



A REPORT ON THE RESULTS OF LOGGING AND TESTING OF UNDERGROUND HYDROCARBON STORAGE WELLS/SALT CAVERNS LOCATED IN KANSAS

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The liquid hydrocarbon salt cavern storage industry has completed the first cycle of logging and testing required by the KDHE Underground Hydrocarbon Storage Program regulations (Article 45) which were became effective on April 1, 2003. This report summarizes the results of this logging and testing.

This report is only for the 383 active storage wells and does not include wells in monitoring status or the wells located at the Yaggy storage facility.

CASING INSPECTION LOG (CIL)

K.A.R. 28-45-16(h) requires on a regular schedule a casing evaluation (CIL) to be conducted to check for internal and external corrosion of the production casing at least once every 5 years if the well has single cemented casing protection into the salt formation or once every 10 years if the well has double cemented casing protection into the salt formation. This log must be capable of detecting the presence of any metal loss, the degree of penetration of the corrosion or casing defect and the circumferential extent of the corrosion or casing defect. Acceptable casing evaluation methods listed in the regulations include magnetic flux and ultrasonic imaging. The magnetic flux is the most commonly used log. KDHE has established a decision tree to determine appropriate action to be taken based on the results of this log. This "decision tree" can be found at the following website:

<http://www.kdheks.gov/uhs/download/GuideCasingLog.pdf>

The results are as follows:

- ♦ 28 wells were placed on a 3-year CIL logging schedule due to casing defects of 40% or more metal loss.

- ◆ 32 wells had liners or casing patches installed to repair casing defects detected by the CIL.
- ◆ 6 wells had near surface casing defects that were excavated and repaired.
- ◆ 4 wells had the effective casing seat raised due to casing defects near the bottom of the production casing string.
- ◆ 4 wells were placed into monitoring status due to problems detected by the CIL.

This is a total of 74 or 19% out of the 383 wells requiring some type of corrective action based on the CIL results.

MECHANICAL INTEGRITY TESTING

K.A.R. 28–45a–16(c)(1)(B) requires on a regular schedule each storage well and cavern to be tested for mechanical integrity. The nitrogen/brine interface test or similar type test shall be used to test the well and the brine hydrostatic or similar type test approved by KDHE shall be used to test the cavern.

The results are as follows:

- ◆ 12 wells had liners or casing patches installed.
- ◆ 2 wells had the effective casing seat raised to above the leaking collars.
- ◆ 2 wells were placed into monitoring status.

It should be noted that for the raising of the effective casing seat action the well must still meet the regulatory minimum salt roof requirements and the maximum permitted operational pressure must remain at *0.80 psi/foot of depth* as determined at the re-established casing seat.

This is a total of 16 wells or 4% out of the 383 wells requiring some type of corrective action based on MIT results.

SONAR SURVEY LOG

K.A.R. 28-45–15(f) requires a sonar survey be conducted on a regular schedule of every 10 years to monitor the cavern storage capacity, the cavern geometry and the cavern and overburden stability.

The results are as follows:

- ◆ 10 cases of pairs of adjacent caverns being closure than the required regulatory limit of 100 feet or more were detected and are being addressed by the operators.
- ◆ The survey has been very useful in determining cavern volumes. This has greatly assisted industry in determining cavern storage capacity.
- ◆ The survey has been useful in diagnosing cavern problems such as roof falls. This assists the industry in implementing operational procedures to address these problems.

CEMENT BOND LOG (CBL)

K.A.R. 28-45–16(j) requires conducting a CBL with the casing evaluation log if a CBL has not been previously conducted. The sonic cement bond log is commonly used, but various types of cement evaluation logs are also sometimes conducted. The purpose of these logs is to check the integrity of the cement behind the production casing or liner.

The results are as follows:

- ◆ No significant cement integrity problems were detected.
- ◆ This log has been very useful in determining areas of good cement behind the casing to properly locate packers, casing patches and for conducting other procedures.

GAMMA RAY – DENSITY LOG

K.A.R. 28-45a–15(e), requires a gamma ray – density log be conducted to monitor the thickness of the salt roof on a regular schedule of every 5 years if the salt roof thickness is 100 feet or more and every 3 years if the salt roof thickness is greater than 50 feet but less than 100 feet in thickness. This log has been conducted for years and was also required under the previous set of regulations.

The results are as follows:

- ◆ Roof falls and washouts behind the casing with trapped product are commonly detected by this log.
- ◆ Wells not meeting the salt roof thickness required by the regulations are removed from service and are plugged or placed into monitoring status if approved by KDHE.

- ◆ If the trapped product is indicated by the log at an undesirable depth or if the well is being removed from service, then corrective actions are implemented which can include perforating the casing to remove the trapped product.
- ◆ This log also provides useful geologic information for consideration when developing appropriate operational and workover plans.

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