Quarterly Progress Report

DOE Award No.: DE-FC26-06NT42951
Recipient: Drill Cool Systems, Bakersfield CA.

“Development and Application of Insulated Drill Pipe for High Temperature, High Pressure Drilling” Al T. Champness, Project Director

Report Date: xx April 2007
Report Period: 1 Jan. 2007 – 31 Mar. 2007

Summary: This reporting period was devoted primarily to three principal activities, one of which was completed, and the other two of which received essential preparatory work for milestones to be reached in the next reporting period. These three activities were:

- Preparation of a preliminary design
- Development of a mechanical testing plan
- Groundwork for industry interviews.

Each of these is described in detail below.

Preparation of a preliminary design: The preliminary design for the prototype IDP is based on the latest version of IDP manufactured by Drill Cool Systems. This pipe was sized for the deep-gas market, and thermal modeling showed its benefit in high-temperature reservoirs. Because of its underlying design criteria, and because this existing pipe has actually been run in field drilling operations, we assume that its basic properties are suitable for this environment.

A complete description of the design, including proprietary information concerning the insulation and the attachment methods for the insulation liner, was provided to DOE/NETL for permanent reference. A “sanitized” version of the design, without the proprietary information but still providing a comprehensive description of the pipe’s general properties, was submitted both through e-Link and through the FITS system. In follow-on work, critical activities to confirm the design’s validity include the mechanical testing and the industry collaboration that will define the users’ needs.

Development of a mechanical testing plan: Meetings in Houston with staff from Stress Engineering Services produced a mechanical test plan for the IDP preliminary design. The general approach to mechanical testing is to identify the operating environment that the pipe will see in HTHP use and to analyze the stresses that will result from that situation. The test plan will attempt to reproduce those stresses and to evaluate their effect. An outline of the test plan, with brief descriptions of the rationale for each test, is given below.

1. *Tensile*: The principal concern in tension is that the pipe body is made from stronger steel than the liner. This means that when the assembled pipe is stretched, the liner may yield while the pipe body is still in the elastic range. When the tensile load is relaxed then, the liner will be in compression and might experience slight buckling. In the tensile test, the pipe will be loaded to 90% of the pipe body yield, with simultaneous internal pressure, and will be cycled through this loading several times. The complete inside diameter surface of the pipe will be inspected before and after the test with a “borescope” that can optically identify any distortion. As the final step

in the testing, the pipe will be pulled until the pipe body yields.

2. *Internal pressure*: Internal pressure capacity of the IDP should actually be greater than for the parent drill pipe, but the contribution of the liner and insulation will be ignored. The concern is that somehow a flow path might be established through the fill plugs used to inject the insulation into the annulus between the drill pipe body and the liner. The IDP will be pressurized to 7500 psi and the fill plugs will be monitored for leaks while this pressure is held. Fill plugs will also be monitored during the tensile test, when the pipe will be internally pressurized.

3. *Fatigue*: Most drill pipe failures are related in some way to fatigue loading, and most of these failures occur near where the drillpipe and tool joint are joined. This is particularly relevant for IDP because of the tool joint modifications required to seat the insulation liner. Although the drill pipe manufacturer has done finite-element analysis of this modification and found it to be inconsequential, we feel that it is important to confirm this with fatigue testing.

   Stress levels for the fatigue test will reproduce stresses developed in drilling a deviated well with a build rate of 15^{O}/100 feet. Pipe configuration for the test, to focus on the tool joint area, will be an assembly in which a joint of IDP will be cut in two at the middle and the two ends screwed together. A rotating eccentric weight applied to the end of the pipe will then load the pipe in a fatigue mode until it fails. Pipe condition will be monitored by internal water pressure, with a wet-detector near the tool joint to signal when there is a leak. The pipe will be tested to failure in this fatigue mode, and the results will be compared with other proprietary fatigue data at Stress Engineering. This will enable us to make sure that the IDP fatigue performance lies roughly on the same fatigue curves as conventional drill pipe.

4. *Elevated temperature*: None of the IDP materials should be degraded by the temperatures expected in HTHP drilling, but there is a slight concern created by the temperature difference between the outside of the drill pipe and the inside of the liner. Differential thermal expansion might mean that the pipe would grow away from the liner, opening a leakage path through the fill plug. Calculations show that this difference would only be approximately 0.001" but again we wish to confirm this with a test. Temperature difference for the test will be 50^{O}F, considerably greater than the difference shown in thermal modeling, which is usually under 20^{O}F. Ports will be monitored for leakage during the test.

5. *Torsion*: Torsion load on the drill pipe will be 20,000 ft-lb, which represents 60% of the torsional yield strength of the pipe. It is also well above the recommended make-up torque (11,000 ft-lb) for the connection. The pipe will be cycled through this loading five times and will be monitored for leakage.

6. *Compression*: This test will address any concern that the liner would deform under compressive loads on the drill string. Normally, the bottom-hole assembly is designed so that drill collar weight will keep the drill string in tension, but as deviated wells become common, there is some occasion for drill pipe in compression. The test will load the pipe to 50% of compressive yield.

Groundwork for industry interviews: We believe that the industry interviews will be extremely valuable in both the design criteria and the marketing campaign for insulated pipe.

We will contract with Spears and Associates (Tulsa OK) for industry surveys in depth, but in preparation for that we have developed a preliminary questionnaire to be handed out at the Drill Cool booth at the World Oil HTHP Conference, to be held in Houston on 12-13 April.

The anticipated and actual budget is shown in the Table below:

Task	Task Description	Estimated NETL Expenditure	Actual NETL Expenditure	Estimated Drill Cool Cost	Actual Drill Cool Cost
1.3	Complete preliminary IDP design	1560	931.68	0	1468.32
1.4.1	Develop Mechanical testing plan	9785	524.07	3525	825.93
1.4.3	Complete Industry Interviews	20860	499.78	4350	787.65

Task Number	Critical Path Milestone Description	Project Duration -- Start: 1 Oct 06 End: 30 Sept 08								Plan Start date	Plan End date	Act. Start date	Act. End date	Comments
		Project year 1				Project Year 2								
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8					
1.4.2	Perform mech. tests									5/28/07	6/29/07			Use existing pipe
1.4.3	Complete Industry interviews									1/05/07	7/30/07	4/12/07		
1.4.5	Select prototype pipe size									8/15/07	8/30/07			
2.2	Mfg. prototype IDP									2/01/08	6/30/08			
2.4	Prototype field test									7/15/08	8/15/08			
2.6	Test thermal and hydraulic properties									4/30/08	6/30/08			