Development and Manufacture of Cost Effective Composite Drill Pipe

2001 Annual Technical Progress Report

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ABSTRACT

This technical report presents the engineering research and data accomplishments that have transpired to date in support of the development of Cost Effective Composite Drill Pipe (CDP). The report discusses and illustrates all progress in the first two years of this NETL/DOE supported program. The following have been accomplished and are reported in detail herein:

- Specifications for both 5 5/16” and 3 3/8” composite drill pipe have been finalized.
- All basic laboratory testing has been completed and has provide sufficient data for the selection of materials for the composite tubing, adhesives, and abrasion coatings.
- Successful demonstration of composite/metal joint interfacial connection.
- Upgrade of facilities to provide a functional pilot plant manufacturing facility.
- Arrangements to have the 3 3/8” CDP used in a drilling operation early in C.Y. 2002.
- Arrangements to have the 5 5/16” CDP marketed and produced by a major drill pipe manufacturer.

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1.0 Executive Summary

This three year development program is sponsored by the National Energy Technology Center (NETL) of the U.S. Department of Energy through contract DE-FC26-99FT4062.

1.1 Program Objective and Benefits

The objective of this contract is to develop and demonstrate "cost effective" Composite Drill Pipe (CDP). It is projected that this drill pipe will weigh less than half of its steel counter part. The resultant weight reduction will provide enabling technology drastically increasing the lateral distance which can be reached from an offshore drilling platform and the depth of water in which drilling and production operations can be carried out. Further, composite drill pipe has the capability to carry real time signal and power transmission within the pipe walls. CDP can also accommodate much shorter drilling radius than is possible with metal drill pipe.

As secondary benefits the lighter weight drill pipe can increase the storage capability of floating off shore drilling platforms and provide substantial operational cost savings. It is anticipated that commercial CDP will be available in 2003 at 2 to 5 times the cost of comparable steel pipe.

1.2 Program Status

All materials have been selected, tested and approved. Specifications have been prepared, reviewed and finalized for both 3 3/8" and 5 5/16" inch Composite Drill Pipe. Composite tube design has been completed and successfully tested for both the 3 3/8" and 5 5/16" CDP. The composite/metal interface design has been completed and successfully tested for the 3 3/8 inch CDP.

One third scale testing is underway for the latest revision of the 5 5/16 inch composite/metal interface design. Results will be available in October of 2001.

Abrasion and erosion protection for the CDP will be provided.

1.) Internally by a layer of fiber glass in a polymeric matrix.
2.) Externally by an overall, replaceable abrasion coating and by "industry standard" centralizers.

Three and three eighths inch drill pipe is scheduled to be used (and field tested) early in 2002 for short radius well drilling.

The 5 5/16" composite drill pipe will be ready for initial drilling operations by late fall of 2002.

All test specimen fabrication and initial manufacturing will be at ACPT. All facets of the pilot plant are either operational or in the process of being brought on stream. Some details of the specific fabrication processes are still under development.

2.0 Experimental

Design and Analysis is a continuous effort which will continue throughout the DOE contract and then will be an intimate part of all ongoing C.D.P. manufacturing operations. Initial work concentrated on specifying the requirements for a "typical" drill pipe which when converted to the capabilities of composites would enable extended reach and "deeper" water drilling. These requirements have continually been refined during this program and will be constantly upgraded as more experience in the use and manufacture of CDP are obtained. It will always be our goal to further extended the reach for horizontal drilling and enable drilling into even deeper water.

2.1 Task 1 Mechanical Requirements

2.1.1 5 5/16 Inch Composite Drill Pipe. Defining the mechanical requirements for CDP has been and continues to be an on going effort. Initially, as shown, in table 2.1.1.1, our industry partners supplied mechanical requirements identical to those being sought in 5 7/8 inch high strength steel drill pipe. These were reviewed and modified through open forum industry discussions. The refined mechanical requirements were then converted, as shown in Table 2.1.1.2 to conform to the mechanical/weight characteristics possible with low cost graphite/epoxy materials. More recently the required mechanical specifications have been exhaustively analyzed through joint effort with Omsco. The resulting mechanical specifications, currently in use for design of 5 5/16 inch CDP are included in Table 2.1.1.2.

2.1.2 3 3/8 Inch Composite Drill Pipe.

As a direct result of a technical presentation[1] and attendance at oil industry conferences, an immediate need for 3 3/8 inch drill pipe has been established. Composite Drill Pipe in the 3 3/8 inch range offers another enabling technology: Short Radius Drilling. The initial 1/3 scale testing in this DOE supported program has demonstrated that the ACPT designs will meet the requirements for this 3-3/8 inch drill pipe. The final specifications as arrived at through discussions and analysis with Torch Drilling are presented in Table 2.1.2.1. Short and full length sections designed to these specifications are being manufactured and will be tested in preparation for actual drilling operations which are scheduled for the spring of 2002.

Figure 2.1.1.1 5 7/8 inch CDP Performance Requirements, 11/15/99

Load Case	Applied Load	Test Load	Ultimate Load
Tension	20,000 TVD + 133,000 lb. Load	20,000 TVD + 199,500 lb. Load	20,000 TVD + 399,000 lb. Load
Compression	30,000 lb. Load	45,000 lb. Load	90,000 lb. Load
Torsion	30,000 ft-lb. Load	45,000 ft-lb. Load	90,000 ft-lb. Load
Internal Pressure	3,500 psi.	5,000 psi.	10,500 psi.
External Pressure	4,500 psi.	6,750 psi.	13,500 psi.
Temperature	-67F to 250F	-67F to 250F	-67 to 350F
Fatigue - Tension	1 million cycles	1 million cycles	1 million cycles
Fatigue - Compression	1 million cycles	1 million cycles	1 million cycles
Fatigue – Torsion	1 million cycles	1 million cycles	1 million cycles

Table 2.1.1.2 CDP Performance Requirements, 9/15/01.

		5 7/8" CDP	5 5/16" CDP
Tension, lb. Load	20,000 Ft + 133,000 lb. Pull-Up Load	478,750	450,000
Compression, lb. Load		30,000	30,000
Torsion, ft. lb. Load		56,250	37,500
Internal Pressure, psi		11,875	11,000
External Collapse Pressure (Differential), psi		4,500	6,500
Fatigue, Cycles		2,000,000	2,000,000
Operating Temperature, °F		350	350

2.2 Task 2 Electrical and Magnetic Specifications

CDP can carry power and/or real time communications through lines embedded in the composite walls. This program was empowered to investigate the feasibility of accomplishing these ends. Prior to beginning the program discussions with University of Houston had lead to the conclusion that the key to fruition of these concepts would be through specifying and evaluating the electrical and magnetic characteristics involved in transmitting power and/or communications through the composite. Initial discussions with other industry experts combined with in house knowledge of composites provide a different view of providing LWD/MWD capabilities in the CDP.

In summary: 1.) Signal and power can be transmitted through the composite walls. 2.) The problem to be solved is reliably transmitting signal or power through the metal joints connecting the individual CDP sections. Several concepts are currently being examined:

1.) Direct Connections
2.) Acoustic Transmission
3.) Inductive Transmission
4.) Electromagnetic Signal
5.) Combinations of the above

Direct Connect has been tried unsuccessfully numerous times in the past. Several revised concepts have been investigated. As a result a small "concept demonstration" contract was awarded to Maurer Engineering. If successful, Maurer and ACPT will prepare and submit an unsolicited proposal to demonstrate practicality and reduce this concept to practice.

Acoustic Transmission is being explored under the auspices of DOE funding by NovaTec in Utah. NovaTec has signed a contract with a drill pipe manufacturer which, at the present time, prevents them from sharing further knowledge with ACPT.

Inductive Transmission shows positive potential as a means of transmitting signals through the metal C.D.P. joints. Sandia National Laboratory is continuing to investigate Inductive Transmission with in-house disgressionary funding. Inductive coupling has been considered and will be further investigated if the conceptual demonstrations show sufficient merit.

Electromagnetic Signal transmission is not currently being pursued in this program.

In anticipation of the development of a successful method for transmitting signals across metallic joints, a small contract has been let and with Sandia to measure signal loss/transmission characteristics in CDP which has wires incorporated in the walls. The results are not available at this date.

2.3 Task 3 Physical Requirements

This work is essentially complete and the results are included in Table 2.1.1.2. This is, also an on going effort and the physical requirements will be updated as more actual drilling experience is obtained and as longer reach, deeper water capabilities are defined.

2.4 Task 4 Progress Report

A first year report was presented at NETL in Morgantown on 8/31/01. Task 4 is complete.

2.5 Current Designs

All design calculations and design philosophy used in obtaining the current designs were discussed in the previous quarterly progress report(2).

Figure 2.5.1, ACPT drawing # 3200 is the current design for 5 5/16 inch CDP. Figure 2.5.2, ACPT drawing #3075 is the current 3 3/8 inch CDP design.

Figure 2.5.1 5 5/16" CDP Interface Control Drawing

Intentionally Not Shown

Figure 2.5.2 3 3/8" CDP Control Drawing

Intentionally Not Shown

3.0 Results and Discussion

The Phase II, Testing portion of this program includes all testing from initial material screening through final "in-ground" evaluation of "market-ready" Composite Drill Pipe (CDP).

Material screening and material properties verification are complete and the results are presented below.

Composite-metal end joints and basic composite wall designs were evaluated through fabrication and testing of one third scale pipe sections. Designs, for which the 1/3 scale tests indicated that the full scale specifications would be met, were incorporated into 10 foot long sections of full diameter CDP and tested. Scale-up manufacturing difficulties required several iterations of 1/3 scale/ full size, design/ test/ redesign, efforts. It now appears that a final design, successfully tested with 3 3/8" CDP will meet all current specifications.

As a direct result of technical presentations and industry discussions, another oil field requirement, which can be met by cost effective CDP, has been identified. This is also an enabling technology: "The ability to drill short radius turns". The 1/3 scale test units are almost identical in size to the 3 3/8 inch drill pipe required for short radius drilling. Full length sections of 3 3/8" CDP have been designed. Further proof testing is underway for this specific application and "in-ground" usage is scheduled for 2002.

Extensive temperature, erosion and wear testing has been completed. Temperature capability, under simulated down well conditions indicate the current CDP designs will be useful to 350°F. Internal and external coatings have been selected. These coatings when used with current "industry standard" centralizers will provide adequate wear protection for the CDP. Further with simple visual inspection any sections of CDP which are worn can be pulled from production and recoated or even cleaned, ground, and rebuilt to nearly original condition. Once in operation CDP will be a very cost effective investment.

3.1 Task 5 Laboratory Testing

Laboratory testing is essentially complete. Task 5 included:

- Screening and verification of mechanical properties of resins, fibers, and adhesives for design and fabrication of CDP.
- Temperature and Environmental Resistance of all material to be used in the CDP.
- Measurement of Erosion and Mechanical Abrasion characteristics of interior and exterior coatings for CDP.
- Future work will be conducted in these areas to evaluate possible improvements for the CDP as currently designed.

3.1.1 Structural Materials Screening and Mechanical Properties.
After surveying the industry for materials which could provide composite tubing complying to the specifications established for CDP, test specimens were fabricated and tested. On the basis of this screening specific materials were selected and the laboratory testing was accomplished to obtain mechanical property data which were used for the design and analysis of both the 5 5/16 and 3 3/8 inch drill pipe.

Table 3.1.1.1 is a listing of the materials which have been qualified and are being used in current CDP designs. Table 3.1.1.2 presents the property value used in these designs.

3.1.2 Temperature/Environmental Resistance.
Temperature capability and environmental resistance were evaluated through 1.) short beam shear and 2.) In-plane shear tests.

Short beam shear (SBS) testing provides an excellent screening tool for evaluating the mechanical relationship between the resin and the fiber in composite structures. Short beam shear tests were run on the selected materials after exposure to the following environments:

Dry: RT, 200°F, 250°F, 300°F, 350°F
Wet (24 hour): RT, 200°F, 250°F, 300°F, 350°F
Wet (100 hour): 200°F, 250°F, 300°F, 350°F

SBS tests were also performed after temperature and pressure exposure to drilling mud. The exposure conditions included the following:

> Water base and oil base drilling mud at 200°F and simulated "down well" pressures for 10 days. Testing was run at RT, 200°F, 250°F, 300°F, 350°F.

These tests proved that, as anticipated, the graphite fiber/epoxy matrix experienced a reduction in high temperature shear strength after exposure to moisture. It was postulated that the strength degradation was caused by hydrolysis of the resin. This resin softening is a diffusion controlled phenomena and the very small SBS specimens present the worst possible exposure conditions. The SBS specimens are ¼" x ¼" x 1". CDP will be a continuous tube with environmental protection on the inside and outside and will be on the order of 0.56" thick. In addition drill pipe does not experience long term continuous exposure at the most extreme environmental conditions. Therefore a second set of 100 hour boiling water exposure tests were run with in-plane sheer specimens and with 1/3 scale pipe. The results of these environmental exposure tests show that the current composite matrix can be used in down well conditions up to 350°F.

3.1.3 Erosion and Mechanical Wear Coatings.
Composites are much more susceptible to wear and abrasions than steel. It was recognized at the beginning of this program that the CDP would have to be protected from mechanical wear.

Table 3.1.1.1 Materials Qualified for use in CDP.

- FIBERS
  Carbon Zoltek Panex 33 Tow Size: 48K
  (spec. #SMF-030) 525 Ksi Fiber Strength, 33Msi Fiber Modulus
  Carbon Toray T-700 Tow Size: 12K
  (spec. #SMF-031) 750 Ksi Fiber Strength, 33 Msi Fiber Modulus
  Fiberglass Certainteed Vetrotex Tow Size: 450 Denier
  (spec. #SMF-040) 225 Ksi Fiber Strength, 10 Msi Fiber Modulus

- RESIN
  350 F High Performance Bisphenol A Epoxy with Aromatic Amine Curing Agent qualified to ACPT Specification # SMR-061.

- ADHESIVE
  Scrim Supported Film Adhesive, 350F Service Temperature Epoxy, ACPT Specification # SMA-027.

- SURFACE COATING
  350F Service Temperature coating, ACPT Specification # SMC-042.

Table 3.1.1.2 Composite Lamina Data

	SMF 030	SMF 031	SMF 040
Young's Modulus – Longitudinal	20.5 Msi	19.5 Msi	5.7 Msi
Young's Modulus – Transverse	1.4 Msi	1.1 Msi	1.4 Msi
Poisson's Ratio	.28	.28	.29
In-Plane Shear Modulus	.66 Msi	.66 Msi	.60 Msi
Tension Strain – Longitudinal	.0095 in/in	.01816 in/in	.02246 in/in
Tension Strain – Transverse	.0045 in/in	.00664 in/in	.00688 in/in
Compression Strain – Longitudinal	-.009915	-.01103 in/in	-.01263 in/in
Compression Strain – Transverse	-.01037 in/in	.01673 in/in	-.01143 in/in
In-Plane Shear Strain	±.01066 in/in	±.01066 in/in	±.01453 in/in
CTE – Longitudinal	-.02 ppm/F	.10 ppm/F	4.80 ppm/F
CTE – Transverse	18.50 ppm/F	17.5 ppm/F	12.30 ppm/F

SMF 030 = Zoltek
SMF 031 = Toray
SMF 040 = Certainteed, E Glass

Discussions with drilling companies resulted in the wear program being divided into two areas.

1.) Internal wear and lubricity and
2.) External erosion and abrasion.

3.1.3.1 Internal Wear. Internally, wear is not a serious problem. Steel pipe is typically coated or lined with a thermoplastic, or rubber material. Both water and oil based drilling mud have been evaluated. As a result, and in agreement with oil field industrial personnel: it is concluded internal wear is not a serious problem and can be handled by an inner glass/epoxy liner.

3.1.3.2 Exterior Abrasions and Coatings. A dual approach is planned for protecting the exterior of CDP from abrasion. A very tough, highly wear resistant coating has been developed for overall, external, abrasion protection. The industry already uses "centralizers" for protecting steel drill pipes. Both will be used for CDP.

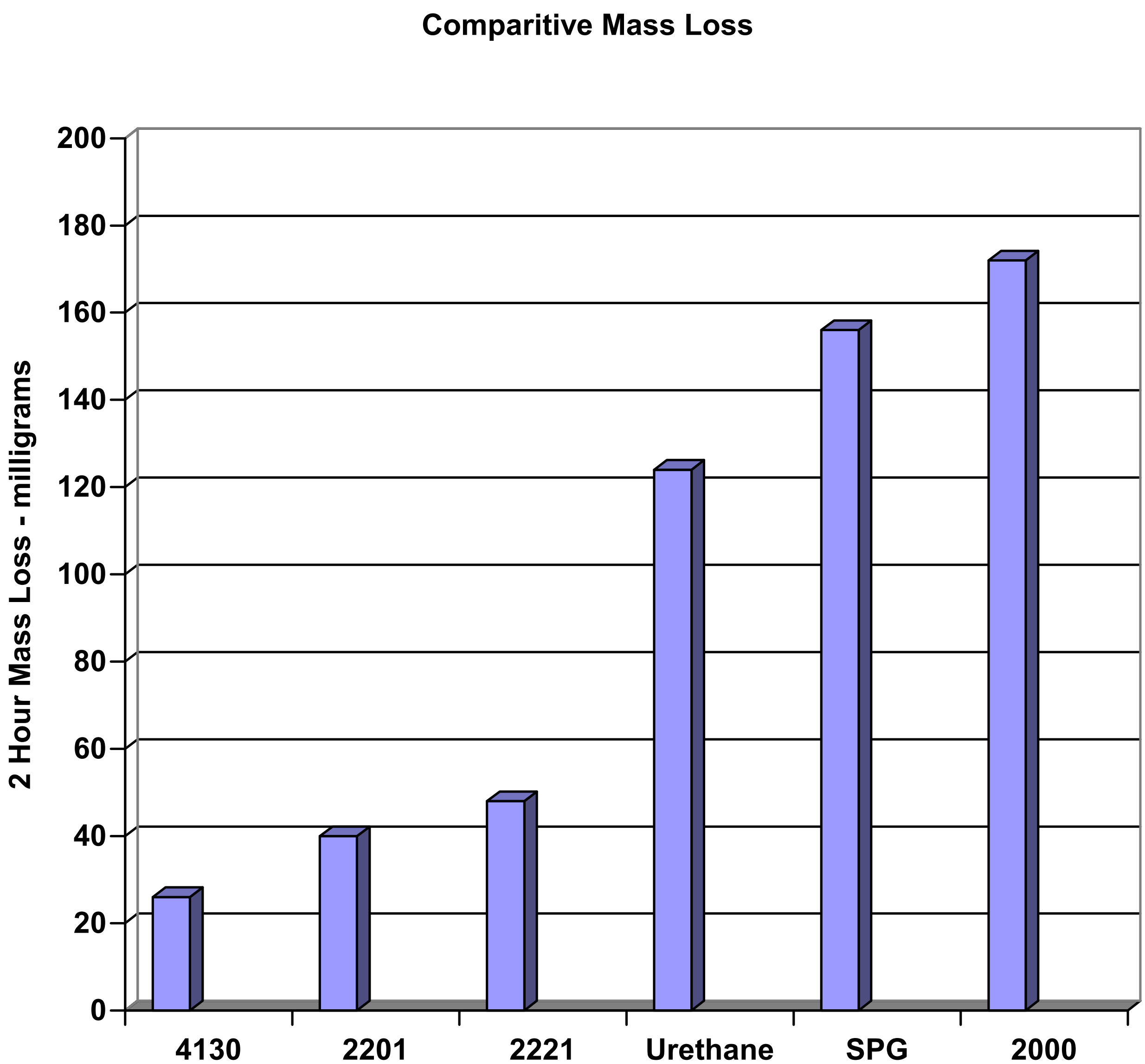
ACPT screened more than 20 potential coatings for external abrasion/wear protection. These were primarily urethane or epoxy based materials capable of use to 350°F. Both filled and unfilled systems were evaluated. After initial screening, 5 systems were selected and evaluated through Slurry Abrasion Resistivity (SAR) testing. SAR is a standard wear test used to measure wear resistance within slurry pumps and is accepted by the oil industry. Figure 3.1.3.2 compares the SAR test results with data run simultaneously on 4130 steel. As shown system, 2201, selected for use with CDP experiences more wear but compares favorably with 4130 steel. It is also noted that if wear is encountered the 2201 coating can be reapplied to protect the basic CDP structure.

Centralizers/Wear "Knots": Centralizers, donut shaped protective rings, are standard equipment for preventing wear and abrasion on steel drill pipe. They will also be used on composite drill pipe.

ACPT has reviewed the industry for "off-the-shelf" centralizers. At present it is planned that high durometer elastomeric units will be utilized with CDP.

It is also noted that, unlike steel, CDP can easily be modified with localized, wound-in-place build-ups for additional wear protection. This technique will also be considered to enhance the effectiveness of commercial centralizers. It is further noted that like the 2201 erosion coating, when worn the localized build-up can be reapplied. Centralizers can also be replaced prior to the CDP's experiencing untoward wear. Finally centralizers also provide protection for the well casing and help in reducing torsional drag on the drill pipe.

Figure 3.1.3.2 Erosion Test Data by SAR



3.1.4 Testing of 1/3 Scale Pipe.

The major difficulty in producing a commercially useful composite drill pipe has always been recognized as the interface between the composite tube (pipe) and the steel joints. In order to reduce developmental costs ACPT broke the CDP development and testing into two distinct areas: subscale design and testing and full scale design and testing. One third (1/3) size (diameter) was chosen for the small scale effort and the full scale work was broken into 1) full diameter pipe in 10 foot sections and 2) full diameter pipe at the full length of 31.5 feet (shoulder-to-shoulder) of the metal joints.

To date the 1/3 scale testing is complete; 10 foot sections of full diameter CDP have been fabricated and tested; and tooling, fabrication equipment, and procedures are being prepared for building the 31.5 foot test units.

The 1/3 scale test specimens are 1.417 inch ID and have 12 inches of composite tube between the steel joints. This configuration provides the following scale up to full size CDP.

Tension load: 1/9th
Torsion load: 1/27th
Pressure load: 1/3rd

Twenty six (26) different 1/3 scale tension tests were completed. These tests evaluated 15 different combinations of composite/metal joint interface and composite wall configuration. As shown in Figure 3.1.4, it appeared after the 8th, 9th and 11th tests, that a successful composite/metal interface design had been achieved.

At this point, after the 11th test, full size –10 foot sections of CDP were fabricated and tested. Due to fabricating difficulties this specific design could not be successfully reproduced and the 1/3 scale testing work was reinstituted. More recently, based upon the final 1/3 scale work and in order to qualify for short radius drilling 3 3/8" sections have been tested. The results of these tests prove that the full scale requirements will be met. Fabrication of specimens for "proof-prior-to-drilling" testing of the CDP, as called out in Table 3.1.7 is underway.

3.1.5 Testing of 10 Foot Sections of CDP

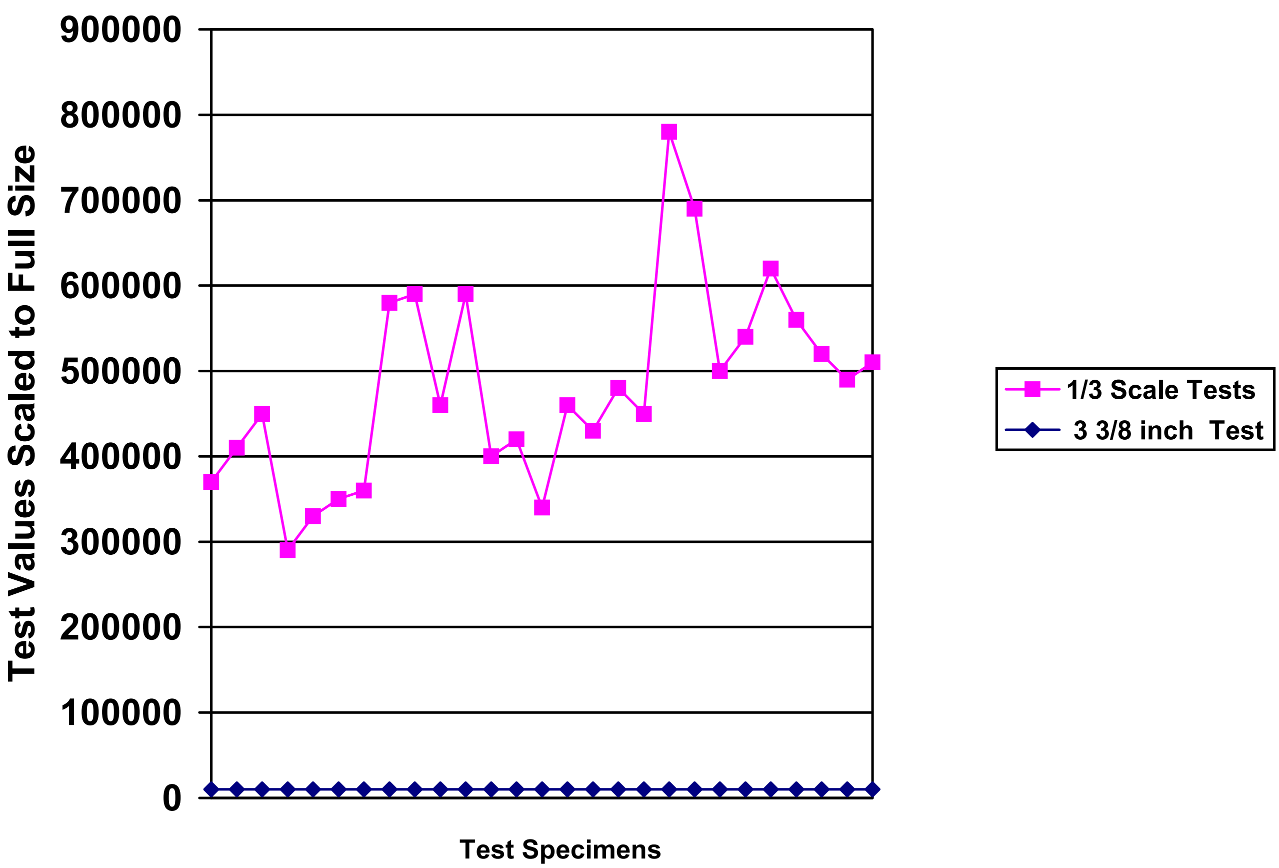
Seven full diameter, 10 foot sections of CDP have been tested. Five tension and two torsion tests were run.

The first scale-up tests, after successful 1/3 scale evaluation, were run in the fall of 2000. Manufacturing scale-up problems resulted in unsatisfactory fiber placement management and tension failures were below design specifications.

The torsion tests showed that, as predicted, the CDP specifications for torsion loading will be met using the current design philosophy.

Another series of 10 foot, full diameter specimens are being prepared at this time. These units will demonstrate all aspects of the latest CDP designs.

Figure 3.1.1.4 : SubScale Tension Test Summary



3.1.6 Laboratory Testing of Full Size 5 5/16" CDP

To date no full length sections of the 5 5/16" CDP have been fabricated or tested. Preparations for the fabrication of full size CDP are nearly complete. This testing will be under way very early in 2002.

3.1.7 Testing of 3 3/8" CDP

Mandrels and ends have been obtained to begin proof testing of 3 3/8" CDP. Initially short 36" lengths of pipe are being tested for tension, torsion, and pressure. After completion of the short specimens full length testing will be accomplished. Table 3.1.7 presents the test matrix to be completed with 3 3/8" CDP.

Preparations are under way to establish capability to fabricate full length 3 3/8" CDP. It is anticipated the test program shown in Table 3.1.7 will be completed during 2001 and "in-ground-use" testing of the 3 3/8" CDP will begin late in 2002.

3.1.8 Testing of 5 5/16" CDP

The final test matrix for the 5 5/16" CDP is shown in Table 3.1.8. The fabrication and testing of 5 5/16" CDP should be completed by late fall of 2002.

Table 3.1.7 Test Matrix for 3 3/8 Inch CDP.

Test Description	Acceptance Criteria	Comments
Tensile		
Static @ R.T.	3 successive tests of final design with no tube or bond failure @ 25% over rating	Mandatory + Production Sampling Also obtain tensile stiffness data
Static @ 350 F	Same, but 2 tests vs. 3	Mandatory
Static @ 350 F Wet	Same, 3 tests	Mandatory
Compression		
Static @ R.T.	3 successive tests of final design with no tube or bond failure @ 25% over rating	Mandatory Also obtain compression stiffness data
Static @ 350 F	Same, but 2 tests vs. 3	Same as R.T.
Torsional		
Static @ R.T.	3 successive tests of final design with no tube or bond failure @ 25% over rating	Mandatory Also obtain torsional stiffness data
Static @ 350 F	Same, but 2 tests vs. 3	Same as R.T.
Static @ 350 F Wet	Same, 3 tests	Mandatory
Burst (Internal Pressure)		
Static @ R.T. Test to 80% of rating.	Hold 15 min., max pressure drop 50 psi, + no failure, repeat	Mandatory
Static @ R.T. Test to Failure	2 tests @ 25% over rating	Mandatory
Collapse (External Pressure)		
Static @ R.T. Test to 80% of Rating.	Hold for 15 min., max pressure drop 50 psi, + no failure	Mandatory
Static @ R.T. Test to Failure	1 tests @ 25% over rating	Mandatory
Bending Fatigue		
1 million cycles Deflection 25% > Steel	2 tests. No Failure Monitor with NDT	Mandatory
200K to 500K cycles Deflection to cause failure Monitor with NDT	3 tests. Confirm Calculated Deflection to Failure and NDT Method	Mandatory

Table 3.1.8 Test Matrix for 5 7/8 Inch CDP.

Test Description	Acceptance Criteria	Comments
Tensile		
Static @ R.T.	3 successive tests of final design with no tube or bond failure @ 25% over rating	Mandatory + Production Sampling Also obtain tensile stiffness data
Static @ 350 F	Same, but 2 tests vs. 3	Mandatory
Alternating Load 1,000 cycles, range 0 to tensile rating	1 test, no failure	Optional, low priority
Compression		
Static @ R.T.	3 successive tests of final design with no tube or bond failure @ 25% over rating	Mandatory Also obtain compression stiffness data
Static @ 350 F	Same, but 2 tests vs. 3	Same as R.T.
Alternating Load 1,000 cycles, range 0 to compression rating	1 test, no failure	Optional, low priority
Buckling		
Determine buckling load for one joint length of steel and composite pipe assembly	Test with and without wear pads at 0,30, 60, 90 degrees.	Optional, low priority
Torsional		
Static @ R.T.	3 successive tests of final design with no tube or bond failure @ 25% over rating	Mandatory Also obtain torsional stiffness data
Static @ 350 F	Same, but 2 tests vs. 3	Same as R.T.
Alternating Torque	2 tests, no failure	Optional, desirable
Burst (Internal Pressure)		
Static @ R.T. Test to 80% of rating.	Hold 15 min., max pressure drop 50 psi, + no failure, repeat once.	Mandatory
Static @ R.T. Test to failure	2 tests @ 25% over rating	Mandatory
Static @ 350 F Test to 80% of rating	Hold 15 minutes, max pressure drop 50 psi, no failure.	Mandatory
Static @ 350 F Test to failure	1 test @ 25% over rating	Mandatory
Collapse (External Pressure)		
Static @ R.T. Test to 80% of rating	Hold 15 min., max pressure drop 50 psi, + no failure.	Mandatory
Static @ R.T. Test to failure	1 tests @ 25% over rating	Mandatory
Static @ 350 F Test to 80% of rating	Hold 15 minutes, max pressure drop 50 psi, no failure.	Mandatory

Static @ 350 F Test to failure	1 test @ 25% over rating	Mandatory
Bending Fatigue		
1 million cycles Deflection 25% > Steel	2 tests. No Failure Monitor with NDT	Mandatory
200K to 500K cycles Deflection to cause failure Monitor with NDT	3 tests. Confirm Calculated Deflection to Failure and NDT Method	Mandatory
BOP		
Shear	2 tests. Normal Operation	Mandatory
Seal	1 test. Normal Operation	Mandatory
Close Blind Rams	1 test. Normal Operation	Mandatory
Fishing		
Overshot catch	1 test. Normal Operation	Mandatory
Milling	1 test. Prove capability. Additional tests problems.	Mandatory
Jarring (impact load @ tensile rating, 50 hits)	No Failure	Mandatory
Field Test @ Lab		
Run 9 joints in string during tests of other tools	No Failure. Test NDT.	Optional
Field Test (actual use)		
Run 21 joints in string Duration to be determined	No Failure. Test NDT	Mandatory

3.2 Task 6 "Field Testing"

3.2.1 Field Testing of 3 3/8" CDP All field testing of 3-3/8" CDP will be accomplished by use in drilling short radius wells.

3.2.2 Field Testing of 5 5/16" CDP The planned field testing of 5-5/16" CDP is included in Table 3.1.8.

3.3 Task 7 Second Year Technical Reporting

An oral presentation of the accomplishments of this program was made at the NETL/DOE facilities in Morgantown, WV on 8/20/01. This report is presented in fulfillment of the requirement of Task 7 for a formal "Technical Report"

4.0 Other Discussion - Manufacturing

The original proposal assumed set-up of a manufacturing facility capable of producing 24 units of 30 foot lengths of 5 7/8 inch CDP per day. The current planning is to modify the existing equipment at ACPT to an acceptable pilot plant operation.

To date the following have been accomplished toward that goal:

- Winding of 10' sections of representative 5 7/8 CDP has been accomplished.
- A winding machine has been modified to increase the winding length to provide capability to wind full 30 foot sections (actual total length, shoulder to shoulder of the metal joints, is 31.5 ft.)

- A “curing cart” capable of curing four 30 foot sections simultaneously, is in place and being used.
- A winding-curing cart designed for use with 3 3/8 CDP has been obtained. It may need modifications (extent to be determined and designed after receipt of the 30 foot 3 3/8 CDP mandrel).
- A winding cart may be required for 5 5/16 inch CDP (also to be determined and designed after receipt of a 5 5/16 CDP winding mandrel).
- A 30 foot lathe for final machining of CDP has been obtained. (This “used” equipment is still in progress of being brought into fully useable condition).
- The current oven is capable of curing 5 sections of CDP simultaneously.
- A “Mandrel Puller” has been designed to extract mandrels from the 30 foot sections of CDP. The mandrel puller is on order.

The above basic facilities will allow “pilot plant” production up to 5 - 30 foot sections of CDP per day (possibly 10 to 15 with more upgrade and modification). It is believed that this production rate will allow initial market evaluation. Additional capacity will require the incorporation of automation and continuous operation to the winding, curing, and machining functions. ACPT is working closely with Omsco to establish marketing levels and schedules. These results will determine the schedule and extent of pilot plant upgrade or the necessity to build a full scale, continuous operation CDP production unit.

4.1 Task 8 Test Samples and Preliminary Drill Pipe Sections

See Sections 3.1.4 and 3.1.5.

4.2 Task 9: Pilot Plant Production

As described above all Pilot Plant production will be performed at ACPT. The existing facilities have or are in the process of modifications to accommodate Task 9.

4.3 Task 10: Full Scale Production

When planned production requirements indicate that the pilot plant capacity will be exceeded, Omsco with technical assistance from ACPT, will set-up a manufacturing facility.

4.4 Task 11: Final Report

A final report will be prepared and presented in September of 2002.

5.0 References

1. Leslie, Dr. J.C. ; Jean, J ; Truong, L ; Neubert, H ; and Leslie, J. II. ; “Cost Effective Composite Drill Pipe: Increased ERD, Lower Cost Deepwater Drilling and Real Time LWD/MWD Communications”; SPE Paper No. 67764; SPE/IADC Conference, The Netherlands, 2/27-3/1/01.
2. Leslie, Dr. J.C. ; Jean, J ; Truong, L ; and Neubert, H : Development and Manufacture of Cost Effective Composite Drill Pipe, Quarterly Progress Report, ACPT, Huntington Beach, CA January 2000.