# WESTERN REFINING

## Jal, NM Storage Facility

## LPG Cavern #4

## Mechanical Integrity Test Report

**JA3301/12 003/O/J/O**

US GEOSTOCK

| | | | |
|---|---|---|---|
| Number of pages: 12 | Revision: O | Status: FINAL | Date of distribution: December 27, 2012 |

| | | |
|---|---|---|
| *B.BATSON/M.COPPERSMITH* | *C. BREHERET* | *C. BREHERET* |
| Issued (name, signature) | Checked (name, signature) | Approved (name, date, signature) |
| | | 12.27.2012 |

## CONTENTS



| MAIN PURPOSE OF THE REVISION AND TYPE OF MODIFICATIONS |
|---|
| |

## 1. INTRODUCTION

Geostock US has performed a mechanical integrity test on Western Refining Jal, NM LPG Storage well #4 using brine as a test medium. The testing procedures were designed to meet the requirements set forth in the OCD regulations for liquid-filled caverns.

Cavern Well #3 and Cavern Well #4 are used for LPG storage in salt caverns. The production casings were successfully pressure tested with a packer; multi-finger calipers and cement bond logs have been performed to verify the integrity of the wells.

The subject wells and salt formation will be tested at maximum operating pressure at the casing, i.e. 1250 psig which corresponds to a pressure gradient of 0.75 psi/ft.

## 2. TEST METHODOLOGY

Wellhead pressure and temperature were recorded, however to eliminate any error on the density of the fluid column in the wellbore a surface read-out (SRO) pressure gauge was set at the casing depth (~1666 ft) to measure directly the pressure in the cavern.

The test was conducted by injection of brine to increase the cavern pressure at the casing shoe to test pressure. By this method, both well and salt formation were tested for potential leak.

The first phase of the MIT test consisted of daily brine injection to maintain test pressure at the casing shoe based on the SRO gauge readings. The volume of brine per day required to return the well to test pressure was measured until stabilized conditions were reached.

In the second phase of the MIT test, after a final brine injection to test pressure, the well was isolated with double valve combinations and the downhole and surface pressures were recorded for a test period of 4 hours. Pressures on the 7" x 4 ½" annulus and the 4 ½" tubing were recorded by the use of calibrated chart recorders, with a one hour clock setting for a period of 4 hours (Appendix 3).

## 3. TEST CHRONOLOGY

Daily brine injection began on 12/17/12. The surface read out gauge was installed on 12/18/12. The MIT began on 12/22/12 at 07:30 and ended on 12/22/12 at 11:30.

| | Start Pressure | End Pressure | Volume Injected |
|---|---|---|---|
| | SRO, psi | SRO, psi | bbl |
| 12/17/2012 | | | 3.5 |
| 12/18/2012 | 1032 | 1185 | 0.4 |
| 12/19/2012 | 1122 | 1185 | 0.4 |
| 12/20/2012 | 1108 | 1185 | 0.4 |
| 12/21/2012 | 1109 | 1185 | 1 |
| 12/22/12 | 1109 | 1185 | 0.4 |

## 4. RESULTS

### 4.1. Data Collected

During the pre-test period, the amount of daily brine injection required to return the cavern to test pressure was recorded. (see Appendix 1) The cavern quickly stabilized to the point that the daily brine injection required was less than 1 bbl/day, which an be compared to the acceptable leak rate of 2.64 bbl/day

The wellhead pressures, downhole pressure, and ambient temperature were recorded during the MIT. (see Appendix 2) The wellhead pressure loss recorded by the digital gauges on the 4 ½" tubing during the MIT was:

Initial pressure: 470.95 psi
Final pressure: 459.47 psi
Pressure loss: 11.48 psi (2.44%)

The cavern pressure loss recorded with the SRO gauge during the MIT was:

Initial Pressure: 1180.75 psi
Final Pressure: 1165.25 psi
Pressure loss: 15.48 psi (1.31%)

### 4.2. Apparent leak rate

Using the pressure increase and daily brine injection from the pre-test period, a stabilized seepage rate can be calculated that relates the amount of pressure change in the cavern to the apparent leak rate.

| | ΔP | Volume Injected | Seepage |
|---|---|---|---|
| | psi | bbl | bbl/psi |
| 12/18/12 | 153 | 0.4 | 0.00261 |
| 12/19/12 | 63 | 0.4 | 0.00635 |
| 12/20/12 | 76.1 | 0.4 | 0.00526 |
| 12/21/12 | 76 | 1 | 0.01316 |
| 12/22/12 | 76 | 0.4 | 0.00526 |

*From SRO tool

Using the stabilized observed seepage rate of 0.00526 bbl/psi and recorded pressure loss of 15.48 psi during the 4 hour MIT period, the apparent leak rate during the MIT can be calculated:

15.48 psi x .00526 bbl/psi = .0814 bbl apparent leak during 4 hours
= .489 bbl/day apparent leak rate
= 178.32 bbl/yr apparent leak rate

Using the maximum observed seepage rate of .01316 bbl/psi and performing the same calculation results

15.48 psi x .01316 bbl/psi = .204 bbl apparent leak during 4 hours
= 1.22 bbl/day apparent leak rate
= 446 bbl/yr apparent leak rate

### 4.3. Pass/fail criteria

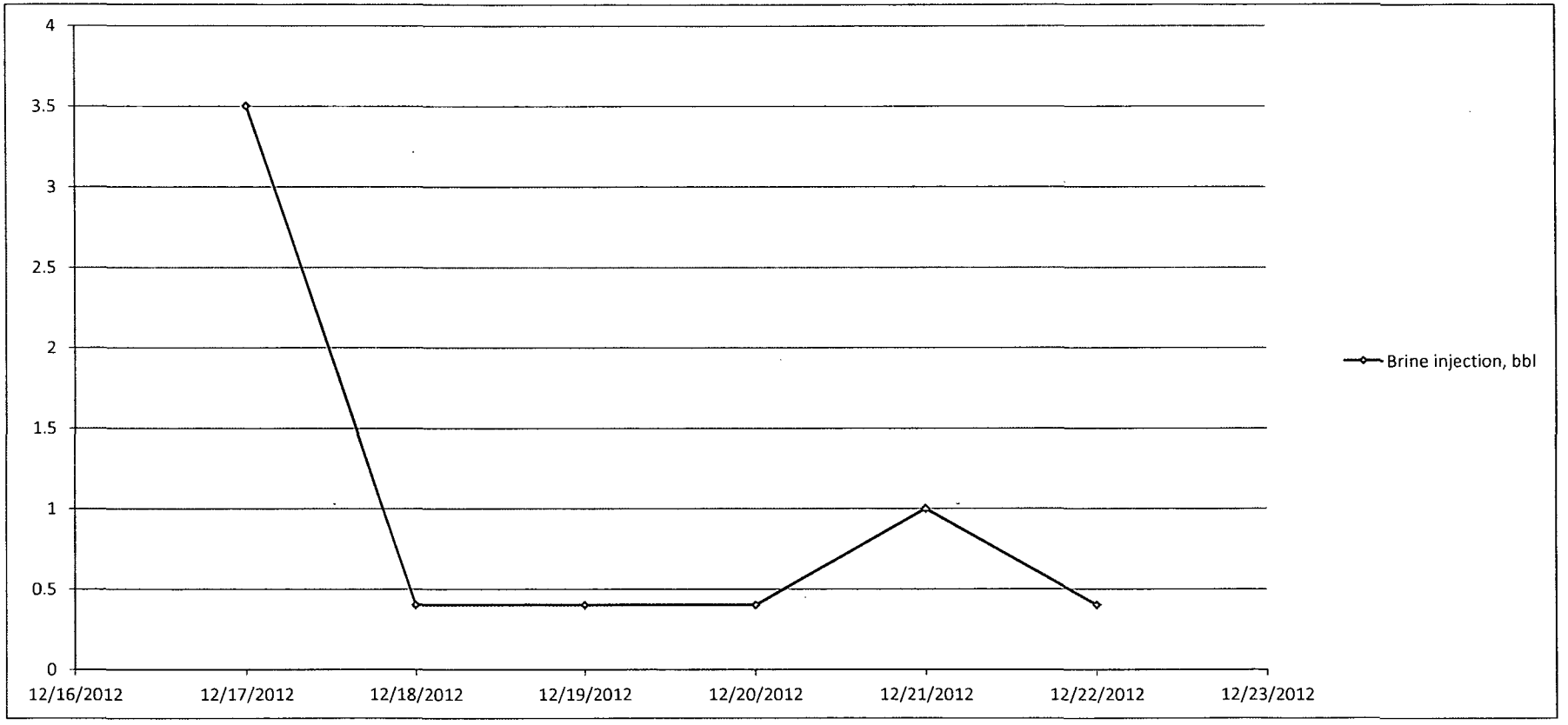
Apparent leak rate, 446 bbl/yr < 963.6 bbl/yr (2.64 bbl/day)

Pressure loss at casing shoe over 4 hour MIT period, 1.31% < 10%

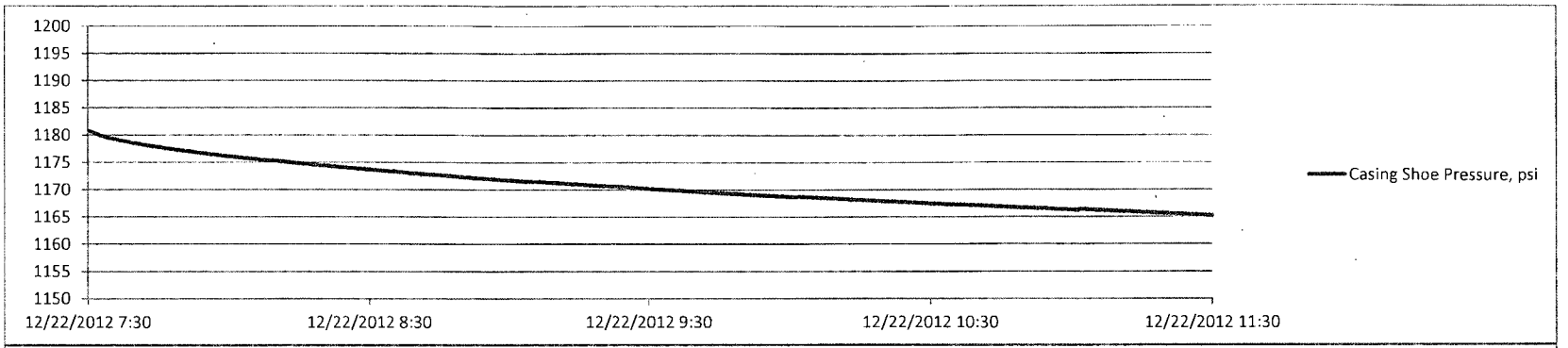
### 4.4. Test Result

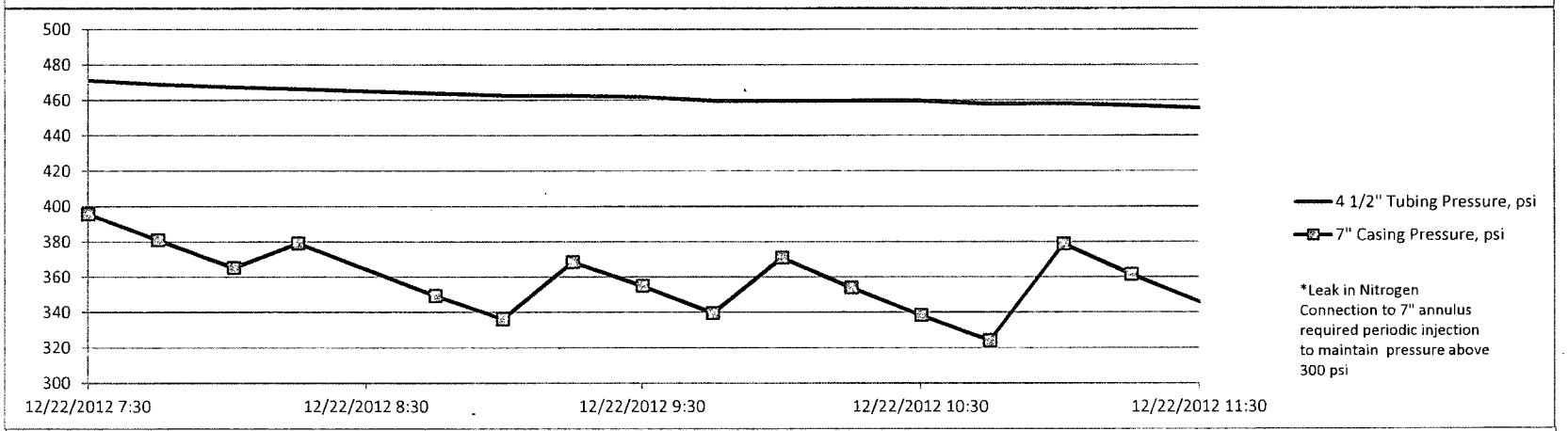
Based on the data collected during the test and the definition of the pass/fail criteria, Well #4 has passed the mechanical integrity test.

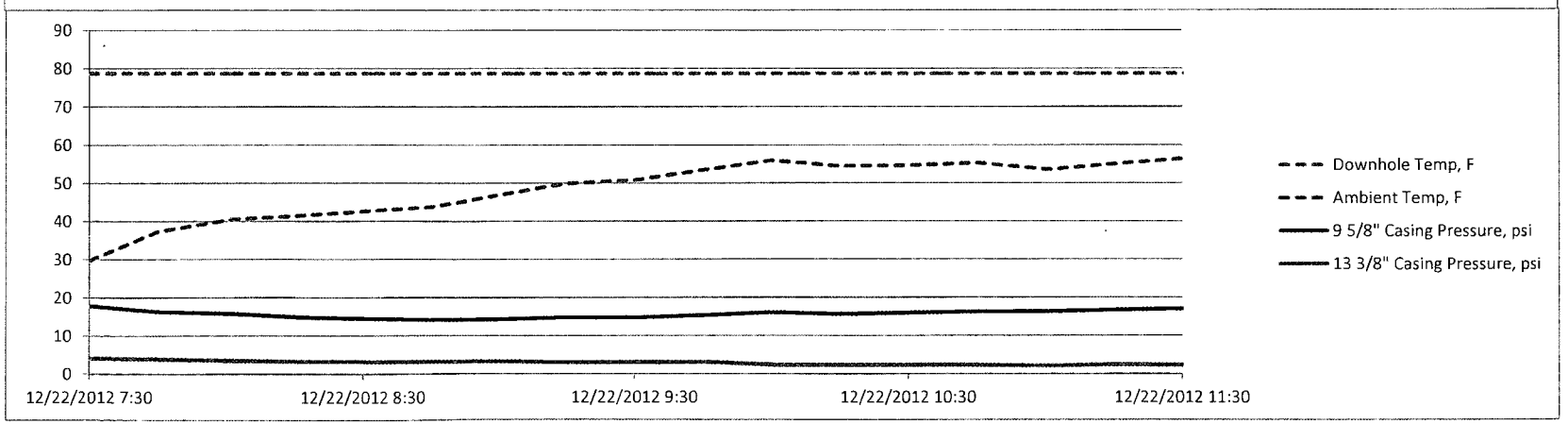
## APPENDIX 1 – PRE-TEST BEHAVIOR


4
3.5
3
2.5
2
1.5
1
0.5
0
12/16/2012
12/17/2012
12/18/2012
12/19/2012
12/20/2012
12/21/2012
12/22/2012
12/23/2012
Brine injection, bbl

## APPENDIX 2 – MIT TEST PERIOD


1200
1195
1190
1185
1180
1175
1170
1165
1160
1155
1150
12/22/2012 7:30
12/22/2012 8:30
12/22/2012 9:30
12/22/2012 10:30
12/22/2012 11:30
Casing Shoe Pressure, psi


500
480
460
440
420
400
380
360
340
320
300
12/22/2012 7:30
12/22/2012 8:30
12/22/2012 9:30
12/22/2012 10:30
12/22/2012 11:30
4 1/2" Tubing Pressure, psi
7" Casing Pressure, psi
*Leak in Nitrogen Connection to 7" annulus required periodic injection to maintain pressure above 300 psi

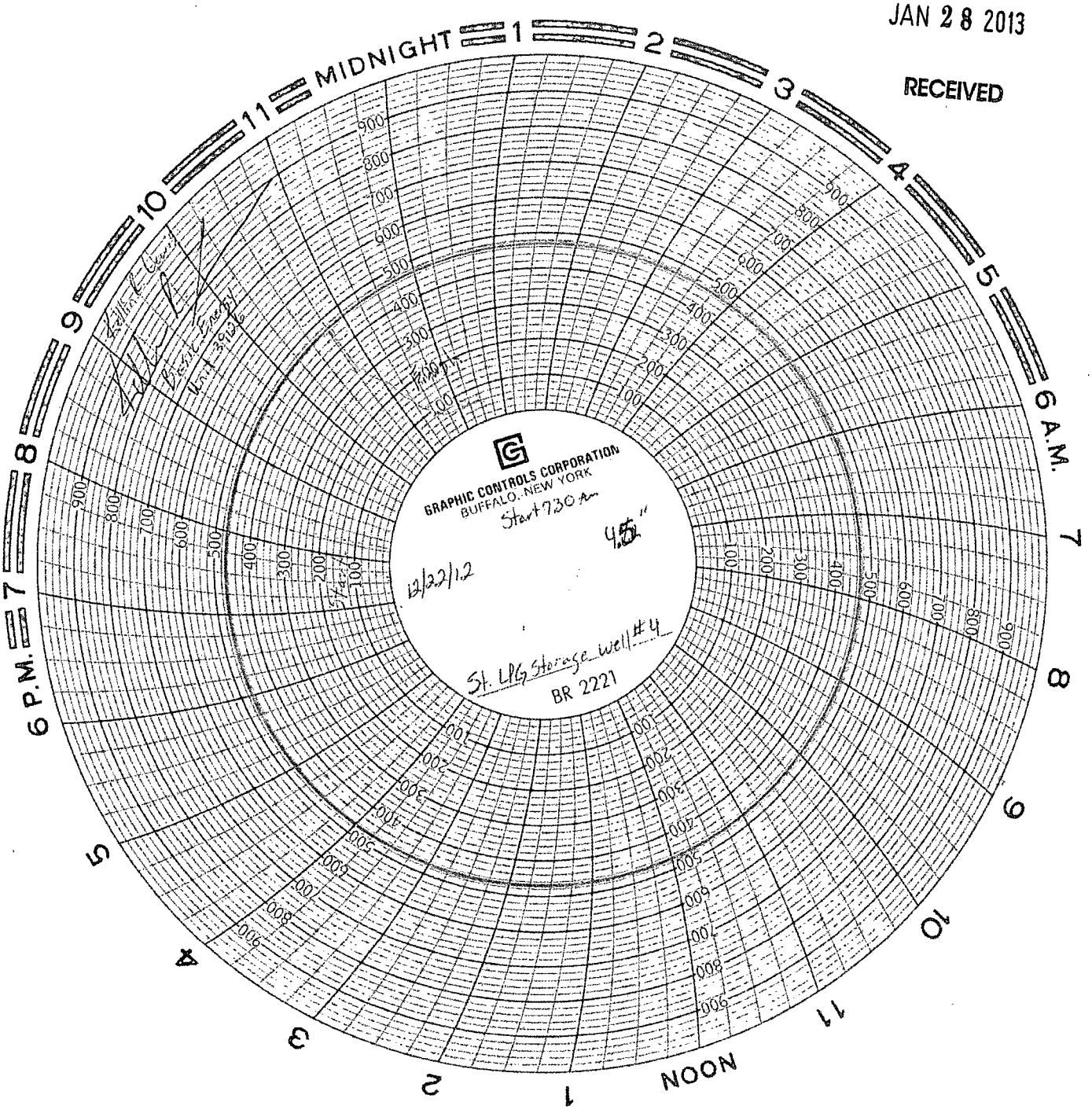

90
80
70
60
50
40
30
20
10
0
12/22/2012 7:30
12/22/2012 8:30
12/22/2012 9:30
12/22/2012 10:30
12/22/2012 11:30
Downhole Temp, F
Ambient Temp, F
9 5/8" Casing Pressure, psi
13 3/8" Casing Pressure, psi

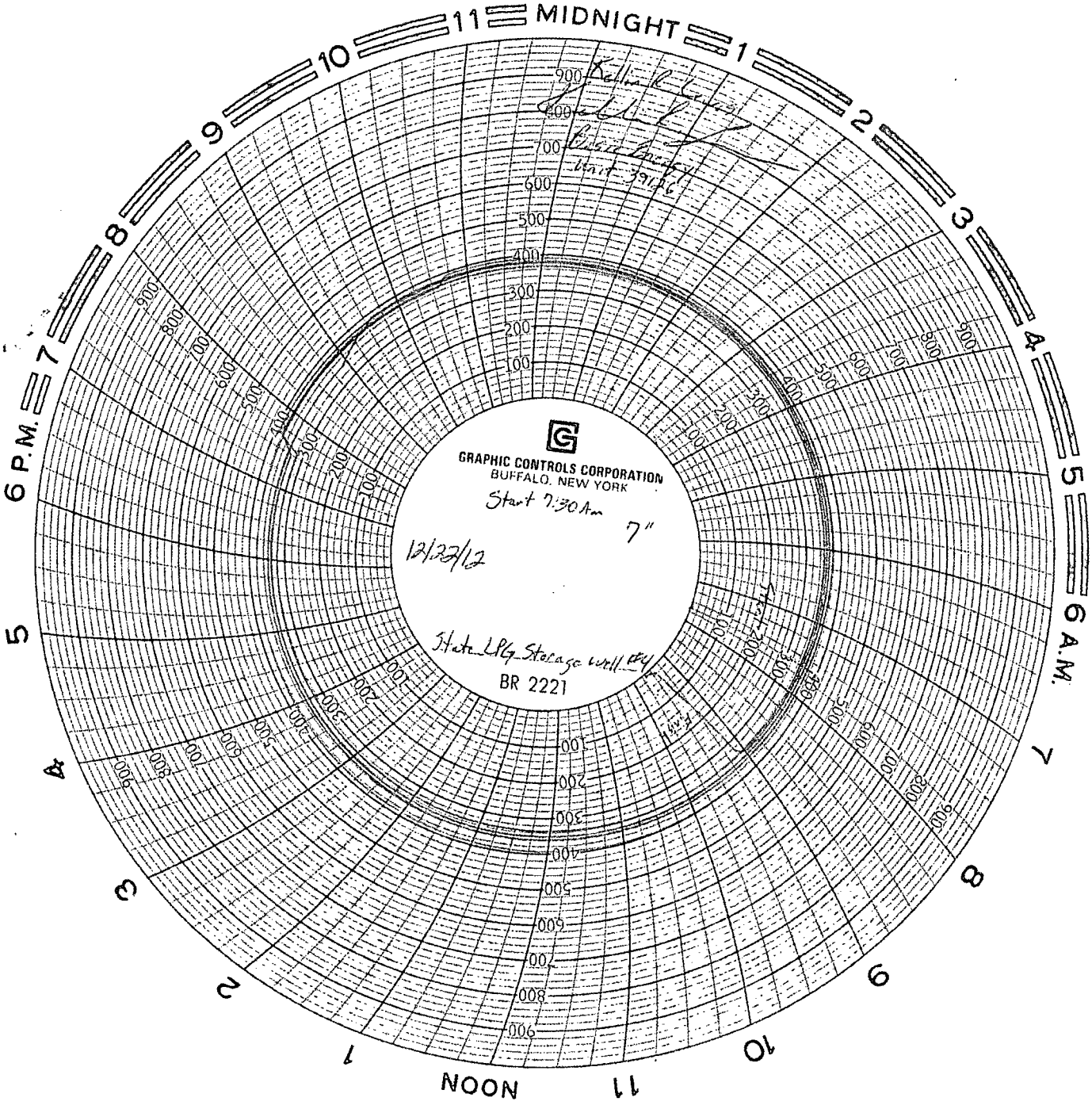
## APPENDIX 3 – PRESSURE CHARTS (SCANS)

HOBBS OCD

JAN 28 2013

RECEIVED




MIDNIGHT
NOON
6 P.M.
6 A.M.
GRAPHIC CONTROLS CORPORATION
BUFFALO, NEW YORK
Start 7:30 Am
7"
12/22/12
State LPG Storage well #4
BR 2221