

**FATIGUE TEST  
WEARSOX APPLICATIONS  
ON 5-7/8 DRILL PIPE**

**PROJECT NUMBER 117460  
PROJECT MANAGER: JACKIE E. SMITH, P.E.**

**WEARSOX  
9618 WEST TIDWELL ROAD  
HOUSTON, TX 77041**

**FEBRUARY 2008**



**Fatigue Test  
Wearsox Applications  
on 5-7/8 Drill pipe**

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**Prepared by:**

  
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**February 2008**



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Houston, Texas 77041  
[www.stress.com](http://www.stress.com)**

## Test Description

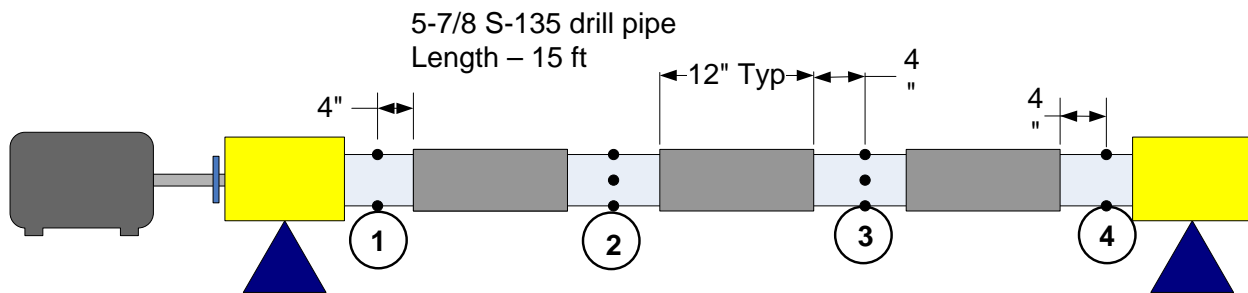
A 15 foot length of 5-7/8 23.40 ppf S-135 drill pipe with no tool joints was sent to Stress Engineering Services (SES) for fatigue testing. The pipe had three bands of WearSox, each approximately 12 inches long and ¼ inch deep, applied to the outside surface. A photograph of the pipe is in Figure 1, Appendix A. The center band, applied using the preferred production procedure, was of primary interest. The outboard bands were applied using a discontinued procedure and were expected to fail.

The objective of the test was to verify the durability of the WearSox application when subjected cyclic bending stresses simulating 5 deg/100 ft doglegs and axial stresses from internal pressure in the pipe simulating 313 kip hanging weight.

The test program consisted of the following internal pressures and load conditions supplied by WearSox:

1. No internal pressure. Bring the bending stress up to 5 deg/100 ft and run for 500,000 cycles.
2. While maintaining the 5 deg/100 ft cyclical stress, raise the internal pressure up to 2,500 psi and run for an additional 500,000 cycles (end total 1 million cycles)
3. While maintaining the 5 deg/100 ft cyclical stress, raise the internal pressure up to 5,000 psi and run for an additional 500,000 cycles (end total 1.5 million cycles)
4. While maintaining the 5 deg/100 ft cyclical stress, raise the internal pressure up to 7,500 psi and run for an additional 500,000 cycles (end total 2 million cycles)
5. While maintaining the 5 deg/100 ft cyclical stress, raise the internal pressure up to 10,000 psi and run for an additional 500,000 cycles (end total 2.5 million cycles)
6. While maintaining the 5 deg/100 ft cyclical stress, raise the internal pressure up to 15,000 psi and run for an additional 500,000 cycles (end total 3 million cycles)
7. Increase bend stress to 10 deg/100 ft while maintaining 15,000 psi internal pressure and run 133,070 cycles

8. Increase bend stress to 15 deg/100 ft while maintaining 15,000 psi internal pressure and run 195,861 cycles.



**Strain gage placement**

### Test Results and Conclusions

A crack formed in the drive end outboard WearSox band late during Load Step 6 between 2.5 and 3.0 million cycles. A photograph of the crack is in Figure 3.

The center WearSox band did not crack during any of the testing.

Load Step	Stresses in Pipe Body	Strain Gage Location			
		1	2	3	4
1	Bending Stress Amplitude	6,148	6,596	6,109	4,366
	Mean Stress from Internal Pressure	0	0	0	0
2	Bending Stress Amplitude	6,110	6,634	6,168	4,373
	Mean Stress from Internal Pressure	8,338	8,338	8,338	8,338
3	Bending Stress Amplitude	6,068	6,642	6,177	4,369
	Mean Stress from Internal Pressure	16,675	16,675	16,675	16,675
4	Bending Stress Amplitude	Data set was lost.			
	Mean Stress from Internal Pressure	25,013	25,013	25,013	25,013
5	Bending Stress Amplitude	5,930	6,668	6,204	4,273
	Mean Stress from Internal Pressure	24,438	26,536	24,671	17,490
6	Bending Stress Amplitude	6,030	6,788	6,339	4,330
	Mean Stress from Internal Pressure	50,025	50,025	50,025	50,025

7	Bending Stress Amplitude	11,078	12,894	13,809	8,660
	Mean Stress from Internal Pressure	50,025	50,025	50,025	50,025
8	Bending Stress Amplitude	12,196	14,666	14,487	10,886
	Mean Stress from Internal Pressure	50,025	50,025	50,025	50,025

### Conclusions

- The center WearSox band performed satisfactorily with no cracks forming during the test. Total cycles on the pipe was 3.329 million cycles.
- The WearSox band nearest the motor (drive end) developed cracks at some point before 3.000 million cycles. The WearSox band that cracked did not spall or become separated from the pipe.
- The WearSox band on the “dead” end did not crack.

**Appendix A - Photographs**



Figure 1

As received test sample with three WearSox bands. Pipe is 5-7/8 23.40 ppf S-135



Figure 2

Test sample in SES pit being made ready for testing. Test equipment induced cyclic bending loads at rate of 15.8 Hertz.



Figure 3  
Outboard WearSox band that developed cracks.



Figure 4  
Center WearSox band did not develop any cracks.



Figure 5  
WearSox band on "dead" end that did not crack.

**Appendix B - Hand Log Sheet**



**Appendix C – Calculation Sheet**



117460 VME.xmcd

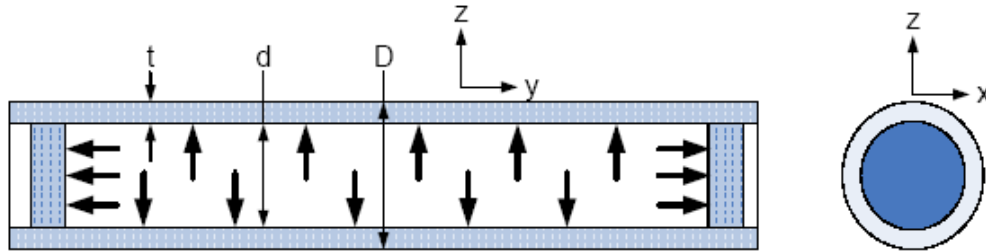
2/8/2008

CLIENT: WearSox

PROJECT: 117460 Fatigue Test

Sy := 135000psi E := 30 · 10<sup>6</sup>psi

CALCULATION BY Jack Smith PE



$$D := 5.875 \text{ in}$$

$$P := 15000 \text{ psi}$$

$$t := 0.361 \text{ in}$$

$$d := D - 2t = 5 \text{ in}$$

$$\frac{D}{2t} = 8$$

Less than 10 - thick wall  
cylinder

$$A_{pb} := \frac{\pi}{4} \cdot (D^2 - d^2) = 6.254 \text{ in}^2$$

$$A_b := \frac{\pi}{4} d^2 = 20.855 \text{ in}^2$$

$$F_y := P \cdot A_b = 312825 \text{ lbf}$$

Pressure endload

$$\sigma_{yp} := \frac{F_y}{A_{pb}} = 50024 \text{ psi}$$

Axial stress from pressure

$$\sigma_{xo} := \frac{P \cdot d^2 \cdot (D^2 + d^2)}{D^2 \cdot (D^2 - d^2)} \quad \sigma_{xo} = 88508 \text{ psi}$$

Tangential OD stress from  
pressure

$$\sigma_{xi} := P \cdot \frac{(D^2 + d^2)}{(D^2 - d^2)} \quad \sigma_{xi} = 115048 \text{ psi}$$

Tangential ID stress from  
pressure

$$\sigma_z := -P$$

Radial ID stress from  
pressure

**Bending stresses**



117460 VME.xmcd

2/8/2008

$$\text{Dogleg} := 5 \frac{\text{deg}}{100\text{ft}}$$

$$\sigma_{bo} := \frac{D}{2} \cdot \text{Dogleg} \cdot E$$

$$\sigma_{bo} = 6409 \text{ psi}$$

**Bending Stress Amplitude OD**

$$\sigma_{bi} := \frac{d}{2} \cdot \text{Dogleg} \cdot E$$

$$\sigma_{bi} = 5621 \text{ psi}$$

**Bending Stress Amplitude ID****Von Mises Equivalent Stresses on OD surface**

$$\sigma_{y0} := \sigma_{yp} + \sigma_{bo}$$

$$\sigma_{y0} = 56433 \text{ psi}$$

**Max axial stress OD**

$$\text{VME}_0 := \sqrt{\sigma_{y0}^2 - \sigma_{y0} \cdot \sigma_{x0} + \sigma_{x0}^2}$$

$$\text{VME}_0 = 77612 \text{ psi}$$

**Von Mises Equivalent Stresses on ID surface**

$$\sigma_{yi} := \sigma_{yp} + \sigma_{bi}$$

$$\sigma_{yi} = 55645 \text{ psi}$$

**Max axial stress ID**

$$\text{VME}_i := \sqrt{\frac{1}{2} [(\sigma_{yi} - \sigma_{xi})^2 + (\sigma_{yi} - \sigma_z)^2 + (\sigma_{xi} - \sigma_z)^2]}$$

$$\text{VME}_i = 112765 \text{ psi}$$

$$\frac{\text{VME}_0}{S_y} = 0.57$$

$$\frac{\text{VME}_i}{S_y} = 0.84$$

**Internal stress greater than 2/3 yield strength of material****OD Strains**

$$\text{Stress\_Range} := 2 \cdot \sigma_{bo} = 12817 \text{ psi}$$

$$\text{Strain\_Range} := \frac{\text{Stress\_Range} \cdot 1 \cdot 10^6}{E} = 427$$