material that will deploy at the appropriate time under HTHP conditions
  - SMP material with proper mechanical and flow properties
  - Development of a reliable delivery system
- **Tasks**
  - Develop a Detailed Specification
  - Selection of Materials and Components Designs
  - Screening and Evaluation of Potential Zonal Isolation Designs
  - Manufacture and Testing of Qualification Prototype
  - Develop Pilot-Scale Manufacturing Plan
- **FY10 Go/No Go decisions**
  - End of year screening/testing of engineering models and concepts

Accomplishments, Expected Outcomes and Progress to Date

- **Investigating and developing specifications**
  - Need clear, unambiguous set of goals for the device to be developed and qualified
  - In progress
- **Aspects of the specification and system design criteria**
  - Well Environment and Conditions
  - Shape Memory Polymer Seal Material
  - Operational System Performance
  - Delivery System
  - System operational design
- **Gathering information**
  - Reaching out to entities involved EGS Development
    - Learn requirements and needs for zonal isolation in EGS well systems
    - Ensure the device can be employed for wide range of zonal isolation operations and a wide range of well conditions and geology
    - Explore potential sites and opportunities for field testing

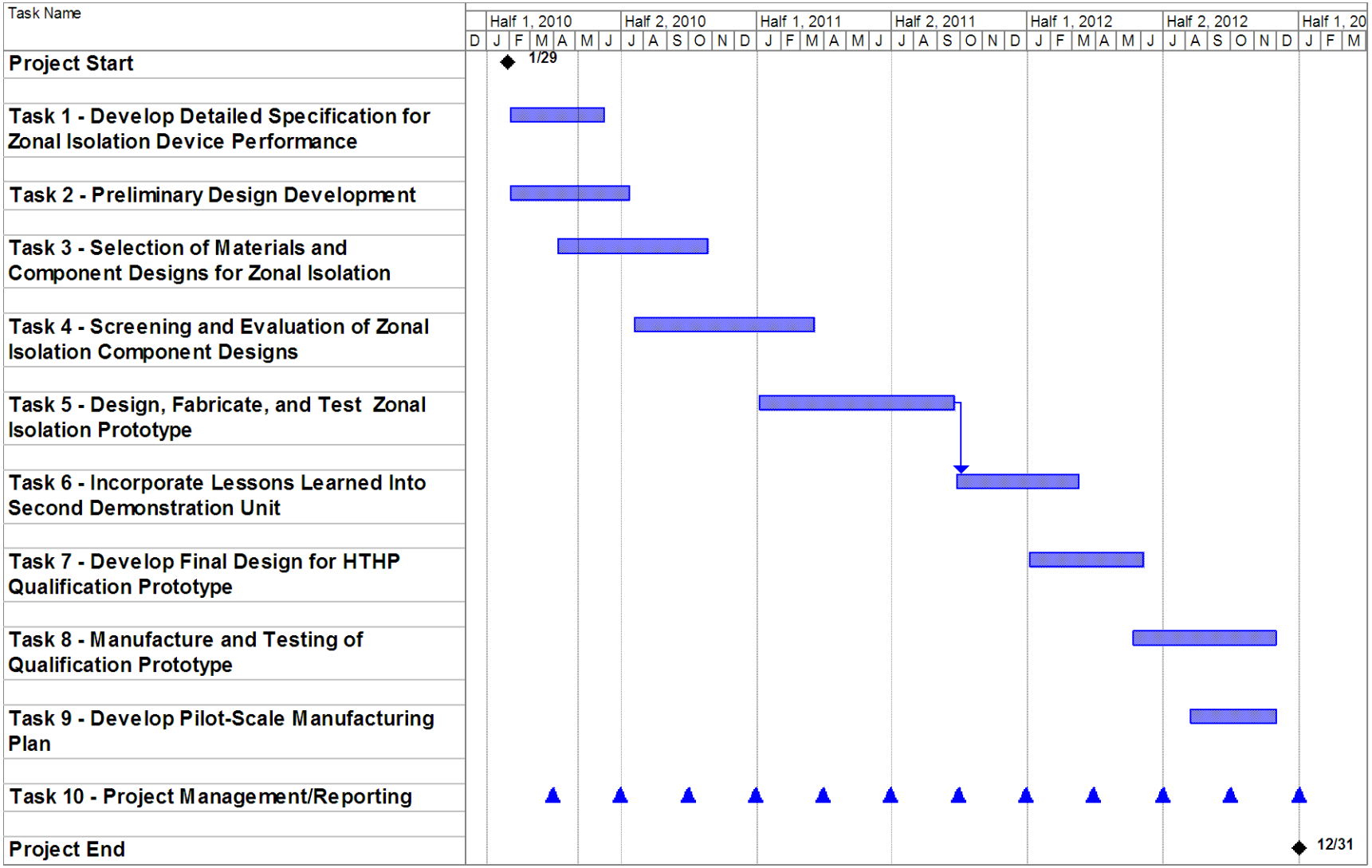
Accomplishments, Expected Outcomes and Progress to Date

- **Analytical model development**
  - Considers basic well characteristics
  - Zonal isolation needs
  - Outputs details & requirements
    - Enables design of specific device to serve a particular need
- **Seal material tests and calculations**
  - Determine necessary material properties
  - Quantify basic material properties
    - Material performance in downhole environment
    - Deployment temperature
    - Mechanical strength

Project Management/Coordination

- **Project management activities**
  - Oversight of technical work
  - Establish priorities of technical support staff
  - DOE reporting and documentation requirements
  - Budget management
- **Coordination of work with collaborators and vendors**
  - Communication with Brontosaurus Technologies and Sandia National Laboratories
- **Spend Plan**
  - Heavy 1st year bias, front end loaded
    - ~ 50% spending in first year
    - Large subcontract to Sandia National Laboratories
  - Field testing, design & system iterations in later years

Project Management/Coordination



Future Directions

- **Program is just underway**
- **Year 2010 plans**
  - Finalizing a detailed zonal isolation performance specification
  - Selection of materials and components designs
    - Material performance screening tests
  - Screening and evaluation of potential zonal isolation designs
  - Go/No Go decisions
    - End of year screening/testing of engineering models and concepts
- **Year 2011 plans**
  - Design, fabrication, & field testing of prototype
  - Analysis of performance
  - Incorporation of lessons learned

Summary

- **Goal: Develop HTHP EGS zonal isolation devices**
  - 10,000 psi differential pressure at 300° C
- **HTHP zonal isolation enabling for EGS**
  - Allow operation at higher temperatures and pressures
  - Seal off unwanted flow regions
  - Enable greater stimulation (fraccing) efficiency
  - Result in greater reservoir flow rates
- **New zonal isolation at HTHP achieved by use of shape memory polymer materials**
- **Utilize CTD and Brontosaurus Technologies' expertise in**
  - Shape memory polymers
  - Deployment mechanisms
  - EGS operations