

MIT and Monitoring Protocols for the 16" wells are presented at the end of this attachment.

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## **Mechanical Integrity Test Plan**

Several testing methods shall be employed to demonstrate mechanical integrity of the well/cavern system. These methods vary depending upon the stage of development of the well or cavern.

### **During Drilling**

After cementing the 20" production casing, the casing will be tested before continuing drilling. A hydraulic pressure test of the 20" production casing will be conducted before drilling out the plug (shoe) and after waiting on cement at least 72 hours to allow the cement to set. The operator shall test the casing at a pump pressure in pounds per square inch (psi) calculated by multiplying the length of the casing by 0.2. The maximum pressure required however, unless otherwise ordered by the commission need not exceed 1500 psi (Texas Rule 3.13 (b)(1)(D)). This rule would require a surface pressure of 800 psi. Although this is less than maximum allowable operating pressure at the casing shoe, it is high enough to detect a leak in the casing. The test shall last 30 minutes. The test will be considered good if the pressure loss is less than 10%.

After drilling out the cement plug and completing the hole, the integrity test as outlined hereafter will verify the casing/cement shoe/borehole at maximum operating pressure.

### **Test of the 20" Casing and the Cavern during Development**

Magnum Solutions LLC will utilize the guidelines for Mechanical Integrity Testing used by the State of Kansas as attached hereto. Any changes to the testing procedure will be coordinated and discussed, with the regulatory agency and approval obtained prior to implementation.

### **Storage Operations**

Following the mechanical integrity test after completion of mining the caverns will be tested on a periodic basis using methods and procedures in accordance with requirements set forth by the State of Utah.



## KANSAS DEPARTMENT OF HEALTH & ENVIRONMENT

### NITROGEN/BRINE INTERFACE MECHANICAL INTEGRITY TEST (MIT)

#### PART I: CASING (INTERNAL) MIT

#### PART II: CAVERN (EXTERNAL) MIT

Procedure #: UICLPG-20  
(6/06)

Narrative:

K.A.R. 28-45-16 requires that each well and each cavern be tested for integrity every five years. The nitrogen/brine interface test is designed to evaluate the internal (well) mechanical integrity and/or the external (cavern) mechanical integrity. The MIT procedure consists of filling the cavern with brine and then injecting nitrogen into the well and establishing an interface at a depth appropriate for either a well or cavern test. The nitrogen test pressure should be equal to the maximum allowable operating pressure gradient based on the casing seat. The interface, temperature and pressure data are used to calculate the pre-test and post-test nitrogen volumes. Comparison of the pre-test and post-test nitrogen volumes and movement of the nitrogen/brine interface are used to evaluate the well/cavern integrity.

#### TEST PROCEDURE SUMMARY

### NITROGEN/BRINE INTERFACE MECHANICAL INTEGRITY TEST (MIT)

#### PART I: CASING (INTERNAL) MIT

#### PART II: CAVERN (EXTERNAL) MIT

All nitrogen/brine mechanical integrity tests must be conducted by a party that has experience in conducting this type of test due to the complexity of the test and associated safety requirements. The test contractor must have knowledge of: 1) the pressure rating of the well and wellhead components; 2) the use of dead-weight tests or calibrated data loggers to verify brine and nitrogen pressure; 3) methods to track the volume of nitrogen injected before and during the test; 4) differential pressure monitoring to prevent collapse of the tubing; and 5) a working knowledge of other procedural tasks that ensure a viable and safe test.

The permittee is responsible for verifying that the party/company contracted to conduct the mechanical integrity test has experience and is qualified to conduct the test in a safe manner. Failure to follow test procedure and failure to submit any supporting data required by KDHE may result in the test being considered invalid by KDHE. An invalid test will not meet the regulatory requirement.

Submit a test plan as specified in Procedure #UICLPG-21 to KDHE for review and approval at least 30 days prior to test commencement. Do not commence test operations until approval for the plan is received from the Kansas Department of Health and Environment (KDHE).

#### TEST PREPARATION:

- Certify that pressure ratings of the wellhead and the tubulars are adequate for the test pressures.
- Visually inspect the wellhead.
- Ensure fittings are adequate to facilitate wireline equipment, nitrogen injection, and pressure instrumentation. Install an accurate electronic pressure recording system on the well's annulus and brine tubing.
- Remove all product (feasible) from the cavern prior to conducting the test.
- Note the presence of any product in the annulus.
- Coordinate the test time with KDHE so that KDHE may have the opportunity to witness the test.

**PRE-PRESSURIZATION:** (Typically for cavern test)

Prepressure the cavern with brine prior to nitrogen injection, if necessary. The compressibility of the cavern and the volume of nitrogen to be injected must be considered (estimated) in calculating the pressure required prior to nitrogen injection.

1. Record the volume of fluid injected and the rate of pressurization. The fluid used for prepressuring should be saturated brine. The rate of pressurization typically should not exceed 2.5 psi/min. The casing seat pressure is not to exceed the regulatory MAOP of either 0.75 or 0.8 psi/ft. K.A.R. 28-45-12 requires that a wellhead be equipped with a continuous pressure monitoring system that is capable of maintaining a pressure history before the well can be operated with a MAOP greater than 0.75 psi/ft. The well should be tested at the MAOP allowed by regulation.
2. Record the tubing and annulus pressures.
3. Monitor the cavern pressure until the rate of pressure change is 10 psi/day or less. Stabilization period must be a minimum of 24 hours.

**PRE-NITROGEN INJECTION:**

4. Check with nitrogen supplier for the nitrogen volume required for equipment "cool down".
5. Nitrogen must be measured with a meter. Connect pressure and flow recording equipment to the wellhead so that accurate nitrogen pressure and volume data can be obtained for the test analysis.
6. Prior to nitrogen injection, conduct a temperature survey (base log) from the surface to 50 ft below the expected nitrogen interface for the casing or cavern MIT.
7. Conduct a density survey from 50 feet below the lowest expected nitrogen interface to 50 feet above the uppermost. Note the location of any product present in the annulus. Optimal logging speed for the density log is approximately 15 – 20 ft/min. Subsequent logging runs with the density tool should be at approximately the same speed as the initial logging run for accuracy and correlation purposes.

**PART I: CASING TEST****NITROGEN INJECTION:**

8. Inject nitrogen into the annulus between the cemented casing and the hanging string at a constant rate and at (approximately) the same temperature indicated by the temperature log. Measure nitrogen with a nitrogen meter.
9. Position the logging tools at regular depth intervals and record the annulus, brine pressure, nitrogen temperature and time as the nitrogen interface passes.
10. Terminate nitrogen injection when the interface depth is just above the casing seat (if this is the only interval being tested). If multiple intervals are to be tested, test shallow intervals before testing the deep intervals.
11. If a single test interval is used to test the casing, use the following formula to calculate the time required to achieve a minimum detectable leak rate (MDLR), or test sensitivity, of less than 100 barrels of nitrogen per year.

$$T = \frac{V * R * 365 \text{ days / year} * 24 \text{ hours / day}}{100 \text{ bbls / year}}$$

T = Duration of test in hours

V = Unit annular volume of casing, bbls/ft

R = Resolution of the interface tool in feet

Note: reference programs or tables and show calculations for converting weight or volume (SCF) of nitrogen to barrels (bbls) of nitrogen.

The test duration may be shortened if a leak is identified.

A one-hour casing test may be conducted if it is followed by a cavern nitrogen/brine interface test. The minimum test duration for the cavern test is 24 hours.

12. Record the time, nitrogen pressure, tubing pressure and the interface depth. Initialize the test for the calculated test duration.
13. At the end of the test, relog the interface depth with the density tool and record the surface pressures. Down-hole movement of the interface may indicate that the test length should be extended.
14. If the nitrogen interface test is being run on the casing only, run a final temperature log.
15. Any up-hole movement of the interface accompanied by a loss in nitrogen pressure indicates nitrogen is being lost from that portion of the casing in contact with the nitrogen. Any interface movement greater than the resolution of the tool should be explained. If a leak is located in the casing above the interface depth, the interface may move up hole to the location of the leak. If multiple leaks are present in the casing, the interface may rise to the location of the greatest leak, however, conclusive determination of the leak location may not be possible.

If the casing test is not followed by a cavern test, calculate the MDLR and the CNLR.

16. Calculate the minimum detectable leak rate (MDLR):

$$\text{MDLR (bbls/yr)} = \frac{V * R * 365 \text{ days / year}}{T}$$

V = Unit volume of borehole, bbls/ft

R = Resolution of the interface tool, ft

T = Duration of test, days

17. Calculate the nitrogen leak rate (CNLR). Submit supporting data for determination of nitrogen volume (charts, conversion tables, weight measurements, mass-balance calculations accounting for temperature and pressure, source for values used in equation, data from software packages, etc)

$$\text{CNLR (bbls/day)} = \frac{1}{T} \left[ (VS) - \frac{(PF)(VF)}{(PS)} \right]$$

CNLR = Calculated nitrogen leak rate

T = test duration, days

VS = nitrogen volume at test start (bbls)

VF = nitrogen volume at test finish (bbls)

PS = nitrogen pressure at the test start (psia)

PF = nitrogen pressure at test finish (psia)

CNLR (bbls/yr) = CNLR (bbls/day) \* 365 days/year

Pass/fail criteria: The MDLR must be less than 100 barrels of nitrogen per year.  
The CNLR must be less than the MDLR to demonstrate integrity.

## PART II: CAVERN TEST

1. Resume the nitrogen injection and monitor the interface location with the logging tools. Record the time and surface pressures as the interface crosses the casing seat.
2. Spot the nitrogen below the casing seat and terminate the nitrogen injection.
3. Calculate the initial nitrogen volume at the start of the test. Submit formulas (PVT) and calculations used to determine nitrogen volume. The unit volume of the borehole can be determined from casing and tubing sizes. The open-hole volume below the casing seat may be determined with a sonar survey. Another method for determining the annular or borehole unit volume is as follows:

Pump a finite volume of nitrogen into the annulus and log the interface.

Calculate unit volume:

$$\left[ \frac{\text{nitrogen (bbls)}}{\text{depth (ft)}} \right] \text{ Nitrogen pumped/change in interface depth}$$

4. Run the post-nitrogen injection density survey to log the nitrogen interface.
5. Record the nitrogen and brine wellhead pressures.
6. Conduct a temperature survey over the test interval.
7. The test length is typically not less than 24 hours. Monitor the brine and nitrogen wellhead pressures during the test period. The test duration should ensure that the leak rate can be resolved with the accuracy of the instrumentation used.
8. At the end of the test, record the final brine and nitrogen wellhead pressures.
9. Run a density survey to determine if the nitrogen interface has moved. Down-hole movement of the interface may indicate that the test length should be extended.
10. Run a final temperature log over the test interval.
11. Calculate the final nitrogen volume. Submit formulas (PVT) and calculations used to determine nitrogen volume. Accurate nitrogen volume is necessary to determine if pressure changes were affected by temperature, salt leaching, salt creep or from volume loss in the cavern system.
12. Calculate the minimum detectable leak rate (MDLR).

$$\text{MDLR (bbls/yr)} = \frac{V * R * 365 \text{ days / year}}{T}$$

V = Unit volume of borehole, bbls/ft

R = Resolution of the interface tool, ft

T = Duration of test, days

Pass/fail criteria: The MDLR must be less than 1000 barrels of nitrogen per year. The CNLR must be less than the MDLR to demonstrate integrity.

13. Calculate the nitrogen leak rate (CNLR):

$$\text{CNLR (bbls/day)} = \frac{1}{T} \left[ (VS) - \frac{(PF)(VF)}{(PS)} \right]$$

CNLR = Calculated nitrogen leak rate

T = test duration, days

VS = nitrogen volume at test start (bbls)

VF = nitrogen volume at test finish (bbls)

PS = nitrogen pressure at the test finish (psia)

PF = nitrogen pressure at test start (psia)

CNLR (bbls/yr) = CNLR (bbls/day) \* 365 days/year

#### References:

Mechanical Integrity Test-Nitrogen Interface Method; SMRI Short Course; Spring 1998 Meeting  
 Goiz, Kenneth L., 1983, A Plan For Certification and Related Activities For The Department of Energy  
 Strategic Petroleum Reserve Oil Storage Caverns: SPR Geotechnical Division 6257, Sandia National  
 Laboratories, Albuquerque, New Mexico  
 McDonald, Larry K., Nitrogen Leak-Rate Testing; Subsurface Technology, Inc.: 2003 KDHE/KCC  
 Underground Liquid Hydrocarbon and Natural Gas Cavern Well Technology Fair  
 Joe Ratigan, PB Energy Storage Services, Inc., Rapid City, South Dakota



## KANSAS DEPARTMENT OF HEALTH & ENVIRONMENT

### NITROGEN/BRINE INTERFACE TEST PLAN

Procedure #: UICLPG-21  
(6/06)

Narrative:

K.A.R. 28-45-16 requires that each well and each cavern be tested for integrity. Each cavern with a single casing must be tested for integrity every five years. Each cavern with double casing protection must be tested every ten years. The nitrogen/brine interface test is designed to evaluate the integrity of the underground hydrocarbon storage well and/or cavern.

Submit a test plan to KDHE for review and approval at least 30 days prior to test commencement. Use the following format. Do not alter the format.

Submit a casing schematic. Attachment #:	Depth to salt:	
Single casing <input type="checkbox"/> Double casing <input type="checkbox"/>	Depth to casing shoe:	
	Depth to cavern:	
	Total depth:	
Describe roof configuration:	Date of last sonar survey:	
Salt roof thickness:	Date of last gamma-density log:	
Additional logs or test to be run:	1.	
	2.	
	3.	
Maximum operating pressure and test pressures:	Formulas and calculations:	
Proposed changes to FIELD PROCEDURE (UICLPG-22):		
TEST DESIGN: Estimate nitrogen for cool down:  Estimate compressibility:  Estimate nitrogen volume for test:	Casing test and/or Cavern test (Circle)	
	Interval Depth:	Test Duration:
	1.	
	2.	
	3.	
4.		

Submit the final report in the format specified in Procedure # UICLPG-23 to KDHE within 45 days after completion of the test.

Reply to: (785) 296-7254 FAX (785) 296-5509  
 Bureau of Water - Geology Section  
 1000 S. W. Jackson, Ste. 420  
 Topeka, KS 66612-1367



KANSAS DEPARTMENT OF HEALTH & ENVIRONMENT

FIELD PROCEDURE REPORT  
 NITROGEN/BRINE INTERFACE TEST

Procedure #: UICLPG-22  
 (6/06)

Narrative:

The following field procedure for the nitrogen/brine interface test must be completed and submitted with the final report (Procedure #UICLPG-23). Do not alter the format.

<b>Type of MIT:</b>	<b>Well Casing</b>	<b>Cavern</b>	<b>Casing/Cavern</b>
<b>Facility:</b>	<b>Well:</b>		

<b>TEST PREPARATION</b>	<b>Date/time:</b>
<b>Wellhead inspection results:</b> external corrosion, faulty valves, gasket leaks, etc)	
<b>Removal of product</b>	
<b>Date:</b>	
<b>Check wellhead, piping, and connection for leaks. Describe results.</b>	

<b>PRE-PRESSURIZATION</b>			
<b>Date/time:</b>			
<b>Brine pressure</b>		<b>Product pressure</b>	
<b>Cavern compressibility:</b>			
<b>Cavern pressure change &lt; 10 psi/day</b>			

<b>PRE-NITROGEN INJECTION</b>			
<b>Nitrogen cool down volume</b>			
<b>Base temperature log from surface to 50 ft below expected interface</b>	<b>Date/time:</b>	<b>Temperature (F):</b>	
<b>Base density log (a minimum of 50 ft below the expected interface level or an acceptable depth above the casing seat)</b>	<b>Date/time:</b>	<b>Interface depth:</b>	
		<b>Anomalies (washouts, etc)</b>	

**PART 1: CASING TEST**

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Interval Depth	Nitrogen pressure	Brine pressure	Nitrogen temperature	Time nitrogen interface passed

Measure nitrogen with a meter. Terminate nitrogen injection when the interface depth is just above the casing seat. If multiple intervals are to be tested, test intervals from shallow to deep.

<b>CASING TEST</b>			
<b>Interval 1</b>			
Test Start	Time:		
	Interface depth		
	N pressure		
	Brine pressure		
<b>TEST END</b>	Time:	Length of test:	
Density log	Interface depth:	Brine pressure:	Nitrogen pressure:
Temperature log Interval logged	Time:		
	Maximum temperature		
	Average temperature		
	Surface temperature		
Comments: Note any interface movement or loss of nitrogen pressure			

<b>CASING TEST</b>			
<b>Interval 2</b>			
Test Start	Time:		
	Interface depth		
	N pressure		
	Brine pressure		
<b>TEST END</b>	Time:	Length of test:	
Density log	Interface depth:	Brine pressure:	Nitrogen pressure:
Temperature log Interval logged	Time:		
	Maximum temperature		
	Average temperature		
	Surface temperature		
Comments: Note any interface movement or loss of nitrogen pressure			

<b>CASING TEST</b>			
<b>Interval 3</b>			
Test Start	Time:		
	Interface depth		
	N pressure		
	Brine pressure		
<b>TEST END</b>	Time:	Length of test:	
Density log	Interface depth:	Brine pressure:	Nitrogen pressure:
Temperature log Interval logged	Time:		
	Maximum temperature		
	Average temperature		
	Surface temperature		
Comments: Note any interface movement or loss of nitrogen pressure			



PART 2: CAVERN TEST

<b>Cavern Test</b>		
<b>Resume nitrogen injection</b>	Record surface pressures and time the interface crosses the casing seat	
	<b>Brine pressure:</b>	
	<b>Nitrogen pressure:</b>	
	<b>Time:</b>	
Set interface below the casing and terminate nitrogen injection		
<b>Log interface with density log</b>	<b>Interface depth:</b>	
<b>Brine pressure:</b>	<b>Nitrogen pressure:</b>	
<b>Temperature log over test interval</b>	<b>Comments:</b>	
<b>START TEST</b>		
Calculate initial nitrogen volume at start of test:		
<b>Test period</b>	<b>Length:</b>	
Monitor brine and nitrogen pressures during test		
<b>Time:</b>	<b>Brine:</b>	<b>Nitrogen:</b>
<b>Time:</b>	<b>Brine:</b>	<b>Nitrogen:</b>
<b>Time:</b>	<b>Brine:</b>	<b>Nitrogen:</b>
<b>Time:</b>	<b>Brine:</b>	<b>Nitrogen:</b>
<b>Time - Final:</b>	<b>Brine:</b>	<b>Nitrogen:</b>
<b>Final Density log:</b>	<b>Depth:</b>	
<b>Final Temperature log:</b>	<b>Comments:</b>	
<b>Final nitrogen volume:</b>		

**Comments:**

K.A.R. 28-45-16 requires that a licensed professional engineer or licensed geologist, or a licensed professional engineer's or licensed geologist's designee supervise all test procedures and associated field activity.

Supervised by: (Print name)

Company/Title:

Signature:

Date:



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Reply to: (785) 296-7254 FAX (785) 296-5509  
Bureau of Water - Geology Section  
1000 S. W. Jackson, Ste. 420  
Topeka, KS 66612-1367

**KANSAS DEPARTMENT OF HEALTH & ENVIRONMENT**

**FINAL REPORT  
NITROGEN/BRINE INTERFACE TEST**

Procedure #: UICLPG-23  
(6/06)

Narrative:

Submit the final report in the format specified to KDHE within 45 days after completion of the nitrogen/brine interface test. Do not alter this format.

<b>Test Results</b>	
Show formula and calculation for MDLR:	Compare MDLR and NLR:
Show formula and calculation for NLR:	
Explain any interface movement during the test:	
Discuss the relationship of pressure trends to cavern integrity:	
Discuss temperature stability and any accompanying effect on the MIT:	
Discuss pressure changes in adjacent caverns. Attach a chart or a graph.	

Summarize test results:

Submit FIELD PROCEDURE REPORT (UICLPG-22)

Submit all required logs.

Submit supporting data, including graphs for stabilization, temperatures, pressures, injection, etc. Submit appropriate charts.

Submit calibration charts for gauges and meters.

K.A.R. 28-45-16 requires that a licensed professional engineer or licensed geologist review all test results.

Submit the final report to KDHE within 45 days after completion of the test.

## ATTACHMENT J - UIC MONITORING, RECORDING AND REPORTING PLAN

### 1.0 REQUIREMENTS

Submit a monitoring, recording, and reporting plan, including maps, for meeting the monitoring and reporting requirements of R317-7-10.3(B), 40CFR146.33, 40CFR146.8, and R317-7-10(B). In the plan

- Identify types of tests, methods, and equipment used to generate monitoring data
- Address the proper use, maintenance, and installation of monitoring equipment
- Propose the type, intervals, and frequency sufficient to yield data that are representative of monitored activity.

### 2.0 PHYSICAL AND CHEMICAL CHARACTERISTICS OF INJECTED FLUID

The Magnum Wells will be solution mined using fresh water produced from water wells located on the Magnum facility. The salinity of the injected fluid will be measured, along with the fluid temperature on a daily basis. Specific gravity and temperature will be monitored using calibrated hydrometers and thermometers. Hydrometers will be calibrated and maintained in accordance with ASTM A126-05a and thermometers will be calibrated and maintained in accordance with ASTM E77-07.

The data will be trended to ensure that no changes in the injected water take place during the duration of the solution mining operations.

### 3.0 MONITORING OF INJECTION PRESSURE AND FLOW

Injection pressures, injection flow rates, injection temperature, brine pressure, brine flow rate, brine temperature and the nitrogen blanket pressure will be monitored continuously by instrumentation in the control room. The information will be recorded at least once per day as a daily summary. The daily summary will be included in quarterly reports. This data will be used to calculate the growth of the cavern and provide a daily check on well integrity by ensuring that the water inflow and brine outflow balance. All the recorded data will be available to the Executive Secretary upon request.

All pressure monitoring, temperature monitoring, and flow rate monitoring instrumentation calibration will be done in accordance with manufacturer recommendations.

### 4.0 DEMONSTRATION OF MECHANICAL INTEGRITY

Prior to initiating solution mining and at the completion of leaching, the cavern will be tested using the nitrogen mechanical integrity technique. The test pressure at the shoe of the [REDACTED] cemented casing will be slightly above (about 0.92 psi per foot of depth) the permitted operating pressure (0.90 psi per foot of depth) to ensure that the casing and cement are not leaking. The nitrogen mechanical integrity test technique essentially involves pressuring the cavern or well to the desired test pressure, and injecting nitrogen in the outer annulus of the well (the space between the cemented [REDACTED] casing and the hanging [REDACTED] tubing) to a depth about 50 to 100 feet below the casing shoe.

The well will then be shut-in for 24 to 48 hours to allow the nitrogen temperature to equalize with the in-situ temperature. The initial depth of the nitrogen/brine interface below the casing shoe and the temperature of the wellbore will then be measured with a wireline tool. After a period of time, not less than 24 hours, determined by the size of the borehole below the casing shoe, a second interface and temperature survey will be run. The pressure at the wellhead will be monitored and recorded continuously during the test.

The change in the calculated volume of the nitrogen between the two interface measurements will be determined from the surface nitrogen pressure, the well temperature logs and the change in the level of the nitrogen/brine interface. The change in the nitrogen volume will then be converted to an equivalent fluid loss.

The temperature stabilization period, the duration of the test and the desired depth of the initial nitrogen/brine interface level will be determined from logs run during and after well construction. The selection of these features will be made so as to ensure that the test has a minimum detectable leak rate (test sensitivity) of no more than 100 barrels per year of nitrogen.

All pressure monitoring instruments will be calibrated in accordance with manufacturer's recommendations. Testing will be performed under the supervision of a degreed engineer and the report submitted to the Executive Secretary within 30 days of test completion.

Following the mechanical integrity test after completion of mining the caverns will be tested on a periodic basis using methods and procedures in accordance with requirements set forth by the State of Utah.

#### 5.0 MONITORING OF CAVERN DEVELOPMENT

During solution mining of the caverns, the development of the cavern will be controlled by monitoring of the fluid injection and production quantities (Item 3.0 above) and periodic performance of sonar caliper surveys. The measured quantity of water injected and salinity of the produced brine will be used to calculate the daily increase in cavern volume. The sonar caliper surveys will be run at least once a year and at completion of mining in each cavern. The sonar survey will provide a check on the calculated cavern volume and the shape of the cavern.

#### 6.0 MONITORING OF FLUID LEVEL IN FORMATION

This section is not applicable for solution mining wells since the well is full at all times. 7.0 QUARTERLY REPORTING ON MONITORING WELLS IN SUBSIDENCE ZONES

No monitoring wells are planned for the Magnum project.

Subsidence will be monitored on an annual basis by Magnum and will be evaluated by a degreed engineer who is thoroughly experienced in subsidence of cavern storage facilities. Subsidence measurements will begin with a baseline survey that will be run prior to starting solution mining. Subsidence surveys will be conducted throughout the life of the facility. The subsidence report will be submitted to the Executive Secretary on an annual basis.

Subsidence surveys will be conducted by measuring precise elevations of fixed points within the cavern field, the total Magnum facility and along public right-of-ways. The elevations of the points in and adjacent to the cavern field will be measured from a benchmark located at a distance from the facility that will not be impacted by any subsidence related to the caverns.

8.0 QUARTERLY REPORTING — EXECUTIVE SECRETARY

Daily summaries of water and brine pressures, temperatures, fluid volumes, and space created as well as the nitrogen blanket pressure will be reported to the Executive Secretary on a quarterly basis. Total volume of water injected and brine withdrawn from the storage cavern will be reported to the Executive Secretary on a quarterly basis.

## **Part J**

Magnum Solution Mining, LLC

Millard County, Utah

Magnum Gas Storage Project

**16-inch Injection Well Monitoring, Recording, and Reporting Plan**

## **Part J – 16-inch Injection Well UIC Monitoring, Recording, and Reporting Plan**

### **1.0 REQUIREMENTS**

Submit a monitoring, recording, and reporting plan, including maps, for meeting the monitoring and reporting requirements of R317-7-10.3(B), 40CFR146.33, 40CFR146.8, and R317-7-10(B). In the plan:

1. Identify types of tests, methods, and equipment used to generate monitoring data
2. Address the proper use, maintenance, and installation of monitoring equipment
3. Propose the type, intervals, and frequency sufficient to yield data that are representative of monitored activity.

### **2.0 PHYSICAL AND CHEMICAL CHARACTERISTICS OF INJECTED FLUID**

The Magnum salt storage caverns will be solution mined using fresh water produced from water wells located on the Magnum facility. The salinity of the injected fluid will be measured, along with the fluid temperature on a daily basis. Specific gravity and temperature will be monitored using calibrated hydrometers and thermometers. Hydrometers will be calibrated and maintained in accordance with ASTM A126-05a and thermometers will be calibrated and maintained in accordance with ASTM E77-07.

The data will be trended to ensure that no changes in the injected water take place during the duration of the solution mining operations.

### **3.0 MONITORING OF INJECTION PRESSURE AND FLOW**

Injection pressures, injection flow rates, injection temperature, brine pressure, brine flow rate, brine temperature and the nitrogen blanket pressure will be monitored continuously by instrumentation in the control room. The information will be recorded at least once per day as a daily summary. The daily summary will be included in quarterly reports. This data will be used to calculate the growth of the cavern and provide a daily check on well integrity by ensuring that the water inflow and brine outflow balance. All the recorded data will be available to the State of Utah DWQ Executive Secretary upon request.

All pressure monitoring, temperature monitoring, and flow rate monitoring instrumentation calibration will be done in accordance with manufacturer recommendations.

### **4.0 DEMONSTRATION OF MECHANICAL INTEGRITY**

Prior to initiating solution mining and at the completion of leaching, the cavern will be tested using the nitrogen mechanical integrity technique. The test pressure at the shoe of the 16-inch cemented casing will be slightly above (about 0.92 psi per foot of depth) the permitted operating pressure (0.90 psi per foot of depth) to ensure that the casing and cement are not leaking. The nitrogen mechanical integrity test technique essentially



involves pressuring the cavern or well to the desired test pressure, and injecting nitrogen in the outer annulus of the well (the space between the cemented [REDACTED]-inch casing and the hanging 16-inch tubing) to a depth about [REDACTED] feet below the casing shoe.

The well will then be shut-in for 24 to 48 hours to allow the nitrogen temperature to equalize with the in-situ temperature. The initial depth of the nitrogen/brine interface below the casing shoe and the temperature of the wellbore will then be measured with a wire line tool. After a period of time, not less than 24 hours, determined by the size of the borehole below the casing shoe, a second interface and temperature survey will be run. The pressure at the wellhead will be monitored and recorded continuously during the test.

The change in the calculated volume of the nitrogen between the two interface measurements will be determined from the surface nitrogen pressure, the well temperature logs and the change in the level of the nitrogen/brine interface. The change in the nitrogen volume will then be converted to an equivalent fluid loss.

The temperature stabilization period, the duration of the test, and the desired depth of the initial nitrogen/brine interface level will be determined from logs run during and after well construction. The selection of these features will be made so as to ensure that the test has a minimum detectable leak rate (test sensitivity) of no more than 500 barrels per year of nitrogen.

Prior to the commencement of testing all pressure monitoring instruments will be calibrated in accordance with manufacturer's recommendations. Testing will be performed under the supervision of a degreed engineer and the report submitted to the Executive Secretary within 30 days of test completion.

Following the post-completion mechanical integrity test the caverns will be tested on a periodic basis using methods and procedures in accordance with requirements set forth by the State of Utah.

## **5.0 MONITORING OF CAVERN DEVELOPMENT**

During solution mining of the caverns, the development of the cavern will be controlled by monitoring of the fluid injection and production quantities (Item 3.0 above) and periodic performance of sonar caliper surveys. The measured quantity of water injected and salinity of the produced brine will be used to calculate the daily increase in cavern volume. The sonar caliper surveys will be run at least once a year and at completion of mining in each cavern. The sonar survey will provide a check on the calculated cavern volume and the shape of the cavern.

## **6.0 MONITORING OF FLUID LEVEL IN FORMATION**

This section is not applicable for solution mining wells since the well is full at all times.

## **7.0 QUARTERLY REPORTING ON MONITORING WELLS IN SUBSIDENCE ZONES**

No monitoring wells are planned for the Magnum project. Subsidence will be monitored on an annual basis by Magnum and will be evaluated by a degreed engineer who is

thoroughly experienced in subsidence of cavern storage facilities. Subsidence measurements will begin with a baseline survey that will be run prior to starting solution mining.

Subsidence surveys will be during operations of the facility. The subsidence report will be submitted to the Executive Secretary on an annual basis. Subsidence surveys will be conducted by measuring precise elevations of fixed points within the cavern field, the total Magnum facility and along public right-of-ways. The elevations of the points in and adjacent to the cavern field will be measured from a benchmark located at a distance from the facility that will not be impacted by any subsidence related to the caverns.

### **8.0 QUARTERLY REPORTING —EXECUTIVE SECRETARY**

Daily summaries of water and brine pressures, temperatures, fluid volumes, and space created as well as the nitrogen blanket pressure will be reported to the Executive Secretary on a quarterly basis. Total volume of water injected and brine withdrawn from the storage cavern will be reported to the Executive Secretary on a quarterly basis.