IMPROVED WELL PLUGGING EQUIPMENT AND WASTE MANGEMENT TECHNIQUES EXCEED ALARA GOALS AT THE OAK RIDGE NATIONAL LABORATORY

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ABSTRACT

In 2000, Bechtel Jacobs Company LLC (BJC) contracted Tetra Tech NUS, Inc. (TtNUS) and their sub-contractor, Texas World Operations, Inc. (TWO), to plug and abandon (P&A) 111 wells located in the Melton Valley area of Oak Ridge National Laboratory (ORNL). One hundred and seven of those wells were used to monitor fluid movement and subsurface containment of the low level radioactive liquid waste/grout slurry that was injected into the Pumpkin Valley Shale Formation, underlying ORNL. Four wells were used as hydrofacture injection wells to emplace the waste in the shale formation. Although the practice of hydrofacturing was and is considered by many to pose no threat to human health or the environment, the practice was halted in 1982 after the Federal Underground Injection Control regulations were enacted by United States Environmental Protection Agency (USEPA) making it necessary to properly close the wells. The work is being performed for the United States Department of Energy Oak Ridge Operations (DOE ORO).

The project team is using the philosophy of minimum waste generation and the principles of ALARA (As Low As Reasonably Achievable) as key project goals to minimize personnel and equipment exposure, waste generation, and project costs. Achievement of these goals was demonstrated by the introduction of several new pieces of custom designed well plugging and abandonment equipment that were tested and used effectively during field operations. Highlights of the work performed and the equipment used are presented.

Performance on this project has exceeded expectations and is setting new standards for all downhole projects involving contaminated fluids. All other DOE sites with similar remedial activities can benefit from the newly developed Best Available Demonstrated Technology that is in use at ORNL on the Melton Valley Hydrofracture Well P& A Project.

INTRODUCTION

On August 11, 2000 BJC awarded a contract to TtNUS to P&A 107 wells associated with hydrofracture facilities previously utilized by ORNL to dispose of low level radioactive liquid waste/grout slurry. The project is being performed for DOE ORO. The four primary goals of the project are to:

1. Prepare and implement a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Remedial Action Work Plan that properly closes all of the wells in accordance with current Underground Injection Control regulations and all other environmental and safety laws governing subsurface installations used for waste disposal.

2. Protect health, safety, and the environment.

3. Perform the work in a manner that is consistent with the Integrated Safety Management System (ISMS) and the As Low As Reasonably Achievable (ALARA) philosophy.

4. Complete the project with Zero Accidents and Zero Occurrences.

During the first year of the project, the team has plugged 33 wells listed in the original scope of work and 9 other wells located during the work that were not previously known. All project goals, including Zero Accidents and Zero Occurrences, have been obtained.

BACKGROUND

In the late 1950's, scientists at ORNL started experimenting with the concept of subsurface disposal of low level radioactive liquid waste. Underlying the ORNL site in Melton Valley is a thick, low permeability geologic formation known as the Pumpkin Valley Shale that fractures horizontally along bedding planes when sufficient hydraulic pressure is applied. Recognizing this rock characteristric, site personnel designed and implemented a series of experiments to determine if low level radioactive liquid waste could be safely injected into and contained by the formation.

The first two experimental sites were known as Hydrofracture-1 (HF-1) and Hydrofracture-2 (HF-2). At HF-1 a single injection well was drilled. A series of twenty-four observation and monitoring wells were installed surrounding the injection well. A radioactive tracer mixed with cement grout was injected into the Pumpkin Valley Shale. The extent of the resultant grout sheet in the subsurface was measured and mapped from data gathered via the surrounding wells.

After successfully completing the first experiment, a similar experimental site was developed at HF-2. Again, a single injection well was surrounded by twenty-four observation or monitoring wells. One injection of a radioactive tracer mixed with cement grout was made into the host formation at HF-2. The results of both experiments demonstrated low level radioactive liquid waste mixed with cement grout could be successfully injected and contained within the host formation.

A third site, known as the Old Hydrofracture Facility (OHF) or Hydrofracture-3 (HF-3), was developed in Melton Valley. At HF-3 surface facilities were constructed and equipment (e.g., permanent pumps, fluid handling systems, grout mixing capabilities and waste storage tanks) installed to support experimental and later operational waste disposal. Again a single injection well surrounded by twenty-four other wells was installed to monitor waste injections beneath the land surface. Several injections of waste materials were made at HF-3.

The fourth operational waste injection site known as the New Hydrofracture Facility (NHF) or Hydrofracture-4 (HF-4) was installed. A number of surface facility and support equipment improvements were included to make this site a fully functional and safer installation. This facility was routinely operated until the waste injection program was halted in 1982.

Overall the concept and waste injection program at ORNL were very successful and would have continued if USEPA had not promulgated the Underground Injection Control (UIC) regulations. Under the UIC rules and guidelines, the injection of radioactive waste into the subsurface was effectively banned unless an owner/operator performed several additional extensive studies to obtain the necessary permitting. Not wishing to undergo the expensive and uncertain permitting process, ORNL decided to abandon the hydrofracture effort.

In 1987, TWO was contracted by ORNL to prepare preliminary closure plans for the hydrofracture wells. Since then several studies of the HF-3 and HF-4 sites were conducted to characterize the condition of the wells, and determine the type and extent of contamination. These studies provided essential data and downhole information that was necessary to design and safely execute the final closure plans for the hydrofracture wells.

PLANNING FOR WELL PLUGGING AND ABANDONMENT

Plugging and abandonment of wells is a very common activity in the oilfield. However, standard oilfield equipment and practices cannot be used to perform the ORNL work. The ISMS and ALARA goals of the project required several equipment and oilfield methodology modifications to work safely in an environment contaminated with radioactive materials.

TWO's extensive experience with UIC Class I injection wells and related facilities was used to provide the solutions necessary to achieve the project goals. Class I wells are injection wells used by industry to dispose of both hazardous and non-hazardous wastes defined in both Resource Conservation and Recovery Act (RCRA) and UIC regulations administered by the USEPA or state enforcement agencies. All hydrofracture well closure activities at ORNL are to use current Class I UIC regulations as guidance even though these wells were never permitted or listed under the Class category.

Under the Class I rules, closure must isolate the wellbore from groundwater, not pose a threat to human health and be protective of the environment. Under the project goals the closure activity must avoid, contain or eliminate any and all fluid spills, use ALARA practices, generate a minimum amount of waste, protect workers from hazards and exposure to radioactive materials and meet the Integrated Safety Management System (ISMS) standard of Zero Accidents and Zero Occurrences. The expectations posed by these standards necessitated new thinking about traditional work methods and practices.

Standard oilfield practice uses a written downhole work program that assumes the actual fieldwork will be performed based on the knowledge and experience of the crews, engineering personnel and service providers on site at the time each individual portion of the program is undertaken. This traditional practice results in very short, simple work programs that leave many critical items not addressed and/or completely left for site personnel to develop the methodology depending on downhole conditions encountered.

At ORNL the thorough safety, planning and work practice standards for projects requires each and every individual step in a work plan to be fully analyzed and assessed by members of the project team prior to implementation. All plans must be complete and must include all of the minute details necessary to deal with any foreseeable downhole condition. Planning under these circumstances lead to the preparation of very different documentation than used in the oilfield or even in industrial work. Instead of the normal single page oilfield program, the team developed a detailed overall work program dealing with many common well issues and a set of individual detailed work plans for each individual well that addresses all phases of a well's particular downhole work. During the preparation, input from all parties was received and analyzed to improve the likelihood of achieving the project goals.

As work progresses, many of the individual plans are being changed as new and better techniques are found. Several modifications to the work plans have not only increased personnel safety but also resulted in increased efficiency. After each well is closed, the project team discusses the work and incorporates any improvements into the future work plans. In addition, TWO has adopted an internal system based on the "Lessons Learned" program. Any event that poses a new challenge or presents an opportunity for improvement is discussed by all of the TWO personnel involved. New modifications that are accepted or recommended by the TWO subgroup; are presented to and approved by the larger project team before implementation. This has led to several time saving modifications and safety improvements.

EQUIPMENT AND CONTAMINATION CONTROL

The project team recognized immediately that the use of conventional workstrings was neither the best nor the safest method for plugging the hydrofracture wells. Workstrings are composed of a number of individual joints of pipe screwed together while they are inserted into the wellbore to reach a predetermined depth. However, this poses an unnecessary work hazard and exposure potential by placing personnel above and/or near a possibly contaminated wellhead for long periods of time.

Instead of using conventional well service rigs, coiled tubing units are being used where it is possible. Coiled tubing is either steel or high-pressure plastic tubing rolled up like a garden hose. A guide system and injector head is used to straighten the tubing as it is lowered into the well or to place the tubing back on the spool during removal. Once the injector head is mounted to the wellhead, crewmembers are no longer required to work directly above the wellbore, thus significantly reducing exposure at the wellhead.

Sealing the outside of the coiled tubing to the wellhead is accomplished with a new piece of equipment developed specifically for the project. If a well is capped mechanically and has no method of safe entry, the casing is hot tapped using conventional equipment (some wells in the area are artesian). The pressure in the wellbore is bled to a containment tank via a hose connected from the tank to the hot tap unit. When the well is stable or not flowing back, the cap is removed and replaced with a flange. Then a standard oilfield blow out preventer is mounted atop the flange. Next a custom designed tubing seal and wash unit is bolted to the top of the blow out preventer. The wash unit contains an upper and lower seal that is hydraulically activated to tightly seal against the outside of the tubing. Four nozzles are located between the two seals. The nozzles are connected via high-pressure hoses to a combination high-pressure steam and water-pumping unit. The coiled tubing is put through the center of the seal and wash unit before it is lowered down the wellbore. The seals are activated to prevent any water from flowing out of the well. The blow out preventer rams are then opened to allow the tubing to go downhole. Clean uncontaminated water is slowly pumped through the inside of the workstring to prevent contamination of the workstring and circulate the well. Water is returned from the well and flows to a containment vessel for disposal later.

The wash unit is activated when the tubing is being withdrawn from the wellbore. The jets inside the unit spray water on the outside of the tubing to wash any contamination off the outer surface. All decontamination water is captured for disposal later. The upper seal is activated and acts as a squeegee to wipe the tubing dry.

On wells where a standard well service rig and a workstring must be used, a similar wash system has been fabricated to wash the outside of the conventional workstring. This unit is larger and can accommodate a variety if workstring sizes from 1-1/4" drill pipe thru 3-1/2" tubing by simply changing the upper and lower seal rubbers. The unit is mounted below the work platform on the back of the rig. The distance between the work platform and the wash unit is sufficient for the workstring to be lowered back into the wash unit before personnel come in contact if contamination is detected by either of the remote readouts connected to the Beta/Gamma pancake meters mounted atop the wash unit.

Standard radiation monitoring equipment is employed to monitor the dry tubing for contamination. The monitoring is accomplished by means of two Beta/Gamma pancake detectors mounted near the tubing directly above the upper seal. The sensors are cabled to a remote read out device to remove the reader (RAD Technician) from close proximity with the wellhead. The team's health physicist monitors the readings to determine if the tubing is clean and can be returned to the tubing reel, or must be handled as contaminated. If contamination is detected, the tubing or workstring can be lowered back into the wash unit for further cleaning before being removed from the wellbore. This setup significantly reduces hazards, possible personnel exposure, equipment contamination and waste.

The tubing wash unit has been used successfully to plug 33 hydrofracture wells to date. No recordable level of contamination has been found on the exterior of the tubing or transferred to the coiled tubing unit spool. In addition, the seals have prevented spills during insertion and extraction of the workstring.

SPILL CONTAINMENT

A number of individual containment units known as "rig pans" are used to contain spills around the pump unit, coiled tubing unit or service rig. After the well site is cleared of undergrowth and leveled to allow access to the wellhead by the well service equipment, 10-mil plastic sheeting is laid on the ground. A 40-mil pre-fabricated vinyl rig pan is laid on top the plastic. The equipment is then set on top of the rig pan. The outer edges of the rig pan are then raised to form a containment unit. The plastic sheeting is used to protect the rig pan from contamination that maybe present on the ground. This reduces cost and waste because the plastic sheeting is less expensive and bulky then the heavier rig pan. There have been no recorded spills during the well plugging activities.

The team has extensively used the ALARA concept to minimize exposure and reduce risk. Once the well site is cleared and checked for contamination, the hot tap is mounted to the casing. The unit is connected to the containment tank. A welder and fire watch enter the area. If the well has no pressure, the casing is cut off. A prefabricated extension is then welded to the casing. This minimizes the welding and personnel exposure time around the wellhead.

All of the equipment units, pump units, and containment tanks are linked together by hoses with quick connections. All connections are made and broken inside of the rig pans or containment areas. The hoses used are of sufficient length to eliminate connections outside of containment and all hoses can be flushed with clean water, blown out and/or drained before they are disconnected. Connection time and spill risk has been greatly reduced.

In all conventional drilling and workover projects the immediate area around the wellhead known as the cellar is the collection point for a great many spills. This problem area was addressed by having special cellar liners fabricated from 40-mil vinyl. Cellar liners look like an angel food cake pan. The inside of the liner has a round vinyl tube that extends upward.

The area approximately six feet in diameter around the well casing is dug out to a depth of approximately four feet. A corrugated culvert, five foot in diameter is placed over the casing and wellhead within the excavation. Once the culvert is in place, the cellar liner is placed in the culvert, the inner tube lowered over the casing stub and the top of the outer ring folded over the top of the culvert. Once in place the inner tube is connected to the casing using bandit material and chalk to form a seal. Any water or fluids collected in the liner are pumped out by means of an air-activated diaphragm pump connected into the return line of the well.

Another way waste is minimized is by viewing the fluid returning from the well through a clear section of hose. As cement is circulated from the bottom of well to fill the wellbore, water in the wellbore is displaced. A clear section of discharge hose is located next to the casing fluid exit point. As soon as cement can be seen in the clear section, pumping of additional cement is halted to minimize fluid generation. While this may seem trivial, compared to many standard oilfield techniques, waste generation is reduced by more then 75%. This greatly reduces the quantity of returned fluid that must be properly disposed.

CONCLUSION

This paper has dealt with some methods, techniques and processes that are being utilized to increase safety, minimize risk and increase the efficiency on the hydrofracture well plugging and abandonment project. These methods and devices have not increased the cost of the work but have functioned as designed without hindrance. Not mentioned is the extensive training required and serious attitude toward safety displayed by all members of the team. The group effort that has been part of this project since the beginning has profoundly affected the positive parts of the project. Many of these suggestions have originated from the crews who have taken the ISMS and ALARA systems to heart. All team members' suggestions are welcome and acted upon as soon as possible to maintain moral and continue attempting to meet the ALARA and Zero Accidents and Zero Occurrences goals.

The team has properly closed 33 wells that were known before work began and 9 wells that were located in the field during the work. The goals set forth in the project have all been met. There have been Zero Accidents and Zero Occurrences since fieldwork began. The project is on schedule and within the original budget. Both USEPA Region IV and TDEC have witnessed and approved the well closures without requesting or requiring additional work. The lessons learned on this project are being routinely applied to other TWO projects being conducted in the industrial sector. The ISMS and ALARA concepts do work when they are fully implemented by a unified team dedicated to the principles and practices of these important safety programs.