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B.W.I.P.
ES-1 SEALING
CONSIDERATIONS

February 9, 1983

INTRODUCTION

Based on personal experience, I foresee no reason why the proposed BWIP shaft seal materials will not be stable during the life of a nuclear waste repository - 75 to 100 years.

Listed below is some information which strengthens my belief that the current state of the art is satisfactory for use in constructing and operating a nuclear waste repository.

Discussion:
- Expanding Cement - General
- Expanding Cement - Case Histories
- Governmental and Private Sector Studies
- CSR - General
- CSR - Case Histories
- Questions and Answers

Articles:
- "New Cementing Process For Big Pipe In A Salt Plug"
- "Improved Bonding and Zone Isolation With A New Expanding Cement"
- "New Expanding Cement Promotes Better Bonding"
- "Drips or Blasts - Chemical Seal Ring Stops Water or Gas"

Dowell Literature:
- Discontinued Technical Report - "Dowell Chemical Seal Ring and Dowell Chemical Seal Ring Gasket"
- Technical Information Sheet - "Dowell Chemical Seal Ring"
- "Regulated Fill-Up Cement Controls Slurry Loss For More Predictable Fill-Up"

L. D. Boughton

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EXPANDING CEMENTS - GENERAL

The first known shaft use of an expanding cement with calcium aluminum sulfate hydrate producing the expansion was in completing the Project Dribble nuclear emplacement shaft. Aluminum powder has been used to generate gas in a cement slurry in an attempt to produce expansion, as well as various salts to produce expansion.

Several shafts had been drilled in the Tatum Dome, Mississippi, for the Project Dribble event. The primary cementing operations did not produce a dry seal as required. The event called for an absolutely dry environment. Over 50 remedial squeeze operations using various cement systems and plastics did not produce a dry test.

Chem-Comp cement, at the time (1964), was beginning to be used by the construction industry. This manufactured specialty cement is designed to chemically compensate for the shrinkage due to atmospheric drying. When placed in a humid environment it does not dry and consequently has a net expansion.

Dowell was called in, studied the Project Dribble problem and recommended a twofold approach. First was to use an expanding cement, and secondly to develop and use a unique chemical sealant as a backup to the expanding cement.

Due to the relative short storage life of unmixed Chem-Comp, limited production facilities, and to realize better quality control, Dowell developed a family of two expanding systems which have been named Regulated Fill Cement (RFC) and Self Stress. RFC is a thixotropic cement while Self Stress is not.

RFC was developed and first used in 1967. Industry recognized the merit of this cement system and immediately put it into use. It continues to be used as a cost effective well completion aid. Over 10,100 RFC jobs have been performed in the past two years in the US alone. Thousands more were performed by Dowell of Canada and Dowell Schlumberger throughout the remainder of the free world.

RFC is blended in the Dowell bulk plant servicing the particular cementing operation. The formulation is within prescribed limits and is designed for the specific operation.

EXPANDING CEMENT - CASE HISTORIES

1. Tatum Salt Dome, Mississippi. Project Dribble 1964. Salt formation. The integrity of the shaft permitted it to be used as an emplacement hole for two separate nuclear events. Refer to the enclosed article "New Cementing Process For Big Pipe In A Salt Plug" for details.

2. New Jersey - mined anhydrous ammonia storage cavern access shaft in 1965. A 42-inch shaft liner was sealed in a 56-inch hole drilled to 340 feet in mica gneiss. Expanding cement along with CSR was used to complete the shaft. No water leaked into the cavern nor ammonia out of the cavern which was mined in the gneiss.

3. Ambrosia Lake, New Mexico - in the late 60's. Shoot and Grout service was utilized to rubblize the Dakota formation to intersect natural fractures. The natural fractures in the Dakota have tremendous flow capacities in this area. The fractures, man-made and natural, were sealed with RFC.

   The 16-foot diameter shaft was air drilled to over 800 feet, with some misting from ungrouted formations toward total depth. A steel liner was grouted and the shaft put into duty as a production shaft.

4. Nuclear Emplacement Shaft - Central Nevada Supplemental Test Site.

5. Several Nuclear Emplacement Shafts on Pahute Mesa, Nevada Test Site.

6. Nuclear Emplacement Shaft on Amchitka Island. Grout lines could not be used below a bubble in the shaft lining. Two remedial pressure grouting jobs obtained a dry test.

7. Three Uranium Mine Shafts near Crown Point, New Mexico were not put into mining use due to depressed price of yellow coke - 1980.

8. Lead Mine Shaft near Ellington, Missouri was declared "bone" dry after opening the shaft below the liner - 1982.

9. Mined Product Storage Cavern Shafts throughout the US, primarily for LPG storage.

10. Numerous reservoir-type gas storage wells.

11. Bunker Hill Lead Mine Shaft in Missouri. Used to seal an 86-inch liner in a 108-inch shaft to 1450 feet - 1967.

GOVERNMENTAL AND PRIVATE SECTOR STUDIES

Dowell has conducted studies for governmental agencies. Our evaluation of these study results confirms the writer's opinion that RFC will meet the requirements imposed in operating a nuclear repository in basalt formations.

1. Subcontract No. 78X-15966C. A laboratory study of prospective materials for use in sealing boreholes in the vicinity of nuclear waste repositories. Subcontract to Union Carbide Corp., Nuclear Division, Oak Ridge, Tennessee.

2. Subcontract 78X033542C. Sealing AEC #1 Well, Lyons, Kansas. Utilize results obtained under Subcontract 78X-15966C to seal a borehole. Subcontract to Union Carbide Corp., Nuclear Division, Oak Ridge, Tennessee.

3. DOE Contract No. DE-AC02-77ET28324 for "Development of Geothermal Well Completion Systems - Final Report" - Report No. COO/4190-9, March 1981.

We have provided materials for testing by several agencies or their subcontractors but in turn have not received reports from them.

W.E.S. has conducted studies of expanding cements (Chem-Comp, Dowell RFC and Dowell Self Stress - all of which are in the same family). Studies were conducted for the AEC at Mercury, Tonopah, and Amchitka and for Sandia in the Carlsbad waste study and possibly others. Penn State, Arizona State and private labs have conducted studies of their own design and their own formulations using expanding cement components furnished by Dowell. We are not provided with copies of their findings.

In addition to the above, there are many scientific books dealing with cement and concrete. Many deal with expanding cement in which calcium aluminum sulfate hydrate is producing the expansion. Taylor's comments regarding sulfate ground water follows.

"It has been argued that concrete which has expanded might change its dimensions further or lose strength, when exposed to aggressive chemical agents such as ground waters containing sulfate ions, or even milder influences such as atmospheric carbon dioxide. In the former case this might be due to further calcium aluminum sulfate hydrate formation and in the latter case to its destruction by carbonation. There is little practical evidence to support these fears, which seem contradicted by the stability of supersulfated cement concrete when exposed to these agents."

GENERAL - CSR

CSR is a dispersion of a water-sensitive, high molecular-weight polymer in a glycerine, glycol mixture. A water soluble chromium compound crosslinks the polymer dispersion.

CSR was developed in 1964. We do not know of any accelerated tests that can be utilized to determine the durability of the material. Unfortunately it appears the only durability test is of necessity the actual project itself.

Some test results are included in the enclosed sales literature and articles. These are concerned primarily with short-term performance.

CSR was designed to function as a gasket. In a shaft the steel liner and drilled formation provide radial confinement while concrete or cement provides the vertical confinement. The CSR must be placed opposite impermeable formations with no vertical fractures so as to eliminate vertical flow through drilled formations as well as through the shaft wall-shaft liner annulus.

The confining cement or concrete must be of adequate vertical extent to achieve the desired gasketing action. Taking into account possible cracking of cement, as in a breakout, an extent of 50 feet of cement above and below 20 feet of CSR may be in order. A sufficient body of cement is required in case remedial operations are required. It is a consideration to safe mining operations.

CSR CASE HISTORIES

Dowell Chemical Seal Ring was developed in 1964 to solve a shaft sealing problem encountered by the AEC in attempting to complete a nuclear emplacement shaft for Project Dribble at the Tatum Dome in Mississippi. Since then CSR has been used for mine shaft seals and construction shaft seals. Case histories are cited as follows:

1. AEC nuclear emplacement hole for Project Dribble. The cavern created by the first test was dry due to the integrity of the shaft seal. The shaft served as an emplacement hole for a second nuclear event and remained dry even after the second shot. CSR was used in conjunction with expanding cement.

2. Anhydrous ammonia storage cavern mined in a granite gneiss formation in New Jersey. CSR was successfully used in conjunction with expanding cement. The cavern is operational.

3. CSR along with cement was next used to seal a conventionally sunken shaft used to mine an LPG storage cavern in shale. The shaft was sealed and the cavern was put into operation.

4. CSR was used to stem nuclear weapon tests shot at NTS and Amchitka.

5. CSR was introduced to the Canadian potash industry in the late 60's. The first use was a cautious seal of CSR backed up by the standard pikotage seal. Pikotage had been used for decades to seal the top and bottom of cast iron tubbing installed opposite aquifers by the Germans. Subsequent usage of CSR in potash mine shafts in Saskatchewan, England and Brazil has eliminated the use of pikotage at a major savings to the owners. In two instances an initial small leak was detected and pressure grouted to achieve a completely dry test. All of the mines are fully operational.

Canadian operations include:

Alwinsal - Bottom seal in conjunction with pikotage	1967
Sylvite - Salt protection ring in each of two shafts	1969
PCA -	
500'	1976
1700' below frozen Blairmore with no pikotage	1977
1400' above frozen Blairmore with no pikotage	1977
2700'	1978
Allan - Replaced asphalt seal of bottom catch ring	1968
Allan - One seal above and one below the Blairmore with no pikotage	1980
PCA - Catch ring	1969
Noranda - One seal above and one below the Blairmore along with pikotage	Late 60's
Whitby Chemical, Whitby, England - Seal assemblies in two potash mine shafts	Late 60's
Norsk Hydro, Norway - Two seals in an LPG cavern	1968

6. CSR was used to seal bulkheads in the former Morton Salt Co., Weeks Island, LA mine during its conversion for SPR usage. Crude oil is being pumped into the mine which will eventually hold some 60-70 million barrels of crude oil.

7. CSR was recently used to seal a mined storage cavern shaft in Taiwan, a salt mine in Southern Louisiana and a cast iron tubbing section in a German coal mine.

8. Three intervals of CSR were installed in the W.I.P.P. shaft near Carlsbad.

QUESTIONS AND ANSWERS

1. Q. What accelerated laboratory aging tests can be conducted within a six-month time period to simulate a 75-year time period?

   A. An extensive review of the problem indicates to us that a credible short-term accelerated test of CSR is not possible. Unfortunately the test is the actual operation itself which therefore places a premium on case histories of a material only 19 years old.

   A. Accelerated aging tests of cement systems have credibility, within limits. It is known in general terms that cement will not suffer strength retrogression from temperatures of less than 230°F and that specific additives will prevent strength retrogression due to temperatures in excess of 500°F.

   Similar cement systems can be manufactured to be sulfate resistant or through the use of additives such as in RFC a cement system can be made sulfate resistant. In neither case can the life expectancy be quantified with accuracy.

2. Q. Have shafts been successfully sealed under environmental surroundings similar to BWIP?

   A. We are not aware of any shafts completed in basalt formations. Shafts have been completed in more hostile environments - both temperature and formation waters. AEC operations involved shafts completed in tuff and ryholite.

   The physical characteristics of drilled formations such as vertical permeability, fractures, vugs and fissures, degree of consolidation, etc. have more of a bearing on water shut-off than does the chemical composition of other than soluble (evaporite) formations.

3. Q. What specific laboratory tests have been conducted and what are the results?

A. (1) Cement specimens were exposed to flowing geothermal brines at 150° to 170°C for up to 17 months. The brines were extremely corrosive, typically containing about 27,000 mg/L total dissolved solids. High concentrations of CO_2 and SO_4^{2-} were also present.

The results showed that, in general, normal density (14.5-16.0 ppg) portland cement-based systems with low permeability performed satisfactorily.

(2) Numerous studies have produced and confirmed the merit of systems which are resistant to sulfate attack.

(3) No accelerated CSR stability tests have been conducted. Confined samples prepared in 1964 remain stable. Unconfined samples of CSR in a large excess of water having a range of pH from 2 to 12 gradually disintegrate as cited in tests conducted by Rockwell.

(4) Physical tests of CSR and their results are contained in the paper titled "New Cementing Process For Big Pipe In A Salt Plug" and in the discontinued Technical Bulletin titled "Dowell Chemical Seal Ring and Dowell Chemical Seal Ring Gasket."

COMMENT:

During the entire operating life of the repository, the shaft will be open and repairs can be effected if necessary. In the installation of the final seal a section of the lining will be removed and a different seal material will be used.

New cementing process for big pipe in a salt plug

Expanding cement, chemical seal, aerated fluid successful with 20-inch casing to 2,200 feet

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T. B. Dellinger, Assistant Chief Drilling Engineer, Fenix & Scisson, Inc., Tulsa

A NEW CEMENTING PROCESS, using expanding cement and a special chemical seal, has proved successful in cementing large-diameter casing in salt plug at the Tatum Salt Dome near Hattiesburg, Miss.

The process involved the use of two new cementing materials, and was applied in the primary cementing of 20-inch casing in a 28-inch hole for Project Dribble, code name for a series of tests being conducted by the Atomic Energy Commission.

This is believed to be the first successful primary cementing job under such conditions, either in salt-mining operations or prior AEC operations. Careful preplanning and engineering, as well as use of the new materials, led to the success of the operation.

The usual problems encountered in cementing casing in a drilled hole increase greatly as casing size increases. Expansion and contraction of the casing due to pressure and temperature changes become critical with large diameter casing, and must be controlled to some degree if satisfactory bonding is to be obtained.

Cementing problems at Project Dribble were compounded by the existence of several major aquifers in the formations overlying the salt and by the need to positively seal the casing in salt and air drill below the casing.

Tatum dome geology. Figure 1 shows the general geology of the Tatum Dome. The top of the salt plug is about 1,500 feet below the surface. A 500-600-foot thick caprock covers the salt. The upper section of the caprock is highly fractured, vugular limestone about 150 feet thick, and the lower section is anhydrite. The anhydrite-salt contact is "mushy" and has been the interval of lost circulation in several of the holes drilled for Project Dribble.

Five major fresh water aquifers have been identified in the formations overlying the caprock. Communication exists between most of the aquifers and the caprock. The static fluid level is about 150 feet from the surface.

Over-all program design. Success of Project Dribble depends on positive exclusion of fluids from an open bore hole in the salt below the casing. After casing was cemented in the salt plug, the hole was evacuated and deepened by air drilling. During this and subsequent operations, the hole must remain completely dry.

[redacted]

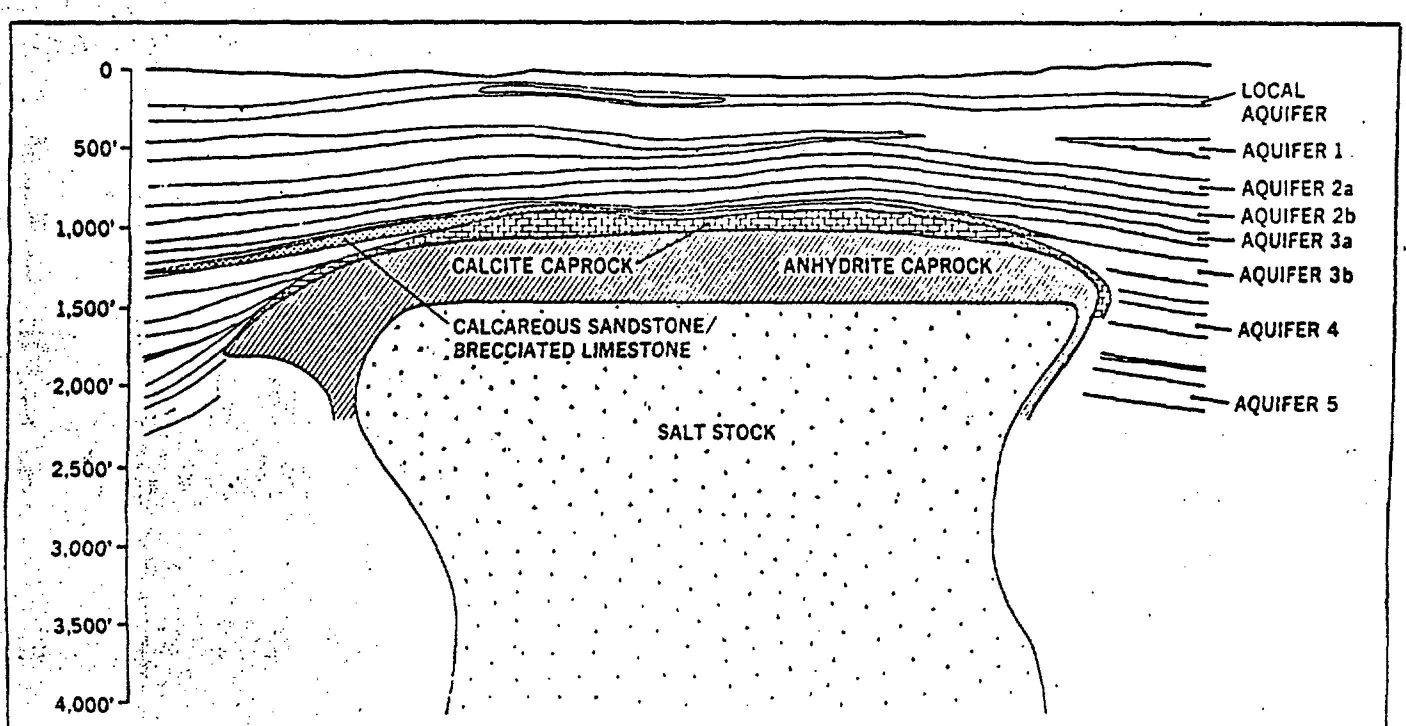

FIG. 1—General geology of the Tatum Salt Dome, scene of Project Dribble, near Hattiesburg, Miss.

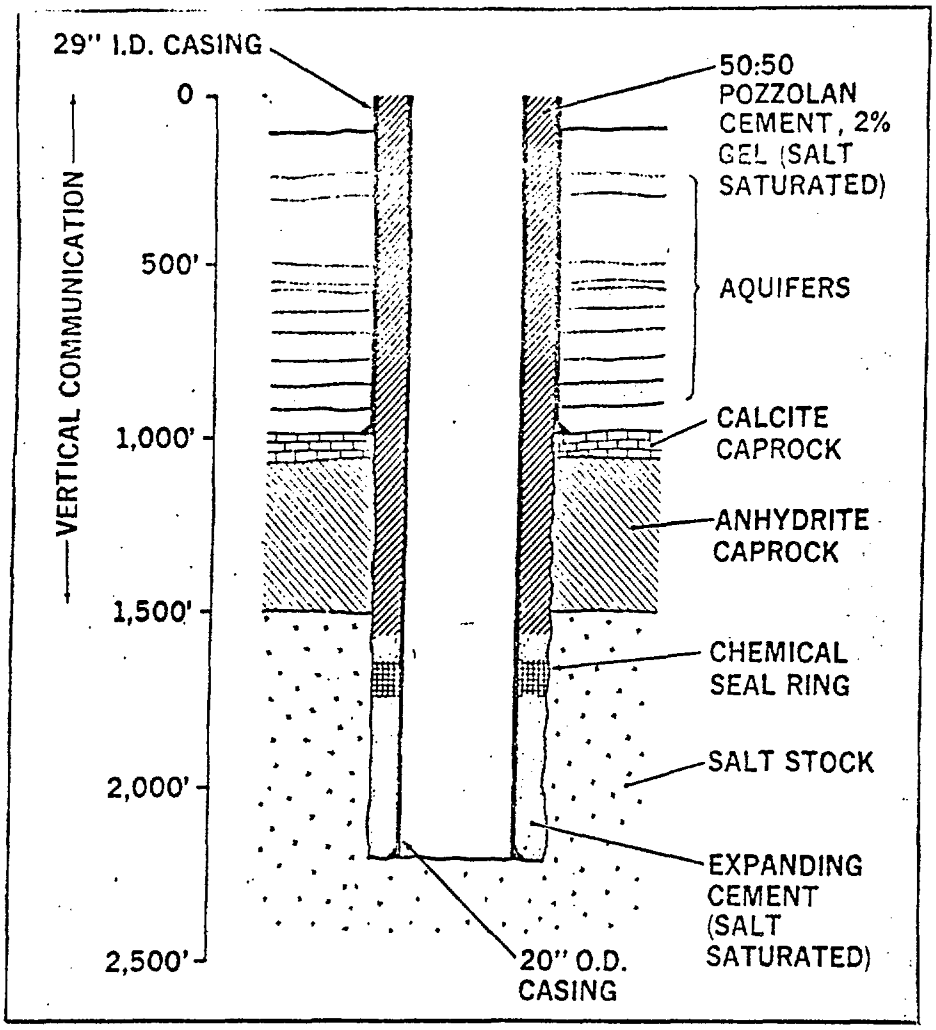

FIG. 2—Approximate placement of the various cementing materials in the unique big hole operation is indicated.

[redacted] Therefore, the entire drilling, casing and cementing program was designed to provide conditions favorable to an effective primary seal.

Drilling and casing program. A 28-inch hole was drilled with stabilized drill collars to produce a hole without doglegs. This allowed the 20-inch casing to be run freely and easily centered. Mud was designed to produce a minimum of washouts and sloughing so a gage hole could be maintained for good bore-hole deviation surveys. Maximum change of deviation of ¼ degree per 100 feet, with a total change of ½ of a degree per 500-foot interval, was established.

Pipe selected was 20-inch OD, weighing 133 pounds per foot. The portion of the pipe to go in the salt plug was cleaned and partially coated with an epoxy-sand for good pipe-cement bond. Centralizers centered the pipe in the hole, and scratchers cleaned the hole and helped prevent channeling during slurry placement. Plans called for reciprocation of the pipe before and during the first stage cementing operations and for five minutes after the shut-off plug had bumped.

Special stage cementing tools were built and tested to permit slurry placement according to a predesigned program.

Cementing program. All previous attempts to cement large-diameter casing in the salt stock were studied in detail before designing a cementing program. Factors of prime importance in contributing to an effective seal were given special attention in the design of the program. Some of these were:

Formation preparation. A study of salt cores indicated that shallow fractures or fissures on the salt formation wall could be caused by drilling. With this condition, a seal might not be obtained even though cementing materials completely filled the annular void between the casing and the formation. Therefore, shallow notches were to be cut in the formation wall by hydraulic jetting prior to running casing.

Type and placement of slurry. Due to vertical communication between aquifers, caprock and anhydrite-salt contact, plans did not call for a seal above the salt section. [redacted].

For the sealing cement in the lower 500 feet of the annulus, the cement would be such that it would not leach the salt and would bond hydraulically to both the pipe and salt formation. It would be placed in a primary stage.

Above this 500-feet cement section, 100 feet of chemical sealing material would be placed. This protective chemical seal would be in the competent salt section and would act as a first-line defense to prevent uphole water from contacting the lower pipe-cement-salt seal. The chemical seal would absorb water. Thus, it could expand and continue to provide an effective and strong seal. The chemical seal would be required to withstand a minimum differential pressure of 1,000 psi.

Above the chemical seal, an inexpensive filler cement would be placed and circulated to the surface. The filler cement was not expected to effect a hydraulic seal. Approximate placement of all materials would be as shown in Figure 2.

Compensation for differential pressures and temperatures. Differential temperatures created by heat of hydration of cement cause casing to expand during the cementing operation and the WOC period. At Project Dribble, bottom hole static temperature at 1,700 feet is 113° F. Pipe temperature, due to heat of hydration of the cement, was expected to be about 170° F to 180° F. Subsequent air drilling lowered this temperature by 100° F, causing significant casing contraction.

Hydrostatic pressure at the Tatum Dome at 2,200 feet is 860 psi. When the hole was evacuated after cementing, a differential hydrostatic pressure could cause further contraction of the

casing. Therefore, adverse effects of temperature and pressure differentials on the sealing stage of cement had to be minimized.

The internal hydrostatic pressure and pipe temperature was reduced by circulating gas-laden, 4½-lb-per gallon cooled fluid while the cement was setting and gaining initial strength. The 4½ ppg fluid reduced the internal hydrostatic head, but provided enough weight to prevent flotation of the pipe. Liquid CO_2 was introduced into a water stream at the ratio of 200 standard cubic feet per barrel of water to give an average fluid density of 4½ ppg to 2,200 feet. The liquid CO_2 also cooled the circulating fluid by 10° F.

To provide circulating means for the temperature and pressure reductions following the first stage, concentric tubular strings were used. An inflatable packer was run on 5½-inch drill pipe and set below the lower cementing stage tool. The 5½ by 20-inch annulus was packed off with a bradenhead.

A string of 2⅜-inch tubing was run to bottom inside the 5½-inch drill pipe, and the 2⅜-inch by 4½-inch annulus was packed off. Gas-laden water was circulated down the 2⅜-inch tubing, opposite the cement which had just been placed, and returned to the surface. To keep the stage tool and annulus open, mud was circulated down the 5½ to 20-inch annulus, through the lower tool and back to the surface (Figure 3).

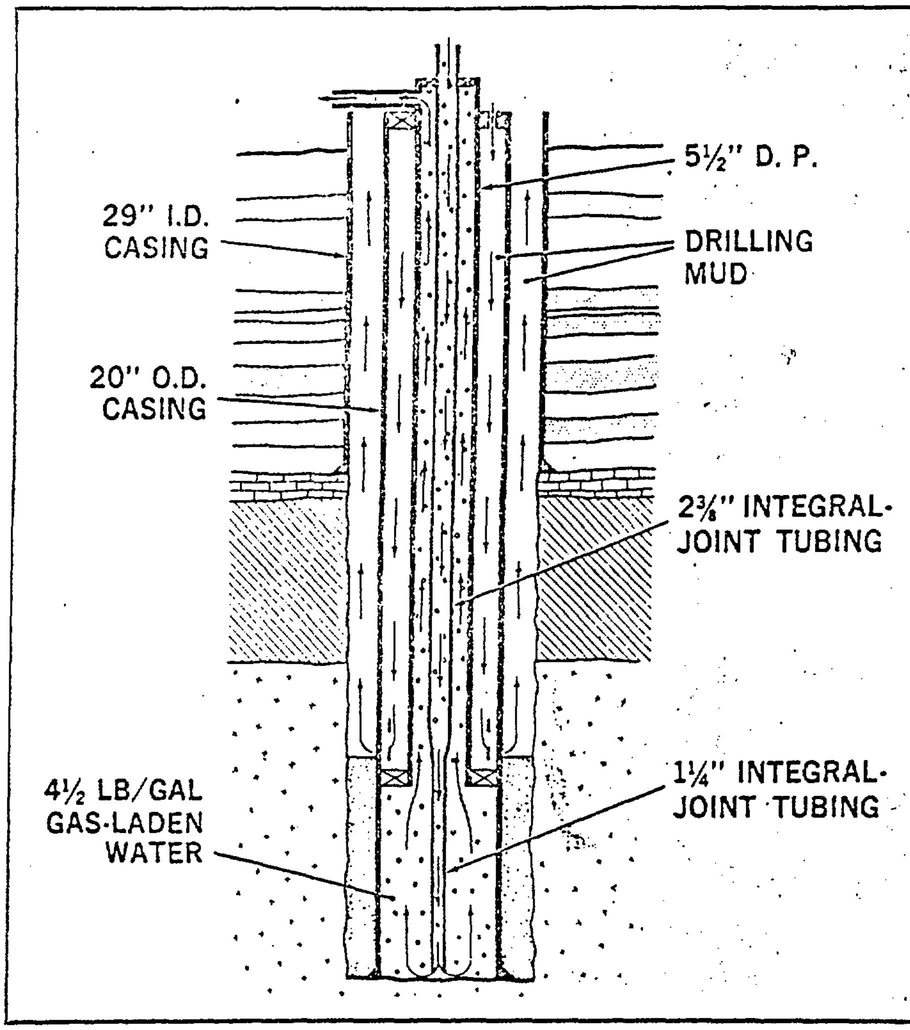

FIG. 3—Circulating system which controls internal hydrostatic pressure and pipe temperature. Liquid CO_2 was used to lower the density of the circulating water to 4.5 ppg, and also to cool the circulating fluid by about 10° F.

Materials selected. To fulfill material requisites for this job, special cement and a unique chemical sealing material were used.

To select the proper cement for the bottom 500 feet, many cement systems—as well as common cement—were lab-tested. Expanding cement was selected for the job. This cement shows a slight degree of expansion when setting, and it was felt that this would help compensate for pipe contraction during subsequent operations. Expansion tests of this material were conducted using API Class A cement as a control agent. Results are shown in Table 1.

Test data. Hydraulic bond tests were conducted by cementing salt cores in pipe sections, using salt-saturated Class A cement and salt-saturated expanding cement. Hydraulic tests of the Class A cement resulted in failure at the cement-salt contact. The contact of the salt and expanding cement did not fail; the salt cores failed at hydraulic pressure below that which would be imposed by the fluids in the hole. Results of the bond tests are shown in Table 2.

The compressive strength of the expanding cement was satisfactory, and density and yield were designed to insure that there would be no water separation.

TABLE 1—Cement Expansion Tests Volumetric

Class A Salt Saturated	Expanding Salt Saturated	Class A Neat	Expanding Neat
−1.37%	+0.68%	−2.02	+1.04

The cement samples were cured at 120° F and 1,500 psi. Reported values are averaged values for 9 days.

TABLE 2—Hydraulic Bond Test Data

Cement	Hydraulic Bond Strength, psi		
	Test 1	Test 2	Test 3
Expanding Cement (Salt-saturated)	375 psi*	390 psi*	360 psi*
Class A (Salt-saturated)	500	212	273

* Salt cores failed through fractures existing in core samples.

Chemical seal. The chemical seal was a polymeric material capable of setting or thickening. Thickening time of the chemical seal was adjusted according to conditions of temperature and pressure. Material used in the seal sets up in a rubbery mass somewhat similar in appearance to an art gum eraser. When water contacts the material, the water is imbibed and the seal ring expands.

As mentioned, the hydraulic bond test of the expanding cement was not entirely satisfactory since the salt core would permit passage of fluid when fluid pressure equal to that expected was encountered. This was believed to be primarily due to fractures created when coring the salt.

To insure that the seal ring would

[illegible] the same test setup was used as that used to conduct the hydraulic bond tests. [redacted].

Field tests were then run to determine the mixing characteristics when used in large volumes, and also to provide additional sealing-property tests at elevated pressures. [redacted]

About the authors

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THOMAS B. DELLINGER *is a drilling engineer with Fenix & Scisson, Inc. He has been working primarily on big hole drilling, being concerned in particular with large hole surveying and cementing. Dellinger holds a B.S. degree in Chemical Engineering from Purdue and a M.S. in Petroleum Engineering from the University of Tulsa. He is a registered professional engineer in Oklahoma and a member of the AIME. Dellinger's experience prior to joining Fenix & Scisson, Inc., included 11 years with the Creole Petroleum Corp. in Venezuela. Next he worked three years with Jersey Production Research Co. as a research engineer working mainly in improving drilling practices. During this time, he was a consultant to the foreign affiliate of Standard Oil Company of New Jersey on projects in Spain and France.*

[redacted]

Actual cementing procedure. To prepare the formation, shallow 2-foot vertical notches were hydraulically jetted with a sand abrasive at 1,900 to 1,902 feet, 1,686 to 1,688 and 1,627 to 1,629 feet. The drilling mud and hole were conditioned to run casing. A caliper log was run to determine the annular capacity for calculating cementing material requirements.

Casing was run to 2,200 feet and a single plug container was installed on top. The hole was circulated while pipe reciprocation was gradually increased from 2-foot to 30-foot strokes.

Twenty-four barrels of salt-saturated chemical wash were pumped into the casing, and the bypass plug was dropped. A scavenger slurry of 100 sacks of salt-saturated 90:10 pozzolan-cement with a dispersant was mixed and pumped. The salt-saturated expanding cement (1,486 sacks) with dispersant followed, and the top closing plug was dropped and displaced. A pressure increase was observed, indicating the closing plug had bumped. Pressure was released with no flowback.

The cementing head cap was removed. A retrievable opening bomb, attached to jars on a sand line, was run into the hole. This assembly had previously been made up and threaded through a second cementing head cap and made ready. The lower stage tool at 1,706 feet was opened with this bomb. Excess expanding cement was circulated from above the stage tool.

The 20-inch casing head was installed only after considerable difficulty and excessive delay. The procedure had to be changed at this point since it was evident that the originally planned cooling system could not be run and set prior to the time the expanding cement was taking its initial set.

The 5½-inch drill pipe was run to bottom. The 5½-inch by 20-inch annulus was packed off at the surface by welding the bradenhead to the casing. Liquid CO_2 was discharged into the mud tank to cool the mud. The cool mud was circulated down the 5½-inch drill pipe, up the 5½-inch by 20-inch annulus, to and through the lower stage tool, and up the annulus between the casing and formation wall.

Nineteen tons of CO_2 were introduced while circulating the hole at 3½ to 4 barrels per minute until 2 hours after the cement temperature had reached its peak due to heat of hydration. The average mud temperature while circulating was 88° F to the hole and 113° F returned from the hole.

A 24-hour WOC time period elapsed prior to the placement of the chemical seal ring. Twenty barrels of saturated brine and 36 barrels of salt-saturated chemical wash preceded the 2,520 gallons of chemical seal material.

A top plug, which was displaced with mud, followed the sealing material. The lower stage closed properly. The opening bomb to open the upper stage cementing tool was dropped, and the tool opened. Excess chemical seal material was circulated out of the hole from above the upper stage tool.

Samples of the chemical seal material were caught and put in a water bath at a temperature corresponding to bottom hole temperature. The WOC time was adjusted to insure a proper set of the chemical seal ring.

The third stage consisted of filling the annulus from the upper stage tool to the surface. Twenty-four barrels of salt-saturated chemical wash were pumped ahead of 3,660 sacks of salt-saturated 50:50 pozzolan-cement with 2 percent gel and tailed in with [illegible] sacks of salt-saturated expanding cement. The closing plug was dropped and displaced to a shutoff.

Following the cementing job, the hole was shut in for 24 hours to allow cement to set. Stage tools were drilled out and a 24-hour drillstem test run. This test was dry, indicating no fluid entry though the stage tools.

The hole was cleaned out to the float shoe, evacuated and shut in for 48 hours to take advantage of any salt creep that might occur around the evacuated casing. After 10 days, the casing shoe and 5 feet of salt plug were drilled. Another 24-hour drillstem test of the open hole below the casing indicated no fluid entry.

The hole again was evacuated and air drilled to contract depth of 2,800 feet in the salt plug with no evidence of fluid entry.

ACKNOWLEDGMENTS

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IMPROVED BONDING AND ZONE ISOLATION WITH A NEW EXPANDING CEMENT

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ABSTRACT

Cement bonding to the formation and subsequent isolation of productive intervals from non-productive intervals are essential to achieve the optimum results in stimulation and production of oil and gas. This paper describes a number of factors which cause poor bonding to pipe and formation and which can contribute to poor zone isolation and therefore ineffective stimulation treatments. A cementing system is described which combines the advantages of expansive properties with the other desirable properties of conventional cementing systems. The expansive properties of this system help to overcome the factors which contribute to poor bonding.

INTRODUCTION

Among the numerous techniques available to improve cementing results are mud conditioning[1], pipe movement,[1,2] and centralization,[2] use of scratchers,[2] and the efficient use of spacers and washes.[3] These techniques are designed to aid in mud removal resulting in the surface of the casing and formation being exposed. This allows for a more efficient bond between these surfaces and the naturally adhesive products of the cement. There are, however, certain conditions that can result in the formation of a micro-annulus and prevent good bonding, even though these techniques are employed. This paper describes conditions which can result in the formation of a micro-annulus and a new cementing system that is designed to overcome these problems and result in a tight bond between the cement, formation, and casing.

CONDITIONS LEADING TO THE FORMATION OF A MICRO-ANNULUS

Certain conditions leading to the formation of a micro-annulus (Figure 1) between the cement and the formation, or casing, are due to the chemical reactions of cement hydration and the mechanics of cement placement. Following the placement of cement, hydration reactions occur causing the cement to set, giving off heat. The liberated heat causes an expansion in the casing. After hydration is complete, the casing will eventually cool to the formation temperature and contract. The contraction of the casing causes it to pull away from the set cement forming the micro-annulus. Occasional failures of float equipment can also indirectly lead to the formation of a micro-annulus. When a piece of float equipment fails to function properly, it becomes necessary to hold pressure on the casing to prevent the cement from flowing back into it. This pressure expands the casing followed by a subsequent contraction when it is relieved.

H. G. Kozik reports contraction of casing can be in the range of 0.001 to 0.007 inch for 4-1/2 to 10-3/4 inch casing (depending on weight) for a 500 psi reduction in internal pressure. This contraction can also be caused by a temperature reduction of 60°F.

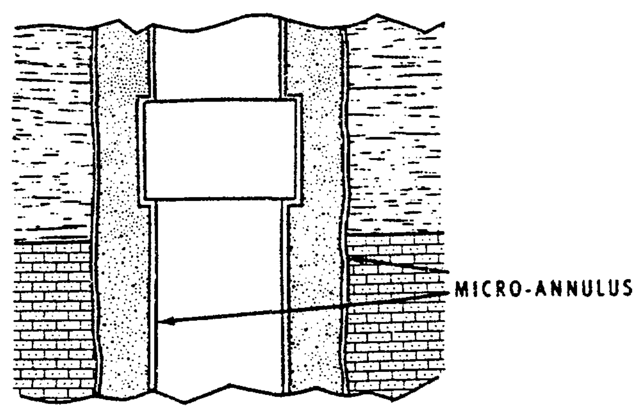

FIGURE 1 —MICRO-ANNULUS FORMED WHEN CASING AND OR CEMENT CONTRACTS AFTER SETTING.

A micro-annulus of 0.002 to 0.003 inch would show intermediate to poor bonding on a bond log.[4] Gas could readily pass through such an annulus if such conditions existed.

A mud film on the pipe and formation, tar, paraffin, and mill scale can also cause incomplete bonding. Shrinkage and cracking of the cement sheath are other instances leading to the formation of a micro-annulus. Cementing dry formations, such as ones encountered in air, gas, or mist drilling can result in a water loss to the formation as the cement is setting, resulting in shrinkage of the cement.[5]

PAST METHODS OF PREVENTING MICRO-ANNULUS FORMATION

In the past, several expanding cement systems were used to prevent or reduce micro-annulus formation. One of these involves the use of salt in Portland cement to produce a cement which expands more than the neat cement. These systems rely on crystalline growth for expansion.[6] This expansion occurs as the result of water being taken up during cement hydration, causing the salt to become supersaturated and to crystallize. A problem with this type of system is that exposure to formation waters which are not salt-saturated may allow leaching of the salt from the cement, causing contraction of the cement and an increase in its permeability.

Another cement system used to prevent micro-annulus formation is ChemComp* expanding cement.[7,8] This is a patented system developed to overcome the dry-shrinkage problem associated with conventional Portland cement which shrinks because of evaporation of water from the cement or concrete as it sets. The system was adapted for oil field use with very good results under most conditions.[9]

Unfortunately, this cement has limited storage life and does not respond well to oil-well cement additives. Also, it is only manufactured at a few locations and is not readily available in most oil and gas well producing areas.

NEW TECHNOLOGY: EXPANDING CEMENT

A new product which creates a self-stress in the cement has been developed to fill the need for an expanding cement. This "self-stress" cement expands after the cement has set and before it develops its complete compressive strength. It occurs while it is still pliable. Consequently, this cement maintains its integrity yet expands to maintain a tight fit around the casing as it shrinks. This prevents the formation of a micro-annulus and exerts pressure on any mud film, scale or tar which may be left on the casing. It sometimes penetrates the scale or film by crystalline growth of the cement. This maintenance of a tight fit results in a positive seal and superior bonding (Figure 2).

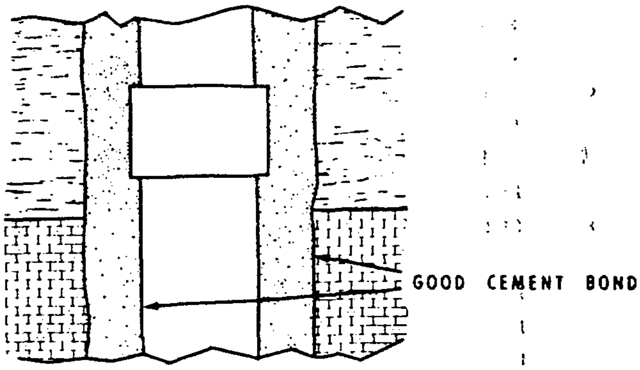

FIGURE 2—EXPANDING CEMENTS MAINTAIN TIGHT FIT AROUND CASING AS IT SHRINKS, THUS PREVENTING FORMATION OF A MICRO-ANNULUS.

Dowell's self-stress cement composition is more versatile than the commercial expanding cement described earlier, because it responds well to conventional oil-well cementing additives. As a result of this, it can be used in almost any circumstance where an expanding cement would be advantageous and other properties are desirable in the cementing system. An added benefit of the system is that the expansive reaction provides resistance to attack by sulfate waters.

LABORATORY DATA

Laboratory testing of the Dowell self-stress cement system indicates it is very suitable for use in oil and gas well cementing. Tests conducted confirm that it will respond adequately to retarders used in high temperature cementing. Figure 3 shows a comparison of the viscosity curves of two systems retarded for four hours pumping time at 302°F BHCT (16,000 ft casing schedule). Both systems contained silica for control of strength retrogression and an 0.8-percent high temperature retarder. Other results of thickening time testing are shown in Table

TABLE 1 –THICKENING TIME & COMPRESSIVE STRENGTH OF SELF-STRESS CEMENT SYSTEMS RETARDED FOR DOWNHOLE CONDITIONS

Class Cement used for Prep. of Self-Stress Cement	Density (ppg)	Other Additives	Thickening Time (Hr:Min)	Compressive Strength (psi) 8 Hr	24 Hr
Thickening time at 80°F, BHCT (Scd 1); compressive strength at 95°F, BHST					
A	14.8	--	+6:00	170	780
H	14.8	--	+6:00	95	450
G	14.8	--	+6:00	295	1370
Thickening time at 140°F, BHCT (Scd 5); compressive strength at 200°F, BHST					
A	14.8	--	2:03	2000	2895
A	15.1	Salt Sat'd	+6:00	1065	1545
A	14.9	50:50 Flyash	2:18	955	1600
H	15.0	35% Silica +.5% Retarder	+6:00	Not Set	1925
Thickening time at 197°F, BHCT (Scd 7); compressive strength at 260°F, BHST					
A	15.0	35% Silica +.5% Retarder	3:23	2080	3280
A	15.0	35% Silica +.5% Diacel LWL	5:17	1745	2440
A	15.0	35% Silica +.5% HT Retarder*	4:43**	2055	3405
H	15.0	35% Silica +.5% Retarder	4:47	925	2400
G	15.0	35% Silica +.5% Retarder	4:38	1655	3650

* HT - High temperature retarder
** Thickening time at 233° BHCT (Scd 8)

1 along with compressive strength data for the same systems.

Compressive strength testing indicates that the Dowell self-stress cement system, although mixed with more water, develops early compressive strength at a faster rate than comparable neat cement systems (Table 2). The six-hour compressive strength of a self-stress cement system prepared from Class C cement cured at 80°F developed greater strength than a Class C cement (which is a high early strength cement) cured under the same conditions. The neat cement systems will rapidly overtake the self-stress cement system in compressive strength as indicated by the Class G cement in Table 2. These neat cement systems develop higher ultimate compressive strength than the self-stress system, but the ultimate strength of self-stress is more than adequate for almost all applications. Plug cementing is an exception to this because development of very high strengths in short periods of time is desirable. Ultimate compressive strength of the self-stress system is in the range of 2500-5000 psi, depending on the cement used, amount of mix water, and other factors.

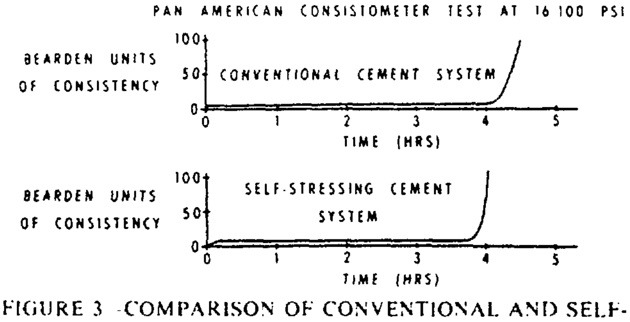

FIGURE 3 –COMPARISON OF CONVENTIONAL AND SELF-STRESSING CEMENT SYSTEM RETARDED TO 4 HOURS PUMPING TIME AT 302°F.

Figure 4 shows expansion data of Dowell self-stress cement compared to neat cement, ChemComp cement, and salt-saturated Portland cement. Normally, the self-stress system expands in

TABLE 2 COMPRESSIVE STRENGTH DATA

System	Density (ppg)	Cure Temp °F	Compressive Strength (psi) 6 Hr	1 Day	7 Day
Class G	15.6	140	--	2275	3925
Class G - Self-Stress	14.8	140	--	1070	1660
Class C	14.8	80	195	1925	--
Class C - Self-Stress	14.8	80	544	2120	--

the range of 0.20-0.50 percent, depending on chemical factors (variations in cement), degree of retardation, and temperature. Salt systems used as expanding cement expand from 0.10 to 0.16 percent compared to neat cement which expands 0.02 to 0.08 percent, again depending on some of the same factors. Expansion occurs from the time the cement is first mixed with water. The desirable expansion is primarily that which occurs after the cement reaches a rigid state and will not flow or move as it expands. It is then necessary to design expanding cement systems to have a minimum pumping time plus a workable safety factor in order to take advantage of as much expansion as possible.

FIELD APPLICATION

Dowell self-stress cement systems have been applied under a variety of conditions across the United States and Canada. Over one hundred treatments have been performed. Excellent results have been obtained, where in the past, logs have indicated little or no bond. The self-stress cement system is used like any other system. The dry ingredients are blended together with API Portland cement in the service company's bulk cement blending equipment. After being transferred to the well site by cement transports, it is mixed and

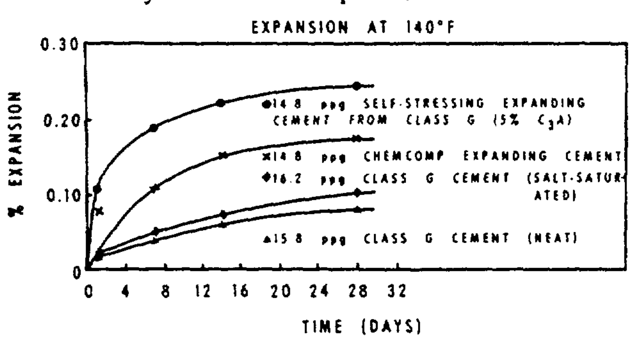

FIGURE 4—COMPARISON OF SELF-STRESSING AND OTHER EXPANDING CEMENT SYSTEMS.

pumped into the well by conventional cementing methods. Of course, the cement must be mixed as designed or the slurry won't have the proper characteristics. Depths of use range from shallow wells of 1000 ft or less to greater than 10,000 ft. Bottom-hole temperatures have ranged from 95°F to over 250°F. Virtually all conditions encountered in oilwell cementing can be safely handled with this system.

This system is so versatile that it is used in cementing where low density is required for control of lost circulation or high density for control of highly pressurized formations. By the use of conventional oil well cementing additives, the self-stress cement system can be adjusted to a wide variety of properties, such as fluid-loss control, dispersion for turbulent flow, and many more.

This system has been applied in shallow gas storage wells, deep liners in the Rocky Mountains, and medium depth liners and long strings. The following specific applications demonstrate the value of expanding cement in achieving zone isolation and good bond logs.

In Callahan County of West Texas, good bond logs of wells drilled through the Duffer Lime were very difficult to achieve. This is a fractured limestone at about 3300 feet. ChemComp expanding cement was used with good success to overcome the problems in achieving bond logs. However, since then the manufacture of ChemComp cement in this area has ceased. Self-stress expanding cement has been used in its place in numerous treatments with excellent bond log results. The wells in this area range from 2000 to 4500 ft deep with bottom-hole temperatures of 110-120°F.

Excellent results have also been achieved in Custer County, Oklahoma. A 2-7 8-inch liner (600-1000 ft long) was set to 10-11,000 feet in 4-3 4-inch

hole. Bottom-hole temperature was in the range of 190-200°F. Following cementing, the liners were pressure tested and logged to evaluate the cement job. Quite often, the pressure test indicates incomplete seal at the top of the liner and the bond log indicated poor cement bond. Similar treatments with self-stress cement have shown excellent results. Pressure tests showed a positive seal at the liner top and bond logs indicated good bonding.

These results are typical of those achieved when Dowell self-stress cement is used to overcome problems of zone isolation and bonding due to micro-annulus formation.

CONCLUSION

Like any advance in technology, a self-stress cementing system is no cure-all. It must be designed for the conditions of the well, and it must be applied using the best placement techniques well conditions will allow. It is one more step toward getting the optimum results from oil or gas well cementing.

REFERENCES

1. Suman, G. O., Jr. and Ellis, R. C.: "Cementing Oil and Gas Wells - Part 4", *World Oil's Cementing Handbook* (1977) 32-40.
2. Tiplitz, A. J. and Hassenbroek, W. E.: "An Investigation of Oil Well Cementing", *Drilling and Production Practice*, American Petroleum Institute (1946) 76-103.
3. Griffin, T. J., Jr. and Root, R. L.: "Cementing Spacers and Washes Improve Production", *Oil & Gas Journal* (Sept. 12, 1977) 115-122.
4. Kozik, H. G.: "Notes on Cement Bond Logging", Squeeze Cementing Symposium, Tulsa (Dec. 1977).
5. Setter, N. and Roy, D. M. P.: "Mechanical Features of Chemical Shrinkage of Cement Paste", *Cement and Concrete Research*, Volume 8 (1978) 623-634.
6. Hansen, W. C.: "Crystal Growth as a Source of Expansion in Portland Cement Concrete", American Society for Testing and Materials, *Proceedings*, Volume 63 (1963) 932-945.
7. Klein, A.: "Calcium Alumino-Sulfate and Expansive Cements Containing Same", *U S. Patent 3,155,526*: (Nov. 3, 1964).
8. Klein, A. and Troxell, G. E.: "Studies of Calcium Sulfoaluminate Admixtures for Expansive Cements", American Society for Testing and Materials, *Proceedings*, Volume 58 (1958) 986-1008.
9. Root, R. L. and Calvert, D. G.: "The Real Story of Cement Expansion", SPE 3346, Presented at SPE Rocky Mountain Regional Meeting, Billings, Montana (June 1971).

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New expanding cement promotes better bonding

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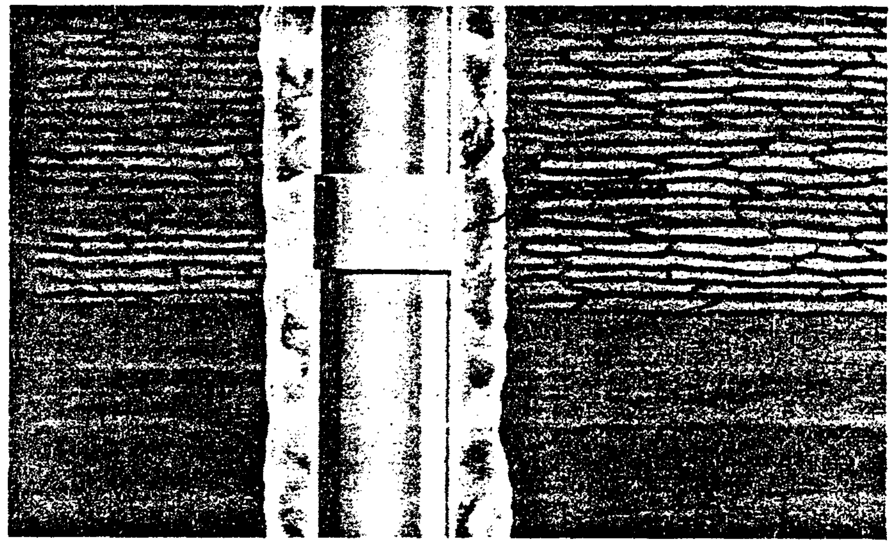
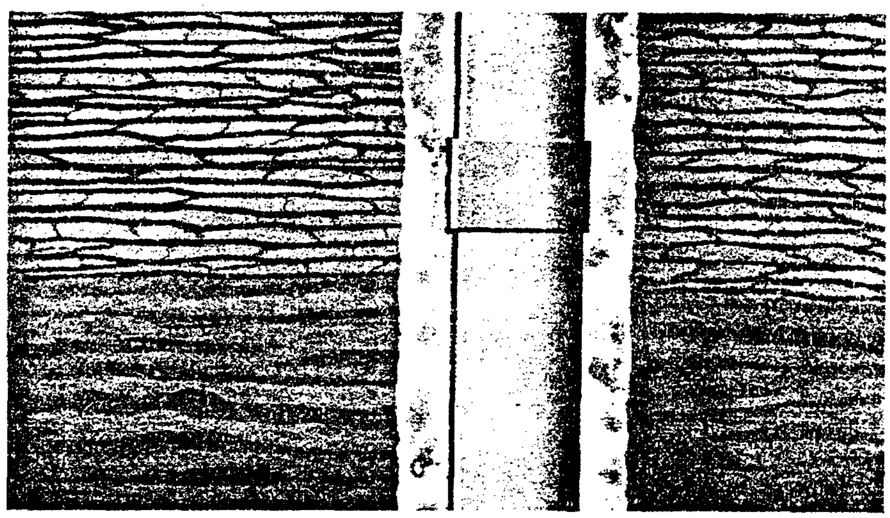
A VERSATILE cementing system has been designed to expand and provide a better pipe-cement and formation-cement bond in oil, gas, and gas-storage wells. Versatility is provided by its ease of preparation and use.

Self-stress cement is prepared at any local storage facility by dry blending an expansive component with normally stocked Portland cements. It is compatible with most cementing additives and is placed by conventional cementing techniques and equipment.



MICRO-ANNULUS formed by expansion and contraction of casing with conventional cementing systems (Fig. 1).



GOOD bond obtained by tight fit to casing and formation due to cement expansion (Fig. 2).

Inadequate bonding. Many factors can result in poor bonding of cement-to-pipe and/or cement-to-formation. These include mill scale or varnish on the pipe, mud filter cake, mud contamination of the cement slurry, incomplete mud removal, etc.

Most of these problems can be minimized by such procedures as cleaning the pipe, using scratchers, use of chemical spacers and washes during the cementing operation, and by the cementing technique itself (low displacement rate or turbulent flow with adequate contact time).

However, even with carefully designed procedures under ideal conditions, poor bonding can result from temperature and pressure-related expansion and contraction of the casing.

Expansion may occur during the cementing operation and while the cement is setting. Thermal expansion occurs as a result of the heat evolved as the cement hydrates.

Pressure expansion can occur when pressure is maintained on the casing to prevent back flow.

After the cement has set, the displacement fluid (usually drilling mud) is generally replaced with a completion fluid. Contraction of the casing can occur at this time again due to temperature and pressure effects. While some contraction probably has occurred due to the cement cooling to formation temperature after it has set, the contraction is compounded by the cooler completion fluids.

The reduction of pressure inside the pipe also causes contraction. This pressure reduction is caused by release of any pressure maintained on the casing and by the density differential between the mud and the completion fluid.

The overall contraction of the casing can cause it to pull away from the cement, either damaging the cement/casing bond or leaving a space referred to as a micro-annulus (Fig. 1).

Casing contraction. Kozik[1] reports contraction of casing can be in the range of 0.001-0.007 in. for 4½ to 10¾-in. casing (depending on weight) for a reduction of 500 psi in internal pressure. This contraction can also result from a temperature reduction of 60° F.

A micro-annulus of 0.002-0.003 in. would show intermediate to poor bonding on a bond log.

Not only can gas readily pass through such an annulus, but the annulus would provide a weak spot through which stimulation fluids under pressure might later migrate and result in failure of the stimulation job.

A micro-annulus might also be formed by shrinkage of the cement due to fluid loss when cured under dry conditions. This is not normally a problem since cement slurries cure under moist conditions down hole.

However, when cementing dry formations such as in air, gas, or mist drilling, water loss to the formation can cause drying conditions and result in shrinking of the cement.

Fig. 3

Expansion comparison

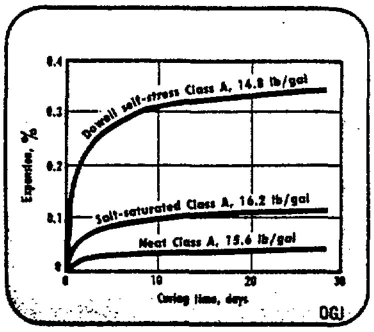
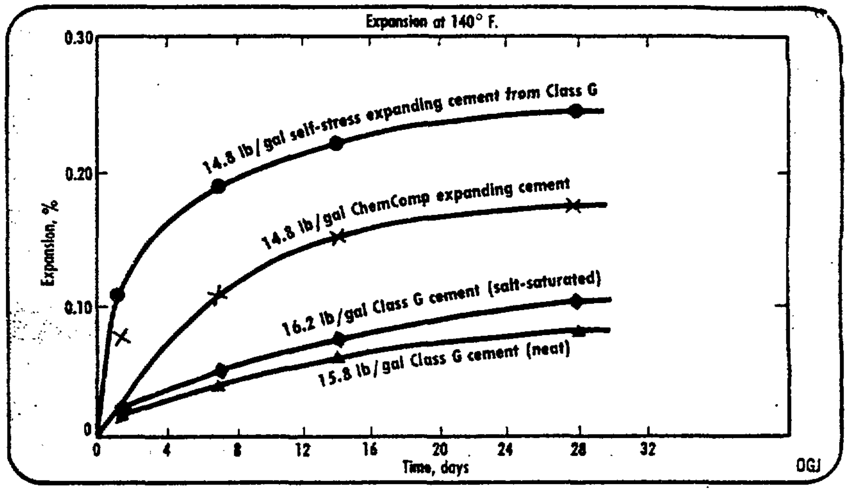


Fig. 4

Expansion with time



Previous expanding cements. It has been recognized for many years that an expanding cement might compensate for casing contraction and maintain a tight fit between casing and cement and formation and cement as shown in Fig. 2.

In the mid 1960s, two types of expanding cements were introduced to the oil industry and met with considerable success.

The benefits derived from the use of these expanding cements in terms of improved bond logs are well established.[2 3] The two systems used were ChemComp (trademark of the Chemically Prestressed Concrete Corp.) and salt-saturated cement systems.[2 3 4]

Major problems, however, have prevented these cements from being widely used and the full potential of expanding cements has never been fully realized. The commercial expanding cements did not respond well to retarders and often there was insufficient time to permit their use at higher temperatures.

Other problems were short storage life, requirements for separate storage facilities, and limited availability since they were manufactured in only a few areas.

Problems encountered with some of the salt-saturated cements were mainly fluid-loss control.

Self-stress cement systems. In order to take advantage of cement expansion, Dowell has developed a new product which creates a self-stress in the cement. This cement expands after its initial set but before it has developed its complete compressive strength.

In other words, expansion occurs while the cement is still pliable. Thus, the cement can maintain its integrity yet expand to maintain a tight fit around the casing as it contracts.

It exerts pressure on any mud film, scale, or tar which may be left on the pipe and can penetrate the scale or film by crystalline growth.

Many people believe that little adhesive bond exists between cement and formation.

Filter cake and adverse fluids, such as oil in the pay zone, minimize this type of bond.

If this is the case, then the seal between the formation and cement is probably due to the set cement following the contour of irregularities in the borehole and in the formations. Under such conditions, expanding cement could be highly advantageous.

Since self-stress exhibits a high degree of expanison, it maintains a tight fit not only against the casing but against the formation as well. Thus, it provides a more positive seal between cement and formation and reduces the possibility of interzonal communication (Fig. 2).

It also overcomes many of the problems associated with the older commercial expanding cements.

Since it is prepared from most brands of Portland cement already inventoried at cementing locations, there are no storage or availability problems.

The self-stress system is also compatible with conventional cementing additives. It responds well to retarders and can be used over a wide temperature range.

An added benefit of the self-stress system is that the expansive reaction provides resistance to attack by sulfate waters.

This greatly reduces the possibility of cement deterioration and subsequent casing corrosion.

Laboratory data. Laboratory testing of the new system indicates that it is suitable for oil and gas well cementing.

Ultimate compressive strength of the system is in the range of 2,500-5,000 psi depending on the cement used and amount of mix water. This is more than adequate for almost all applications.

Other tests conducted with the self-stress system indicate that it responds adequately to retarders and can be used in high-temperature cementing applications.

Results of the thickening time te of several different self-stress syste are shown in Table 1 along with compressive strength data for the same systems.

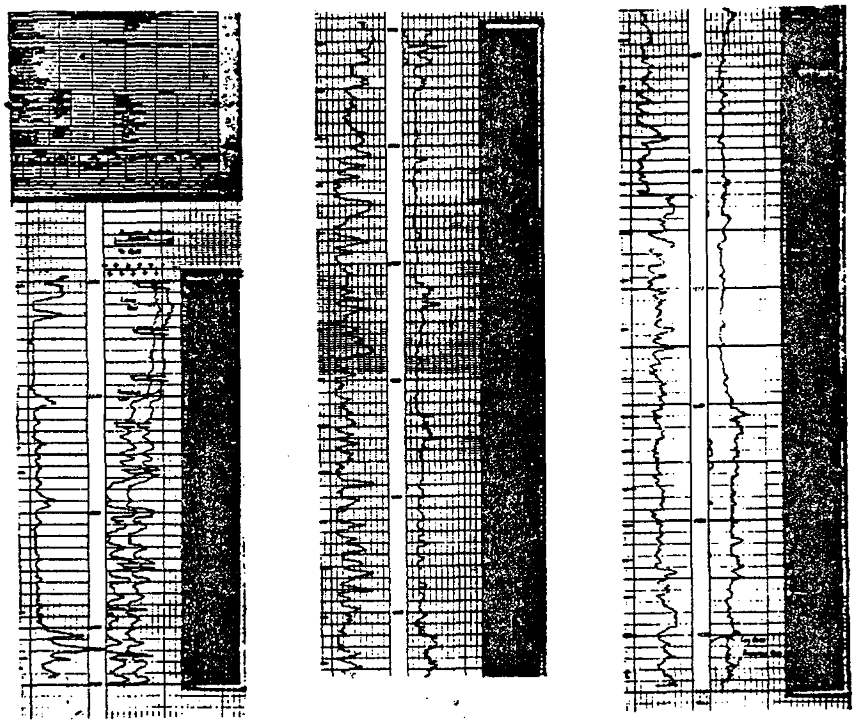
Comparative expansion data for a neat, a salt-saturated, and a self-stress slurry are shown in Fig. 3. Fig. 4 shows expansion data of self-stress cement compared to neat cement, ChemComp expanding cement, and salt-saturated Portland cement.

Usually the expansion of the self-stress system is in the range of 0.20 to 0.50% depending on chemical factors (variation in cement), degree of retardation, and temperature conditions.

Salt systems used as expanding cements expand from 0.10-0.16% compared to neat cement which expands 0.02-0.08%, again depending on some of the same factors.

Expansion actually starts when the cement is first mixed with water. However, the usable expansion is primarily that which occurs after the slurry reaches a rigid state and will not flow or move. It is important to design expanding cement systems with a minimum of pumping ti plus a realistic safety factor, in or to take advantage of as much expansion as possible.

Field applications. Self-stress ce-



BOND log from Hockley Co., Tex. (Fig. 5).

Table 1

Lab data on self-stress slurries

Cement class	Density, lb/gal	Other additives	Thickening time, (hr:min)	Compressive strength, psi 8 hr	Compressive strength, psi 24 hr
Thickening time at 80° F., BHCT (scd 1); compressive strength at 95° F. BHST					
A	14.8	....	+6:00	170	780
H	14.8	....	+6:00	95	450
G	14.8	....	+6:00	295	1,370
Thickening time at 140° F., BHCT (scd 5); compressive strength at 200° F. BHST					
A	14.8	....	2:03	2,000	2,895
A	15.1	Salt-saturated	+6:00	1,065	1,545
A	14.9	50:50 Fly ash	2:18	955	1,600
H	15.0	35% silica + 0.5% retarder	+6:00	Not set	1,925
Thickening time at 197° F., BHCT (scd 7); compressive strength at 260° F. BHST					
A	15.0	35% silica + 0.5% retarder	3:23	2,080	3,280
A	15.0	35% silica + 0.5% Diacel LWL	5:17	1,745	2,440
A	15.0	35% silica + 0.5% HT retarder*	4:43†	2,055	3,405
H	15.0	35% silica + 0.5% retarder	4:47	925	2,400
G	15.0	35% silica + 0.5% retarder	4:38	1,655	3,650

*HT—high temperature retarder. †Thickening time at 233 BHCT (schedule 8).

ment systems are used in the field in the same manner as conventional cement systems. The dry ingredients are blended with API Portland cement at the service company's bulk blending location. After being transported to the well site, it is mixed in the same manner as conventional slurries and pumped according to any desired cementing technique.

These systems have been used in more than 200 jobs and under a variety of conditions throughout the U.S. and Canada. Excellent results have been obtained in all areas including those where, in the past, bond logs have indicated little or no bond.

Well depths where self-stress has been used have ranged from less than 1,000 ft to greater than 10,000 ft.

Bottom-hole temperatures have ranged from 95° F. to over 250° F.

The system has been used in virtually all types of cementing operations including shallow gas storage wells, long strings, and deep liners. The following case histories demonstrate the value of expanding cement in specific applications.

Case history 1. Operators in Callahan Co., West Texas, have long had difficulty in obtaining good bonding as indicated by bond logs. ChemComp cement was used successfully to solve this problem until its manufacture was discontinued in this area.

Self-stress has since been used in numerous jobs, and bond logs indicate excellent results. These wells are from 2,000-4,000 ft deep with bottom-hole temperatures from 110-120° F.

Case history 2. Hockley Co., Tex., is another area where poor bonding was common. Fig. 5 is a bond log of a well in this area which was cemented with self-stress cement.

Excellent bonding of both pipe-to-cement and cement-to-formation is indicated. The pipe-cement bond line is difficult to discern since it lies directly on the base line throughout the interval except for an occasional small deviation.

Case history 3. In Custer Co., Okla., it is common practice to set 600-1,000 ft of 2⅞-in. liner in 4¾-in. hole to depths between 10,000 and 11,000 ft. Bottom-hole temperature is in the range of 190-200° F. Following cementing, the liners are pressure tested and bond logs are run to evaluate the cement job.

Frequently in the past, the pressure test had indicated an incomplete seal at the top of the liner and a squeeze job has been required. The bond logs have also indicated poor bonding.

Following cementing with self-stress cement, however, pressure tests have shown a positive seal at the liner top and bond logs have indicated good bonding.

Summary. Self-stress cement is a versatile new expanding cement with six advantages over other expanding cement systems.

Expansion properties are better than those of commercially available expanding cements. This expansion is far superior to that of salt-saturated systems.

Self-stress cement is prepared from Portland cement normally stocked at a cementing facility, so there is no storage life or availability problem.

The material is compatible with conventional cement retarders and is applicable over a wide temperature range.

Most cement additives, such as dispersants, fluid-loss additives, and ex-

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tenders, can be used effectively in self-stress systems.

Better fluid-loss control can be obtained than is available in salt-expanding systems.

Finally, it is sulfate resistant.

While self-stress cement is an important technological advance, it is no cure-all. However, when properly designed and applied with good cementing techniques, it can provide superior bonding and zone isolation in many situations.

Acknowledgement

The authors wish to thank the Dowell Division of Dow Chemical U.S.A. for permission to publish this article.

References

1. Kozik, H. G., "Notes on cement bond logging," Squeeze cementing symposium, Tulsa, Okla., 1977.
2. Carter, L. G., Waggoner, H. F., and George, C., "Expanding cements for primary cementing," JPT, May 1966.
3. Parker, P. N. and Wahl, W. W., "Expanding cement—A new development in well cementing," JPT, May 1966.
4. Klein, A., U.S. Patent 3,155,526, "Calcium sulfoaluminate and expansive cements containing same," Nov. 3, 1964.

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E. B. Nelson is a research chemist, Dowell, Tulsa. His research currently involves retarders for high-temperature application, and basic studies concerning cement chemistry. Nelson has been with Dowell 2 years since his graduation with BS and MS degrees in chemistry from Colorado School of Mines.

Epoxy aids large engine foundations

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Creole Production Services Inc.
Houston

A NEW hydrid foundation grouting system has been developed for stationary engines. It employs the best of the old grouting systems used for both marine and stationary engines.

The new system, which uses epoxy to cap the concrete foundation and epoxy chocks to support the unit, is a result of 50 years' evolution of grouting system design for both concrete block and steel beam foundations.

History. Experience with engine and compressor installation in both marine and petroleum industries has revealed advantages and disadvantages of a variety of foundation designs.

While the hybrid system essentially borrows much from the marine designs, an understanding of all the systems is necessary to appreciate the new design.

Marine engines. Marine engines have typically been installed on large I-beams in the ships' hulls. Adequate support was afforded, but the beam surfaces were not smooth enough to offer intimate contact with the milled bottom of the engine.

This problem and the problem of alignment were overcome by using "chocks," which are shim plates 1-2 in. thick located at each anchor bolt. The earliest marine engines used steel chocks which were hand-fitted by master craftsmen in a slow, tedious operation of filing and bluing.

To realign the engines, the chocks could be removed and their thickness changed.

Later, chocks made of type metal were employed. Type-metal is a lead-based alloy which does not shrink when it solidifies and is used to cast type for printing. The engine was aligned with wedges or jack screws, and asbestos or clay dams were constructed around each anchor bolt to contain the molten metal until it solidified.

The type metal technique performed satisfactorily, but it involved the safety hazards associated with handling hot metal. This metal also tended to pound out because of the cyclic loading.

In 1963, a specially formulated epoxy compound began to be used in the same manner as type metal. This epoxy chocking compound gained wide acceptance because it was safer to

REGROUTING 8,400-hp diesel engine foundation using hybrid design. Top to bottom, chock epoxy, grout epoxy, and epoxy concrete sealer.

work with than type metal. Although epoxy does not have compressive strength as high as type metal, the size of the chocks can be increased to achieve acceptable unit loadings.

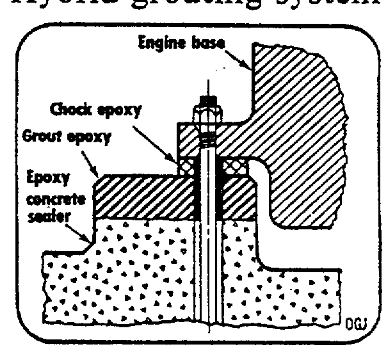
Epoxy chocks are used extensively in the marine industry. So far they have not been widely employed by the petroleum industry for stationary engines.

Stationary engines. Stationary engines are normally installed on concrete foundations with grouting systems using either sand and cement grout, or a cement grout with metal filler, or epoxy grout.

In the earliest type of grouting, sand

Fig. 1

Hybrid grouting system



Drips or Blasts—Chemical Seal Ring Stops Water or Gas

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ABSTRACT

A unique polymer sealant, placed as a pumpable slurry with ordinary well-cementing equipment, is described. The patented composition sets into a firm insoluble elastomer which forms gas and water-tight seals between shaft walls and shaft linings. Because the sealant swells when contacted by formation waters, it is able to protect potable water zones from gas stored in mined caverns while at the same time preventing migration of water into the cavern. It has also been used as a stemming material in nuclear device emplacement holes where it is the key material preventing escape of radioactive gases to the atmosphere. The material is also available in the form of prefabricated gaskets which can be compounded and molded to serve a wide range of applications.

The forerunner of this family of sealants was invented to stop water from entering a nuclear test hole in Mississippi. That successful job sparked a series of more and more difficult applications by imaginative engineers, and the products used today evolved to meet their requirements.

INTRODUCTION

During the completion of a hole drilled into the Tatum Salt Dome water, from many overlying aquifers, continued to "dribble" through the fractures in the caprock and made it impossible to obtain a dry shaft in the salt. Remedial work with cement had not solved the problem and, since the salt below had to be air drilled in order to provide a dry emplacement for a nuclear device, the success of "Project Dribble" was at stake.

The solution to this critical problem was a pumpable slurry which set up into a water-swellable elastomer and formed a self-sealing ring in the annulus between the formation and the steel casing. This so-called Chemical Seal Ring not only completely isolated the aquifers, but has withstood the shock of two nuclear detonations without failing.

Since then Chemical Seal Ring has successfully prevented the escape of radioactive gases through the tamped column above many nuclear devices tested underground. It has also efficiently kept water out of mined caverns used to store natural gas and liquified ammonia. A major use was in confining high-pressure aquifers so that mine shafts could be dug into the rich potash deposits of Saskatchewan.

Prefabricated gaskets of Chemical Seal Ring promise to make construction of water-tight steel tunnel and mine-shaft linings easier and less expensive.

The materials for Chemical Seal Ring are mixed and placed, batchwise or continuously, with regular oil-well cementing trucks. The resulting slurry, after a controlled thickening or working time, sets, at a predictable time, into a rubber-like solid. When the proper cross-linking additives are used, Chemical Seal Ring has the unique property of swelling, by imbibing water, but not dissolving. Thus, when properly confined, Chemical Seal Ring forms a permanent self-actuating seal.

Prefabricated gaskets are made by adding suitable fillers and curing the slurry, in molds, under controlled conditions. Joints, and bolted flanges for tunnel and mine-shaft linings have been sealed with Chemical Seal Ring gaskets and have

withstood 1400 psi water pressure during long-term tests. Specially designed seals have withstood cyclic tests where the maximum water pressure was 4500 psi.

PROPERTIES OF CHEMICAL SEAL RING

In general there are two types of Chemical Seal Ring placeable as a pumpable slurry: (1) a composition intended primarily for sealing gas, and (2) a composition intended for sealing water as well as gas. Each can be modified to control loss of fluids to formations by including an inert material such as silica flour.

The solid component is a linear polyacrylamide. The mixing fluid consists of polyhydric alcohols and water. When a Chemical Seal Ring must permanently seal off water, a cross-linking agent is dissolved in the water.

Slurries have an initial viscosity of about 5 to 15 poise, depending on the temperature, when mixed. The compositions are varied, with the mixing temperature, to provide a working time of about 30 minutes. The setting time, arbitrarily 10,000 poise, or the time other operations may be resumed, varies between 2 and 4 hours depending on the temperature where the slurry has been placed.

Prefabricated gaskets are made by curing a composition that is augmented with polymer, filler and cross-linker under controlled conditions. The gaskets produced can be molded in any desired shape or stock can be cut and ground, like rubber, for custom fitting.

After setting, both the slurry and gasket compositions will swell several hundred percent if immersed unconfined in water (Fig. 1). This occurs at high water pressures as well as at ordinary pressures. Uncross-linked compositions will, of course, eventually go into complete solution; however, Chemical Seal Ring slurries and gaskets contain a cross-linking system. Thus, the cross-linked Chemical Seal Ring will swell only until tensile and swelling forces are equal and will not dissolve. The behavior is similar to a sponge.

Table 1 gives some of the physical properties of a typical gasket composition (CSRG-201) and a typical slurry composition (CSR-300) after aging 30 days at ambient temperature.

Life expectancy of Chemical Seal Ring is of interest. Since the material is relatively new, by time standards, and [redacted]

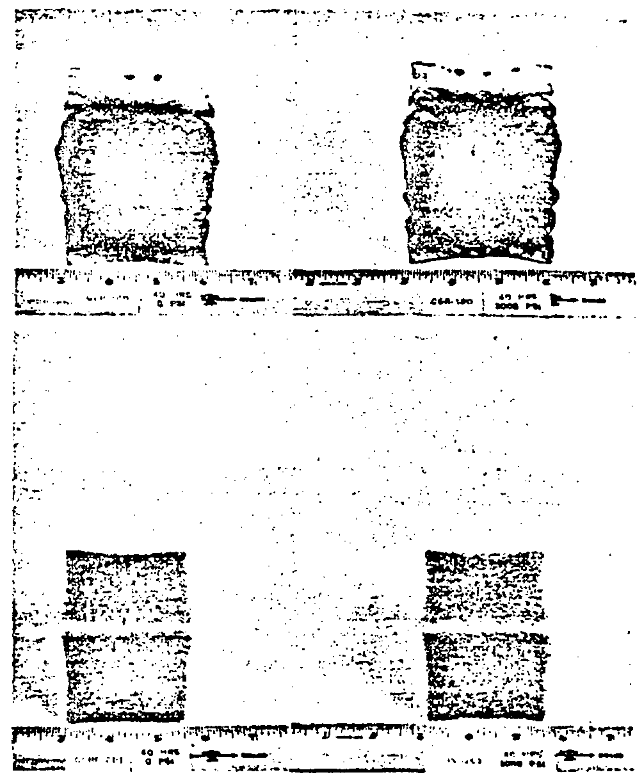

Figure 1. Swelling of Chemical Seal Ring after 40 hours at zero and 1000 psi: Top, CSR-300 Bottom, CSRG-201.

[redacted] In the range of pH between 2 and 12 the sealant only swells as if it were in water. In fact, formulations having acceptable properties have been made using 10% sulfuric acid instead of water as part of the mixing fluid.

Several important features of Chemical Seal Ring stem from the nature of the chemicals used in its manufacture. A corrosion inhibitor prevents rust wherever the sealant is in contact with iron. This is extremely important in mine shafts.

Gaskets in the warehouse need only be protected from rain—normal humidity does not result in noticeable dimension increase. In tropical storage, however, dimensional changes may occur; but, the pliability and compressibility allows gaskets to be used with no more trouble than that given by any other prefabricated sealing material.

With regard to possible fire hazard, the polyhydric alcohols used apparently become an integral part of the cured polymer, because no fluid can be squeezed out by any mechanical pressure. Furthermore, a standard method of flame

Table 1. Properties of Chemical Seal Ring Formulations.

Property	Specimen Thickness (inches)	ASTM Method	CSRG–201 Gasket System	CSR–300 Slurry System
Tensile Strength, psi	1/8	D412-66	61	60
Tensile Strength, psi	1/4	D412-66	80	56
Elongation, %	1/8	D412-66	118	330
Elongation, %	1/4	D412-66	137	335
Secant Modulus, 2% Elongation, psi	1/4	D638-64T	151	33
Shear Strength, psi	1/2	D732-46	192	58
Tear Resistance, lb/in	1/8	D1004-66	13.1	7.8
Tear Resistance, lb/in	1/2	D1004-66	14.7	7.1
Hardness, Shore A	1/2	D2240-64	30	10
Thermal Conductivity, BTU-in/hr·°F Ft²	1	Dow Heat Meter	3.3	2.0
Compressive Strength, psi at:				
5% deformation	1	D695-63	7.3	1.3
10% deformation	1	D695-63	15.0	2.7
25% deformation	1	D695-63	44.0	8.0
Compressive Modulus, psi	1	D695-63	146	27
Resistivity, ohm-cm	1/4	D257	2.7×10^7	5.2×10^7
Compressibility, in/in/psi	—	—	—	7.02×10^6
Density, gm/cu cm	—	—	1.367	1.194
lbs/gal	—	—	11.40	9.96
lbs/cu ft	—	—	85.27	74.50

testing (ASTM D1692-59T) has shown that the gasket is self-extinguishing. "Samples tend to burn only on the exterior and would not flame-propagate after removal of the flame source."

Setting of Chemical Seal Ring does not release any measurable heat. Thus, large pours are no problem in this respect. Thickening time control methods have been developed which allow slurries to be placed at ambient temperatures from 40°F to 1[illegible]°F.

Each application of Chemical Seal Ring slurry as an annular seal in, for example, a mine shaft will require application of good engineering design [redacted]

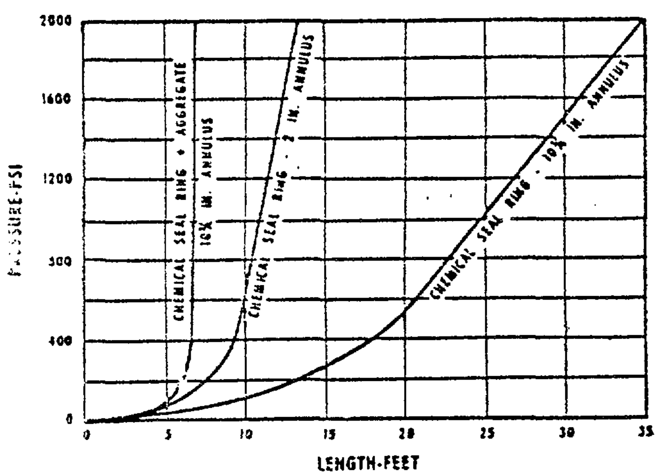

Figure 2. Length of Chemical Seal Ring required for the pressure to drop to zero psi.

[redacted]

Another test of interest was extrusion resistance. [redacted]

CASE HISTORIES

The following case histories have been selected to give a historical as well as technical introduction to Chemical Seal Ring applications:

Project dribble.

One of the early uses of Chemical Seal Ring was in cementing 20-inch casing in a 28-inch hole in competent salt stock at the Tatum Salt Dome near Hattiesburg, Mississippi (Dillinger and Boughton, 1965). Many overlying aquifers and a fractured caprock had made it impossible to obtain a dry shaft in the salt. Since the rest of the hole was to be air drilled to provide a dry emplacement for detonating a nuclear device, the success of the entire project was at stake. Many remedial squeeze jobs with cement and other sealants had failed to obtain a dry shaft. The Dowell Division of Dow Chemical Company, however, quickly developed a solution to the problem.

A new sealant (Eilers and Parks, 1967), placed as shown in Figure 3, resulted in a completely dry shaft.

A nuclear device was detonated in the salt and the shaft still was dry. Later operations in the shaft wore a hole through the casing opposite the sealant, but no leak occurred. After a steel liner was set and cemented to cover the hole, a second device was detonated in the cavity formed by the first shot. The shaft remained dry and is dry at the present time, almost five years later.

Project long shot.

Another special Chemical Seal Ring composition was developed to prevent radioactive gases from venting through the stemming column above an 80 kiloton nuclear device fired on Amchitka Island in 1965.

The composition previously used in Project Dribble was impractical for use in cold climates; therefore, different materials had to be used. Enough materials to make 500 gallons on the job

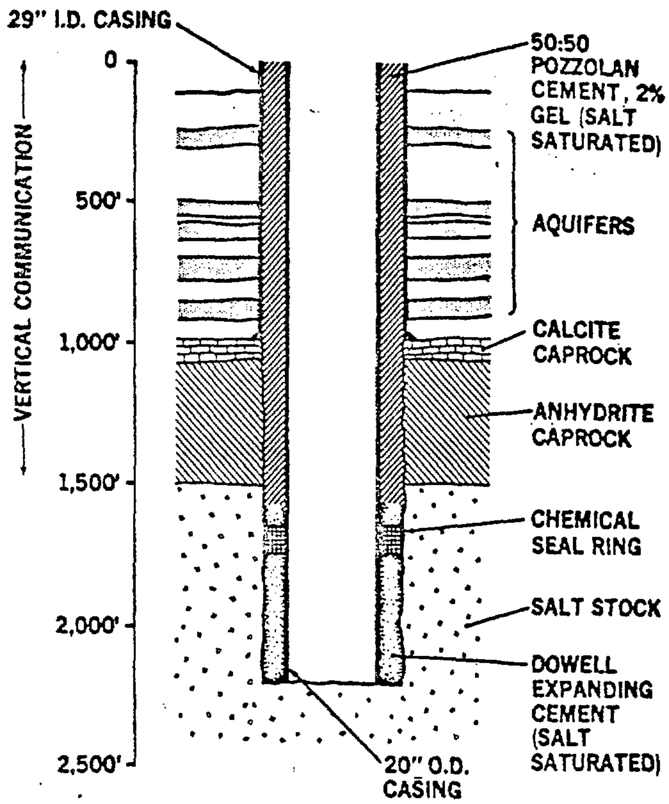

Figure 3. Drawing of placement of Chemical Seal Ring at the Tatum Salt Dome.

were flown from Tulsa, Oklahoma to the island and a Dowell chemist supervised the mixing and placing of the sealant in the hole—four days before the detonation. The device was at a depth of 2,300 feet in a 32 inch casing. The stemming column consisted of layers of sand and cement topped off with a 10 foot "cork" of chemical sealant which worked perfectly.

Nevada test site applications.

Since the successful use of Chemical Seal Ring at Amchitka Island, many jobs using continuously improved compositions, have been done for the Atomic Energy Commission at the Nevada Test Site. Probably the largest of these jobs was done in February, 1966. A total of 17,000 gallons was successfully used to seal a 12-ft diameter hole. In this test, no leak developed even when the entire system dropped 100 feet to form a huge crater after the device had detonated.

Natural gas storage cavern.

The first non-atomic application of Chemical Seal Ring was done in the 10 foot diameter access

hole to a cavern mined for storing natural gas. The job was done in November, 1965, in northern Illinois. The customer had completed the first stage of cement in the annulus between 30 inch casing and the 10 foot diameter hole through which the cavern had been mined. Sheet iron was used to form 8 inch thick × 3 foot deep molds around the 30 inch casing and on the periphery of the hole. A total of 750 gallons of Chemical Seal Ring slurry was mixed and pumped, with an ordinary oil well cementing truck, to fill these molds. After the slurry was set, the balance of the hole was filled with concrete.

The two doughnut-shaped seals in this shaft serve to keep gas from seeping up the annulus to a water zone which furnished potable water to the areas nearby. At the same time, of course, the sealant also prevents migration of the water down into the cavern.

Liquid ammonia storage cavern.

In 1966 the vent and access shafts at DuPont's Repauno Plant in Gibbstown, N.J., were sealed with a Chemical Seal Ring composition designed to withstand liquid ammonia at -28°F (Better Living, 1968).

The access hole contains about 340 feet of 42" casing. The Chemical Seal Ring was placed in the annulus, through 2 inch grout lines, and confined above and below with portland cements. The 1,174 gallons of Chemical Seal Ring used formed a 25 foot long seal which has the dual job of keeping water from seeping down and keeping ammonia gas from leaking upward through the annulus.

Chemical Seal Ring in potash mining.

In February of 1967, 3,420 gallons of a new type of Chemical Seal Ring (S.A. Pence, U.S. Patent, 1968) were poured into the annulus between an 18 foot I.D. mine shaft lining and a salt formation about 2,870 feet below the surface as shown in Figure 4. After the lining had been built up to 1,832 feet, another 1,125 gallons of Chemical Seal Ring was placed as shown in Figure 5. Although some repair grouting was necessary, it was felt that the use of Chemical Seal Ring contributed greatly towards the successful driving of a dry shaft (Storck, 1968). This mine produced its first ton of potash in October of 1968.

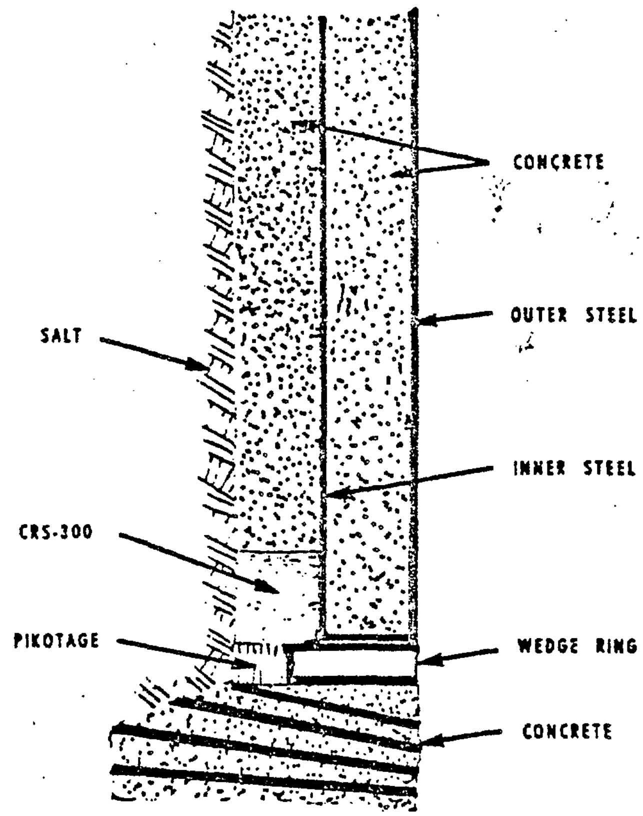

Figure 4. Installation of Chemical Seal Ring in a potash mine at 2870 feet.

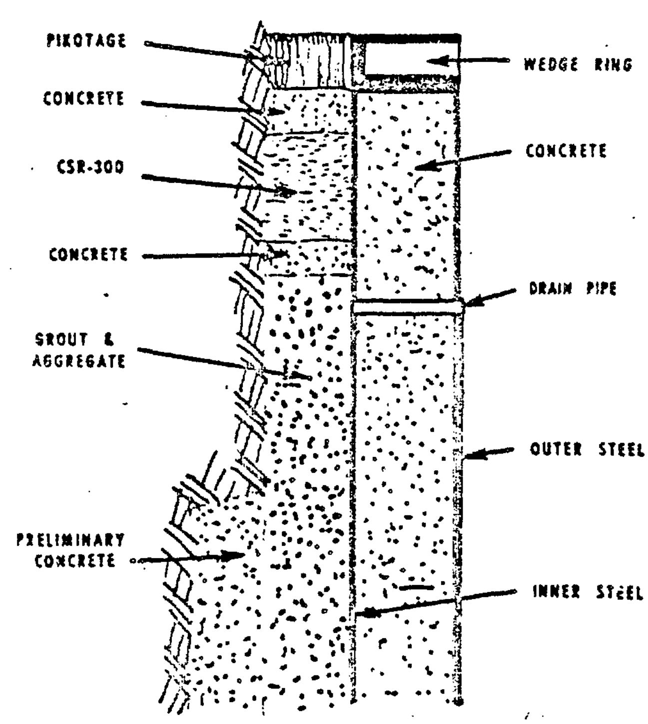

Figure 5. Installation of Chemical Seal Ring in a potash mine at 1832 feet.

SUMMARY

A unique polymer sealant, placed as a pumpable slurry with ordinary well-cementing equipment, is described. The patented composition sets into a

firm insoluble elastomer which forms gas and water-tight seals between shaft walls and shaft linings. Because the sealant swells when contacted by formation waters, it is able to protect potable water zones from gas stored in mined caverns while at the same time preventing migration of water into the cavern. It has also been used as a stemming material in nuclear device emplacement holes where it is the key material preventing escape of radioactive gases to the atmosphere. The material is also available in the form of prefabricated gaskets which can be compounded and molded to serve a wide range of applications.

The forerunner of this family of sealants was invented to stop water from entering a nuclear test hole in Mississippi. That successful job sparked a series of more and more difficult applications by imaginative engineers, and the products used today evolved to meet their requirements.

ACKNOWLEDGEMENT

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REFERENCES

Better Living, Sept./Oct. 1968, p. 11-13.

Dellinger
T.B., and Boughton, L.D., 1965, "Unique Materials Mix Used to Seal Large Diameter Casing in Borehole," *E. & M.J.*, v. 166, no. 6, p. 114-118.

Eilers, L.H., and Parks, C.F., February 28, 1967, U.S. Patent 3,306,870.

Pence, S.A., Jr., October 1, 1968, Can. Pat. No. 795,843. U.S. 3,502,149

Storck, U., 1968, "First Use of Double Steel and Concrete Sandwich Lining for Keeping High Pressure Water Out of a Potash Shaft," Paper no. 28, 70th Annual Mtg. The Canadian Institute of Mining and Metallurgy, Vancouver, B.C., April 1968.

Dowell Chemical Seal Ring and Dowell Chemical Seal Ring Gasket

Technical Report

DOWELL

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INTRODUCTION

Dowell Division of The Dow Chemical Company developed Chemical Seal Ring to provide fluid-tight seals between shaft walls and shaft linings. It has been used successfully to seal tunnel liners, casing in gas storage wells, mine-shaft liners and casing in oil and gas wells. It has also been used as a tamp (stemming material) in nuclear emplacement holes and has been a key material in preventing the escape of radioactive gases into the atmosphere. The unique properties of Dowell Chemical Seal Ring suggest its use for a wide range of applications.

Two formulations of the material for Dowell Chemical Seal Ring have become the most widely used: the 300 system which is used for slurry placement, and the 201 system which is cast into gaskets, sheets, strips, water stops, or into almost any desired shape. The physical properties of both systems are shown in Table I.

TABLE I

PROPERTIES OF DOWELL CHEMICAL SEAL RING FORMULATIONS

Property	Thickness, Inches	ASTM Method	201 System	300 System
Tensile Strength, Ultimate, psi	1/8	D412-6	61	60
Tensile Strength, Ultimate, psi	1/4	D412-6	80	56
Elongation, Ultimate, percent	1/8	D412-6	118	330
Elongation, Ultimate, percent	1/4	D412-6	137	335
Secant Modulus at 2% Elongation, psi	1/4	D638-64T[2]	151	33
Shear Strength, psi of Shear Area	1/2	D732-46[3]	192	58
Tear Resistance, lbs/in of Thickness	1/8	D1004-66[4]	13.1	7.8
Tear Resistance, lbs/in of Thickness	1/2	D1004-66[4]	14.7	7.1
Hardness, Durometer A	1/2	D2240-64T	30	10
Thermal Conductivity, BTU in/hr ^{o}F ft^2	1	Dow Heat Flow Meter Method (Modified)	3.3	2.0
Compressive Strength, psi at:				
5% Deformation	1	D695-63T[5]	7.3	1.3
10% Deformation	1	D695-63T[5]	15.0	2.7
25% Deformation	1	D695-63T[5]	44.0	8.0
Compressive Modulus, psi	1	D695-63T[5]	146	27
Resistivity, ohm-cm	1/4	D257	2.7×10^7	5.2×10^7
Compressibility, in/in/psi	-	-	-	7.02×10^{-6}
Density, gm/cu cm	-	-	1.367	1.194
lbs/gal	-	-	11.40	9.96
lbs/cu ft	-	-	85.27	74.50

I. Description of Dowell Chemical Ring (300 system)

Chemical Seal Ring is an elastic, polymeric seal. It can be mixed and placed as a slurry which sets into a rubber-like material. Figure 1 shows a sample of Chemical Seal Ring which has swelled to more than 150 percent of its original volume by imbibing water. It is still an integral, sealing material in its swollen state. This single property sets Dowell Chemical Seal Ring apart from other sealing materials.

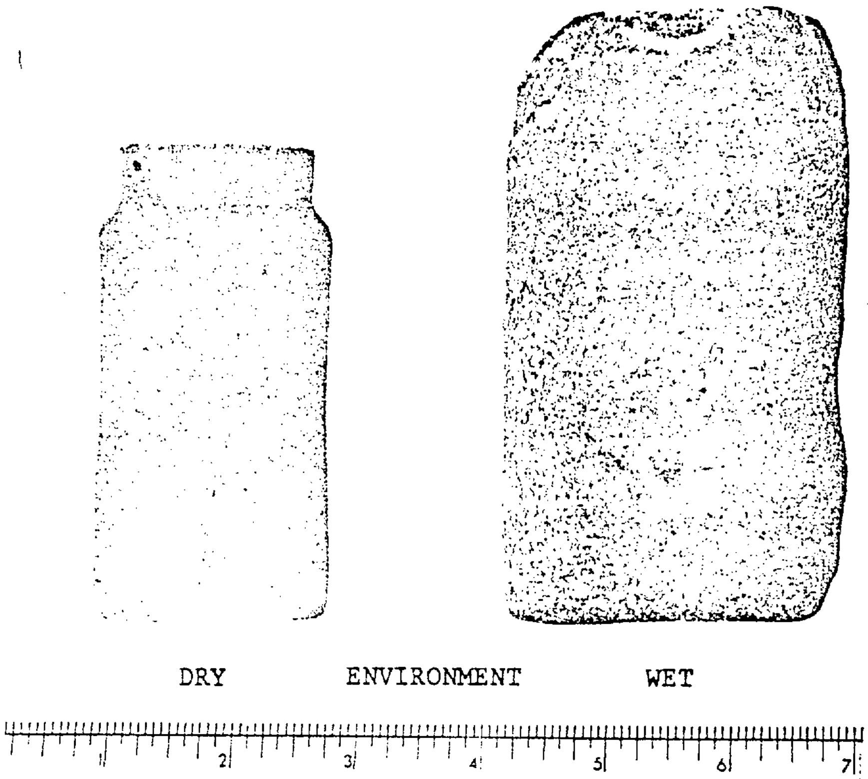

Figure 1. Sample of Dowell Chemical Seal Ring which has swelled to more than 150 percent of its original volume by imbibing water.

Life expectancy of set Chemical Seal Ring is of interest. Since the material is relatively new, by time standards, there is no method for determining how long it will actually last. Accelerated tests have been under way in concentrated environments of acid, caustic, brines, ozone, ammonia, hydrocarbons and fresh water for periods ranging from 90 days to four years. In all these tests, Chemical Seal Ring has maintained its integrity and sealing properties without apparent deterioration. Extrapolated values from these tests show that the material should last indefinetely. In fact, the chemistry of the

reaction by which Chemical Seal Ring is formed indicates permanency. The cross-linkage of the molecules is permanent and the material should be inert to further reaction.

In an actual case, Dowell Chemical Seal Ring was placed in a shaft in the Tatum Salt Dome in 1964. It has remained intact under the most severe conditions that could be imposed. This particular application is described later as a case history.

In casing and shaft-lining applications, Chemical Seal Ring normally is used in conjunction with more conventional sealants, such as cement. The cement provides support for the liner while Chemical Seal Ring provides the seal. Temperature and pressure changes during cementing operations cause the liners to expand and contract. This expansion and contraction often causes a micro-annulus, or channel, to form between the liner and the cement or the shaft wall and the cement. Great quantities of water or other fluids can flow through even the smallest channels. Chemical Seal Ring, spotted in the proper place in the cement column, is pliable enough to accommodate expansion and contraction while providing a positive seal. Further, any water flowing through the channel will be imbibed by the Chemical Seal Ring, causing it to swell and seal even tighter.

II. Description of Dowell Chemical Seal Ring Gasket (201 system)

Dowell Chemical Seal Ring Gaskets are manufactured from a unique polymer which swells in water. This polymer is chemically cross-linked during formation of the gasket. The result is a three-dimensional network of polymer molecules which has adequate physical strength, yet retains the property of swelling in water.

When a Dowell Chemical Seal Ring Gasket is confined in the flanged joints of a tunnel or mine-shaft lining, the rubber-like nature of the material makes it possible to assemble an air-tight, as well as a water-tight, structure. This property can help, for instance, to minimize air-compressing costs while driving a tunnel under a river. Furthermore, any tendency for water to leak through joints containing Chemical Seal Ring Gasket is immediately counteracted, since gasket material swells tighter and blocks the leakage path.

Several important features of Dowell Chemical Seal Ring Gasket stem from the nature of the chemicals used in its manufacture. A corrosion inhibitor prevents rust wherever Dowell Chemical Seal Ring Gasket is in contact with iron. A standard method of flame testing (ASTM D1692-59T) shows that Dowell Chemical Seal Ring Gasket is self-extinguishing. "Samples tend to burn only on the exterior and would not flame-propogate after removal of the flame source."

The pressure-sealing ability of Dowell Chemical Seal Ring Gasket depends on good seal design practices. Figure 2 is a schematic drawing of test apparatus used to pressure test Chemical Seal Ring Gasket in the laboratory. Under conditions shown here (without back-up shims), gasket successfully sealed pressures of 1200 psi for extended periods with no leak. With a back-up shim, pressures in excess of 4500 psi were sealed.

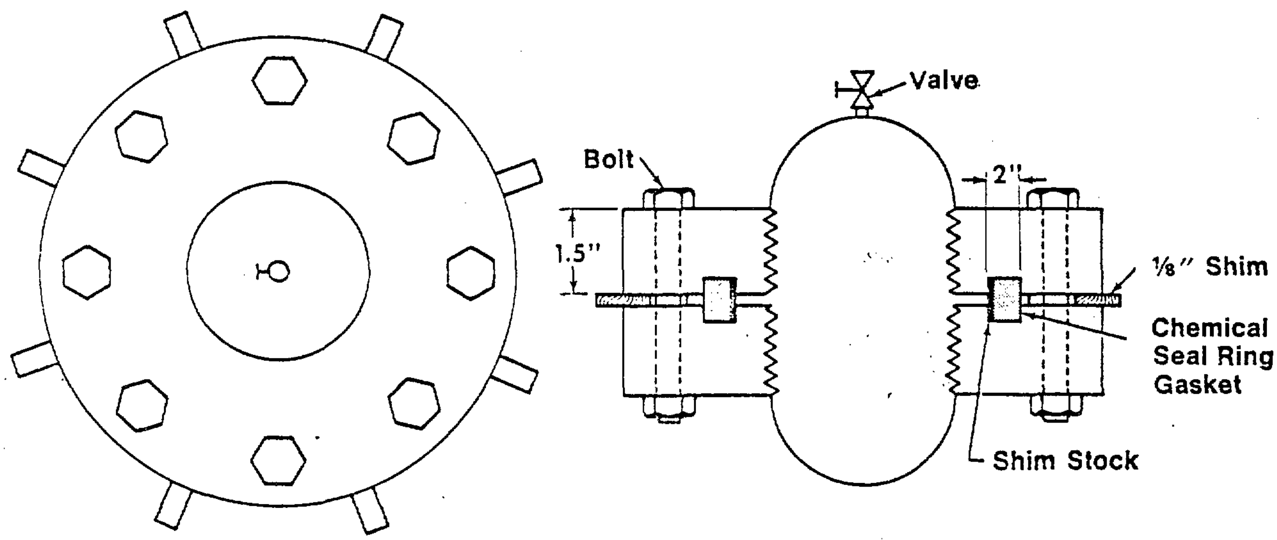

Figure 2. Schematic drawing of apparatus used to pressure test Dowell Chemical Seal Ring Gasket in the laboratory.

Figure 3 is a photograph of a full-scale model of the T-joints that will exist in a tunnel or mine-shaft lining built up of segments and rings. The T-joint is considered the critical leakage location. Long-term tests of such joints are presently being conducted by Commercial Shearing and Stamping Company, a leading supplier of underground supports with over 47 years of experience in the design and manufacture of steel supports for tunnels, shafts, and caissons throughout the free world. The joints are presently holding 1400 psi water pressure with no leaks or failures. These tests have now been in progress for months and are continuing.

Should a shaft lining containing Dowell Chemical Seal Ring Gasket ever leak after installation, several methods of repair exist. First, because the material swells in water, it is self-healing and further repair efforts may not be required. Time-lapse movies of very large, deliberately formed, leakage paths (Figure 4) have been made while water was pumped through them. Chemical Seal Ring Gasket not only withstood the flow of water, but swelled to shut off the leak. Swelling continued thereafter so that the self-repaired leak would hold more and more pressure.

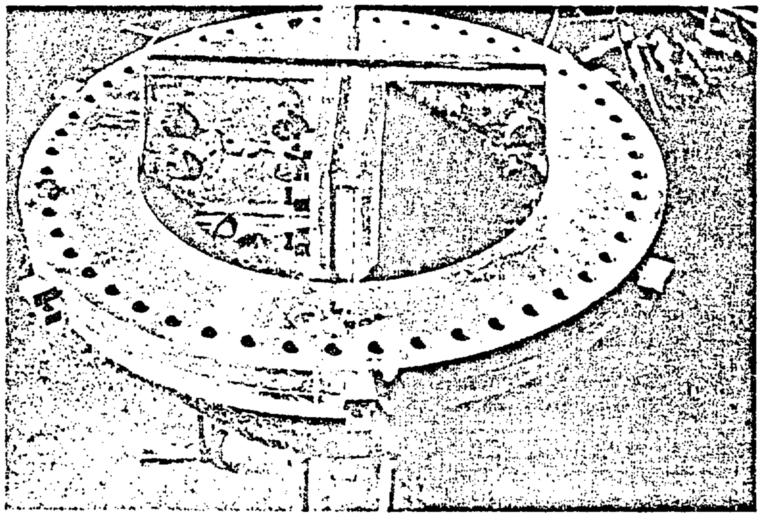

Figure 3. Photograph of a full-scale model of the T-joints that will exist in a tunnel or mine-shaft lining built up of segments and rings.

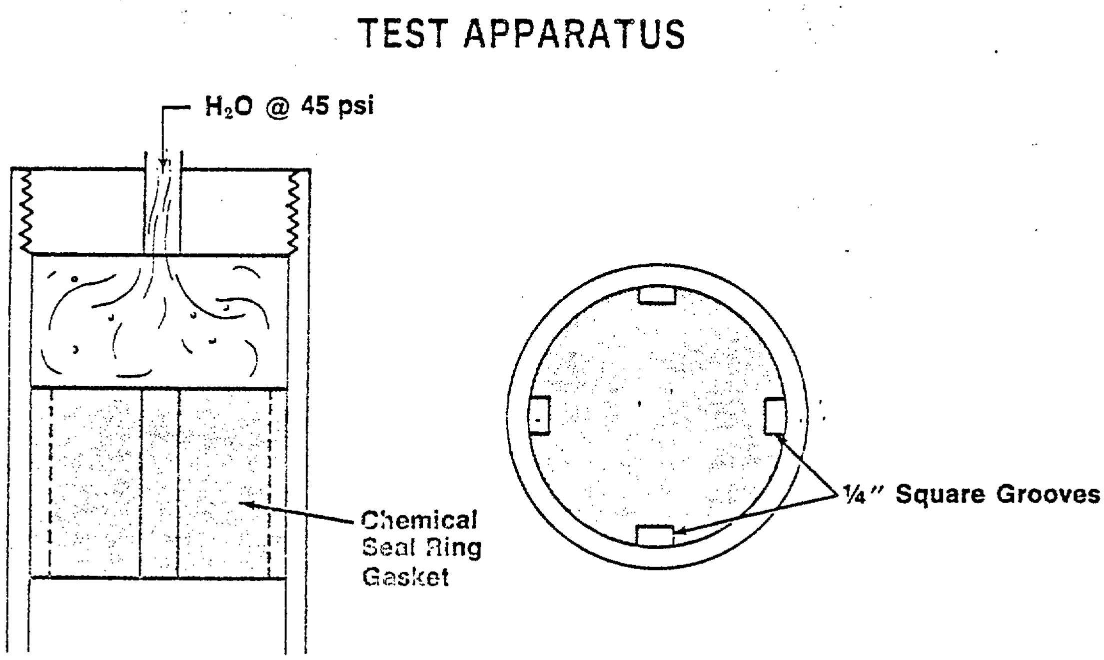

Figure 4. Test apparatus used to determine self-healing properties of Chemical Seal Ring.

Should extensive damage ever occur, leaks can be repaired by grouting with Chemical Seal Ring slurry or by conventional cementing procedures.

Figure 5 shows examples of the infinite number of sizes and shapes of Chemical Seal Ring Gaskets. Since nearly every application requires gaskets designed specifically for a particular purpose, the gaskets are not maintained in stock. Chemical Seal Ring Gaskets are packaged in protective wrapping so that only sheltered storage is required to shield them from moisture to facilitate their handling.

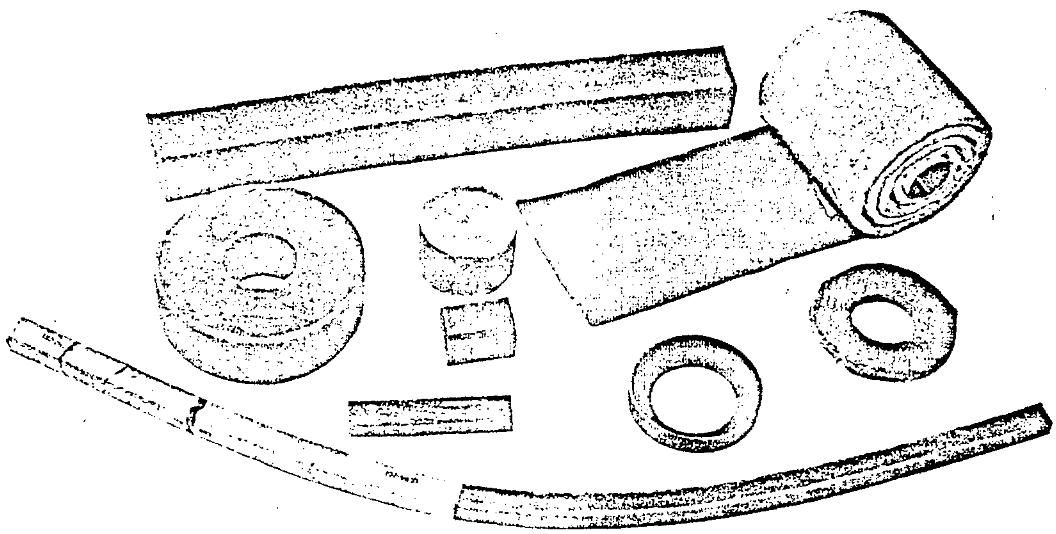

Figure 5. Examples of the infinite number of sizes and shapes of Dowell Chemical Seal Ring Gasket.

III. Technical Discussion

Mixing

Dowell Chemical Seal Ring is mixed by adding a powdered polymer to a premixed fluid phase. The polymer disperses readily and is easily mixed with a minimum of stirring or agitation. Conventional oilfield mixing and pumping equipment and specially designed continuous-mix units can be used. Even hand-drill-driven paddles in a 50-gallon drum have been used to mix small quantities of Chemical Seal Ring.

Viscosity

Chemical Seal Ring slurry viscosity varies with the formulation, but is relatively low. The five-minute viscosity of a typical slurry is about 4 poises. By comparison, a cement grout (5.2 gallons of water per sack of cement) has a viscosity of approximately 15 poises.

Heat of Reaction

Setting of the Chemical Seal Ring is not an exothermic reaction. The heat of reaction is negligible; viz., it is too low to measure by ordinary laboratory tests. Monolithic pours thus create no problems in this respect.

Thickening and Setting Times

Thickening time and setting time of Chemical Seal Ring are controlled by adding a catalyst to the slurry during mixing. Thickening time is that time required for the slurry to reach a viscosity equivalent to 100 poise as measured in a standard cement thickening time tester. This is also the working time because at higher viscosities the slurry cannot be easily moved or placed. The amount of catalyst, then, is based on the working time required and the temperature. Setting time is defined as that time after mixing which is required for the slurry to reach a viscosity of 10,000 poises. Cement grout, concrete and stemming sand can all be placed on top of the Chemical Seal Ring when its viscosity has reached 10,000 poises. Setting time is also directly related to the amount of catalyst used.

~~Typical thickening and setting time curves are shown in Figures 6 and 7.~~

Slurries with a temperature of 40°F to 120°F are routinely used with predictable thickening and setting times. Laboratory tests are conducted to determine the required amount of catalyst and thickening and setting times in those cases where the slurry temperatures will fall outside this range.

Seal Height vs. Pressure Drop

One of the many series of tests conducted to define and understand Chemical Seal Ring properties, involved the determination of pressure drop per foot of Chemical Seal Ring height. Various sizes of pipes were filled with 20 feet of Chemical Seal Ring slurry. Pressure gauges were installed every two feet. Water pressure was applied to the confined Chemical Seal Ring for short-term and intermediate-term tests. These data, using a typical Chemical Seal Ring formulation, are presented in Figure 8. It shows the length of Chemical Seal Ring required for the pressure to drop to 0 psi.

LENGTH CHEMICAL SEAL RING REQUIRED

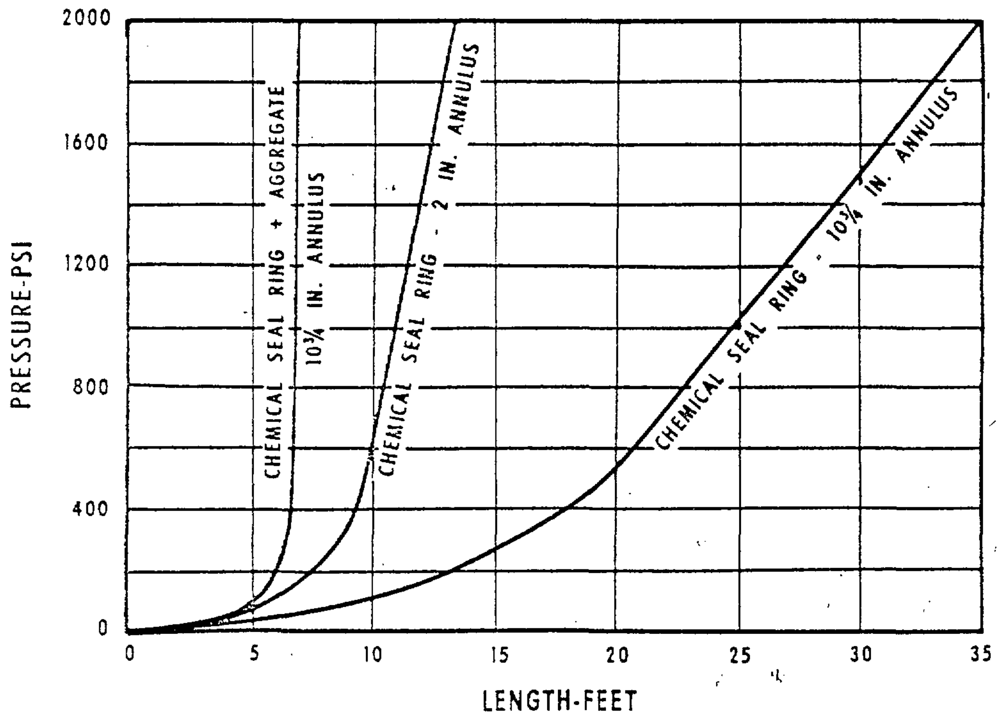

Figure 8. Graph showing the length of Dowell Chemical Seal Ring required for the pressure to drop to 0 psi.

Effect of Aggregate on Seal Ring Height vs. Pressure Drop

The previously discussed pressure-drop tests indicate that the pressure is dissipated over a shorter interval in smaller pipe. This finding was as expected. Tests were conducted to determine if incorporating coarse aggregate would produce the same effect as reducing the cross-sectional area of Chemical Seal Ring.

The addition of two parts of 3/4-inch to 1-1/2-inch aggregate to one part Chemical Seal Ring was tested. Test data indicate that height of aggregate-Chemical Seal Ring need be approximately one-third that of Chemical Seal Ring alone to dissipate a given input pressure.

The use of aggregate offers two advantages. The prime advantage is that the volume of Chemical Seal Ring, hence cost, is substantially reduced. The second advantage is in placing a seal opposite frozen formations, such as those encountered when freeze-sinking through the Blairmore in Saskatchewan. A heated

aggregate, dumped into the poured Chemical Seal Ring, will reduce the setting time and reduce down-time for the shaft sinker.

Resistance to Extrusion

A series of tests were conducted to determine the pressures required to extrude Chemical Seal Ring. The test procedure was purposely severe. Two-inch-long slots were machined in a steel plate. This test apparatus produces a cutting action as compared to long slots formed by rough surface walls, such as formation and concrete. The pressures required to extrude the Chemical Seal Ring through two-inch-long slots of various widths were:

Slot Width (inches)	Pressure (psi)
1/64	600
1/32	500
1/16	400

Extrusion can be prevented by using inert bridging materials in the slurry or using shims with gaskets.

Typical Sunken-Shaft Seal Assembly

Figure 9 is a schematic of a seal assembly in a sunken shaft. The Chemical Seal Ring pressure is maintained some 200 ± psi greater than the fluid pressure it is sealing off. Constant seal pressure can be maintained manually or through the use of automatic equipment.

The seal assembly is, in essence, an impermeable, hydraulic seal pressured in slight excess of aquifer pressures.

IV. [redacted]

Large samples of Chemical Seal Ring formulations have been decomposed without toxic products resulting. Although the material is relatively new, these tests indicate that it can be heated to 500°F and remain safe from the standpoint of toxic products.

Both the liquids and polymer powder used in Chemical Seal Ring formulations can be handled safely. Eyes and skin should be protected.

Unset Dowell Chemical Seal Ring slurry will burn with a self-propagating flame. The flame is low and spreads very slowly. Once set, however, Chemical Seal Ring is self-extinguishing.

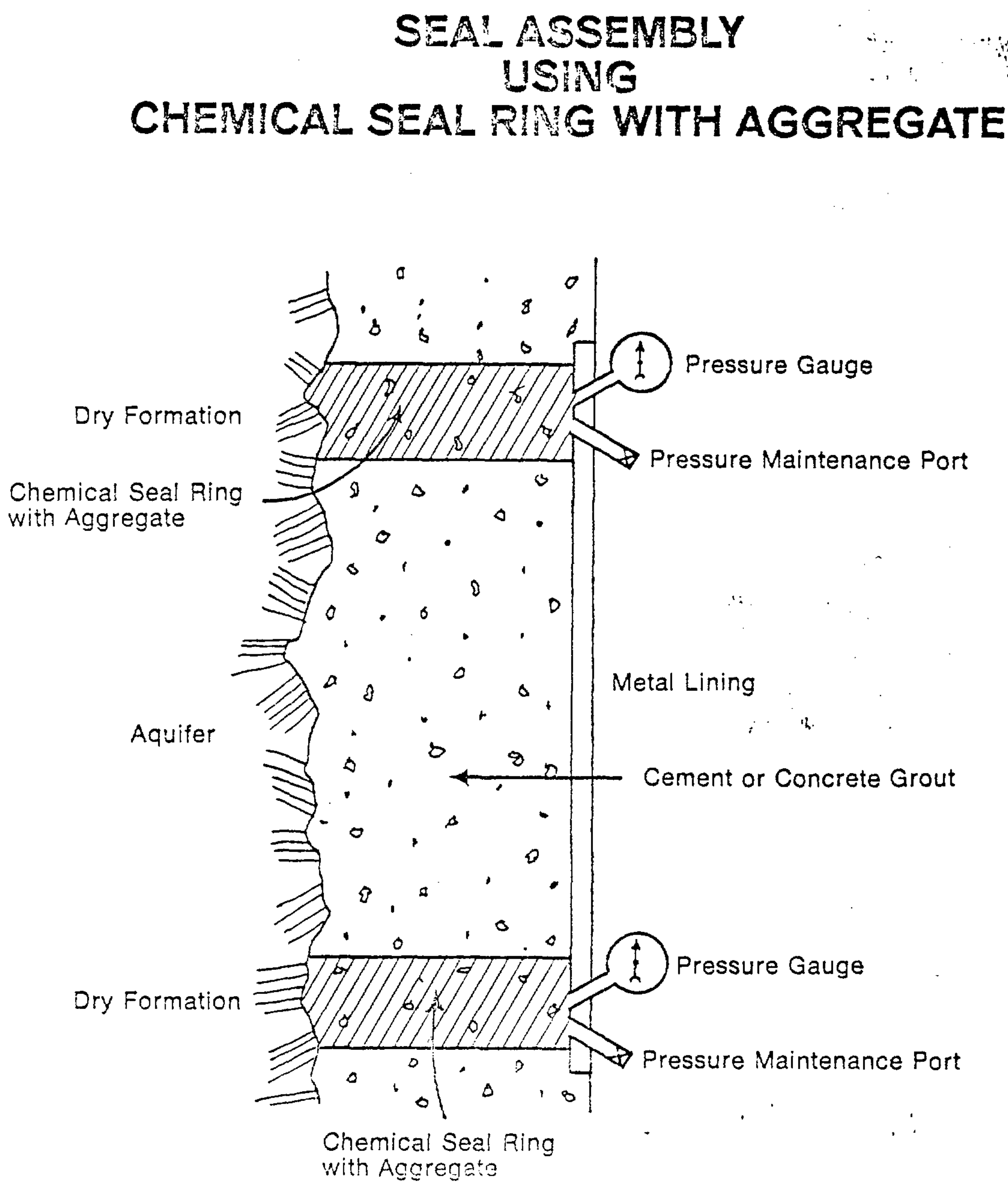

Figure 9. Schematic drawing of a seal assembly in a sunken shaft.

V. Case Histories

Dowell Chemical Seal Ring has proved highly successful in a wide variety of sealing uses. These include stemming underground nuclear tests to prevent escape of radioactive gases; annular seals and water stops in Canadian potash mine shafts; and seals in anhydrous ammonia storage caverns, LPG storage caverns, salt mines and reservoir gas storage wells.

One of the early uses of Chemical Seal Ring was to seal large-diameter pipe in competent salt stock at the Tatum Salt Dome near Hattiesburg, Mississippi. Many overlying aquifers and a fractured caprock had made it impossible to obtain a dry shaft in the salt. Many remedial squeeze jobs with cement also failed to obtain a dry shaft. Chemical Seal Ring, placed as shown in Figure 10,

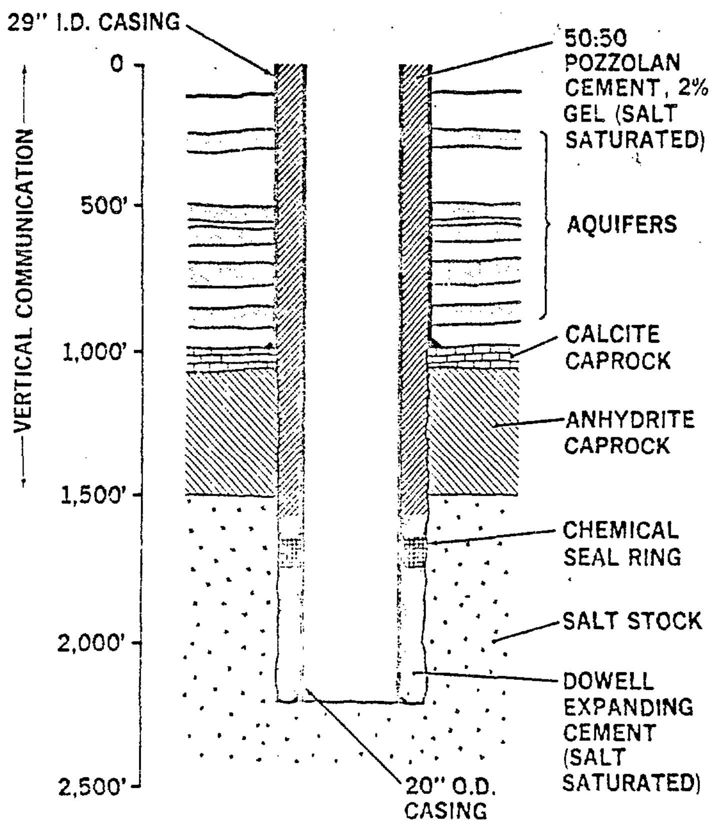

Figure 10. Drawing of placement technique for Dowell Chemical Seal Ring used to seal large-diameter pipe at the Tatum Salt Dome.

resulted in a completely dry shaft. A nuclear device was detonated in the salt about four months later and the shaft still remained dry. During an extensive testing period following the detonation, many tools and devices were run in the shaft. This resulted in a hole in the casing opposite the Chemical Seal Ring. A steel liner was run and cemented to cover the hole. Subsequently, a second nuclear device was detonated in the cavity created by the first shot. The shaft still remained dry and is dry at the present time, nearly four years later.

A more recent use of Dowell Chemical Seal Ring has been in a Canadian potash mine shaft in Saskatchewan. This shaft was sunk to a depth of 3300 feet by the freeze method. The seal was placed to insure that no water bypassed a water-collecting ring placed opposite a salt formation. The seals successfully prevented water migration in the annulus of this shaft.

MINING SERVICES

TECHNICAL INFORMATION SHEET

DOWELL CHEMICAL SEAL RING

Chemical Seal Ring is a unique grouting material successfully being used in demanding applications to seal against the migration of aqueous fluids and low-pressure gases. Its chief applications are in conjunction with cement grouts for sealing shaft liners. Shafts drilled or sunk through soluble formations (rock salt and potash) as well as shale, sand and lime formations have been sealed using staged applications of cement and Chemical Seal Ring. Critical applications requiring a total seal have used DOWELL Chemical Seal Ring. Chemical Seal Ring has been used in conjunction with the Strategic Petroleum Reserve Programs, nuclear emplacement shafts, evaporite mine shafts and mined storage cavern shafts.

Chemical Seal Ring is truly unique. It is mixed as a slurry with controlled setting properties. It is placed by either pumping through grout or tremie pipes or draining or pouring from buckets lowered to a Galloway work stage. It fills the void to be sealed with a set material with most of the properties of a natural rubber. An additional prime property is that unconfined Chemical Seal Ring imbibes aqueous fluids, including brines, and physically becomes larger. Thus, confined Chemical Seal Ring provides a tighter, positive seal when contacted with aqueous fluids.

TYPICAL PHYSICAL PROPERTIES

Slurry

Form and Color — Pourable, Yellow-Green

Density — 9.95 lb/gal at 70°F

Cured Solid

Form and Color — Gunmetal Gray Rubber

Density — 9.95 lb/gal

Tensile Strength — 80 psi ultimate; ¼-in. thickness

Elongation — 137% ultimate

Hardness — 30 Durometer A

Tear Resistance — 14.7 lb/in. of thickness

Swelling Capacity — greater than 50% dimensional increase when exposed to aqueous fluids

COMPOSITION

Chemical Seal Ring slurry consists of a dispersion of a water-sensitive, high-molecular-weight polymer in a hygroscopic organic liquid. A water-soluble chromium compound crosslinks the polymer dispersion.

A cured Chemical Seal Ring resists biodegradation, and is considered to have a permanency at least equal to that of cement.

DISCUSSION

Repeated efforts with conventional cements and plastic grouts failed to provide the water-tight seal required for the nuclear placement shaft drilled into the Tatum Salt Dome. Chemical Seal Ring was developed to solve this and similar types of problem applications.

In the Tatum Salt Dome application, conventional cements were used to fill most of the annular space between the steel shaft liner and rock-salt formation. Chemical Seal Ring slurry was pumped to form a water-expanding gasket opposite the rock-salt formation in a zone below the aquifers. This successful application in 1964 has been followed by similar demanding uses throughout the Free World. The properties of Chemical Seal Ring which made these applications successful include

the following.

- A pumpable slurry with controllable setting times between 40° to 100°F.
- The slurry neither shrinks nor expands upon setting.
- Set Chemical Seal Ring imbibes aqueous fluids (even saturated brines) with dimensional enlargement that provides a positive water-tight seal.
- Set Chemical Seal Ring is flexible and geologic shifts have not been reported to have damaged the seals.

Chemical Seal Ring has been cast in molds to form water-expandable gaskets. The shape of the gasket can be varied and extenders, such as fine sand, have been used. Applications of such gaskets include plugs for core holes and as water-expandable packers for groundwater monitoring wells.

SERVICE

Dowell provides Chemical Seal Ring service which comprises job design, materials, personnel, mixing and pumping of the slurry to the operator's surface conveyance (bucket, tremie or grout pipe). When water exists in the void to be sealed, a liquid wash (compatible with Chemical Seal Ring) is used ahead to displace the water. The wash is also used to displace Chemical Seal Ring slurry from tremie or grout pipe.

CASE HISTORIES

- Nuclear detonations in Nevada and Amchitka were stemmed with Chemical Seal Ring.
- Potash mine shafts sunk through the Blaremore (Canada) aquifer are routinely being sealed with Chemical Seal Ring.
- Rock-salt mines in Louisiana are completed with Chemical Seal Ring to prevent flooding by overlying water zones.

AVAILABILITY

Chemical Seal Ring material and some uses are patented by Dowell and the material is available from any service district within the United States. It is available from Dowell-Schlumberger service locations throughout the non-Communist world.

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MINING SERVICES

TECHNICAL INFORMATION SHEET

DOWELL CHEMICAL SEAL RING

Chemical Seal Ring is a unique grouting material successfully being used in demanding applications to seal against the migration of aqueous fluids and low-pressure gases. Its chief applications are in conjunction with cement grouts for sealing shaft liners. Shafts drilled or sunk through soluble formations (rock salt and potash) as well as shale, sand and lime formations have been sealed using staged applications of cement and Chemical Seal Ring. Critical applications requiring a total seal have used DOWELL Chemical Seal Ring. Chemical Seal Ring has been used in conjunction with the Strategic Petroleum Reserve Programs, nuclear emplacement shafts, evaporite mine shafts and mined storage cavern shafts.

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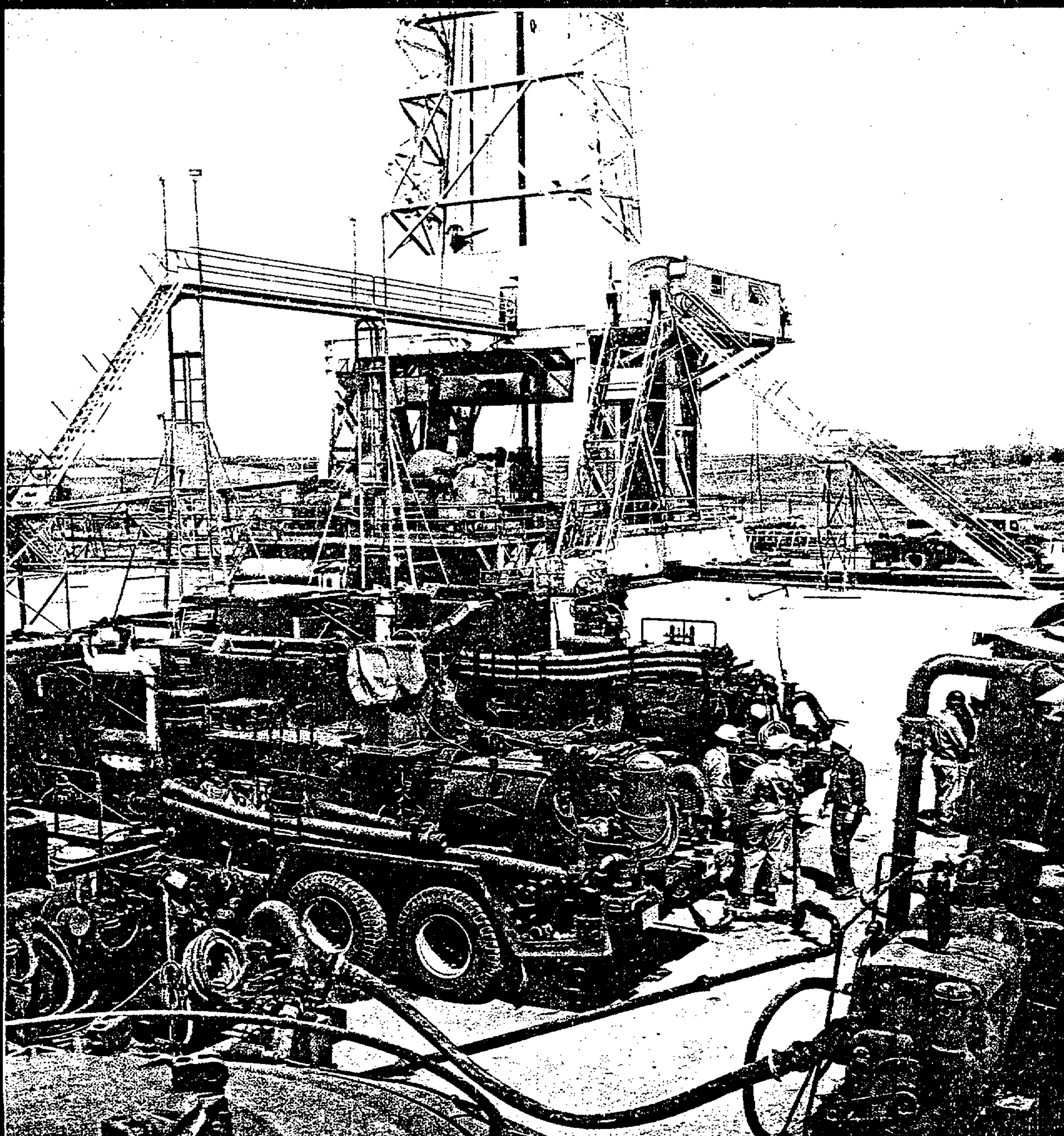
REGULATED FILL-UP CEMENT CONTROLS SLURRY LOSS FOR MORE PREDICTABLE FILL-UP



How it works

The specially designed slurries used in Regulated Fill-up Cement service are thixotropic. That is, they are thin when mixed and pumped, but gel quickly into a rigid state when pumping stops. They are self-supporting in this state, but become fluid again when enough force is applied to move the slurry. These qualities are summarized in the name of the slurries, Regulated Fill-up Cement.

Why it works

Since the Regulated Fill-up Cement slurries are thixotropic, they will in a sense transfer hydrostatic pressures to the pipe and walls of the formation rather than to the bottom of the hole. This property cannot be shown on conventional viscosimeters; however, a Dowell designed apparatus was made to show this reduction of hydrostatic pressure.

FIGURE 1

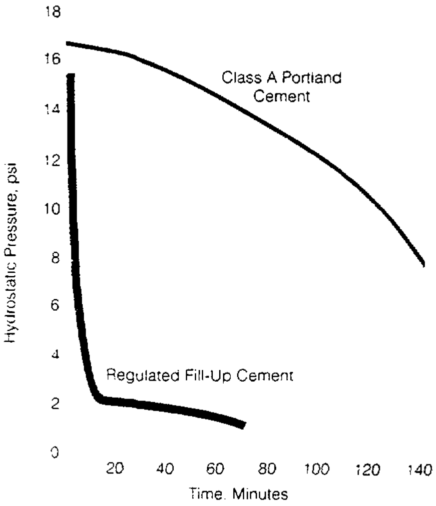
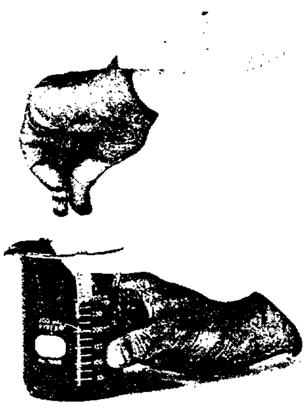


Figure 1 contains the results of the measured hydrostatic pressure with time for a Class A portland mixed at 15.5 lb/gal and Regulated Fill-up Cement. The tests were performed at 70°F. As shown, there was a rapid reduction in the hydrostatic pressure exerted by the Regulated Fill-up Cement as compared to the Class A portland cement.

1. Thin when mixed.

2. Rigid when pumping stops.



3. Fluid again when force applied.

4. Thin when pumping is resumed.

Advantages

1. It limits or prevents the loss of slurry into weak and highly permeable zones.
2. It provides more predictable fill-up.
3. It decreases the need for stage cementing or the use of mechanical devices such as baskets.
4. It provides high yield slurries (with no water separation).
5. It is highly resistant to mud contamination.
6. It is highly resistant to diluting or cutting by water or gas.
7. It provides better bonding due to its expanding properties.
8. It is comparable to conventional high-sulfate resistant cements.

How it has been used

A large cavern fissure below surface pipe caused a series of problems in a Sandoval County, New Mexico, geothermal well. While trying to realign joints of intermediate pipe, the operator knocked three holes in the casing opposite the cavern. Attempts to fill the cavern with mud were unsuccessful. The self-supporting quality of Regulated Fill-up Cement, however, enabled Dowell to bridge the fissure. After the cementing job, drilling was resumed with full returns.

Cementing by a competitor had split the formation and plugged fractures on wells in the Mt. Pleasant field of Pennsylvania. On their first job in the field, the Dowell team designed a cementing system based upon Regulated Fill-up Cement. Used after washes and spacers, the Regulated Fill-up Cement prevented slurry migration into fractures and protected the highly permeable zones. After the job, the operator was able to fracture three zones in his well successfully.

An operator in the Gibson County, Indiana, area needed a cement that would maintain circulation to the surface and reduce waiting time before drilling out. Regulated Fill-up Cement gave him the predictable fill-up and bond properties he asked for, plus good setting time. He was able to start drilling from under the surface pipe in only three hours.

Wells in the Jasper County, Illinois area often required squeeze jobs following primary cementing jobs. Dowell recommended using its SLOFLO* cementing service, a patented technique. DOWELL Spacer 1000 was used to clean up the well bore, followed by Regulated Fill-up Cement containing Cellophane flakes. The recommendation resulted in successful completion of the well without a squeeze job and in a good bond log.

The Regulated Fill-up Cement system is not a low fluid loss slurry but has been used in carefully controlled squeeze jobs to plug high pressure zones. The high gel strength helps to prevent feedback of the slurry. This application has been used quite frequently in the midwestern areas of the United States.

Applications other than cementing oil and gas wells are occurring more frequently. Because of Regulated Fill-up Cement gel characteristics, the system was utilized in rip-rap grouting on high water drainage slopes. The gelling prevented the cement from flowing to the bottom of the slope and also limited penetration depth into the soil.

*Trademark of The Dow Chemical Company

SLURRY PROPERTIES OF REGULATED FILL-UP CEMENT COMPARED TO A CONVENTIONAL SYSTEM

Cement System	Percent RF Component	Percent Accelerator	Percent Water	Water Gal/Sk	Slurry Weight Lb/Gal	Slurry Yield Ft³/Sk
1	0	0	46	5.20	15.6	1.18
2	12	3	60	6.78	14.9	1.48
3	12	3	64	7.20	14.6	1.54
4	12	1	68	7.70	14.4	1.58
5	10	0	70	7.90	14.2	1.60

PERFORMANCE DATA OF REGULATED FILL-UP CEMENT

Cement System	Well Conditions (°F) BHCT	BHST	Thickening Time at BHCT	Compressive Strengths (psi) at BHST (Hr.) 7	18	24	96
1	113	170	+4:00	325	1750	2900	—
2	70	60	3:10	105	360	515	1125
3	80	95	1:50	500	1240	1330	—
4	103	140	2:00	520	1000	1150	—
5	125	200	3:15	930	1725	2200	—

EXPANDING PROPERTIES OF REGULATED FILL-UP CEMENT COMPARED TO CONVENTIONAL SYSTEM

Cement System	Days	Percent Linear Expansion 0 psi 100°F	Cement System	Days	Percent Linear Expansion 0 psi 100°F
Class	1	.020	Class	1	.163
A	2	.023	A	2	.202
46%	3	.032	+ 10% RF	3	.228
Water	5	.032		5	.249
	7	.034	+ 1% Accel.	7	.282
	14	.037	66% Water	14	.357
	28	.046		28	440

API permeability measurements
To those accustomed to construction cement systems and testing, the high water to cement ratio of Regulated Fill-up Cement systems might seem to indicate a set product having a high permeability. If the complicated crystalline and gel structures are known, and considered, it can be realized how the permeability will be of the same order of magnitude as conventional systems. Also the system is designed to make the set product sulfate resistant. Permeability and/or porosity studies of cements must take into account the fact that any air drying of the set product at any time will result in loss of hydrate water, collapse of gel structures and possibly cause microcracking of the set cement. This behavior is well documented in published cement literature. The permeability values tabulated below were obtained using the procedure as outlined by API standards. Distilled water was used as the test fluid. The cement samples were cured under pressure to simulate well conditions.

PERMEABILITY PROPERTIES OF REGULATED FILL-UP CEMENT COMPARED TO OTHER CEMENT SYSTEMS

Cement System	Percent Water	Slurry Weight (Lb/Gal)	Permeability, md (to water)
Class A	46.0	15.6	0.0001
Regulated Fill-up Cement	60.0	14.9	0.0038
Regulated Fill-up Cement	64.0	14.6	0.0036
Regulated Fill-up Cement	70.0	14.2	0.0050
50:50 Pozzolan: Class A + 2% Gel	57.0	14.2	0.0200

DOWELL DIVISION OF DOW CHEMICAL U.S.A., HOUSTON, TEXAS 77042
AN OPERATING UNIT OF THE DOW CHEMICAL COMPANY

TSL-4007

LITHO IN U.S.A.
10623M

Rockwell Hanford Operations
Richland, WA 99352

ENGINEERING ORDER

EO 00195

EO TYPE			
	Release		Supersedure
X	Release To File		Cancellation
	Authorize Requirements		Obsoletion
	Change		File As Drawing

QA Level	Change Type	Building	Project No.
I	-	800-G	B-314

Cognizant Engineer: J. S. Ritchie (KE/PB) — Phone: 415-271-5281

Responsible Organization: R. M. Ybarra — Phone: 376-6204

Priority: N

Is A Cross Reference To — AUTHORIZATION NO.: WBS LF2222, CEI - CM014

Index No.	CEI No.	Document No.	Sheet No.	Rev.	Next Used On
-	CM014	B-314-P-S28005	i-ii 1-20	0	H8-S20901, H8-S20902, H8-S20903
		Appendix A	A-1 & A-3		
		Appendix B	B-1		

Initiated By: KE/PB
Used By: Rockwell

BASALT

Approval	Name	Date
X Prepared By	P. K. Brockman	12/28/82
X Cognizant Manager	R. M. Ybarra	
X Checker	P. J. Reder (M. D. Connor for) Config. Mgmt.	12/29/82
Cognizant Engineer		
Authorizer		
X Quality Assurance	C. D. [signature]	12-28-82
X Health, Safety & Environment	L. K. Aldrich	12-29-82
Criticality Engineering & Analysis		
X	R. M. Ybarra, Design Review Chairman	

Reasons & ESR No.
All Design Review Comments Incorporated Per DR-B314-82-17

DISTRIBUTION
L. K. Aldrich (HS&E)
H. W. Brandt
P. K. Brockman (15 XR Dist. #527)
R. W. Carlson 1 cont.
T. L. Walton (1 cont, 2 info)
R. L. Edler (40-Procurement)
M. F. Nicol
P. J. Reder (EO only)
W. F. Toddish (Orig.)
M. T. Black (1 cont, 1 info)
R. E. Brooks

Work Completed — Date

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BWIP-7473

Rev. 0, 12-17-82

SPECIFICATION TITLE PAGE

SPECIFICATION NO. B-314-P-S28005

QA LEVEL I

PROCUREMENT SPECIFICATION FOR

72" ID STEEL CASING

BWIP EXPLORATORY SHAFT

PROJECT B-314

Prepared By:

Kaiser Engineers, Inc./Parsons Brinckerhoff Quade & Douglas, Inc.

For the U.S. Department of Energy

Contract No. DE-AC06-80RL10000

E. L. Heard	12/17/82	Lino Zoppi for	12-17-82
Specifications Engineer	Date	Job Engineer	Date
	12/17/82	D. A. Watson	12/17/82
Design Manager	Date	Project Engineer	Date
H. E. Thayer	12/17/82	L. E. Thomas	12-20-82
QC Engineer/Constr. Engr.	Date	Quality Assurance Engr.	Date
R. G. Bubke	12/17/82	J S Ritchie by PGB	12-20-82
Deputy Project Manager	Date	Project Manager	Date

ROCKWELL HANFORD OPERATIONS:

R. F. Bielefeld — 12-28-82
Date

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CAUTION
THIS DOCUMENT NOT COMPLETE WITHOUT THESE ATTACHMENTS

BWIP17G: 12/~~17/82~~

DEC B-314-046
WT 2/23/83

RELEASE VIA
EO N12 00195
Doc. Rev. 0
Rel. Date 12/29/82

TABLE OF CONTENTS

BWIP17H: 12/16/82

72" ID STEEL CASING

1.0 SCOPE

This Specification describes the requirements for the fabrication and delivery to the project site of ninety-eight (98) welded steel 72-inch inside diameter shaft casing units, and associated grout guides, and guide plates; ventilation and dewatering lines and fittings; support plates, centralizers, and skid plates.

1.1 Work Included

1.1.1 Labor

1.1.2 Tools, materials, and equipment

1.1.3. Fabrication

1.1.4 Testing

1.1.5 Records Management

1.1.6 Packaging

1.1.7 Transporting to site

1.1.8 Offloading at site

1.1.9 Placing in storage at site

1.2 Work Not Included

1.2.1 Maintenance in storage

2.0 GENERAL PROVISIONS

2.1 Applicable Codes, Standards, and Publications

Work performed and materials furnished under this Specification shall conform to the requirements of the documents listed below, to the extent specified herein. In the event of conflict between applicable requirements of two or more of those documents, the most stringent requirement shall apply.

ANSI, American National Standards Institute

B2.1 1968,	Pipe Threads (Except Dryseal)
B16.11-1973,	Forged Steel Fittings, Socket-Welding and Threaded
B16.9-1978,	Factory-Made Wrought Steel Buttwelding Fittings

NQA-1-1979,	Quality Assurance Program Requirements for Nuclear Power Plants
N45.2.2-1978,	Packaging, Shipping, Receiving, Storage and Handling of Items for Nuclear Power Plants
N45.2.15-1981	Hoisting, Rigging and Transporting of Items at Nuclear Power Plants

API, American Petroleum Institute

Spec. 5A, March 1979 w/Supplement 1, March 1980	Casing, Tubing, and Drill Pipe

ASTM, American Society for Testing and Materials

A 53-77a	Pipe, Steel, Black and Hot-Dipped Zinc Coated Welded and Seamless
A 570-79	Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality
A 588-81	High-Strength Low-Alloy Structural Steel with 50,000 psi Minimum Yield Point to 4 in Thick
E 165-75	Liquid Penetrant Inspection Method
E 709-80	Magnetic Particle Examination

ASME, American Society of Mechanical Engineers
Boiler and Pressure Vessel Code as amended through 1981

Section V,	Nondestructive Examination
Section VIII,	Pressure Vessels, Division 1
Section IX,	Welding and Brazing Qualifications

AWS, American Welding Society

A3.0-80	Welding Terms and Definitions
D1.1-82	Structural Welding Code - Steel

DOE, U. S. Department of Energy

HS-BP-8002,	Supplier Acceptance Data Package (ADP)

2.2 Drawings and Attachments

2.2.1 Drawings

The drawings listed in the "Purchase Order" are incorporated and made a part of this Specification:

2.2.2 Attachments

The following listed attachments are incorporated and made a part of this Specification:

Appendix A	"Bidder and Seller Information Requirements" with attached submittal matrix.
Appendix B	"Information Required for Quality Control Program."

2.3 Definitions

2.3.1 Unit

"Unit" shall mean a prefabricated casing assembly, of length indicated on the Drawings, consisting of a string of cans with attached circumferential external stiffener and lifting lug rings and internal continuous-slot channels, with ends of unit suitably prepared for field welding, and individually identified by a mark number.

2.3.2 Can

"Can" shall mean the single rolled element of a casing unit.

2.3.3 Subassembly

"Subassembly" shall mean two or more cans of the casing string but less than a unit.

2.3.4 Stiffener

"Stiffener" shall mean the circumferential solid bar reinforcing rib welded to the outside of each unit.

2.3.5 Inspection Port

"Inspection port" shall mean the plugged opening in the casing plate required for placing a radioactive source for use in radiographic examination.

2.3.6 Lifting Lug Ring

"Lifting lug ring" shall mean the the circumferential solid bar rib welded to each unit to provide a lifting shoulder.

2.3.7 Grout Guide

"Grout guide" shall mean the slotted vertical piping that is to be attached (by Others) to the outside of the casing to provide a conduit for placing grout.

2.3.8 Continuous-Slot Channel

"Continuous-slot channel" shall mean the rings, with formed channel cross section, welded to the inside of each unit for supporting piping to be furnished and installed by Others.

2.3.9 Ventilation Line

"Ventilation line" shall mean the vertical piping that is to be attached (by Others) to the outside of the casing for supplying ventilation air to the bottom of the casing.

2.3.10 Dewatering Line

"Dewatering line" shall mean the vertical piping that is to be attached (by Others) to the outside of the casing for removal of water from the bottom of the casing.

2.3.11 Porthole

"Porthole" shall mean the hole through the casing plate, and the associated plugs, provided for examination of the strata outside the casing.

2.3.12 Hold Point

"Hold point" shall mean that activity in the production sequence where work shall not proceed without written release by the Inspector.

2.3.13 Witness Point

"Witness point" shall mean that activity in the production sequence scheduled for surveillance by the Inspector where work may proceed upon verbal release by the Inspector or upon the expiration of a one hour wait for inspection from the scheduled time.

2.3.14 Purchaser

"Purchaser" shall mean the U.S. Department of Energy or its appointed representative.

2.3.15 Engineer

"Engineer" shall mean the Purchaser's appointed representative authorized to act on technical matters as specified herein and to assure compliance with the requirements of this Specification and the Drawings.

2.3.16 Inspector

"Inspector" shall mean those persons or agencies appointed by the Purchaser to conduct quality control surveillance, audits and inspection activities of the fabrication process and to authorize release for shipment.

2.3.17 Supplier

"Supplier" shall mean the party responsible for the fabrication and delivery of the units.

2.3.18 The applicable definitions contained in the following publications shall also pertain:

a. ANSI NQA-1, Supplement S-1

b. AWS A3.0

2.4 Quality Assurance

2.4.1 The products furnished hereunder are to be components of a structure classified Level I for nuclear safety purposes and are therefore subject to the requirements of a quality assurance program established and implemented in accordance with ANSI NQA-1, ANSI N45.2.2, and ANSI N45.2.15.

2.4.2 Each bidder shall submit with the proposal one copy of his quality assurance program and quality control manual, approved internally, for review and evaluation as to his acceptability as a qualified vendor of Level I components.

2.4.3 Supplier shall be responsible for assuring that his subcontractors' quality-assurance/quality control programs are in compliance with the Specifications. Subcontracting shall conform to the provisions of ANSI NQA-1, Basic Requirements 4 and 7, and Supplements 4S-1 and 7S-1.

2.4.4 Subsequent to the notice to proceed, the Purchaser will provide the Supplier comments on the quality assurance program and the quality control manual submitted with the bid. Prior to the start of fabrication, the Supplier shall re-submit the program and manual incorporating the Purchaser comments. At this time, a joint Purchaser/Supplier quality assurance coordinating meeting shall be conducted to clarify requirements and acceptance criteria. Upon acceptance by the Purchaser of the program and manual, as revised, the Supplier shall proceed with fabrication in accordance with the provisions of the program and accepted procedures.

2.4.5 The minimum information required for the quality control program is contained in the listing attached as Appendix B.

2.5 Inspection Program

2.5.1 The Supplier shall be responsible for the physical performance and documentation of all required in-process inspection, testing, and other quality control functions during the manufacture of the casing units.

2.5.2 The Inspector will perform the surveillance inspection and audits of all required documentation and in-process operations of manufacturing, fabrication, shipment, and quality assurance to ensure compliance with the requirements herein.

2.5.3 The Purchaser will identify to the Supplier the authorized agencies and individuals who will perform inspection surveillance and audit functions.

2.5.4 The Work will be inspected by the Supplier and the Inspector during fabrication, packaging, shipment, and placement in storage. The Supplier shall furnish all facilities, tools, jigs, gauges, materials, and personnel necessary for inspection. This shall include personnel, equipment, and materials required to perform nondestructive examinations. Supplier's inspection and test personnel shall be certified and qualified in accordance with ANSI NQA-1 and Supplement 2S-1. Supplier's non destructive examination personnel shall be certified and qualified in accordance with ANSI NQA-1, Supplement 2S-2. The Inspector shall have access to all areas of the Supplier's and his subcontractors' plants concerned with the supply, fabrication, and shipment of the casing and its components. Inspection by the Inspector shall not relieve the Supplier of his responsibility to provide casing that complies with the requirements of the Specification and the Drawings.

2.5.5 An inspection plan incorporating hold points and witness points shall be developed by the Supplier and submitted to the Purchaser, within four weeks from notice to proceed, for review, comment, and acceptance. The inspection plan shall

be subject to the Purchaser's review for conformance to the accepted quality assurance program and incorporation of hold and witness points. Fabrication shall not commence prior to acceptance of the inspection plan by the Purchaser. The inspection plan shall identify pertinent manufacturing and testing operations and steps critical to quality control. The following shall be included as minimum hold points:

a. Initial forming of each plate, stiffener, and lifting lug ring

b. Initial welding of each weldment

c. Initial positioning and alignment of each stiffener and lifting lug ring

d. Any non-destructive examination

e. Preparation for shipment.

2.6 Records and Submittals

2.6.1 The Supplier shall establish and maintain a records system in accordance with ANSI NQA-1, Basic Requirement 17 and Supplement 17S-1. This system shall be incorporated into the Supplier's quality assurance program and submitted for the Purchaser's review and acceptance. The records system shall provide complete traceability of all materials, equipment, workmanship, quality controls, and handling of each unit. All documentation shall be clear, legible, and of suitable quality for microfilming and for long term storage. Complete traceability for welds shall include the following:

a. Each weld shall be identified by a weld number, using paint or crayon. Weld numbers shall not be duplicated.

b. Inspection reports and radiographs shall include weld number identification.

c. Inspection reports shall be accompanied by weld identification drawings which define location of the weld.

2.6.2 The Supplier shall obtain, maintain, and submit to the Purchaser the following:

2.6.2.1 Steel plate, pipe, and fittings mill-test certified reports to include heat number, chemical composition, ASTM/ANSI/API grade, and tensile test results.

2.6.2.2 Welding electrode and flux manufacturers' certified material test reports, including the heat number and AWS specification.

2.6.2.3 Welder and welding machine operator test result records. Format shall be as shown in the accepted quality control manual.

2.6.2.4 Welding procedure specifications and qualification records in the format as shown in the accepted quality control manual.

2.6.2.5 Nondestructive examination procedures in the format as shown in the accepted quality control manual.

2.6.2.6 Completed weld report for each casing unit covering all completed welds and containing all the information necessary to verify the quality of the weld and welded material. Radiographs with completed report form and other nondestructive examination reports shall be included. The reports shall be in the format shown in the accepted quality control manual.

2.6.2.7 Certification documentation for non-destructive examination personnel and inspection and test personnel per ANSI NQA-1, Supplements 2S-1 and 2S-2, as applicable.

2.6.2.8 A listing of the completed units that indicates the most suitable fit-up sequence for field assembly of a continuous casing string based on compatibility of rim configuration for field welding. This best fit listing shall be called the unit matching list.

2.6.2.9 Supplier's certificate of compliance that the delivered fabricated product meets the requirements of the Specification and Drawing.

2.6.3 The Supplier shall submit the information listed in Appendix A, "Bidder and Seller Information Requirements" and the attached submittal matrix.

2.6.4 All Supplier final data shall be submitted in accordance with DOE HS-BP-8002.

2.7 Nonconforming Conditions

The Supplier shall identify each nonconforming condition relative to this Specification and the Drawings and shall notify the Purchaser and Engineer of each such condition. Disposition to "use as is" or to "repair" for each nonconforming condition shall require approval by the Purchaser/Engineer as a condition of acceptance of the work.

3.0 TECHNICAL PROVISIONS

3.1 Materials

3.1.1 Casing, Hemispherical Head, Stiffeners, Lifting Lug Rings, and reinforcement pads.

Steel plate and bar stock shall conform to ASTM A 588, Grade optional, normalized.

3.1.2 Grout Guides

The materials for the grout guides shall conform to the following:

3.1.2.1 Grout guide pipe: ASTM A 53, Schedule 40, black, type F.

3.1.2.2 Support plates and guide plates: ASTM A 588, Grade optional.

3.1.3 Ventilation and Dewatering Lines

The materials for the ventilation and dewatering lines shall conform to the following:

3.1.3.1 Ventilation and dewatering line pipes and slip collars: API Spec. 5A, Grade J-55, Casing.

3.1.3.2 Elbows: ANSI B16.9 long radius buttwelding 90° elbow for Schedule 160 pipe.

3.1.3.3 Reducers: ANSI B16.9 buttwelding reducer for Schedule 160 pipe.

3.1.3.4 Support plates and skid plates: ASTM A 588, Grade optional.

3.1.4 Inspection Port

The materials for the inspection part shall conform to the following:

3.1.4.1 Body: Forged steel coupling per ANSI B16.11 or steel conforming to ASTM A 588 with threads for plug.

3.1.4.2 Plug: ANSI B16.11

3.1.5 Continuous-Slot Channel

The continuous-slot channel shall be a commercial standard product fabricated from ASTM A 570, Grade C steel, with plain finish.

3.1.6 Centralizers

Steel plate conforming to ASTM A 588, Grade optional

3.1.7 Filler Metals

Filler metals for arc welding shall conform to Tables 4.1.1 and 4.1.4 of AWS D1.1. Material selected shall be identified in the weld procedures submittal. Filler metals and fluxes shall be traceable from purchase order to consumption.

3.1.8 Porthole

The materials for the porthole shall conform to the following:

3.1.8.1 Body: Forged steel or steel conforming to ASTM A 588, with threads for plugs as shown on the Drawing.

3.1.8.2 Plugs: ANSI B16.11.

3.2 Fabrication

3.2.1 Plate Thickness

Prior to processing each plate, thickness measurements shall be recorded and shall be made available for examination by the Inspector. Each plate shall be measured, with a micrometer or ultrasonic devices at each corner and not less than 2 points equally spaced on each edge of the plate. Plates shall be ordered to, and shall be not more than 0.010" below, the nominal thickness indicated in the schedule on the Drawing.

3.2.2 Plate Dimensions

Selection of plate width and length shall be commensurate with the casing dimensions specified.

3.2.3 Plate Identification

Each plate shall be marked with an identification number, using steel low-stress (interrupted dot) stamps with

1/2-inch-high characters, for the purpose of in-process identification of cans. Marking shall be in a location which will not be obscured by subsequent processing. Marking shall be circled with a high-contrast paint.

3.3 Welding

3.3.1 Welding Processes

The fusion welding processes for the weld fabrication of the units shall be as permitted by AWS D1.1 and ASME Boiler and Pressure Vessel Code, Section IX.

3.3.2 Weld Joint Root Beads

The back side of every longitudinal and circumferential plate weld root bead shall be mechanically cleaned or air arc gouged to clean metal prior to the deposition of additional weld metal.

3.3.3 Preparation for Welding

3.3.3.1 The edges of plates shall be formed to accommodate the applicable welding condition. All projecting burrs shall be removed. Hammering shall not be used to shape the edges preparatory to welding.

3.3.3.2 Surfaces to be welded shall be clean and smooth. Petroleum products shall not be used as cleaner on surfaces to be welded.

3.3.4 Qualifications

Welding procedure specifications shall be prepared, and the procedures, welders, and welding operators used for the fabrication of casing shall be qualified as specified herein. No previous procedure, welder, or welding operator qualification will be accepted. Production welds shall not be used to qualify weld procedures, welders, or welding operators. All procedure and performance qualification welds and tests shall be subject to witness by the Inspector. The Inspector shall be notified 48 hours in advance of qualification activities to permit him to attend.

3.3.4.1 Welding procedure specifications (WPS) shall be prepared in accordance with AWS D1.1, Section 5. The WPS shall include all essential and non-essential variables. All welding parameters shall be recorded in the WPS, with special consideration to joint configuration dimensions and weld metal deposition.

3.3.4.2 Welding procedures shall be qualified in accordance with AWS D1.1, Section 5, Part B, except as follows:

a. Qualification test specimens shall be radiographically examined and accepted in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Articles UW51 a and b. Radiographic examination is in addition to applicable guided bend tests.

b. Guided bend tests are required for procedure qualification for plate thicknesses of 3/4" and thinner, and shall include both face and root bends. The acceptance criteria for quided bend tests shall be in accordance with ASME Boiler and Pressure Vessel Code, Section IX.

c. The base metal used in procedure qualification tests shall be of the same specification and grade as specified in the Contract Specification.

3.3.4.3 Welders and welding operators shall be qualified prior to production welding. Qualification shall be in accordance with AWS D1.1, Section 5, Part C or Part D as applicable, except as follows:

a. Qualification test specimens shall be radiographically examined and accepted in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Articles UW51 a and b.

b. Guided bend test specimens shall be tested in accordance with AWS D1.1, Section 5, Part C or D as applicable, and ASME Boiler and Pressure Vessel Code, Section IX. Acceptance Criteria shall be in accordance with ASME Boiler and Pressure Vessel Code, Section IX.

3.3.4.4 Procedure, welder, and welding operator qualification records shall be maintained including certified radiographic examination report, radiographic film, and qualification report for each welder and welding operator including his/her unique identifier.

3.3.4.5 When there is a specific reason, as determined by the Inspector, to question the ability of a welder, welding operator, or welding equipment to consistently produce welds that meet the specifications,

the welder or welding operator shall be requalified. If the welder or welding operator continues to produce welds that do not meet the specifications, the Supplier shall, at the request of the Inspector, remove the welder, welding operator, or welding equipment from the job.

3.3.5 Weld Quality and Workmanship

3.3.5.1 Weld Type

Weld type shall be as shown on the Drawing.

3.3.5.2 Stress Risers

Visually discernable stress risers upon weld or parent metal surfaces, i.e. sharp and abrupt changes in weld bead geometry, laminations, inclusions, open porosity, arc starts, cold laps, lack of fusion, parent metal damage caused by removal of temporary appurtenances, chisel marks, or gouges, are not acceptable and shall be repaired prior to final inspection. Repair of welds shall be in accordance with the methods permitted by AWS D1.1 Article 3.7, except that oxygen gouging shall not be used on normalized steel.

3.3.5.3 Undercuts

Weld undercuts shall be rejected except, intermittent undercuts (6" long in 24" of weld) having a smooth and gradual transition and having a depth of 1/32" or less are acceptable.

3.3.5.4 Acceptance Standards

Weld acceptance shall be in accordance with the criteria for workmanship and nondestructive examination as specified herein and in Sections V and VIII of the ASME Boiler and Pressure Vessel Code and in AWS D1.1, Section 8, Part D for the inspection and examination methods used.

3.4 Tolerances

Casing assembly shall be fabricated to the following tolerances and as shown on the Drawings. Tolerances not specified otherwise shall be ± 1/8".

3.4.1 Weld Joint Root Openings

Longitudinal and circumferential plate welds shall have the option of a root gap ranging up to 3/16" maximum.

3.4.2 Staggered Welds

Longitudinal welds of cans in a casing subassembly shall be staggered circumferentially a minimum of 24".

3.4.3 Mismatch

The mismatch of the interior surfaces of abutting cans shall not exceed 1/16" along the longitudinal weld seam nor 1/8" along the circumferential weld seam.

3.4.4 Unit Straightness

Completed casing unit shall be straight, with walls parallel to the axis of the casing within a tolerance not exceeding 3/16" in 10' when measured from a reference line parallel to the axis.

3.4.5 Section Ends

3.4.5.1 The planes of the ends of the casing unit shall be normal to a line parallel to the axis of the casing section with a tolerance of ± 15 minutes of arc at all locations on the circumference.

3.4.5.2 The maximum gap between the end of the unit and a plane surface pressed against the end of the unit shall be 1/8 inch.

3.4.6 Fillet Weld Size

Close fitup is required at those joints where fillet welds (except for lifting lug rings and stiffener) are applied in order to insure full fusion welds at the bottom of the fillet. Fillet weld fit-up shall be in accordance with AWS D1.1, Section 3.0. Fillet weld specified size is a minimum. For lifting lug rings and stiffener, if the gap at any point between the shell and lifting lug ring or stiffener exceeds 1/16 inch but is less than 1/8 inch, it will be acceptable providing that the fillet weld size is increased 1/16 inch throughout 360°. Gaps exceeding 1/16 inch on lifting lug rings shall be indentified in Supplier's inspection report.

3.4.7 Lifting Lug Rings

The uppermost ring on a casing unit is the lifting lug ring for that section of casing. The plane of the bottom edge of each lifting lug ring shall be parallel with the plane of the top of the casing unit within 1/8". The angle between the casing and the lower surface of the lifting lug ring shall be 90° +3°/-0°.

3.4.8 Ring Closure Welds

There shall be a maximum of 2 closure welds for each stiffener ring and lifting lug ring. Closure welds may be made before installation of rings if shrink-fit installation is employed; however, if rings are installed in sections, closure welds shall be made after the attachment weld.

3.4.9 Casing Unit Length

The finished length for each casing unit may vary ± 1/8" from the nominal lengths indicated on the Drawings.

3.4.10 Weld Reinforcement

Weld reinforcement of inside diameter welds shall not exceed 3/32" for plate thickness of 3/16" to 1" and 1/8" for plate thickness of 1" to 2", and shall be smoothly blended from weld metal to parent metal. Outside diameter weld reinforcement shall not exceed 1/4" and shall be smoothly blended from weld metal to the parent metal.

3.4.11 Casing Unit Diameter and Out-of-Roundness Tolerances

Casing units shall be manufactured to the following tolerances:

a. The diameter as determined by a circumferential measurement with a π tape may be 1/4" over to 0" less than the sum of the nominal diameter plus twice the nominal plate thickness indicated on the Drawings.

b. The difference between the maximum and minimum diameter (out-of-roundness) at any cross section shall not exceed 3/8".

c. Circumferential and diametral measurements shall be made at the end of each casing unit and at not less than 7 points approximately equally spaced between the ends of the unit with the measuring points to be selected by the Inspector.

3.4.12 Tapered Transition

The lower edge of the lowest can in the bottom casing unit shall have a tapered transition, for the weld joint with the abutting hemispherical end, as shown on the Drawings and in accordance with Article UW-9(c) of Section VIII of the ASME Boiler and Pressure Vessel Code.

3.4.13 Hemispherical End Tolerances

The hemispherical end shall be manufactured to the following tolerances:

a. The hemispherical shape shall conform to the requirements of Article UG-81(a) of Section VIII of the ASME Boiler and Pressure Vessel Code.

b. The diameter and out-of-roundness tolerances at the skirt (i.e., at the edge to be welded to the abutting can of the casing unit) shall be the same as specified above for the casing unit.

c. The weld joint root gap between abutting segments (if head is not formed in one piece) and between the skirt and the abutting can of the casing unit shall be the same as specified above for "Weld Joint Root Openings" of casing units.

d. The mismatch of the interior surfaces of abutting segments shall not exceed 1/16", and the mismatch of the interior surfaces of the skirt and the abutting can of the casing unit shall not exceed 1/8".

3.5 Identification Marking

3.5.1 Welding Operator Identification

All welds shall bear the welding operator's identification mark. Such identification shall be located on surface (exterior or interior) from which welding is performed adjacent to the weld but not closer than 1" from the heat affected area. Steel stamps employed shall imprint a radius, not a sharp notch.

3.5.2 Casing Unit

3.5.2.1 Data Required

Each completed casing unit shall be marked on the inside, 6" from each end as follows:

a. Using metal stamps having numerals and letters not less than 3/8" high, denote Supplier, ASTM designation of base metal, and total calculated weight of completed unit in pounds.

b. Using a paint stencilling system which yields not less than 1" high figures and letters, denote the internal diameter, wall thickness, length in feet and decimal, and purchase order number. The stencilling shall be placed upon

clean base metal free of scale, rust, or other foreign matter. Color of the stencilling shall be in contrast to the base metal.

3.5.2.2 Mark and Unit Matching Identification

Each completed casing unit shall bear a free-hand applied mark and unit matching identification located at each end of the unit on the inside and outside surface. In addition each end of each unit shall be match marked to correlate with the information in the Unit Matching List showing most suitable fit-up sequence for field assembly. Such mark identification shall be placed at a distance from each end to permit ready visibility to the viewer without entry into the casing. The mark identification may be applied with a paint spray gun, aerosol can or brush and shall be not less than 18" in height. The mark identification shall be a number as shown on the Drawing and assigned by the Supplier.

4.0 NON-DESTRUCTIVE EXAMINATION AND VISUAL INSPECTION

4.1 Continuous-Slot Channel

Fillet and closure welds for continuous-slot channel rings shall be 100% visually inspected.

4.2 Lifting Lug and Stiffener Rings

Welds on rings shall be examined as follows:

4.2.1 Closure welds for lifting lug rings and for stiffener rings shall be 100% magnetic particle examined.

4.2.2 Fillet and groove welds for lifting lug rings and stiffener rings shall be 100% magnetic particle examined.

4.3 Casing Seams and Casing Penetrations

All longitudinal and circumferential plate welds and welds at penetrations through the casing shall be 100% radiographic inspected. Radiographic film shall be placed so that the weld seam is centered on the film. Reinforcement pad to casing fillet welds shall be 100% magnetic particle and visually inspected.

4.4 Radiography

4.4.1 The radiographic inspections shall be performed as stipulated for technique and quality in Paragraph UW51, Section VIII, ASME Boiler and Pressure Vessel Code

4.4.2 If adjacent areas of a weld are covered on separate radiographs, each radiograph shall provide at least 2 inches of weld coverage overlap with the adjacent radiograph(s).

4.4.3 Exposed radiographic film that is defective shall be basis for rejection of the film, and repeating the radiographic inspection of the weld.

4.5 Magnetic Particle Examination

4.5.1 Groove and fillet welds on lifting lug rings and stiffeners shall be 100% magnetic particle inspected at the root bead, at one half weld thickness on lifting lug rings only, and after all grinding or machining is complete. Closure welds on lifting lug rings and stiffeners shall be 100% magnetic particle inspected at the root bead and at each 10% of weld thickness thereafter. The magnetic particle inspection shall be in accordance with ASTM E 709 using the DC prod method, and ASME Section V, Standard SE 109.

4.5.2 The quality acceptance standard shall be as specified in Section 3.3, "Welding," herein.

4.5.3 Surface imperfection interpretations in dispute with the magnetic particle inspection indications shall be verified by an alternate nondestructive examination method as determined by the Inspector.

4.6 Visual Inspection

4.6.1 Visual inspection shall be performed during all in-process fabrication operation and upon all completed welds. Visibly discernable weld defects shall be repaired and visually reinspected prior to the application of other nondestructive examination procedures.

4.6.2 The Inspector may request additional non-destructive examination when the structural integrity of a repair is in question.

4.6.3 Standards of acceptance shall be as specified in Section 3.3, "Welding," herein and in AWS D1.1, Section 3, and Section 8, Part D.

4.7 Witnessing by Inspector

The Inspector may witness any or all nondestructive examinations of welds. When the Inspector disagrees with the performance of any nondestructive examination, or with the Supplier's acceptance of examination results, the decision of the Inspector will be final.

5.0 SHOP DRAWINGS

5.1 Fabrication Drawings

The Supplier shall provide detailed shop drawings reflecting all the information and data pertinent to fabrication and related quality control. Submittal shall be made at least 15 working days prior to scheduled start of fabrication. The Purchaser will review and comment on the drawings. Appendix A pertains.

5.2 Packaging and Shipping Drawings

The Supplier shall provide detailed drawings of casing supports, surface protection, and shipping bracing of the finished unit. Special rigging or handling requirements shall also be shown and specified. Submittal shall be made 60 working days prior to scheduled shipment of the first unit. Appendix A pertains.

5.3 Acceptance of Shop Drawings

The Purchaser's acceptance of any shop drawing or other comment that directs the Supplier to proceed on technical matters does not relieve the Supplier of his responsibility for supplying the casing units in conformance with the Specification, the Drawing, and the Purchase order.

6.0 PACKING, HANDLING, SHIPPING, AND STORING

6.1 Casing Protection

The Supplier shall take necessary precautions to prevent damage to the casing units during handling, loading/offloading, and transporting. The provisions of ANSI N45.2.2 shall be complied with.

6.2 Supports

Suitable mechanical supports and other devices as required shall be provided for each casing unit to maintain dimensions within specified tolerances and to prevent deformation during handling, loading, transporting, offloading, and storing.

6.3 Tack Welding

Tack welding of supports and protective devices on the units will be permitted only as indicated on the accepted packaging and shipping drawings submittal.

6.4 End Protection

Both ends of each completed casing unit shall be mechanically cleaned to parent metal for a distance of not less than 1", internally and externally, beyond the terminating ends of weld joint preparation. Cleaned areas shall be masked with a material of the

type accepted on the packaging and shipping drawings submittal to protect the ends from corrosion and damage in transit and in storage. The masking material shall be readily removable when preparing the casing units for field welding.

6.5 Shipping Release

No loading for shipment shall commence prior to the issuance of a written release for shipping by the Inspector. Nonconforming products shall not be shipped.

6.6 Off-Loading and Storing Procedure

The Supplier shall provide a procedure for off-loading and storing at the destination. Procedure shall be submitted for Purchaser's review and comment 60 working days prior to scheduled delivery date. Storage will be in the vicinity of the exploratory shaft site at an area designated by the Purchaser. Handling and storage procedures shall be in accordance with ANSI N45.2.15.

6.7 Acceptance at Site

Products furnished hereunder will be subject to re-inspection upon delivery at the site, before being off-loaded from the transport vehicle(s). Non-conforming products shall not be off-loaded nor accepted for delivery. Conforming products will be accepted for delivery, off-loading, and placing in storage.

BWIP17I: 12/17/82

BIDDER AND SELLER INFORMATION REQUIREMENTS

TYPE OF INFORMATION	BY BIDDER	BY SELLER (NOTE - LAST COLUMN TO BE COMPLETED BY SELLER)						
	COPIES WITH EACH BID	REPRODUCIBLE* TO BE SUBMITTED FOR REVIEW	CERTIFIED DRAWINGS TO BE SUBMITTED AFTER REVIEW: PAPER PRINTS	REPRODUCIBLE *: PAPER	REPRODUCIBLE *: PERMANENT	COPIES REQUIRED WITHOUT REVIEW	POST AWARD: REVIEW DATA REQUIRED (WEEKS AFTER AWARD)	POST AWARD: SELLER PROMISE SUBMITTAL (WEEKS AFTER AWARD)
1. DRAWING LIST AND SCHEDULE		**	6	1				
2. DIMENSIONED OUTLINE DRAWINGS AND/OR CATALOG INFORMATION								
3. SCHEMATIC PIPING DIAGRAMS								
4. ELECTRICAL AND INSTRUMENTATION INFORMATION								
5. SHOP DETAIL DRAWINGS		**	6	1			See Par 5.1	
6. FOUNDATION OUTLINE AND ANCHOR BOLT LOCATIONS								
7. LOAD DIAGRAMS								
8. DATA SHEETS, AS NOTED THEREON								
9. PERFORMANCE DATA AND CURVES								
10. Certified Test & Inspection Reports, Weld Backing Ring						3		
11. BILLS OF MATERIAL								
12. INSTALLATION INSTRUCTIONS								
13. MAINTENANCE AND OPERATING								
14. NAMEPLATE DATA, AND MOTOR LIST								
15. CALCULATIONS								
16. PRELIMINARY DESIGN DRAWINGS								
17. FINAL DESIGN DRAWINGS								
18. Quality Assurance Program	3	**	6	1				
19. Quality Control Manual	3	**	6	1				
20. Inspection Plan		**	6	1			See Par. 2.5.5	
21. Plate, Shape, Pipe, & Fitting Mill-Test Certified Reports						3		
22. Welding Electrode & Flux Matl. Manufacturer's Certification						3		
23. Welder & Welding Operator Test Records						3		
24. Welding Procedure Spec.		**	6	1				
25. Weld Reports (including NDE)						3		
26. Personnel Qualification Cert.						3		
27. Unit Matching List						3		
28. Certificates of Compliance						3		
29. Shop Dwgs.(Packaging&Shipping)		**	6	1			See Par 5.2	
30. Off-Loading & Storage Procedure		**	6	1			See Par 6.6	
31. Nondestructive Examination Procedures		**	6	1				
		**	6	1				
* Reproducible required only for data larger than 11" x 17". **One reproducible plus 6 copies								

See Next Page for Definitions and Instructions

APPENDIX A, Sheet 2 of 3

DEFINITIONS

1. DRAWING LIST AND SCHEDULE A complete list of all drawings and data by title that the Bidder expects to furnish on this order. Schedule to show, in weeks after award, submittal of each type of review and certified drawings.

2. DIMENSIONED OUTLINE DRAWINGS AND/OR CATALOG INFORMATION Drawings to scale showing the relative size, configuration, and location of all material to be furnished. Show two or more views of unit, clearances and area required for operation and maintenance. Show unit in relation to nearby structures and other equipment or operating floor, location of utility connections and direction of rotation, if applicable. When submitting data for "off the shelf" equipment/materials, catalog cuts and information are acceptable provided they are submitted in ample detail.

3. SCHEMATIC PIPING DIAGRAMS Show equipment to be interconnected, flow quantities, pipe sizes, valves and instruments.

4. ELECTRICAL AND INSTRUMENTATION INFORMATION Show all data pertaining to instrumentation, control and power electrical equipment. Include "one-line", "elementary" wiring, panel interior wiring and exterior interconnection wiring, dimensioned outlines of enclosures with raceway entries shown.

5. SHOP DETAIL DRAWINGS Show all necessary details and data required for fabrication and maintenance. For structural details show all connections and member sizes.

6. FOUNDATION OUTLINE AND ANCHOR BOLT LOCATIONS Show all data required for foundation design including location, blockouts, embedded items, grout required, and size, type and projection of anchor bolts.

7. LOAD DIAGRAMS Show total static and dynamic loads and load centers.

8. DATA SHEETS Sheets shall be completed for the equipment proposed with all information noted thereon.

9. PERFORMANCE DATA AND CURVES

10. CERTIFIED TEST AND INSPECTION REPORTS Reports by recognized commercial laboratories of indicated chemical and physical tests of materials as required by the specifications. In addition where applicable, weld inspection and stress relieving records and code nameplate rubbings shall be furnished.

11. BILLS OF MATERIAL Show for each unit: item no., shop order no., mark or name, part no., or pattern no., and drawing reference.

12. INSTALLATION INSTRUCTIONS Complete, detailed and sequenced instructions for original installation and for removals and replacements as well as erection information.

13. MAINTENANCE AND OPERATING MANUALS Complete installation, starting and operating instructions. Complete descriptions of preventive and repair maintenance, including detailed lubrication chart showing every lubrication point, grade of lubricant, lubrication schedule and amount of oil or grease required for refill after drainage. Manuals include parts list with recommended spares.

14. NAMEPLATE DATA AND MOTOR LIST

15. CALCULATIONS Shall be checked and stamped by a registered professional engineer, licensed to practice in the state where installation occurs.

16. PRELIMINARY DESIGN DRAWINGS Seller provided design services such as pre-engineered buildings, silos and other structures, conveyor systems, bins and chute design, large ductwork and supports.

17. FINAL DESIGN DRAWINGS Same as Item No. 16.

INSTRUCTIONS

1. DIMENSIONS Shown on all but schematic drawings and diagrams shall be in feet and inches, unless noted otherwise.

2. CERTIFIED DRAWINGS Shall be so marked by Seller. They shall conform to Seller's drawings as finally accepted by the Purchaser and shall be forwarded at commencement of manufacture. The drawings shall be revised and resubmitted to reflect any changes approved during the manufacturing period.

3. REPRODUCIBLE PERMANENT PRINTS Shall be cloth, "Chronaflex", or "Mylar". They shall depict the material as shipped and shall be forwarded upon completion of shipment.

APPENDIX A (Sheet 3 of 3)

RECORDS AND SUBMITTALS

	Q A Program	Q C Manual	Steel Plate, Strip Pipe & Fitting Material	Welding Electrodes & Fluxes	Welders & Welding Machine Operators	Welding Procedures	Production Welds	Nondestructive Examination	Q C Personnel	In-plant Inspection	Fabrication	Packaging	Shipment	Handling & Storage	Unit Matching	Welding Backing Ring Material
Drawings											a	b	b	b		
Procedures	a	a				a				a	a	b	b	b		
Manuals	a	a														
Records							b	b					c			
Certificates			a	a	a	a			a							a
Plans	a									a						
Lists													c		c	
Formats		a														
Schedules										a			b			

LEGEND: a. Submit to Owner for review and concurrence prior to fabrication

b. Submit to Owner for review and concurrence prior to shipment

c. Submit upon delivery.

APPENDIX B

INFORMATION REQUIRED FOR QUALITY CONTROL PROGRAM

1. Identification of organizations/personnel responsible for the performance and verification of activities affecting the quality of the work and its conformance to Specification and Drawing requirements.
2. Material storage facilities and weather protection.
3. Methods of controlling and measuring material dimensions.
4. Material records and marking system.
5. Non-destructive examination and quality control personnel qualification and certification program.
6. Identification of organizations/personnel responsible for control of special processes such as welding and non-destructive examination.
7. Identification of organizations/personnel responsible for welding procedure, welding operator, and welder qualification and tests.
8. Quality control manual containing all policies, assignments of responsibility, procedures, forms, and controls.
9. In progress and final inspection procedures.
10. Document and record controls.
11. Control of nonconformances.

BWIP17J: 12/10/82

RL F 1300.4
54 2040 144 (12 80)

DESIGN / FIELD CHANGE

(1) Classification: ☐ Type I ☒ Type II

(2) Number: B-314-046

(3) Project No.: B-314

(4) Project Title: EXPLORATORY SHAFT - PHASE I

(15) Final Approval Date: 2/8/83

(5) Documents Affected — Bldg. 807 Index 1000
1. Dwg. H8-S20901 R-0
2. Dwg. H8-S20902 R-0
3. Dwg. H8-S20903 R-0
4. Spec. No. B-314-P-S28005, Rev. 0

(16) All Documents Revised By
(Name) (Date)

(6) Description Of Change

018-003

72" Casing: Further changes to welding and to casing end preparation.

See Attachment. (BWIP-8014) ~~Five~~ Eight pages BLS 2/3/83

BASALT

(14) Distribution

DOE
J. A. Acsai
*R. D. Hudson

RHO J. L. Ash
*M. T. Black
H. W. Brandt
P. K. Brockman
M. F. Nicol
P. J. Reder (PR)
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*W. F. Todish
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(7) Justification

To improve welding control, acceptance procedures, tolerance specifications, and end preparations.

(8) Estimated Effect

A) Engineering Cost	$ 1,000	☒ Additional ☐ Savings
B) Construction Cost	$ 25,000	☐ Additional ☒ Savings
C) Schedule Impact	None	☐ Delay ☐ Improvement

Remarks

(9) Initiator/Author	(10) Phone	(11) Organization(s)	(12) Date
Bryan Schroeder	6-7283	BWIP Engineering Design Dept.	2/4/83

(13) **APPROVALS:**

ARCHITECT ENGINEER		OPERATING CONTRACTOR	DEPARTMENT OF ENERGY
A) Design [signature] 2/7/83 [signature]	C) QA [signature] L. G. Thomas QAE 2/7/83	E) [signature] 2/7/83 H. B. [signature] for [signature]	G)
B) Safety [signature] 2/7/83	D) PE Peter Bibbus 2/7/83 by J. S. Ritchie	F) [signature] 2-8-83	H)

(17A) Operating Contractor Use	B)	C)	D)

WT 7/10/83

SPECIFICATION NO. B-314-P-S28005, REV. 0

Para. 1.0 - Delete "and associated grout guides,"

Para 1.1.8 - Delete entire paragraph.

Para 1.1.9 - Delete entire paragraph.

Page 2 - Delete reference to Section VIII and IX of the ASME Code and N45.2.15 - 1981.

Para 2.2.1 - Delete this entire section and replace with the following:

2.2.1 Drawings

The following listed design drawings are incorporated and made a part of this specification:

NUMBER	TITLE
H8-S20901	72" I.D. Casing
H8-S20902	72" I.D. Casing Utilities Layout
H8-S20903	72" I.D. Casing Utilities Details

Para 2.2.2 - Add "Appendix C: Sketch of utility collar, 1/4" plug, and 5" plug. (Details later)"

Para 2.4.1 - Delete "ANSI N45.2.15.

Para 3.1.1 - Replace "optional" with "supplied by purchaser"

Para 3.1.2 - Delete entire paragraph and replace with:

"3.1.2 Support Plates: ASTM A588, Grade supplied by purchaser."

Para 3.1.3.1 - Add "and free of mill varnish."

Para 3.1.3.2 - Replace entire paragraph with Utility Collar, ASTM A588 [illegible] 2/5/83

Para 3.1.3.3 - Delete entire paragraph.

Para ~~3.1.3.3 - Delete entire paragraph.~~ [illegible] 2/7/83

Para 3.1.5 - Delete entire paragraph.

Para 3.1.6 - Replace "optional" with "supplied by purchaser".

Para 3.3.1 - Delete the words "and ASME boiler and Pressure Vessel Code, Section IX."

Para. 3.3.3.3 - Add the following: "The end preparation on each casing unit welded at the site prior to erection shall have 22-1/2 degree by 22-1/2 degree bevel with a maximum 1/4-inch ~~maximum~~ land. All material thickness change shall also be double jointed. Below is the schedule of units to be double jointed. BD 2/7/83

1 and 2	(1 is the hemispherical end)
3 and 4	
5 and 6	
7 and 8	
9 and 10	
11 and 12	(Thickness transition from 1-3/4 to 1-5/8). BD 2/7/83
13 and 14	
16 and 17	(Thickness transition from 1-5/8 to 1-1/2).
18 and 19	
20 and 21	
22 and 23	
24 and 25	(Thickness transition from 1-1/2 to 1-3/8)
26 and 27	
28 and 29	
30 and 31	
32 and 33	
35 and 36	(Thickness transition from 1-3/8 to 1-1/4)
37 and 38	
39 and 40	
42 and 43	(Thickness transition from 1-1/4 to 1-1/8)
44 and 45	
46 and 47	
48 and 49	
51 and 52	(Thickness transition from 1-1/8 to 1)
53 and 54	
55 and 56	
57 and 58	(Thickness transition from 1 to 7/8)
59 and 60	
62 and 63	(Thickness transition from 7/8 to 3/4)
64 and 65	
66 and 67	
68 and 69	
70 and 71	
72 and 73	(Thickness transition from 3/4 to 5/8)
74 and 75	
76 and 77	
78 and 79	
80 and 81	
82 and 83	
84 and 85	
87 and 88	(Thickness transition from 5/8 to 1/2)
89 and 90	
91 and 92	
93 and 94	
95 and 96	
97 and 98	(98 is a half section)

The following units will be jointed under the rig at both ends using a single bevel as shown on detail 1 of drawing H8-S20901.

15
34
41
50
61
86

Para 3.3.4 - Delete the words - "No previous procedure, welder, or welding operator qualification will be accepted."

Replace the above words with - "Previous welder or welder operator qualifications will be acceptable only if qualification was performed within 90 days prior to start of actual production welding for this contract."

Para 3.3.4.2 - Delete entire paragraph, including Subsections a, b, and c and replace with the following: "Welding procedures shall be qualified in accordance with AWD D1.1, Section 5, Part A and Part B."

Para 3.3.4.3 - Delete entire paragraph, including Subsections a and b and replace with the following: "Welder and welder operators shall be qualified prior to production welding. Qualification shall be in accordance with AWS D1.1, Section 5, Part A, Part E, and Part C or D as applicable."

~~Para 3.3.4.5 - Add "do not" between the words "that and "meet" of the first sentence.~~ BLS 2/8/83

Para 3.3.5.4 - Delete entire paragraph and replace with the following: "Weld acceptance shall be in accordance with the criteria established in AWS D1.1, Section 3 and Section 8, Part A and Part D. NDE techniques are as established in paragraphs 4.4, 4.5, and 4.6."

Para 3.4.5.3 - The fabricator is responsible to machine the ends of designated abutting units such that the following field assembly tolerances can be achieved without additional machining:

1. The mismatch of the interior surfaces of designated abutting units shall not exceed 1/8" along with circumferential weld seam.

-NOTE-

The interior of the units will not be accessible to the field assembly personnel. Therefore, a diagram of required external mismatch measurements to achieve the internal mismatch tolerance shall be included with the overall documentation of each unit.

2. The maximum gap between designated abutting units shall not exceed 1/8" when the designated abutting units are aligned to meet the linearity requirement below.

3.4.5.4 Add "The section straightness, measured across the ends of two designed abutting units, shall be walls parallel to the axis of the assembled sections within a tolerance not exceeding 3/16" in 10' when measured from a reference line parallel to the axis."

Para 3.4.10 - Delete entire paragraph and replace with the following:

Material Thickness, in.	Max. Thickness of Reinforcement, in.
Less than 3/32	1/32
3/32 to 3/16, incl.	1/16
Over 3/16 to 1, incl.	3/32
Over 1 to 2, incl.	1/8
Over 2 to 3, incl.	5/32
Over 3 to 4, incl.	7/32
Over 4 to 5, incl.	1/4
Over 5	5/16

Para 3.4.11 Add subparagraph d:

"d. Internal supports shall not be used as an aid to attain the Out-Of-Roundness Tolerances."

Para 3.4.12 - Delete entire paragraph and replace with the following: "Transition of thickness shall be in accordance with AWS D1.1, Section 10, Part C, paragraph 10.11."

Para 3.4.13 - Delete entire paragraph and replace with the following: "The inner surface of a torispherical, toriconical, hemispherical, or ellipsoidal head shall neither deviate outside of the specified shape by more than 1-1/4% of D nor inside the specified shape by more than 5/8% of D, where D is the nominal inside diameter of the vessel. Such deviations shall be measured perpendicular to the specified shape and shall not be abrupt. The knuckle radius shall not be less than that specified.

Para 4.1 - Delete entire paragraph.

Para 4.4.1 - Delete entire paragraph and replace with the following: "All welded joints to be radiographed shall be examined in accordance with ASME Section V, Article 2 except as specified below.

a. A complete set of radiographs and records, as described in T-292 and T-293 of Article 2 of Section V, for each job shall be retained by the Manufacturer and kept on file for a period of at least 5 years.

b. The fabricator shall certify that personnel performing radiographic examinations have been qualified and certified in accordance with SNT-TC-1A (1975) for the technique and methods used.

c. The requirements of T-251 of Article 2 of Section V are to be used only as a guide. Final acceptance of radiographs shall be based on the ability to see the prescribed penetrameter image and the specified hole.

d. Sections of welds that are shown by radiography to have any of the imperfection identified in paragraph 3.3.5.4 shall be judged unacceptable and shall be repaired using an approved weld repair procedure in accordance with paragraph 3.3.5.2 and re-radiographed.

Para 4.5.1 - Delete entire last sentence and replace with: "The magnetic particle inspection shall be in accordance with ASME Section V, Article 7 using the DC prod method.

Para 4.5.2 - Delete entire paragraph and replace with: "The Quality Acceptable standard shall be as specified in paragraph 3.3.5.4." cdh 2-8-83

Para 4.6.1 - Delete entire first sentence and replace with: "Visual inspection shall be performed during all in-process fabrication operations, including all tack welds and all completed welds."

Para 4.6.3 - Delete entire sentence and replace with: "The Quality Acceptenace standard shall be as specified in paragraph 3.3.5.4."

Para 6.2 - Add: "Mechanical supports shall not be used to attain the Out-Of-Roundness Tolerances specified in paragraph 3.4.11."

Para 6.4 - Add to the end of the paragraph: "Masking tape shall not be used."

Para 6.6 - Delete entire paragraph.

Para 6.7 - Add in first sentence that inspection will be by the purchaser.

Appendix A, Sheet 1, Item #15 - Delete the word calculations and add the following as a submittal requirement:

"Temporary attachment and removal procedure"
Submittal requirements same as item #1 BLS 2/8/83
Item #30 - Delete off-loading and storage procedures.
Item #10 - Delete certified test and inspection reports for weld backing ring.

Attachment A, Sheet 3 - Delete last column.
Delete column entitled "Handling and Storage"

JUSTIFICATION

- Prequalified procedures have been used for welding inside nuclear reactor containment vessels. For example, at Satsop III-the main steam whip restraints. Prequalified procedures are permitted by AWS D1.1 for 50,000 psi tensile stress material. The credibility of overall welding program is established through the welder qualification program, not the procedure qualification.

- The AWS D1.1 code allows either the guided bend test or the radiographic test, it does not require both. The radiographic test is definitive to establish the qualifications of the welders.

- ASME Secton IX addresses welder procedure qualification and does not by itself consist of a welding code. AWS requires welders to be tested for the position to be welded.

- All other changes are for clarity or a change in scope or plans.

Drawing H8-S20901

Section D - Delete this section detail. Slot channel will be field installed during shaft guides installation. This reduces 360 degree channel requirement to approximately 90 degrees.

BLS 2/8/83

Detail 2 - Replace Detail 2 with Figure 1 (attached) ~~and add the following note: Supplier is to provide utility collar and plugs. Welding to casing will be provided by others - show all welds as field welds. Justification: location of utility lines may change depending upon the horizon selected.~~

Detail 3 - (1) Delete reference to 3 inch NP threads. All threads shall be 2 inch. Justification: uniformity.

(2) Delete "Mark No. A and B and Mark No. C to P" and 5" DIA". Justification: Same as above.

(3) Install inspection ports (one per 80 foot) section according to the schedule shown in paragraph 3.3.3.3 of specification B-314-P-S28005. Justification: A substantial cost savings is realized by eliminating 46 inspection ports.

Detail 5: (1) Change not to read, "111 horizontal" and "36 down angled". Justification: Change in test plans.

(2) Add identification of both plugs (i.e. 3-1/2" NPT and 4" NPT). Justification: clarity.

(3) Change 5/16 weld between reinforcement pad and casing to 5/8. Justification: strength and analysis requirements.

(4) Change 3/8 weld between porthole and reinforcement pad to a full penetration weld. Justification: Same as 3 above.

Drawing H8-S20902

Notes: Delete grout guides and guide plates. Justification: Supplied by others. Add, "utility collar and reinforcing plates, if applicable".

Detail 1, 4, and 6: Add note, "Quality Level III, by others."

Drawing H8-S20903

Detail 8: Same change as detail 2 of drawing H8-S20901.

Schedule of Materials - Add note: "Grout guides and guides plates are QA Level III and supplied by others.

Grout Guide: Change dimension ±1 and ±6 to 1" and 6" respectively.

Justification: QA level changed since grout lines are construction aids.

Concept for Detail 2 of
Drawing H8-520901

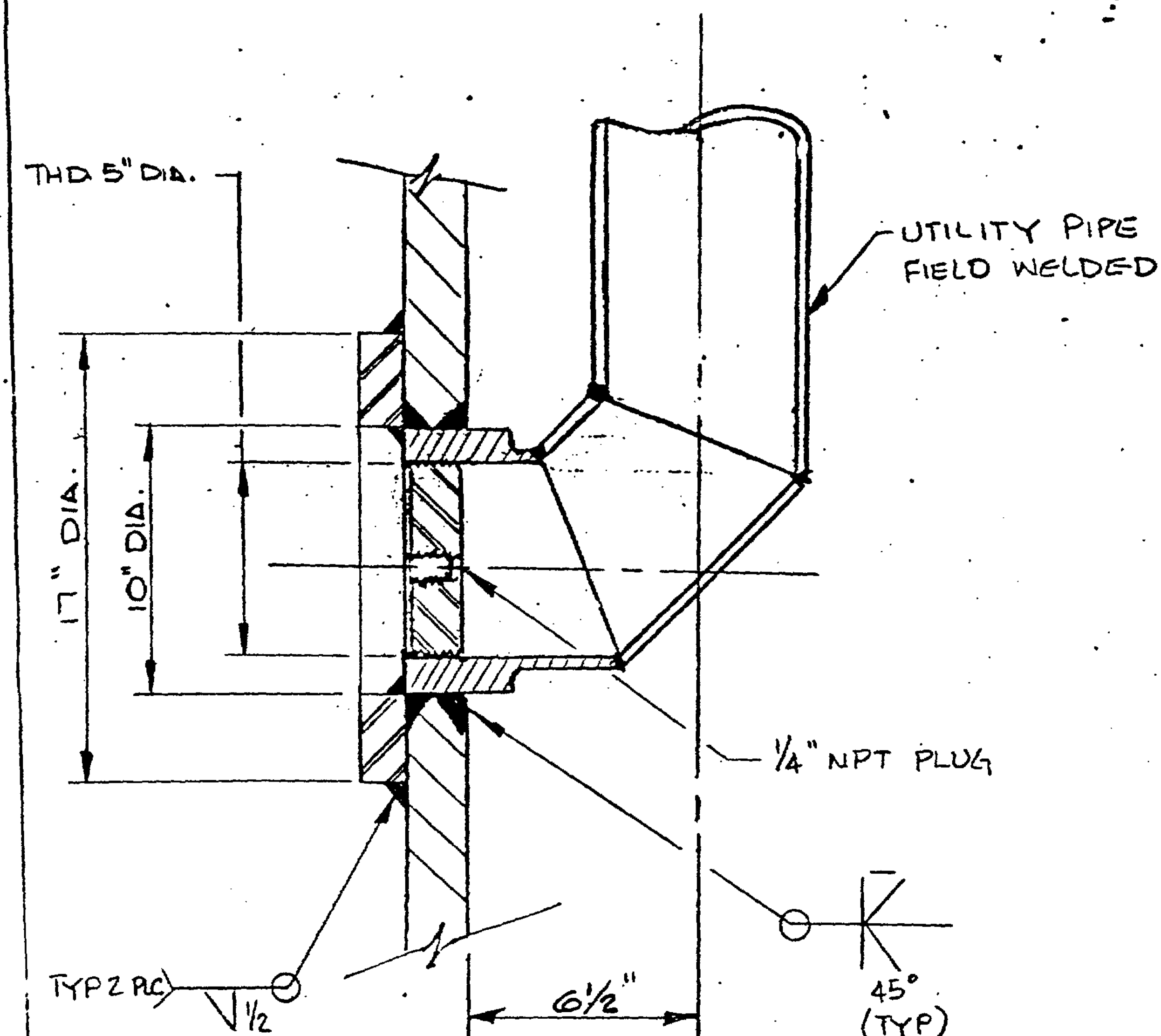

FIGURE 1

Rockwell Hanford Operations
Richland, WA 99352

ENGINEERING ORDER

EO TYPE			
X	Release		Supersedure
	Release To File		Cancellation
	Authorize Requirements		Obsoletion
	Change		File As Drawing

QA Level	Change Type	Building	Project No.
I	2	800-G	B-314

EO 02683

Cognizant Engineer: JS Richie (KE/PB) Phone: 415-271-5281

Responsible Organization: BM Schroeder Phone: 6-7283

Priority: E

Is A Cross Reference To
AUTHORIZATION NO.
WBS LF2222

Index No.	CEI No.	Document No.	Sheet No.	Rev.	Next Used On
	CM014	B-314-P-S28004	1-23	R002	H8-S20801

Procurement Specification for 112" I.D. Steel Casing (B-314-P-S28004 Rev. 2)

Initiated by: KE/PB
Used by: Rockwell

BASALT

Signature	Date
HW Brandt (signed) — Prepared By	
BK Schroeder (signed) — Cognizant Manager	11/19/82
X PJ Reder (signed) — xxxxxConfManage.	11/19/82
Cognizant Engineer	
Authorizer	
X MF Nicol (signed) — Quality Assurance (QA RHO 95 stamp)	11/19/82
X LK Aldrich (signed for, per telecon) — Health, Safety & Environment	11/19/82
Criticality Engineering & Analysis	
X (signed) Design Review Chrm	11/19/82

Reasons & ESR No.

RELEASE STAMP

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Work Completed | Date

BWIP 6984

Rev. 2, 11/17/82

SPECIFICATION TITLE PAGE

SPECIFICATION NO. B-314-P-S28004

QA LEVEL I

PROCUREMENT SPECIFICATION FOR

112" ID STEEL CASING

BWIP EXPLORATORY SHAFT
PROJECT B-314

Pepared By:

Kaiser Engineers, Inc./Parsons Brinckerhoff Quade & Douglas, Inc.

For the U.S. Department of Energy

Contract No. DE-AC06-80RL10000

Specifications Engineer	Date 11-17-82	Job Engineer	Date 11-17-82
Design Manager	Date 11-17-82	Project Engineer	Date 11-17-82
QC Engineer/Constr. Engr.	Date 11-17-82	Quality Assurance Engineer	Date 11-17-82
Deputy Project Manager	Date 11-17-82	J. S. Ritchie / Project Manager	Date 11-17-82

ROCKWELL HANFORD OPERATIONS:

11/19/82
Date

Released for Procurement:

11/19/82
Date

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RELEASE VIA
EO 02683
Doc. Rev. R 002
Rel. Date 11/19/82

TABLE OF CONTENTS

112" ID STEEL CASING

1.0 SCOPE

This Specification describes the requirements for the fabrication and delivery to the project site of seventeen (17) welded steel 112 inch inside diameter shaft casing units, and associated grout guides, support plates, and weld backing strips.

1.1 Work Included

1.1.1 Labor

1.1.2 Tools, materials, and equipment

1.1.3. Fabrication

1.1.4 Testing

1.1.5 Records Management

1.1.6 Packaging

1.1.7 Transportation

1.1.8 Offloading

1.1.9 Placing in storage

1.2 Work Not Included

1.2.1 Maintenance in storage

2.0 GENERAL PROVISIONS

2.1 Applicable Codes, Standards, and Publications

Work performed and materials furnished under this Specification shall conform to the requirements of the documents listed below, to the extent specified herein. In the event of conflict between applicable requirements of two or more of these documents, the most stringent requirement shall apply.

ANSI, American National Standards Institute

B16.11-1973,	Forged Steel Fittings, Socket-Welding and Threaded
NQA-1-1979,	Quality Assurance Program Requirements for Nuclear Power Plants
N45.2.2-1978,	Packaging, Shipping, Receiving, Storage and Handling of Items for Nuclear Power Plants

N45.2.15-1981	Hoisting, Rigging and Transporting of Items at Nuclear Power Plants

ASTM, American Society for Testing and Materials

A 36-77a	Structural Steel
A 53-77a	Pipe, Steel, Black and Hot-Dipped Zinc Coated Welded and Seamless
A 441-79	High-Strength Low-Alloy Structural Manganese Vanadium Steel
E 165-75	Liquid Penetrant Inspection Method
E 709-80	Magnetic Particle Examination

ASME, American Society of Mechanical Engineers
Boiler and Pressure Vessel Code as amended through 1981

Section V,	Nondestructive Examination
Section VIII,	Pressure Vessels, Division 1
Section IX,	Welding and Brazing Qualifications

AWS, American Welding Society

A3.0	Welding Terms and Definitions, 1980
D1.1	Structural Welding Code - Steel, 1982

DOE, U. S. Department of Energy

HS-BP-8002,	Supplier Acceptance Data Package (ADP)

2.2 Drawings and Attachments

2.2.1 Drawings

The following listed design drawings are incorporated and made a part of this Specification:

Number	Title
H8-S20801	112" I.D. Casing
H8-S20802	112" I.D. Casing Grout Guide and Details

2.2.2 Attachments

The following listed attachments are incorporated and made a part of this Specification:

Appendix A	"Bidder and Seller Information Requirements" with attached submittal matrix.
Appendix B	"Information Required for Quality Control Program."

2.3 Definitions

2.3.1 Unit

"Unit" shall mean a prefabricated casing assembly, of length indicated on the Drawings, consisting of a string of cans with attached circumferential stiffeners and lifting lug ring, with ends suitably prepared for field welding, and individually identified by a mark number.

2.3.2 Can

"Can" shall mean the single rolled element of a casing unit.

2.3.3 Subassembly

"Subassembly" shall mean two or more cans of the casing string but less than a unit.

2.3.4 Stiffener

"Stiffener" shall mean the circumferential solid bar reinforcing rib welded to the outside of the unit.

2.3.5 Inspection Port

"Inspection port" shall mean the capped opening in the casing plate required for placing a radioactive source for use in radiographic examination.

2.3.6 Lifting Lug Ring

"Lifting lug ring" shall mean the the circumferential solid bar rib placed on each unit to provide a lifting shoulder.

2.3.7 Grout Guide

"Grout guide" shall mean the slotted vertical piping that is to be attached to the side of the casing to provide a conduit for placing grout.

2.3.8 Hold Point

"Hold point" shall mean that activity in the production sequence where work shall not proceed without written release by the Inspector.

2.3.9 Witness Point

"Witness point" shall mean that activity in the production sequence scheduled for surveillance by the Inspector where work may proceed upon verbal release by the Inspector or upon the expiration of a one hour wait for inspection from the scheduled time.

2.3.10 Purchaser

"Purchaser" shall mean the U.S. Department of Energy or its appointed representative.

2.3.11 Inspector

"Inspector" shall mean those persons or agencies appointed by the Owner to conduct quality control surveillance audits and inspection activities of the fabrication process and to authorize release for shipment.

2.3.12 Supplier

"Supplier" shall mean the party responsible for the fabrication and delivery of the units.

2.3.13 The applicable definitions contained in the following publications shall also pertain:

a. ANSI NQA-1, Supplement S-1

b. AWS A3.0

2.4 Quality Assurance

2.4.1 The casing units are to be components of a structure classified Level I for nuclear safety purposes and are therefore subject to the requirements of a quality assurance program established and implemented in accordance with ANSI NQA-1, ANSI N45.2.2, and ANSI N45.2.15.

2.4.2 Each bidder shall submit with the proposal one copy of his quality assurance program and quality control manual for review and evaluation as to his acceptability as a qualified vendor of Level I components.

2.4.3 Supplier shall be responsible for assuring that his subcontractors' quality-assurance/quality control programs are

in compliance with the Specifications. Subcontracting shall conform to the provisions of ANSI NQA-1, Basic Requirements 4 and 7, and Supplements 4S-1 and 7S-1.

2.4.4 Subsequent to the notice to proceed, the Purchaser will provide the Supplier comments on the quality assurance program and the quality control manual submitted with the bid. Prior to the start of fabrication, the Supplier shall re-submit the program and manual incorporating the Purchaser comments. At this time, a joint Purchaser/Supplier quality assurance coordinating meeting shall be conducted to clarify requirements and acceptance criteria. Upon acceptance by the Purchaser of the program and manual, as revised, the Supplier shall proceed with fabrication in accordance with the provisions of the program and accepted procedures.

2.4.5 The minimum information required for the quality control program is contained in the listing attached as Appendix B.

2.5 Inspection Program

2.5.1 The Supplier shall be responsible for the physical performance and documentation of all required in-process inspection, testing, and other quality control functions during the manufacture of the casing units.

2.5.2 The Inspector will perform the surveillance inspection and audit of all required documentation and in-process operations of manufacturing, fabrication, shipment, and quality assurance to ensure compliance with the requirements herein.

2.5.3 The Purchaser will identify to the Supplier the authorized agencies and individuals who will perform inspection surveillance and audit functions.

2.5.4 The Work will be inspected by the Supplier and the Inspector during fabrication, packaging, shipment, and placement in storage. The Supplier shall furnish all facilities, tools, jigs, gauges, materials, and personnel necessary for inspection. This shall include personnel, equipment, and materials required to perform nondestructive examinations. Supplier's inspectors and test personnel shall be certified and qualified in accordance with ANSI NQA-1, Supplement 2S-1 and Appendix 2A-1. Supplier's nondestructive examination personnel shall be certified and qualified in accordance with ANSI NQA-1, Supplement 2S-2. The Inspector shall have access to all areas of the Supplier's and his subcontractors' plants concerned with the supply, fabrication, and shipment of the casing and its components. Inspection by the Inspector shall not relieve the Supplier of his responsibility to provide casing that complies with the requirements of the Specification and the Drawings.

2.5.5 An inspection plan incorporating hold points and witness points shall be developed by the Supplier and submitted to the Purchaser, within four weeks from notice to proceed, for review, comment, and acceptance. The inspection plan shall be subject to the Purchaser's review for conformance to the accepted quality assurance program and incorporation of hold and witness points. Fabrication shall not commence prior to acceptance of the inspection plan by the Purchaser. The inspection plan shall identify pertinent manufacturing and testing operations and steps critical to quality control. The following shall be included as minimum hold points:

a. Initial forming of each plate, stiffener, and lifting lug ring

b. Initial welding of each weldment

c. Any non-destructive examination

d. Preparation for shipment.

2.6 Records and Submittals

2.6.1 The Supplier shall establish and maintain a records system in accordance with ANSI NQA-1, Basic Requirement 17, Supplement 17S-1, and Appendix 17A-1. This system shall be incorporated into the Supplier's quality assurance program and submitted for the Purchaser's review and acceptance. The records system shall provide complete traceability of all materials, equipment, workmanship, quality controls, and handling of each unit. All documentation shall be clear, legible, and of suitable quality for microfilming and for long term storage.

2.6.2 The Supplier shall obtain, maintain, and submit to the Purchaser the following:

2.6.2.1 Steel plate, pipe, and fittings mill-test certified reports to include heat number, chemical composition, ASTM/ANSI grade, and tensile test results.

2.6.2.2 Welding electrode and flux manufacturers' material certification, including the heat number and AWS specification.

2.6.2.3 Welder and welding machine operator test result records. Format shall be as shown in the accepted quality control manual.

2.6.2.4 Welding procedure specifications and qualification records in the format as shown in the accepted quality control manual.

2.6.2.5 Completed weld report for each casing unit covering all completed welds and containing all the information necessary to verify the quality of the weld and welded material. Radiographs with completed report form and other nondestructive examination reports shall be included. The reports shall be in the format shown in the accepted quality control manual.

2.6.2.6 Certification documentation for non-destructive examination and inspection and test personnel per ANSI NQA-1, Supplements 2S-1, 2S-2, and Appendix 2A-1 as applicable.

2.6.2.7 A listing of the completed units that indicates the most suitable fit-up sequence for field assembly of a continuous casing string based on compatibility of rim configuration for field welding. This best fit listing shall be called the unit matching list.

2.6.2.8 Supplier's certificate of compliance that the delivered fabricated product meets the requirements of the Specification and Drawing.

2.6.3 The Supplier shall submit the information listed in Appendix A, "Bidder and Seller Information Requirements" and the attached submittal matrix.

2.6.4 All Supplier final data shall be submitted in accordance with DOE HS-8002.

3.0 TECHNICAL PROVISIONS

3.1 Materials

3.1.1 Casing, Stiffeners, and Lifting Lug Rings

Steel plate and bar stock shall conform to ASTM A 441 or A 36.

3.1.2 Grout Guides

The materials for the grout guides shall conform to the following:

3.1.2.1 Grout guide pipe: ASTM A 53, Schedule 40, black, type F

3.1.2.2 Grout guide splice pipe: ASTM A 53, Schedule 40, black, Type F

3.1.2.3 Support plate: ASTM A 36

3.1.2.4 Guide plate: ASTM A 36

3.1.3 Inspection Port

The inspection port shall be a forged steel half-coupling with plug of quality, configuration, and threads as stipulated in ANSI B16.11 and as shown on the Drawing.

3.1.4 Filler Metals

Filler metals for arc welding shall conform to Table 4.1.1, AWS D1.1. Material selected shall be identified in the weld procedures submittal. Filler metals and fluxes shall be traceable from purchase order to consumption.

3.1.5 Weld Backing

The weld backing ring shall be as shown on the Drawing and shall consist of ASTM A 441 steel or a material of equal chemical and mechanical properties as accepted by the Purchaser. Backing rings shall be traceable from purchase order to consumption.

3.2 Fabrication

3.2.1 Plate Thickness

Prior to processing each plate, thickness measurements shall be recorded and shall be made available for examination by the Inspector. Each plate shall be measured, with a micrometer or ultrasonic devices at each corner and not less than 2 points equally spaced on each edge of the plate. Plates shall be ordered to, and shall be not more than 0.010" below, the nominal thickness indicated in the schedule on the Drawing.

3.2.2 Plate Dimensions

Selection of plate width and length shall be commensurate with the casing dimensions specified.

3.2.3 Plate Identification

Each plate shall be marked with an identification number, using steel stamps with 1/2-inch-high characters, for the purpose of in-process identification of cans.

3.3 Welding

3.3.1 Welding Processes

The fusion welding processes for the weld fabrication of the units shall be as permitted by AWS D1.1 and ASME Boiler and Pressure Vessel Code, Section IX.

3.3.2 Weld Joint Root Beads

The back side of every longitudinal and circumferential plate weld root bead shall be mechanically cleaned or air arc gouged to clean metal prior to the deposition of additional weld metal.

3.3.3 Preparation for Welding

3.3.3.1 The edges of plates shall be formed to comply with the applicable weld procedure specification joint configuration. All projecting burrs shall be removed. Hammering shall not be used to shape the edges preparatory to welding.

3.3.3.2 Surfaces to be welded shall be clean, smooth, and free of deleterious metal Petroleum products shall not be used as cleaner on surfaces to be welded.

3.3.4 Qualifications

Welding procedure specifications shall be prepared, and procedures, welders, and welding operators used for the fabrication of casing shall be qualified as specified herein. No previous procedure, welder, or welding operator qualification will be accepted. Production welds shall not be used to qualify weld procedures, welders, or welding operators. All procedure and performance qualification welds and tests shall be subject to witness by the Inspector. The Inspector shall be notified 48 hours in advance of qualification activities to permit him to attend.

3.3.4.1 Welding procedure specifications (WPS) shall be prepared in accordance with AWS D1.1, Section 5. The WPS shall include all essential and non-essential variables. All welding parameters shall be recorded in the WPS, with special consideration to joint configuration dimensions and weld metal deposition.

3.3.4.2 Welding procedures shall be qualified in accordance with ASW D1.1, Section 5, Part B, except as follows:

a. Qualification test specimens shall be radiographically examined and accepted in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Articles UW51 a and b. Radiographic examination is in addition to applicable guided bend tests.

b. Guided bend tests are required for procedure qualification for plate thicknesses of 3/4" and thinner, and shall include both face and root bends. The acceptance criteria for quided bend tests shall be in accordance with ASME Boiler and Pressure Vessel Code, Section IX.

c. The base metal used in procedure qualification tests shall be of the same specification and grade as specified in the Contract Specification.

3.3.4.3 Welders and welding operators shall be qualified prior to production welding. Qualification shall be in accordance with AWS D1.1, Section 5, Part C or Part D as applicable, except as follows:

a. Qualification test specimens shall be radiographically examined and accepted in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Articles UW51 a and b.

b. Guided bend test specimens shall be tested in accordance with AWS D1.1, Section 5, Part C or D as applicable, and ASME Boiler and Pressure Vessel Code, Section IX. Acceptance Criteria shall be in accordance with ASME Boiler and Pressure Vessel Code, Section IX.

3.3.4.4 Procedure, welder, and welding operator qualification records shall be maintained including certified radiographic examination report, radiographic film, and qualification report for each welder and welding operator including his/her unique identifier.

3.3.4.5 When there is a specific reason, as determined by the Inspector, to question the ability of a welder, welding operator, or welding equipment to consistently produce welds that meet the specifications,

the welder or welding operator shall be requalified. If the welder or welding operator continues to produce welds that do not meet the specifications, the Supplier shall, at the request of the Inspector, remove the welder, welding operator, or welding equipment from the job.

3.3.5 Weld Quality and Workmanship

3.3.5.1 Weld Type

Weld type shall be as shown on the Drawing.

3.3.5.2 Stress Risers

Visually discernable stress risers upon weld or parent metal surfaces; i.e. sharp and abrupt changes in weld bead geometry, laminations, inclusions, open porosity, arc starts, cold laps, lack of fusion, parent metal damage caused by removal of temporary appurtenances, chisel marks or gouges are not acceptable and shall be repaired by welding prior to final inspection.

3.3.5.3 Undercuts

Weld undercuts shall be rejected, except that intermittent undercuts (6" long in 24" of weld) having a smooth and gradual transition and having a depth of 1/32" or less are acceptable.

3.3.5.4 Acceptance Standards

Weld acceptance shall be in accordance with the criteria for workmanship and nondestructive examination as specified herein and in Sections V and VIII of the ASME Boiler and Pressure Vessel Code and in AWS D1.1, Section 5, Part C, and Section 8, Part D for the inspection and examination methods used.

3.4 Tolerances

Casing assembly shall be fabricated to the following tolerances and as shown on the Drawings. Tolerances not specified otherwise shall be ± 1/8".

3.4.1 Weld Joint Root Openings

Longitudinal and circumferential plate welds shall have the option of a root gap ranging up to 3/16" maximum.

3.4.2 Staggered Welds

Longitudinal welds of cans in a casing subassembly shall be staggered circumferentially a minimum of 24".

3.4.3 Mismatch

Longitudinal weld seam abutting edges of cans shall not exceed 1/16" mismatch. Circumferential weld seam abutting edges shall not exceed 1/8" mismatch.

3.4.4 Unit Straightness

Completed casing unit shall be straight, with walls parallel to the axis of the casing. The variation in straightness of casing when measured from a reference line parallel to the axis shall not exceed 3/16" in 10 ft.

3.4.5 Section Ends

3.4.5.1 The planes of the ends of the casing unit shall be normal to a line parallel to the axis of the casing section with a tolerance of ± 15 minutes of arc at all locations on the circumference.

3.4.5.2 The maximum gap between the end of the unit and a plane surface pressed against the end of the unit shall be 1/8."

3.4.6 Fillet Weld Size

Close fitup is required at those joints where fillet welds are applied in order to insure full fusion welds at the bottom of the fillet. Fillet weld specified size is a minimum. If at any point, the gap between the shell and lifting lug ring or stiffener exceeds 1/16 inch but is less than 1/8 inch, it will be acceptable providing that the fillet weld size is increased 1/16 inch throughout 360°. Gaps exceeding 1/16 inch on lifting lug rings shall be indentified in Supplier's inspection report.

3.4.7 Lifting Lug Rings

The uppermost ring on a casing unit is the lifting lug ring for that section of casing. The plane of the bottom edge of each lifting lug ring shall be parallel with the plane of the top of the casing unit within 1/8". The cross section of the lifting lug ring stock shall not vary in rectangularity by 1/32" difference in length of the diagonals.

3.4.8 Ring Closure Welds

Closure welds for stiffener rings and lifting lug rings shall be made after the attachment weld. There shall be a maximum of 2 closure welds per ring.

3.4.9 Casing Unit Length

The finished length for each casing unit may vary ± 1" from the nominal lengths indicated on the Drawings.

3.4.10 Weld Reinforcement

Weld reinforcement of inside diameter welds shall not exceed 3/32" for plate thickness of 3/16" to 1" and 1/8" for plate thickness of 1" to 2", and shall be smoothly blended from weld metal to parent metal. Outside diameter weld reinforcement shall not exceed 1/4" and shall be feather edged to the parent metal.

3.4.11 Diameter and Out-of-Roundness Tolerances

Casing units shall be manufactured to the following diametric tolerances:

(a) The diameter as determined by a circumferential measurement with a π tape may be 1/4" over to 0" less than the sum of the nominal diameter, plus twice the nominal plate thickness indicated on the Drawings.

(b) The internal diameter of the casing unit shall be not less than 111-11/16 inches nor more than 112-5/16 inches.

(c) Circumferential and diametric measurements shall be made at the end of each casing unit and at not less than 7 points approximately equally spaced between the ends of the unit with the measuring points to be selected by the Inspector.

3.5 Identification Marking

3.5.1 Welding Operator Identification

All welds shall bear the welding operator's identification mark. Such identification shall be located adjacent to the weld but not closer than 1" from the heat affected area. Steel stamps employed shall imprint a radius, not a sharp notch.

3.5.2 Casing Unit

3.5.2.1 Data Required

Each completed casing unit shall be marked on the inside, 6" from each end as follows:

a. Using metal stamps having numerals and letters not less than 3/8" high, denote Supplier, ASTM designation of base metal, and total calculated weight of completed unit in pounds.

b. Using a paint stencilling system which yields not less than 1" high figures and letters, denote the internal diameter, wall thickness, length in feet and decimal, and purchase order number. The stencilling shall be placed upon clean base metal free of scale, rust, or other foreign matter. Color of the stencilling shall be in contrast to the base metal.

3.5.2.2 Mark Identification

Each completed casing unit shall bear a free-hand applied mark identification located at each end of the unit on the inside and outside surface. In addition, each end of each unit shall be match marked to correlate with the information in the Unit Matching List showing most suitable fit-up sequence for field assembly. Such mark identification shall be placed at a distance from each end to permit ready visibility to the viewer without entry into the casing. The mark identification may be applied with a paint spray gun, aerosol can or brush and shall be not less than 18" in height. The number shall be a number as shown on the Drawing and assigned by the Supplier.

4.0 NON-DESTRUCTIVE EXAMINATION

4.1 Lifting Lug and Stiffener Rings

Welds on rings shall be examined as follows:

4.1.1 Closure welds for lifting lug rings and for stiffener rings shall be 100% magnetic particle examined.

4.1.2 Fillet and groove welds for lifting lug rings and stiffener rings shall be 100% magnetic particle examined.

4.2 Casing Seams

All longitudinal and circumferential plate welds including intersections in the casing shall be 100% radiographic inspected. Radiographic film shall be placed so that the weld seam is centered on the film.

4.3 Radiography

4.3.1 The radiographic inspections shall be performed as stipulated for technique and quality in Paragraph UW51, Section VIII, ASME Boiler and Pressure Vessel Code

4.3.2 Each radiographic film shall show not less than one foot of weld.

4.3.3 Exposed radiographic film that is defective shall be basis for rejection of the film, and repeating the radiographic inspection of the weld.

4.4 Magnetic Particle Examination

4.4.1 Groove and fillet welds on lifting lug rings and stiffeners shall by 100% magnetic particle inspected at the root bead, at one half weld thickness, and after all grinding or machining is complete. The magnetic particle inspection shall be in accordance with ASTM E 709 using the DC prod method, and ASME Section V, Standard SE 109.

4.4.2 The quality acceptance standard shall be as specified in Section 3.3, "Welding," herein.

4.4.3 Surface imperfection interpretations in dispute with the magnetic particle inspection indications shall be verified by an alternate nondestructive examination method as determined by the Inspector.

4.5 Visual Inspection

4.5.1 Visual inspection shall be performed upon all in-process operation and completed welds. Visibly discernable weld rejections which are readily repairable without adverse effect to the weld or parent metal shall be repaired prior to the application of non-destructive examination procedures.

4.5.2 Weld repairs necessitated by visual inspection shall be visually reexamined subsequent to the repairs. The Inspector will request a radiographic examination when the structural integrity of a repair is in question.

4.5.3 Standards of acceptance shall be as specified in Section 3.3, "Welding," herein and in AWS D1.1.

5.0 SHOP DRAWINGS

5.1 Fabrication Drawings

The Supplier shall provide detailed shop drawings reflecting all the information and data pertinent to fabrication and related quality control. Submittal shall be made 10 working days prior to scheduled start of fabrication. The Owner will review and comment on the drawings. Appendix A pertains.

5.2 Packaging and Shipping Drawings

The Supplier shall provide detailed drawings of casing supports, surface protection, and shipping bracing of the finished unit. Special rigging or handling requirements shall also be shown. Submittal shall be made 60 working days prior to scheduled completion of the first unit. Appendix A pertains.

5.3 Acceptance of Shop Drawings

The Purchaser's acceptance of any shop drawing or other comment that directs the Supplier to proceed on technical matters does not relieve the Supplier of his responsibility for supplying the casing units in conformance with the Specification, the Drawing, and the Purchase order.

6.0 PACKAGING, HANDLING, SHIPPING, AND STORING

6.1 Casing Protection

The Supplier shall take necessary precautions to prevent damage to the casing units during handling, loading/offloading, and transporting. The provisions of ANSI N45.2.2 shall be complied with.

6.2 Supports

Suitable mechanical supports and other devices as required shall be provided for each casing unit to maintain dimensions within specified tolerances and to prevent deformation during handling, loading, transporting, offloading, and storing.

6.3 Tack Welding

Tack welding of supports and protective devices on the units will be permitted only as indicated on the accepted packaging and shipping drawings submittal.

6.4 End Protection

Both ends of each completed casing unit shall be mechanically cleaned to parent metal for a distance of not less than 1", internally and externally, beyond the terminating ends of weld joint preparation. Cleaned areas shall be masked with a tape of the type accepted on the packaging and shipping drawings submittal to protect the ends from corrosion and damage in transit and in storage.

6.5 Shipping Release

No loading for shipment shall commence prior to the issuance of a written release for shipping by the Inspector. Nonconforming products shall not be shipped.

6.6 Off-Loading and Storing

The Supplier shall provide a procedure for off-loading and storing at the destination. Procedure shall be submitted for Purchaser's review and comment 60 working days prior to scheduled delivery date. Storage will be in the vicinity of the exploratory shaft site at an area designated by the Purchaser. Handling and storage procedures shall be in accordance with ANSI N45.2.15.

BWIP01J: 11/17/82

APPENDIX A (Sheet 1 of 3)

BIDDER AND SELLER INFORMATION REQUIREMENTS

TYPE OF INFORMATION	BY BIDDER: COPIES WITH EACH BID	BY SELLER (NOTE - LAST COLUMN TO BE COMPLETED BY SELLER): REPRODUCIBLE TO BE SUBMITTED FOR REVIEW	CERTIFIED DRAWINGS TO BE SUBMITTED AFTER REVIEW: PAPER PRINTS	CERTIFIED DRAWINGS TO BE SUBMITTED AFTER REVIEW: REPRODUCIBLE: PAPER	CERTIFIED DRAWINGS TO BE SUBMITTED AFTER REVIEW: REPRODUCIBLE: PERMANENT	COPIES REQUIRED WITHOUT REVIEW	POST AWARD: REVIEW DATA REQUIRED (WEEKS AFTER AWARD)	POST AWARD: SELLER PROMISE SUBMITTAL (WEEKS AFTER AWARD)
1. DRAWING LIST AND SCHEDULE		3	2					
2. DIMENSIONED OUTLINE DRAWINGS AND/OR CATALOG INFORMATION								
3. SCHEMATIC PIPING DIAGRAMS								
4. ELECTRICAL AND INSTRUMENTATION INFORMATION								
5. SHOP DETAIL DRAWINGS (Fabrication)		3	2				See Par 5.1	
6. FOUNDATION OUTLINE AND ANCHOR BOLT LOCATIONS								
7. LOAD DIAGRAMS								
8. DATA SHEETS, AS NOTED THEREON								
9. PERFORMANCE DATA AND CURVES								
10. CERTIFIED TEST AND INSPECTION REPORTS						2		
11. BILLS OF MATERIAL								
12. INSTALLATION INSTRUCTIONS								
13. MAINTENANCE AND OPERATING								
14. NAMEPLATE DATA, AND MOTOR LIST								
15. CALCULATIONS								
16. PRELIMINARY DESIGN DRAWINGS								
17. FINAL DESIGN DRAWINGS								
18. Quality Assurance Program	3	3	2					
19. Quality Control Manual	3	3	2					
20. Inspection Plan		3	2					
21. Plate, Pipe & Fitting Mill-Test Certified Reports						2		
22. Welding Electrode & Flux Matl. Manufacturer's Certification						2		
23. Welder & Welding Operator Test Records						2		
24. Welding Procedure Spec.		3	2					
25. Weld Reports, Including NDE.						2		
26. Personnel Qualification Cert.						2		
27. Unit Matching List						2		
28. Certificates of Compliance						2		
29. Shop Dwgs.(Pkging & Shipping)		3	2				See Par 5.2	
30. Off-Loading & Storage Procedure		3	2				See Par 6.6	
31.								
32.								
33.								
34.								

See Next Page for Definitions and Instructions

DEFINITIONS

1. DRAWING LIST AND SCHEDULE A complete list of all drawings and data by title that the Bidder expects to furnish on this order. Schedule to show, in weeks after award, submittal of each type of review and certified drawings.

2. DIMENSIONED OUTLINE DRAWINGS AND/OR CATALOG INFORMATION Drawings to scale showing the relative size, configuration, and location of all material to be furnished. Show two or more views of unit, clearances and area required for operation and maintenance. Show unit in relation to nearby structures and other equipment or operating floor, location of utility connections and direction of rotation, if applicable. When submitting data for "off the shelf" equipment/materials, catalog cuts and information are acceptable provided they are submitted in ample detail.

3. SCHEMATIC PIPING DIAGRAMS Show equipment to be interconnected, flow quantities, pipe sizes, valves and instruments.

4. ELECTRICAL AND INSTRUMENTATION INFORMATION Show all data pertaining to instrumentation, control and power electrical equipment. Include "one-line", "elementary" wiring, panel interior wiring and exterior interconnection wiring, dimensioned outlines of enclosures with raceway entries shown.

5. SHOP DETAIL DRAWINGS Show all necessary details and data required for fabrication and maintenance. For structural details show all connections and member sizes.

6. FOUNDATION OUTLINE AND ANCHOR BOLT LOCATIONS Show all data required for foundation design including location, blockouts, embedded items, grout required, and size, type and projection of anchor bolts.

7. LOAD DIAGRAMS Show total static and dynamic loads and load centers.

8. DATA SHEETS Sheets shall be completed for the equipment proposed with all information noted thereon.

9. PERFORMANCE DATA AND CURVES

10. CERTIFIED TEST AND INSPECTION REPORTS Reports by recognized commercial laboratories of indicated chemical and physical tests of materials as required by the specifications. In addition where applicable, weld inspection and stress relieving records and code nameplate rubbings shall be furnished.

11. BILLS OF MATERIAL Show for each unit: item no., shop order no., mark or name, part no., or pattern no., and drawing reference.

12. INSTALLATION INSTRUCTIONS Complete, detailed and sequenced instructions for original installation and for removals and replacements as well as erection information.

13. MAINTENANCE AND OPERATING MANUALS Complete installation, starting and operating instructions. Complete descriptions of preventive and repair maintenance, including detailed lubrication chart showing every lubrication point, grade of lubricant, lubrication schedule and amount of oil or grease required for refill after drainage. Manuals include parts list with recommended spares.

14. NAMEPLATE DATA AND MOTOR LIST

15. CALCULATIONS Shall be checked and stamped by a registered professional engineer, licensed to practice in the state where installation occurs.

16. PRELIMINARY DESIGN DRAWINGS Seller provided design services such as pre-engineered buildings, silos and other structures, conveyor systems, bins and chute design, large ductwork and supports.

17. FINAL DESIGN DRAWINGS Same as Item No. 16.

INSTRUCTIONS

1. DIMENSIONS Shown on all but schematic drawings and diagrams shall be in feet and inches, unless noted otherwise.

2. CERTIFIED DRAWINGS Shall be so marked by Seller. They shall conform to Seller's drawings as finally accepted by the Purchaser and shall be forwarded at commencement of manufacture. The drawings shall be revised and resubmitted to reflect any changes approved during the manufacturing period.

3. REPRODUCIBLE PERMANENT PRINTS Shall be cloth, "Chronaflex", or "Mylar". They shall depict the material as shipped and shall be forwarded upon completion of shipment.

RECORDS AND SUBMITTALS

	Q A Program	Q C Manual	Steel Plate, Strip Pipe & Fitting Material	Welding Electrodes & Fluxes	Welders & Welding Machine Operators	Welding Procedures	Production Welds	Nondestructive Examination	Q C Personnel	In-plant Inspection	Fabrication	Packaging	Shipment	Handling & Storage	Unit Matching	Welding Backing Ring Material
Drawings											a	b	b	b		
Procedures	a	a				a				a	a	b	b	b		
Manuals	a	a														
Records							b	b					c			
Certificates			a	a	a	a			a							a
Plans	a									a						
Lists													c		c	
Formats		a														
Schedules										a			b			

LEGEND:
- a. Submit to Owner for review and concurrence prior to fabrication
- b. Submit to Owner for review and concurrence prior to shipment
- c. Submit upon delivery.

APPENDIX B (Sheet 1 of 1)

INFORMATION REQUIRED FOR QUALITY CONTROL PROGRAM

1. Quality control department organization, responsibilities, and authorities.

2. Material storage facilities and weather protection.

3. Methods of measuring material dimensions.

4. Material records and marking system.

5. Personnel qualification and certification program.

6. Employee or independent firm responsible for weld procedure specifications and tests.

7. Employee or independent firm responsible for welding operator and welder qualification and tests.

8. Quality control manual containing all policies, assignments of resposnibility, procedures, forms, and controls.

9. Employee or firm designated to perform radiographic inspection and radiographic interpretation. Include experience summary of personnel if they are employees, and records of qualification.

10. Employees performing other nondestructive testing and their experience, and records of qualification.

11. In progress and final inspection procedures.

12. Document and record controls.

BWIP01M: 05/17/82

Rockwell Hanford Operations
Richland, WA 99352

ENGINEERING ORDER

EO TYPE			
XX	Release		Supersedure
	Release To File		Cancellation
	Authorize Requirements		Obsoletion
	Change		File As Drawing

QA Level	Change Type	Building	Project No.
II III	--	8901, 8903	B-314

EO 02696

Cognizant Engineer: J. S. Ritchie (KE/PB) Phone: 415-271-5281

Responsible Organization: B. K. Schroeder-ES Design (Acting) Phone: 6-7283 (signed R.M. Yana for)

Priority: N

Is A Cross Reference To — AUTHORIZATION NO.: WBS LF2223 (2222), CEI CM014

Index No.	CEI No.	Document No.	Sheet No.	Rev.	Next Used On
N/A	CM014	B-314-C-X28018 ~~Procurement~~ CONSTRUCTION Specification for Shaft Drilling and Rig Services	1-22	0	
N/A	CM014	** B-314-P-X28~~0~~28 Procurement Specification for Drilling Mud	1-18	0	

**Note;B-314-P-X28028

Initiated by: KE/PB
Used By: Rockwell

BASALT

Prepared By: M. J. Lauterbach Date 2/8/83
Cognizant Manager: B. K. Schroeder, Acting (R.M. Yana for) Date 2/8/83
X Configuration Mgmt. Checker: P. J. Reder Date 2-9-83
Cognizant Engineer Date
Authorizer Date
X Quality Assurance: M. F. Nicol Date 2/9/83
Health, Safety & Environment Date
Criticality Engineering & Analysis Date
XX Design Review Chairman: B. K. Schroeder (R.M. Yana for) Date 2/8/83
Project Engineer (R.M. Yana) Date 2/8/83
Date
Date
Date

Reasons & ESR No. All Design Review comments incorporated per DR-B314-83-~~10~~ 21. RCR's not verified, omissions (if any) will be incorporated by DFC.

RELEASE STAMP: (10) OFFICIALLY RELEASED 1983 FEB -9 AM 10:13 — 1983-Feb 9

DISTRIBUTION
H. W. Brandt
M. T. Black (1 construction, 1 control)
R. D. Hudson (DOE) (3)
~~T. R. Cloud (1 control, 6 construction)~~ 2/8/83
T. L. Walton (KEH) (1 control, 6 construction)
F. C. Laruie (M-K) (1 control, 3 construction)
M. F. Nicol
J. V. Mohatt
R. W. Carlson
P. J. Reder (EO Only)
W. F. Todish ~~(orig.)~~
Engineering Files ORIG (Fed Bldg)

Work Completed: Rec Ret. Date

BD-6400-093.1 (N-2-82)

SPECIFICATION TITLE PAGE

SPECIFICATION NO. B-314-P-X28028

QA LEVEL III

PROCUREMENT SPECIFICATION FOR

DRILLING MUD

BWIP EXPLORATORY SHAFT

PROJECT B-314

Prepared By:

Kaiser Engineers, Inc./Parsons Brinckerhoff Quade & Douglas, Inc.

For the U.S. Department of Energy

Contract No. DE-AC06-80RL10000

B. H. Kitchen / Leard	2/3/83 12-22-82	Jim Zeppieri / JZ	3 FEB. 1983 12-22-82
Specifications Engineer	Date	Job Engineer	Date
J. Hoecke by PGB	2/3/83 12-22-82	D. L. Watson by JZ	2/3/83 12-22-82
Design Manager	Date	Project Engineer	Date
H. Thayer by L. G. Thomas	12-22-82	L. G. Thomas / L. G. Thomas	2/3/83 12-22-82
QC Engineer/Constr. Engr.	Date	Quality Assurance Engineer	Date
P G Bebbe	2-3-83 12-22-82	J S Ritchie by PGB / JS Ritchie	2-3-83 12-22-82
Deputy Project Manager	Date	Project Manager	Date

ROCKWELL HANFORD OPERATIONS:

B. Schroeder — 2/7/83

INFORMATION COPY
THIS COPY WILL NOT BE REPLACED AND MAY BE CHANGED WITHOUT NOTICE

DRILLING MUD

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont)

DRILLING MUD

1.0 SCOPE

This Specification describes the requirements for the delivery to the site and performance of drilling fluid additives for the control of: loss of circulation, hole stability, drilled solids removal, lubrication of pipe and tools, formation pressure control and other special conditions that may arise during the shaft boring operations.

1.1 Work Included in Drilling Mud Subcontractor's Work Scope

1.1.1 Mud engineering services

1.1.2 Special tools, materials and equipment

1.1.3 Testing

1.1.4 Records management

1.1.5 Inventory management

1.1.6 Packaging

1.1.7 Transportation to site

1.1.8 Quality control

1.2 Work Provided by Contractor

1.2.1 Maintenance of storage facility

1.2.2 Offloading at site

1.2.3 Placing in storage at site

1.2.4 Handling from on-site storage to point of use

1.2.5 Labor to mix mud

1.2.6 Equipment, operation and maintenance of mud circulation system

2.0 GENERAL PROVISIONS

2.1 Cited References

Materials and equipment furnished under this specification shall conform to the requirements of the documents listed below to the extent specified herein.

MAGCOBAR DIVISION, DRESSER INDUSTRIES

Drilling Fluids Handbook, 1981

API, American Petroleum Institute

Spec. 13A-79, Specification for Oil Well Drilling Fluid Materials

RP 13B-82, Standard Procedures for Testing Drilling Fluids, 1982

Bul 13F-78, Bulletin on Oil and Gas Well Drilling Fluid Chemicals

2.2 Drawings and Attachments

2.2.1 Drawings

Drawings (if any) listed in the "Purchase Order" are part of this Specification.

2.2.2 Attachments

The following listed attachment is incorporated as a part of this specification.

Appendix A Bidder and Seller Information Requirements

2.3 Definitions

2.3.1 Annular

Ring-shaped. The space between casing and the wall of the hole or between drill pipe and casing is an annular space.

2.3.2 Attapulgite Clay

Clay mineral characterized by rod or lath shaped crystals. Used primarily for increasing fluid viscosity in salt solutions.

2.3.3 Barite-Barytes-Heavy Spar

Natural barium sulphate. Occurs in white, grayish, greenish, and redish ores or crystalline masses.

2.3.4 Bentonite

A highly plastic, highly colloidal clay, largely made up of the mineral montmorillonite.

2.3.5 Boring

Synonumous with the term drilling.

2.3.6 Centipoise (CP)

A unit of viscosity equal to 0.01 poise. A poise = 1 gram/sec cm. The viscosity of water at 20°C is 1.005 centipoises.

2.3.7 Contractor

The organization responsible to the Owner for the construction and construction management of the Exploratory Shaft, Phase I.

2.3.8 Detergent

Water soluble organic chemical used to emulsify oils, hold particles in suspension and as a wetting agent.

2.3.9 Down Hole

The area from the collar or begining of the hole in the earth to its end or termination.

2.3.10 Drilled Solids

Particles of formation dislodged by the drill bit that are entrained in the drilling fluid.

2.3.11 Drilling Fluid Additives/Mud

Chemicals and organic or inorganic additives used with water, brine or a similar fluid vehicle to control various parameters of the down hole environment during both the active and dormant phases of a hole boring program.

2.3.12 Filter Cake Thickness/Filtration Property

The measure of the thickness of the filter cake deposited by a drilling fluid against a porous medium. Cake thickness and filtrate loss constitute the determining factors of filtration property.

2.3.13 Gel

A colloidal suspension in such a state that shearing stresses below a certain finite value fail to produce permanent deformation. The minimum shearing stress that will produce permanent deformation is known as the Shear or Gel Strength of the gel. Gels commonly occur when the dispersed colloidal particles have a great affinity for the dispersing medium. Gels commonly occur with bentonite in water.

2.3.14 Lost Circulation Material

Plugging agent added to the drilling fluid for the purpose of plugging pores on voids in the geologic formations to control excessive circulation loss.

2.3.15 Mud Engineer

A specialist in the testing, preparation, design, application, use and treatment of drilling fluids and those organic and inorganic materials which are used to supplement and/or enhance these fluids for the purpose of advancing and supporting a bored hole in a rock or mineral medium. He will be a representative of the Subcontractor. The Mud Engineer shall be responsible for the administration of the drilling fluids program specified herein.

2.3.16 Owner

The U.S. Department of Energy (DOE) or its appointed representative.

2.3.17 Plastic Viscosity

The part of flow resistance in a mud which represents mechanical friction (1) between solids in the mud, (2) between the solids and the liquid which surrounds them, and (3) of the shearing of the liquid itself. Plastic viscosity is measured in centipoise.

2.3.18 Polymer

A substance composed of giant molecules that have been formed by the union of a considerable number of simple molecules. The number of simple molecules may vary from two to hundreds to thousands. The simple molecules (monomers) which polymerize may be all alike or of many varieties.

2.3.19 Rheometer

Instrument used to measure rheological properties of a fluid; alternatively Fann VG meter.

2.3.20 Sand Content

Usually expressed as the percentage bulk volume of sand in a drilling fluid.

2.3.21 Sepiolite Clay

Chain-lattice clay mineral often occurring in fibrous matted crystals. Use to increase fluid viscosity.

2.3.22 Shaft Boring Subcontractor

The party selected by the Contractor to bore the shaft.

2.3.23 Subcontractor

BLF 2/3/83 The party responsible for the ~~fabrication, packaging~~ furnishing and delivery of the required drilling fluids, and mud engineering services.

2.3.24 Surfactant

Contraction of Surface Active Agent. A substance that affects the properties of the surface of a liquid or solid by concentrating in the surface layer.

2.3.25 Triglyceride

Hygroscopic alcohol used as a solvent and viscosity increaser.

2.3.26 Viscometer - Viscosimeter

An instrument for determining viscosity.

2.3.27 Yield Point

The part of the resistance to flow in a drilling fluid caused by forces between the particles in the suspension. Yield point is measured in pounds per 100 square feet.

2.4 Records and Submittals

The Subcontractor shall establish and maintain records as specified herein. All documentation shall be clear, legible, and reproducible.

2.4.1 The subcontractor shall obtain, maintain and submit to the ~~owner~~ Contractor the following.

BLF 2/9/83

2.4.1.1 Tradename where applicable, and published performance characteristics for all drilling fluid additives supplied to the worksite.

2.4.1.2 A complete inventory control list of all drilling fluid additives delivered, used and returned.

2.4.1.3 Complete daily records of job site examinations shall be maintained and submitted containing all of the data obtained from the measurements and tests listed herein as well as an inventory of additives used.

2.4.1.4 A program of expected additives use.

2.5 Nonconforming Conditions

The Subcontractor shall identify each nonconforming condition relative to this Specification and shall notify the Contractor of each such condition. Disposition to "Use as supplied" or to "replace" for each nonconforming condition shall require approval by the Owner as a condition of acceptance of the additives in question.

3.0 TECHNICAL PROVISIONS

3.1 Components

3.1.1 Dry Additive Components

Dry components which may include bentonite, attapulgite clay and sepiolite clay shall conform to the specifications in API 13A and API 13F.

3.1.2 Fluid Additive Components

Fluid components which may include surfactants, polymers, detergents, triglycerides and alcohols shall conform to specifications in API 13F and in the absence of specific guidelines, the Subcontractor and Owner shall develop agreements as to individual content, quality and reliability prior to shipment and delivery.

3.1.3 Other Additive Components

Any components not mentioned above shall conform to specifications agreed to by the Subcontractor and Owner prior to shipment and delivery.

3.2 Manufacturing

Manufacturing procedures with regard to blending, volume percent content by individual ingredient and packaging shall conform to API 13F.

3.3 Quality Control

3.3.1 Purity

Purity of all additive ingredients shall be maintained in accordance with API bulletins 13A and 13F.

3.3.2 Formula Control

The volume percent content of individual additive ingredients shall not exceed ± 5 percent of that shown in the generic additive formula provided to the Contractor. Proprietary formulas will be exempt from this requirement if a

certification by the Subcontractor as to the conformity of the proprietary product to the above ±5 percent tolerance is provided.

3.4 Identification

All containers and packages used for the delivery and storage of drilling fluids additives shall be marked with product name and weight or volume, to aid in the tracking and inventory of all additives delivered and consumed.

4.0 ADDITIVES EXAMINATION

4.1 Testing Methods

All tests shall be conducted in accordance with the procedures outlined in API Bulletins 13A and 13B. These tests shall be performed on those additives and their components designated in the drilling fluids program; all prior to their mixture for use during drilling. Records shall be maintained and submitted to the Owner.

4.2 Specific Tests and Criteria

The particular additive components: bentonite, attapulgite clay and sepiolite clay, if required, shall conform to those requirements set forth in API Bulletin 13A.

5.0 PACKAGING, HANDLING, SHIPPING AND STORAGE

5.1 Packaging

All packaging used to contain, store or transport drilling fluid additives shall conform to API bulletin 13A and to manufacturer's standard packaging procedures. Packaging shall be designed for safe transport, handling and storage and shall prevent accidental damage and contamination under the conditions of this project. Hazardous materials shall appropriately marked and stored and data sheets defining emergency first aid procedures shall be available at the site.

5.2 Container Protection

Substantial protection in the form of plastic shrouds, tarps or similar shall be used to protect all additives from the weather.

5.3 Content

Each bag or other additive container shall contain the net weight marked thereon ± 5 percent. The average weight of 5 percent of all bags in a shipment taken at random, shall not be less than the specified weight.

5.4 Storage

Additive materials shall be stored in such manner as to permit easy access for inspection. Bulk materials and packaged material shall be stored in such manner as to afford protection from the elements. All packages, receptacles and bulk containers shall be in serviceable condition to Manufacturers recommendations. An on site storage area will be provided by the Owner.

5.5 Acceptance at Site

Products furnished hereunder shall meet the requirements of the purchasing documents upon delivery at the site, before being off-loaded from the transport vehicle(s). Non-conforming products shall not be off-loaded nor accepted for delivery. Conforming products shall be accepted for delivery, off-loading, and placed in storage. Inspection shall be conducted by the ~~Inspector~~. Records shall be submitted to the Owner. ~~Contractor~~ Stet 2/9/83

5.6 Payment for Additives

Additives will be paid for as used. Subcontractor shall maintain inventory as required at his own initial expense. Additives in packages damaged at the site through no fault of the Subcontractor shall be considered used and be paid for accordingly.

6.0 DRILLING FLUID ADDITIVES PROGRAM

6.1 Program Development

A program of expected additives use shall be developed by the Subcontractor who shall make himself familiar with the drilling conditions and requirements to be expected at or near the drill site. The Subcontractor shall make recommendations concerning the implementation of this program. The program shall be approved by the Contractor. The program shall include but not be limited to the following:

- Expected fluid types
- Estimated fluid properties
- Procedure to obtain estimated properties
- Potential problems with recommendation
- Corrosion control
- ~~Driving~~ Drilling mud report format
- Testing procedures

6.2 Program Implementation

6.2.1 Personnel

The Subcontractor shall provide a qualified Mud Engineer to be ~~on site 24 hours per day during surface hole drilling,~~

BLL 2/9/83 ~~and~~ on site or on call 24 hours per day at the discretion of and upon request by the Contractor, during other drilling, casing running or cementing operations.

6.2.2 Supply of Material

The completed program shall be examined by the Subcontractor and the Contractor to develop a minimum inventory of additives for initial stocking at the site. The Mud Engineer shall monitor the use of materials and ~~make~~ recommend stocking of additional material as required, for the Contractor's approval. BLL 2/9/83

6.2.3 Changes in Mud Program

The Mud Engineer shall monitor the performance of the drilling fluid, including the maintenance of fluid properties and indications of circulation loss, and shall make recommendations regarding the make-up of the drilling fluid as required or requested by the Contractor, for the Contractor's approval.

7.0 FLUID LOSS AND CAVING CONTROL

7.1 In the event of excessive drilling fluid loss in the borehole, and after reasonable efforts have been expended to stop or reduce the fluid loss by means of lost circulation materials, the Contractor may direct the placement of a cement plug in the borehole.

7.2 In the event of excessive hole instability or caving, and after reasonable efforts have been expended to maintain hole stability by use of drilling fluid additives, the Contractor may direct the placement of a cement plug in the borehole.

BLL 2/9/83 7.3 The placement of a cement plug in the borehole would be performed by others under the provisions of the Casing Cementing Specification (B-314-C-X28048).

8.0 JOB SITE EXAMINATIONS

In support of the drilling fluid additives program, the data described in Section 8.1 data shall be determined and collected by the Mud Engineer during all phases of active hole boring. Testing and measurements shall also include selected tests from section 8.2 as required and authorized. A record of such tests shall be submitted to the Contractor. All tools and equipment required for testing shall be provided by the Subcontractor. The method of execution for each test can be found in either the Magcobar Division of Dresser Industries Drilling Fluid Handbook or the appropriate API publication unless the method is inherently obvious.

In addition to the tests and measurements described in Section 8.1 and 8.2, which may be submitted on the Subcontractor's standard daily drilling mud report form, the Subcontractor shall report any abnormal conditions or problems, including period circulation losses, and measures taken to remedy such conditions.

8.1 Daily Job Site Tests and Measurements

8.1.1 Location

The location from which the drilling fluid sample is taken wheather flow line, pit or tank shall be noted.

8.1.2 Time

The time of sampling shall be recorded. This time of sampling shall be at or near the same hour each day.

8.1.3 Temperature

The temperature of the drilling fluid sample shall be recorded along with all other tests and measurements. The temperature shall be recorded in degrees Fahrenheit.

8.1.4 Depth

The bore hole depth shall be measured from the collar at ground level and shall be recorded at 6:00 a.m. each day.

8.1.5 Weight

The weight of the circulating drilling fluid shall be measured in pounds per gallon (ppg) with a mud balance scale.

8.1.6 Viscosity (Marsh Funnel Test)

Viscosity tests on the circulating fluid shall be conducted daily using the Marsh Funnel Viscometer.

8.1.7 Water Loss

Water loss (filtration property) shall be measured daily using a standard filter press device.

8.1.8 Filter Cake

Filter cake thickness shall be measured daily and shall be defined as the thickness of residual solids on the filter paper following the filter press water loss determination.

8.1.9 pH

pH readings shall be recorded daily using an approved pH meter.

8.1.10 Gel Strength

During operation, the design mix as well as the fluid in use shall be tested.

Two gel strength values are to be recorded daily: first, an initial measurement and second, a ten minute measurement. Both measurements shall be recorded using a rheometer.

8.1.11 Percent Solids

Percent solids shall be recorded daily using a retort kit ~~and~~ or appropriate formula.

8.1.12 Percent Sand

The sand content of the drilling fluid shall be recorded daily using a sandscreen analysis set.

8.1.13 Chemical Analysis

Specific individual chemical analysis shall be selected, as required, by the Mud Engineer, for performance on a daily basis.

8.1.14 Plastic Viscosity

Plastic viscosity shall be recorded daily with a Fann V-G meter or its equivalent.

8.1.15 Yield Point

Yield point shall be recorded daily with a Fann V-G meter or its equivalent.

8.2 Other Job Site Tests and Measurements

The following tests and measurements may be conducted on an "as needed" basis as recommended by the Mud Engineer and authorized by the Contractor.

8.2.1 Resistivity

Resistivity shall be measured in ohm-meters. The sample temperature shall be recorded for correction purposes.

8.2.2 Emulsion Stability

The stability of emulsions of water in oil shall be measured using an emulsion tester.

8.2.3 Chemical Analysis

The drilling fluid may be subject to the following chemical analyses which have proved useful in the engineering of drilling fluids (procedures for each of these can be found in API RP 13B):

a. Chloride

b. Alkalinity and Lime Content

c. Alternate filtrate alkalinity

d. Total hardness

e. Calcium

f. Cation exchange capacity

g. Soluable carbonates in water based fluids

8.2.4 Corrosion

Corrosion shall be measured by means of test coupons installed on the air pipe and the bit body and then visually examined after an API-specified period of time, or by other approved method.

8.2.5 Lubricity

Lubricity, if required, shall be measured with suitable equipment as described in the Magcobar Division of Dresser Industries Drilling Fluid Handbook.

8.3 Objectives

The tests and measurements outlined under 8.1 and 8.2 above shall be conducted to provide support for the developed drilling fluid program and to detect and eliminate any problems that may arise during the shaft boring operation.

9.0 OPERATING DRILLING FLUID SYSTEM

The system for cleaning and maintaining the drilling fluid will be an open pit, gravity settling system. It will be provided, operated and maintained under the provisions of Specification No. B-314-C-X28018, Shaft Drilling and Rig Services. The Subcontractor shall assist in the design of the circulation system and shall review the system for adequacy. The system shall be subject to approval by the Contractor.

BWSP01B: 2/3/83

BIDDER AND SELLER INFORMATION REQUIREMENTS

TYPE OF INFORMATION	PREAWARD BY BIDDER: COPIES WITH EACH BID	PREAWARD BY BIDDER: REVIEW DATA REQUIRED (WEEKS AFTER AWARD)	PREAWARD BY BIDDER: BIDDER PROMISE SUBMITTAL (WEEKS AFTER AWARD)	POSTAWARD BY SELLER: REPRODUCIBLE* TO BE SUBMITTED FOR REVIEW	CERTIFIED DRAWINGS TO BE SUBMITTED AFTER REVIEW: PAPER PRINTS	CERTIFIED DRAWINGS: REPRODUCIBLE *: PAPER	CERTIFIED DRAWINGS: REPRODUCIBLE *: PERMANENT	COPIES REQUIRED WITHOUT REVIEW
1. DRAWING LIST AND SCHEDULE								
2. DIMENSIONED OUTLINE DRAWINGS AND/OR CATALOG INFORMATION								
3. SCHEMATIC PIPING DIAGRAMS								
4. ELECTRICAL AND INSTRUMENTATION INFORMATION								
5. SHOP DETAIL DRAWINGS								
6. FOUNDATION OUTLINE AND ANCHOR BOLT LOCATIONS								
7. LOAD DIAGRAMS								
8. DATA SHEETS, AS NOTED THEREON								
9. PERFORMANCE DATA AND CURVES								
10. CERTIFIED TEST AND INSPECTION REPORTS								
11. BILLS OF MATERIAL								
12. INSTALLATION INSTRUCTIONS								
13. MAINTENANCE AND OPERATING MANUALS								
14. NAMEPLATE DATA, AND MOTOR LIST								
15. CALCULATIONS								
16. PRELIMINARY DESIGN DRAWINGS								
17. FINAL DESIGN DRAWINGS								
18. Fluid Additives Data				**				
19. Inventory of Fluid Additives								3
20. Daily Records								3
21. Program of Additive Use				**				
22. Additive Test Records								3
23.								
24.								
25.								
26.								
27.								
28.								
29.								
30.								

NOTE-BIDDER (applies to the three PREAWARD BY BIDDER columns)

* Reproducible required only for data larger than 11" x 17"

** One Reproducible plus 6 copies

SEE SHEET 2 OF 2 FOR DEFINITIONS AND INSTRUCTIONS.

DEFINITIONS

1. DRAWING LIST AND SCHEDULE A complete list of all drawings and data by title that the Bidder expects to furnish on this order. Schedule to show, in weeks after award, submittal of each type of review and certified drawings.

2. DIMENSIONED OUTLINE DRAWINGS AND/OR CATALOG INFORMATION Drawings to scale showing the relative size, configuration, and location of all material to be furnished. Show two or more views of unit, clearances and area required for operation and maintenance. Show unit in relation to nearby structures and other equipment or operating floor, location of utility connections and direction of rotation, if applicable. When submitting data for "off the shelf" equipment/materials, catalog cuts and information are acceptable provided they are submitted in ample detail.

3. SCHEMATIC PIPING DIAGRAMS Show equipment to be interconnected, flow quantities, pipe sizes, valves and instruments.

4. ELECTRICAL AND INSTRUMENTATION INFORMATION Show all data pertaining to instrumentation, control and power electrical equipment. Include "one-line", "elementary" wiring, panel interior wiring and exterior interconnection wiring, dimensioned outlines of enclosures with raceway entries shown.

5. SHOP DETAIL DRAWINGS Show all necessary details and data required for fabrication and maintenance. For structural details show all connections and member sizes.

6. FOUNDATION OUTLINE AND ANCHOR BOLT LOCATIONS Show all data required for foundation design including location, blockouts, embedded items, grout required, and size, type and projection of anchor bolts.

7. LOAD DIAGRAMS Show total static and dynamic loads and load centers.

8. DATA SHEETS Sheets shall be completed for the equipment proposed with all information noted thereon.

9. PERFORMANCE DATA AND CURVES

10. CERTIFIED TEST AND INSPECTION REPORTS Reports by recognized commercial laboratories of indicated chemical and physical tests of materials as required by the specifications. In addition where applicable, weld inspection and stress relieving records and code nameplate rubbings shall be furnished.

11. BILLS OF MATERIAL Show for each unit: item no., shop order no., mark or name, part no., or pattern no., and drawing reference.

12. INSTALLATION INSTRUCTIONS Complete, detailed and sequenced instructions for original installation and for removals and replacements as well as erection information.

13. MAINTENANCE AND OPERATING MANUALS Complete installation, starting and operating instructions. Complete descriptions of preventive and repair maintenance, including detailed lubrication chart showing every lubrication point, grade of lubricant, lubrication schedule and amount of oil or grease required for refill after drainage. Manuals include parts list with recommended spares.

14. NAMEPLATE DATA AND MOTOR LIST

15. CALCULATIONS Shall be checked and stamped by a registered professional engineer, licensed to practice in the state where installation occurs.

16. PRELIMINARY DESIGN DRAWINGS Seller provided design services such as pre-engineered buildings, silos and other structures, conveyor systems, bins and chute design, large ductwork and supports.

17. FINAL DESIGN DRAWINGS Same as Item No. 16.

INSTRUCTIONS

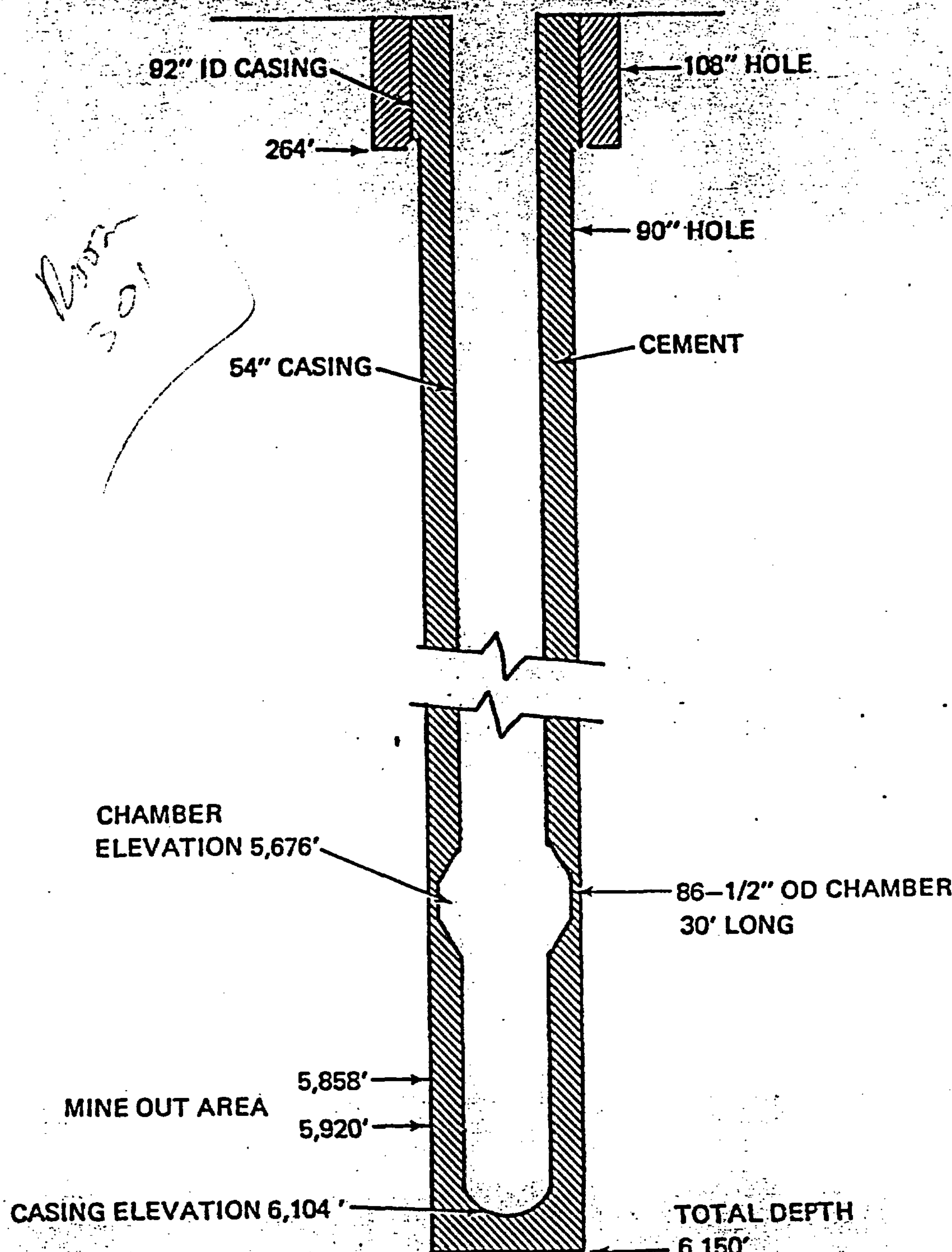
1. DIMENSIONS Shown on all but schematic drawings and diagrams shall be in feet and inches, unless noted otherwise.

2. CERTIFIED DRAWINGS Shall be so marked by Seller. They shall conform to Seller's drawings as finally accepted by the Purchaser and shall be forwarded at commencement of manufacture. The drawings shall be revised and resubmitted to reflect any changes approved during the manufacturing period.

3. REPRODUCIBLE PERMANENT PRINTS Shall be cloth, "Chronaflex", or "Mylar". They shall depict the material as shipped and shall be forwarded upon completion of shipment.

4. ________________ EQUIPMENT NUMBERS Shall be used for reference and identification of the units on all data required hereunder.

UA-1 AMCHITKA-ALASKA



January 19, 1971 Revision No. 3

FENIX & SCISSON, INC.

HOLE HISTORY DATA

DATE: November 7, 1969

APPROVED: [signature]

HOLE NO.: UA-1	CONTRACT NO.: AT(26-1)-300	I. D. NO.:
USER: LRL	TYPE HOLE: Emplacement	
LOCATION: STS	COUNTY:	AREA: Amchitka
SURFACE COORDINATES: N-5,704,185.92 M; E-646,321.59 M		
GROUND ELEVATION: 208'	PAD ELEVATION:	TOP CASING ELEVATION:
RIG ON LOCATION:	SPUDDED: 8-22-67	COMPLETED: 7-26-69
CIRCULATING MEDIA: Mud		
MAIN RIG & CONTRACTOR: Parco, Inc. Rig #3		NO. OF COMPRESSORS & CAPACITY: 6-1100 Ea.

BORE HOLE RECORD			CASING RECORD							
FROM	TO	SIZE	DIAMETER	WT. FT.	WALL	GRADE	CPL'G.	FROM	TO	CU. FT. CMT.
0'	10'	Excav.	168" I.D.			CMP		0'	10'	*
10'	264'	108"	92" I.D.	**				0'	263'	6,060
264'	6150'	90"	54" I.D.	***				0'	6104'	204,619
6150'	6473'	8-5/8"								
6473'	6500'	6-1/8"								

TOTAL DEPTH: 6150' GL | AVERAGE MANDREL DEPTH: | FROM REFERENCE ELEVATION

JUNK & PLUGS LEFT IN HOLE: Fluid Density and NAIL logging tools in monitor lines at 674' and 2343'

SURVEYS PAGE: 52 | CORING PAGE: 44 | CU. FT. CMT. TOTAL IN PLUGS, ETC:

LOGGING DATA: Page 50

BOTTOM HOLE COORDINATES: N-5,704,186.22M; E-646,321.76M @ 6100' | REFERENCE: Average In and Out 303-SU3-303

RIGS USED

RIG NO.	NAME	TYPE	CLASS	DAYS OPERATING	SECURED W/CREW	SECURED W/O CREW	TOTAL DAYS ON LOC.
3	Parco, Inc.	Ideco 3000 HP		681.73	9.38	11.67	702.78

REMARKS:

* Cemented in place with pad.

** See Page 2

*** See Page 40 (An 86" O.D. x 43.04' Chamber was Centered at 5654.76').

NOTE: Centerpunch hole from 6150' to 6500' was plugged back with cement.

PREPARED BY WDS and HF

TIME BREAKDOWN ON NEXT PAGE

January 19, 1971 Revision No. 3

FENIX & SCISSON, INC.
HOLE HISTORY DATA

DATE: November 7, 1969

APPROVED: [signature]

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CONTRACT NO.: AT(26-1)-300

I. D. NO.:

USER: LRL

TYPE HOLE: Emplacement

LOCATION: STS

COUNTY:

AREA: Amchitka

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GROUND ELEVATION: 208'

PAD ELEVATION:

TOP CASING ELEVATION:

RIG ON LOCATION:

SPUDDED: 8-22-67

COMPLETED: 7-26-69

CIRCULATING MEDIA: Mud

MAIN RIG & CONTRACTOR: Parco, Inc. Rig #3

NO. OF COMPRESSORS & CAPACITY: 6-1100 Ea.

BORE HOLE RECORD			CASING RECORD							
FROM	TO	SIZE	DIAMETER	WT. FT.	WALL	GRADE	CPL'G.	FROM	TO	CU. FT. CMT.
0'	10'	Excav.	168" I.D.			CMP		0'	10'	*
10'	264'	108"	92" I.D.	**				0'	263'	6,060
264'	6150'	90"	54" I.D.	***				0'	6104'	204,619
6150'	6473'	8-5/8"								
6473'	6500'	6-1/8"								

TOTAL DEPTH: 6150' GL

AVERAGE MANDREL DEPTH: FROM REFERENCE ELEVATION

JUNK & PLUGS LEFT IN HOLE: Fluid Density and NAIL logging tools in monitor lines at 674' and 2343'

SURVEYS PAGE: 52

CORING PAGE: 44

CU. FT. CMT. TOTAL IN PLUGS, ETC:

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RIGS USED							
RIG NO.	NAME	TYPE	CLASS	DAYS OPERATING	SECURED W CREW	SECURED W/O CREW	TOTAL DAYS ON LOC.
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REMARKS:

* Cemented in place with pad.

** See Page 2

*** See Page 40 (An 86" O.D. x 43.04' Chamber was Centered at 5654.76').

NOTE: Centerpunch hole from 6150' to 6500' was plugged back with cement.

PREPARED BY: WDS and HF

TIME BREAKDOWN ON NEXT PAGE.

TIME BREAKDOWN

SITE PREPARATION

DRILLING OPERATION TIME (DOT)		OTHER SCHEDULED TIME (OST)		OPERATIONAL DELAY TIME (ODT)	
DRILL		MOVE		RIG REPAIRS	
TRIPS		RUN CASING		W. O. DRILLING SUPPLIES	
SURVEYS		CEMENT CASING		CLEAN OUT FILL	
				SECURED WITH CREWS	
SITE DOT ____ DAYS		SITE OST ____ DAYS		SITE ODT ____	

TOTAL SITE PREP TIME ____ DAYS REMARKS:

MAIN HOLE CONSTRUCTION

DRILLING OPERATION TIME (DOT)		OTHER SCHEDULED TIME (OST)		OPERATIONAL DELAY TIME (ODT)	
DRILL	289.15	MOBILIZATION & DEMOBILIZATION		RIG REPAIRS	8.19
TRIPS	23.63	CORE	55.25	W. O. EQUIPMENT	4.72
DRESS DRILLING ASSEMBLY	15.73	LOG	5.54	FISH	30.68
SINGLE SHOT DEV. SURVEYS		CASED HOLE DIR. SURVEYS	0.17	CLEAN OUT FILL	34.56
OPEN HOLE DIRECTION SURVEYS	3.01	UNLOAD CASED HOLE	4.79	UNLOAD WATER INFLOW	
Cluster Shot	5.07	RUN MANDREL	0.38	REAM CROOKED HOLE	
		HYDROLOGICAL TESTS	8.99	PLUG BACK	13.88
		Run, cement and		DRILL OUT PLUGS	12.69
MAIN HOLE DOT 336.59 DAYS		recover 10-3/4"	20.33	SECURED WITH CREWS	9.38
		*Centerpunch Operations	8.24	Mud System Delay	2.77
				Lost Circulation	1.56
				Repair Dropped	
				Blocks Damage	19.30
				High Winds	2.85
		MAIN HOLE OST 103.69 DAYS		MAIN HOLE ODT 140.58 DAYS	

CASING OPERATION TIME (COT)			
RUN	92"	CASING	3.73
RUN	54"	CASING	83.10
CEMENT	92"	CASING	2.21
CEMENT	54"	CASING	15.25
DRILL OUT SHOE			0.58
Alignment Tool Repairs			5.38
MAIN HOLE COT 110.25 DAYS			

TOTAL MAIN HOLE CONST. TIME 691.11 DAYS REMARKS:

TOTAL ELAPSED TIME

TOTAL SITE PREP TIME		DAYS
TOTAL MAIN HOLE CONST. TIME	691.11	DAYS
SEC. W O CREW SITE PREP		DAYS
SEC. W O CREW MAIN HOLE CONST.	11.67	DAYS
TOTAL SUSPENDED (NO RIG)		DAYS
TOTAL ELAPSED TIME	702.78	DAYS

REMARKS: * Centerpunch Operations

Drill	4.42
Trips	0.68
Direction Survey	0.78
Log	2.02
Clean Out Fill	0.34
	8.24 Days

HOLE HISTORY

Assembled Parco, Inc. Rig #3 and started rigging up on 7-31-67.

Prior to rigging up, the site was excavated for the pad foundation and conductor casing. The 168" I.D., 8 gauge galvanized conductor casing was set at 10' G.L. and cemented in place along with the foundation pad.

8-22-67 Assembled 108" bit and stabilizer and spudded hole at 1400 hours. Drilled 108" hole from 10' to 13' using drilling mud and conventional method of circulation. Drilling assembly consisted of a 108" bit, 107-1/2" stabilizer and starting sub.

8-23-67 Drilled 108" hole from 13' to 27'.

8-24-67 Drilled 108" hole from 27' to 34'. Ran Sperry-Sun Directional Survey at 27'.

8-25-67 Made up drilling assembly consisting of a 108" bit, 108" reamer, 16" O.D. starting mandrel, 3 - 60" weights, 107-1/2" stabilizer and sub. Drilled 108" hole from 34' to 36'.

8-26-67 Drilled 108" hole from 36' to 84'. Ran Sperry-Sun Directional survey at 81', single shot directional surveys will be run on approximately 45' intervals during the drilling progress of the hole.

8-27-67 Making up drilling assembly consisting of a 108" bit, 16" O.D. x 60' mandrel, 108" reamer, 14 - 60" weights, 107-1/2" string stabilizer, 3 - 60" weights and hold down assembly.

8-28-67 Completed drilling assembly and drilled 108" hole from 84' to 95'. Changed over to reverse circulation air-assist method.

8-29-67 Drilled 108" hole from 95' to 113'.

8-30-67 Drilled 108" hole from 113' to 132', used 3 compressors at 3300 cfm and 110 psi. Mud circulation rate 1800 gpm. 3-1/2" O.D. jet string 5' above bit.

8-31-67 Drilled 108" hole from 132' to 149', used 3 compressors at 3300 cfm and 125 psi. Mud circulation 2000 gpm.

9-1-67 Drilled 108" hole from 149' to 167'. 3-1/2" O.D. jet string 9' above bit.

9-2-67 Drilled 108" hole from 167' to 185', used 2 compressors at 2200 cfm and 100 psi. Mud circulation 2100 gpm.

9-3-67 Drilled 108" hole from 185' to 204'. 3-1/2 O.D. jet string 12' above bit. Mud circulation 2200 gpm.

9-4-67 Drilled 108" hole from 204' to 221', used 2 compressors at 2400 cfm and 100 psi. Mud circulation 2200 gpm.

9-5-67 Drilled 108" hole from 221' to 241', used 2 compressors at 2200 cfm and 120 psi. Mud circulation 2450 gpm.

9-6-67 Drilled 108" hole from 241' to 256', used 2 compressors at 2200 cfm and 125 psi. Mud circulation 2650 gpm.

9-7-67 Drilled 108" hole from 256' to 264', measured out of hole, no correction. Ran Birdwell Caliper log. Ran bit assembly in hole, had 6" of fill.

9-8-67 Conditioned hole and prepared to run casing.

9-9-67 Ran and welded joint #1 and #2 of 92" I.D., 1-3/8" wall thickness casing. Welded 3-1/2" O.D. grout line guides on outside of 92" I.D. casing. Welding on joint #3.

9-10-67 Ran and welded 92" I.D. casing and grout line guides on joint #3, #4, #5, and #6.

9-11-67 Ran and welded 92" I.D. casing and grout line guides on joint #7, #8, and #9, overall length of 92" I.D. casing was 270.19', landed at 263.19' G.L. Bottom joint had stand off guides fabricated out of steel plate welded to outside of 92" I.D. casing instead of a guide shoe. Casing details:

NO. OF JOINTS	WALL THICKNESS	WEIGHT PER FOOT	DEPTH INTERVAL
3	1-3/8"	1372#	263.19' - 173.13'
2	1-1/4"	1246#	173.13' - 113.09'
2	1-1/8"	1120#	113.09' - 53.05'
2	1"	994#	53.05' - 0'

3-1/2" O.D., 7.58# line pipe was welded to the outside of the 92" I.D. casing for grout line guides, 1" x 6" long torch cut slots alternated 180° around the guides on 3' intervals for its entire length. Three guides were spaced 120° around the 92" I.D. casing and were run from 0' to 263'. Ran 1.9" O.D. tubing for grout lines inside each of the grout line guides and landed at 263.50'. Ran 1.9" O.D. grout line inside of the 92" I.D. casing, landed at 263.50'. Flushed each grout line with 5 barrels of water. Cemented stage #1 by Dowell down each grout line using [illegible]56 ft^3 of neat cement plus 3% calcium chloride. CIP at 2315 hours. Waited on cement.

9-12-67 Waited on cement until 1130 hours. Tagged top of cement in annulus at 252', tagged top of cement inside 92" I.D. casing at 251'. Ran 1.9" O.D. grout lines inside the 3 grout line guides to 250'. Cemented stage #2 down grout lines using 2055 ft^3 of neat cement plus 2% calcium chloride. CIP at 1315 hours. Waited on cement.

9-13-67 Waited on cement until 0200 hours. Tagged top of cement at 144'. Ran 1.9" O.D. tubing inside the 3 grout line guides to 144'. Cemented down grout lines with 2932 ft^3 of neat cement plus 2% calcium chloride. CIP at 0310 hours. Waited on cement and nippled up until 1500 hours. Top of stage #3 was 9' by Birdwell. Cemented stage #4 to surface with ready-mix cement using 945 ft^3. CIP at 1800 hours. Waited on cement.

9-14-67 Made up drilling assembly consisting of a 90" bit #2, 16" O.D. x 60' mandrel. Assembly on mandrel consisted of a 90" reamer - stabilizer, 14 - 60" O.D. x 18" thick split type weights, 90" string stabilizer, 3 - 60" O.D. x 18" thick split type weights and hold down plate.

9-15-67 Completed drilling assembly, drilled out cement to 264'. Drilled 90" hole from 264' to 272', using drilling mud, reverse circulation air-assist method. 3-1/2" O.D. jet string 56' above bit. Used 2 compressors at 150 psi and 2200 cfm. Mud circulation rate 3250 gpm.

9-16-67 Drilled 90" hole from 272' to 293', used 2 compressors at 110 psi and 2200 cfm. Mud rate 3220 gpm. 3-1/2" O.D. jet string 100' above bit.

9-17-67 Drilled 90" hole from 293' to 314'. Ran Sperry-Sun single shot directional at 274'. Single shot directional surveys will be run on approximately 45' intervals during the drilling progress of the hole.

9-18-67 Drilled 90" hole from 314' to 338', air pressure increased to 120 psi. 3-1/2" O.D. jet string 144' above bit.

9-19-67 Drilled 90" hole from 338' to 366'.

9-20-67 Drilled 90" hole from 366' to 391'. 3-1/2" O.D. jet string 173' above bit.

9-21-67 Drilled 90" hole from 391' to 426'. 3-1/2" O.D. jet string 217' above bit.

9-22-67 Drilled 90" hole from 426' to 457'.

9-23-67 Drilled 90" hole from 457' to 474'.

9-24-67 Drilled 90" hole from 474' to 504'. 3-1/2" O.D. jet string 279' above bit.

9-25-67 Drilled 90" hole from 504' to 514'. 3-1/2" O.D. jet string length 256'. Ran bit #3 in-hole at 511'.

9-26-67 Drilled 90" hole from 514' to 557'. 3-1/2" O.D. jet string length 347' or 275' above bit. Used 2 compressors at 105 psi and 2200 cfm mud rate 3220 gpm.

9-27-67 Drilled 90" hole from 557' to 594'. Air pressure changed to 140 psi.

9-28-67	Drilled 90" hole from 594' to 635'. Air pressure 150 psi. 3-1/2" jet string length 347'.
9-29-67	Drilled 90" hole from 635' to 670'.
9-30-67	Drilled 90" hole from 670' to 704'.
10-1-67	Drilled 90" hole from 704' to 737'.
10-2-67	Drilled 90" hole from 737' to 748'. Ran bit #4 at 748'.
10-3-67	Drilled 90" hole from 748' to 788'. 3-1/2" O.D. jet string length 346'.
10-4-67	Drilled 90" hole from 788' to 823'.
10-5-67	Drilled 90" hole from 823' to 856'.
10-6-67	Drilled 90" hole from 856' to 882'.
10-7-67	Drilled 90" hole from 882' to 895', ran bit #5 at 888'.
10-8-67	Drilled 90" hole from 895' to 917'.
10-9-67	Drilled 90" hole from 917' to 942'.
10-10-67	Drilled 90" hole from 942' to 961'. 3-1/2" O.D. jet string length changed to 406'.
10-11-67	Drilled 90" hole from 961' to 976'. Ran bit #6 at 967', 3-1/2" jet string length 346'.
10-12-67	Drilled 90" hole from 976' to 1000'.
10-13-67	Drilled 90" hole from 1000' to 1028'.
10-14-67	Drilled 90" hole from 1028' to 1054'.
10-15-67	Drilled 90" hole from 1054' to 1080'.
10-16-67	Drilled 90" hole from 1080' to 1105'.
10-17-67	Drilled 90" hole from 1105' to 1131'.
10-18-67	Drilled 90" hole from 1131' to 1150'. Ran Sperry-Sun Multishot Gyro survey inside drill pipe on 45' stations while pulling out of hole. Started running Birdwell Caliper.

10-19-67	Completed running Caliper log. Ran Sperry-Sun multishot gyro survey inside drill pipe on 45' stations while going in hole with bit #7. Surveyed from 0' to 1109'. Drilled 90" hole from 1150' to 1155'. Hole caving, drill rough fractured formation causing key to shear in rotary drive, drill pipe backed off. Screwed drill pipe together and pulled from hole checking each joint.
10-20-67	Completed pulling drill pipe and ran back into hole. Drilled 90" hole from 1157' to 1161'. Drill pipe backed off, screwed together and pulled from hole, checking each joint.
10-21-67	Completed trip with drill pipe and drilled 90" hole from 1161' to 1173'. 3-1/2" O.D. jet string length 346'.
10-22-67	Drilled 90" hole from 1173' to 1188'.
10-23-67	Drilled 90" hole from 1188' to 1203'.
10-24-67	Drilled 90" hole from 1203' to 1221'.
10-25-67	Drilled 90" hole from 1221' to 1239'.
10-26-67	Drilled 90" hole from 1239' to 1257', used 2 compressors at 150 psi and 2200 cfm. Mud rate 3220 gpm.
10-27-67	Drilled 90" hole from 1257' to 1265', ran bit #8 at 1265'. Air pressure 165 psi.
10-28-67	Drilled 90" hole from 1265' to 1276'.
10-29-67	Drilled 90" hole from 1276' to 1294'.
10-30-67	Drilled 90" hole from 1294' to 1314', used 2 compressors at 135 psi and 2200 cfm. Mud rate 3545 gpm. 3-1/2" O.D. jet string length 346'.
10-31-67	Drilled 90" hole from 1314' to 1339'.
11-1-67	Drilled 90" hole from 1339' to 1366'.
11-2-67	Drilled 90" hole from 1366' to 1392'. Air pressure 145 psi.
11-3-67	Drilled 90" hole from 1392' to 1416'. Air pressure 135 psi.
11-4-67	Drilled 90" hole from 1416' to 1454'. Air pressure 140 psi.
11-5-67	Drilled 90" hole from 1454' to 1491'.
11-6-67	Drilled 90" hole from 1491' to 1505'. Ran Birdwell Caliper log. Ran bit #9 at 1505', cleaned out 1' of fill, bit plugging.

11-7-67	Drilled 90" hole from 1505' to 1519', ran bit #10 at 1519'. Air pressure 145 psi.
11-8-67	Drilled 90" hole from 1519' to 1533'.
11-9-67	Drilled 90" hole from 1533' to 1548', used 2 compressors at 2200 cfm and 145 psi. Mud rate 3220 gpm. 3-1/2" O.D. jet string length 346'.
11-10-67	Drilled 90" hole from 1548' to 1566'.
11-11-67	Drilled 90" hole from 1566' to 1576'. Air Pressure 140 psi.
11-12-67	Drilled 90" hole from 1576' to 1590'.
11-13-67	Drilled 90" hole from 1590' to 1611'.
11-14-67	Drilled 90" hole from 1611' to 1636'. Air pressure 150 psi.
11-15-67	Drilled 90" hole from 1636' to 1646'.
11-16-67	Ran bit #11 at 1646'. Drilled 90" hole from 1646' to 1648'. Air pressure 105 psi, 3-1/2" O.D. jet string length 256'.
11-17-67	Drilled 90" hole from 1648' to 1666'. Air pressure 105 psi to 140 psi. 3-1/2" O.D. jet string length changed to 346'.
11-18-67	Drilled 90" hole from 1666' to 1696'.
11-19-67	Drilled 90" hole from 1696' to 1718'.
11-20-67	Drilled 90" hole from 1718' to 1744'.
11-21-67	Drilled 90" hole from 1744' to 1767'. Air pressure 170 psi. 3-1/2" O.D. jet string length 437'.
11-22-67	Drilled 90" hole from 1767' to 1780'. Ran bit #2 at 1780', had 1' of fill on trip. Air pressure 180 psi.
11-23-67	Drilled 90" hole from 1780' to 1796'.
11-24-67	Drilled 90" hole from 1796' to 1820'. Used 2 compressors 170 to 180 psi and 2200 cfm. Mud circulation rate 3220 gpm. 3-1/2" O.D. jet string length 437'.
11-25-67	Drilled 90" hole from 1820' to 1845'.
11-26-67	Drilled 90" hole from 1845' to 1853'. Cleaned out pump suctions and manifolds.
11-27-67	Drilled 90" hole from 1853' to 1856'. Cleaned out mud pits and pump suctions.

11-28-67 Cleaned out mud pits and pump suctions. Ran bit #13 at 1856'. Drilled 90" hole from 1856' to 1858'. Air pressure 185 psi.

11-29-67 Drilled 90" hole from 1858' to 1870', checked mud flow by varying jet string length and number of compressors, returned to original setting.

11-30-67 Drilled 90" hole from 1870' to 1889'. Used 2 compressors at 180 psi and 2200 cfm. Mud circulation rate 2760 gpm. 3-1/2" O.D. jet string length 437'.

12-1-67 Drilled 90" hole from 1889' to 1912'.

12-2-67 Drilled 90" hole from 1912' to 1938'.

12-3-67 Drilled 90 " hole from 1938' to 1964'. Air pressure 190 psi.

12-4-67 Drilled 90" hole from 1964' to 1988'. Air pressure 175 psi.

12-5-67 Drilled 90" hole from 1988' to 2017'.

12-6-67 Drilled 90" hole from 2017' to 2039'.

12-7-67 Drilled 90" hole from 2039' to 2063'.

12-8-67 Drilled 90" hole from 2063' to 2069', pulled out of hole for new bit running Sperry-Sun Gyroscopic multishot survey on approximately 44' stations from 2029' to 1109'. Ran Birdwell Caliper log. Ran bit #14 in hole and started Sperry-Sun survey.

12-9-67 Completed trip in hole running Sperry-Sun multishot survey at every joint from 1109' to 2029', had 1' of fill. Drilled 90" hole from 2069' to 2097'. Used 2 compressors at 2200 cfm and 180 psi. Mud circulation rate 2760 gpm. 3-1/2" O.D. jet string length 437'.

12-10-67 Drilled 90" hole from 2097' to 2101', 12 joints of 3-1/2" O.D. jet string backed off and dropped inside 13-3/8" O.D. drill pipe. Ran in hole with 8-5/8" O.D. Bowen overshot and recovered 8 joints of 3-1/2" O.D. tubing leaving 4 joints. Ran 8-5/8" O.D. Bowen overshot with 4-1/2" Grapple.

12-11-67 Recovered fish and made up jet string. Drilled 90" hole from 2101' to 2111'. Air pressure 160 psi, 3-1/2" O.D. jet string length 440'.

12-12-67 Drilled 90" hole from 2111' to 2135'. Air pressure 175 psi.

12-13-67 Drilled 90" hole from 2135' to 2155'. Used 2 compressors at 2200 cfm and 170 psi. Mud circulation rate 3200 gpm. 3-1/2" O.D. jet string length 440'.

12-14-67 Drilled 90" hole from 2155' to 2174'. Used 3 compressors at 3300 cfm and 180 psi. Mud circulation rate 2760 gpm.

12-15-67 Drilled 90" hole from 2174' to 2190'. Used 2 to 3 compressors at 2200 to 3300 cfm and 160 psi. Mud circulation rate 3120 gpm. 3-1/2" O.D. jet string length 533'.

12-16-67 Drilled 90" hole from 2190' to 2206'. Air pressure 200 psi.

12-17-67 Drilled 90" hole from 2206' to 2215'. Ran bit #15 at 2212', had 6' of fill on trip. Mud circulation rate 3200 gpm.

12-18-67 Drilled 90" hole from 2215' to 2235'. Used 2 compressors at 2200 cfm and 190 psi. Mud circulation rate 3245 gpm. 3-1/2" O.D. jet string length 533'.

12-19-67 Drilled 90" hole from 2235' to 2253'. Used 3 compressors at 3300 cfm and 205 psi. Mud circulation rate 3525 gpm.

12-20-67 Drilled 90" hole from 2253' to 2282'. Used 2 compressors at 2200 cfm and 195 psi. Mud circulation rate 3245 gpm.

12-21-67 Drilled 90" hole from 2282' to 2311'. Air pressure 205 psi.

12-22-67 Drilled 90" hole from 2311' to 2330'. Air pressure 200 psi.

12-23-67 Drilled 90" hole from 2330' to 2342'. Ran bit #16 at 2341', had 1' of fill on trip.

12-24-67 Drilled 90" hole from 2342' to 2374'.

12-25-67 Drilled 90" hole from 2374' to 2403'.

12-26-67 Drilled 90" hole from 2403' to 2425'. Used 3 compressors at 3300 cfm at 205 psi. Mud circulation rate 3525 gpm. 3-1/2" O.D. jet string length 533'.

12-27-67 Drilled 90" hole from 2425' to 2447'.

12-28-67 Drilled 90" hole from 2447' to 2467'.

12-29-67 Drilled 90" hole from 2467' to 2490'. Air pressure 210 psi to 215 psi.

12-30-67 Drilled 90" hole from 2490 to 2512'. Welded hole in 3-1/2" O.D. jet string at 270'.

12-31-67 Drilled 90" hole from 2512' to 2536'.

1-1-68 Drilled 90" hole from 2536' to 2539'. Lost 100 psi of air pressure, pulled 3-1/2" O.D. jet string and welded hole at 300'. Ran Birdwell Caliper log. Ran bit #17 and drilled 90" hole from 2539' to 2544', had 1' of fill on trip.

1-2-68 Drilled 90" hole from 2544' to 2583'. Air pressure 200 psi.

1-3-68 Drilled 90" hole from 2583' to 2610'.

1-4-68 Drilled 90" hole from 2610' to 2635'.

1-5-68 Drilled 90" hole from 2635' to 2663'. Air pressure 200 psi to 210 psi.

1-6-68 Drilled 90" hole from 2663' to 2682'.

1-7-68 Drilled 90" hole from 2682' to 2714'.

1-8-68 Drilled 90" hole from 2714' to 2735'.

1-9-68 Drilled 90" hole from 2735' to 2753'.

1-10-68 Drilled 90" hole from 2753' to 2764'. Ran bit #18 at 2755', had 1' of fill on trip. Used 3 to 5 compressors at 3300 cfm to 5500 cfm and 200 psi to 240 psi. Mud circulation rate 3525 gpm. 3-1/2" O.D. jet string length 533'.

1-11-68 Drilled 90" hole from 2764' to 2788'. Air pressure 240 psi to 245 psi, mud circulation rate 3570 gpm.

1-12-68 Drilled 90" hole from 2788' to 2811'.

1-13-68 Drilled 90" hole from 2811' to 2833'.

1-14-68 Drilled 90" hole from 2833' to 2855'.

1-15-68 Drilled 90" hole from 2855' to 2872', started losing mud, estimated fluid loss 15,000 barrels. Mixed lost circulation materials. Fluid loss was 29 inches per minute with pumps off.

1-16-68 Mixed mud and lost circulation materials. Fluid level dropped 24' in 5-1/2 hours.

1-17-68 Ran drilling assembly in hole (bit #19), cleaned out 5' of fill and bit plugged. Losing fluid at 1-3/4 barrels per minute. Building mud volume.

1-18-68 Drilled 90" hole from 2872' to 2875', drilling on boulders, bit plugging. Used 3 compressors at 3300 cfm and 190 psi to 200 psi. Mud circulation rate 3000 gpm. 3-1/2" O.D. jet string length 533'.

1-19-68 Drilled 90" hole from 2875' to 2879', drilling on boulders, bit plugging. No fluid lost at 1800 hours.

1-20-68 Drilled 90" hole from 2879' to 2884', drilling on boulders, bit plugging. Changed from 3 to 2 compressors at 2200 cfm and 200 psi. Lost 1000 barrels of mud in 12 hours at 0600 hours.

1-21-68 Drilled 90" hole from 2884' to 2889', drilling on boulders, bit plugging. Mud circulation rate 2700 gpm.

1-22-68	Drilled 90" hole from 2889' to 2895', drilling on boulders, bit plugging.
1-23-68	Drilled 90" hole from 2895' to 2901', drilling on boulders, bit plugging, cleaning out fill.
1-24-68	Drilled 90" hole from 2901' to 2907', drilling on boulders, bit plugging, and cleaning out fill. Ran Birdwell Caliper log.
1-25-68	Reran Caliper log. Ran 5" drill pipe to 2907'. Set plug #1 with Dowell using 2360 ft^3 of class 'A' cement with 3% calcium chloride. CIP at 1930 hours. Waited on cement.
1-26-68	Waited on cement. Ran bit #20 in hole.
1-27-68	Waited on cement until 0800 hours, cleaned out 1' of fill and drilled cement from 2896' to 2902' with 90" bit.
1-28-68	Drilled cement from 2902' to 2907' and formation from 2907' to 2911', drilling on boulders. Bit plugged, started out of hole. Used 2 compressors at 2200 cfm and 190 psi. Mud circulation rate 2700 gpm. 3-1/2" O.D. jet string length 533'.
1-29-68	Drilled 90" hole from 2911' to 2913' and bit plugged.
1-30-68	Ran bit #21 and drilled 90" hole from 2913' to 2930', drilling on boulders, cleaning out fill, bit plugging. Used 2 compressors at 2200 cfm and 200 psi, mud circulation rate 3225 gpm.
1-31-68	Drilled 90" hole from 2930' to 2944', drilling on boulders. Used 3 compressors at 3300 cfm and 200 psi, mud circulation rate 3366 gpm.
2-1-68	Drilled 90" hole from 2944' to 2983'.
2-2-68	Drilled 90" hole from 2983' to 3015'. Used 2 compressors at 2200 cfm and 190 psi to 200 psi. Mud circulation rate 3225 gpm. 3-1/2" O.D. jet string length 533'.
2-3-68	Drilled 90" hole from 3015' to 3038'.
2-4-68	Drilled 90" hole from 3038' to 3059'.
2-5-68	Drilled 90" hole from 3059' to 3070'. Ran Sperry-Sun Gyroscopic multishot survey inside 13-3/8" O.D. drill pipe on approximately 44' stations from 3001' to 2029' while pulling out of hole. Ran Birdwell Caliper log.
2-6-68	Completed Caliper log. Ran bit #22 in hole and completed Sperry-Sun Gyroscopic multishot in run survey on approximately 44' stations from 2029' to 3001'. Drilled 90" hole from 3070' to 3080', had 6' of fill on trip.

2-7-68	Drilled 90" hole from 3080' to 3102'.
2-8-68	Drilled 90" hole from 3102' to 3123'.
2-9-68	Drilled 90" hole from 3123' to 3137', bit plugged. 3-1/2" O.D. jet string parted while trying to clean bit. Rigged up to fish.
2-10-68	Ran in hole with overshot and recovered fish. Drilled 90" hole from 3137' to 3140'.
2-11-68	Drilled 90" hole from 3140' to 3155'. Used 2 compressors at 2200 cfm and 200 psi to 210 psi. Mud circulation rate 3225 gpm. 3-1/2" O.D. jet string length 534'.
2-12-68	Drilled 90" hole from 3155' to 3175'.
2-13-68	Drilled 90" hole from 3175' to 3196'.
2-14-68	Drilled 90" hole from 3196' to 3202'. Ran bit #23 at 3199'.
2-15-68	Drilled 90" hole from 3202' to 3223'. Air pressure 190 psi to 205 psi.
2-16-68	Drilled 90" hole from 3223' to 3253'.
2-17-68	Drilled 90" hole from 3253' to 3281'.
2-18-68	Drilled 90" hole from 3281' to 3304'.
2-19-68	Drilled 90" hole from 3304' to 3326'.
2-20-68	Drilled 90" hole from 3326' to 3344', losing some fluid while drilling from 3340' to 3344'.
2-21-68	Drilled 90" hole from 3344' to 3365'.
2-22-68	Drilled 90" hole from 3365' to 3386'.
2-23-68	Drilled 90" hole from 3386' to 3405'.
2-24-68	Drilled 90" hole from 3405' to 3417'. Ran bit #24 at 3413'.
2-25-68	Drilled 90" hole from 3417' to 3438'.
2-26-68	Drilled 90" hole from 3438' to 3453'. 3-1/2" O.D. air string parted, pulled out of hole and recovered.
2-27-68	Ran bit #25. Strung up new drilling line. Drilled 90" hole from 3453' to 3456'. Used 2 compressors at 2200 cfm and 195 psi to 200 psi. Mud circulation rate 3225 gpm. 3-1/2" O.D. jet string length 532'.
2-28-68	Drilled 90" hole from 3456' to 3475'.

2-29-68	Drilled 90" hole from 3475' to 3494'.
3-1-68	Drilled 90" hole from 3494' to 3512'. Mud circulation rate 2972 gpm.
3-2-68	Drilled 90" hole from 3512' to 3528', lost approximately 1500 barrels of mud.
3-3-68	Drilled 90" hole from 3528' to 3563'.
3-4-68	Drilled 90" hole from 3563' to 3578'. Used 3 compressors at 3300 cfm and 190 psi. Mud circulation rate 3100 gpm. 3-1/2" O.D. jet string length 527'.
3-5-68	Drilled 90" hole from 3578' to 3584', bit locked, pulled out of hole and changed rollers on stabilizer, ran bit #26.
3-6-68	Drilled 90" hole from 3584' to 3603'. Mud circulation rate 3410 gpm.
3-7-68	Drilled 90" hole from 3603' to 3623'. Air pressure 190 psi to 200 psi.
3-8-68	Drilled 90" hole from 3623' to 3649'.
3-9-68	Drilled 90" hole from 3649' to 3672'.
3-10-68	Drilled 90" hole from 3672' to 3690'.
3-11-68	Drilled 90" hole from 3690' to 3695'. Ran bit #27 and cleaned out 5' of fill.
3-12-68	Drilled 90" hole from 3695' to 3719'.
3-13-68	Drilled 90" hole from 3719' to 3739'. Air pressure 205 psi.
3-14-68	Drilled 90" hole from 3739' to 3765'. Air pressure 190 psi to 210 psi.
3-15-68	Drilled 90" hole from 3765' to 3792'.
3-16-68	Drilled 90" hole from 3792' to 3808'.
3-17-68	Drilled 90" hole from 3808' to 3826'.
3-18-68	Drilled 90" hole from 3826' to 3832'. Used 2 compressors at 2200 cfm and 195 psi to 210 psi. Mud circulation rate 2900 gpm. 3-1/2" O.D. jet string length 618'. Ran bit #28.
3-19-68	Drilled 90" hole from 3832' to 3853'.
3-20-68	Drilled 90" hole from 3853' to 3875'. Air pressure 200 psi to 220 psi.
3-21-68	Drilled 90" hole from 3875' to 3899'. Air pressure 195 psi to 205 psi. 3-1/2" O.D. jet string length 526'.

3-22-68	Drilled 90" hole from 3899' to 3922'.
3-23-68	Drilled 90" hole from 3922' to 3950'. Air pressure 200 psi to 210 psi.
3-24-68	Drilled 90" hole from 3950' to 3971'. Mud circulation rate 2550 gpm.
3-25-68	Ran Sperry-Sun Gyroscopis multishot survey on 44' stations from 3001' to 3930' on trip out of hole with drill pipe. Ran Birdwell Caliper log. Ran Sperry-Sun Gyroscopic multishot survey on 44' stations from 3001' to 3930' on trip in hole with bit #29 Drilled 90" hole from 3971' to 3972'.
3-26-68	Drilled 90" hole from 3972' to 3994'.
3-27-68	Drilled 90" hole from 3994' to 4014'. Used 2 compressors at 2200 cfm and 200 psi to 210 psi. Mud circulation rate 2900 gpm. 3-1/2" O.D. jet string length 526'.
3-28-68	Drilled 90" hole from 4014' to 4037'.
3-29-68	Drilled 90" hole from 4037' to 4060'.
3-30-68	Drilled 90" hole from 4060' to 4084'.
3-31-68	Drilled 90" hole from 4084' to 4106'.
4-1-68	Drilled 90" hole from 4106' to 4126'.
4-2-68	Drilled 90" hole from 4126' to 4141'. Made trip for bit #30.
4-3-68	Drilled 90" hole from 4141' to 4155', cleaned out 1' of fill on trip in hole.
4-4-68	Drilled 90" hole from 4155' to 4178'.
4-5-68	Drilled 90" hole from 4178' to 4200'. Used 3 compressors at 3300 cfm and 210 psi to 220 psi. Mud circulation rate 2950 gpm. 3-1/2" O.D. jet string length 526'.
4-6-68	Drilled 90" hole from 4200' to 4217'.
4-7-68	Drilled 90" hole from 4217' to 4227'. Ran bit #31 at 4227'.
4-8-68	Drilled 90" hole from 4227' to 4245', had 1' of fill on trip in hole.
4-9-68	Drilled 90" hole from 4245' to 4270', Drilling on boulders, bit plugged from 4264' to 4270'.
4-10-68	Drilled 90" hole from 4270' to 4285', drilling on boulders, bit plugging.
4-11-68	Drilled 90" hole from 4285' to 4301', drilling on boulders, bit plugging.
4-12-68	Drilled 90" hole from 4301' to 4315', drilling on boulders, bit plugging.

4-13-68 Ran bit #32 at 4315', cleaned out 4' of fill. Drilled 90" hole from 4315' to 4319'.

4-14-68 Drilled 90" hole from 4319' to 4334', bit plugging.

4-15-68 Drilled 90" hole from 4334' to 4349', drilling on boulders, bit plugging.

4-16-68 Drilled 90" hole from 4349' to 4367'.

4-17-68 Drilled 90" hole from 4367' to 4380', drilling on boulders, bit plugging.

4-18-68 Drilled 90" hole from 4380' to 4391'. Ran bit #33 at 4391', cleaned out 4' of fill on trip.

4-19-68 Cleaned out fill and drilled 90" hole from 4391' to 4406'.

4-20-68 Drilled 90" hole from 4406' to 4427', drilling on boulders, bit plugging.

4-21-68 Drilled 90" hole from 4427' to 4436', bit plugging. Boulders fell in hole while drilling at 4435'. had 2' of fill.

4-22-68 Cleaned out fill and unplugged bit. Drilled 90" hole from 4436' to 4451'.

-23-68 Drilled 90" hole from 4451' to 4468', drilling on boulders between 4464' and 4468'. Used 3 compressors at 3300 cfm and 210 psi to 220 psi. Mud circulation rate 2050 gpm. 3-1/2" O.D. jet string length 526'.

4-24-68 Drilled 90" hole from 4468' to 4486'.

4-25-68 Drilled 90" hole from 4486' to 4504'.

4-26-68 Ran bit #34 at 4504', drilled 90" hole from 4504' to 4508'.

4-27-68 Drilled 90" hole from 4508' to 4528'.

4-28-68 Drilled 90" hole from 4528' to 4543'.

4-29-68 Drilled 90" hole from 4543' to 4551'.

4-30-68 Ran bit #35 at 4551', drilled 90" hole from 4551' to 4567'.

5-1-68 Drilled 90" hole from 4567' to 4583'.

5-2-68 Drilled 90" hole from 4583' to 4600'.

5-3-68 Drilled 90" hole from 4600' to 4601', changed to bit #36 and drilled 90" hole from 4601' to 4610'. Jet string parted, replaced 3 joints. 3-1/2" O.D. jet string length 523'.

5-4-68	Drilled 90" hole from 4610' to 4629'.
5-5-68	Drilled 90" hole from 4629' to 4636', ran bit #37 in hole.
5-6-68	Cleaned out 1-1/2' of fill and jet string parted. Pulled out of hole and recovered 3-1/2" O.D. jet string. Cleaned out 1' of fill and drilled 90" hole from 4636' to 4637', hole caving, bit plugging.
5-7-68	Drilled 90" hole from 4637' to 4642', drilling on boulders, bit plugging.
5-8-68	Ran bit #38 at 4642'; cleaned out 2' of fill and drilled 90" hole from 4645'.
5-9-68	Drilled 90" hole from 4645' to 4662'.
5-10-68	Drilled 90" hole from 4662' to 4685'.
5-11-68	Drilled 90" hole from 4685' to 4702', bit plugging.
5-12-68	Drilled 90" hole from 4702' to 4720'.
5-13-68	Drilled 90" hole from 4720' to 4730'.
5-14-68	Ran bit #39 at 4730', cleaned out 1' of fill, bit plugging and drilled 90" hole from 4730' to 4739'.
15-68	Drilled 90" hole from 4739' to 4759'.
5-16-68	Drilled 90" hole from 4759' to 4771', changed out kelly.
5-17-68	Drilled 90" hole from 4771' to 4790'.
5-18-68	Drilled 90" hole from 4790' to 4815'. Used 3 compressors at 3300 cfm and 205 psi to 210 psi. Mud circulation rate 2950 gpm. 3-1/2" O.D. jet string length 532'.
5-19-68	Drilled 90" hole from 4815' to 4819'. Ran bit #40 at 4818'.
5-20-68	Drilled 90" hole from 4819' to 4849'.
5-21-68	Drilled 90" hole from 4849' to 4889'.
5-22-68	Drilled 90" hole from 4889' to 4921'.
5-23-68	Drilled 90" hole from 4921' to 4941'.
5-24-68	Drilled 90" hole from 4941' to 4949'. Ran bit #41 at 4941' and cleaned out 2' of fill after trip. Used 3 compressors at 3300 cfm and 215 psi to 225 psi. Mud circulation rate 2950 gpm. 3-1/2" O.D. jet string length 593'.
5-25-68	Drilled 90" hole from 4949' to 4969'. Air pressure 225 psi to 235 psi.

5-26-68 Drilled 90" hole from 4969' to 4985'.

5-27-68 Drilled 90" hole from 4985' to 5000'

5-28-68 Ran Sperry-Sun Gyroscopic multishot survey in and out of hole inside 13-3/8" O.D. drill pipe on 45' stations from 3930' to 4989'. Laid down drill pipe.

5-29-68 Ran Birdwell Caliper log. Laid down 90" drilling assembly and rigged up to run 10-3/4" casing for center punch operations.

5-30-68 Ran 10-3/4" O.D. buttress thread casing as follows:

4998.00' to 4957.00'	3 Joints of schedule 60 aluminum casing with J-55 Collars.
4957.00' to 0'	162 joints, 51#, N-80 casing.

Casing was landed at 4998'. Baker float shoe on bottom joint along with a field fabricated 10-3/4" by 88" by 8' long aluminum centralizer. Cemented using Dowell with 25 barrels of water ahead of 1605 ft^3 of class "A" cement plus 2% Calcium chloride. CIP at 1400 hours. Waited on cement.

5-31-68 Ran Birdwell Temperature and NCTL logs. Found top of cement at 4961' in the annulus by temperature log, could not get below 4964' with the NCTL log. Tagged top of cement with 8-5/8" bit at 4981' inside the 10-3/4" O.D. casing at 1445 hours. Drilled out cement and shoe to 4998' using water as a circulating fluid.

6-1-68 Drilled out cement and center punched new hole to 5020' with 8-5/8" bit. Ran Birdwell NCTL log and found top of cement at 4964' in the annulus, 7' below the top of the 10-3/4" O.D. aluminum casing. Cut core #1 with 7" by 2-7/8" Hughes type 'J' bit from 5020' to 5050', cored 30', recovered 30'. Conventional circulation with water.

6-2-68 Cut core #2 from 5050' to 5073', cored 23', recovered 17'. Reamed core hole with 8-5/8" bit.

6-3-68 Cut core #3 from 5073' to 5093', cored 20', recovered 20'. Cut core #4 from 5093' to 5109', cored 16', recovered 6'. Mud down 12' in 92" I.D. casing in 10 hours.

6-4-68 Cut core #5 from 5109' to 5139', cored 30', recovered 30'. Reamed 7" core hole to 5139' and drilled to 5140' with 8-5/8" bit.

6-5-68 Cut core #6 from 5140' to 5163', cored 23', recovered 3'. Cut core #7 from 5163' to 5173', cored 10', recovered 9'. Mud level dropped 7.50' in 4 hours inside the 92" I.D. Casing.

TIME	MUD LEVEL
1115	17.20'
1515	24.70'
2300	39.40'

6-6-68 Cut core #8 from 5173' to 5192', cored 19', recovered 4'. Reamed 7" core hole and drilled to 5193' with 8-5/8" bit. Ran Birdwell Caliper log. Cut core #9 from 5193' to 5203'. Mud level inside 92" I.D. casing, 45' at 0500 hours, 66' at 1500 hours.

6-7-68 Core #9, cored 10', recovered 9'. Cut core #10 from 5203' to 5208', cored 5', recovered 4-1/2'. Cut core #11 from 5208' to 5218', cored 10', recovered 10'. Cut core #12 from 5218' to 5229', cored 11', recovered 5'. Cut core #13 from 5229' to 5231'. Mud level inside 92" I.D. casing, 88' at 0500 hours, 102' at 1530' hours, filled casing to surface with mud.

6-8-68 Completed core #13 from 5231' to 5239', cored 10', recovered 10'. Cut core #14 from 5239' to 5249', cored 10', recovered 9-1/2'. Cut core #15 from 5249' to 5256', cored 7', recovered 7'. Reamed 7" core hole to 5256' with 8-5/8" bit.

6-9-68 Cut core #16 with 6-3/4" by 2-7/8" Hughes type 'J' bit from 5256' to 5267', cored 11', recovered 11'. Cut core #17 from 5267' to 5297', cored 30', recovered 12'. Cut core #18 from 5297' to 5303'. Mud level inside 92" I.D. casing, 42.60' at 1600 hours, filled to surface.

6-10-68 Completed core #18 from 5303' to 5307', cored 10', recovered 7'. Cut core #19 from 5307' to 5317', cored 10', recovered 1-1/2'. Reamed 6-3/4" core hole with 8-5/8" bit. Cut core #20 with 6-1/4" by 2-7/8" Hughes type 'J' bit from 5317' to 5327'. Mud level inside 92" I.D. casing, 44.60' at 1600 hours, filled to surface.

6-11-68 Core #20, cored 10', recovered 3'. Cut core #21 from 5327' to 5337', cored 10', recovered 9'. Cut core #22 from 5337' to 5341', cored 4', recovered 4'. Cut core #23 from 5341' to 5351', cored 10', recovered 10'. Cut core #24 from 5351' to 5361'. Mud level inside 92" I.D. casing, 36.20' at 1600 hours, filled to surface.

6-12-68 Completed core #24 from 5361' to 5374', cored 23', recovered 22'. Measured out of hole and made 10' depth correction. Cut core #25 from 5384' to 5410', cored 26', recovered 25'. Reamed 6-1/4" core hole with 8-5/8" bit from 5317' to 5374'. Mud level inside 92" I.D. casing, 19.20' at 1100 hours.

6-13-68 Reamed 6-1/4" core hole with 8-5/8" bit to 5410'. Ran Birdwell Caliper log and started hydrologic testing. Mud level inside 92" I.D. casing, 36.20' at 1600 hours, filled to surface.

6-14-68 Completed hydrologic testing. Cut core #26 from 5410' to 5440', cored 30', recovered 13'. Mud level inside 92" I.D. casing, 35' at 1200 hours, filled to surface.

6-15-68 Cut core #27 from 5440' to 5453', cored 13', recovered 4'. Cut core #28 from 5453' to 5463', cored 10', recovered 9'. Cut core #29 from 5463' to 5474', cored 11', recovered 11'. Cut core #30 from 5474' to 5484', cored 10', recovered 7'. Mud level inside 92" I.D. casing, 35.20' at 1130 hours, 18' at 2000 hours, filled to surface each time.

5-16-68 Reamed 6-1/4" core hole to 5484' with 8-5/8" bit. Cut core #31 from 5484' to 5494', cored 10', recovered 1'. Mud level inside 92" I.D. casing, 11' at 1100 hours, 16' at 1830 hours, filled to surface each time.

6-17-68 Cut core #32 from 5494' to 5504', cored 10', recovered 2'. Cut core #33 from 5504' to 5514', cored 10', recovered 1'. Cut core #34 from 5514' to 5524', cored 10', recovered 1/2'. Cut core #35 from 5524' to 5534', cored 10', recovered 8'. Mud level in 42" I.D. casing, 28.30' at 1200 hours, filled to surface.

6-18-68 Cut core #36 from 5534' to 5542', cored 8', recovered 3-1/2'. Cut core #37 from 5542' to 5552', cored 10', recovered 0'. Cut core #38 from 5552' to 5556', cored 4', recovered 1'. Cut core #39 from 5556' to 5566', cored 10', recovered 7'. Mud level in 92" I.D. casing, 30.50' at 1130 hours, 22.10' at 1600 hours, filled to surface each time.

6-19-68 Cut core #40 from 5566' to 5571', cored 5', recovered 2'. Cut core #41 from 5571' to 5583', cored 12', recovered 11'. Cut core #42 from 5583' to 5598', cored 15', recovered 3'.

6-20-68 Reamed tight place from 5450' to 5480' and 6-1/4" core hole from 5424' to 5598' with 8-5/8" bit. Ran Birdwell Caliper log. Cut core #43 from 5598' to 5601' with 6-1/8" Williams Diamond bit. Mud level in 92" I.D. casing, 44.50' at 0900 hours. Filled to surface. Deviation survey: 2° at 5598'.

6-21-68 Core #43, cored 3', recovered 3'. Cut core #44 from 5601' to 5605', cored 4', recovered 1-1/2'. Cut core #45 from 5605' to 5608', cored 3', recovered 3'. Cut core #46 with 6-1/4" Hughes 'J' bit from 5608' to 5613', cored 5', recovered 1'. Cut core #47 from 5613' to 5623'. Mud level in 92" I.D. casing, 22' at 1000 hours. Filled to surface.

6-22-68 Core #47, cored 10', recovered 2'. Cut core #48 from 5623' to 5633', cored 10', recovered 10'. Cut core #49 from 5633' to 5653', cored 20', recovered 3'. Cut core #50 from 5653' to 5663', cored 10', recovered 0'. Cut core #51 from 5663' to 5665'. Mud level in 92" I.D. casing, 21' at 0900 hours, filled to surface.

6-23-68 Completed core #51 from 5665' to 5673'', cored 10', recovered 0'. Cut core #52 from 5673' to 5683', cored 10' recovered 1'. Cut core #53 with 6-1/8" Williams Diamond bit from 5683' to 5688', cored 5', recovered 1/2'. Cut core #54 from 5688' to 5695'. Mud level in 92" I.D. casing, 22' at 0900 hours. Filled to surface.

6-24-68 Completed core #54 from 5695' to 5698', cored 10', recovered 10'. Cut core #55 from 5698' to 5708', cored 10', recovered 10'. Reamed core hole with 8-5/8" bit from 5598' to 5698'. Mud level in 92" I.D. casing, 15' at 0800 hours. Filled to surface. Deviation survey: 2° at 5698'.

6-25-68	Cleaned out 5' of fill and cut core #56 from 5708' to 5715', cored 7', recovered 7'. Cleaned out 4' of fill and cut core #57 from 5715' to 5721', cored 6', recovered 6'. Cleaned out bridge at 5700' and 5' of fill on bottom. Cut core #58 from 5721' to 5729', cored 8', recovered 8'.
6-26-68	Cut core #59 from 5729' to 5741', cored 12', recovered 12'. Reamed 6-1/8" core hole with 8-5/8" bit from 5698' to 5731'. Cut core #60 from 5741' to 5748'. Mud level in 92" I.D. casing, 46' at 1200 hours. Deviation survey: 2° at 5731'.
6-27-68	Completed core #60 from 5748' to 5756', cored 15', recovered 15'. Cleaned out 20' of fill and cut core #61 from 5756' to 5771', cored 15', recovered 15'. Cleaned out 5' of fill and cut core #62 from 5771' to 5788'.
6-28-68	Core # 62, cored 17', recovered 17'. Cut core #63 from 5788' to 5805', cored 17', recovered 17', no fill on trip in hole. Reamed 6-1/8" core hole with 8-5/8" bit from 5731' to 5805'. Deviation survey: 1-3/4° at 5805'.
6-29-68	Ran Birdwell Caliper log and started hydrologic testing. Completed testing. Cleaned out 2' of fill and cut core #64 from 5805' to 5812'.
6-30-68	Core #64, cored 7', recovered 7'. Cleaned out 3' of fill and cut core #65 from 5812' to 5819'. Set back kelly, pulled one stand of drill pipe. Ran into crown block pulling second stand, cutting drilling line and dropping travelling block to the floor. Drilling string fell approximately 243' to bottom. Top of fish at 154.42' G.L. Left in hole:

5" O.D. drill pipe stub on top of fish	4.20'
172 joints of 5" drill pipe	5347.03'
Drill collars, subs and core barrel	314.05'
Total Length of Fish	5665.28'

Cleaned up rig floor and started repairs.

7-1-68	Repairing rig.
7-2-68	Repairing rig and waiting on materials.
7-3-68	Repairing rig and waiting on materials.
7-4-68 to	Standby secured.
7-12-68 to	Rig repairs, working days only
7-16-68	Resumed operations at 1600 hours, ran 9-1/8" overshot to top of fish at 164', did not recover.
7-17-68	Fishing.

7-18-68 Waited on fishing tools.

7-19-68 Waited on fishing tools, resumed fishing operations.

7-20-68 Fishing, recovered 59 stands of drill pipe and 6 drill collars.

7-21-68 Reccovered all of fish except 5/6 of matrix on diamond core head. Reamed 6-1/8" core hole with 8-5/8" bit from 5805' to 5819'. Recovered large portion of diamond core head in junk sub above bit. Cleaned out 15' of fill and cored from 5819' to 5820' with Globe basket, recovered all of matrix except for some small pieces.

7-22-68 Reamed from 5819' to 5820' and drilled 8-5/8" hole to 5823', no indication of junk in hole. Cut core #66 from 5823' to 5833', cored 10', recovered 5-1/3'. Cut core #67 from 5833' to 5841', cored 8', recovered 8'.

7-23-68 Cut core #68 from 5841' to 5847', cored 6', recovered 6'. Cut core #69 from 5847' to 5861', cored 14', recovered 14'. Cut core #70 from 5861' to 5879', cored 18', recovered 18'. Cleaned out 15' of fill and cut core #71 from 5879' to 5887'.

7-24-68 Completed core #71 from 5887' to 5909', cored 30', recovered 30'. Cut core #72 from 5909' to 5925', cored 16', recovered 16'. Reamed 6-1/8" core hole with 8-5/8" bit from 5823' to 5881'.

7-25-68 Reamed 6-1/8" core hole with 8-5/8" bit from 5881' to 5925'. Cut core #73 from 5925' to 5937', cored 12', recovered 12'. Cut core #74 from 5937' to 5951', cored 14', recovered 14'.

7-26-68 Ran in hole with core barrel, core barrel plugged, pulled out of hole and the 10-3/4" O.D. casing started flowing water and stopped flowing when the water turned to mud. Ran 8-5/8" bit in hole and stopped going at 496.91'. Ran 8-3/4" O.D. impression block in hole, indicated casing had collapsed.

7-27-68 Ran drill pipe with 2-7/8" O.D. tubing stinger on bottom in hole to 5917.30'. Ran Sperry-Sun Gyroscopic multishot survey in the hole on 30' stations and out of the hole on 60' stations from 4990' to 5880'. Ran Birdwell Caliper log, log indicated casing collapse. Ran 2-7/8" O.D. tubing in annulus and tagged top of cement at 4968'.

7-28-68 Cemented annulus down 2-7/8" O.D. tubing using Dowell with 1000 ft^3 of class 'A' cement plus 2% calcium chloride. CIP at 0300 hours. Waited on cement until 2015 hours, ran 8-3/4" bit inside the 10-3/4" casing and tagged top of cement at 4932'. Displaced mud with water. Waited on cement.

7-29-68 Waited on cement until 0300 hours and drilled soft cement from 4932' to 4939'. Waited on cement until 1030 hours, drilled cement from 4939' to 4962', milled collapsed aluminum casing to 5027'.

UA-1
Hole History

7-30-68 Drilled 8-3/4" hole from 5027' to 5062', aluminum and formation in cuttings. Ran Sperry-Sun Gyroscopic Multishot survey. Survey indicated hole had been side tracked. Ran drill pipe in hole with 2-7/8" diamond point stinger and tried to get into old hole with no success.

7-31-68 Tried to work drill pipe back into old hole.

8-01-68 Tried to work drill pipe back into old hole.

8-02-68 Waited on Dyna-Drill operator.

8-03-68 Ran Birdwell NCTL log. Ran Dyna-Drill with 2-1/2° kick sub, attempted to sidetrack hole into original hole, no results.

8-04-68 Drilled 8-5/8" hole with Dyna-Drill from 5062' to 5154' and ran Sperry-Sun single shot surveys.

8-05-68 Drilled 8-5/8" hole from 5154' to 5274' and ran single shot surveys. Recovered some lost circulation material in samples, probed to find old hole.

8-06-68 Changed out Dyna-Drill to 2° kick sub and drilled 8-5/8" hole from 5274' to 5292'. Ran in hole with 5-3/4" bit and cleaned out to 5951' at total depth of old hole. Ran 12 stands of tubing on bottom of 5-1/2" drill pipe to 5937' and plugged back the open hole with 649 ft^3 of class 'A' cement. CIP at 2330 hours.

8-07-68 Waited on cement. Built strong back to run 2-7/8" O.D. tubing in the 90" by 10-3/4" annulus, ran 2-7/8" O.D. tubing and tagged top of cement at 4937'. Ran 8-3/4" bit inside the 10-3/4" casing and tagged top of cement at 4925', drilled out cement to 4950'. Ran Dowell Abrasijet tool to 4938' and made cut with 35 barrels of water and 4000# of sand.

8-08-68 Worked and pulled 10-3/4" O.D. casing but could not break loose. Ran drill pipe inside casing and cleaned out sand to 4950'. Attempted to run string shot with Birdwell, lost shot at 2670'.

8-09-68 Ran in hole with 8-5/8" bit, pushed shot to bottom and drilled up. Ran string shot #2, stopped at 4940', shot casing but could not work loose. Ran collar locator and shot casing at 4925', worked 10-3/4" O.D. casing loose.

8-10-68 Laid down drill pipe and 10-3/4" O.D. casing. Ran 2-7/8" O.D. tubing in hole and tagged bottom at 4937'. Set cement plug using 590 ft^3 of class 'A' cement plus 2% calcium chloride. CIP at 1655 hours. Laid down tubing.

8-11-68 Dressed 90" drilling assembly.

8-12-68 Completed dressing 90" drilling assembly with 90" bit #42 and long mandrel dressed with 90" bottom stabilizer, 14-60" O.D. weights, 90" top stabilizer, 3-60" O.D. weights and hold down clamp. Picked up 13-3/8" O.D. drill pipe and started in hole.

8-13-68	Cleaned out bridges at 4644', cleaned out fill to top of cement at 4921', drilled cement and casing from 4921' to 4931', casing shot off at 4925'. Used air assist reverse circulation with mud.
8-14-68	Drilled cement and 10-3/4" O.D. casing from 4931' to 4954'.
8-15-68	Pulled bit to unplug, made repairs to rotary beam and ran back in hole.
8-16-68	Measured in hole and made 5' depth correction, cleaned out fill from 4956' to 4960', drilled cement and 10-3/4" O.D. casing from 4960' to 4981' with 90" bit.
8-17-68	Drilled cement and 10-3/4" casing from 4981' to 5000' and new hole from 5000' to 5007', with 90" bit.
8-18-68	Ran bit #43, cleaned out 3' of fill and drilled 90" hole from 5007' to 5019'. Circulated 2950 gpm mud and 3300 cfm air at 200 psi using 3 compressors. 3-1/2" O.D. jet string length 530'.
8-19-68	Drilled 90" hole from 5019' to 5051'.
8-20-68	Drilled 90" hole from 5051' to 5070'.
8-21-68	Drilled 90" hole from 5070' to 5091'.
8-22-68	Drilled 90" hole from 5091' to 5102'.
8-23-68	Ran bit #44 at 5102', cleaned out 3' of fill, drilled 90" hole from 5102' to 5108'.
8-24-68	Drilled 90" hole from 5108' to 5136'.
8-25-68	Drilled 90" hole from 5136' to 5155'.
8-26-68	Drilled 90" hole from 5155' to 5175'.
8-27-68	Drilled 90" hole from 5175' to 5195'.
8-28-68	Drilled 90" hole from 5195' to 5205', ran bit #45 in hole.
8-29-68	Cleaned out 6' of fill and drilled 90" hole from 5205' to 5221'.
8-30-68	Drilled 90" hole from 5221' to 5251'.
8-31-68	Drilled 90" hole from 5251' to 5280'.
9-1-68	Drilled 90" hole from 5280' to 5309'.
9-2-68	Drilled 90" hole from 5309' to 5323', pulled bit.

9-3-68 Ran bit #46 in hole, started cleaning out fill, hole caving.

9-4-68 Hole caving and plugging bit, cleaned out fill and drilled 90" hole from 5323' to 5329'.

9-5-68 Drilled 90" hole from 5329' to 5345', hole caving and plugging bit.

9-6-68 Drilled 90" hole from 5345' to 5362', hole caving. Circulated 2950 gpm of mud and 3300 cfm of air at 200 psi using 3 compressors. 3-1/2" O.D. jet string length 530'.

9-7-68 Drilled 90" hole from 5362' to 5380', hole caving.

9-8-68 Drilled 90" hole from 5380' to 5398'.

9-9-68 Drilled 90" hole from 5398' to 5404'. Ran Sperry-Sun Gyroscopic multi-shot survey in and out of the hole on 44' stations from 4909' to 5405'. Ran Birdwell Caliper log.

9-10-68 Completed Caliper log. Cleaned out 6' of fill and started laying down 13-3/8" O.D. drill pipe.

9-11-68 Completed laying down drill pipe, measured out of hole and corrected depth to 5399.38'. Laid down drilling assembly and started running 10-3/4" O.D. casing.

9-12-68 Ran 174 joints plus 2 pup joints (5400.81') of 10-3/4" O.D., 51#, N-80 butress thread casing, landed at 5397.22'. Baker float shoe on bottom with float ball removed. Cemented using Dowell with 4880 ft^3 of class 'A' cement with 2% prehydrated gel and 2% calcium chloride. CIP at 1255 hours. Waited on cement.

9-13-68 Waited on cement until 0945 hours, ran Birdwell NCTL and Temperature logs. Top of cement in annulus at 5327' by the NCTL log and at 5330' by the temperature log. Rigged up to drill 8-5/8" hole, conventional circulation with water.

9-14-68 Drilled cement from 5396' to 5399' and 8-5/8" hole from 5399' to 5450'. Ran Sperry-Sun survey to check bottom hole location of the 10-3/4" O.D. casing.

9-15-68 Completed Sperry-Sun survey. Drilled 8-5/8" hole from 5450' to 5532'. Deviation survey: 1/4° at 5528'.

9-16-68 Drilled 8-5/8" hole from 5532' to 5600'. Ran Birdwell Caliper log. Deviation survey: 3/4° at 5595'.

9-17-68 Ran hydrological test and drilled 8-5/8" hole from 5600' to 5623'.

9-18-68 Drilled 8-5/8" hole from 5623' to 5760'.

9-19-68 Drilled 8-5/8" hole from 5760' to 5894', had 19' of fill after bit change at 5818'.

9-20-68 Drilled 8-5/8" hole from 5894' to 5940'. Ran Sperry-Sun survey to check bottom hole location. Ran Birdwell Caliper log and started hydrological testing.

9-21-68 Completed hydrologic test, cleaned out 3' of fill and cut core #75 using 6-1/8" Willisms Diamond bit from 5940' to 5960', cored 20', recovered 20'. Cut core #76 from 5960' to 5965'.

9-22-68 Core #76, cored 5', recovered 5'. Cut core #77 from 5964', cored 10', recovered 8'. Cut core #78 from 5974' to 5979', cored 5', recovered 5'. Cut core #79 from 5979' to 5988', cored 9', recovered 9'. Reamed 6-1/8" core hole from 5940' to 5944' with 8-5/8" bit.

9-23-68 Reamed core hole to 5980' with 8-5/8" bit, cut core #80 from 5988' to 6012', cored 24', recovered 4-1/2'. Cut core #81 from 6012' to 6025', cored 13', recovered 13'.

9-24-68 Cut core #82 from 6025' to 6032', cored 7', recovered 7'. Corrected measurements and cut core #83 from 6033' to 6039', cored 6', recovered 6'. Reamed 6-1/8" core hole to 6039' with 8-5/8" bit.
Deviation survey: 3/4° at 6038'.

9-25-68 Cut core #84 from 6039' to 6048', cored 9', recovered 9'. Cut core #85 from 6048' to 6060', cored 12', recovered 12'. Cut core #86 from 6060' to 6063', cored 3', recovered 1'. Cut core #87 from 6063' to 6065'.

9-26-68 Completed core #87 from 6065' to 6090', cored 27', recovered 27'. Cut core #88 from 6090' to 6107', cored 17', recovered 17'. Reamed 6-1/8" core hole to 6107' with 8-5/8" bit.

9-27-68 Ran Sperry-Sun survey. Ran Birdwell Caliper log and started hydrologic test.
Deviation survey: 1/2° at 6107'.

9-28-68 Completed test and cut core #89 from 6107' to 6110', cored 3', recovered 2-1/2'. Cut core #90 from 6110' to 6130'.

9-29-68 Core #90, cored 20', recovered 20'. Cut core #91 from 6130' to 6146'.

9-30-68 Core #91, cored 16', recovered 15'. Cut core #92 from 6146' to 6157', cored 11', recovered 11'. Reamed 6-1/8" core hole to 8-5/8" to 6157'.

10-1-68 Cut core #93 from 6157' to 6166', cored 9', recovered 8-1/2'. Cut core #94 from 6166' to 6176', cored 10', recovered 10'. Cut core #95 from 6176' to 6184', cored 8', recovered 7'.
Deviation survey: 1/2° at 6156'.

10-2-68 Cut core #96 from 6184' to 6191', cored 7', recovered 7'. Cut core #97 from 6191' to 6208', cored 17', recovered 17'. Cleaned out 5' of fill and cut core #98 from 6208' to 6212'.

10-3-68 Core #98, cored 4', recovered 4'. Reamed 6-1/8" core hole to 8-5/8" to 6212'. Down for rig repairs. Fluid level in annulus at 144'.

10-4-68 Cut core #99 from 6212' to 6218', cored 6', recovered 6'. Cut core #100 from 6218' to 6224-1/2', cored 6-1/2', recovered 6-1/2'.
Deviation survey: 3/4° at 6212'.

10-5-68 Cut core #101 from 6224-1/2' to 6235', cored 10-1/2', recovered 10-1/2'. Cut core #102 from 6235' to 6265', cored 30', recovered 30'. Reamed 6-1/8" core hole to 8-5/8" from 6212' to 6225'. Fluid level in annulus at 145'.

10-6-68 Completed reaming core hole to 8-5/8" to 6265'. Cut core #103 from 6265' to 6274'. Fluid level in annulus at 168'.
Deviation survey: 1/2° at 6265'.

10-7-68 Core #103, cored 9', recovered 9'. Cleaned out 9' of fill and cut core #104 from 6274' to 6288', cored 14', recovered 14'. Reamed 6-1/8" core hole to 6288' and drilled 8-5/8" hole to 6289'. Fluid level in annulus at 172'.

10-8-68 Ran Birdwell Caliper log. Ran Sperry-Sun survey and started hydrological testing.

10-9-68 Completed hydrological testing. Cleaned out 12' of fill and cut core #105 from 6289' to 6307'. Fluid level in annulus at 161'.

10-10-68 Completed core #105 from 6307' to 6309', cored 20', recovered 20'. Cut core #106 from 6309' to 6316', cored 7', recovered 5'. Cut core #107 from 6316' to 6320', cored 4', recovered 1-1/2'. Reamed 6-1/8" core hole to 8-5/8" from 6289' to 6310'.

10-11-68 Completed reaming core hole to 6320' with 8-5/8" bit. Cut core #108 from 6320' to 6327', cored 7', recovered 7'. Cut core #109 from 6327' to 6331', cored 4', recovered 2-1/2'. Cleaned out 5' of fill and cut core #110 from 6331' to 6332'.
Deviation survey: 1/2° at 6318'.

10-12-68 Completed core #110 from 6332' to 6339', cored 8', recovered 7'. Cut core #111 from 6339' to 6343', cored 4', recovered 4'. Reamed 6-1/8" core hole to 8-5/8" to 6343'.

10-13-68 Cut core #112 from 6343' to 6353', cored 10', recovered 7'. Cut core #113 from 6353' to 6363', cored 10', recovered 4-1/2'. Cut core #114 from 6363' to 6369', cored 6', recovered 3'. Reamed 6-1/8" core hole to 8-5/8" from 6343' to 6358'.

10-14-68 Reamed core hole to 6369' with 8-5/8" bit. Cleaned out 4' of fill and cut core #115 from 6369' to 6377', cored 8', recovered 8'. Cut core #116 from 6377' to 6389'.

10-15-68 Completed core #116 from 6389' to 6393', cored 16', recovered 16'. Cut core #117 from 6393' to 6413', cored 20', recovered 12-1/2'. Reamed 6-1/8" core hole to 8-5/8" from 6369' to 6407'.

10-16-68 Completed reaming core hole to 6413' with 8-5/8" bit. Cut core #118 from 6413' to 6430', cored 17', recovered 17'. Cut core #119 from 6430' to 6437'. Deviation survey: 1/2° at 6413'.

10-17-68 Core #119, cut 7' recovered 7'. Reamed 6-1/8" core hole to 6437' with 8-5/8" bit. Cut core #120 from 6437' to 6453', cored 16', recovered 5'.

10-18-68 Cleaned out 12' of fill and cut core #121 from 6453' to 6473', cored 20', recovered 2-1/2'. Reamed 6-1/8" core hole to 6473' with 8-5/8" bit.
Fluid level in annulus at 150'.
Deviation survey: 1/2° at 6473'.

10-19-68 Cleaned out 10' of fill and cut core #122 from 6473' to 6485', cored 12', recovered 12'. Cut core #123 from 6485' to 6493', cored 8', recovered 5'.

10-20-68 Measured in the hole, cleaned out 30' of fill and corrected depth from 6493' to 6492'. Cut core #124 from 6492' to 6500', cored 8', recovered 8'. Spotted clean water from 6500' up to 5760'. Ran Birdwell Caliper log and started hydrological testing.

10-21-68 Hydrological testing.

10-22-68 Hydrological testing

10-23-68 Completed hydrological testing and ran Birdwell Electric and Gamma Ray-Neutron logs.

10-24-68 Ran Birdwell Density, Neutron - Neutron, Temperature, Velocity and 3-D logs.

10-25-68 Ran in hole with 997' of 2-7/8" O.D. Hydril tubing on bottom of the drill pipe, tagged top of fill at 6457.33'. Set plug #1 using Dowell with 454 ft^3 of class 'A' cement plus 2% calcium chloride. CIP at 1730 hours. Waited on cement.

10-26-68 Waited on cement until 0600 hours, tagged top of plug #1 at 5920'. Set plug #2 with 472 ft^3 of class 'A' cement plug 2% calcium chloride. CIP at 0620 hours. Waited on cement until 1700 hours, tagged top of plug #2 at 5401'. Set plug #3 with 71 ft^3 of class 'A' cement plus 2% calcium chloride. CIP at 1710 hours. Waited on cement.

10-27-68 Waited on cement until 0100 hours, tagged top of plug #3 at 5195', drilled out cement to 5255' and found hole clean to the top of plug #2 at 5401'. Set plug #4 at 5400' with 89 ft^3 of class 'A' cement. CIP at 0735 hours. Waited on cement until 1945 hours, tagged top of plug #4 at 5234' and drilled cement to 5337'.

10-28-68 Displaced water with mud inside the 10-3/4" O.D. casing. Ran Birdwell Free Point Indicator, casing free at 5330'. Reamed 10-3/4" casing with 9-5/8" bit from 5234' to 5337' to clean casing wall.

10-29-68 Cut 10-3/4" O.D. casing with a modified AZ underreamer at 5330' and let mud equalize. Pulled 47.80' of 10-3/4" O.D. casing and hung remaining casing in slips. Tagged top of cement in the annulus at 5330' and inside the 10-3/4" O.D. casing at 5335'. Set plug #5 at 5335' in and around the 10-3/4" O.D. casing and in the 90" annulus with 475 ft^3 of class 'A' cement plus 2% calcium chloride. CIP at 1935 hours. Laid down drill pipe while waiting on cement.

10-30-68 Laid down 5335.92' of 10-3/4" O.D. casing and started dressing 90" drilling assembly.

10-31-68 Completed dressing 90" drilling assembly and started picking up 13-3/8" O.D. drill pipe. Drilling assembly consisted of 90" bit #47, 60' mandrel dressed with 90" bottom stabilizer, 14-60" O.D. weights, 90" top stabilizer, 3-60" O.D. weights and a hold down clamp.

11-1-68 Ran 90" drilling assembly in the hole and tagged top of cement at 5325'. Pulled out of hole and ran Birdwell Caliper log.

11-2-68 Completed running log and cleaned out fill from 5316' to 5325'.

11-3-68 Drilled cement from 5325' to 5334' with 90" bit, hole caving badly.

11-4-68 Drilled cement from 5334' to 5336', made connection and drill pipe parted at kelly saver sub. Pumped mud out of 90" hole and found the top of the 13-3/8" O.D. drill pipe at 45'. Strung up new 1-1/2" drilling line.

11-5-68 Ran 20-1/4" O.D. Bowen overshot, slips would not hold. Dressed 20-1/4" O.D. Bowen overshot with 15-3/4" slips, picked up on drill pipe to 480,000# and pipe parted. Laid down 13-3/8" O.D. drill pipe.

11-6-68 Recovered 118 joints of 13-3/8" O.D. drill pipe and 28.70' of joint #119, leaving 16.30' of drill pipe on top of mandrel. Picking up new 13-3/8" O.D. drill pipe.

11-7-68 Completed picking up new drill pipe and ran 20-1/4" O.D. Bowen overshot with 15-3/4" basket grapple.

1-8-68 Tagged top of fish at 5226.44', did not attempt to latch on. Pull out of hole and left the following fishing tools in the hole, 1 -80" O.D. Bowen overshot skirt (5.51') 1 -20-3/8" O.D. overshot bowl (2.44') 1 -20" O.D. extension (31.55') extension had parted in a collar.

11-9-68 Ran 60" tar impresson block, tagged top of top fish at 5226.29'. Top of bottom fish at 5257.20' indicating overshot is 6' down on bottom fish. Impresson block indicated fish may be laying off center.

11-10-68 Standby ready until 1600 hours and started in hole with 80" Globe basket on a bent joint of 13-3/8" O.D. drill pipe.

11-11-68 Rotated basket once on fish and fishing tools dropped 5' to 5231.29'. Pulled out of hole, recovered fishing tools lost in hole.

11-12-68 Ran 20-1/4" Bowen overshot with 80" skirt, 15-3/4" control mill and 15-3/4" grapple. Tagged top of fish at 5265.99', could not catch fish.

11-13-68 Pulled out of hole, no recovery. Started running. Globe basket modified into a milling tool.

11-14-68 Shut down because of high winds.

11-15-68 Rig repairs. Completed going in hole with modified Globe basket. Tagged top of fish at 5265.11', milled on fish from 5265' to 5272' and started out of hole.

11-16-68 Completed trip out of hole, ran 20-1/4" O.D. Bowen overshot. Went over fish at 5270.73', rotated tools and went to 5274.03'. Pulled out of hole, no recovery. Some indication of tools going by fish on the outside of the 80" O.D. skirt.

11-17-68 Ran 20-1/4" O.D. Bowen overshot with 56" O.D. skirt, unable to locate fish. Went to 5304.93' before taking weight. Pulled out of hole, overshot appeared to have gone to the retainer clamp on the mandrel.

11-18-68 Ran 20-1/4" O.D. Bowen overshot with 80" skirt and 13-3/8" box grapple with 13-3/8" mill control guide, skirt dressed with tungsten carbide. Ran fishing tools to top of fish at 5265.11'. Set down to 5269.93' with 150,000# of weight. Skirt showed no markings on the outside, showed marks 2.80' up inside of the skirt, bottom had marks 1/2" wide by 1/4" deep.

11-19-68 Ran 20-1/4" O.D. Bowen overshot with 20-1/2" skirt with 13-3/8" basket grapple with 13-3/8" mill control guide on a bent joint of 13-3/8" O.D. drill pipe. Did not contact fish, went to 5303' before taking weight. Ran 80" O.D. Globe basket with fingers removed and modified for milling. Milled on fish from 5265.11'.

11-20-68 Milled on fish to 5281.41'. Pulled out of hole, bottom of mill grooved 3/16" wide by 3/16" deep. Outside flenge where tools bolted together was polished without cuts. Some wear showed on tungsten carbide on the inside but no cuts. Shut down waiting on impression block.

11-21-68 Waited on impression block and ran 20-1/4" O.D. Bowen overshot with 15-1/2" grapple with 15-3/4" mill control guide on a bent joint of 13-3/8" O.D. drill pipe, tried to find top of fish.

11-22-68 Tried to find top of fish from 5272' to 5284'. Pulled out of hole, overshot showed no markings. Ran 88" O.D. lead impression block, set down on fish at 5277.42' with 25,000# of weight, picked up, rotated 180° and set down again.

11-23-68 Pulled out of hole, no marks on face of impression block, 2 marks 180° apart on side of block approximately 5/8" wide by 1/2" deep. Shut down waiting on fishing tools.

11-24-68 Ran 20-1/4" O.D. Bowen overshot with 15-1/2" basket grapple and 15-3/4" mill control with field fabricated wall hook and guide on bottom of the overshot. Hook was made on the bottom of a 24" O.D. by 22" I.D. casing guide with a 2" thick by 6" wide steel plate flaring out from the casing to a maximum of 47" from the centerline of the casing. Ran tool to 5283.96', hooked around fish or mandrel with 3/4" round of torque and worked up to 5271.96'. Released torque and pulled out of hole. Markings indicated fish was inside of bowl.

11-25-68 Ran 88" O.D. impression block, tagged top of fish at 5264.40', applied 10,000# of weight to fish. Picked up and turned tool 180°, lowered to 5266.10' rotary table turned indicating fish was turning downward. Pulled impression block, marks showed a portion of the 13-3/8" O.D. drill pipe. Started in hole with overshot and wall hook.

11-26-68 Contacted fish at 5267.41', lowered tool to 5309.21', pulled up to 5303.41', had 35,000# pull before losing weight. Pulled out of hole, indications showed the fish inside the overshot extension.

11-27-68 Changed out grapple and mill control guide to 13-3/8". Ran fishing tool worked overshot from 5264.50' to 5280.50', pulled up to 450,000# but slips would not hold. Pulled out of hole.

11-28-68 Changed overshot out to 14-3/4" grapple and 16" mill control guide. Ran fishing tool in hole, worked overshot from 5264.50' to 5280.50', caught fish and worked drill pipe from 575,000# to 700,000#.

11-29-68 Worked drill pipe from 575,000# up to 700,000# and pulled fish from hole.

11-30-68 Laid down fishing tools, recovered drilling assembly intact. Changed out drilling assembly.

12-1-68 Dressed new drilling assembly consisting of 90" bit #48, 60' mandrel dressed with 90" bottom stabilizer, 13 -60" O.D. weights, 90" top stabilizer, 4 -60" O.D. Weights and retainer clamp. Started running drilling assembly in hole, stopping at approximately 1000' intervals and circulating mud.

12-2-68 Completed running 90" drilling assembly in hole to 5324.61' and cleaned out fill to 5326'.

12-3-68 Cleaned out fill from 5326' to 5328' and bit plugged. Pulled out of hole.

12-4-68 Ran Birdwell Caliper log. Ran drilling assembly in hole and started cleaning out fill at 5324'.

12-5-68 Cleaned out fill to 5328' and prepared to set a cement plug.

12-6-68 Set cement plug on top of fill using Dowell with 3425 ft^3 of class 'A' cement with 2% calcium chloride. CIP at 1243 hours. Waited on cement until 1945 hours and tagged top of cement at 5302' with 5" drill pipe.

12-7-68 Waited on cement until 1600 hours and drilled cement from 5305' to 5317' with 90" drilling assembly.

12-8-68 Drilled cement from 5317' to 5327' and cleaned out fill from 5327' to 5331'.

12-9-68 Cleaned out fill from 5331' to 5336'.

12-10-68 Cleaned out fill from 5336' to 5337' and prepared to set cement plug.

12-11-68 Set plug at 5337' using Dowell with 2360 ft^3 of class 'A' cement plus 2% calcium chloride. CIP at 0215 hours. At 1000 hours tagged top of cement at 5320' with 5" drill pipe. Waited on cement.

12-12-68 Ran 90" drilling assembly and tagged cement at 5311', drilled cement to 5320'.

12-13-68 Drilled cement from 5320' to 5336' and cleaned out fill from 5336' to 5338'.

12-14-68 Cleaned out fill and started drilling cement and casing to 5345', first indications of casing in cutting was at 5338'.

12-15-68 Drilled cement, 10-3/4" O.D. casing and cleaned out fill from 5345' to 5354'.

12-16-68 Drilled cement, 10-3/4" O.D. casing and cleaned out fill from 5354' to 5363'.

12-17-68 Drilled cement, 10-3/4" O.D. casing and cleaned out fill from 5363' to 5377'.

12-18-68	Drilled cement, 10-3/4" O.D. casing and cleaned out fill from 5377' to 5392'.
12-19-68	Drilled cement, 10-3/4" O.D. casing and cleaned out fill from 5392' to 5404'. Drilled 90" hole from 5404' to 5406'.
12-20-68	Drilled 90" hole from 5406' to 5413', hole caving, having trouble with boulders. Circulated 2750 gpm mud and 3300 cfm air at 186 psi with 3 compressors. 3-1/2" O.D. jet string length 542'.
12-21-68	Drilled 90" hole from 5413' to 5418', hole caving. Ran Birdwell Caliper log.
12-22-68	Tagged top of fill at 5412.89' with 5" drill pipe and set plug with 6400 ft^3 of class 'A' cement with 2% prehydrated gel and 3% calcium chloride. COP at 1815 hours. Waited on cement.
12-23-68	Tagged top of cement at 5334' at 1700 hours and pulled drill pipe out of hole.
12-24-68	Ran 90" drilling assembly with bit #49, tagged top of cement at 5338', drilled cement to 5373'.
12-25-68	Drilled cement from 5373' to 5405'.
12-26-68	Drilled cement from 5405' to 5418' and formation to 5427'.
12-27-68	Drilled 90" hole from 5427' to 5448'.
12-28-68	Drilled 90" hole from 5448' to 5466'.
12-29-68	Drilled 90" hole from 5466' to 5474', ran bit #50 in the hole.
12-30-68	Cleaned out 5' of fill and drilled 90" hole from 5474' to 5481'.
12-31-68	Drilled 90" hole from 5481' to 5500'.
1-1-69	Drilled 90" hole from 5500' to 5519' and hole caved back to 5517'.
1-2-69	Cleaned out fill, hole caved back to 5514'.
1-3-69	Cleaned out fill at 5514'. Ran Birdwell Caliper log.

1-4-69 Tagged top of fill at 5510' with 5" drill pipe. Set plug at 5510' using Dowell with 3600 ft.^{3} of class 'A' cement plus 2% calcium chloride. CIP at 0400 hours. Waited on cement until 1615 hours and tagged top with 5" drill pipe at 5464'.

1-5-69 Ran 90" bit #51 and tagged top of cement at 5470', drilled cement from 5470' to 5481'.

1-6-69 Drilled cement from 5481' to 5509' and cleaned out fill from 5509' to 5511'.

1-7-69 Cleaned out fill from 5511' to 5519' and drilled 90" hole from 5519' to 5526'.

1-8-69 Drilled 90" hole from 5526' to 5540'.

1-9-69 Drilled 90" hole from 5540' to 5557'.

1-10-69 Drilled 90" hole from 5557' to 5572'.

1-11-69 Drilled 90" hole from 5572' to 5588'. Circulated 2160 gpm mud and 2700 cfm air at 185 psi with 3 compressors. 3-1/2" O.D. jet string length 542'.

1-12-69 Drilled 90" hole from 5588' to 5599', hole caved, cleaned out fill.

1-13-69 Ran bit #52 and started cleaning out fill at 5587'.

1-14-69 Cleaned out fill, hole caving.

1-15-69 Ran Birdwell Caliper log. Tagged fill at 5582' and set plug using Dowell with approximately 2832 ft.^{3} of class 'A' cement plus 2% calcium chloride. CIP at 1454 hours. Pump truck failure and plugging of cement line made cement volumes approximate.

1-16-69 Tagged cement with 5" O.D. drill pipe at 5556.83'. Ran 90" drilling assembly and started cleaning out fill at 5554'.

1-17-69 Cleaned out fill from 5554' to 5556' and hole caved.

1-18-69 Hole caved to 5552', cleaned out 5555' and ran Birdwell Caliper Log. Prepared to set cement plug.

1-19-69 Tagged fill at 5550.28' and set plug with 4760 ft.^{3} of class 'A' cement with 2% prehydrated gel and 2% calcium chloride. CIP at 0313 hours. Waited on cement, tagged top of plug at 5504'.

1-20-69 Waited on cement until 1400 hours and tagged top of cement plug with 90" drilling assembly at 5509' and drilled cement to 5523'.

1-21-69 Drilled cement from 5523' to 5523' to 5554' and cleaned out fill from 5554' to 5557'.

1-22-69 Drilled cement from 5557' to 5583' and cleaned out fill to 5588'.

1-23-69 Cleaned out fill from 5588' to 5596'.

1-24-69 Cleaned out fill from 5596' to 5599' and drilled 90" from 5599' to 5610'.

1-25-69 Drilled 90" hole from 5610' to 5618'.

1-26-69 Drilled 90" hole from 5618' to 5627'. Circulated 2160 gpm mud and 2700 cfm air at 215 psi with 3 compressors. 3-1/2" O.D. jet string length 547'.

1-27-69 Drilled 90" hole from 5627' to 5632'. Shut down for high winds.

1-28-69 Shut down for high winds.

1-28-69 Shut down for high winds until 1300 hours and pulled drilling assembly from hole.

1-30-69 Ran Birdwell Caliper log, tool stopped at 5618'. Tagged top of fill at 5625' and set plug using Dowell with 4860 ft.^{3} of class 'A' cement with 6% gel and 2% calcium chloride. CIP at 1610 hours.

31-69 Waited on cement until 1630 hours. Tagged top of cement at 5579.40' and set plug with 1416 ft.^{3} of class 'A' cement plus 2% calcium chloride. CIP at 1842 hours. Waited on cement.

2-1-69 Tagged top of cement with 5" drill pipe at 5562', pulled from hole. Ran 90" bit #53 and tagged top of cement at 5565' at 1745 hours. Drilled cement to 5575'.

2-2-69 Drilled cement from 5575' to 5615'.

2-3-69 Drilled cement and fill from 5615' to 5632' and formation to 5634'.

2-4-69 Drilled 90" hole from 5634' to 5646'. Circulated 2160 gpm mud and 2700 cfm air at 220 psi. 3-1/2" O.D. jet string length 547'.

2-5-69 Drilled 90" hole from 5646' to 5656', hole caving.

2-6-69 Drilled 90" hole from 5656' to 5670', hole cleaning up.

2-7-69 Drilled 90" hole from 5670' to 5692'.

2-8-69 Drilled 90" hole from 5692' to 5708'.

2-9-69 Drilled 90" hole from 5708' to 5726'.

-69 Drilled 90" hole from 5726' to 5737'.

2-11-69	Ran bit #54 in the hole.
2-12-69	Cleaned out 4' of fill and drilled 90' hole from 5737' to 5747', hole caving.
2-13-69	Cleaned out fill and drilled 90" hole from 5746' to 5759'.
2-14-69	Drilled 90" hole from 5759' to 5772'.
2-15-69	Drilled 90" hole from 5772' to 5777', hole caving, cleaning out fill.
2-16-69	Drilled 90" hole from 5777' to 5783', hole caving, cleaning out fill.
2-17-69	Drilled 90" hole and cleaned out fill from 5783' to 5791'.
2-18-69	Drilled 90" hole from 5791' to 5802'.
2-19-69	Drilled 90" hole and cleaned out fill from 5802' to 5812'.
2-20-69	Drilled 90" hole from 5812' to 5824'.
2-21-69	Drilled 90" hole and cleaned out fill from 5824' to 5829'.
-22-69	Changed out rollers on stabilizers and ran bit #55.
2-23-69	Hole caved to 5815', cleaned out fill.
2-24-69	Cleaned out fill and drilled 90" hole from 5829' to 5834'.
2-25-69	Drilled 90" hole from 5834' to 5853'.
2-26-69	Drilled 90" hole from 5853' to 5871' hole caving.
2-27-69	Drilled 90" hole from 5871' to 5889'.
2-28-69	Cleaned out fill and drilled 90" hole from 5889' to 5901'.
3-1-69	Drilled 90" hole from 5901' to 5916'.
3-2-69	Drilled 90" hole from 5916' to 5922' and ran Birdwell Caliper log.
3-3-69	Completed logging. Changed out bit to #56, cleaned out 3' of fill and drilled 90" hole from 5922' to 5927'.
3-4-69	Drilled 90" hole from 5927' to 5940'. Circulated 2160 gpm mud and 2700 cfm air at 220 psi. 3-1/2" O.D. jet string length 547'.
3-5-69	Drilled 90" hole from 5940' to 5950'.

3-6-69 Drilled 90" hole from 5950' to 5958'.

3-7-69 Drilled 90" hole from 5958' to 5979'.

3-8-69 Drilled 90" hole from 5979' to 5997'.

3-9-69 Drilled 90" hole from 5997' to 6016'

3-10-69 Drilled 90" hole from 6016' to 6018' and changed out bit to #57. Cleaned out 1-1/2' of fill.

3-11-69 Drilled 90" hole from 6018' to 6038'.

3-12-69 Drilled 90" hole from 6038' to 6052'.

3-13-69 Drilled 90" hole from 6052' to 6065'.

3-15-69 Drilled 90" hole from 6080' to 6096'.

3-16-69 Drilled 90" hole from 6096' to 6109', drilling on boulders, bit plugging.

3-17-69 Drilled 90" hole from 6109' to 5120', bit plugging.

18-69 Drilled 90" hole from 6120' to 6122' and removed bit #57.

3-19-69 Repaired, dressed bit #58 and ran in hole. Cleaned out 4' of fill and drilled 90" hole from 6122' to 6123'.

3-20-69 Drilled 90" hole from 6123' to 6140'.

3-21-69 Drilled 90" hole from 6140' to 6150' and started Sperry-Sun survey.

3-22-69 Completed Sperry-Sun Gyroscopic Multishot survey ran in and out of the hole on 30' stations from 0' to 6143'. Made outrun drill pipe survey on 44' stations from 5404' to 6146'. Ran Birdwell Caliper log.

3-23-69 Laid down 5" O.D. drill pipe. Rig on standby secured at 1030 hours.

3-24-69 Standby secured until 0800 hours. Ran Birdwell Temperature and Dowell Sonar Caliper log.

3-25-69 Completed logging. Standby secured at 0600 hours, waiting on casing alignment tool.

4-2-69 Standby secured until 0800 hours and ran bit #58 in the hole.

4-3-69 Ran Sperry-Sun Gyroscopic Multishot inrun drill pipe survey on 44' stations from 5404' to 6101'. Cleaned out fill from 6140' to 6148'.

-69 Cleaned out fill from 6148' to 6150' and laid down 13-3/8" O.D. drill pipe.

4-5-69	Laid down drilling assembly and started rigging up to run 54" I.D. casing.
4-6-69	Preparing rig to run casing.
4-7-69	Preparing rig to run casing.
4-8-69	Preparing rig to run casing.
4-9-69	Preparing rig to run casing. Rigging up to run 54" I.D. casing.
4-10-69	Rigging up to run 54" I.D. casing.
4-11-69	Rigging up to run 54" I.D. casing.
4-12-69	Rigging up to run 54" I.D. casing.
4-13-69	Rigging up to run 54" I.D. casing.
4-14-69	Rigging up to run 54" I.D. casing.
4-15-69	Rigging up to run 54" I.D. casing.
4-16-69	Rigging up to run 54" I.D. casing.
4-17-69	Rigging up to run 54" I.D. casing.
4-18-69	Completed rigging up welding enclosure, preheating and dehydrating equipment and casing alignment tool. Started welding float shoe to joint #2 of the 54" I.D. casing. Float shoe is joint #1.
4-19-69	Completed welding shoe to joint #2 of the 54" I.D. casing. Picked up joint #3.
4-20-69	Welded joint #3, picked up and tack welded joint #4.
4-21-69	Repaired weld on joint #4, 187.54' in well bore.
4-22-69	Shut down and repaired welding enclosure.
4-23-69	Checked fluid level inside casing and started welding joint #5.
4-24-69	Completed welding joint #5, started on joint #6. 299,64' in well bore.
4-25-69	Welded joint #6, started welding joint #7. 359.58' in well bore.
4-26-69	Completed welding on joint #7, started on joint #8.
4-27-69	Shut down for weather.
4-28-69	Completed welding joint #8. 419.62' in well bore.

4-29-69	Welding landing rest to chamber, joint #9 and #10.
4-30-69	Repairing root welds. 469.88' in well bore.
5-1-69	Ran and welded joint #11. 529.92' in well bore.
5-2-69	Welding on joint #12.
5-3-69	Completed welding joint #12 and started on joint #13. 590.02' in the hole.
5-4-69	Completed welding joint #13 and #14, picked up joint #15. 710.13' in the hole.
5-5-69	Completed welding joint #15 and #16. 777.23' in the hole.
5-6-69	Welding on joint #17.
5-7-69	Completed welding joint #17. 837.23' in the hole.
5-8-68	Welded landing joint for jacks.
5-9-69	Removed welding enclosure and setting up casing jacks.
-10-69	Setting up casing jacks.
5-11-69	Setting up casing jacks.
5-12-69	Setting up casing jacks and welding enclosures.
5-13-69	Working on welding enclosure and casing jacks.
5-14-69	Working on welding enclosure and casing jacks.
5-15-69	Working on casing jacks, cut off transfer joint and laid down.
5-16-69	Welded and lowered joint #18. 871.27' of casing in well bore.
5-17-69	Welded joint #19, started welding on joint #20. 931.29' of casing in the well bore.
5-18-69	Ran and welded joint #20 and #21, started welding joint #22. 105'.33 of casing in the hole.
5-19-69	Ran and welded joint #22 and #23. 1171.41' of casing in the hole.
5-20-69	Welded joint #24 and started welding on joint #25.
5-21-69	Welded joint #25 and #26. 1317.60' in the hole.
-22-69	Welded joint #27 and #28. 1437.63 in the hole.

5-23-69 Welded joint #29 and #30. 1531.59' of casing in the hole.

5-24-69 Welded joint #31. Rigging up internal casing alignment tool. 1651.63' of casing in the hole.

5-25-69 Rigging up internal casing alignment tool.

5-26-69 Welded joint #32 and #33. 1711.68' of casing in the hole.

5-27-69 Welded joint #34, #35 and started on #36. 1881.68' of casing in the hole.

5-28-69 Welded joint #36, #37 and started on #38. 2011.73' of casing in the hole.

5-29-69 Welded joint #38, #39 and started on #40. 2131.78' of casing in the hole.

5-30-69 Welded joint #40, #41 and started on #42. Repaired casing alignment tool.

5-31-69 Welded joint #42, #43, #44 and started on #45. 2431.83' of casing in the hole.

6-1-69 Welded joint #45 and #46. Repaired alignment tool. 2517.81' of casing in the hole.

6-2-69 Welded joint #46, #47 and #48.

6-3-69 Lowered joint #48, welded joint #49 and started on #50. 2731.86' of casing in the hole.

6-4-69 Welded joint #50 and #51. Worked on casing alignment tool. 2851.91' of casing in the hole.

6-5-69 Repaired casing alignement tool and started welding on joint #52.

6-6-69 Welded joint #52, #53 and started on #54. 2971.96' of casing in the hole.

6-7-69 Welding joint #54, #55 and started on #56. 3151.98' of casing in the hole.

6-8-69 Welded joint #56, #57, #58 and started on #59. 3271.92' of casing in the hole.

6-9-69 Welded joint #59 and started on #60. Shut down working on internal casing alignment tool stuck in casing, 3331.93' of casing in the well bore.

6-10-69 Worked on casing alignment, released tool from casing and laid down. Welded on joint #60.

6-11-69 Lowered joint #60 in the. Worked on alignment tool. Rigged up to run 7" O.D. casing.

6-12-69 Ran 7" O.D. casing inside the 54" I.D. casing, hung 7" O.D. casing at 33333.91'. Ran 2-7/8" O.D. tubing inside the 7" O.D. casing and hung at 816'. Started jetting water with air from the 54" I.D. casing in order to pick up the casing and repair the hydraulic jacks.

6-13-69 Jetted water from casing.

6-14-69 Jetted water from casing.

6-15-69 Jetted water from casing down to 3273'. Laid down 2-7/8" O.D. tubing and 7" O.D. casing. Picked up 54" I.D. casing with rig.

6-16-69 Repaired casing jacks and pumped water back into 54" I.D. casing.

6-17-69 Welded joint #61 and started on #62. 3451.97' of casing below ground level.

6-18-69 Welded joint #62, #63 and started on #64. 3572.03' of casing below ground level.

6-19-69 Welded joint #64 and #65.

6-20-69 Worked on casing alignment tool.

21-69 Could not get internal casing alignment tool to work. Laid down and started with external tool. Started welding joint #66.

6-22-69 Welded joint #66 and #67. 3812.17' of casing below ground level.

6-23-69 Welded joint #68 and #69.

6-24-69 Welded joint #70 and #71.

6-26-69 Welded joint #72 and #73.

6-26-69 Welded joint #74, 75 and #76. 4352.40' of casing below ground level.

6-27-69 Welded joint #77 and #78. Attempted to get internal alignment tool to work, would not function.

6-28-69 Welded joint #79 and #80.

6-29-69 Welded joint #81, #82 and #83. 4772.48' of casing below ground level.

6-39-69 Welded joint #84, #85 and #86.

7-1-69 Welded joint #87 and #88.

7-2-69 Welded joint #89, #90 and #91. 5252.48' of casing below ground level.

-69 Welded joint #92 and #93.

7-4-69 Welded joint #94.

7-5-69 Welded joint #95, #96, #97 and started on #98. 5611.53' of casing below ground level.

7-6-69 Welded joint #98, #99, #100 and started on #101. 5852.51' of casing below ground level.

7-7-69 Welded joint #101, #102, #103 and started on #104. 6032.57' of casing below ground level.

7-8-69 Completed running 54" I.D. casing as follows:

No. of Joints	Wall Thickness	Ring Size	Ring Spacing	Weight Per Foot	Depth Run
5	1-5/16"	2-1/2" x 6"	24"	1172#	6104.00' - 5796.36'
2	1-1/4"	2-1/2" x 6"	24"	1133#	5796.36' - 5676.28'
2		Chamber & Landing Joint			5676.28' - 5626.15'
5	1-1/4"	2-1/2" x 6"	24"	1133#	5626.15' - 5325.87'
1	1-3/4"	Landing Joint			5325.87' - 5318.77'
2	1-1/4"	2-1/2" x 6"	24"	1133#	5318.77' - 5198.73'
7	1-1/8"	2-1/2" x 6"	24"	1112#	5198.73' - 4778.57'
9	1-1/16"	2-1/2" x 6"	24"	1075#	4778.57' - 4238.36'
8	1"	2-1/2" x 6"	24"	1036#	4238.36' - 3758.22'
9	7/8"	2-1/2" x 6"	24"	1024#	3758.22' - 3218.13'
8	13/16"	2-1/2" x 6"	24"	922#	3218.13' - 2738.11'
10	11/16"	2-1/2" x 4"	24"	762#	2738.11' - 2137.80'
15	5/8"	2-1/2" x 8"	32"	765#	2137.80' - 1237.56'
21	3/4"	2-1/2" x 3"	40"	705#	1237.56' - 0'

The 54" I.D. casing was equipped with a Baker Type "C" shoe on bottom 7.45' long. Four stand-off guides were used, made out of 5-1/2" O.D. drill pipe 4' long, centered at 5856.41' and spaced 90° apart outside the casing. Three 5-1/2" O.D., schedule 40 grout line guides were welded to the outside of the 54" I.D. casing. One guide was run on the V-door side (southwest) and the other two were run 135° from the first. The guides were run from surface to the top of the chamber with one line terminating 100' above the chamber. Two slotted

logging monitor lines of 2-7/8" O.D., 5.79# line pipe were run 45° west of the southwest grout line guide and 180° from the same guide. Center of 86" O.D. by 43.04' chamber at 5654.76'.

7-9-69 Rigged down welding and casing running equipment. Rigged up for cementing. Ran Birdwell Temperature and Caliper logs.

7-10-69 Ran Birdwell Caliper, Nuclear Cement Analyzer (NCA) and NAIL logs. Ran 1 joint of 7" O.D., N-80, 26# casing with Baker latch-in tool on bottom and cement landing collar on top followed by 7" O.D., J-55, 23# casing.

7-11-69 Completed running casing, landed at 6095.29'. Ran 77 joints of 7" O.D., N-80, 26# casing for jet string, landed at 6045.78' G.L. Filled 54" I.D. casing with water to 94' G.L.

7-12-69 Ran 2-7/8" O.D. tubing for air string, landed at 528.08' G.L. Latched 7" O.D. casing into cement shoe. Rigged up Dowell and tested lines to 4000 psi, repaired leaks. Circulated 2000 barrels of mud at 52 barrels per minute with 1000 psi. Pumped 200 barrels of water ahead of Stage #1. Mixed and pumped Stage #1 with 31,827 ft^3 of expanding cement (Chem-Comp). Displaced 7" O.D. casing with 240 barrels of water. Plug set with 800 psi, float held. Monitored cement rise with Birdwell Fluid Density and NAIL logs, top of cement at 5423' by log. Started cementing at 1717 hours. CIP at 2100 hours. Waited on cement.

7-13-69 Waited on cement and picked up 2-7/8" O.D. tubing. Unlatched 7" O.D. casing from Baker shoe at 2315 hours. Laid down 15' pup joint of 7" O.D. casing and cementing head.

7-14-69 Picked up 3 strings of 2-7/8" O.D. tubing for grout lines and tagged top of cement at 5433'. Pumped 60 barrels of water ahead of Stage #2. Mixed and pumped Stage #2 down the 3 grout lines using 23,424 ft^3 of Class "A" cement with 2% prehydrated gel and 3% calcium chloride. Monitored cement rise with Birdwell Fluid Density and NAIL logs. Top cement at 4716' by log. Started cementing at 1335 hours. CIP at 1904 hours. Waited on cement.

7-15-69 Started laying down 7" O.D. casing. Waited on cement until 1330 hours and tagged top of Stage #2 at 4727.55', 4731.18' and 4744.66' for an average top of 4734.46'. Pumped 60 barrels of water ahead of Stage #3. Mixed and pumped Stage #3 down 3 grout lines using 17,980 ft^3 of Class "A" cement with 2% prehydrated gel and 3% calcium chloride. Monitored cement rise with Birdwell Fluid Density and NAIL logs. Top of cement at 4150' by log. Started cementing at 1500 hours. CIP at 1825 hours. Waited on cement and laid down 7" O.D. casing.

7-16-69 Waited on cement and laid down 7" O.D. casing. Tagged top of Stage #3 at 4149.53', 4152.49' and 4152.91' for an average top of 4151.64'. Pumped 60 barrels of water ahead of Stage #4. Mixed and pumped Stage #4 down

3 grout lines using 19,690 ft^3 of Class "A" cement with 2% prehydrated gel and 3% calcium chloride. Monitored cement rise with Birdwell, top of cement at 3518' by log. Started cementing at 1519 hours. CIP at 1850 hours. Waited on cement and laid down 7" O.D. casing.

7-17-69 Waited on cement and laid down 7" O.D. casing. Tagged top of Stage #4 at 3529.26', 3544.56', and 3521.21' for an average top of 3531.68'. Pumped 60 barrels of water ahead of Stage #5. Mixed and pumped Stage #5 down 3 grout lines using 22,794 ft^3 of Class "A" cement with 2% prehydrated gel and 3% calcium chloride. Monitored cement rise with Birdwell, top of cement at 2828' by log. Started cementing at 1155 hours. CIP at 1630 hours. Waited on cement and laid down 7" O.D. casing.

7-18-69 Waited on cement and laid down 7" O.D. casing. Tagged top of Stage #4 at 2877.24', 2826.74' and 2828.56'. Ran grout lines, checked cement tops at 2869.24', 2828.56' and 2826.74', used cement top of 2828'.

7-19-69 Pumped 60 barrels of water ahead of Stage #6. Mixed and pumped Stage #6 using 20,023 ft^3 of Class "A" cement with 2% prehydrated gel and 3% calcium chloride. Monitored cement rise with Birdwell, logging tool hung up at 2342', worked up to 2333', unable to move up or down. Top of cement at 2177' by log. Started cementing at 0005 hours. CIP at 0300 hours. Pulled loose from Birdwell tool, left Fluid Density and NAIL tool at 2333' and 950' of wire line in the hole. Waited on cement. Picked up 1.59" O.D. Hydril tubing for fishing string, tagged cement at 2196.36'. Laid down tubing. Tagged top of Stage #5 with grout lines at 2190.31', 2180.24', and 2183.66' for an average top of Stage #6 of 2184.74'.

7-20-69 Pumped 60 barrels of water ahead of Stage #7. Mixed and pumped Stage #7 down 3 grout lines using 24,268 ft^3 of Class "A" cement with 2% prehydrated gel and 3% calcium chloride. Monitored cement rise with Birdwell. Top of cement at 1410' by log. Started cementing at 0013 hours. CIP at 0350 hours. Birdwell logging tool hung up at 267'. Fished for logging tool, recovered sinker bar and left remainder of Fluid Density and logging tool in hole. Waited on cement. Tagged top of Stage #7 at 1406.67', 1405.96' and 1407.12' for an average top of 1406.58'.

7-21-69 Pumped 60 barrels of water ahead of Stage #8. Mixed and pumped Stage #8 using 25,335 ft^3 of Class "A" cement with 2% prehydrated gel and 3% calcium chloride. Monitored cement rise with Birdwell, top of cement at 609' by log. Started cementing at 0010 hours. CIP at 0325 hours. Waited on cement until 1700 hours. Tagged top of Stage #8 at 609.42', 620.36', and 615.03' for an average top of 614.94'. Pumped 60 barrels of water ahead of Stage #9. Mixed and pumped Stage #9 down 3 grout lines using 19,278 ft^3 of Class "A" cement with 2% prehydrated gel and 3% calcium chloride. Monitored

	cement rise with Birdwell. Cement circulated to surface. Started cementing at 2002 hours. CIP at 2308 hours. Waited on cement.
7-22-69	Waited on cement. Ran Birdwell Gamma Ray log and located the Birdwell Fluid Density and NAIL tools at 674' and 2343'. Laid down 7" O.D. casing.
7-23-69	Laid down 7" O.D. casing. Ran Birdwell Temperature and Caliper logs. Ran Sperry-Sun Gyroscopic Multishot survey in and out of the hole on 25' stations from 0' to 3800'.
7-24-69	Completed running Sperry-Sun. Rigged down work platform, released pressure on casing jacks. Cut off 54" I.D. casing 2' above G.L.
7-25-69	Rigged down casing jacks and welded cap on 54" I.D. casing.
7-26-69	Released rig for demobilization at 0600 hours. Hole suspended.
8-6-69	Hole suspended from 0600 hours on 7-26-69 to 0500 hours on 8-6-69. Moved in crane and ran Birdwell Temperature log. Hole suspended at 1730 hours.
8-11-69	Hole suspended from 1730 hours on 8-6-69 to 0745 hours on 8-11-69. Ran Sperry-Sun Gyroscopic Multishot survey in and out of the hole on 25' stations from 3800' to 6100'. No rig on hole, logged with a crane. Hole suspended at 1530 hours.
8-12-69	Hole suspended from 1530 hours on 8-11-69 to 0900 hours on 8-12-69. Ran Birdwell NCA log. No rig on hole, logged with a crane. Hole suspended at 1500 hours.
8-20-69	Hole suspended from 1500 hours on 8-12-69 to 1200 hours on 8-20-69. Ran Birdwell Temperature log. No rig on hole, logged with a crane. Hole suspended at 1830 hours.
9-4-69	Hole suspended from 1830 hours on 8-20-69 to 0800 hours on 9-4-69. Ran Birdwell Temperature log. No rig on hole, logged with a crane. Hole suspended at 1230 hours.
9-15-69	Hole suspended from 1230 hours on 9-4-69 to 0800 hours on 9-15-69. Ran Birdwell Temperature log. No rig on hole, logged with a crane. Hole suspended at 1200 hours.
10-16-69	Hole suspended from 1200 hours on 9-15-69 to 0800 hours on 10-16-69. Cut off lugs and removed 54" I.D. casing cover. Ran Birdwell Caliper log. No rig on hole, logged with a crane. Replaced casing cover. Hole suspended at 1300 hours.

CORE RECORD

Core No.	Interval	Recovery	Formation
1.	5020' - 5050'	30'	Breccia, dark greenish gray with basalt lithic fragments
2.	5050' - 5073'	23'	Breccia, dark greenish gray with basalt lithic fragments
3.	5073' - 5093'	20'	Breccia, dark greenish gray with basalt lithic fragments
4.	5093' - 5109'	6'	Breccia, dark greenish gray with basalt lithic fragments
5.	5109' - 5139'	3'	Breccia, dark greenish gray with basalt lithic fragments
6.	5140' - 5163'	3'	Breccia, dark greenish gray with basalt lithic fragments
7.	5163' - 5173'	9'	Breccia, dark greenish gray with basalt lithic fragments
8.	5173' - 5192'	4'	Breccia, dark greenish gray with basalt lithic fragments
9.	5193' - 5203'	9'	Breccia, dark greenish gray with basalt lithic fragments
10.	5203' - 5208'	4½'	Breccia, dark greenish gray with basalt lithic fragments
11.	5208' - 5218'	10'	Siltstone, greenish black, equigranular
12.	5218' - 5229'	5'	Siltstone, greenish black, equigranular
13.	5229' - 5239'	10'	Breccia, dark greenish gray, minor siltstone beds
14.	5239' - 5249'	9½'	Breccia, dark greenish gray, minor siltstone beds
15.	5249' - 5256'	7'	Breccia, dark greenish gray, minor siltstone beds
16.	5256' - 5267'	11'	Breccia, dark greenish gray, minor siltstone beds
17.	5267' - 5297'	12'	Breccia, dark greenish gray, minor siltstone beds
18.	5297' - 5307'	7'	Breccia, dark greenish gray, minor siltstone beds
19.	5307' - 5317'	1½'	Breccia, dark greenish gray, minor siltstone beds
20.	5317' - 5327'	3'	Breccia, dark greenish gray, minor siltstone beds
21.	5327' - 5337'	9'	Breccia, dark greenish gray, minor siltstone beds
22.	5337' - 5341'	4'	Breccia, dark greenish gray, minor siltstone beds

Core No.	Interval	Recovery	Formation
23.	5341' - 5351'	10'	Breccia, dark greenish gray, minor siltstone beds
24.	5351' - 5374'	22'	Breccia, dark greenish gray, minor siltstone beds
25.	5384' - 5404'		
	5404' - 5410'	25'	Basalt, greenish black, fine grained
26.	5410' - 5434'		
	5434' - 5440'	13'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
27.	5440' - 5453'	4'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
28.	5453' - 5463'	9'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
29.	5463' - 5474'	11'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
30.	5474' - 5484'	7'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
31.	5484' - 5494'	1'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
32.	5494' - 5504'	2'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
33.	5504' - 5514'	1'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
34.	5514' - 5524'	½'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
35.	5524' - 5534'	8'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
36.	5534' - 5542'	3½'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
37.	5542' - 5552'	0'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments

Core No.	Interval	Recovery	Formation
38.	5552' - 5556'	1'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
39.	5556' - 5566'	7'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
40.	5566' - 5571'	2'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
41.	5571' - 5583'	11'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
42.	5583' - 5598'	3'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
43.	5598' - 5601'	3'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
44.	5601' - 5605'	1½'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
45.	5605' - 5608'	3'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
46.	5608' - 5613'	1'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
47.	5613' - 5623'	2'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
48.	5623' - 5633'	10'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
49.	5633' - 5653'	3'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
50.	5653' - 5663'	0'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
51.	5663' - 5673'	0'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
52.	5673' - 5683'	1'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments

Core No.	Interval	Recovery	Formation
53.	5683' - 5688'	½'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
54.	5688' - 5698'	10'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
55.	5698' - 5708'	10'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
56.	5708' - 5715'	7'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
57.	5715' - 5721'	6'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
58.	5721' - 5729'	8'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
59.	5729' - 5741'	12'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
60.	5741' - 5756'	15'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
61.	5756' - 5771'	15'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
62.	5771' - 5788'	17'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
63.	5788' - 5805'	17	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
64.	5805' - 5812'	7'	Breccia, dark greenish gray to greenish black, 65% rounded to subrounded lithic fragments
65.	5812' - 5815'		
	5815' - 5819'		Basalt, light greenish gray, fine grain
66.	5823' - 5833'	5½'	Basalt, light greenish gray, fine grain
67.	5833' - 5841'	8'	Basalt, light greenish gray, fine grain
68.	5841' - 5847'	6'	Basalt, light greenish gray, fine grain
69.	5847' - 5861'	14'	Basalt, light greenish gray, fine grain
70.	5861' - 5879'	18'	Basalt, light greenish gray, fine grain
71.	5879' - 5909'	30'	Basalt, light greenish gray, fine grain

Core No.	Interval	Recovery	Formation
72.	5909' - 5925'	16'	Basalt, light greenish gray, fine grained
73.	5925' - 5937'	12'	Basalt, Light greenish gray, fine grained
74.	5937' - 5951'	14'	Basalt, light greenish gray, fine grained
75.	5940' - 5960'	20'	Basalt, light greenish gray, fine grained
76.	5960' - 5965'	5'	Basalt, light greenish gray, ine grained
77.	5965' - 5974'	8'	Basalt, light greenish gray, fine grained
78.	5974' - 5979'	5'	Basalt, light greenish gray, fine grained
79.	5979' - 5988'	9'	Basalt, light greenish gray, fine grained
80.	5988' - 6012'	4½'	Basalt, light greenish gray, fine grained
81.	6012' - 6024'		
	6024' - 6025'	13'	Basalt, dark gray, dense, brittle
82.	6025' - 6032'	7'	Basalt, dark gray, dense, brittle
83.	6033' - 6039'	6'	Basalt, dark gray, dense, brittle
84.	6039' - 6041'		
	6041' - 6048'	9'	Breccia, dark greenish gray
85.	6048' - 6060'	12'	Breccia, dark greenish gray
86.	6060' - 6063'	1'	Breccia, dark greenish gray
87.	6063' - 6090'	27'	Breccia, dark greenish gray
88.	6090' - 6107'	17'	Breccia, dark greenish gray
89.	6107' - 6110'	2½'	Breccia, dark greenish gray
90.	6110' - 6130'	20'	Breccia, dark greenish gray
91.	6130' - 6146'	15'	Basalt dike, grayish black, aphanitic
92.	6146' - 6151'		Basalt dike, grayish black, aphanitic
	6151' - 6157'	11'	Breccia, dark greenish gray
93.	6157' - 6166'	8½'	Breccia, dark greenish gray
94.	6166' - 6176'	10'	Breccia, dark greenish gray
95.	6176' - 6184'	7'	Breccia, dark greenish gray
96.	6184' - 6191'	7'	Breccia, dark greenish gray
97.	6191' - 6206'		
	6206' - 6208'	17'	Basalt, grayish black, dense, microcrystalline ground mass, zeolite filled amygdules
98.	6208' - 6212'	4'	Basalt, grayish black, dense microcrystalline ground mass, zeolite filled amygdules

Core No.	Interval	Recovery	Formation
99.	6212' - 6218'	6'	Basalt, grayish black, dense microcrystalline ground mass, zeolite filled amygdules
100.	6218' - 6224½'	6½'	Basalt, grayish black, dense microcrystalline ground mass, zeolite filled amygdules
101.	6224½' - 6233'		
	6233' - 6235'	10½'	Breccia, dark greenish gray, massive and competent
102.	6235' - 6265'	30'	Breccia, dark greenish gray, massive and competent
103.	6265' - 6266'		
	6266' - 6274'	9'	Basalt, dark gray, dense, microcrystalline, prophyritic
104.	6274' - 6282'		
	6282' - 6288'	14'	Breccia, dark greenish gray
105.	6289' - 6309'	20'	Breccia, dark greenish gray
106.	6309' - 6316'	5'	Breccia, dark greenish gray
107.	6316' - 6320'	1½'	Breccia, dark greenish gray
108.	6320' - 6327'	7'	Breccia, dark greenish gray
109.	6327' - 6331'	2½'	Breccia, dark greenish gray
110.	6331' - 6339'	7'	Breccia, dark greenish gray
111.	6339' - 6343'	4'	Breccia, dark greenish gray
112.	6343' - 6353'	7'	Breccia, dark greenish gray
113.	6353' - 6363'	4½'	Breccia, dark greenish gray
114.	6363' - 6369'	3'	Breccia, dark greenish gray
115.	6369' - 6377'	8'	Breccia, dark greenish gray
116.	6377' - 6393'	16'	Breccia, dark greenish gray
117.	6393' - 6413'	12½'	Breccia, dark greenish gray
118.	6413' - 6430'	17'	Breccia, dark greenish gray
119.	6430' - 6437'	7'	Breccia, dark greenish gray
120.	6437' - 6453'	5'	Breccia, dark greenish gray
121.	6453' - 6454'		
	6454' - 6473'	2½'	Basalt, dark gray to black, fine grained, dense amygdaloidal.
122.	6473' - 6485'	12'	Breccia, dark greenish gray
123.	6485' - 6493'	5'	Breccia, dark greenish gray
124.	6492' - 6500'	8'	Breccia, dark greenish gray

LOG INDEX SHEET

Type Log	Date	Run No.	Log Depth	Drillers Depth	Interval Logged
Caliper	09-07-67	1	264'	264'	0' - 259'
Caliper	10-18-67	2	1148'	1150'	200' - 1143'
Caliper	11-06-67	3	1505'	1505'	240' - 1500'
Caliper	12-08-67	4	2070'	2069'	200' - 2065'
Caliper	01-01-68	5	2541'	2539'	200' - 2537'
Caliper	01-24-68	6	2907'	2907'	200' - 2903'
Caliper	02-06-68	7	3068'	3070'	200' - 3063'
Caliper	03-25-68	8	3971'	3971'	210' - 3966'
Caliper	05-29-68	9	5006'	5000'	4000' - 5002'
Caliper	06-06-68	10	5190'	5193'	4920' - 5188'
Caliper	06-13-68	11	5405'	5410'	4900' - 5402'
Caliper	06-20-68	12	5590'	5598'	4900' - 5588'
Caliper	07-01-68	13	4793'	5805'	4900' - 5791'
Caliper	07-27 68	14	5060'	5951'	4890' - 5060'
Caliper	09-09-68	15	5399'	5404'	200' - 5395'
Caliper	09-16-68	16	5589'	5600'	5300' - 5587'
Caliper	09-20-68	17	5934'	5940'	5350' - 5932'
Caliper	09-27-68	18	6102'	6107'	5350' - 6100'
Caliper	10-08-68	19	6281'	6289'	5350' - 6278'
Caliper	10-20-68	20	6458'	6500'	5300' - 6454'
Caliper	11-01-68	21	5320'	5325'	0' - 5316'
Caliper	12-04-68	22	5324'	5326'	4650' - 5318'
Caliper	12-21-68	23	5411'	5418'	4900' - 5406'
Caliper	01-03-69	24	5508'	5519'	4900' - 5505'
Caliper	01-15-69	25	5583'	5599'	200' - 5580'
Caliper	01-18-69	26	5551'	5555'	200' - 5548'
Caliper	01-29-69	27	5618'	5632'	150' - 5614'
Caliper	03-02-69	28	5914'	5922'	150' - 5910'
Caliper	03-22-69	29	6145'	6150'	150' - 6140'
Caliper	07-10-69	30	6085'	6104'	0' - 6080'
Caliper	07-10-69	31	6085'	6104'	5300' - 6080'
Caliper	07-23-69	32	6085'	6104'	0' - 6080'
Caliper	10-16-69	33	6102'	6104'	0' - 5624'
Density	10-24-68	1	6432'	6500'	5300' - 6431'
Electric	10-23-68	1	6442'	6500'	5350' - 6442'
Electric	10-23-68	2	6442'	6500'	5350' - 6442'
Fluid Density	07-12-69	1	5627'	5629'	5350' - 5621'
Fluid Density	07-14-69	2	5492'	5492'	4700' - 5388'
Fluid Density	07-15-69	3	4720'	4743'	4100' - 4649'
Fluid Density	07-15-69	4	4720'	4723'	4100' - 4714'
Fluid Density	07-16-69	5	4147'	4151'	3450' - 4096'
Fluid Density	07-16-69	6	4145'	4151'	3450' - 4096'
Fluid Density	07-17-69	7	3516'	3521'	2800' - 3512'
Fluid Density	07-17-69	8	3412'	3521'	2750' - 3408'
Fluid Density	07-18-69	9	2825'	2827'	2341' - 2816'
Fluid Density	07-18-69	10	2828'	2833'	2140' - 2816'
Fluid Density	07-20-69	11	2177'	2180'	1350' - 2171'

Type Log	Date	Run No.	Log Depth	Drillers Depth	Interval Logged
NAIL	07-10-69	1	5628'	5629'	0' - 5626'
NAIL	07-10-69	2	5628'	5629'	0' - 5626'
NAIL	07-12-69	3	5627'	5269'	5350' - 5625'
NAIL	07-14-69	4	5492'	5492'	4700' - 5390'
NAIL	07-15-69	5	4720'	4743'	4100' - 4649'
NAIL	07-15-69	6	4720'	4723'	4100' - 4718'
NAIL	07-16-69	7	4147'	4151'	3450' - 4100'
NAIL	07-16-69	8	4145'	4151'	3450' - 4100'
NAIL	07-16-69	9	3516'	3521'	2800' - 3516'
NAIL	07-17-69	10	3412'	3521'	2750' - 3412'
NAIL	07-18-69	11	2825'	2827'	2341' - 2820'
NAIL	07-18-69	12	2828'	2833'	2140' - 2820'
NAIL	07-20-69	13	2177'	2180'	1190' - 2174'
NAIL	07-20-69	14	2177'	2180'	1350' - 2175'
NAIL	07-21-69	15	1404'	1405'	550' - 1396'
NAIL	07-21-69	16	610'	609'	3' - 520'
NCA	07-10-69	1	6085'	6104'	0' - 6074'
NCA	08-12-69	2	6085'	6104'	0' - 6074'
Gamma Ray Neutron	10-23-68	1	6440'	6500'	5300' - 6439'
Gamma Ray Neutron	07-22-69	2		6104'	0' - 2900'
Neutron/Neutron	10-24-68	1	6400'	6500'	5300' - 6439'
NCTL	09-13-67	1	132'	145'	0' - 130'
NCTL	05-30-68	2	4964'	5000'	4850' - 4962'
NCTL	05-31-68	3	4998'	5022'	4900' - 4997'
NCTL	08-03-68	4	4950'	4967'	4900' - 4950'
NCTL	09-13-68	5	5392'	5393'	5250' - 5392'
Temperature	05-30-68	1	4964'	5000'	4800' - 4964'
Temperature	09-13-68	2	5391'	5391'	5000' - 5391'
Temperature	10-24-68	3	6429'	6500'	5300' - 6429'
Temperature	03-24-69	4	6145'	6150'	0' - 6145'
Temperature	07-09-69	5	5627'	5629'	0' - 5627'
Temperature	07-23-69	6	6097'	6104'	0' - 6097'
Temperature	08-06-69	7	6097'	6104'	10' - 6097'
Temperature	08-20-69	8	6101'	6104'	0' - 6101'
Temperature	09-04-69	9	6101'	6104'	0' - 6101'
Temperature	09-15-69	10	6101'	6104'	0' - 6101'
Velocity	10-24-68	1	6431'	6500'	5250' - 6426'
3-D	10-24-68	1 & 2	6431'	6500'	5300' - 6426'
3-D	10-24-68	3 & 4	6434'	6500'	5300' - 6425'

UA-1
SPERRY-SUN GYROSCOPIC MULTISHOT SURVEY
303 - SU3 - 303 IN RUN

This survey was run on a wire line inside 54" I.D. casing.

Measured Depth	True Vertical Depth	Latitude	Departure
0'	0'	0'	0'
100'	100.00'	0.10' N	0.15' E
200'	200.00'	0.23' N	0.15' E
300'	300.00'	0.27' N	0.12' E
400'	400.00'	0.29' N	0.13' E
500'	500.00'	0.31' N	0.13' E
600'	600.00'	0.33' N	0.00' W
700'	700.00'	0.36' N	0.07' W
800'	800.00'	0.44' N	0.04' W
900'	900.00'	0.49' N	0.15' W
1000'	1000.00'	0.45' N	0.28' W
1100'	1100.00'	0.37' N	0.31' W
1200'	1200.00'	0.37' N	0.31' W
1300'	1300.00'	0.33' N	0.24' W
1400'	1400.00'	0.34' N	0.48' W
1500'	1500.00'	0.28' N	0.43' W
1600'	1600.00'	0.26' N	0.44' W
1700'	1700.00'	0.29' N	0.49' W
1800'	1800.00'	0.35' N	0.42' W
1900'	1900.00'	0.32' N	0.52' W
2000'	2000.00'	0.31' N	0.38' W
2100'	2100.00'	0.37' N	0.47' W
2200'	2200.00'	0.37' N	0.48' W
2300'	2300.00'	0.39' N	0.69' W
2400'	2400.00'	0.32' N	0.79' W
2500'	2500.00'	0.31' N	0.93' W
2600'	2600.00'	0.32' N	1.06' W
2700'	2700.00'	0.32' N	1.12' W
2800'	2800.00'	0.36' N	1.16' W
2900'	2900.00'	0.31' N	1.19' W
3000'	3000.00'	0.27' N	1.23' W
3100'	3100.00'	0.25' N	1.16' W
3200'	3200.00'	0.09' N	1.15' W
3300'	3300.00'	0.09' N	1.19' W
3400'	3400.00'	0.12' N	1.30' W
3500'	3500.00'	0.08' N	1.34' W
3600'	3600.00'	0.05' N	1.39' W
3700'	3700.00'	0.12' N	1.50' W
3800'	3800.00'	0.06' N	1.58' W
3900'	3900.00'	0.02' N	1.60' W
4000'	4000.00'	0.02' S	1.62' W

UA-1
SPERRY-SUN GYROSCOPIC MULTISHOT SURVEY (CON'T)
303 - SU3 - 303 IN RUN

Measured Depth	True Vertical Depth	Latitude	Departure
4100'	4100.00'	0.01' S	1.57' W
4200'	4200.00'	0.11' S	1.49' W
4300'	4300.00'	0.26' S	1.47' W
4400'	4400.00'	0.37' S	1.54' W
4500'	4500.00'	0.35' S	1.67' W
4600'	4600.00'	0.40' S	1.83' W
4700'	4700.00'	0.65' S	1.73' W
4800'	4800.00'	0.86' S	1.76' W
4900'	4900.00'	0.83' S	2.01' W
5000'	5000.00'	0.79' S	2.17' W
5100'	5100.00'	0.99' S	2.15' W
5200'	5200.00'	1.35' S	2.27' W
5300'	5300.00'	1.63' S	2.11' W
5400'	5400.00'	1.76' S	2.00' W
5500'	5500.00'	1.98' S	1.90' W
5600'	5599.99'	1.74' S	1.32' W
5700'	5699.99'	1.42' S	0.88' W
5800'	5799.99'	0.82' S	0.12' W
5900'	5899.98'	0.45' S	0.08' E
6000'	5999.98'	0.06' N	0.22' E
6100'	6099.98'	0.67' N	0.36' E

UA-1

BIT RECORD

Bit No.	Size	Make	Type	Depth Out	Feet Drilled	Rotating Hours
1	108"	Reed	BHB-2	264'	254'	287-3/4
2	90"	Reed	BHB-4	511'	247'	221-1/4
3	90"	Reed	T-1	747'	236'	142-1/4
4	90"	Reed	T-1	888'	141'	97-1/2
5	90"	Reed	T-1	967'	79'	81
6	90"	Reed	T-1	1150'	183'	165
7	90"	Reed	T-1	1265'	115'	152-1/4
8	90"	Reed	QS	1505'	240'	212-1/2
9	90"	Reed	QKC	1519'	14'	22
10	90"	Reed	QS	1646'	127'	183
11	90"	Reed	QS	1780'	134'	132
12	90"	Reed	QS	1856'	76'	82-1/4
13	90"	Reed	QS	2069'	213'	193-3/4
14	90"	Reed	QS	2212'	143'	155-1/4
15	90"	Reed	QS	2341'	129'	128-1/2
16	90"	Reed	QS	2539'	198'	187-1/4
17	90"	Reed	QH	2755'	216'	192
18	90"	Reed	QH	2872'	117'	112
19	90"	Reed	QH	2907'	35'	90-1/2
20	90"	Reed	QH	2913'	6'	38-1/2
21	90"	Reed	QH	3070'	157'	146-1/2
22	90"	Reed	QH	3199'	129'	203-1/2
23	90"	Reed	QH	3413'	214'	224-1/2
24	90"	Reed	QH	3453'	40'	44
25	90"	Reed	QH	3584'	131'	143-3/4
26	90"	Reed	QH	3695'	111'	166
27	90"	Reed	QS	3828'	133'	136-1/2
28	90"	Reed	QS	3971'	143'	142-1/4
29	90"	Reed	QS	4141'	170'	183-1/2
30	90"	Reed	QS	4227'	86'	99-3/4
31	90"	Reed	QH	4315'	88'	103
32	90"	Reed	QH	4391'	76'	103
33	90"	Reed	QS	4504'	113'	140-1/2
34	90"	Reed	QH	4551'	47'	66
35	90"	Reed	QS	4601'	50'	62
36	90"	Reed	QS	4636'	35'	45
37	90"	Smith	DT	4642'	6'	15-3/4
38	90"	Reed	QH	4730'	88'	111-1/2
39	90"	Reed	QS	4818'	88'	105-1/2
40	90"	Smith	DT	4941'	123'	90
41	90"	Reed	QS	5000'	59'	76-1/2
42	90"	Reed	QS	5007'	7'	5-1/2
43	90"	Smith	DT	5102'	95'	98-1/4

BIT RECORD (CON'T)

Bit No.	Size	Make	Type	Depth Out	Feet Drilled	Rotating Hours
44	90"	Reed	QH	5205'	103'	110-1/4
45	90"	Reed	QH	5323'	118'	100-3/4
46	90"	Reed	QH	5399'	76'	91-3/4
47	90"	Reed	QH	Drilled cement, dropped in hole		
48	90"	Reed	QHQS	Cement and casing		
				5418'	13'	29-1/4
49	90"	Reed	QHQS	Cement	80'	51
				5474'	56'	60-1/4
50	90"	Reed	QH	5519'	45'	55
51	90"	Reed	QH	Drilled out cement		
	90"	Reed	QH	5599'	80'	116-1/2
52	90"	Reed	QH	Drilled cement and fill		
				5632'	33'	73-3/4
53	90"	Reed	QH	Drilled cement and fill		
				5737'	105'	127-1/2
54	90"	Reed	QS	5829'	92'	182-3/4
55	90"	Reed	QH	5922'	93'	110-3/4
56	90"	Reed	QH	6018'	96'	151-1/4
57	90"	Reed	QH	6122'	104'	157-3/4
58	90"	Reed	QS	6150'	28'	41

BIT RECORD - CENTER PUNCH

Bit No.	Size	Make	Type	Depth Out	Feet Drilled	Rotating Hours	Condition
1	8-5/8"	Reed	YT1AJ	5020'	20'	4-1/2	
2	8-5/8"	Reed	YHGJ	5140'	120'	7-1/2	
3	8-5/8"	Reed	YHGJ	5410'	270'	24-1/4	
1 Rerun	8-5/8"	Reed	YT1AJ	5484'	74'	11	
4	8-5/8"	Reed	YHGJ	5698'	214'	21-3/4	
3 Rerun	8-5/8"	Reed	YHGJ	5731'	33'	5	
5	8-5/8"	Reed	YS1G	5819'	88'	11-1/2	
3 Rerun	8-5/8"	Reed	YHGJ	5823'	4'	1-1/4	
6	8-5/8"	Reed	YHGJ	5951'	128'	10-1/2	
				Cement	95'		
7	8-5/8"	Reed	YHGJ	Dyna-Drill			
8	8-5/8"	Reed	ST1AG	Dyna-Drill			
9	8-5/8"	Reed	ST1AG	Dyna-Drill			
10	8-5/8"	Reed	ST1AG	Dyna-Drill			
11	8-5/8"	Reed	ST1AG	Dyna-Drill			
12	8-5/8"	Reed	YHGJ	5532'	133'	22-3/4	
13	8-5/8"	Reed	YHGJ	5600'	68'	17-1/2	
14	8-5/8"	Reed	YHGJ	5818'	218'	38	
15	8-5/8"	Reed	YHGJ	5940'	217'	42	
13 Rerun	8-5/8"	Reed	YHGJ	6289'	132'	16-1/2	
[illegible]	8-5/8"	Reed	YHGJ	6437'	148'	14-3/4	
[illegible] Rerun	8-5/8"	Reed	YHGJ	6473'	36'	5-3/4	
17	8-5/8"	Reed	YS1GJ	6500'	27'	3	

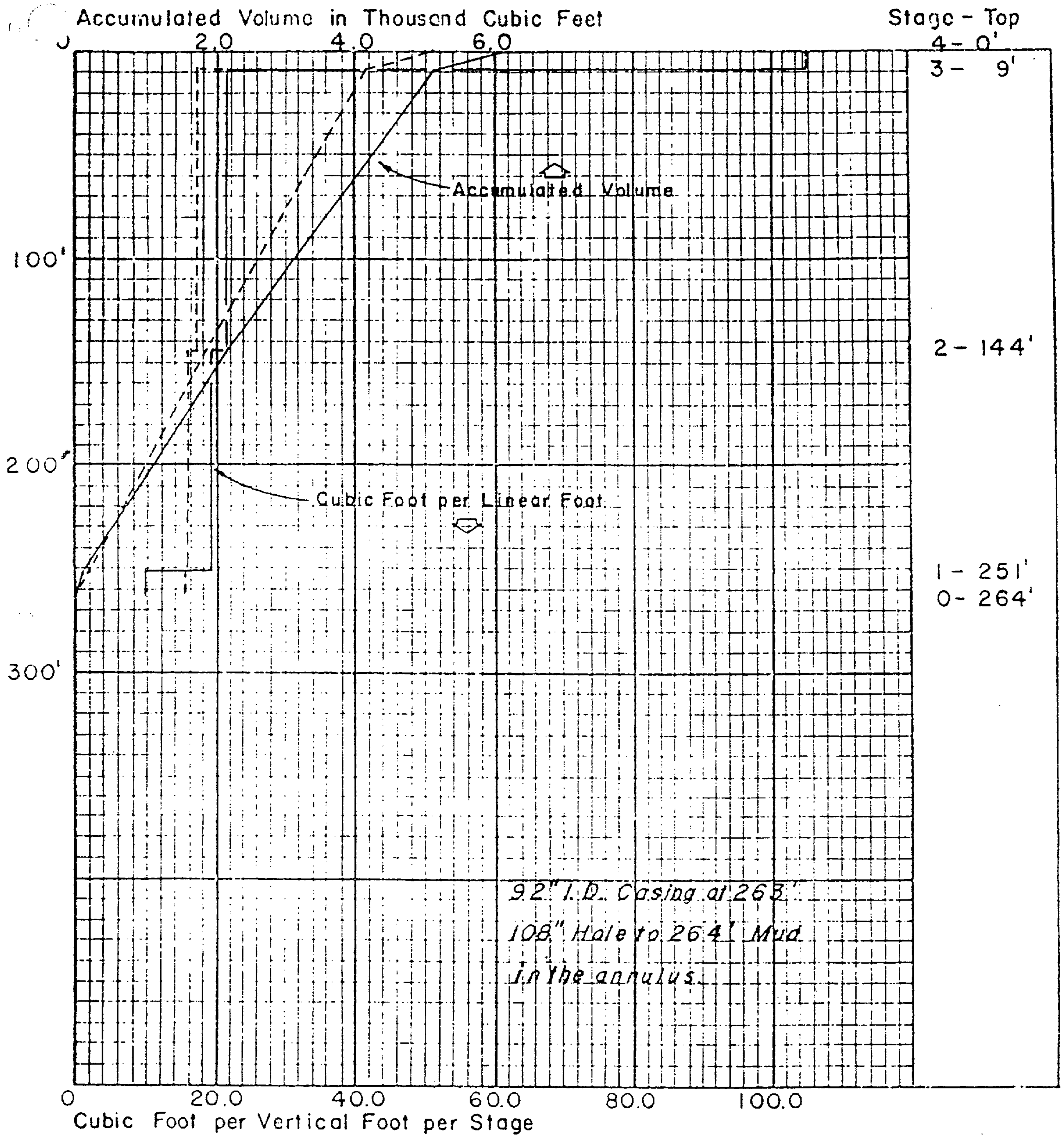
CORE BIT RECORD

Bit No.	Size	Make	Type	Depth Out	Feet Drilled	Rotating Hours	Condition
1	7"	Hughes	J	5050'	30'	66-1/2	Worn Out
2	7"	Hughes	J	5073'	23'	9-3/4	Worn Out
3	7"	Hughes	J	5093'	20'	6-3/4	Worn Out
4	7"	Hughes	J	5109'	16'	5-1/4	50% Used
5	7"	Hughes	J	5139'	30'	8	
6	7"	Hughes	J	5163'	23'	10-1/2	Worn Out
7	6-3/4"	Hughes	J	5173'	10'	3	85% Used
8	6-3/4"	Hughes	J	5192'	19'	3-1/2	90% Used
9	7"	Hughes	J	5208'	15'	3-3/4	
10	7"	Hughes	J	5218'	10'	2	
11	7"	Hughes	J	5239'	21'	4-1/2	50% Used
10 Rerun	7"	Hughes	J	5256'	17'	4-1/2	
12	6-3/4"	Hughes	J	5297'	41'	8-1/2	75% Used
13	6-3/4"	Hughes	J	5317'	20'	4-1/2	50% Used
14	6-1/4"	Hughes	J	5337'	20'	4	95% Used
15	6-1/4"	Hughes	J	5374'	37'	7-1/4	
16	6-1/4"	Hughes	J	5410'	26'	5-1/2	

CORE BIT RECORD (CON'T)

Bit No.	Size	Make	Type	Depth Out	Feet Drilled	Rotating Hours	Condition
17	6-1/4"	Hughes	J	5440'	30'	8-3/4	75% Used
18	6-1/4"	Hughes	J	5484'	31'	6	70% Used
19	6-1/4"	Hughes	J	5524'	40'	9-3/4	
20	6-1/4"	Hughes	J	5534'	10'	1-3/4	95% Used
21	6-1/4"	Hughes	J	5542'	8'	2	
22	6-1/4"	Hughes	J	5552'	10'	2-3/4	Locked
23	6-1/4"	Hughes	J	5571'	19'	6-1/2	
24	6-1/4"	Hughes	J	5583'	12'	1-3/4	Worn Out
25	6-1/4"	Hughes	J	5598'	15'	3	
26	6-1/8"	Williams	Dia.	5604'	6'	3-1/2	
27	6-1/8"	Williams	Dia.	5608'	3'	1	
28	6-1/4"	Hughes	J	5613'	5'	1	
29	6-1/4"	Hughes	J	5633'	20'	4-1/2	
30	6-1/4"	Hughes	J	5663'	30'	5	Dull
31	6-1/4"	Hughes	J	5683'	20'	3-3/4	
27 Rerun	6-1/8"	Williams	Dia.	5688'	5'	1-3/4	
32	6-1/8"	Williams	Dia.	5756'	68'	27	Grooved
27 Rerun	6-1/8"	Williams	Dia.	5812'	46'	13	35% Used
33	6-1/8"	Williams	Dia.	5819'	7'	2	Dropped
34	6-1/8"	Williams	Dia.	5833'	10'	2	5% Used
	6-1/8"	Williams	Dia.	5951'	118'	21-1/2	50% Used
	6-1/8"	Williams	Dia.	5979'	34'	4-3/4	
37	6-1/8"	Williams	Dia.	5988'	9'	1-3/4	
38	6-1/4"	Hughes	J	6012'	24'	2-1/2	
37 Rerun	6-1/8"	Williams	Dia.	6060'	47'	11-1/4	
39	6-1/8"	Williams	Dia.	6130'	70'	20	
40	6-1/8"	Williams	Dia.	6184'	554'	18-1/4	
41	6-1/8"	Williams	Dia.	6212'	20'	2-1/4	
40 Rerun	6-1/8"	Williams	Dia.	6274'	62'	20-1/2	
39 Rerun	6-1/8"	Williams	Dia.	6288'	14'	7	
42	6-1/8"	Williams	Dia.	6343'	54'	20-1/2	
43	6-1/4"	Hughes	J	6353'	10'	2	
44	6-1/4"	Hughes	J	6363'	10'	2-3/4	
42 Rerun	6-1/8"	Williams	Dia.	6369'	6'	2-3/4	
40 Rerun	6-1/8"	Williams	Dia.	6393'	24'	12-1/2	
45	6-1/4"	Hughes	J	6413'	20'	7	
46	6-1/8"	Williams	Dia.	6437'	24'	8-1/2	
47	6-1/4"	Hughes	J	6453'	16'	4	
48	6-1/4"	Hughes	J	6473'	20'	7	
49	6-1/8"	Williams	Dia.	6485'	12'	6-1/4	
50	6-1/4"	Hughes	J	6493'	8'	1-1/2	
51	6-1/4"	Hughes	J	6500'	8'	1-1/2	

CEMENTING GRAPH UA-I

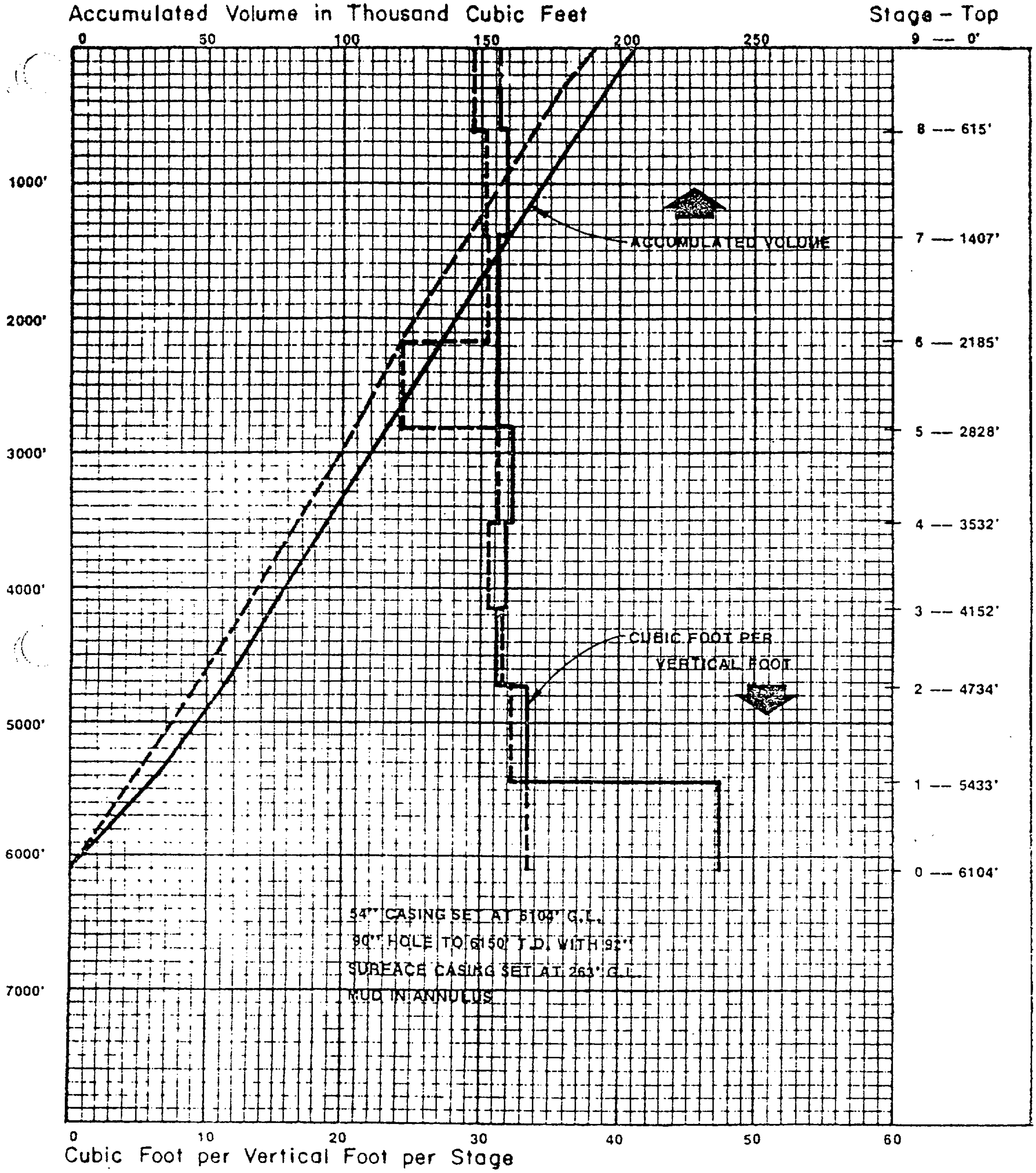


- - - - - - - Calc. Ann. Vol.

———————— Cement Used

Total Cement Used	=	6,060 $Ft.^3$
Total Calculated	=	5,099
Difference		961

UA-1



------- Calc. Ann. Vol.

——— Cement Used

Total Cement Used	=	204,819 ft.^{3}
Total Calculated	=	194,728 ft.^{3}
Difference		9,891 ft.^{3}

UA-1

REVIEW OF HOLE CONDITIONS

Spudded 8-22-67	Completed 7-26-69.
Excavated to 10'	168" I.D. galvanized conductor casing at 10' G.L., cemented in place with pad.
108" hole to 264'	92" I.D. casing at 263' G.L., cemented annulus to surface with 6060 ft^3 of slurry.
90" hole to 6150'	54" I.D. casing at 6104' G.L., cemented annulus to surface with 204619 ft^3 of slurry. (Casing string includes an 86" O.D. x 43' chamber.)

I. This hole was drilled with mud using air assisted reverse circulation. Hole caving and fractured formations were first encountered while drilling from 1150' to 1161'. Minor fill problems were encountered except for those depths at which cement plugs were set and drilled out to control caving as follows:

Depth	Cement Used
2896' - 2907'	2360 Ft^3
5302' - 5328'	3425 Ft^3
5311' - 5337'	2360 Ft^3
5333' - 5413'	6400 Ft^3
5470' - 5510'	3600 Ft^3
5557' - 5582'	2382 Ft^3
5504' - 5550'	4760 Ft^3
5579' - 5625'	4860 Ft^3

A major loss of mud was encountered while drilling from 2855' to 2872'. Some fluid loss occurred while drilling from 3340' to 3344' and 3512' to 3528'. During centerpunch operations, the mud in the annulus kept dropping resulting in a minor loss of mud.

II. Centerpunch operations were first started with 10-3/4" O.D. casing set at 4998'. The traveling block was dropped leaving the drill pipe and coring assembly in the hole; the coring depth was 5819'. As a result of this accident, the 10-3/4" O.D. casing was damaged which was later recemented as a corrective measure. In the process of drilling out cement below the 10-3/4" O.D. casing, the hole was sidetracked. The casing was then cut, pulled and the 90" hole drilled ahead to 5397'.

Centerpunch operations were started again with the 10-3/4" O.D. casing set at 5397'. Coring and testing were completed at 6500' and the casing cut and pulled. Operations were delayed on the fishing job from 6-30-68 to 7-16-68 to make rig repairs and waiting on equipment and materials. The fish was recovered on 7-21-68.

III. A connection was made while drilling out cement at a depth of 5336' and the drill pipe parted at the kelly saver sub. The drill pipe dropped to bottom and was found to be parted at 45' and 5226'. The fishing job started on 11-4-68 and completed on 11-29-68, all the fish was recovered.

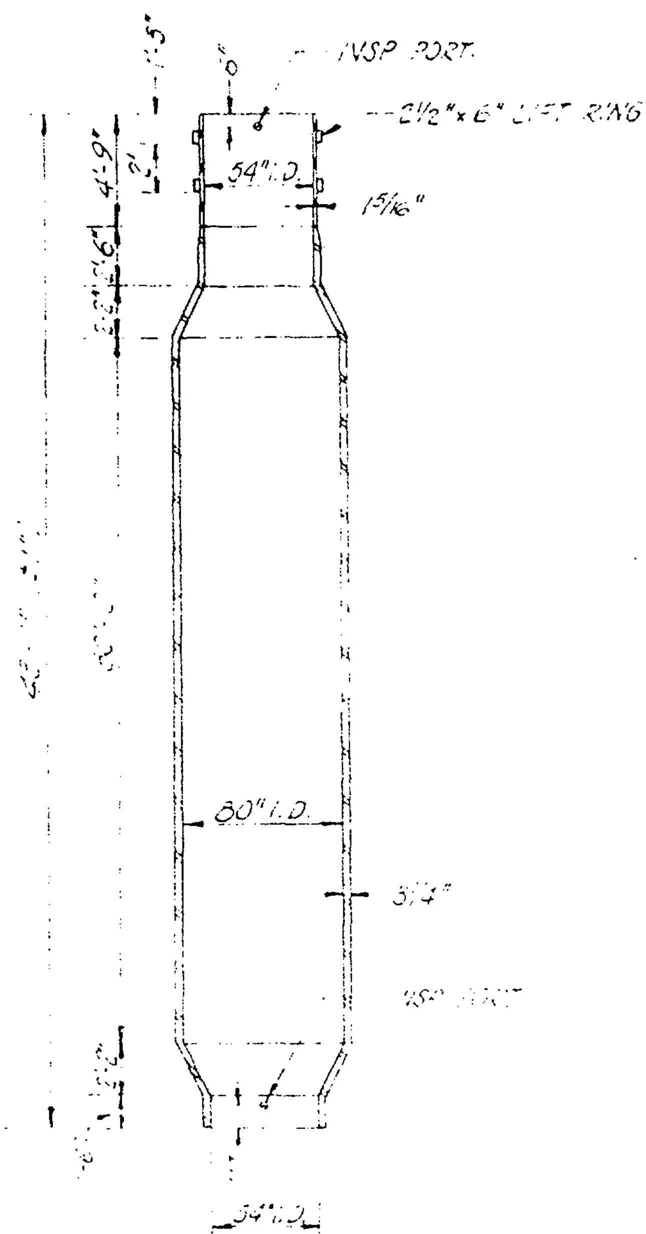
IV. Two Birdwell Fluid Density and NAIL logging tools were lost while monitoring cement operations, one tool in each monitor line. They were located at 674' and 2343'.

V. A caliper log was run prior to setting the 54" I.D. casing. The hole was slightly enlarged over the 90" bit size with the following exceptions:

Interval	Average Diameter	Maximum Diameter
2870' - 2894'	104"	121"
2894' - 2937'	95-3/4"	101"
4779' - 4988'	97	108"
5260' - 5306'	102"	112"
5420' - 5442'	103"	113-1/2"
5590' - 5633'	99"	102"
5633' - 5662'	102"	115-1/2"
5700' - 5830'	111"	126"+
6075' - 6104'	102"	114-1/2"

VI. Cementing of the 54" I.D. casing. Mud was in the annulus.

Stage No.	Interval	Cement Used	Calculated Annular Vol.
1	6104' - 5433'	31,827 $ft.^3$	22,650 $ft.^3$
2	5433' - 4734'	23,424 $ft.^3$	22,596 $ft.^3$
3	4734' - 4152'	17,980 $ft.^3$	18,409 $ft.^3$
4	4152' - 3532'	19,690 $ft.^3$	19,064 $ft.^3$
5	3532' - 2828'	22,794 $ft.^3$	21,906 $ft.^3$
6	2828' - 2185'	20,023 $ft.^3$	19,594 $ft.^3$
7	2185' - 1407'	24,268 $ft.^3$	23,837 $ft.^3$
8	1407' - 615'	25,335 $ft.^3$	23,959 $ft.^3$
9	615' - 0'	19,278 $ft.^3$	18,063 $ft.^3$
	TOTAL	204,619 $ft.^3$	190,078 $ft.^3$



PREPARED BY

FENIX & SCISSON, INC.
ENGINEERS & CONTRACTORS
LAS VEGAS, NEVADA

FOR

U.S. ATOMIC ENERGY COMMISSION
NEVADA OPERATIONS OFFICE — LAS VEGAS, NEVADA

80" I.D. CHAMBER FOR UA-1

DRAWN	CHECKED	DATE	SCALE	DRAWING NO.
[illegible]		[illegible]	[illegible]	SHEET ____ OF ____

OUTGOING LTR. NO.			
R83-0283.1			
INCOMING LTR. NO.			
ACT			
REPLY DUE			
DIST:	LTR.	ENCL.	APPR.
Bartholomew, D.C.			
Bellofatto, M.			
Carey, J.M.			
Cockeram, D.J.			
Crawford, A.C.			
Deju, R.A.	X	X	
Deichman, J.L.			
Donahue, J.W.			
Freeman, R.A.			
Gimera, R.J.	X	X	X
Gruhn, R.S.			
Hammond, R.D.			
Hei[illegible]an, R.E.			
K[illegible] E.			
Lorenzini, P.G.			
McDermott, R.J.			
Ogletree, L.R.			
Pitts, G.G.			
Roecker, J.H.			
Salina, C.M.			
Shaw, H.P.			
Weil, V.R.			
Zahn L.L.			
Contract Administrator	X	X	
Central Files	X	X	
Rm Ybarra	X	X	
LL Johnson	X	X	
JL Ash	X	X	
OF Harden	X	X	
HW Brandt	X	X	
HB Dietz	X	X	
CT Webster	X	X	
File [redacted]	X	X	
R[illegible] m (2)	X	X	

54-6000-117 (R-10-81)

DOE Richland, WA

45

Rockwell Hanford Operations
Energy Systems Group
P.O. Box 800
Richland, WA 99352

Rockwell International

January 28, 1983

In reply, refer to letter #R83-0283.1

Mr. O. L. Olson, Project Manager
Basalt Waste Isolation Project Office
U. S. Department of Energy
Richland Operations Office
Richland, Washington 99352

Dear Mr. Olson:

CONTINGENCY PLAN FOR ANOMALY DETECTION AND RESOLUTION
DURING EXPLORATORY SHAFT CONSTRUCTION
(Contract DE-AC06-77RL01030)

Reference: (1) Letter, December 13, 1982, R. J. Gimera to O. L. Olson, "Contingency Planning for Unusual Occurrences During Exploratory Shaft Construction"

(2) Letter, January 21, 1983, R. J. Gimera to O. L. Olson, "Contingency Plan for Anomaly Detection and Resolution During Exploratory Shaft Construction"

The Reference 1 letter transmitted a plan of action for developing contingency planning for the Exploratory Shaft (ES) construction activity. The Reference 2 letter submitted to the U.S. Department of Energy-Richland Operations Office (DOE-RL) the Contingency Plan for Anomaly Detection for ES-Phase I large hole drilling. Please replace the Reference 2 letter with this transmittal. This transmittal contains several clarifications of the intent of contingency planning for ES (in the Introduction and Sections 3.5, 5.2, 5.5, 12.6, and 14.6).

Additional contingency plans will be prepared and submitted to DOE-RL for Phase II of the ES construction prior to January 1984 as indicated in the referenced letter.

Very truly yours,

R. J. Gimera, Associate Director
Basalt Waste Isolation Project

RJG/RMY/jh

Attachment

cc: J. H. Anttonen - DOE-RL
P. E. Rasmussen - DOE-RL
J. J. Sutey - DOE-RL

CONTENTS

CONTINGENCY PLAN FOR ANOMALY DETECTION AND RESOLUTION
EXPLORATORY SHAFT-PHASE I - PROJECT B-314

INTRODUCTION

This document describes a series of anomalies which could occur during the construction of the Exploratory Shaft-Phase I (ES-I) facilities. Each event is discussed using the following outline:

1. Description
2. Causes
3. Resolution Alternatives
4. Recovery
5. Prevention
6. Project Preparations

Although these potential anomalous events each involve pre-planning, it should be noted that much of the necessary pre-planning is routinely completed as standard and basic precautions in such construction activities. Accordingly, in most instances the impact on cost and schedule of planning for the potential anomaly cannot realistically be separated from the cost and schedule for basic project planning activity. Perhaps the greatest value derived in developing this contingency plan is in the increased awareness of the importance of having skilled professionals closely involved in all operations in this developmental program.

The Basalt Waste Isolation Project (BWIP) wishes to emphasize that, while many anomalies may be encountered during the ES-I activities, engineering judgment was relied upon to generate a list of critical occurrences, i.e., "show stoppers", to focus project attention on these and not diffuse or shield such considerations by more trivial occurrences.

1.0 "EXCESSIVE WALL CAVE-IN DURING SURFACE SEDIMENT PENETRATION" (144 INCH)

1.1 DESCRIPTION

During penetration of the sediments of the first several hundred feet, some sloughing of material from the upper wall of the deepening, unlined shaft can be expected. Normally, this sloughed material will simply tumble through the bit collar and into the bit working area and be appropriately ground up and entrained through the recirculation system. An excessive amount of sloughed material could result from a collapse of a major portion of the wall into the shaft. If a sufficient amount of material overburden were brought to bear on the bit collar, it could conceivably overload and stop the drill rotary motion and result in a stuck bit.

1.2 CAUSES

Such an occurrence is without precedent in shaft drilling, largely because normal drilling operations preclude the conditions necessary to cause the problem.

- During normal bit tripping, careless handling of the rig could cause the bit to engage and damage the shaft wall, causing significant wall collapse.
- Improper mud maintenance could result in reduced fluid density, or in the extreme, loss of hydraulic head sufficient to lose the needed counteracting hydraulic forces which tend to keep the shaft walls intact.
- Unusual sediment composition which tends to flow rather than hold the cut shape.

1.3 RESOLUTION ALTERNATIVES

The generic resolution to this occurrence and for the identified causes is to retain known, competent professionals and to provide them with the appropriate tools for the job.

- A professional (driller) would not handle drill rig operations carelessly, thus causing unusual and damaging contact of the bit with the shaft wall. However, a remote circumstance, involving separation of the drill stem during tripping can be envisioned. The bit and remnant stem could then drop back into the shaft, ricocheting off the shaft walls causing excessive sloughing and cave-in. However, if the drill mud viscosity is correctly maintained, the shaft wall contact should not result in undue material sloughing.
- A professional (mud engineer) would not allow the drill fluid composition to depart significantly from optimum. If wall sloughing appeared to be developing to an excess, it would be a special case of the next alternative.
- In drilling through a sediment layer which tended to flow easily into the shaft, the added material would affect the rotation characteristics of the system (slowing/increasing torque). The competent professional would perceive the change in the drilling operation (driller) and/or the mud composition (mud engineer). Mud viscosity adjustment might be a selected resolution; alternatively, grouting of the loose layer interval might be a selected resolution, followed by redrilling through the stabilized medium.

1.4 RECOVERY

On the assumption that the drill bit becomes frozen in place and cannot be used to free itself, the preferred recovery technique is to agitate the system with mechanical and fluid activity in context with the perceived problem. If the drill stem is intact, a push-pull technique

while forcing fluids through the circulation system can be initiated. If the circulation system is not functional, auxiliary circulations must be developed, working downward toward the frozen bit. Sufficient agitation must be achieved to develop bit movement. If the drill stem is separated but accessible, this becomes a special case of the unusual occurrence titled, "Drill Stem Separation", discussed later. If all else fails, material and equipment will be fished and otherwise extracted from the shaft and the drilling operation resumed. It is probable that grouting will be required to stabilize the shaft prior to continued drilling.

1.5 PREVENTION

Prevention will be ensured through professionally conducted drilling operations. To support and augment the drilling management system, independent, knowledgeable auditing of all operations on a routine basis will be separately developed.

1.6 PROJECT PREPARATIONS

<u>Activity</u> - Appropriate section of personnel for construction management and operations.

- Careful selection of a construction quality auditing capability.
- Timely procedure* identification and/or development program for construction management implemented in a timely fashion.
- Provide grout standby capability.

<u>Cost</u> - Not an incremental cost. This pre-planning is consistent with established program/project objectives and procedures.

<u>Schedule</u> - No schedule impact, for the same reasons.

2.0 "EXCESSIVE HOLE DEVIATION FROM VERTICALITY" (144 INCH AND 110 INCH)

2.1 DESCRIPTION

Shaft verticality should not deviate more than five minutes per 100 feet. Accordingly, this parameter will be checked by downhole gyrocompass

*Procedures will be general in nature rather than detailed to take the fullest advantage of the professional capabilities of the construction team.

at no greater bit advance interval than 30 feet. Deviation trends will be identified and appropriate countermeasures initiated using common drilling procedures. Excessive hole deviation is interpreted to be identification of a trend which if not corrected could result in axial deflections greater than 0.38 foot in 180 feet.

2.2 CAUSES

The basic cause of hole deviation is geologic material contrasts which present a variable resistance cross section to the advancing bit. For example, the bit could intercept an inclined interface between clay and gravel, or a fault line in hard rock. The drill train weight on the bit and the bit rotation speed are two variables which can affect the verticality trends at these resistance interfaces.

2.3 RESOLUTION ALTERNATIVES

When the trend away from verticality is identified, a combination of operations may be required to correct the deviation as well as the trend. Basically, the drill train is pulled up, then reinserted at a higher rotary speed, lighter drill train weight to allow the massive bit time to grind into any eccentricities and to follow its normal, gravity guided vertical path. The bit advance through the problem area can be expected to be slower as a result of these actions.

2.4 RECOVERY

The recovery is the same combination of actions described above as alternatives, conducted by the skilled professional.

2.5 PREVENTION

Based on principal borehole information, the intercepts of geologic stratigraphic contrasts can be anticipated. Drill string weight and bit rotary speed can be modified appropriately to minimize undesirable trend developments. These techniques in conjunction with periodic gyrocompass plotting of the bit advance path ensure acceptable verticality.

2.6 PROJECT PREPARATIONS

<u>Activity</u>

- Appropriate selection of personnel for construction management and construction operations.
- Carefully selected construction quality audit capability.
- Availability to the driller of stratigraphic details.

- Timely mud analysis capability.

- Timely procedures* identification and/or development program for construction management.

Cost - Not an incremental cost. This pre-planning is consistent with program/project objectives and procedures.

Schedule - No schedule impact, for the same reason.

3.0 "DRILL STEM SEPARATION" (144 INCH AND 110 INCH)

3.1 DESCRIPTION

Either from tool joint backoff or from material failure, the drill stem can be accidentally separated downhole such that it is necessary to probe downhole to locate and extract the lost string and bit.

3.2 CAUSES

- Drill stem material failure can occur as a result of metal fatigue or simply through basic material flaw.
- Tool joint backoff is commonly caused as a consequence of high bit torque which is suddenly released allowing a rapid backspin of the drill stem train. A low torque, threaded joint comes loose. This should be expected only with very long drill stem trains and an encounter with a highly resistive bit loading.

3.3 RESOLUTION ALTERNATIVES

One resolution is available; probe for, capture, and retrieve the lost drill stem and appendages. Once the stem is located and its condition/configuration determined, the stem is engaged by either of two types of grapples; one type, the overshot slips over and engages the stem; the second type, the spear inserts into and engages the stem. The equipment is then raised for inspection and re-engagement.

3.4 RECOVERY

The selection of engaging tool (overshot or spear) is based on the experience of the persons conducting the operation.

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*Ibid.

3.5 PREVENTION

- Proper makeup torque using a special hydraulic torque wrench.
- Drill stem failure through flaw is a contingency which is avoided through quality control of drill stem sections. This is augmented operationally by inspection of equipment on an established schedule.
- Drill stem failure through fatigue is most likely to occur at the threaded joints. All critical threaded joints are inspected on a regular basis during tripping, a routine operation conducted every 200-300 feet of bit advance. Nascent wear will be detected and appropriately dealt with.
- Backspin from abruptly released torsion energy is normally avoidable by the skilled professional. Project management attention to operating configuration (torque, drill stem length, and bit environment) will avoid operator error such as inadvertent release of stem engagement and drive mechanism at the drill rig, or "snagging" of drill bit in a resistive medium under already high loading, favorable (for backspin) circumstances. In addition, the drill rig controls system incorporates over-torque safeguards which virtually preclude reaching a level of stored torsion energy sufficient to support a backspin of a magnitude which could separate the drill stem.

3.6 PROJECT PREPARATIONS

<u>Activity</u> - Competent staffing, as described in other occurrences.

- Construction quality audit systems.

- Provisions for interface materials and equipment, such as threaded adapters to permit use of otherwise incompatible systems, spears, and overshots.

<u>Cost</u> - Acquisition of threaded adapters has been included in the basic equipment already provided for.

<u>Schedule</u> - Timely acquisition of fishing equipment such as spears and overshots from the Department of Energy facilities in Nevada has been assured. Acquisition time will not be a significant impact on the basic fishing operation.

4.0 "LACK OF ADEQUATE PENETRATION" (110 INCH)

4.1 DESCRIPTION

Bit advance rate is slow and deemed inadequate.

4.2 CAUSES

- Rotary speed too slow.
- Drill string too light.
- Rock too hard for cutter head design.

4.3 RESOLUTION ALTERNATIVES

- Based on professional skills, combinations of rotation and drill stem weight can be selected to optimize bit advance rate.
- Upgrade cutter head.
- Resort to drill-blast and muck techniques to sink shaft.

4.4 RECOVERY

An optimized combination of bit rotation and drill stem weight will be used in conjunction with augmented bit maintenance upgrade as necessary to ensure the best possible advance rate.

4.5 PREVENTION

Prevention is through selection of bit and cutter head design for the expected service and by skilled utilization of equipment to maintain an optimized drill advance rate.

4.6 PROJECT PREPARATIONS

None required beyond present activities.

5.0 "EXCESSIVE WATER INFLOW" (144 INCH AND 110 INCH)

5.1 DESCRIPTION

If the drilling fluid level is below the natural head on an encountered aquifer, there could be a general inflow of water which could disturb the engineered mud equilibrium.

5.2 CAUSES

This circumstance has either of two origins:

- Inadvertent loss of drilling fluid level coincident with penetrating the aquifer horizon, or
- Unexpected artesian conditions, i.e., hydraulic heads encountered which are substantially greater than those measured at the Reference Repository Location-2 borehole, 300 feet distant.

Neither is considered probable.

5.3 RESOLUTION ALTERNATIVES

- The inadvertent loss of fluid head will be corrected. Grouting will be considered.
- For artesian conditions, the horizon will be pressure grouted to seal out the source, then re-drilled.

5.4 RECOVERY

Identical with "Resolution Alternatives" above.

5.5 PREVENTION

Skilled professionals, who will be utilized on the ES Project, will be continuously cautioned against making the mistake of inadvertently lowering the drilling fluid level; the principal borehole and other exploratory penetrations of the shaft general area will be used to monitor for such conditions as potential artesian sources.

5.6 PROJECT PREPARATIONS

No preparations are necessary beyond those already discussed and which are intrinsic to present program and project planning.

6.0 "DECREASED OR LACK OF RECIRCULATION" (144 INCH AND 110 INCH)

6.1 DESCRIPTION

A loss of recirculation would be seen as a lowering of the fluid level in the mud pits and by a change in volume/composition of the return fluid.

6.2 CAUSES

- Intersection of a highly permeable medium could cause either symptom.

6.3 RESOLUTION ALTERNATIVES

- Modify mud viscosity or type.
- Charge the drilling fluid with lost circulation materials (LCM) such as cedar chips and treated paper whose function is to clog porous media and thus restore recirculation.
- Quick setting grout can be injected to plug the porous horizon. The drilling can then be resumed through the grouted and sealed-off horizon.
- A combination of LCM/grout injections can be used if necessary.

6.4 RECOVERY

The recovery of circulation follows the alternatives described above, i.e.:

- Basic reliance is placed on adjusting the character of the drilling fluid. If a prompt response is not evident,
- LCM's and/or grout will be injected until recirculation is established.

6.5 PREVENTION

Borehole stratigraphic information will permit anticipation of the horizons where circulation may be lost. Appropriate and timely incorporation of LCM's into the drilling fluid can minimize the circulation losses.

6.6 PROJECT PREPARATION

No preparations are necessary beyond those already discussed and which are intrinsic to present program and project planning.

7.0 "EXCESSIVE NON-VERTICALITY OF LINER" (144 INCH AND 110 INCH)

7.1 DESCRIPTION

Excessive non-verticality of liner is construed to be a change in axial direction of the liner which over a distance of 180 feet exceeds

0.38 foot axial displacement from where it would have been if exactly straight over that same length.

7.2 CAUSES

- Cumulative alignment error of liner segments during assembly and welding.

7.3 RESOLUTION ALTERNATIVES

There is no alternative but to correct the alignment to meet tolerances.

7.4 RECOVERY

Following precision survey to establish the extent of the "fix" required, the liner will be hoisted and segments repaired as necessary until they are within acceptable limits. Because the wall thickness varies with depth, it is impractical to provide spare liner segments.

7.5 PREVENTION

Two planned fabrication activities, precise survey of each segmented assembly/welding operation and sonar "tracking" of verticality ensure that excessive misalignment will not occur.

- Acquire competent professional help.
- Provide timely procedures.
- Use precision instrument sight-in of assembly, welding, and liner sinking operations.
- Verify installation alignment by sonar survey.

7.6 PROJECT PREPARATIONS

No preparations are necessary or practical beyond those already discussed and which are intrinsic to present program and project planning. However, irreparable damage to a liner segment is possible. In such event, the supplier would be asked to provide a substitute segment of the proper dimensions. Cost and schedule impact would occur, but contingency planning will not effectively alter that fact. It is not feasible to have spare liner segments for each of the eleven thicknesses.

8.0 "PLUGGED OR DEFORMED GROUT LINE GUIDES" (144 INCH AND 110 INCH)

8.1 DESCRIPTION

- Upon initial insertion of the grout lines, an obstruction may be encountered.
- Utility lines found to be obstructed and unable to perform their planned role.

8.2 CAUSES

During liner installation, shaft wall irregularities, sloughed wall material, and/or eccentricities of the liner could cause a jamming and deformation of the conduits and guides which were fabricated and installed with each liner segment. A major shaft wall cave-in in conjunction with liner movement is a second scenario, for the sediment area only.

8.3 RESOLUTION ALTERNATIVES

- A mandrel or a reamer can be forced into the obstruction in an attempt to clear the channel.
- Availability of redundant grout line guides and utility conduits (three each) make it acceptable to consider abandoning a defective grout line guide.
- Following grouting, damaged lines in the grout matrix can be bored/reamed to return them to limited service.

8.4 RECOVERY

If appropriate force on the grouting line does not re-open the damaged grout line guide, the grouting line will be withdrawn and reinserted in an acceptable alternate grout line guide. Should an acceptable alternate be unavailable, a mandrel will be used to attempt to re-open the guide sufficiently to accept the grouting line. If the mandrel fails, an attempt will be made to drill through the obstruction to re-establish the grout guide channel. Redundant utility lines can be pressed into grouting service if required.

For utilities, the availability of alternate lines is necessary and planned, including the possibility of running new utility lines down the shaft interior.

8.5 PREVENTION

With the use of correct mud mixtures to support the shaft walls against failure, and with an essentially vertical shaft axis throughout its length damage to the grout line guide is unlikely. The primary prevention mode again is continued, competent construction management specialists on the job, including appropriate audit functions.

8.6 PROJECT PREPARATIONS

No preparations are necessary beyond those already discussed and which are intrinsic to present program and project planning.

9.0 "INABILITY TO INSERT LINER" (110 INCH)

9.1 DESCRIPTION

- The liner could jam during insertion.
- The liner could bottom out before fully inserted.

9.2 CAUSES

- Jamming when partially inserted could be caused by eccentricities in shaft and/or liner.
- Rock wall failure (slip) at an incompetent or fault zone could jam the liner.
- Failure to fully seat in the drilled shaft could be caused by excessive material filling the over-drill pocket.

9.3 RESOLUTION ALTERNATIVES

The event is unacceptable. Resolution is discussed under "Prevention" below.

9.4 RECOVERY

Nothwithstanding the unacceptability of the event, if it did occur, the installed liner could be segmented and removed, the obstruction eliminated, and the liner re-inserted. This contingency, however, is not discussed further in this document.

9.5 PREVENTION

Eccentricities are prevented by proper shaft and liner construction, discussed elsewhere in this document as deviation from verticality for both.

Rock wall failure of a nature to result in liner jamming is not credible in context with the actual conduct of drilling operations. Every 200-300 feet of bit advance, the drill stem train is fully extracted from the shaft, maintenance on bit and stem is performed, and the drill train is reinstalled. These iterative passes of the working bit through the shaft will eliminate protuberances from the shaft wall such as from an incompetent rock horizon, or as a result of stress relief. The iterative drill bit passes effectively prevent the indicated jamming.

The same actions ensure that little loose rock remains along the length of the drilled shaft. The most likely places for residual loose rock is at the interbed horizons. Prevention of their inadvertent discharge of loose material into the shaft after the completion of drilling is implemented by either grouting the interbed on the first bit pass, or for the lesser potential interbeds mud density control. These decisions and actions occur in conjunction with normal drilling operations utilizing the experience gained from other boreholes in the area, including stratigraphic details and operational encounters.

The final prevention with regard to fully seating the liner is also in the planned drilling operation. The shaft is overdrilled to form a 60 foot pocket expressly to have room for the loose material which may be dislodged during liner sinking.

9.6 PROJECT PREPARATIONS

No preparations are necessary beyond those already discussed and which are intrinsic to present program and project planning.

10.0 "GROUT INVENTORY OUT-OF-TOLERANCE" (110 INCH)

10.1 DESCRIPTION

Based on shaft dimensions as determined by physical and/or electronic means, an unusual amount of grout is being absorbed without reasonable "advance" of the grout level.

10.2 CAUSES

- In-leakage could be occurring at some damaged point in the installed shaft system, such as a utility line, or less probable, the liner itself.

- A highly permeable (to grout) horizon could be responsible including aquifers which had been stabilized by the mud program but unbalanced by the higher density grout.

10.3 RESOLUTION ALTERNATIVES

The initial response in any case is to shut down the grout operation and allow the installed grout sufficient time to set up. After re-examination of available information (stratigraphic in particular) a determination of alternatives will be made. If the loss is consistent with stratigraphic characteristics, grouting in some form can be resumed on a tentative basis. If this is not successful, an assessment of in-leakage possibilities will be made including, if necessary, probing of the utility conduits. (NOTE: It is most improbable that liner wall damage could occur without more significant and detectable damage to the intervening service conduits.)

10.4 RECOVERY

- If equipment/materials damage is found, appropriate blocking (stuffing) of the ruptured area(s) will be completed and grouting operations resumed.
- If it is concluded that the grout is being lost to a highly permeable zone, grout characterisitics will be modified and/or various LCM's will be introduced into the system. Iterative injections and set-up intervals will be tried until closure is achieved and the general grouting operation can be resumed. Grout lifts will be held to a minimum in permeable zones.

10.5 PREVENTION

Basically, with the available stratigraphic information and drilling experience, problem areas can be defined and most of them anticipated and eliminated during the shaft boring operations. Questionable areas will be identified for informational support to the grouting management operations.

10.6 PROJECT PREPARATIONS

No preparations are necessary beyond those already discussed and which are intrinsic to present program and project planning.

11.0 "INADEQUATE GROUT SEAL" (110 INCH)

11.1 DESCRIPTION

During liner penetrations through portholes to the grouted and the natural environment, the bond of the grout and the liner, and/or the grout and the natural environment may be found to be inadequate. This finding could be accompanied by water inflow.

11.2 CAUSES

- Grout shrinkage during curing.
- Incompatible materials at the bond surfaces. In particular, one or more of the constituents of the drilling mud may affect the interface of grout and liner/rock.
- Defective grouting operations, resulting in ungrouted areas, particularly likely to occur in the mazes created by the conduits and other materials appended to the shaft exterior.

11.3 RESOLUTION ALTERNATIVES

Evaluation of the cause will be made:

- If found to be grout shrinkage, an investigation of extent and impact will be completed as basis for a plan of selective pressure grouting of the inadequately sealed areas.
- If incompatible materials at the grout interfaces are the cause, it will basically be an aggravated case of grout shrinkage. When the critical areas are defined, a pressure washing of the critical unbonded areas will be conducted utilizing appropriate chemical solutions. When satisfactory cleanliness is achieved, selective pressure grouting will be used to close and bond the selected areas.
- Defective grouting operations resulting in unacceptable criteria are a special case of shrinkage. After assessment of the extent of the problem or, more importantly, the extent of a necessary fix, selective pressure grouting will be conducted to fill the cavities as appropriate.

11.4 RECOVERY

The key to resolution of each of the contingency problems is the assessment of extent and of the critical portions of the grout deficiency, i.e., the portions of the ungrouted system which if adequately repaired

will neutralize the effects of the otherwise inadequate grout seal. The assumption made here is that isolation of the reference horizon from the nearest aquifer above and below is the shaft seal primary goal.

The primary function of thirty-six of the portholes planned for the Exploratory Shaft is to verify the grout seal by means of cored penetrations of the grout and shaft walls for detailed examination of the grout bond at both interfaces. The selected locations and orientations of these thirty-six portholes are keyed to the need to confirm that the shaft construction, lining, and grouting have not resulted in an undesirable groundwater flow path to or from the reference horizon.

These portholes, in the event of seal inadequacy, are also the access needed for countermeasures such as cleaning and pressure grouting.

11.5 PREVENTION

Preventive measures are the subject of ongoing studies and testing. The availability of grouting materials that do not shrink is complicated by the possibility that they may expand. Some expansion is acceptable, planned, and desirable, but at the end of that spectrum is overstressing of the shaft liner or its components.

Equally important evaluations are being made of the chemistry of drilling mud and of grout in context with mutual compatibility, including the chemistry and mechanics of rinse solutions such as might be used to displace drilling mud in the liner-shaft annulus.

Prevention with regard to a "defective grouting operation" includes:

- Design control to guard against inherently difficult zones/areas for grout penetration, such as liner stiffeners, utility lines, etc.
- Close control of the assembly of the grout line guides to ensure their orientation (slots) is correct.
- Knowledgeable (professional) grout control operations.

11.6 PROJECT PREPARATIONS

Activity - Studies/tests to ensure best selection of grouts.

- Studies/tests to ensure best selection of shaft annulus preparation for grouting, including chemical and mechanical properties of wash solutions and systems.

Cost - None additional. Now in progress.

Schedule - None additional. Now in progress.

12.0 "FAILURE OF PORTHOLE SEAL" (110 INCH)

12.1 DESCRIPTION

Although mechanical damage could occur as discussed under "Grout Inventory Out of Tolerance", porthole seal failure is construed to involve only activities related to a porthole in use to penetrate the grout and/or shaft wall with a resultant tapping of environmental hydraulic energies.

- Failure of a tap fitting in a porthole plug or a fitted instrument.
- Failure of a diverter assembly
  - Mechanically broken
  - Valve seal or stuffing box failure.
- Failure of a downhole packer.
- Failure of downhole grout.

12.2 CAUSES

Most probably cause of failure will be mechanical damage as a result of shaft operations, such as a dropped tool impinging a plug or instrument fitting which is installed to monitor or give access to the shaft external environment.

A functional failure of a diverter assembly valve or stuffing box seal material could occur.

An open porthole which has been isolated from the exterior hydraulic system by grout or packer could lose its isolation through seal failure.

12.3 RESOLUTION ALTERNATIVES

Knowledge of the reservoir behind the hydraulic system which is inadvertently tapped by porthole seal failure is important. The assumption must otherwise be that it is limitless and cannot be "waited out".

The failure modes have a common resolution, i.e., installation of a fully functional diverter assembly which will provide a controlled environment for any additional repair or maintenance needs. The worst case is discussed under "Recovery" below.

12.4 RECOVERY

For low volume inflow due to seal failure, for whatever reason, involves only refitting a diverter assembly to the porthole. This can be done with both valves open to minimize the back pressure buildup. When fully installed, the valves can be closed to regain complete seal control of the porthole.

Mechanical shear failure of the diverter assembly wherein it is the only barrier to a high potential reservoir poses the most difficult conditions for solution to "failure of porthole seal". The nature of the problem is removal of the broken remnant of the diverter assembly and installation of a sound, complete assembly in its place against a major influx of hot groundwater under high pressure.

The most direct action is to re-plug the exterior porthole opening. Sufficient hydraulic ram capability is available on the work platforms (porthole drill) to insert a specially designed plug, one with a tapered (bayonet) lead to penetrate the water stream. The plug and other support equipment must be immediately available.

12.5 PREVENTION

Prevention is largely administrative. There should be few (if any) instances when a major aquifer will be contained only by the diverter assembly and the potential for this is predictable. Accordingly, operations at such time which can conceivably cause shear failure of the diverter assembly will be given unusually close scrutiny and control. Support equipment and personnel will be available.

12.6 PROJECT PREPARATIONS

Activity - Analyze worst cases to determine the nature of the hydraulic "jet". If it is greater than the largest influx which can be handled by the identified "low volume inflow" under Section 12.4 above, additional activity includes:

- Design and procure a porthole plug for use against the hot hydraulic jet.

- Design and procure an adapter for the drill ram which will enable positive handling of the tapered porthole plug.

- From the analysis of worst case, determine the available time before inundation of the work site. This assumes an influx greater than the capacity of the dewatering pumps (400 gpm).

- Prepare and demonstrate procedures for freeing the hydraulic ram from a broken diverter assembly including such impediments as the drill stem sections; loading the ram with the tapered plug; re-establishing the ram in position; installing the porthole plug.

These procedures to be executed expeditiously in an environment of hot water/vapor, without undue risk to personnel involved. Pending further analysis, assume a flow of 2000 gpm of 140°F water through a 3.5 inch porthole exterior opening.

Cost	-	Analysis	1MM + $5,000 computer
		Design	5MM
		Procurement	$5,000
		Procedures	3MM
		Training	1MM
Schedule	-	Analysis	1 month
		Design	3 months
		Procurement	6 months
		Procedures	(1 month) concurrent
		Training	1/2 month
		Cumulative	10-1/2 months

It is the judgment of the BWIP engineering staff that such occurrence is sufficiently remote that it is not cost effective to expend the funds required to be prepared for such occurrence, especially in view of the uncertain elevation and hydrostatic head at which such incident may occur.

13.0 "EXCESSIVE WATER INFLOW DURING BREAKOUT" (STATION)

13.1 DESCRIPTION

Excessive inflow can occur in two broad fashions, from a discrete source and from general "sweating" from excavation walls. Excessive inflow is deemed to be greater than 200 gpm, i.e., the capacity of one of the two dewatering pumps.

13.2 CAUSES

The presence of an apparent discrete source of water of any volume would suggest:

- Shaft seal failure
- Fault system intersecting an aquifer.

Generalized water inflow along cooling fractures in the rock mass requires permeabilities not expected and not characteristic of the reference horizon.

13.3 RESOLUTION ALTERNATIVES

Shaft seal failure was discussed under the heading of "Inadequate Grout Seal". Breakout will not be initiated until shaft seal verification and appropriate corrective measures have been completed.

Whether apparently from shaft seal fault, or other source, the following steps are probably necessary. First, the actual discrete source should be bulwarked off to temporarily reduce or eliminate the flow. Next, small holes should be drilled into the general area for conducting constant head injection tests to gain a feeling for the pressures involved and the grouting pressures needed. Third, pressure grout the general area through the small test holes, and others as necessary. Finally, return to the bulwarked source. Drill and test this area to establish the degree of success in eliminating the undesirable inflow.

13.4 RECOVERY

This process is as described as the singular alternative in Section 13.3.

13.5 PREVENTION

A more comprehensive pre-breakout test procedure might detect the problem, but would not change the resolution. An adequate shaft seal will ensure against that source of excessive inflow and, indeed, specially prepared chemical seal rings above and below the reference horizon will be installed with the appropriate liner sections.

13.6 PROJECT PREPARATIONS

No preparations are necessary beyond those already discussed and which are intrinsic to present program and project planning.

14.0 "ROCK INSTABILITY AFTER BREAKOUT"

14.1 DESCRIPTION

- Rockburst
- Rockfall.

14.2 CAUSES

- High stress ratios
- Low unconfined rock strength.

14.3 RESOLUTION ALTERNATIVES

- Rockbolts
- Shotcrete
- Stress relief drilling
- Unique supports
- General supports.

14.4 RECOVERY

- Rockburst - shotcrete, unique supports
- Rockfall - supports, grout, rockbolts.

14.5 PREVENTION

Pressure grouting of weak rock systems when identified.

14.6 PROJECT PREPARATIONS

Prior to shaft station "breakout", rock deformation instrumentation will be installed in the region of the breakout excavation. As breakout progresses, the rock instrumentation will be monitored and, as warranted, excavation support provisions will be implemented. Shotcrete installation equipment will be planned for ready access and rock bolting equipment and materials will be immediately available. Although other excavation support equipment and materials will be considered, they will not be immediately available as their potential need is judged to not warrant the expense involved.