# REPORT ON DRILLED SHAFT
# LOAD TESTING (OSTERBERG METHOD)

## Test Shaft #1 - Highway 81 over Missouri River
## Yankton, South Dakaota (LT-9152)

**Prepared for:** **Jensen Construction Co.**
**5550 NE 22nd Street**
**Des Moines, Iowa 50316**

**Attention:** **Mr. Dan Timmons**

**PROJECT NUMBER: LT-9152, July 2, 2007**


Head Office:
2631-D NW 41st Street, Gainesville FL 32606
Telephone: 352-378-3717 800-368-1138
Fax: 352-378-3934

Regional Offices:
785 The Kingsway, Peterborough, Ontario, Canada K9J 6W7
Telephone: 705-749-0076
Fax: 705-743-6854

5740 Executive Drive, Suite 108, Baltimore, MD 21228
Telephone: 410-788-4180 800-436-2355
Fax: 410-788-4182

**E-mail: Info@loadtest.com** **Internet: www.loadtest.com**


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July 2, 2007

**Jensen Construction Co.**
**5550 NE 22nd Street**
**Des Moines, Iowa 50316**

Attention: Mr. Dan Timmons

**Load Test Report:** Test Shaft #1 - Highway 81 over Missouri River
**Location:** Yankton, South Dakaota (LT-9152)

Dear Mr. Timmons,

The enclosed report contains the data and analysis summary for the O-cell test performed on Test Shaft #1 - Highway 81 over Missouri River, on June 27, 2007. For your convenience, we have included an executive summary of the test results in addition to our standard detailed data report.

We would like to express our gratitude for the on-site and off-site assistance provided by your team and we look forward to working with you on future projects.

We trust that the information contained herein will suit your current project needs. If you have any questions or require further technical assistance, please do not hesitate to contact us at 800-368-1138.

Best Regards,

William G. Ryan, B.S.C.M.
Regional Manager, LOADTEST, Inc.

## EXECUTIVE SUMMARY

On June 27, 2007, we tested a 96-inch (2,438-mm) diameter dedicated test shaft constructed by Jensen Construction Co. Mr. Michael D. Ahrens and Mr. Rick Usab of LOADTEST, Inc. carried out the test. Jensen Construction Co. completed construction of the 115.1-foot (35.08-meter) deep shaft on June 20, 2007. Sub-surface conditions at the test shaft location consist primarily of loose to medium dense sand underlain by hard silty shale (Carlile Shale). Representatives of the Nebraska Department of Roads observed construction and testing of the shaft.

The maximum sustained bi-directional load applied to the shaft was 4,522 kips (20.11 MN). At the maximum load, the displacements above and below the O-cell were 0.207 inches (5.25 mm) and 0.504 inches (12.81 mm), respectively. Unit shear data calculated from strain gages indicated average values of 4.9 ksf (234 kPa) and 6.4 ksf (305 kPa) in the zones directly above and below the O-cell at the noted displacements. The strain gage data also indicates that none of the applied load was transferred to end bearing.

Using the procedures described in the report text and in Appendix C, we constructed an equivalent top load curve for the test shaft. For a top loading of 1,850 kips (8.2 MN), the adjusted test data indicate this shaft would settle approximately 0.08 inches (2.0 mm) of which 0.06 inches (1.6 mm) is estimated elastic compression.

## LIMITATIONS OF EXECUTIVE SUMMARY

We include this executive summary to provide a very brief presentation of some of the key elements of this O-cell test. It is by no means intended to be a comprehensive or stand-alone representation of the test results. The full text of the report and the attached appendices contain important information which the engineer can use to come to more informed conclusions about the data presented herein.

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## SITE CONDITIONS AND SHAFT CONSTRUCTION

**Site Sub-surface Conditions:** The sub-surface stratigraphy at the general location of the test shaft is reported to consist primarily of loose to medium dense sand underlain by hard silty shale (Carlile Shale). The generalized subsurface profile is included in Figure A and a boring log indicating conditions near the shaft is presented in Appendix E. More detailed geologic information can be obtained from the Nebraska Department of Roads.

**Test Shaft Construction:** Jensen Construction Co. constructed the dedicated test shaft between June 11 and 20, 2007. We understand that the 96-inch (2,438-mm) diameter test shaft was excavated wet to a tip elevation of +1041.8 feet (+317.53 meters) using an auger. After cleaning the base with a cleanout bucket, the reinforcing cage with attached O-cell assembly was inserted into the excavation and temporarily supported at the surface. Concrete was then delivered by tremie through a nominal 12-inch (300-mm) O.D. pipe into the base of the shaft until reaching the cutoff elevation. Representatives of the Nebraska Department of Roads observed construction of the shaft.

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## OSTERBERG CELL TESTING

**Shaft Instrumentation:** Test shaft instrumentation and assembly was carried out under the direction of Mr. Rick Usab and Aaron King of LOADTEST, Inc. on June 18 through 20, 2007. The loading assembly consisted of three 21-inch diameter (540-mm) O-cells located 29.3 feet (8.92 meters) above the tip of shaft. Calibrations of O-cells and instrumentation used for this test are included in Appendix B.

O-cell testing instrumentation included four Linear Vibrating Wire Displacement Transducers (LVWDTs - Geokon Model 4450 series) positioned between the lower and upper plates of the O-cell assembly to measure expansion (Appendix A, Page 4). Two telltale casings (nominal ½-inch steel pipe) were attached to the reinforcing cage, diametrically opposed, extending from the top of the O-cell assembly to beyond the top of concrete. Compression of the shaft below the O-cell was measured by one section of Embedded Compression Telltales (ECT), consisting of telltale rods in nominal ½-inch steel pipe casings with an attached LVWDT (Appendix A, Page 3).

Strain gages were used to assess the side shear load transfer of the shaft above and below the Osterberg cell assembly. One level of four sister bar vibrating wire strain gages (Geokon Model 4911 Series) was installed in the shaft below the base of the O-cell assembly and two levels of two were installed in the shaft above it. Details concerning the strain gage placement appear in Table B and Figures A & B. The strain gages were positioned as recommended by LOADTEST, Inc.

Three lengths of steel pipe were also installed, extending from the top of the shaft to the top of the bottom plate, to vent the break in the shaft formed by the expansion of the O-cells. The pipes also provide access for post-test grouting of the annular void surrounding the O-cell assembly as described in Appendix H.

**Test Arrangement:** Throughout the load test, key elements of shaft response were monitored using the equipment and instruments described herein. Shaft compression was measured using ¼-inch telltales installed in the ½-inch steel pipes (described under Shaft Instrumentation) and monitored by Linear Variable Displacement Transducers (LVDTs - RDP DCW Series). Two LVDTs attached to a reference system were used to monitor the top of shaft movement (Appendix A, Page 2). An automated digital survey level (Leica NA3003) was used to independently monitor the top of shaft movement during testing from a distance of approximately 35.8 feet (10.91 meters).

The reference system consisted of a steel wide flange section supported on wooden crane mats. The supports were located approximately three shaft diameters from the center of the test shaft. The beam was partially shaded for the duration of the test. A second automated digital survey level (Leica NA3003) was used to monitor the reference beam for movement during testing from a distance of approximately 36.5 feet (11.11 meters). A maximum range of vertical movement of 0.044 inches (1.12 mm) was observed for the reference beam. The top of shaft movements have been corrected for movement of the reference system (Appendix A, Page 2).

Both a Bourdon pressure gage and electronic pressure transducers were used to measure the pressure applied to the O-cell at each load interval. We used the Bourdon pressure gage for setting and maintaining loads and for data analysis. The transducer readings were used for real time plotting and as a check on the Bourdon gage. There was close agreement between the Bourdon gage and the pressure transducers.

**Data Acquisition:** All instrumentation were connected through a data logger (Campbell Scientific CR-10) to a laptop computer allowing data to be recorded and stored automatically at 30-second intervals and displayed in real time. The same laptop computer synchronized to the data logging system was used to acquire the Leica NA3003 data sets.

**Testing Procedures:** As with all of our tests, we begin by pressurizing the O-cells in order to break the tack welds that hold them closed (for handling and for placement in the shaft) and to form the fracture plane in the concrete surrounding the base of the O-cells. After the break occurs, we immediately release the pressure and then begin the loading procedure. Zero readings for all instrumentation are taken prior to the preliminary weld-breaking load-unload cycle, which in this case involved a maximum applied pressure of 500 psi (3.45 MPa) to the O-cells.

The Osterberg cell load test was conducted as follows: We pressurized the 21-inch (540-mm) diameter O-cell assembly, with its base located 29.3 feet (8.92 meters) above the base of shaft to assess the combined end bearing and lower side shear below the O-cell and the upper side shear above. We pressurized the O-cell in 12 loading increments to 6,000 psi (41.37 MPa) resulting in a bi-directional gross O-cell load of 4,522 kips (20.11 MN). The loading was halted after load interval 1L-12 because the rate of displacement of the upper side shear was beginning to increase. The O-cell was then depressurized in four decrements. The O-cell was re-pressurized in three loading increments to a bi-directional gross O-cell load of 3,395 kips (15.10 MN) at 2L-3 in order to demonstrate that the test shaft was suitable for use as a production shaft. The O-cell was then unloaded in one decrement and the test was concluded.

We applied the load increments using the Quick Load Test Method for Individual Piles (ASTM D1143 *Standard Test Method for Piles Under Static Axial Load*), holding each successive load increment constant for eight minutes by manually adjusting the O-cell pressure. The data logger automatically recorded the instrument readings every 30 seconds, but herein we report only the 1, 2, 4 and 8-minute readings (where applicable) during each increment of maintained load.

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## TEST RESULTS AND ANALYSES

**General:** The loads applied by the O-cell act in two opposing directions, resisted by the capacity of the shaft above and below. Theoretically, the O-cell does not impose an additional upward load until its expansion force exceeds the buoyant weight of the shaft above the O-cell. Therefore, *net load*, which is defined as gross O-cell load minus the buoyant weight of the shaft above, is used to determine side shear resistance above the O-cells and to construct the equivalent top-loaded load-settlement curve. For this test we calculated a buoyant weight of shaft of 391 kips (1.74 MN) above the O-cells.

**Upper Side Shear Resistance:** The maximum upward applied *net load* to the upper side shear was 4,131 kips (18.37 MN) which occurred at load interval 1L-12. At this loading, the upward movement of the O-cell top was 0.207 inches (5.25 mm).

In order to assess the side shear resistance of the test shaft, loads are calculated based on the strain gage data (Appendix A, Page 6) and estimates of shaft stiffness (AE) which are presented below. We used the ACI formula ($E_c=57000\sqrt{f'_c}$) to calculate an elastic modulus for the concrete, where the average $f'_c$ was reported to be 3,256 psi (22.45 MPa) on the day of the test. This, combined with the area of reinforcing steel and nominal shaft diameter, provided an average shaft stiffness (AE) of 32,100,000 kips (143,000 MN) in the permanently cased zone, 25,800,000 kips (115,000 MN) above the O-cell in the nominal 96-inch shaft and 25,300,000

kips (113,000 MN) below the O-cell. Net unit shear curves are presented in Appendix F. Net unit shear values for loading increment 1L-12 follow in Table A:

**TABLE A: Average Net Unit Side Shear Values for 1L-12**

| Load Transfer Zone | Displacement * | Net Unit Side Shear ** |
|---|---|---|
| Top of Shaft to Strain Gage Level 3 | ↑ 0.176" | 0.1 ksf (4 kPa) |
| Strain Gage Level 3 to Strain Gage Level 2 | ↑ 0.182" | 2.4 ksf (113 kPa) |
| Strain Gage Level 2 to O-cell | ↑ 0.197" | 4.9 ksf (234 kPa) |
| O-cell to Strain Gage Level 1 | ↓ 0.495" | 6.4 ksf (305 kPa) |

* Average displacement of load transfer zone.

** For upward-loaded shear, the buoyant weight of shaft in each zone has been subtracted from the load shed in the respective zone above the O-cell.

NOTE: Net unit shear values derived from the strain gages above the O-cell assembly may not be ultimate values. See Appendix F for net unit shear vs. average shear zone displacement plots.

**Combined End Bearing And Lower Side Shear Resistance:** The maximum O-cell load applied to the combined end bearing and lower side shear was 4,522 kips (20.11 MN) which occurred at load interval 1L-12 (Appendix A, Page 5, Figure 1). At this loading, the average downward movement of the O-cell base was 0.504 inches (12.81 mm). A graphical extrapolation of the strain gage load distribution in Figure 3 indicates that none of the applied load was transferred to end bearing at the above noted displacement.

**Creep Limit**: See Appendix D for our O-cell method for determining creep limit. The combined end bearing and lower side shear creep data (Appendix A, Page 5) indicate that no apparent creep limit was reached at a downward displacement of 0.50 inches (12.8 mm) (Figure 4). The upper side shear creep data (Appendix A, Page 5) also indicate that no apparent creep limit was reached at an upward displacement of 0.21 inches (5.3 mm) (Figure 5). The creep limit for a top loaded shaft will not be reached until both components reach their respective creep limits. This will occur at the maximum of the movements required to reach the creep limit for each component. One interpretation of the data presented herein is that significant creep for this shaft will not begin until a top loading exceeds 9,196 kips (40.9 MN) by some unknown amount. The engineer should come to his own conclusions with regard to the suitability of the creep limit analysis to address long-term creep which may be an important design consideration.

**Equivalent Top Load**: Figure 2 presents the equivalent top-loaded load-settlement curves. The lighter curve, described in Procedure Part I of Appendix C, was generated by using the measured upward top of O-cell and downward base of O-cell data. The curve is extended out to a settlement of 0.5 inches (13 mm) by extrapolating the top of O-cell data (Appendix G). Because it is often an important component of the settlements involved, the equivalent top load curve requires an adjustment for the additional elastic compression that would occur in a top-load test.

The darker curve as described in Procedure Part II of Appendix C includes this adjustment.

For a top loading of 1,850 kips (8.2 MN), the adjusted test data indicate this shaft would settle approximately 0.08 inches (2.0 mm) of which 0.06 inches (1.6 mm) is estimated elastic compression. For a top loading of 3,700 kips (16.5 MN) the adjusted test data indicate this shaft would settle approximately 0.16 inches (4.0 mm) of which 0.12 inches (3.0 mm) is estimated elastic compression.

Note that, as explained previously, the equivalent top load curve applies to incremental loading durations of eight minutes. Creep effects will reduce the ultimate resistance of both components and increase shaft top movement for a given loading over longer times. The Engineer can estimate such additional creep effects by suitable extrapolation of time effects using the creep data presented herein.

**Shaft Compression Comparison:** The measured maximum shaft compression, averaged from two telltales, is 0.032 inches (0.82 mm) at 1L-12 (Appendix A, Page 2). Using an average shaft stiffness of 28,000,000 kips (125,000 MN) and the load distribution in Figure 3 at 1L-12, we calculated an elastic compression of 0.037 inches (0.93 mm) over the length of the compression telltales. We believe this close agreement provides good evidence that the values of the estimated shaft stiffness are reasonable.

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## POST-TEST O-CELL GROUTING

Since the test shaft is intended to carry structural loading (i.e., a production shaft), the contractor needs to fill the O-cell and annular void in the shaft created as a result of the expansion of the cell. The shaft includes the hoses and piping to permit filling the O-cell and void with grout. If not already grouted, we recommend that this be done as soon as possible according to the procedures in Appendix H.

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## LIMITATIONS AND STANDARD OF CARE

The instrumentation, testing services and data analysis provided by LOADTEST, Inc., outlined in this report, were performed in accordance with the accepted standards of care recognized by professionals in the drilled shaft and foundation engineering industry.

Please note that some of the information contained in this report is based on data (i.e. shaft diameter, elevations and concrete strength) provided by others. The engineer, therefore, should come to his or her own conclusions with regard to the analyses as they depend on this information. In particular, LOADTEST, Inc. typically does not observe and record drilled shaft construction details to the level of precision that the project engineer may require. In many cases, we may not be present for the entire duration of shaft construction. Since construction technique can play a significant role in determining the load bearing capacity of a drilled shaft, the engineer should pay close attention to the drilled shaft construction details that were recorded elsewhere.

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We trust that this information will meet your current project needs. If you have any questions, please do not hesitate to contact us at 800-368-1138.

Prepared for LOADTEST, Inc. by

Michael D. Ahrens, M.Eng., P.E.
Geotechnical Engineer

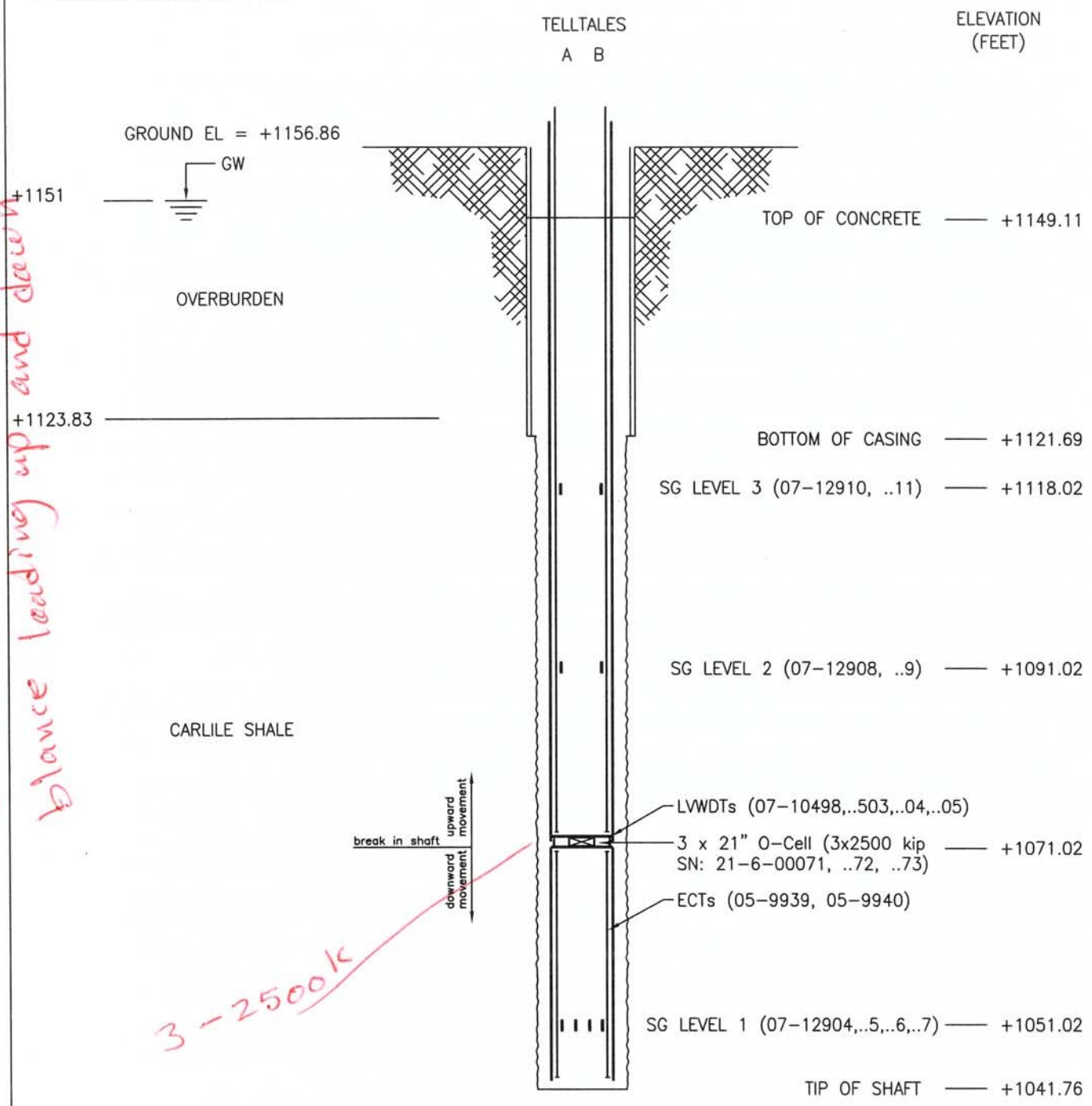
Reviewed by

David J. Jakstis, P.E.
Geotechnical Engineer

## TABLE B:
## SUMMARY OF DIMENSIONS, ELEVATIONS & SHAFT PROPERTIES

| | | | |
|---|---|---|---|
| **Shaft:** | | | |
| Nominal shaft diameter (EL +1149.1 ft to +1121.7 ft) | = | 102 in | 2591 mm |
| Nominal shaft diameter (EL +1121.7 ft to +1041.8) | = | 96 in | 2438 mm |
| O-cells: 21-6-00071, 21-6-00072, 21-6-00073 | = | 21 in | 540 mm |
| Bouyant weight of pile above base of O-cell | = | 391 kips | 1.74 MN |
| Estimated average shaft stiffness, AE (EL +1149.1 ft to +1121.7 ft) | = | 32,100,000 kips | 143,000 MN |
| Estimated average shaft stiffness, AE (EL +1121.7 ft to +1071.0 ft) | = | 25,800,000 kips | 115,000 MN |
| Estimated average shaft stiffness, AE (EL +1071.0 ft to +1044.1 ft) | = | 25,300,000 kips | 113,000 MN |
| Estimated average shaft stiffness, AE (EL +1044.1 ft to +1041.8) | = | 23,500,000 kips | 105,000 MN |
| | | | |
| Elevation of ground surface | = | +1156.9 ft | +352.61 m |
| Elevation of water table | = | +1151.0 ft | +350.82 m |
| Elevation of top of shaft concrete | = | +1149.1 ft | +350.25 m |
| Elevation of base of O-cell (The break between upward and downward movement.) | = | +1071.0 ft | +326.45 m |
| Elevation of shaft tip | = | +1041.8 ft | +317.53 m |
| | | | |
| **Casings:** | | | |
| Elevation of top of permanent casing (102.0 in O.D., 101.1 in I.D.) | = | +1156.9 ft | +352.61 m |
| Elevation of bottom of permanent casing (102.0 in O.D., 101.1 in I.D.) | = | +1121.7 ft | +341.89 m |
| | | | |
| **Compression Sections:** | | | |
| Elevation of top of telltale used for upper shaft compression | = | +1156.9 ft | +352.61 m |
| Elevation of bottom of telltale used for upper shaft compression | = | +1072.2 ft | +326.79 m |
| Elevation of top of ECTs used for lower shaft compression | = | +1070.9 ft | +326.40 m |
| Elevation of bottom of ECTs used for lower shaft compression | = | +1045.0 ft | +318.52 m |
| | | | |
| **Strain Gages:** | | | |
| Elevation of strain gage Level 3 (AE = 25,500,000 kips) | = | +1118.0 ft | +340.77 m |
| Elevation of strain gage Level 2 (AE = 25,500,000 kips) | = | +1091.0 ft | +332.54 m |
| Elevation of strain gage Level 1 (AE = 24,500,000 kips) | = | +1051.0 ft | +320.35 m |
| | | | |
| **Miscellaneous:** | | | |
| Top plate diameter (2 in thickness) | = | 85.5 in | 2172 mm |
| Bottom plate diameter (2 in thickness) | = | 85.5 in | 2172 mm |
| ReBar size (48 No.) | = | # 11 | M 35 |
| Spiral size (12 in spacing) | = | # 5 | M 16 |
| ReBar cage diameter | = | 90 in | 2286 mm |
| Average unconfined compressive concrete strength | = | 3,256 psi | 22.4 MPa |
| O-cell LVWDTs @ 0°, 120°, 180° and 240° with radius | = | 42.0 in | 1067 mm |

NOTE:
- NOMINAL OUTER CASING 102"ø OD
- NOMINAL SOCKET 96"ø OD



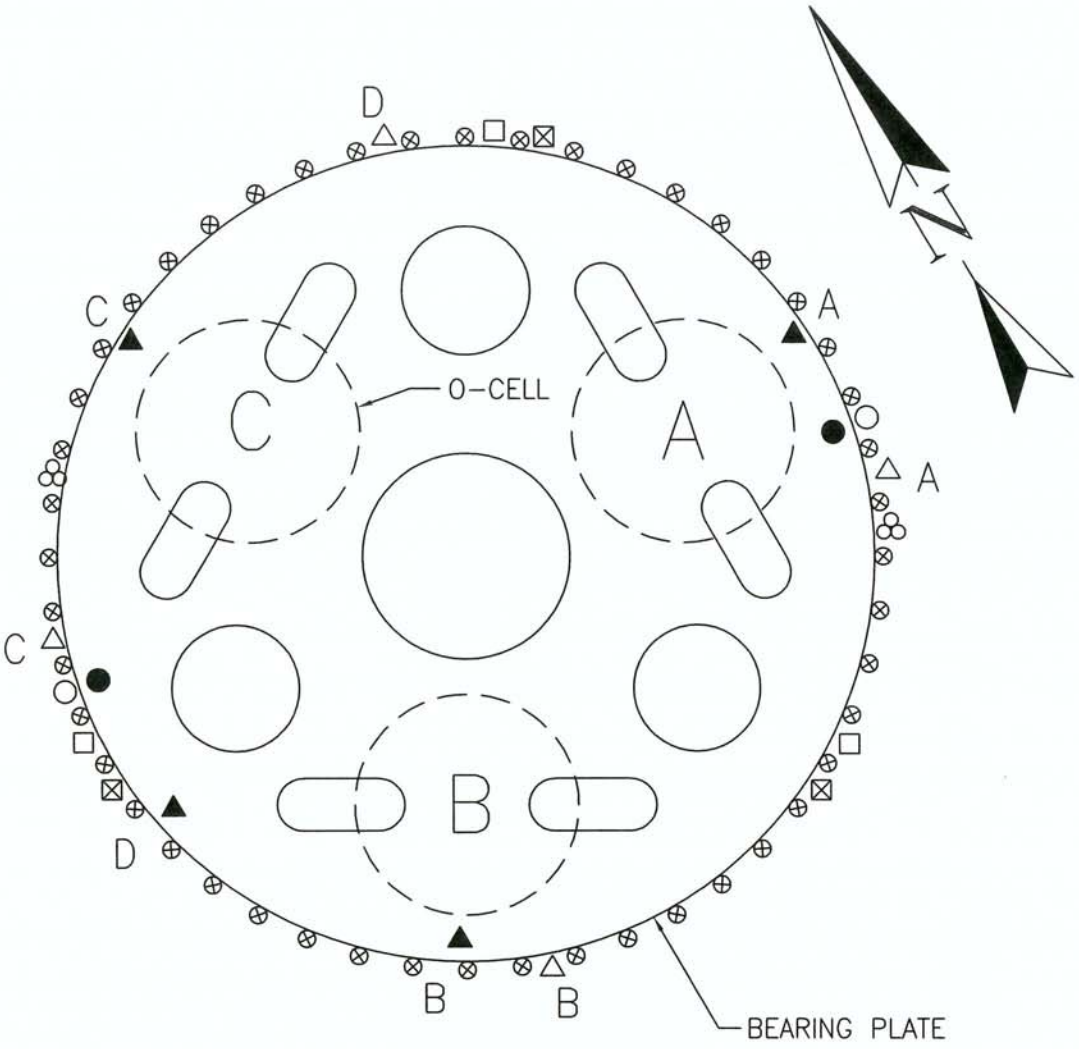

the location of cell is chosen based on balance loading up and down

3-2500k

LOADTEST
2631-D NW 41st St.
Gainesville, FL 32606
Phone 800-368-1138
FAX 352-378-3934

SCHEMATIC SECTION OF TEST SHAFT
US Highway 81 over Missouri River - Yankton, SD

| | | | |
|---|---|---|---|
| DRAWN BY: WGR | DATE: 06/15/07 | CHECKED BY: MDA | LT-9152 |
| REVISED BY: MDA | DATE: 07/02/07 | SCALE: NTS | FIGURE A |




LEGEND:

| | |
|---|---|
| STRAIN GAGE | △ |
| LVWDT | ▲ |
| TELLTALE | ○ |
| ECT | ● |
| VENT PIPE | □ |
| HYDRAULIC HOSES | ⊠ |
| REBAR | ⊗ |
| CABLE BUNDLE | 8 |

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2631-D NW 41st St.
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Phone 800-368-1138
FAX 352-378-3934

INSTRUMENTATION LAYOUT

US Highway 81 over Missouri River – Yankton, SD

| | | | |
|---|---|---|---|
| DWN BY: JFU | DATE: 6/25/07 | CHECKED BY: | LT-9152 |
| REVISED BY: | DATE: | SCALE: NTS | FIGURE B |

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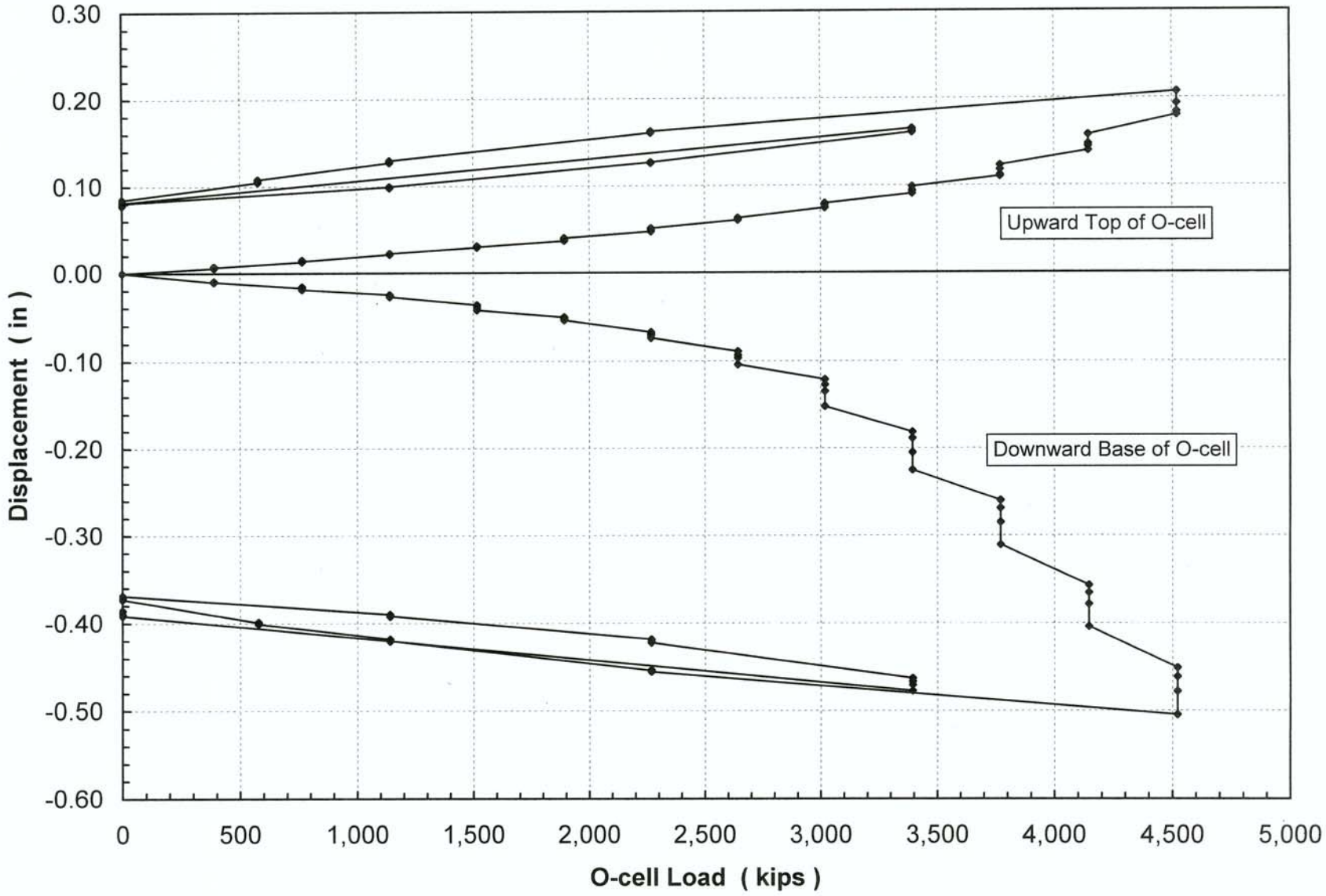
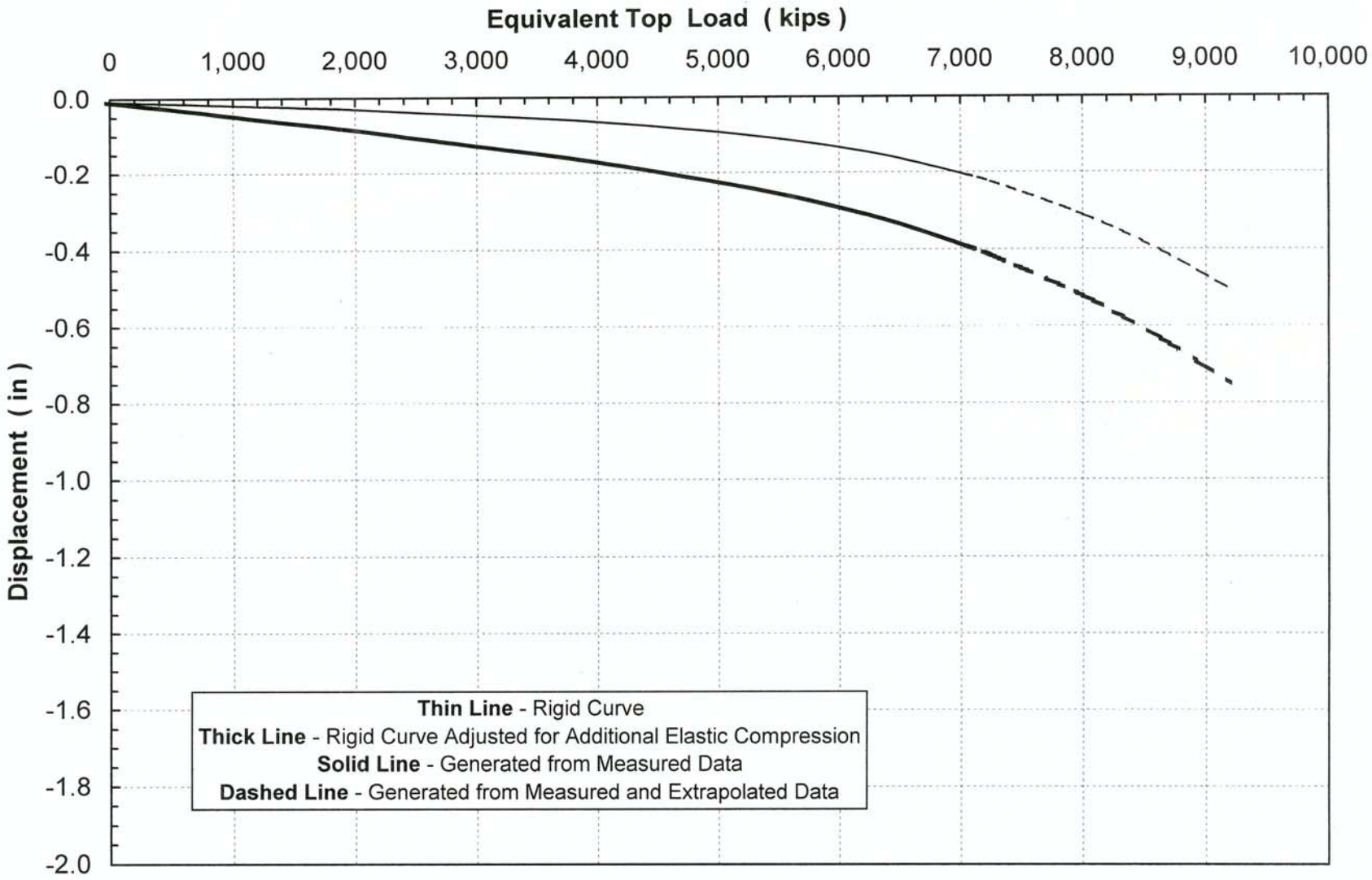
# Osterberg Cell Load-Movement Curves

## Test Shaft #1 - Highway 81 over Missouri River - Yankton, South Dakaota



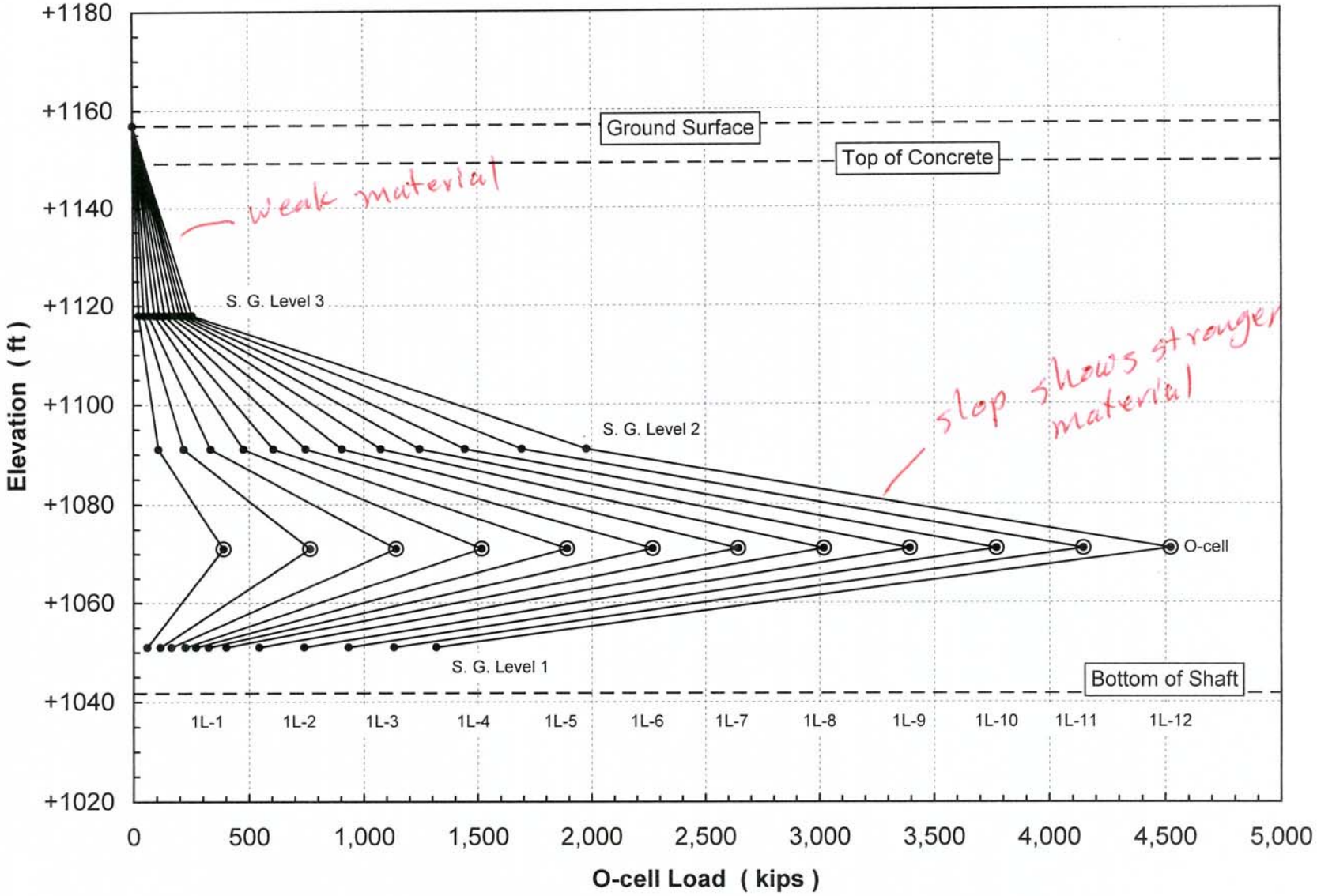
# Equivalent Top Load Load-Movement Curve

## Test Shaft #1 - Highway 81 over Missouri River - Yankton, South Dakaota



# Strain Gage Load Distribution Curves

## Test Shaft #1 - Highway 81 over Missouri River - Yankton, South Dakaota



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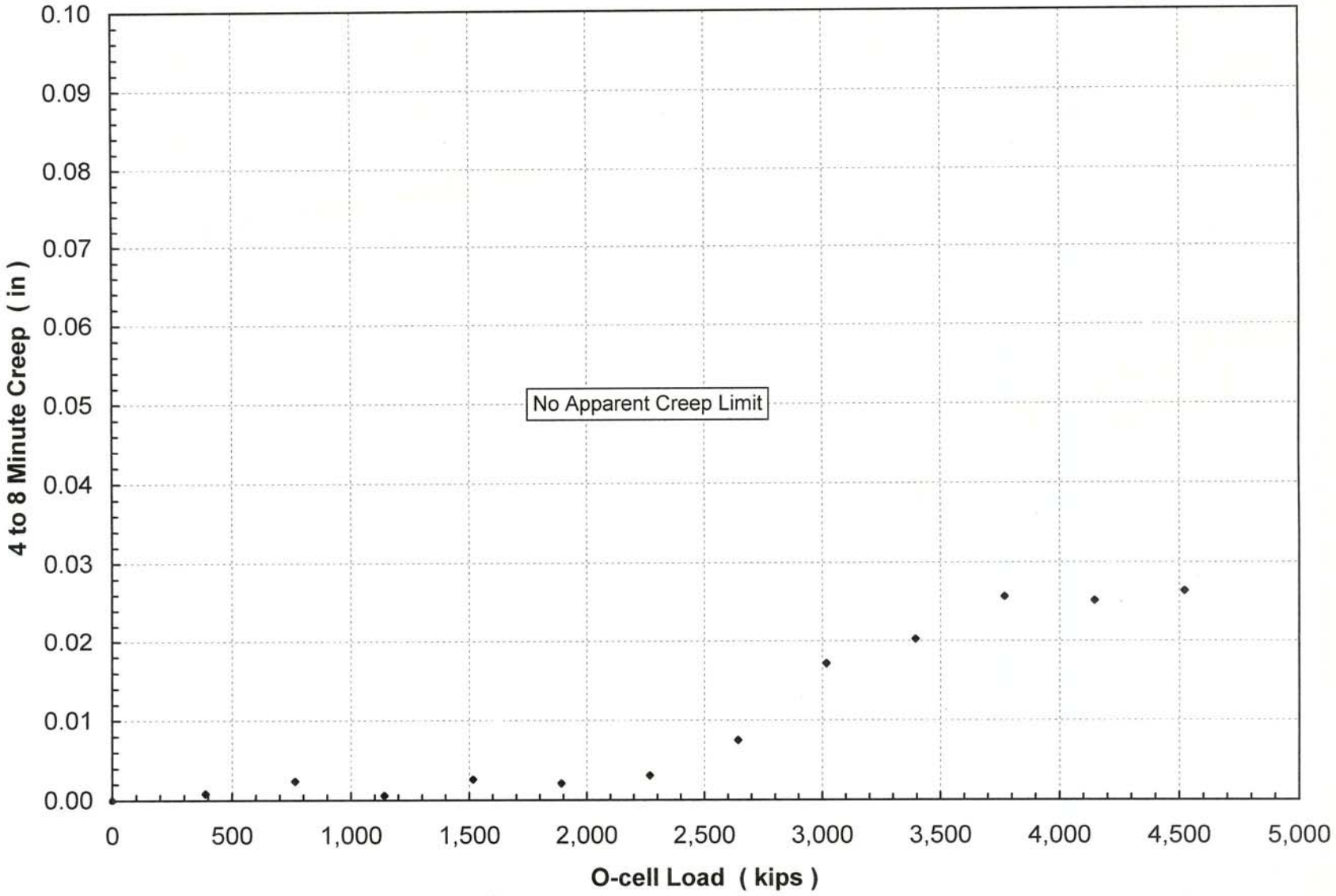
# Combined End Bearing and Lower Side Shear Creep Limit

## Test Shaft #1 - Highway 81 over Missouri River - Yankton, South Dakaota



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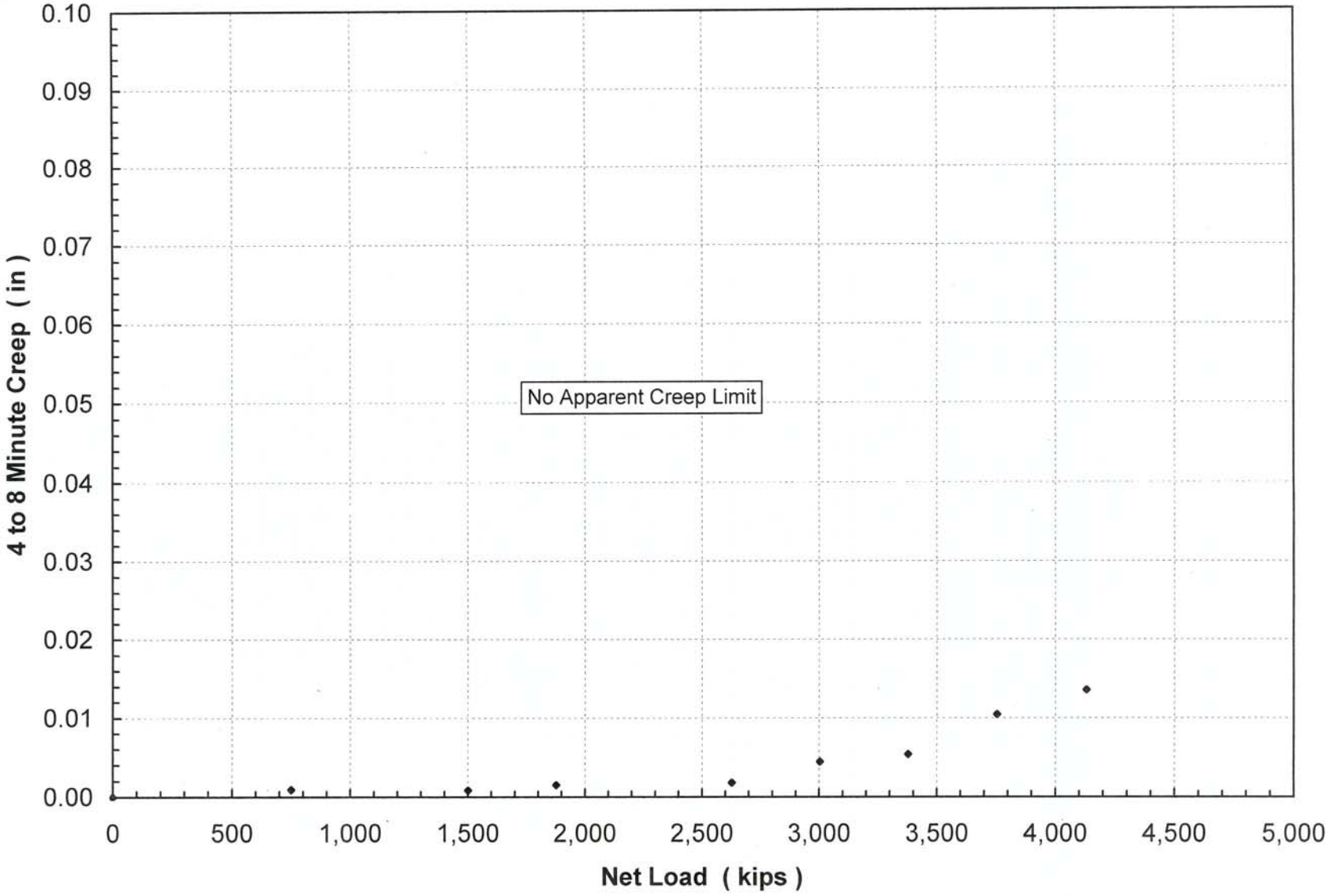
# Upper Side Shear Creep Limit

## Test Shaft #1 - Highway 81 over Missouri River - Yankton, South Dakaota



# APPENDIX A

## FIELD DATA & DATA REDUCTION

## O-cell Loads
## Test Shaft #1 - Highway 81 over Missouri River - Yankton, South Dakaota

| Load Test Increment | Hold Time (minutes) | Time (h:m:s) | O-cell Pressure (psi) | 21-6-00071 (kips) | 21-6-00072 (kips) | 21-6-00073 (kips) | Load (kips) |
|---|---|---|---|---|---|---|---|
| 1 L - 0 | - | 17:31:00 | 0 | 0 | 0 | 0 | 0 |
| 1 L - 1 | 1 | 17:45:30 | 500 | 131 | 129 | 129 | 389 |
| 1 L - 1 | 2 | 17:46:30 | 500 | 131 | 129 | 129 | 389 |
| 1 L - 1 | 4 | 17:48:30 | 500 | 131 | 129 | 129 | 389 |
| 1 L - 1 | 8 | 17:52:30 | 500 | 131 | 129 | 129 | 389 |
| 1 L - 2 | 1 | 17:54:30 | 1,000 | 256 | 254 | 255 | 765 |
| 1 L - 2 | 2 | 17:55:30 | 1,000 | 256 | 254 | 255 | 765 |
| 1 L - 2 | 4 | 17:57:30 | 1,000 | 256 | 254 | 255 | 765 |
| 1 L - 2 | 8 | 18:01:30 | 1,000 | 256 | 254 | 255 | 765 |
| 1 L - 3 | 1 | 18:03:30 | 1,500 | 381 | 380 | 380 | 1,141 |
| 1 L - 3 | 2 | 18:04:30 | 1,500 | 381 | 380 | 380 | 1,141 |
| 1 L - 3 | 4 | 18:06:30 | 1,500 | 381 | 380 | 380 | 1,141 |
| 1 L - 3 | 8 | 18:10:30 | 1,500 | 381 | 380 | 380 | 1,141 |
| 1 L - 4 | 1 | 18:12:30 | 2,000 | 507 | 505 | 505 | 1,516 |
| 1 L - 4 | 2 | 18:13:30 | 2,000 | 507 | 505 | 505 | 1,516 |
| 1 L - 4 | 4 | 18:15:30 | 2,000 | 507 | 505 | 505 | 1,516 |
| 1 L - 4 | 8 | 18:19:30 | 2,000 | 507 | 505 | 505 | 1,516 |
| 1 L - 5 | 1 | 18:22:30 | 2,500 | 632 | 630 | 630 | 1,892 |
| 1 L - 5 | 2 | 18:23:30 | 2,500 | 632 | 630 | 630 | 1,892 |
| 1 L - 5 | 4 | 18:25:30 | 2,500 | 632 | 630 | 630 | 1,892 |
| 1 L - 5 | 8 | 18:29:30 | 2,500 | 632 | 630 | 630 | 1,892 |
| 1 L - 6 | 1 | 18:32:00 | 3,000 | 757 | 755 | 756 | 2,268 |
| 1 L - 6 | 2 | 18:33:00 | 3,000 | 757 | 755 | 756 | 2,268 |
| 1 L - 6 | 4 | 18:35:00 | 3,000 | 757 | 755 | 756 | 2,268 |
| 1 L - 6 | 8 | 18:39:00 | 3,000 | 757 | 755 | 756 | 2,268 |
| 1 L - 7 | 1 | 18:41:30 | 3,500 | 882 | 880 | 881 | 2,643 |
| 1 L - 7 | 2 | 18:42:30 | 3,500 | 882 | 880 | 881 | 2,643 |
| 1 L - 7 | 4 | 18:44:30 | 3,500 | 882 | 880 | 881 | 2,643 |
| 1 L - 7 | 8 | 18:48:30 | 3,500 | 882 | 880 | 881 | 2,643 |
| 1 L - 8 | 1 | 18:51:00 | 4,000 | 1,008 | 1,006 | 1,006 | 3,019 |
| 1 L - 8 | 2 | 18:52:00 | 4,000 | 1,008 | 1,006 | 1,006 | 3,019 |
| 1 L - 8 | 4 | 18:54:00 | 4,000 | 1,008 | 1,006 | 1,006 | 3,019 |
| 1 L - 8 | 8 | 18:58:00 | 4,000 | 1,008 | 1,006 | 1,006 | 3,019 |
| 1 L - 9 | 1 | 19:01:00 | 4,500 | 1,133 | 1,131 | 1,131 | 3,395 |
| 1 L - 9 | 2 | 19:02:00 | 4,500 | 1,133 | 1,131 | 1,131 | 3,395 |
| 1 L - 9 | 4 | 19:04:00 | 4,500 | 1,133 | 1,131 | 1,131 | 3,395 |
| 1 L - 9 | 8 | 19:08:00 | 4,500 | 1,133 | 1,131 | 1,131 | 3,395 |
| 1 L - 10 | 1 | 19:10:30 | 5,000 | 1,258 | 1,256 | 1,257 | 3,771 |
| 1 L - 10 | 2 | 19:11:30 | 5,000 | 1,258 | 1,256 | 1,257 | 3,771 |
| 1 L - 10 | 4 | 19:13:30 | 5,000 | 1,258 | 1,256 | 1,257 | 3,771 |
| 1 L - 10 | 8 | 19:17:30 | 5,000 | 1,258 | 1,256 | 1,257 | 3,771 |
| 1 L - 11 | 1 | 19:20:30 | 5,500 | 1,383 | 1,381 | 1,382 | 4,146 |
| 1 L - 11 | 2 | 19:21:30 | 5,500 | 1,383 | 1,381 | 1,382 | 4,146 |
| 1 L - 11 | 4 | 19:23:30 | 5,500 | 1,383 | 1,381 | 1,382 | 4,146 |
| 1 L - 11 | 8 | 19:27:30 | 5,500 | 1,383 | 1,381 | 1,382 | 4,146 |
| 1 L - 12 | 1 | 19:31:30 | 6,000 | 1,509 | 1,506 | 1,507 | 4,522 |
| 1 L - 12 | 2 | 19:32:30 | 6,000 | 1,509 | 1,506 | 1,507 | 4,522 |
| 1 L - 12 | 4 | 19:34:30 | 6,000 | 1,509 | 1,506 | 1,507 | 4,522 |
| 1 L - 12 | 8 | 19:38:30 | 6,000 | 1,509 | 1,506 | 1,507 | 4,522 |
| 1 U - 1 | 1 | 19:42:30 | 3,000 | 757 | 755 | 756 | 2,268 |
| 1 U - 1 | 2 | 19:43:30 | 3,000 | 757 | 755 | 756 | 2,268 |
| 1 U - 1 | 4 | 19:45:30 | 3,000 | 757 | 755 | 756 | 2,268 |
| 1 U - 2 | 1 | 19:48:00 | 1,500 | 381 | 380 | 380 | 1,141 |
| 1 U - 2 | 2 | 19:49:00 | 1,500 | 381 | 380 | 380 | 1,141 |
| 1 U - 2 | 4 | 19:51:00 | 1,500 | 381 | 380 | 380 | 1,141 |
| 1 U - 3 | 1 | 19:53:30 | 750 | 193 | 192 | 192 | 577 |
| 1 U - 3 | 2 | 19:54:30 | 750 | 193 | 192 | 192 | 577 |
| 1 U - 3 | 4 | 19:56:30 | 750 | 193 | 192 | 192 | 577 |
| 1 U - 4 | 1 | 19:58:30 | 0 | 0 | 0 | 0 | 0 |
| 1 U - 4 | 2 | 19:59:30 | 0 | 0 | 0 | 0 | 0 |
| 1 U - 4 | 4 | 20:01:30 | 0 | 0 | 0 | 0 | 0 |
| 2 L - 0 | - | 20:02:00 | 0 | 0 | 0 | 0 | 0 |
| 2 L - 1 | 1 | 20:05:30 | 1,500 | 381 | 380 | 380 | 1,141 |
| 2 L - 1 | 2 | 20:06:30 | 1,500 | 381 | 380 | 380 | 1,141 |
| 2 L - 1 | 4 | 20:08:30 | 1,500 | 381 | 380 | 380 | 1,141 |
| 2 L - 2 | 1 | 20:12:00 | 3,000 | 757 | 755 | 756 | 2,268 |
| 2 L - 2 | 2 | 20:13:00 | 3,000 | 757 | 755 | 756 | 2,268 |
| 2 L - 2 | 4 | 20:15:00 | 3,000 | 757 | 755 | 756 | 2,268 |
| 2 L - 3 | 1 | 20:19:00 | 4,500 | 1,133 | 1,131 | 1,131 | 3,395 |
| 2 L - 3 | 2 | 20:20:00 | 4,500 | 1,133 | 1,131 | 1,131 | 3,395 |
| 2 L - 3 | 4 | 20:22:00 | 4,500 | 1,133 | 1,131 | 1,131 | 3,395 |
| 2 L - 3 | 8 | 20:26:00 | 4,500 | 1,133 | 1,131 | 1,131 | 3,395 |
| 2 U - 1 | 1 | 20:30:30 | 0 | 0 | 0 | 0 | 0 |
| 2 U - 1 | 2 | 20:31:30 | 0 | 0 | 0 | 0 | 0 |
| 2 U - 1 | 4 | 20:33:30 | 0 | 0 | 0 | 0 | 0 |
| 2 U - 1 | 8 | 20:37:30 | 0 | 0 | 0 | 0 | 0 |

## Top of Shaft Displacement
## Test Shaft #1 - Highway 81 over Missouri River - Yankton, South Dakaota

| Load Test Increment | Hold Time (minutes) | Time (h:m:s) | O-cell Pressure (psi) | O-cell Load (kips) | Ref. Beam (in) | Top of Shaft A (in) | Top of Shaft B (in) | Top of Shaft Avg. * (in) | Top of Shaft Leica (in) |
|---|---|---|---|---|---|---|---|---|---|
| 1 L - 0 | - | 17:31:00 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1 L - 1 | 1 | 17:45:30 | 500 | 389 | -0.004 | 0.008 | 0.007 | 0.004 | 0.005 |
| 1 L - 1 | 2 | 17:46:30 | 500 | 389 | -0.005 | 0.009 | 0.010 | 0.005 | 0.004 |
| 1 L - 1 | 4 | 17:48:30 | 500 | 389 | -0.005 | 0.010 | 0.010 | 0.005 | 0.003 |
| 1 L - 1 | 8 | 17:52:30 | 500 | 389 | -0.006 | 0.011 | 0.011 | 0.005 | 0.005 |
| 1 L - 2 | 1 | 17:54:30 | 1,000 | 765 | -0.005 | 0.015 | 0.014 | 0.009 | 0.008 |
| 1 L - 2 | 2 | 17:55:30 | 1,000 | 765 | -0.005 | 0.016 | 0.015 | 0.011 | 0.010 |
| 1 L - 2 | 4 | 17:57:30 | 1,000 | 765 | -0.007 | 0.017 | 0.017 | 0.011 | 0.008 |
| 1 L - 2 | 8 | 18:01:30 | 1,000 | 765 | -0.007 | 0.016 | 0.017 | 0.010 | 0.008 |
| 1 L - 3 | 1 | 18:03:30 | 1,500 | 1,141 | -0.008 | 0.022 | 0.024 | 0.016 | 0.013 |
| 1 L - 3 | 2 | 18:04:30 | 1,500 | 1,141 | -0.008 | 0.022 | 0.024 | 0.016 | 0.013 |
| 1 L - 3 | 4 | 18:06:30 | 1,500 | 1,141 | -0.009 | 0.024 | 0.024 | 0.016 | 0.015 |
| 1 L - 3 | 8 | 18:10:30 | 1,500 | 1,141 | -0.009 | 0.025 | 0.025 | 0.016 | 0.015 |
| 1 L - 4 | 1 | 18:12:30 | 2,000 | 1,516 | -0.009 | 0.030 | 0.029 | 0.021 | 0.020 |
| 1 L - 4 | 2 | 18:13:30 | 2,000 | 1,516 | -0.010 | 0.032 | 0.031 | 0.022 | 0.020 |
| 1 L - 4 | 4 | 18:15:30 | 2,000 | 1,516 | -0.011 | 0.032 | 0.032 | 0.021 | 0.018 |
| 1 L - 4 | 8 | 18:19:30 | 2,000 | 1,516 | -0.013 | 0.033 | 0.035 | 0.021 | 0.020 |
| 1 L - 5 | 1 | 18:22:30 | 2,500 | 1,892 | -0.013 | 0.038 | 0.041 | 0.026 | 0.025 |
| 1 L - 5 | 2 | 18:23:30 | 2,500 | 1,892 | -0.014 | 0.041 | 0.043 | 0.028 | 0.026 |
| 1 L - 5 | 4 | 18:25:30 | 2,500 | 1,892 | -0.015 | 0.042 | 0.045 | 0.028 | 0.028 |
| 1 L - 5 | 8 | 18:29:30 | 2,500 | 1,892 | -0.020 | 0.047 | 0.052 | 0.029 | 0.028 |
| 1 L - 6 | 1 | 18:32:00 | 3,000 | 2,268 | -0.022 | 0.054 | 0.059 | 0.034 | 0.034 |
| 1 L - 6 | 2 | 18:33:00 | 3,000 | 2,268 | -0.022 | 0.055 | 0.060 | 0.035 | 0.035 |
| 1 L - 6 | 4 | 18:35:00 | 3,000 | 2,268 | -0.023 | 0.057 | 0.062 | 0.036 | 0.035 |
| 1 L - 6 | 8 | 18:39:00 | 3,000 | 2,268 | -0.026 | 0.061 | 0.066 | 0.038 | 0.036 |
| 1 L - 7 | 1 | 18:41:30 | 3,500 | 2,643 | -0.026 | 0.069 | 0.073 | 0.045 | 0.043 |
| 1 L - 7 | 2 | 18:42:30 | 3,500 | 2,643 | -0.026 | 0.070 | 0.074 | 0.046 | 0.044 |
| 1 L - 7 | 4 | 18:44:30 | 3,500 | 2,643 | -0.027 | 0.072 | 0.076 | 0.047 | 0.045 |
| 1 L - 7 | 8 | 18:48:30 | 3,500 | 2,643 | -0.030 | 0.074 | 0.079 | 0.047 | 0.046 |
| 1 L - 8 | 1 | 18:51:00 | 4,000 | 3,019 | -0.028 | 0.082 | 0.086 | 0.056 | 0.054 |
| 1 L - 8 | 2 | 18:52:00 | 4,000 | 3,019 | -0.028 | 0.083 | 0.087 | 0.057 | 0.055 |
| 1 L - 8 | 4 | 18:54:00 | 4,000 | 3,019 | -0.028 | 0.086 | 0.089 | 0.059 | 0.057 |
| 1 L - 8 | 8 | 18:58:00 | 4,000 | 3,019 | -0.029 | 0.089 | 0.090 | 0.060 | 0.058 |
| 1 L - 9 | 1 | 19:01:00 | 4,500 | 3,395 | -0.028 | 0.098 | 0.097 | 0.070 | 0.067 |
| 1 L - 9 | 2 | 19:02:00 | 4,500 | 3,395 | -0.028 | 0.100 | 0.100 | 0.072 | 0.068 |
| 1 L - 9 | 4 | 19:04:00 | 4,500 | 3,395 | -0.028 | 0.102 | 0.100 | 0.073 | 0.070 |
| 1 L - 9 | 8 | 19:08:00 | 4,500 | 3,395 | -0.028 | 0.106 | 0.104 | 0.077 | 0.073 |
| 1 L - 10 | 1 | 19:10:30 | 5,000 | 3,771 | -0.027 | 0.115 | 0.112 | 0.086 | 0.083 |
| 1 L - 10 | 2 | 19:11:30 | 5,000 | 3,771 | -0.028 | 0.117 | 0.114 | 0.088 | 0.084 |
| 1 L - 10 | 4 | 19:13:30 | 5,000 | 3,771 | -0.028 | 0.122 | 0.119 | 0.093 | 0.089 |
| 1 L - 10 | 8 | 19:17:30 | 5,000 | 3,771 | -0.028 | 0.127 | 0.124 | 0.098 | 0.093 |
| 1 L - 11 | 1 | 19:20:30 | 5,500 | 4,146 | -0.027 | 0.141 | 0.137 | 0.112 | 0.108 |
| 1 L - 11 | 2 | 19:21:30 | 5,500 | 4,146 | -0.027 | 0.145 | 0.142 | 0.117 | 0.112 |
| 1 L - 11 | 4 | 19:23:30 | 5,500 | 4,146 | -0.027 | 0.147 | 0.145 | 0.119 | 0.115 |
| 1 L - 11 | 8 | 19:27:30 | 5,500 | 4,146 | -0.026 | 0.157 | 0.155 | 0.129 | 0.124 |
| 1 L - 12 | 1 | 19:31:30 | 6,000 | 4,522 | -0.027 | 0.177 | 0.175 | 0.149 | 0.143 |
| 1 L - 12 | 2 | 19:32:30 | 6,000 | 4,522 | -0.028 | 0.182 | 0.179 | 0.153 | 0.148 |
| 1 L - 12 | 4 | 19:34:30 | 6,000 | 4,522 | -0.027 | 0.190 | 0.188 | 0.162 | 0.157 |
| 1 L - 12 | 8 | 19:38:30 | 6,000 | 4,522 | -0.028 | 0.204 | 0.201 | 0.175 | 0.171 |
| 1 U - 1 | 1 | 19:42:30 | 3,000 | 2,268 | -0.029 | 0.172 | 0.168 | 0.140 | 0.134 |
| 1 U - 1 | 2 | 19:43:30 | 3,000 | 2,268 | -0.029 | 0.172 | 0.167 | 0.140 | 0.133 |
| 1 U - 1 | 4 | 19:45:30 | 3,000 | 2,268 | -0.029 | 0.170 | 0.167 | 0.139 | 0.133 |
| 1 U - 2 | 1 | 19:48:00 | 1,500 | 1,141 | -0.031 | 0.148 | 0.142 | 0.114 | 0.109 |
| 1 U - 2 | 2 | 19:49:00 | 1,500 | 1,141 | -0.031 | 0.145 | 0.142 | 0.113 | 0.107 |
| 1 U - 2 | 4 | 19:51:00 | 1,500 | 1,141 | -0.032 | 0.146 | 0.141 | 0.112 | 0.106 |
| 1 U - 3 | 1 | 19:53:30 | 750 | 577 | -0.032 | 0.132 | 0.126 | 0.097 | 0.092 |
| 1 U - 3 | 2 | 19:54:30 | 750 | 577 | -0.032 | 0.132 | 0.126 | 0.097 | 0.091 |
| 1 U - 3 | 4 | 19:56:30 | 750 | 577 | -0.033 | 0.129 | 0.125 | 0.094 | 0.090 |
| 1 U - 4 | 1 | 19:58:30 | 0 | 0 | -0.033 | 0.114 | 0.109 | 0.078 | 0.072 |
| 1 U - 4 | 2 | 19:59:30 | 0 | 0 | -0.034 | 0.112 | 0.108 | 0.076 | 0.071 |
| 1 U - 4 | 4 | 20:01:30 | 0 | 0 | -0.034 | 0.112 | 0.106 | 0.075 | 0.070 |
| 2 L - 0 | - | 20:02:00 | 0 | 0 | -0.034 | 0.112 | 0.106 | 0.075 | 0.069 |
| 2 L - 1 | 1 | 20:05:30 | 1,500 | 1,141 | -0.034 | 0.125 | 0.120 | 0.088 | 0.083 |
| 2 L - 1 | 2 | 20:06:30 | 1,500 | 1,141 | -0.035 | 0.125 | 0.119 | 0.087 | 0.083 |
| 2 L - 1 | 4 | 20:08:30 | 1,500 | 1,141 | -0.035 | 0.126 | 0.121 | 0.088 | 0.084 |
| 2 L - 2 | 1 | 20:12:00 | 3,000 | 2,268 | -0.035 | 0.146 | 0.142 | 0.109 | 0.103 |
| 2 L - 2 | 2 | 20:13:00 | 3,000 | 2,268 | -0.036 | 0.146 | 0.142 | 0.108 | 0.104 |
| 2 L - 2 | 4 | 20:15:00 | 3,000 | 2,268 | -0.036 | 0.147 | 0.142 | 0.109 | 0.105 |
| 2 L - 3 | 1 | 20:19:00 | 4,500 | 3,395 | -0.035 | 0.174 | 0.170 | 0.136 | 0.131 |
| 2 L - 3 | 2 | 20:20:00 | 4,500 | 3,395 | -0.036 | 0.175 | 0.171 | 0.137 | 0.131 |
| 2 L - 3 | 4 | 20:22:00 | 4,500 | 3,395 | -0.037 | 0.178 | 0.174 | 0.139 | 0.133 |
| 2 L - 3 | 8 | 20:26:00 | 4,500 | 3,395 | -0.037 | 0.180 | 0.175 | 0.140 | 0.135 |
| 2 U - 1 | 1 | 20:30:30 | 0 | 0 | -0.041 | 0.119 | 0.114 | 0.075 | 0.070 |
| 2 U - 1 | 2 | 20:31:30 | 0 | 0 | -0.041 | 0.119 | 0.113 | 0.075 | 0.070 |
| 2 U - 1 | 4 | 20:33:30 | 0 | 0 | -0.041 | 0.119 | 0.114 | 0.075 | 0.069 |
| 2 U - 1 | 8 | 20:37:30 | 0 | 0 | -0.044 | 0.119 | 0.113 | 0.072 | 0.067 |

* Average top of shaft includes reference beam correction.

## Shaft Compression

## Test Shaft #1 - Highway 81 over Missouri River - Yankton, South Dakaota

| Load Test Increment | Hold Time (minutes) | Time (h:m:s) | O-cell | | ECTs - Level 1 | | | Telltales - Level 2 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure (psi) | Load (kips) | A - 9939 (in) | B - 9940 (in) | Average (in) | A (in) | B (in) | Average (in) |
| 1 L - 0 | - | 17:31:00 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1 L - 1 | 1 | 17:45:30 | 500 | 389 | 0.001 | 0.001 | 0.001 | 0.002 | 0.002 | 0.002 |
| 1 L - 1 | 2 | 17:46:30 | 500 | 389 | 0.001 | 0.001 | 0.001 | 0.003 | 0.002 | 0.002 |
| 1 L - 1 | 4 | 17:48:30 | 500 | 389 | 0.001 | 0.001 | 0.001 | 0.002 | 0.002 | 0.002 |
| 1 L - 1 | 8 | 17:52:30 | 500 | 389 | 0.001 | 0.001 | 0.001 | 0.002 | 0.002 | 0.002 |
| 1 L - 2 | 1 | 17:54:30 | 1,000 | 765 | 0.002 | 0.003 | 0.002 | 0.004 | 0.003 | 0.004 |
| 1 L - 2 | 2 | 17:55:30 | 1,000 | 765 | 0.003 | 0.003 | 0.003 | 0.005 | 0.003 | 0.004 |
| 1 L - 2 | 4 | 17:57:30 | 1,000 | 765 | 0.002 | 0.003 | 0.002 | 0.004 | 0.003 | 0.004 |
| 1 L - 2 | 8 | 18:01:30 | 1,000 | 765 | 0.003 | 0.003 | 0.003 | 0.005 | 0.003 | 0.004 |
| 1 L - 3 | 1 | 18:03:30 | 1,500 | 1,141 | 0.003 | 0.004 | 0.004 | 0.007 | 0.005 | 0.006 |
| 1 L - 3 | 2 | 18:04:30 | 1,500 | 1,141 | 0.003 | 0.004 | 0.004 | 0.007 | 0.005 | 0.006 |
| 1 L - 3 | 4 | 18:06:30 | 1,500 | 1,141 | 0.003 | 0.004 | 0.004 | 0.007 | 0.005 | 0.006 |
| 1 L - 3 | 8 | 18:10:30 | 1,500 | 1,141 | 0.004 | 0.004 | 0.004 | 0.007 | 0.006 | 0.006 |
| 1 L - 4 | 1 | 18:12:30 | 2,000 | 1,516 | 0.005 | 0.006 | 0.005 | 0.009 | 0.007 | 0.008 |
| 1 L - 4 | 2 | 18:13:30 | 2,000 | 1,516 | 0.005 | 0.006 | 0.005 | 0.010 | 0.007 | 0.009 |
| 1 L - 4 | 4 | 18:15:30 | 2,000 | 1,516 | 0.005 | 0.006 | 0.005 | 0.010 | 0.008 | 0.009 |
| 1 L - 4 | 8 | 18:19:30 | 2,000 | 1,516 | 0.005 | 0.006 | 0.005 | 0.010 | 0.008 | 0.009 |
| 1 L - 5 | 1 | 18:22:30 | 2,500 | 1,892 | 0.006 | 0.007 | 0.006 | 0.012 | 0.010 | 0.011 |
| 1 L - 5 | 2 | 18:23:30 | 2,500 | 1,892 | 0.006 | 0.007 | 0.007 | 0.012 | 0.010 | 0.011 |
| 1 L - 5 | 4 | 18:25:30 | 2,500 | 1,892 | 0.006 | 0.007 | 0.007 | 0.012 | 0.010 | 0.011 |
| 1 L - 5 | 8 | 18:29:30 | 2,500 | 1,892 | 0.006 | 0.007 | 0.007 | 0.012 | 0.010 | 0.011 |
| 1 L - 6 | 1 | 18:32:00 | 3,000 | 2,268 | 0.007 | 0.009 | 0.008 | 0.014 | 0.012 | 0.013 |
| 1 L - 6 | 2 | 18:33:00 | 3,000 | 2,268 | 0.007 | 0.009 | 0.008 | 0.015 | 0.012 | 0.013 |
| 1 L - 6 | 4 | 18:35:00 | 3,000 | 2,268 | 0.007 | 0.009 | 0.008 | 0.015 | 0.012 | 0.013 |
| 1 L - 6 | 8 | 18:39:00 | 3,000 | 2,268 | 0.008 | 0.009 | 0.008 | 0.015 | 0.012 | 0.013 |
| 1 L - 7 | 1 | 18:41:30 | 3,500 | 2,643 | 0.009 | 0.010 | 0.010 | 0.017 | 0.014 | 0.016 |
| 1 L - 7 | 2 | 18:42:30 | 3,500 | 2,643 | 0.009 | 0.011 | 0.010 | 0.017 | 0.014 | 0.016 |
| 1 L - 7 | 4 | 18:44:30 | 3,500 | 2,643 | 0.009 | 0.011 | 0.010 | 0.017 | 0.014 | 0.016 |
| 1 L - 7 | 8 | 18:48:30 | 3,500 | 2,643 | 0.009 | 0.011 | 0.010 | 0.018 | 0.014 | 0.016 |
| 1 L - 8 | 1 | 18:51:00 | 4,000 | 3,019 | 0.010 | 0.012 | 0.011 | 0.020 | 0.016 | 0.018 |
| 1 L - 8 | 2 | 18:52:00 | 4,000 | 3,019 | 0.011 | 0.013 | 0.012 | 0.020 | 0.016 | 0.018 |
| 1 L - 8 | 4 | 18:54:00 | 4,000 | 3,019 | 0.011 | 0.013 | 0.012 | 0.021 | 0.016 | 0.018 |
| 1 L - 8 | 8 | 18:58:00 | 4,000 | 3,019 | 0.011 | 0.013 | 0.012 | 0.021 | 0.017 | 0.019 |
| 1 L - 9 | 1 | 19:01:00 | 4,500 | 3,395 | 0.013 | 0.015 | 0.014 | 0.023 | 0.019 | 0.021 |
| 1 L - 9 | 2 | 19:02:00 | 4,500 | 3,395 | 0.013 | 0.016 | 0.014 | 0.023 | 0.019 | 0.021 |
| 1 L - 9 | 4 | 19:04:00 | 4,500 | 3,395 | 0.013 | 0.016 | 0.015 | 0.024 | 0.019 | 0.021 |
| 1 L - 9 | 8 | 19:08:00 | 4,500 | 3,395 | 0.013 | 0.017 | 0.015 | 0.024 | 0.019 | 0.022 |
| 1 L - 10 | 1 | 19:10:30 | 5,000 | 3,771 | 0.015 | 0.019 | 0.017 | 0.026 | 0.021 | 0.024 |
| 1 L - 10 | 2 | 19:11:30 | 5,000 | 3,771 | 0.016 | 0.019 | 0.017 | 0.026 | 0.021 | 0.024 |
| 1 L - 10 | 4 | 19:13:30 | 5,000 | 3,771 | 0.016 | 0.020 | 0.018 | 0.027 | 0.022 | 0.024 |
| 1 L - 10 | 8 | 19:17:30 | 5,000 | 3,771 | 0.016 | 0.020 | 0.018 | 0.028 | 0.022 | 0.025 |
| 1 L - 11 | 1 | 19:20:30 | 5,500 | 4,146 | 0.018 | 0.022 | 0.020 | 0.030 | 0.024 | 0.027 |
| 1 L - 11 | 2 | 19:21:30 | 5,500 | 4,146 | 0.019 | 0.023 | 0.021 | 0.031 | 0.024 | 0.028 |
| 1 L - 11 | 4 | 19:23:30 | 5,500 | 4,146 | 0.019 | 0.023 | 0.021 | 0.031 | 0.024 | 0.028 |
| 1 L - 11 | 8 | 19:27:30 | 5,500 | 4,146 | 0.019 | 0.023 | 0.021 | 0.032 | 0.025 | 0.028 |
| 1 L - 12 | 1 | 19:31:30 | 6,000 | 4,522 | 0.021 | 0.025 | 0.023 | 0.034 | 0.027 | 0.031 |
| 1 L - 12 | 2 | 19:32:30 | 6,000 | 4,522 | 0.021 | 0.025 | 0.023 | 0.034 | 0.027 | 0.031 |
| 1 L - 12 | 4 | 19:34:30 | 6,000 | 4,522 | 0.021 | 0.026 | 0.023 | 0.035 | 0.028 | 0.031 |
| 1 L - 12 | 8 | 19:38:30 | 6,000 | 4,522 | 0.021 | 0.026 | 0.024 | 0.036 | 0.028 | 0.032 |
| 1 U - 1 | 1 | 19:42:30 | 3,000 | 2,268 | 0.014 | 0.019 | 0.016 | 0.025 | 0.020 | 0.022 |
| 1 U - 1 | 2 | 19:43:30 | 3,000 | 2,268 | 0.014 | 0.019 | 0.016 | 0.024 | 0.020 | 0.022 |
| 1 U - 1 | 4 | 19:45:30 | 3,000 | 2,268 | 0.014 | 0.019 | 0.016 | 0.024 | 0.020 | 0.022 |
| 1 U - 2 | 1 | 19:48:00 | 1,500 | 1,141 | 0.009 | 0.014 | 0.011 | 0.016 | 0.014 | 0.015 |
| 1 U - 2 | 2 | 19:49:00 | 1,500 | 1,141 | 0.009 | 0.014 | 0.011 | 0.016 | 0.013 | 0.015 |
| 1 U - 2 | 4 | 19:51:00 | 1,500 | 1,141 | 0.009 | 0.013 | 0.011 | 0.016 | 0.013 | 0.015 |
| 1 U - 3 | 1 | 19:53:30 | 750 | 577 | 0.007 | 0.011 | 0.009 | 0.012 | 0.010 | 0.011 |
| 1 U - 3 | 2 | 19:54:30 | 750 | 577 | 0.007 | 0.011 | 0.009 | 0.012 | 0.010 | 0.011 |
| 1 U - 3 | 4 | 19:56:30 | 750 | 577 | 0.006 | 0.011 | 0.009 | 0.012 | 0.010 | 0.011 |
| 1 U - 4 | 1 | 19:58:30 | 0 | 0 | 0.004 | 0.007 | 0.006 | 0.007 | 0.006 | 0.007 |
| 1 U - 4 | 2 | 19:59:30 | 0 | 0 | 0.004 | 0.007 | 0.006 | 0.007 | 0.006 | 0.007 |
| 1 U - 4 | 4 | 20:01:30 | 0 | 0 | 0.004 | 0.007 | 0.005 | 0.007 | 0.006 | 0.006 |
| 2 L - 0 | - | 20:02:00 | 0 | 0 | 0.004 | 0.007 | 0.005 | 0.007 | 0.005 | 0.006 |
| 2 L - 1 | 1 | 20:05:30 | 1,500 | 1,141 | 0.007 | 0.011 | 0.009 | 0.012 | 0.010 | 0.011 |
| 2 L - 1 | 2 | 20:06:30 | 1,500 | 1,141 | 0.007 | 0.011 | 0.009 | 0.012 | 0.010 | 0.011 |
| 2 L - 1 | 4 | 20:08:30 | 1,500 | 1,141 | 0.007 | 0.011 | 0.009 | 0.012 | 0.010 | 0.011 |
| 2 L - 2 | 1 | 20:12:00 | 3,000 | 2,268 | 0.011 | 0.015 | 0.013 | 0.020 | 0.015 | 0.018 |
| 2 L - 2 | 2 | 20:13:00 | 3,000 | 2,268 | 0.011 | 0.015 | 0.013 | 0.020 | 0.016 | 0.018 |
| 2 L - 2 | 4 | 20:15:00 | 3,000 | 2,268 | 0.011 | 0.015 | 0.013 | 0.020 | 0.015 | 0.018 |
| 2 L - 3 | 1 | 20:19:00 | 4,500 | 3,395 | 0.015 | 0.020 | 0.018 | 0.027 | 0.022 | 0.024 |
| 2 L - 3 | 2 | 20:20:00 | 4,500 | 3,395 | 0.015 | 0.020 | 0.018 | 0.027 | 0.022 | 0.025 |
| 2 L - 3 | 4 | 20:22:00 | 4,500 | 3,395 | 0.015 | 0.020 | 0.018 | 0.028 | 0.022 | 0.025 |
| 2 L - 3 | 8 | 20:26:00 | 4,500 | 3,395 | 0.015 | 0.021 | 0.018 | 0.028 | 0.022 | 0.025 |
| 2 U - 1 | 1 | 20:30:30 | 0 | 0 | 0.003 | 0.007 | 0.005 | 0.007 | 0.005 | 0.006 |
| 2 U - 1 | 2 | 20:31:30 | 0 | 0 | 0.003 | 0.007 | 0.005 | 0.007 | 0.005 | 0.006 |
| 2 U - 1 | 4 | 20:33:30 | 0 | 0 | 0.003 | 0.007 | 0.005 | 0.007 | 0.005 | 0.006 |
| 2 U - 1 | 8 | 20:37:30 | 0 | 0 | 0.003 | 0.007 | 0.005 | 0.007 | 0.005 | 0.006 |

## O-cell Expansion
## Test Shaft #1 - Highway 81 over Missouri River - Yankton, South Dakaota

| Load Test Increment | Hold Time (minutes) | Time (h:m:s) | O-cell | | O-cell Expansion | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure (psi) | Load (kips) | A - 10498 - 0° (in) | B - 10503 - 120° (in) | C - 10504 -180° (in) | D - 10505 - 240° (in) | Average * (in) |
| 1 L - 0 | - | 17:31:00 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1 L - 1 | 1 | 17:45:30 | 500 | 389 | 0.023 | 0.018 | 0.014 | 0.026 | 0.016 |
| 1 L - 1 | 2 | 17:46:30 | 500 | 389 | 0.023 | 0.018 | 0.014 | 0.026 | 0.016 |
| 1 L - 1 | 4 | 17:48:30 | 500 | 389 | 0.023 | 0.018 | 0.015 | 0.026 | 0.016 |
| 1 L - 1 | 8 | 17:52:30 | 500 | 389 | 0.024 | 0.019 | 0.015 | 0.026 | 0.017 |
| 1 L - 2 | 1 | 17:54:30 | 1,000 | 765 | 0.038 | 0.032 | 0.028 | 0.040 | 0.030 |
| 1 L - 2 | 2 | 17:55:30 | 1,000 | 765 | 0.038 | 0.033 | 0.028 | 0.039 | 0.030 |
| 1 L - 2 | 4 | 17:57:30 | 1,000 | 765 | 0.039 | 0.033 | 0.029 | 0.040 | 0.031 |
| 1 L - 2 | 8 | 18:01:30 | 1,000 | 765 | 0.041 | 0.035 | 0.031 | 0.042 | 0.033 |
| 1 L - 3 | 1 | 18:03:30 | 1,500 | 1,141 | 0.054 | 0.048 | 0.044 | 0.055 | 0.046 |
| 1 L - 3 | 2 | 18:04:30 | 1,500 | 1,141 | 0.055 | 0.049 | 0.045 | 0.056 | 0.047 |
| 1 L - 3 | 4 | 18:06:30 | 1,500 | 1,141 | 0.057 | 0.050 | 0.046 | 0.058 | 0.048 |
| 1 L - 3 | 8 | 18:10:30 | 1,500 | 1,141 | 0.058 | 0.052 | 0.048 | 0.059 | 0.050 |
| 1 L - 4 | 1 | 18:12:30 | 2,000 | 1,516 | 0.075 | 0.068 | 0.064 | 0.075 | 0.066 |
| 1 L - 4 | 2 | 18:13:30 | 2,000 | 1,516 | 0.077 | 0.070 | 0.066 | 0.077 | 0.068 |
| 1 L - 4 | 4 | 18:15:30 | 2,000 | 1,516 | 0.079 | 0.072 | 0.068 | 0.079 | 0.070 |
| 1 L - 4 | 8 | 18:19:30 | 2,000 | 1,516 | 0.081 | 0.074 | 0.070 | 0.081 | 0.072 |
| 1 L - 5 | 1 | 18:22:30 | 2,500 | 1,892 | 0.097 | 0.089 | 0.086 | 0.097 | 0.088 |
| 1 L - 5 | 2 | 18:23:30 | 2,500 | 1,892 | 0.099 | 0.090 | 0.088 | 0.099 | 0.089 |
| 1 L - 5 | 4 | 18:25:30 | 2,500 | 1,892 | 0.101 | 0.092 | 0.090 | 0.102 | 0.091 |
| 1 L - 5 | 8 | 18:29:30 | 2,500 | 1,892 | 0.105 | 0.095 | 0.094 | 0.105 | 0.094 |
| 1 L - 6 | 1 | 18:32:00 | 3,000 | 2,268 | 0.125 | 0.116 | 0.114 | 0.126 | 0.115 |
| 1 L - 6 | 2 | 18:33:00 | 3,000 | 2,268 | 0.127 | 0.118 | 0.117 | 0.129 | 0.118 |
| 1 L - 6 | 4 | 18:35:00 | 3,000 | 2,268 | 0.131 | 0.121 | 0.120 | 0.132 | 0.121 |
| 1 L - 6 | 8 | 18:39:00 | 3,000 | 2,268 | 0.136 | 0.126 | 0.124 | 0.136 | 0.125 |
| 1 L - 7 | 1 | 18:41:30 | 3,500 | 2,643 | 0.160 | 0.150 | 0.149 | 0.160 | 0.149 |
| 1 L - 7 | 2 | 18:42:30 | 3,500 | 2,643 | 0.165 | 0.156 | 0.154 | 0.164 | 0.155 |
| 1 L - 7 | 4 | 18:44:30 | 3,500 | 2,643 | 0.170 | 0.160 | 0.158 | 0.170 | 0.159 |
| 1 L - 7 | 8 | 18:48:30 | 3,500 | 2,643 | 0.178 | 0.168 | 0.166 | 0.177 | 0.167 |
| 1 L - 8 | 1 | 18:51:00 | 4,000 | 3,019 | 0.206 | 0.195 | 0.195 | 0.205 | 0.195 |
| 1 L - 8 | 2 | 18:52:00 | 4,000 | 3,019 | 0.213 | 0.202 | 0.201 | 0.212 | 0.202 |
| 1 L - 8 | 4 | 18:54:00 | 4,000 | 3,019 | 0.224 | 0.213 | 0.212 | 0.223 | 0.212 |
| 1 L - 8 | 8 | 18:58:00 | 4,000 | 3,019 | 0.243 | 0.231 | 0.232 | 0.243 | 0.231 |
| 1 L - 9 | 1 | 19:01:00 | 4,500 | 3,395 | 0.284 | 0.272 | 0.272 | 0.283 | 0.272 |
| 1 L - 9 | 2 | 19:02:00 | 4,500 | 3,395 | 0.295 | 0.282 | 0.283 | 0.294 | 0.282 |
| 1 L - 9 | 4 | 19:04:00 | 4,500 | 3,395 | 0.311 | 0.298 | 0.301 | 0.311 | 0.299 |
| 1 L - 9 | 8 | 19:08:00 | 4,500 | 3,395 | 0.338 | 0.322 | 0.326 | 0.335 | 0.324 |
| 1 L - 10 | 1 | 19:10:30 | 5,000 | 3,771 | 0.384 | 0.367 | 0.373 | 0.383 | 0.370 |
| 1 L - 10 | 2 | 19:11:30 | 5,000 | 3,771 | 0.395 | 0.378 | 0.383 | 0.394 | 0.380 |
| 1 L - 10 | 4 | 19:13:30 | 5,000 | 3,771 | 0.417 | 0.399 | 0.406 | 0.415 | 0.403 |
| 1 L - 10 | 8 | 19:17:30 | 5,000 | 3,771 | 0.448 | 0.430 | 0.437 | 0.447 | 0.434 |
| 1 L - 11 | 1 | 19:20:30 | 5,500 | 4,146 | 0.511 | 0.491 | 0.501 | 0.511 | 0.496 |
| 1 L - 11 | 2 | 19:21:30 | 5,500 | 4,146 | 0.526 | 0.504 | 0.515 | 0.525 | 0.510 |
| 1 L - 11 | 4 | 19:23:30 | 5,500 | 4,146 | 0.541 | 0.521 | 0.531 | 0.541 | 0.526 |
| 1 L - 11 | 8 | 19:27:30 | 5,500 | 4,146 | 0.577 | 0.556 | 0.567 | 0.578 | 0.561 |
| 1 L - 12 | 1 | 19:31:30 | 6,000 | 4,522 | 0.648 | 0.624 | 0.638 | 0.646 | 0.631 |
| 1 L - 12 | 2 | 19:32:30 | 6,000 | 4,522 | 0.662 | 0.638 | 0.652 | 0.660 | 0.645 |
| 1 L - 12 | 4 | 19:34:30 | 6,000 | 4,522 | 0.689 | 0.664 | 0.678 | 0.687 | 0.671 |
| 1 L - 12 | 8 | 19:38:30 | 6,000 | 4,522 | 0.728 | 0.704 | 0.718 | 0.728 | 0.711 |
| 1 U - 1 | 1 | 19:42:30 | 3,000 | 2,268 | 0.633 | 0.613 | 0.623 | 0.633 | 0.618 |
| 1 U - 1 | 2 | 19:43:30 | 3,000 | 2,268 | 0.630 | 0.610 | 0.621 | 0.630 | 0.615 |
| 1 U - 1 | 4 | 19:45:30 | 3,000 | 2,268 | 0.629 | 0.610 | 0.620 | 0.629 | 0.615 |
| 1 U - 2 | 1 | 19:48:00 | 1,500 | 1,141 | 0.563 | 0.545 | 0.554 | 0.565 | 0.550 |
| 1 U - 2 | 2 | 19:49:00 | 1,500 | 1,141 | 0.561 | 0.544 | 0.553 | 0.564 | 0.548 |
| 1 U - 2 | 4 | 19:51:00 | 1,500 | 1,141 | 0.557 | 0.540 | 0.549 | 0.560 | 0.545 |
| 1 U - 3 | 1 | 19:53:30 | 750 | 577 | 0.521 | 0.504 | 0.514 | 0.523 | 0.509 |
| 1 U - 3 | 2 | 19:54:30 | 750 | 577 | 0.518 | 0.501 | 0.511 | 0.521 | 0.506 |
| 1 U - 3 | 4 | 19:56:30 | 750 | 577 | 0.516 | 0.499 | 0.508 | 0.518 | 0.504 |
| 1 U - 4 | 1 | 19:58:30 | 0 | 0 | 0.462 | 0.453 | 0.462 | 0.466 | 0.457 |
| 1 U - 4 | 2 | 19:59:30 | 0 | 0 | 0.458 | 0.449 | 0.458 | 0.462 | 0.454 |
| 1 U - 4 | 4 | 20:01:30 | 0 | 0 | 0.455 | 0.446 | 0.455 | 0.458 | 0.450 |
| 2 L - 0 | - | 20:02:00 | 0 | 0 | 0.454 | 0.445 | 0.454 | 0.459 | 0.450 |
| 2 L - 1 | 1 | 20:05:30 | 1,500 | 1,141 | 0.501 | 0.485 | 0.493 | 0.502 | 0.489 |
| 2 L - 1 | 2 | 20:06:30 | 1,500 | 1,141 | 0.502 | 0.487 | 0.494 | 0.504 | 0.490 |
| 2 L - 1 | 4 | 20:08:30 | 1,500 | 1,141 | 0.503 | 0.487 | 0.495 | 0.505 | 0.491 |
| 2 L - 2 | 1 | 20:12:00 | 3,000 | 2,268 | 0.558 | 0.540 | 0.549 | 0.559 | 0.545 |
| 2 L - 2 | 2 | 20:13:00 | 3,000 | 2,268 | 0.560 | 0.542 | 0.551 | 0.562 | 0.547 |
| 2 L - 2 | 4 | 20:15:00 | 3,000 | 2,268 | 0.563 | 0.544 | 0.554 | 0.565 | 0.549 |
| 2 L - 3 | 1 | 20:19:00 | 4,500 | 3,395 | 0.640 | 0.618 | 0.630 | 0.638 | 0.624 |
| 2 L - 3 | 2 | 20:20:00 | 4,500 | 3,395 | 0.644 | 0.622 | 0.634 | 0.643 | 0.628 |
| 2 L - 3 | 4 | 20:22:00 | 4,500 | 3,395 | 0.649 | 0.628 | 0.640 | 0.649 | 0.634 |
| 2 L - 3 | 8 | 20:26:00 | 4,500 | 3,395 | 0.659 | 0.636 | 0.649 | 0.658 | 0.642 |
| 2 U - 1 | 1 | 20:30:30 | 0 | 0 | 0.478 | 0.468 | 0.477 | 0.480 | 0.473 |
| 2 U - 1 | 2 | 20:31:30 | 0 | 0 | 0.475 | 0.466 | 0.475 | 0.478 | 0.470 |
| 2 U - 1 | 4 | 20:33:30 | 0 | 0 | 0.471 | 0.462 | 0.471 | 0.475 | 0.467 |
| 2 U - 1 | 8 | 20:37:30 | 0 | 0 | 0.468 | 0.459 | 0.468 | 0.472 | 0.464 |

* Average of 0° and 180° gages.

## Upward and Downward O-cell Plate Movement and Creep (calculated)
## Test Shaft #1 - Highway 81 over Missouri River - Yankton, South Dakaota

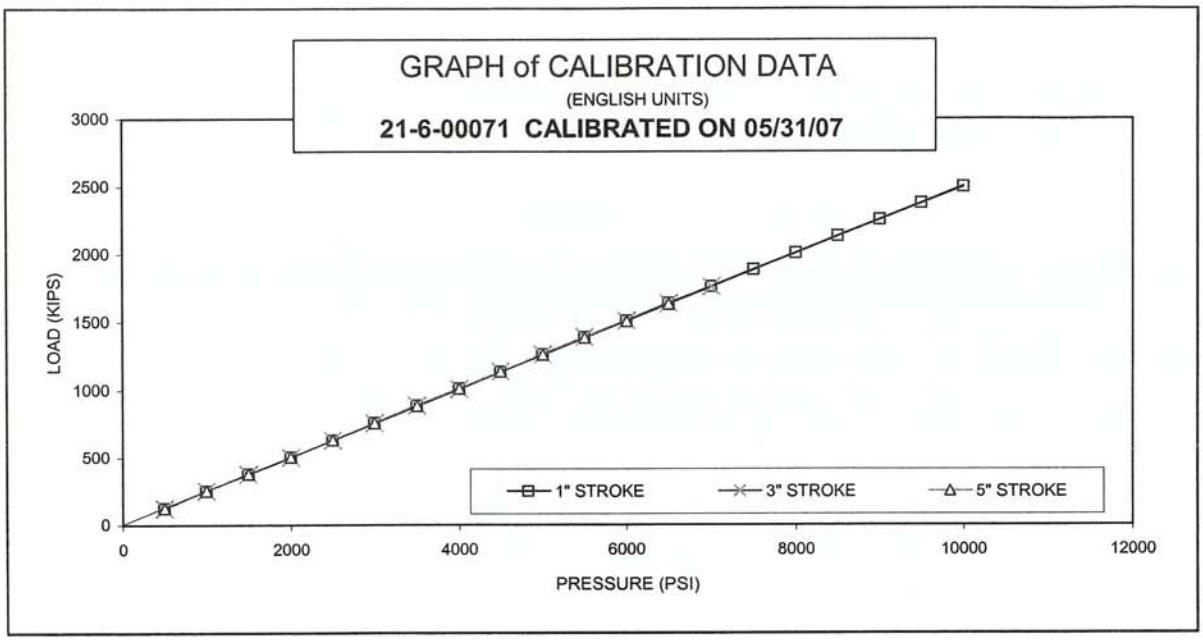
| Load Test Increment | Hold Time (minutes) | Time (h:m:s) | O-cell Pressure (psi) | O-cell Load (kips) | Top of Shaft (in) | Upper Comp. (in) | Top Plate Movement (in) | O-cell Expansion (in) | Bot. Plate Movement (in) | Lower Comp. (in) | Base of Shaft (in) | Creep Up Per Hold (in) | Creep Dn Per Hold (in) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 L - 0 | - | 17:31:00 | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | |
| 1 L - 1 | 1 | 17:45:30 | 500 | 389 | 0.004 | 0.002 | 0.006 | 0.016 | -0.010 | 0.001 | -0.009 | | |
| 1 L - 1 | 2 | 17:46:30 | 500 | 389 | 0.005 | 0.002 | 0.007 | 0.016 | -0.010 | 0.001 | -0.008 | 0.001 | -0.001 |
| 1 L - 1 | 4 | 17:48:30 | 500 | 389 | 0.005 | 0.002 | 0.007 | 0.016 | -0.009 | 0.001 | -0.008 | 0.001 | -0.001 |
| 1 L - 1 | 8 | 17:52:30 | 500 | 389 | 0.005 | 0.002 | 0.007 | 0.017 | -0.010 | 0.001 | -0.009 | -0.001 | 0.001 |
| 1 L - 2 | 1 | 17:54:30 | 1,000 | 765 | 0.009 | 0.004 | 0.013 | 0.030 | -0.017 | 0.002 | -0.015 | | |
| 1 L - 2 | 2 | 17:55:30 | 1,000 | 765 | 0.011 | 0.004 | 0.015 | 0.030 | -0.015 | 0.003 | -0.013 | 0.002 | -0.002 |
| 1 L - 2 | 4 | 17:57:30 | 1,000 | 765 | 0.011 | 0.004 | 0.014 | 0.031 | -0.016 | 0.002 | -0.014 | -0.001 | 0.001 |
| 1 L - 2 | 8 | 18:01:30 | 1,000 | 765 | 0.010 | 0.004 | 0.014 | 0.033 | -0.019 | 0.003 | -0.016 | 0.000 | 0.002 |
| 1 L - 3 | 1 | 18:03:30 | 1,500 | 1,141 | 0.016 | 0.006 | 0.021 | 0.046 | -0.025 | 0.004 | -0.021 | | |
| 1 L - 3 | 2 | 18:04:30 | 1,500 | 1,141 | 0.016 | 0.006 | 0.022 | 0.047 | -0.025 | 0.004 | -0.022 | 0.000 | 0.001 |
| 1 L - 3 | 4 | 18:06:30 | 1,500 | 1,141 | 0.016 | 0.006 | 0.022 | 0.048 | -0.027 | 0.004 | -0.023 | 0.000 | 0.001 |
| 1 L - 3 | 8 | 18:10:30 | 1,500 | 1,141 | 0.016 | 0.006 | 0.023 | 0.050 | -0.027 | 0.004 | -0.023 | 0.001 | 0.001 |
| 1 L - 4 | 1 | 18:12:30 | 2,000 | 1,516 | 0.021 | 0.008 | 0.029 | 0.066 | -0.037 | 0.005 | -0.032 | | |
| 1 L - 4 | 2 | 18:13:30 | 2,000 | 1,516 | 0.022 | 0.009 | 0.031 | 0.068 | -0.038 | 0.005 | -0.032 | 0.001 | 0.001 |
| 1 L - 4 | 4 | 18:15:30 | 2,000 | 1,516 | 0.021 | 0.009 | 0.030 | 0.070 | -0.040 | 0.005 | -0.035 | -0.001 | 0.002 |
| 1 L - 4 | 8 | 18:19:30 | 2,000 | 1,516 | 0.021 | 0.009 | 0.030 | 0.072 | -0.042 | 0.005 | -0.037 | 0.000 | 0.003 |
| 1 L - 5 | 1 | 18:22:30 | 2,500 | 1,892 | 0.026 | 0.011 | 0.037 | 0.088 | -0.051 | 0.006 | -0.044 | | |
| 1 L - 5 | 2 | 18:23:30 | 2,500 | 1,892 | 0.028 | 0.011 | 0.038 | 0.089 | -0.051 | 0.007 | -0.044 | 0.002 | 0.000 |
| 1 L - 5 | 4 | 18:25:30 | 2,500 | 1,892 | 0.028 | 0.011 | 0.039 | 0.091 | -0.052 | 0.007 | -0.045 | 0.001 | 0.001 |
| 1 L - 5 | 8 | 18:29:30 | 2,500 | 1,892 | 0.029 | 0.011 | 0.040 | 0.094 | -0.054 | 0.007 | -0.047 | 0.001 | 0.002 |
| 1 L - 6 | 1 | 18:32:00 | 3,000 | 2,268 | 0.034 | 0.013 | 0.047 | 0.115 | -0.068 | 0.008 | -0.060 | | |
| 1 L - 6 | 2 | 18:33:00 | 3,000 | 2,268 | 0.035 | 0.013 | 0.048 | 0.118 | -0.069 | 0.008 | -0.061 | 0.001 | 0.002 |
| 1 L - 6 | 4 | 18:35:00 | 3,000 | 2,268 | 0.036 | 0.013 | 0.050 | 0.121 | -0.071 | 0.008 | -0.063 | 0.001 | 0.002 |
| 1 L - 6 | 8 | 18:39:00 | 3,000 | 2,268 | 0.038 | 0.013 | 0.051 | 0.125 | -0.074 | 0.008 | -0.066 | 0.002 | 0.003 |
| 1 L - 7 | 1 | 18:41:30 | 3,500 | 2,643 | 0.045 | 0.016 | 0.060 | 0.149 | -0.089 | 0.010 | -0.079 | | |
| 1 L - 7 | 2 | 18:42:30 | 3,500 | 2,643 | 0.046 | 0.016 | 0.061 | 0.155 | -0.093 | 0.010 | -0.083 | 0.001 | 0.004 |
| 1 L - 7 | 4 | 18:44:30 | 3,500 | 2,643 | 0.047 | 0.016 | 0.063 | 0.159 | -0.096 | 0.010 | -0.086 | 0.001 | 0.003 |
| 1 L - 7 | 8 | 18:48:30 | 3,500 | 2,643 | 0.047 | 0.016 | 0.063 | 0.167 | -0.104 | 0.010 | -0.094 | 0.000 | 0.007 |
| 1 L - 8 | 1 | 18:51:00 | 4,000 | 3,019 | 0.056 | 0.018 | 0.074 | 0.195 | -0.121 | 0.011 | -0.109 | | |
| 1 L - 8 | 2 | 18:52:00 | 4,000 | 3,019 | 0.057 | 0.018 | 0.075 | 0.202 | -0.127 | 0.012 | -0.115 | 0.001 | 0.006 |
| 1 L - 8 | 4 | 18:54:00 | 4,000 | 3,019 | 0.059 | 0.018 | 0.078 | 0.212 | -0.135 | 0.012 | -0.123 | 0.003 | 0.008 |
| 1 L - 8 | 8 | 18:58:00 | 4,000 | 3,019 | 0.060 | 0.019 | 0.080 | 0.231 | -0.152 | 0.012 | -0.139 | 0.002 | 0.017 |
| 1 L - 9 | 1 | 19:01:00 | 4,500 | 3,395 | 0.070 | 0.021 | 0.090 | 0.272 | -0.181 | 0.014 | -0.167 | | |
| 1 L - 9 | 2 | 19:02:00 | 4,500 | 3,395 | 0.072 | 0.021 | 0.093 | 0.282 | -0.189 | 0.014 | -0.175 | 0.003 | 0.007 |
| 1 L - 9 | 4 | 19:04:00 | 4,500 | 3,395 | 0.073 | 0.021 | 0.094 | 0.299 | -0.205 | 0.015 | -0.191 | 0.001 | 0.016 |
| 1 L - 9 | 8 | 19:08:00 | 4,500 | 3,395 | 0.077 | 0.022 | 0.099 | 0.324 | -0.225 | 0.015 | -0.210 | 0.004 | 0.020 |
| 1 L - 10 | 1 | 19:10:30 | 5,000 | 3,771 | 0.086 | 0.024 | 0.110 | 0.370 | -0.260 | 0.017 | -0.243 | | |
| 1 L - 10 | 2 | 19:11:30 | 5,000 | 3,771 | 0.088 | 0.024 | 0.111 | 0.380 | -0.269 | 0.017 | -0.252 | 0.001 | 0.009 |
| 1 L - 10 | 4 | 19:13:30 | 5,000 | 3,771 | 0.093 | 0.024 | 0.117 | 0.403 | -0.285 | 0.018 | -0.268 | 0.006 | 0.016 |
| 1 L - 10 | 8 | 19:17:30 | 5,000 | 3,771 | 0.098 | 0.025 | 0.123 | 0.434 | -0.311 | 0.018 | -0.293 | 0.005 | 0.026 |
| 1 L - 11 | 1 | 19:20:30 | 5,500 | 4,146 | 0.112 | 0.027 | 0.139 | 0.496 | -0.357 | 0.020 | -0.337 | | |
| 1 L - 11 | 2 | 19:21:30 | 5,500 | 4,146 | 0.117 | 0.028 | 0.144 | 0.510 | -0.366 | 0.021 | -0.345 | 0.005 | 0.009 |
| 1 L - 11 | 4 | 19:23:30 | 5,500 | 4,146 | 0.119 | 0.028 | 0.147 | 0.526 | -0.379 | 0.021 | -0.358 | 0.003 | 0.013 |
| 1 L - 11 | 8 | 19:27:30 | 5,500 | 4,146 | 0.129 | 0.028 | 0.158 | 0.561 | -0.404 | 0.021 | -0.383 | 0.010 | 0.025 |
| 1 L - 12 | 1 | 19:31:30 | 6,000 | 4,522 | 0.149 | 0.031 | 0.180 | 0.631 | -0.451 | 0.023 | -0.428 | | |
| 1 L - 12 | 2 | 19:32:30 | 6,000 | 4,522 | 0.153 | 0.031 | 0.183 | 0.645 | -0.461 | 0.023 | -0.438 | 0.004 | 0.010 |
| 1 L - 12 | 4 | 19:34:30 | 6,000 | 4,522 | 0.162 | 0.031 | 0.193 | 0.671 | -0.478 | 0.023 | -0.455 | 0.010 | 0.017 |
| 1 L - 12 | 8 | 19:38:30 | 6,000 | 4,522 | 0.175 | 0.032 | 0.207 | 0.711 | -0.504 | 0.024 | -0.481 | 0.014 | 0.026 |
| 1 U - 1 | 1 | 19:42:30 | 3,000 | 2,268 | 0.140 | 0.022 | 0.163 | 0.618 | -0.456 | 0.016 | -0.439 | | |
| 1 U - 1 | 2 | 19:43:30 | 3,000 | 2,268 | 0.140 | 0.022 | 0.162 | 0.615 | -0.454 | 0.016 | -0.437 | | |
| 1 U - 1 | 4 | 19:45:30 | 3,000 | 2,268 | 0.139 | 0.022 | 0.161 | 0.615 | -0.454 | 0.016 | -0.438 | | |
| 1 U - 2 | 1 | 19:48:00 | 1,500 | 1,141 | 0.114 | 0.015 | 0.130 | 0.550 | -0.420 | 0.011 | -0.409 | | |
| 1 U - 2 | 2 | 19:49:00 | 1,500 | 1,141 | 0.113 | 0.015 | 0.128 | 0.548 | -0.421 | 0.011 | -0.409 | | |
| 1 U - 2 | 4 | 19:51:00 | 1,500 | 1,141 | 0.112 | 0.015 | 0.127 | 0.545 | -0.418 | 0.011 | -0.407 | | |
| 1 U - 3 | 1 | 19:53:30 | 750 | 577 | 0.097 | 0.011 | 0.108 | 0.509 | -0.401 | 0.009 | -0.392 | | |
| 1 U - 3 | 2 | 19:54:30 | 750 | 577 | 0.097 | 0.011 | 0.108 | 0.506 | -0.398 | 0.009 | -0.390 | | |
| 1 U - 3 | 4 | 19:56:30 | 750 | 577 | 0.094 | 0.011 | 0.105 | 0.504 | -0.399 | 0.009 | -0.390 | | |
| 1 U - 4 | 1 | 19:58:30 | 0 | 0 | 0.078 | 0.007 | 0.085 | 0.457 | -0.373 | 0.006 | -0.367 | | |
| 1 U - 4 | 2 | 19:59:30 | 0 | 0 | 0.076 | 0.007 | 0.083 | 0.454 | -0.371 | 0.006 | -0.365 | | |
| 1 U - 4 | 4 | 20:01:30 | 0 | 0 | 0.075 | 0.006 | 0.081 | 0.450 | -0.369 | 0.005 | -0.364 | | |
| 2 L - 0 | - | 20:02:00 | 0 | 0 | 0.075 | 0.006 | 0.081 | 0.450 | -0.369 | 0.005 | -0.363 | | |
| 2 L - 1 | 1 | 20:05:30 | 1,500 | 1,141 | 0.088 | 0.011 | 0.099 | 0.489 | -0.390 | 0.009 | -0.381 | | |
| 2 L - 1 | 2 | 20:06:30 | 1,500 | 1,141 | 0.087 | 0.011 | 0.098 | 0.490 | -0.392 | 0.009 | -0.384 | | |
| 2 L - 1 | 4 | 20:08:30 | 1,500 | 1,141 | 0.088 | 0.011 | 0.100 | 0.491 | -0.392 | 0.009 | -0.383 | | |
| 2 L - 2 | 1 | 20:12:00 | 3,000 | 2,268 | 0.109 | 0.018 | 0.127 | 0.545 | -0.418 | 0.013 | -0.405 | | |
| 2 L - 2 | 2 | 20:13:00 | 3,000 | 2,268 | 0.108 | 0.018 | 0.126 | 0.547 | -0.421 | 0.013 | -0.408 | | |
| 2 L - 2 | 4 | 20:15:00 | 3,000 | 2,268 | 0.109 | 0.018 | 0.127 | 0.549 | -0.422 | 0.013 | -0.409 | | |
| 2 L - 3 | 1 | 20:19:00 | 4,500 | 3,395 | 0.136 | 0.024 | 0.161 | 0.624 | -0.463 | 0.018 | -0.446 | | |
| 2 L - 3 | 2 | 20:20:00 | 4,500 | 3,395 | 0.137 | 0.025 | 0.161 | 0.628 | -0.467 | 0.018 | -0.449 | | |
| 2 L - 3 | 4 | 20:22:00 | 4,500 | 3,395 | 0.139 | 0.025 | 0.163 | 0.634 | -0.471 | 0.018 | -0.453 | | |
| 2 L - 3 | 8 | 20:26:00 | 4,500 | 3,395 | 0.140 | 0.025 | 0.165 | 0.642 | -0.477 | 0.018 | -0.459 | | |
| 2 U - 1 | 1 | 20:30:30 | 0 | 0 | 0.075 | 0.006 | 0.081 | 0.473 | -0.391 | 0.005 | -0.386 | | |
| 2 U - 1 | 2 | 20:31:30 | 0 | 0 | 0.075 | 0.006 | 0.081 | 0.470 | -0.389 | 0.005 | -0.384 | | |
| 2 U - 1 | 4 | 20:33:30 | 0 | 0 | 0.075 | 0.006 | 0.081 | 0.467 | -0.385 | 0.005 | -0.380 | | |
| 2 U - 1 | 8 | 20:37:30 | 0 | 0 | 0.072 | 0.006 | 0.078 | 0.464 | -0.385 | 0.005 | -0.380 | | |

## Strain Gage Readings and Loads at Levels 1, 2 and 3
## Test Shaft #1 - Highway 81 over Missouri River - Yankton, South Dakaota

| Load Test Increment | Hold Time (minutes) | Time (h:m:s) | O-cell Pressure (psi) | O-cell Load (kips) | Level 1 A - 12904 (με) | Level 1 B - 12905 (με) | Level 1 C - 12906 (με) | Level 1 D - 12907 (με) | Level 1 Av. Load (kips) | Level 2 A - 12908 (με) | Level 2 B - 12909 (με) | Level 2 Av. Load (kips) | Level 3 A - 12910 (με) | Level 3 B - 12911 (με) | Level 3 Av. Load (kips) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 L - 0 | - | 17:31:00 | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0 |
| 1 L - 1 | 1 | 17:45:30 | 500 | 389 | 2.7 | 2.0 | 2.7 | 2.5 | 60 | 4.4 | 3.9 | 105 | 0.8 | 1.1 | 24 |
| 1 L - 1 | 2 | 17:46:30 | 500 | 389 | 2.6 | 1.7 | 2.7 | 2.5 | 58 | 4.5 | 3.9 | 107 | 0.7 | 0.1 | 10 |
| 1 L - 1 | 4 | 17:48:30 | 500 | 389 | 2.7 | 2.0 | 2.7 | 2.5 | 60 | 4.9 | 3.9 | 112 | 0.7 | 1.1 | 23 |
| 1 L - 1 | 8 | 17:52:30 | 500 | 389 | 2.7 | 1.9 | 2.4 | 2.5 | 58 | 4.5 | 3.9 | 108 | 0.7 | 1.1 | 23 |
| 1 L - 2 | 1 | 17:54:30 | 1,000 | 765 | 4.8 | 3.8 | 4.8 | 4.8 | 111 | 8.5 | 7.3 | 201 | 1.4 | 1.9 | 43 |
| 1 L - 2 | 2 | 17:55:30 | 1,000 | 765 | 4.8 | 3.4 | 4.7 | 4.8 | 108 | 8.5 | 7.3 | 202 | 1.4 | 2.1 | 44 |
| 1 L - 2 | 4 | 17:57:30 | 1,000 | 765 | 5.2 | 3.3 | 4.5 | 4.8 | 109 | 8.6 | 7.4 | 203 | 1.4 | 1.5 | 36 |
| 1 L - 2 | 8 | 18:01:30 | 1,000 | 765 | 4.9 | 3.7 | 5.0 | 5.1 | 115 | 9.2 | 7.9 | 218 | 1.4 | 2.1 | 45 |
| 1 L - 3 | 1 | 18:03:30 | 1,500 | 1,141 | 7.3 | 5.3 | 6.8 | 7.8 | 166 | 12.8 | 11.5 | 309 | 2.0 | 3.0 | 64 |
| 1 L - 3 | 2 | 18:04:30 | 1,500 | 1,141 | 7.3 | 5.2 | 6.8 | 7.1 | 162 | 13.3 | 11.7 | 318 | 2.1 | 3.0 | 64 |
| 1 L - 3 | 4 | 18:06:30 | 1,500 | 1,141 | 7.4 | 5.2 | 6.8 | 7.2 | 163 | 13.6 | 12.0 | 326 | 2.1 | 3.0 | 65 |
| 1 L - 3 | 8 | 18:10:30 | 1,500 | 1,141 | 7.5 | 4.9 | 6.8 | 7.3 | 162 | 13.9 | 12.2 | 333 | 2.2 | 3.0 | 66 |
| 1 L - 4 | 1 | 18:12:30 | 2,000 | 1,516 | 10.1 | 7.3 | 8.9 | 10.0 | 222 | 18.0 | 16.7 | 442 | 2.8 | 3.9 | 85 |
| 1 L - 4 | 2 | 18:13:30 | 2,000 | 1,516 | 10.9 | 7.3 | 8.9 | 10.0 | 228 | 18.4 | 17.2 | 454 | 3.1 | 3.9 | 89 |
| 1 L - 4 | 4 | 18:15:30 | 2,000 | 1,516 | 10.1 | 7.2 | 8.8 | 10.2 | 223 | 19.2 | 17.5 | 468 | 3.1 | 4.0 | 90 |
| 1 L - 4 | 8 | 18:19:30 | 2,000 | 1,516 | 10.8 | 6.8 | 8.8 | 10.0 | 223 | 19.5 | 17.8 | 476 | 3.1 | 4.0 | 91 |
| 1 L - 5 | 1 | 18:22:30 | 2,500 | 1,892 | 11.9 | 8.9 | 10.5 | 12.4 | 268 | 23.7 | 21.5 | 576 | 3.8 | 4.7 | 109 |
| 1 L - 5 | 2 | 18:23:30 | 2,500 | 1,892 | 11.9 | 8.9 | 10.6 | 12.2 | 267 | 23.9 | 21.7 | 582 | 3.6 | 4.8 | 107 |
| 1 L - 5 | 4 | 18:25:30 | 2,500 | 1,892 | 11.9 | 8.8 | 10.8 | 12.6 | 270 | 24.4 | 22.1 | 592 | 3.9 | 4.8 | 111 |
| 1 L - 5 | 8 | 18:29:30 | 2,500 | 1,892 | 11.8 | 8.7 | 10.6 | 12.7 | 268 | 24.8 | 22.7 | 606 | 4.0 | 4.9 | 113 |
| 1 L - 6 | 1 | 18:32:00 | 3,000 | 2,268 | 14.5 | 10.2 | 12.8 | 15.2 | 323 | 29.5 | 26.7 | 717 | 4.6 | 5.7 | 132 |
| 1 L - 6 | 2 | 18:33:00 | 3,000 | 2,268 | 14.4 | 10.2 | 12.8 | 15.2 | 323 | 29.7 | 27.0 | 722 | 4.5 | 5.8 | 132 |
| 1 L - 6 | 4 | 18:35:00 | 3,000 | 2,268 | 14.5 | 10.5 | 12.9 | 15.3 | 326 | 30.1 | 27.6 | 737 | 4.6 | 5.9 | 134 |
| 1 L - 6 | 8 | 18:39:00 | 3,000 | 2,268 | 14.2 | 10.1 | 13.0 | 15.5 | 323 | 30.5 | 28.0 | 747 | 4.7 | 6.0 | 136 |
| 1 L - 7 | 1 | 18:41:30 | 3,500 | 2,643 | 16.9 | 13.0 | 15.4 | 18.3 | 390 | 35.7 | 32.5 | 869 | 5.2 | 6.9 | 155 |
| 1 L - 7 | 2 | 18:42:30 | 3,500 | 2,643 | 17.1 | 12.2 | 16.0 | 18.7 | 392 | 36.2 | 33.3 | 886 | 5.3 | 7.0 | 156 |
| 1 L - 7 | 4 | 18:44:30 | 3,500 | 2,643 | 17.0 | 12.2 | 15.7 | 18.9 | 390 | 36.6 | 33.3 | 890 | 5.3 | 7.1 | 157 |
| 1 L - 7 | 8 | 18:48:30 | 3,500 | 2,643 | 16.9 | 13.2 | 16.0 | 19.2 | 400 | 37.2 | 33.7 | 904 | 5.3 | 7.1 | 159 |
| 1 L - 8 | 1 | 18:51:00 | 4,000 | 3,019 | 20.2 | 15.9 | 19.5 | 22.6 | 479 | 42.1 | 38.5 | 1028 | 5.8 | 7.9 | 175 |
| 1 L - 8 | 2 | 18:52:00 | 4,000 | 3,019 | 20.6 | 16.4 | 20.1 | 23.1 | 491 | 42.7 | 38.9 | 1040 | 5.8 | 8.0 | 176 |
| 1 L - 8 | 4 | 18:54:00 | 4,000 | 3,019 | 21.2 | 17.0 | 21.1 | 23.9 | 510 | 43.2 | 39.3 | 1053 | 5.8 | 8.1 | 178 |
| 1 L - 8 | 8 | 18:58:00 | 4,000 | 3,019 | 22.3 | 17.9 | 22.6 | 25.8 | 543 | 44.3 | 40.0 | 1074 | 5.9 | 8.2 | 181 |
| 1 L - 9 | 1 | 19:01:00 | 4,500 | 3,395 | 26.9 | 22.7 | 27.6 | 30.7 | 660 | 49.2 | 44.0 | 1188 | 6.1 | 9.0 | 193 |
| 1 L - 9 | 2 | 19:02:00 | 4,500 | 3,395 | 27.6 | 23.8 | 28.5 | 31.5 | 682 | 49.4 | 44.4 | 1196 | 6.2 | 9.1 | 195 |
| 1 L - 9 | 4 | 19:04:00 | 4,500 | 3,395 | 28.2 | 25.0 | 29.4 | 32.5 | 705 | 50.3 | 44.8 | 1212 | 6.2 | 9.2 | 196 |
| 1 L - 9 | 8 | 19:08:00 | 4,500 | 3,395 | 29.1 | 26.5 | 31.2 | 33.8 | 739 | 51.8 | 45.8 | 1244 | 6.4 | 9.4 | 201 |
| 1 L - 10 | 1 | 19:10:30 | 5,000 | 3,771 | 33.6 | 31.2 | 36.0 | 38.2 | 852 | 56.4 | 49.8 | 1355 | 6.4 | 10.0 | 209 |
| 1 L - 10 | 2 | 19:11:30 | 5,000 | 3,771 | 34.1 | 31.9 | 36.6 | 38.6 | 865 | 57.1 | 50.1 | 1367 | 6.4 | 10.2 | 211 |
| 1 L - 10 | 4 | 19:13:30 | 5,000 | 3,771 | 35.7 | 33.6 | 38.0 | 39.6 | 900 | 58.7 | 51.7 | 1408 | 6.4 | 10.3 | 214 |
| 1 L - 10 | 8 | 19:17:30 | 5,000 | 3,771 | 36.7 | 35.2 | 39.5 | 40.6 | 932 | 60.1 | 53.1 | 1443 | 6.5 | 10.5 | 217 |
| 1 L - 11 | 1 | 19:20:30 | 5,500 | 4,146 | 42.6 | 41.5 | 45.5 | 45.8 | 1074 | 66.3 | 58.6 | 1592 | 6.7 | 11.2 | 228 |
| 1 L - 11 | 2 | 19:21:30 | 5,500 | 4,146 | 43.2 | 42.3 | 46.3 | 46.3 | 1091 | 67.2 | 59.4 | 1615 | 6.7 | 11.3 | 229 |
| 1 L - 11 | 4 | 19:23:30 | 5,500 | 4,146 | 43.3 | 42.6 | 46.4 | 46.4 | 1094 | 68.1 | 60.0 | 1633 | 6.7 | 11.4 | 230 |
| 1 L - 11 | 8 | 19:27:30 | 5,500 | 4,146 | 44.7 | 44.2 | 48.0 | 47.7 | 1131 | 70.6 | 62.2 | 1693 | 6.8 | 11.6 | 234 |
| 1 L - 12 | 1 | 19:31:30 | 6,000 | 4,522 | 49.6 | 49.8 | 53.3 | 51.8 | 1252 | 76.4 | 68.2 | 1843 | 6.9 | 12.3 | 245 |
| 1 L - 12 | 2 | 19:32:30 | 6,000 | 4,522 | 50.1 | 50.4 | 54.0 | 52.8 | 1269 | 77.4 | 69.2 | 1869 | 6.9 | 12.4 | 247 |
| 1 L - 12 | 4 | 19:34:30 | 6,000 | 4,522 | 50.9 | 51.3 | 54.7 | 53.5 | 1290 | 79.1 | 71.1 | 1914 | 7.0 | 12.6 | 251 |
| 1 L - 12 | 8 | 19:38:30 | 6,000 | 4,522 | 51.9 | 52.3 | 56.1 | 54.5 | 1316 | 81.7 | 73.3 | 1976 | 7.0 | 12.9 | 254 |
| 1 U - 1 | 1 | 19:42:30 | 3,000 | 2,268 | 33.8 | 35.1 | 39.5 | 37.8 | 895 | 57.7 | 52.6 | 1406 | 3.5 | 7.6 | 141 |
| 1 U - 1 | 2 | 19:43:30 | 3,000 | 2,268 | 33.1 | 34.3 | 39.0 | 37.4 | 881 | 57.3 | 52.0 | 1394 | 3.4 | 7.5 | 139 |
| 1 U - 1 | 4 | 19:45:30 | 3,000 | 2,268 | 32.7 | 33.9 | 38.8 | 37.3 | 874 | 57.3 | 52.0 | 1393 | 3.6 | 7.4 | 141 |
| 1 U - 2 | 1 | 19:48:00 | 1,500 | 1,141 | 22.7 | 23.7 | 29.6 | 27.3 | 633 | 39.8 | 37.7 | 988 | 1.7 | 4.5 | 79 |
| 1 U - 2 | 2 | 19:49:00 | 1,500 | 1,141 | 22.7 | 23.6 | 29.7 | 27.9 | 636 | 39.9 | 37.8 | 992 | 1.7 | 4.5 | 79 |
| 1 U - 2 | 4 | 19:51:00 | 1,500 | 1,141 | 22.0 | 22.7 | 29.2 | 27.5 | 620 | 39.1 | 37.2 | 973 | 1.6 | 4.4 | 76 |
| 1 U - 3 | 1 | 19:53:30 | 750 | 577 | 17.1 | 17.4 | 24.1 | 22.7 | 498 | 30.0 | 29.3 | 756 | 0.9 | 3.2 | 52 |
| 1 U - 3 | 2 | 19:54:30 | 750 | 577 | 16.8 | 17.2 | 23.8 | 22.5 | 492 | 29.7 | 28.9 | 747 | 0.8 | 3.2 | 51 |
| 1 U - 3 | 4 | 19:56:30 | 750 | 577 | 16.5 | 16.8 | 23.7 | 22.4 | 486 | 29.3 | 28.6 | 738 | 0.8 | 3.1 | 49 |
| 1 U - 4 | 1 | 19:58:30 | 0 | 0 | 10.8 | 10.4 | 17.5 | 16.8 | 340 | 18.2 | 19.6 | 482 | -0.1 | 1.6 | 20 |
| 1 U - 4 | 2 | 19:59:30 | 0 | 0 | 10.6 | 10.3 | 17.3 | 16.7 | 337 | 17.9 | 19.3 | 475 | -0.1 | 1.1 | 13 |
| 1 U - 4 | 4 | 20:01:30 | 0 | 0 | 10.6 | 10.1 | 17.2 | 16.6 | 334 | 17.5 | 18.7 | 461 | -0.2 | 1.4 | 16 |
| 2 L - 0 | - | 20:02:00 | 0 | 0 | 10.3 | 10.5 | 17.1 | 16.6 | 334 | 17.8 | 19.0 | 469 | -0.2 | 1.4 | 16 |
| 2 L - 1 | 1 | 20:05:30 | 1,500 | 1,141 | 17.7 | 16.6 | 24.4 | 23.5 | 504 | 30.0 | 29.9 | 764 | 1.7 | 3.9 | 71 |
| 2 L - 1 | 2 | 20:06:30 | 1,500 | 1,141 | 17.7 | 16.6 | 24.4 | 23.6 | 504 | 30.0 | 30.2 | 768 | 1.8 | 3.9 | 72 |
| 2 L - 1 | 4 | 20:08:30 | 1,500 | 1,141 | 18.0 | 16.4 | 24.3 | 23.6 | 504 | 30.1 | 30.3 | 770 | 1.7 | 3.9 | 71 |
| 2 L - 2 | 1 | 20:12:00 | 3,000 | 2,268 | 26.3 | 23.5 | 32.4 | 31.9 | 699 | 45.2 | 43.3 | 1129 | 4.0 | 6.3 | 131 |
| 2 L - 2 | 2 | 20:13:00 | 3,000 | 2,268 | 26.3 | 24.6 | 32.4 | 32.0 | 706 | 45.4 | 43.5 | 1134 | 4.0 | 6.7 | 137 |
| 2 L - 2 | 4 | 20:15:00 | 3,000 | 2,268 | 26.4 | 23.5 | 32.4 | 32.2 | 701 | 45.9 | 44.0 | 1146 | 4.1 | 6.8 | 139 |
| 2 L - 3 | 1 | 20:19:00 | 4,500 | 3,395 | 35.4 | 34.4 | 41.4 | 40.6 | 929 | 62.2 | 58.0 | 1533 | 5.7 | 9.4 | 193 |
| 2 L - 3 | 2 | 20:20:00 | 4,500 | 3,395 | 35.6 | 34.7 | 41.5 | 40.8 | 934 | 62.8 | 58.4 | 1546 | 5.8 | 9.7 | 198 |
| 2 L - 3 | 4 | 20:22:00 | 4,500 | 3,395 | 35.7 | 34.7 | 41.5 | 41.0 | 937 | 63.5 | 58.8 | 1560 | 5.9 | 9.8 | 200 |
| 2 L - 3 | 8 | 20:26:00 | 4,500 | 3,395 | 35.9 | 34.8 | 41.7 | 41.2 | 941 | 64.5 | 59.5 | 1582 | 6.0 | 10.0 | 203 |
| 2 U - 1 | 1 | 20:30:30 | 0 | 0 | 9.6 | 9.2 | 15.5 | 15.6 | 306 | 18.5 | 19.8 | 489 | 0.2 | 1.7 | 24 |
| 2 U - 1 | 2 | 20:31:30 | 0 | 0 | 9.5 | 8.9 | 15.4 | 15.6 | 303 | 18.5 | 19.6 | 486 | 0.0 | 1.6 | 20 |
| 2 U - 1 | 4 | 20:33:30 | 0 | 0 | 9.3 | 8.6 | 15.3 | 15.6 | 299 | 17.6 | 19.2 | 470 | 0.0 | 1.5 | 18 |
| 2 U - 1 | 8 | 20:37:30 | 0 | 0 | 9.0 | 8.2 | 15.3 | 15.5 | 294 | 17.6 | 18.8 | 464 | -0.1 | 1.3 | 16 |

# APPENDIX B

## O-CELL AND INSTRUMENTATION CALIBRATION SHEETS




**STROKE:** **1 INCH** **3 INCH** **5 INCH**

**21" O-CELL, SERIAL # 21-6-00071**

| PRESSURE PSI | LOAD KIPS | LOAD KIPS | LOAD KIPS |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 500 | 125 | 125 | 125 |
| 1000 | 253 | 253 | 253 |
| 1500 | 379 | 378 | 379 |
| 2000 | 506 | 504 | 506 |
| 2500 | 632 | 632 | 633 |
| 3000 | 759 | 758 | 761 |
| 3500 | 887 | 886 | 885 |
| 4000 | 1011 | 1007 | 1011 |
| 4500 | 1136 | 1137 | 1137 |
| 5000 | 1262 | 1259 | 1259 |
| 5500 | 1388 | 1388 | 1385 |
| 6000 | 1510 | 1508 | 1508 |
| 6500 | 1639 | 1636 | 1634 |
| 7000 | 1761 | 1759 | |
| 7500 | 1887 | | |
| 8000 | 2007 | | |
| 8500 | 2133 | | |
| 9000 | 2255 | | |
| 9500 | 2377 | | |
| 10000 | 2497 | | |

## LOAD CONVERSION FORMULA

**LOAD = PRESSURE * 0.2505 + ( 5.50 )**
**{KIPS} {PSI}**

**Regression Output:**

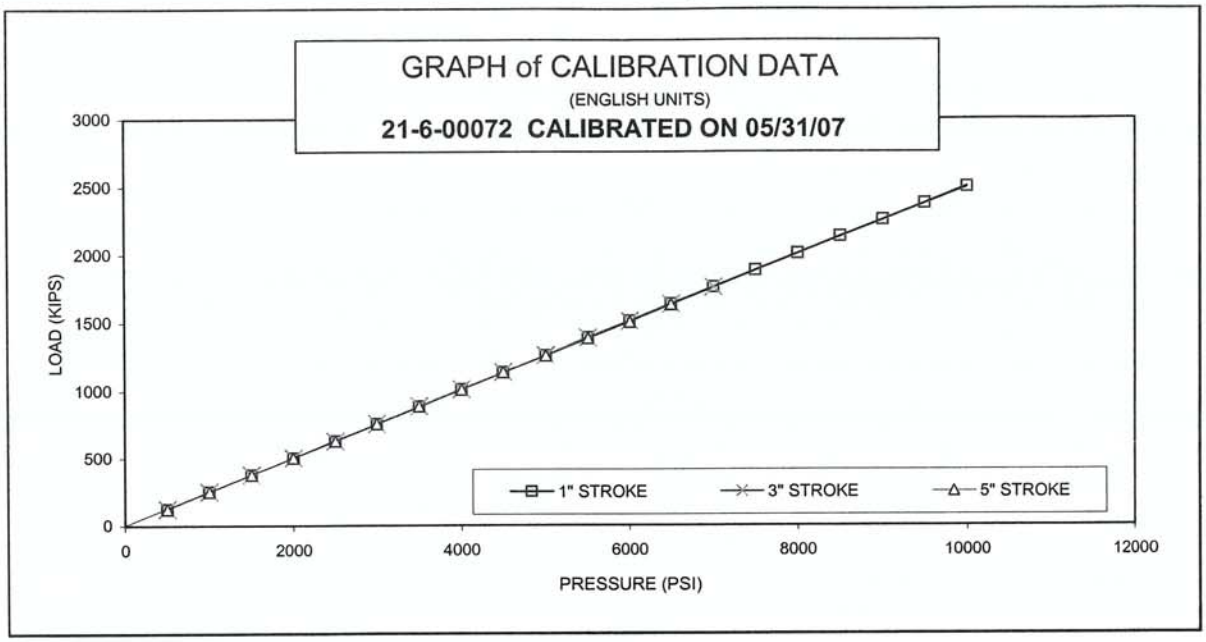
| | |
|---|---|
| Constant | 5.4981 kips |
| X Coefficient | 0.2505 kip / psi |
| R Square | 1.0000 |
| No. of Observations | 47 |
| Degrees of Freedom | 45 |
| Std Err of Y Est | 3.95 |
| Std Err of X Coeff | 0.0002 |

CALIBRATION STANDARDS:

All data presented are derived from 6" dia. certified hydraulic pressure gauges and electronic load transducer, manufactured and calibrated by the University of Illinois at Champaign, Illinois. All calibrations and certifications are traceable through the Laboratory Master Deadweight Gauges directly to the National Institute of Standards and Technology. No specific guidelines exist for calibration of load test jacks and equipment but procedures comply with similar guidelines for calibration of gages, ANSI specifications B40.1.

| | |
|---|---|
| * AE & FC CUSTOMER: LOADTEST Inc | * CONTRACTOR.: JESEN CONSTRUCTION |
| * AE & FC JOB NO: SO2181 | * JOB LOCATION: YANKTON, SD |
| * CUSTOMER P.O. NO.: LT-9152 | * DATED: 12/06/65 |

SERVICE ENGINEER: _____ DATE: 7 June 2005




**STROKE:** **1 INCH** **3 INCH** **5 INCH**

## 21" O-CELL, SERIAL # 21-6-00072

| PRESSURE PSI | LOAD KIPS | LOAD KIPS | LOAD KIPS |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 500 | 124 | 125 | 124 |
| 1000 | 251 | 251 | 251 |
| 1500 | 378 | 377 | 377 |
| 2000 | 503 | 504 | 504 |
| 2500 | 632 | 630 | 629 |
| 3000 | 757 | 757 | 756 |
| 3500 | 884 | 884 | 884 |
| 4000 | 1009 | 1008 | 1007 |
| 4500 | 1136 | 1135 | 1133 |
| 5000 | 1258 | 1258 | 1256 |
| 5500 | 1389 | 1386 | 1384 |
| 6000 | 1510 | 1508 | 1503 |
| 6500 | 1636 | 1634 | 1629 |
| 7000 | 1759 | 1757 | |
| 7500 | 1882 | | |
| 8000 | 2007 | | |
| 8500 | 2131 | | |
| 9000 | 2253 | | |
| 9500 | 2374 | | |
| 10000 | 2495 | | |

## LOAD CONVERSION FORMULA

**LOAD = PRESSURE * 0.2504 + ( 4.00 )**
**{KIPS} {PSI}**

**Regression Output:**

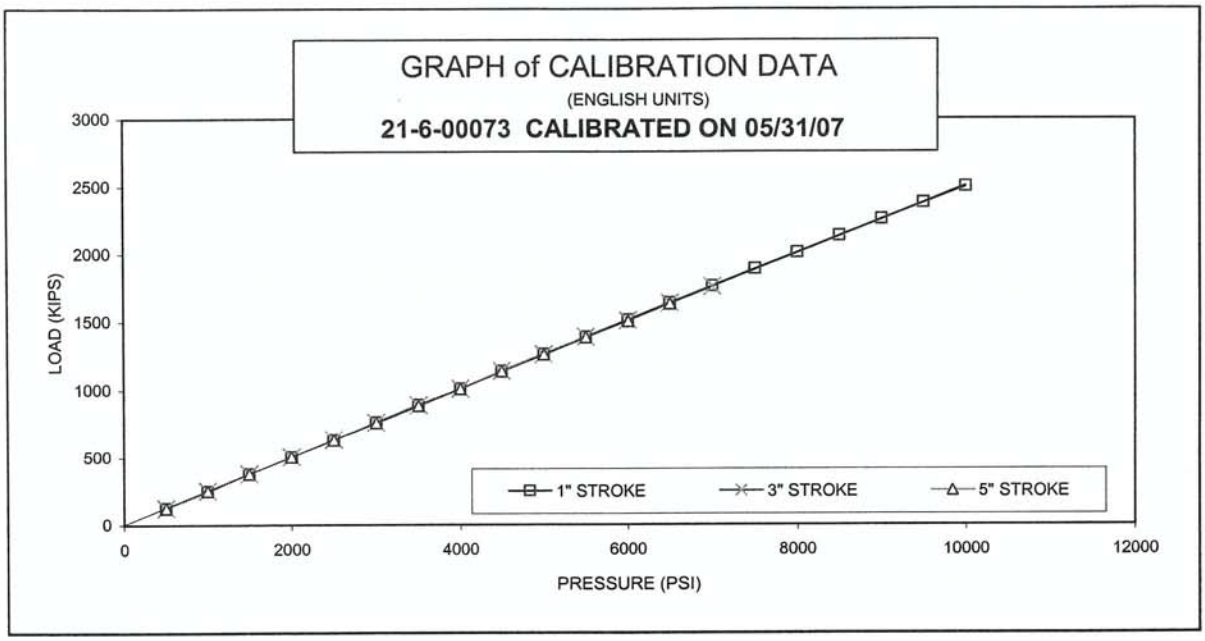
| | |
|---|---|
| Constant | 3.9963 kips |
| X Coefficient | 0.2504 kip / psi |
| R Square | 1.0000 |
| No. of Observations | 47 |
| Degrees of Freedom | 45 |
| Std Err of Y Est | 3.95 |
| Std Err of X Coeff | 0.0002 |

CALIBRATION STANDARDS:

All data presented are derived from 6" dia. certified hydraulic pressure gauges and electronic load transducer, manufactured and calibrated by the University of Illinois at Champaign, Illinois. All calibrations and certifications are traceable through the Laboratory Master Deadweight Gauges directly to the National Institute of Standards and Technology. No specific guidelines exist for calibration of load test jacks and equipment but procedures comply with similar guidelines for calibration of gages, ANSI specifications B40.1.

| | |
|---|---|
| * AE & FC CUSTOMER: LOADTEST Inc | * CONTRACTOR.: JENSEN CONTRUCTION |
| * AE & FC JOB NO: SO2181 | * JOB LOCATION: YANKTON, SD |
| * CUSTOMER P.O. NO.: LT-9152 | * DATED: 06/06/07 |

SERVICE ENGINEER: _____ DATE: 7 June 2007




**STROKE:** **1 INCH** **3 INCH** **5 INCH**

## 21" O-CELL, SERIAL # 21-6-00073

| PRESSURE PSI | LOAD KIPS | LOAD KIPS | LOAD KIPS |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 500 | 125 | 125 | 124 |
| 1000 | 249 | 251 | 251 |
| 1500 | 378 | 377 | 377 |
| 2000 | 504 | 503 | 504 |
| 2500 | 630 | 632 | 630 |
| 3000 | 759 | 758 | 757 |
| 3500 | 887 | 885 | 884 |
| 4000 | 1007 | 1007 | 1006 |
| 4500 | 1138 | 1136 | 1133 |
| 5000 | 1260 | 1259 | 1257 |
| 5500 | 1386 | 1386 | 1384 |
| 6000 | 1511 | 1506 | 1503 |
| 6500 | 1637 | 1635 | 1631 |
| 7000 | 1761 | 1757 | |
| 7500 | 1887 | | |
| 8000 | 2007 | | |
| 8500 | 2132 | | |
| 9000 | 2254 | | |
| 9500 | 2375 | | |
| 10000 | 2495 | | |

## LOAD CONVERSION FORMULA

**LOAD = PRESSURE * 0.2505 + ( 4.04 )**
**{KIPS} {PSI}**

**Regression Output:**

| | |
|---|---|
| Constant | 4.0432 kips |
| X Coefficient | 0.2505 kip / psi |
| R Square | 1.0000 |
| No. of Observations | 47 |
| Degrees of Freedom | 45 |
| Std Err of Y Est | 4.04 |
| Std Err of X Coeff | 0.0002 |

CALIBRATION STANDARDS:

All data presented are derived from 6" dia. certified hydraulic pressure gauges and electronic load transducer, manufactured and calibrated by the University of Illinois at Champaign, Illinois. All calibrations and certifications are traceable through the Laboratory Master Deadweight Gauges directly to the National Institute of Standards and Technology. No specific guidelines exist for calibration of load test jacks and equipment but procedures comply with similar guidelines for calibration of gages, ANSI specifications B40.1.

| | |
|---|---|
| * AE & FC CUSTOMER: LOADTEST Inc | * CONTRACTOR.: JENSEN CONSTRUCTION |
| * AE & FC JOB NO: SO2181 | * JOB LOCATION: YANKTON, SD |
| * CUSTOMER P.O. NO.: LT-9152 | * DATED: 06/06/07 |

SERVICE ENGINEER: _____ DATE: 7 June 2007

# Certificate of Calibration

WIKA

***Certificate No.:*** **9748**
Page 1 of 2
Date of Calibration: 7/5/2006

*Customer* : FLOW TECHNOLOGY

P.O. BOX 8889
JACKSONVILLE, FL 32239-8889

**Pressure and Temperature Measurement**
WIKA Instrument Corporation
1000 Wiegand Boulevard
Lawrenceville, Georgia 30043

Tel 770-513-8200
Fax 770-338-5118
www.wika.com
info@wika.com

*Order No.* : 288276

**Specification of the device under test**

| | |
|---|---|
| *Object* | : Dial Gauge |
| *Manufacturer* | : WIKA |
| *Model* | : 232.50 6 |
| *Serial No.* | : - |
| *Tag* | : - |
| *Pressure range* | : 0 ... 15000 psi |
| *Accuracy* | : 1 % (of span ) |
| *Scale division / Resolution* | : 200 psi |
| *Method of measurement* | : Gauge pressure |
| *Output signal* | : - |

**Working Standard (WS)**

| | |
|---|---|
| *Name* | : Electr. Gauge |
| *Pressure range* | : 0 ... 1000 bar |
| *Calibration-number* | : 31158 12-01-2005 |
| *Accuracy* | : 0.025 % (of span ) |
| *Identity* | : SS 204 |
| *Recal Interval* | : 1 year |

**Calibration parameters**

| | |
|---|---|
| *Place of calibration* | : Cal-Lab (Lawrenceville) |
| *Test temperature (in °F)* | : 71.5 |
| *Humidity (in %)* | : 52.0 |
| *Amb. pressure (in inHg)* | : 29.0 |
| *Pressure medium* | : water |
| *Angle position* | : vertical |
| local gravity (in $m/s^2$) | : 9.79541 |

*Comments* :

**Used auxiliary instruments**

| | |
|---|---|
| *Multimeter* | : - |
| *Resistor* | : - |

Kuldeep Patel

*Quality Assurance* : K. Patel

Nadine Dokara

Calibration technician : N. Dokara

ISO 9001 Certified