May 9, 2013

Recommended Requirements for Collection and Laboratory Testing of Napoleonville Salt
Reviewed/Approved by
Blue Ribbon Commission on Bayou Corne and Grand Bayou Public Safety

The following describes the test matrix necessary to characterize the site specific mechanical response (i.e., strength and creep characteristics) of the Napoleonville salt adequately for use in future geomechanical modeling. It also specifies the elevations where the core should be sampled, and outlines a core handling and logging protocol. The recommendation is that the core handling and logging procedures used by Sandia National Laboratories also be used in this case.

Current geomechanical models of the Oxy-3 collapse rely on three short-term creep tests (about 15 days) and three long-term tests (about 30 days) on Napoleonville salt from wells that are located east of the current collapse area and the adjacent cluster of caverns (Oxy-1, Oxy-2, Oxy-9, Oxy-10 and CrossTex2) (Pfeifle and Vogt, 1993; Pfeifle and Vogt, 1995). Considering the scope and significant impact of the Oxy-3 collapse on the Bayou Corne community, and questions about future stability, it is reasonable to request that site-specific salt properties be established for modeling purposes. The planned 3000-ft geophone well provides an excellent opportunity to accomplish this by selecting intervals over which core is extracted for testing.

To characterize the site-specific creep response into the steady-state regime, the test should be run for a period of minimum 30 days. The creep tests also should be run at the ambient temperature of the core location (probably around 40 C). The recommendation is to pull enough core from the lower half of the borehole to have enough for 9 constant stress creep tests, 9 triaxial compression strength tests (to determine elastic modulus and Poisson's ratio, stress at onset of dilation and peak strength), 9 unconfined compressive strength tests (primarily as an index test for comparison to salt at other locations) and 9 Brazilian tests (indirect tensile strength test). The creep tests should be run for a minimum of 30 days, and the tests should be run at a representative confining stress (e.g., mean stress at mid-level of Oxy-2 cavern, probably around 2750 psi) for 3 levels of axial stress difference (e.g., 1500 psi, 2000 psi and 3000 psi) with 3 creep tests at each stress level (i.e., 3 x 3 = 9 creep tests).

The testing laboratory needs to provide weekly updates of the stain vs. time and strain-rate vs. time graphs to the Louisiana Department of Natural Resources and the Blue Ribbon Commission (BRC). In the event that steady-state is not achieved at the end of the 30-day or that it does not

appear that the steady-state creep rate can be calculated by the BRC, then the creep test time will be extended based on recommendations by the BRC.

Core should be taken from 3 different locations in the lower part of the geophone well; (1) around 1500 ft depth (i.e., some distance above the Oxy-1 cavern), (2) around 2250 ft depth (i.e. the salt above the roof elevation of the Oxy-1 cavern) and (3) near the bottom of the borehole (i.e., the salt at the horizon of the Oxy-1 cavern). A minimum of twenty-five ft of core should be recovered at each of the three locations (i.e., 75 ft total core length), which should provide a sufficient amount to be safe in case there is a problem in the sample prep or during testing to assure the proper number of tests are conducted. However, it is highly recommended to core the entire length of the core barrel (60 ft) at each location. The recommendation also is that the salt is tested for chemistry and mineralogy to correlate with the strength and deformation test response. It is not necessary to core the cap-rock for the purpose of modeling, but rather provide the information from the geophysical logs below for the cap-rock.

The extracted core should have a nominal diameter of 4 in (100 mm) and should be drilled using a double-tube core barrel to minimize core damage. The coring fluid used should have such characteristics that it does not dissolve the salt during drilling, and should otherwise comply with current environmental standards and statutes. When extracting the core from the double-tube, the core should be broken into lengths of approximately 3 to 4 ft (as much as possible). A chalk mark should be placed at the top part of the core section to identify its proper vertical orientation, and the entire core-run should be laid out for inspection and description by a certified professional geologist who is highly experienced at logging salt core and formations. The core should also be photographed at this time.

Procedures must be in place for on-site core handling while laying out the core initially, logging and storage that protect and assure the integrity of each individual piece of core and provide adequate core identification in terms of borehole ID, core run # and its top elevation.

As soon as on-site logging of the core has been accomplished, the core should be prepared for transportation to a designated testing laboratory. This preparation must be such that the core moisture is preserved (e.g., wrap the core in several layers of saran-wrap) and that the core is protected from undue shaking, bumps and impact during handling/transportation. This can be accomplished by wrapping the core in bubble-wrap and placing the wrapped core into 6-in diameter thick-walled PVC pipe (3 to 4 ft long) making sure that a snug fit is achieved. Additional bubble-wrap must be added to the ends of the PVC pipe to make sure the core cannot

move. End-caps should be used on the PVC pipe, and should be fastened with metal screws. The PVC pipe should be marked on the outside with the top elevation of the core it contains, core run# and borehole identification. The PVC pipe should be placed onto pallets and securely strapped down for transportation from the coring site to the testing laboratory. The transporting vehicle should have air-ride suspension to minimize any impact to the core during transportation.

Once the core arrives at the testing laboratory, the handling and preparation of the core for testing should follow established laboratory procedures. The recommendation is that the rock mechanics testing and the chemistry and mineralogy testing be conducted by RESPEC Inc. at their laboratory in Rapid City, South Dakota. Having conducted salt creep testing and strength testing since the 1970's, RESPEC is one of the most experienced salt testing laboratories in the world. RESPEC should also provide a highly experienced and registered professional geologist to coordinate and supervise the core recovery and logging on site.

In addition to the laboratory testing, it is suggested that Texas Brine conduct geophysical logs to obtain density, p- and s-wave velocities. In addition the Baker-Hughes MSLAM and XMAC logs should be run on the open hole and the SBL log should be run on the cased well. As noted above, while cap-rock core is not required, the open-hole logs should be run through the cap-rock as drilling and hydrogen sulfide conditions allow. It is not necessary to run the MSLAM or XMAC logs through the Mississippi River Alluvial Aquifer—the gamma log from the SBL log will be sufficient for characterization of the alluvium.