Offset Access Well Offers Solution to Problem of Debris Accumulation in Bedded Salt Storage Cavities

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ABSTRACT

In the present system for storing liquefied gases and similar products in pressure-tight dissolved in bedded salt, considerable difficulty is experienced because layers of the insoluble material interbedded with the salt are undermined during the dissolving process; these layers collapse as a result of being undermined and accumulate in the bottom of the cavity. This material is referred to as cavity debris. Caving does not cease with the dissolving stage but continues intermittently and unpredictably while the cavity is in use as a storage vessel.

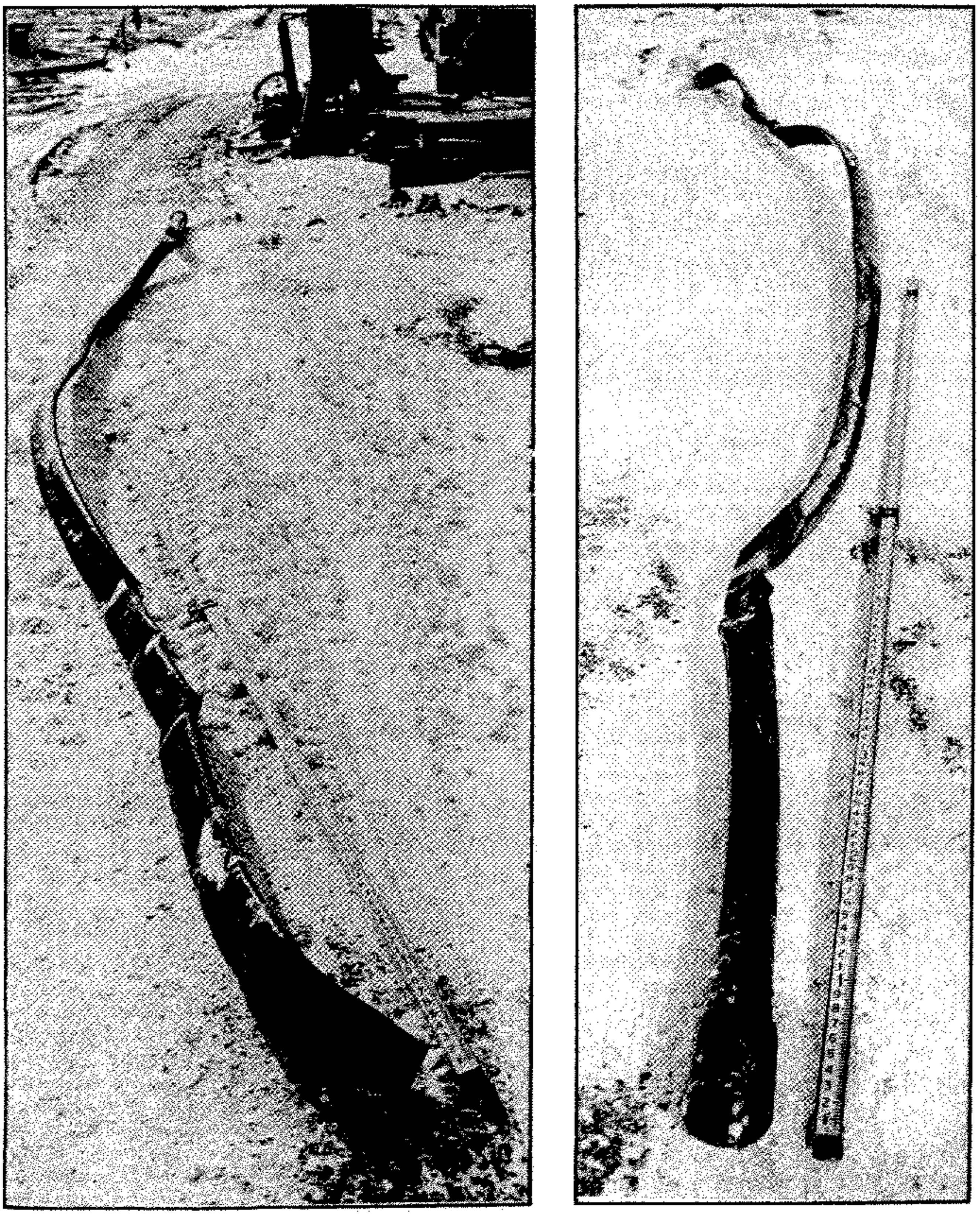
Collapse or relocation of cavity debris usually breaks the tubing in the cavity requiring shut-down to replace the tubing at considerable expense and inconvenience as well as loss of capacity as the tubing setting depth retreats up the cavity in order to stay above the debris. A well drilled in the rock adjacent to the cavity and connected to the base of the cavity by suitable undercutting means eliminates the need for tubing and recovers storage capacity lost in the debris zone.

INTRODUCTION

Operators of storage cavities dissolved in bedded salt are faced with the common problem of the layers or "ledges" of insoluble rock which occur in most bedded salt deposits. These ledges range in thickness from a few inches to 10 or more feet and are interbedded with the salt in what was originally a horizontal tabular arrangement. Major beds and characteristic sequences of rock and salt can be seen to cover large areas—as much as hundreds of miles—by comparison of wireline logs or core descriptions.

Other than the geologic interest which these thin layers create with their extensive areal continuity, they present a mechanical problem to those interested in dissolving, operating and maintaining a salt cavity for underground storage, in that as the solution cavity is developed the ledges become undermined and cave in, accumulating as debris in the cavity. Caving and debris accumulation are well known to operators of brine wells, particularly in the days when successful well operation required maintenance of tubing through the debris pile in order to produce saturated brine from deep in the cavity. The condition was self-aggravating in that extended operation would further undermine the ledges and redrilling or "cleanout" would be required at increased frequencies. Even during the redrilling operation, caving would occur, usually causing loss of the drill string. The photographs below show a piece of well tubing pulled from a salt well; the collapsed condition of the pipe illustrates the force of the caving rock operating against a string of tubing suspended in a cavity. That the piece of 4½" pipe shown was pulled through 8" casing represents no small feat in itself.

Storage cavities in salt are usually not developed to the extent that roof caving or stopping sets in—it can be visualized that bulking of the caved material would ultimately occupy all the open space in the cavity if the process were carried to its limit.



4½" TUBING FROM SALT WELL ILLUSTRATING FORCE OF FALLING CAVITY DEBRIS AND ROOF ROCK.
TUBING WAS PULLED THROUGH 8 5/8" CASING.

Figure 1.

DEBRIS IN STORAGE CAVITIES

Debris accumulates in storage cavities as the result of undermining during dissolving of the cavity—frequently requiring a workover job to replace the tubing. Caving continues after the storage cavity is put into operation however, due to minor solution by the displacement brine beneath the stored material, due to weakening of the ledges from hydration or wetting by the brine or water, and due to flexing of the projecting ledges caused by changes in buoyancy of the displacement brine and stored product as they cycle past the rock layer. Other forces probably operate unrecognized. It is a rare solution cavity in bedded salt which hasn't experienced a cave-in with associated loss of the tubing string.

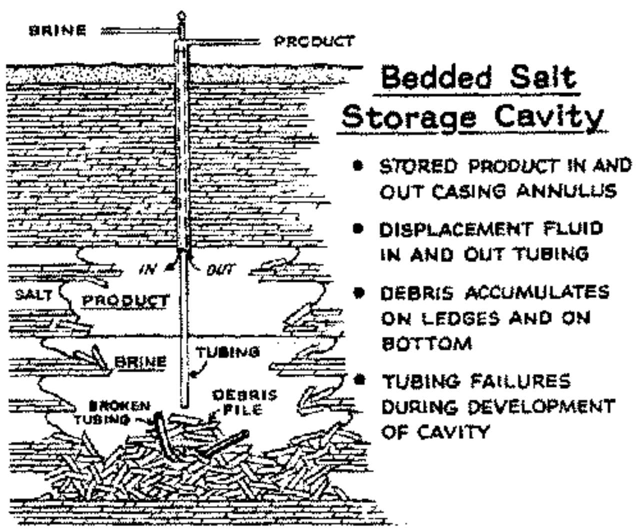


Figure 2.

WELL REPAIR AFTER TUBING FAILURE

Tubing is required in salt storage cavities to serve as the conduit to introduce and remove brine used to displace the stored material. The depth of setting of the tubing thus determines the usable portion of the salt cavity, since no brine can be produced below the tubing. Workover after a tubing failure then requires a decision to regain access of the cavity capacity by redrilling through the debris—with the attendant unreliability created by having tubing set in the caved material, or retreat up the hole with loss of usable storage cavity volume. In either choice the cavity operation is still under jeopardy in that tubing is hanging free in the cavity, subject to breakage due to later shifts, caving and the other causes described above.

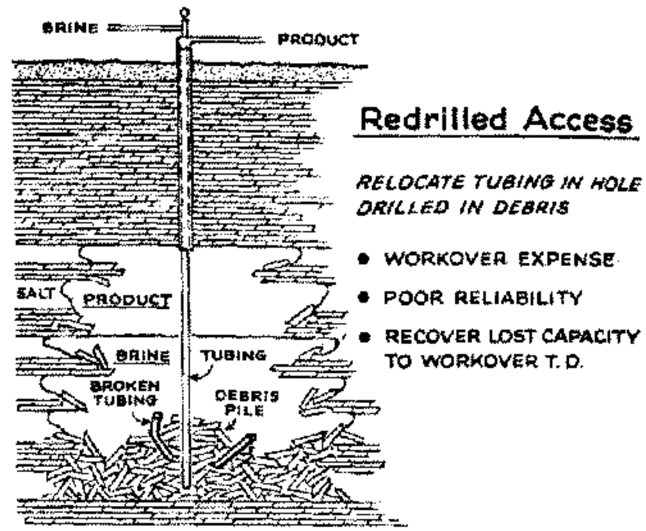


Figure 3.

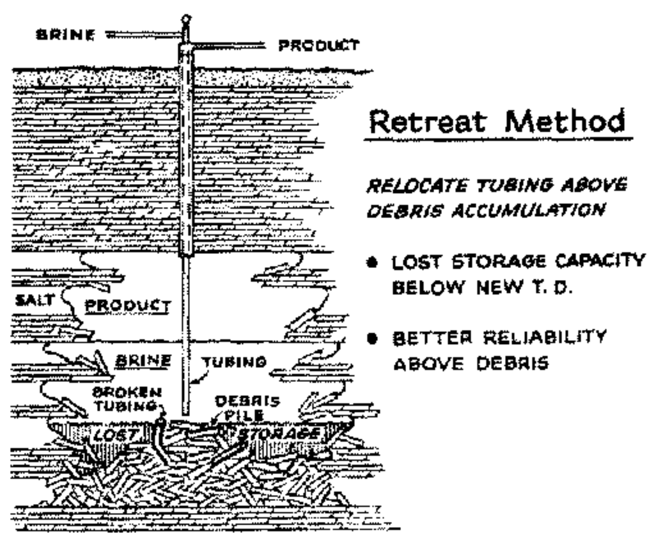


Figure 4.

OFFSET ACCESS WELL

The tubing in the storage cavity system can be eliminated by drilling a second or access well offset from the cavity slightly more than one radius. No harm is done if the well encounters the fringe of the cavity. The well is drilled to the original equivalent depth of the storage cavity and casing cemented in as many stages as required by loss zones or cavity encounters mentioned above.

The access well is then connected to the storage :avity at or near the original depth by one of the undercutting methods, fracturing, controlled solu- :ion, etc. In its final form the system consists of :he storage cavity with its casing cemented to the :oof, serving as the access conduit for stored mate- ·ial, the cavity itself, the undercut, and the offset ıccess well connect to the cavity by way of the ındercut, serving to introduce and remove brine or ›ther displacement fluid.

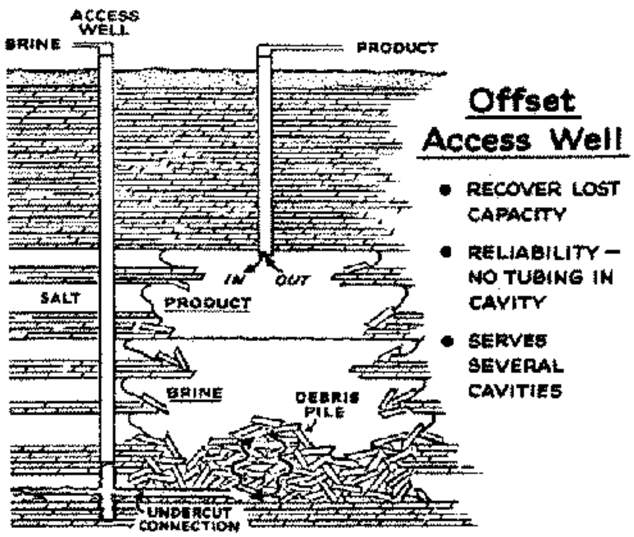


Figure 5.

INCREASING STORAGE CAPACITY WITH THE OFFSET WELL SYSTEM

Additional capacity can be developed during peration of the storage system by introducing 'ater or weak brine through tubing suspended art-way into the storage cavity. Solution would ıke place beneath the level of the stored product ıther than at the cavity roof, and extraction can e controlled by varying the concentration and ıte of solvent introduction. The dissolving project ın be interrupted at will; it creates no interference ith storage operations.

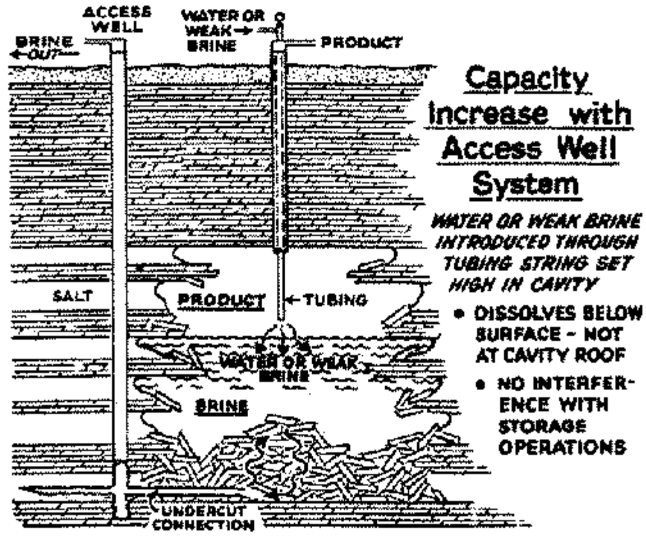


Figure 6.

ADVANTAGES OF THE OFFSET ACCESS WELL

1. Improved reliability. Removing the tubing from the cavity eliminates this element of unreliability from the storage system, as well as the expense of workovers and tubing replacements.
2. Recovered capacity. The original dissolved capacity of the cavity can be used. Caving represents only *relocation* of the rock layers, the full volume of the cavity can be used since stored products and brine can readily disperse through the cavity debris.
3. Eliminate displacement fluid. A logical outgrowth of the development of a usable offset well is elimination of the need for the displacement fluid by installation of a submersible-motor type pump in the access well to lift the stored product. This overcomes the previous objection to use of pumps in that the pump is not suspended in the cavity, subject to risk of loss if caving occurs. The submersible pump can be eliminated through the use of vapor-pressure or other suitable system to force the stored product to the surface.
4. Other advantages: One access well can serve as brine supply to a cluster of cavities as long as the risk of mixing in the event of overfilling can be tolerated. Capacity can be recovered immediately upon completion of the access well and its undercut connection.

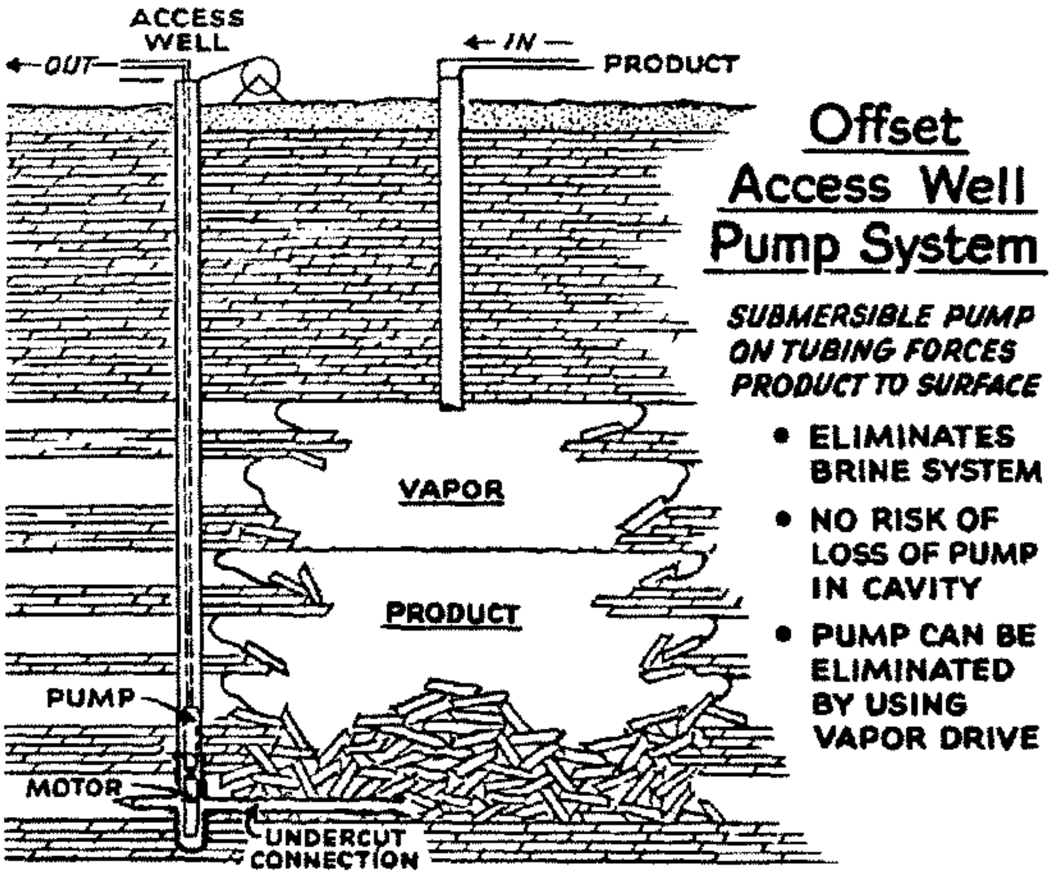

ACCESS WELL
← OUT
← IN —
PRODUCT
Offset Access Well Pump System
SUBMERSIBLE PUMP ON TUBING FORCES PRODUCT TO SURFACE
• ELIMINATES BRINE SYSTEM
• NO RISK OF LOSS OF PUMP IN CAVITY
• PUMP CAN BE ELIMINATED BY USING VAPOR DRIVE
VAPOR
PRODUCT
PUMP
MOTOR
UNDERCUT CONNECTION

Figure 7.