DEA-130
Modernization of Tubular Collapse Performance Properties

PRESENTATION TO THE DEA Q4/02 MEETING

November 21, 2002

SPONSOR = ARCO / MIKE PAYNE
DEA –130 DURATION

PROPOSED - FEBRUARY 1999
FIRST OFFICIAL MEETING - OCTOBER 1999
PROGRAM COMPLETION - OCTOBER 2002

DEA –130 FUNDING

TOTAL FUNDING = $420,000
OPERATOR PARTICIPANTS = $22,500
INDUSTRY & GOVT AGENCY = $22,500
(API = $45,000)
MANUFACTURERS = $7,500 + DONATION OF PIPE & SHIPPING & TENSILE TESTS
TOTAL OF 25 PARTICIPANTS

11 OPERATORS - ARCO (NOW WITH BP)
AMOCO (NOW WITH BP)
BURLINGTON RESOURCES
CHEVRON (NOW WITH TEXACO)
MARATHON OIL
PEMEX
REW-DEA (GERMAN OIL CO.)
SHELL OIL
TEXACO (NOW WITH CHEVRON)
TOTAL FINA ELF
UNOCAL
PHILLIPS (VIA ARCO ALASKA)

3 INDUSTRY/GOVERNMENT AGENCIES –

API
HSE-UK
MMS
SELECTION OF PIPE SAMPLES FOR COLLAPSE TESTING

NUMBER PIPES SELECTED = 216

11D + 72”

18” TT

8D COLLAPSE

3D RST

36” SP

18” TT
PREFERRED SAMPLES AND ACTUAL SAMPLES
DEA-130
PIPE SIZES TESTED

1.375" 15.9%
11.75" 2.0%
10.75" 4.0%
9.625" 16.6%
8.625" 4.6%
7.75" 3.3%
7" 18.5%
5.5" 17.9%
5" 2.0%
3.5" 1.3%
2.875" 0.7%
16" 4.0%
13.625" 2.0%
13.375" 15.9%
DEA-130 TEST SAMPLES BY GRADE

- A: 23.8%
- Q: 9.3%
- P: 13.9%
- N: 18.5%
- L-13Cr: 7.3%
- L: 4.6%
- K: 13.2%
- J: 7.3%
- H: 2.0%
RESIDUAL STRESS TEST

SPLIT RING METHOD

6 WALL THICKNESSES

3 OD MEASUREMENTS

CRAMPTON & THIN SHELL STRESS

DEA-101 RESIDUAL STRESS MEASUREMENT OF PIPE SAMPLES

<table>
<thead>
<tr>
<th>PIPE NO.</th>
<th>OD, INCH</th>
<th>THICKNESS, INCH</th>
<th>L/D</th>
<th>THICKNESS, INCH (SEE NOTE BELOW)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>AVG. BEFORE</th>
<th>AFTER</th>
<th>DIFF.</th>
<th>BEFORE</th>
<th>AFTER</th>
<th>DIFF.</th>
<th>BEFORE</th>
<th>AFTER</th>
<th>DIFF.</th>
<th>BEFORE</th>
<th>AFTER</th>
<th>DIFF.</th>
<th>THIN WALL</th>
<th>CRAMPTON</th>
</tr>
</thead>
<tbody>
<tr>
<td>R312</td>
<td>10.75</td>
<td>0.310</td>
<td>3.00</td>
<td>0.301</td>
<td>0.304</td>
<td>0.305</td>
<td>0.304</td>
<td>0.305</td>
<td>0.304</td>
<td>0.305</td>
<td>11.09</td>
<td>11.12</td>
<td>0.03</td>
<td>11.09</td>
<td>11.12</td>
<td>0.03</td>
<td>11.09</td>
<td>11.12</td>
<td>0.03</td>
<td>11.09</td>
<td>11.12</td>
<td>0.03</td>
<td>10.43</td>
<td>10.56</td>
</tr>
<tr>
<td>R314</td>
<td>10.75</td>
<td>0.310</td>
<td>3.00</td>
<td>0.301</td>
<td>0.304</td>
<td>0.305</td>
<td>0.304</td>
<td>0.305</td>
<td>0.304</td>
<td>0.305</td>
<td>11.09</td>
<td>11.12</td>
<td>0.03</td>
<td>11.09</td>
<td>11.12</td>
<td>0.03</td>
<td>11.09</td>
<td>11.12</td>
<td>0.03</td>
<td>11.09</td>
<td>11.12</td>
<td>0.03</td>
<td>10.43</td>
<td>10.56</td>
</tr>
<tr>
<td>R315</td>
<td>10.75</td>
<td>0.310</td>
<td>3.00</td>
<td>0.301</td>
<td>0.304</td>
<td>0.305</td>
<td>0.304</td>
<td>0.305</td>
<td>0.304</td>
<td>0.305</td>
<td>11.09</td>
<td>11.12</td>
<td>0.03</td>
<td>11.09</td>
<td>11.12</td>
<td>0.03</td>
<td>11.09</td>
<td>11.12</td>
<td>0.03</td>
<td>11.09</td>
<td>11.12</td>
<td>0.03</td>
<td>10.43</td>
<td>10.56</td>
</tr>
</tbody>
</table>

REMOVE ANY LOOSE SCALE AND BURRS WILL VARNISH FROM OD & ID BEFORE MAKING MEASUREMENTS
IDENTIFY DIAMETER LOCATION 1, 2, 3 WITH PAINT SO THAT BEFORE L THICKNESS MEASUREMENTS CAN BE TAKEN AT SAME LOCATIONS

MEASURE WALL THICKNESS USING MICROMETER & VON BAIL

LENGTH = 3 X OD

NOTE: OD MEASUREMENTS LOCATION 1 3/4" FROM TOP EDGE LOCATION 1 3/4" CENTER OF LEHN LOCATION 1 3/4" FROM BOTTOM EDGE

CO MEASUREMENTS 8" TO SAWN CUT PLANE

SAWN CUT OR TORCH PLANE

DATE: 10/29/2011
**PRE-TEST PIPE MEASUREMENTS**

**1D INC. | OD - 0° / 180° & PI TAPE WALL - 8 PLACES 45° INCREMENTS OVALLITY - MAX & MIN LENGTH & WEIGHT**

<table>
<thead>
<tr>
<th>Longitude</th>
<th>End &quot;A&quot;</th>
<th>1 x O.D.</th>
<th>2 x O.D.</th>
<th>3 x O.D.</th>
<th>4 x O.D.</th>
<th>5 x O.D.</th>
<th>6 x O.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degrees</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0.565</td>
<td>0.570</td>
<td>0.570</td>
<td>0.565</td>
<td>0.568</td>
<td>0.572</td>
<td>0.558</td>
</tr>
<tr>
<td>45</td>
<td>0.537</td>
<td>0.539</td>
<td>0.542</td>
<td>0.547</td>
<td>0.549</td>
<td>0.548</td>
<td>0.536</td>
</tr>
<tr>
<td>90</td>
<td>0.550</td>
<td>0.553</td>
<td>0.556</td>
<td>0.556</td>
<td>0.560</td>
<td>0.560</td>
<td>0.559</td>
</tr>
<tr>
<td>135</td>
<td>0.538</td>
<td>0.535</td>
<td>0.536</td>
<td>0.536</td>
<td>0.543</td>
<td>0.537</td>
<td>0.542</td>
</tr>
<tr>
<td>180</td>
<td>0.555</td>
<td>0.552</td>
<td>0.552</td>
<td>0.553</td>
<td>0.559</td>
<td>0.558</td>
<td>0.559</td>
</tr>
<tr>
<td>225</td>
<td>0.533</td>
<td>0.529</td>
<td>0.526</td>
<td>0.526</td>
<td>0.531</td>
<td>0.528</td>
<td>0.535</td>
</tr>
<tr>
<td>270</td>
<td>0.543</td>
<td>0.539</td>
<td>0.535</td>
<td>0.538</td>
<td>0.529</td>
<td>0.532</td>
<td>0.524</td>
</tr>
<tr>
<td>315</td>
<td>0.540</td>
<td>0.541</td>
<td>0.539</td>
<td>0.540</td>
<td>0.532</td>
<td>0.533</td>
<td>0.517</td>
</tr>
</tbody>
</table>

**Avg. Thickness**

| Avg. O.D. | 9.715 |
| Avg. O.D. @ 0/180 | 9.714 |
| Ovallity Gauge Max (+) | .003/270 |
| Ovallity Gauge Max (-) | .005/135 |
| Ovallity Gauge Min (+) | .004/270 |
| Ovallity Gauge Min (-) | .005/135 |

<table>
<thead>
<tr>
<th>Eccentricity</th>
<th>0.08%</th>
<th>0.09%</th>
<th>0.06%</th>
<th>0.20%</th>
<th>0.15%</th>
<th>0.05%</th>
<th>0.15%</th>
</tr>
</thead>
<tbody>
<tr>
<td>(tmax-tmin)/tavg</td>
<td>1.83%</td>
<td>3.30%</td>
<td>3.31%</td>
<td>2.20%</td>
<td>1.65%</td>
<td>2.56%</td>
<td>0.37%</td>
</tr>
<tr>
<td>90-270</td>
<td>1.28%</td>
<td>2.57%</td>
<td>3.86%</td>
<td>3.30%</td>
<td>5.67%</td>
<td>5.13%</td>
<td>6.47%</td>
</tr>
<tr>
<td>135-315</td>
<td>0.37%</td>
<td>1.10%</td>
<td>0.55%</td>
<td>0.37%</td>
<td>2.01%</td>
<td>0.73%</td>
<td>4.62%</td>
</tr>
</tbody>
</table>

**Actual Avg D/T**

| T-Max | 17.82 |
| T-Min | 17.84 |
| T-Avg. | 17.85 |
| STDEV. | 0.013791512 |

**Pipe Sample Failure Details:**

SAMPLE FLATTENED 2D TO 6D W/SMALL AXIS AT 135 & 315 DEG
FIGURE 6-3
Typical Collapse Sample Being Installed Into Chamber

FIGURE 6-4
Typical Collapsed Samples
PIPE CHARACTERISTICS
SIGNIFICANT TO COLLAPSE
(GIVEN OD & WALL)

YIELD STRENGTH

OVALLITY

ECCENTRICITY

RESIDUAL STRESS
PLOT OF NORMALIZED YIELD STRENGTH BY GRADE (ACTUAL / SPECIFIED)
NORMALIZED P-110
BY PROCESS

All P-Grade Yield Tests

Normalized Yield

EW
Smls
RESIDUAL STRESS
HIGH COLLAPSE VS NON-HC

All Residual Stress Reports

Residual Stress [ksi]

-20 -10 0 10 20 30 40 50

HC
Non-HC
RESIDUAL STRESS
BY PROCESS
SEAMLESS vs WELDED
RESIDUAL STRESS
BY GRADE

Residual Stress by Grade Letter
RESIDUAL STRESS
BY HOT vs COLD STRAIGHTENING

All Residual Stress Reports

Residual Stress [ksi]
OVALITY
HIGH COLLAPSE VS NON-HC

All Ovality Measurements

Ovality [%]
OVALLITY
BY HOT vs COLD STRAIGHTENING

All Ovality Measurements

Hot
Cold

Ovality [%]

0  0.2  0.4  0.6  0.8  1  1.2
ECCENTRICITY
HIGH COLLASPE
VS NON-HC
ECCENTRICITY
BY PROCESS
SEAMLESS vs WELDED

All Eccentricity

Eccentricity [%]

EW

Smls
ALL COLLAPSE PRESSURES
TOTAL NUMBER = 151 TESTS
COMPARISON OF NORMALIZED OD
(ACTUAL / SPECIFIED)
BY MANUFACTURER
COMPARISON OF NORMALIZED WALL (ACTUAL / SPECIFIED) BY MANUFACTURER
COMPARISON OF NORMALIZED YIELD STRENGTH (ACTUAL / SPECIFIED) BY MANUFACTURER
COMPARISON OF NORMALIZED OVALITY (ACTUAL / SPECIFIED) BY MANUFACTURER
COMPARISON OF NORMALIZED ECCENTRICITY (ACTUAL / SPECIFIED) BY MANUFACTURER
COMPARISON OF RESIDUAL STRESS BY MANUFACTURER

RS Crampton
COMPARISON OF NORMALIZED API – MIN COLLAPSE PRESSURE
BY MANUFACTURER
COMPARISON OF NORMALIZED API – AVG COLLAPSE PRESSURE BY MANUFACTURER
THE END

THANKS TO -
DEA
MIKE PAYNE
ALL PARTICIPANTS