Atlantic Richfield Hanford Company
Richland, Washington 99352

APPROVED
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**SUBSURFACE STABILIZATION BY GROUTING
OF A SIMULATED UNDERGROUND TANK**

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PREPARED FOR THE U.S. ENERGY RESEARCH AND DEVELOPMENT
ADMINISTRATION UNDER CONTRACT E (45-1) 2130

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SUBSURFACE STABILIZATION BY GROUTING
OF A SIMULATED UNDERGROUND TANK

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Environmental Engineering Section
Research Department
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SUBSURFACE STABILIZATION BY GROUTING OF A SIMULATED UNDERGROUND TANK

SUMMARY

A moisture barrier using water, sodium silicate, formamide, calcium chloride and penechem with a gel time of one-half hour was constructed around a simulated tank 10 feet deep by 10 feet diameter in the subsurface of the 200 West Area. As a test of the moisture barrier integrity, the volume which would normally be occupied by a tank was excavated and filled with water. The barrier was unable to contain the water. The failure to achieve a water-tight barrier was attributed to a leak in the floor grout.

INTRODUCTION

Large volumes of high-level radioactive liquid wastes have been produced in the chemical processing of spent fuels from plutonium production reactors. These wastes have been accumulated since the World War II effort at the U. S. Energy Research and Development Administration's Hanford Laboratories and were stored in large underground steel-lined concrete tanks. In 1973, a program to reduce the liquid volume to as low as practically possible by evaporation was initiated, and the stored liquid has now been reduced. The development of leaks in some of these tanks resulted in the release of radioactive process wastes to the surrounding sediments.

Large quantities of high-level radioactive waste will continue to be stored in existing underground storage tanks for years. The tanks must provide safe storage until the waste is removed. The responsibility of storage system integrity rests with the Atlantic Richfield Hanford Company Advanced Waste Engineering Department. One of their program objectives is to investigate methods which may be used to assure containment of stored waste.

The Environmental Engineering Section personnel met with Hanford Waste Engineering Section to discuss doing an experimental test using a sodium-silicate grout for encompassing an underground tank.

The objectives of this experiment were:

1. To determine if a moisture barrier, such as a sodium-silicate grout can encompass a leaking underground tank and prevent the spread of radioactive contamination in the subsurface sediment.

2. To establish the grouting techniques of a two-component chemical grout in the Hanford sediment.
3. Develop a method of identifying the flow of grout in the subsurface sediment.
4. To determine the interaction between grouts and soil structures present in the 200 Area sediments.

The test agreed upon would simulate a ten foot diameter by 10 ft deep tank in the sediment of the 200 West Area (Figure 1). This tank when constructed would be excavated within the grouted area and filled with water to determine its integrity.

DISCUSSION

The Pressure Grout Company of San Francisco, California was contracted to construct a silicate grout barrier around a simulated tank. The tank was defined as 3.1 m (10 ft) high, 3.1 m (10 ft) in diameter and 0.9 m (3 ft) underground. Pressure Grout Company was required to form a wall around the tank and a floor under it using soil grouting techniques. To make a watertight structure they proposed to inject three rows of interlocking points. This would form a grout envelope approximately 1.8 m (6 ft) thick around the tank and 1.8 m (6 ft) thick on the floor.

Prior to construction of the grout barrier, two test points in soil adjacent to the underground tank was injected to a depth of 5.5 m (18 ft). These tests gave initial data on "ease of drilling," pumping rates and pressures that could be used in the test site without grout returning to the surface. The pumping rate is a significant factor in computing gel time. Figure 2 shows a section of the test grout column produced by the injection technique described above. Fracture of the grout is along the sediment bed planes. Figure 3 is another section of the same column. Both show clearly the form the injected grout produces for a set volume and pressure.

CONSTRUCTION OF THE TANK WALL

A grout formation was constructed from a series of points or columns of grout. Each column of grout injected soil was 4.6 m (15 ft) tall and 0.9 m (3 ft) diameter. To form an ideal column 106 liters (28 gallons) of grout was injected at a depth of 1.2 m (4 ft). The grout is assumed to occupy the void volume of a 0.9 m (3 ft) sphere. The end of the grout pipe is advanced downward 0.3 m (1 ft) where 53 liters (14 gal.) of grout are injected. This is expected to form a soil-grout

FIGURE 1

TANK CONSTRUCTION

FIGURE 2

GROUT TEST SECTION

FIGURE 3

GROUT TEST SECTION

matrix occupying a disk, 0.9 m (3 ft) in diameter and 0.3 m (1 ft) tall. Repetition of this last step will produce a grout column of the desired length.

Twenty points at a radius of 2.0 m (6.5 ft) were laid out and numbered clockwise around the simulated tank (Figure 4). Each point, theoretically would just be touching the tank and would overlap the adjacent injections by about 15 centimeters (6 inches). Odd numbered points were injected first to allow the grout to set. Even numbered points were then injected to lock together the inner ring.

An outside ring of 30 points was laid out and numbered at a radius of 2.9 m (9.5 ft). These points were designed to just contact the inner ring. Neighboring members of this ring overlap each other by approximately 15 cm (6 in.).

Between the inner and outer rings is a lockup ring of 25 points at a radius of 2.6 m (8 ft). The purpose of this ring is to fill voids between the inner and outer ring. Grout is injected at each point until the point will not take any more. It was expected that about 380 liters (100 gal.) would be required for each point. Only 114 liters (30 gal.) on the average was required.

CONSTRUCTION OF THE TANK FLOOR

To make the floor of the tank, a 4.9 m (16 ft) deep and 3.1 m (10 ft) wide working pit was dug. This exposed the outer wall of the vertical grout so that horizontal injections could be made. A horizontal string and a plumb line were used to establish a reference line tangent to the outside wall. This reference line was used to determine the position and the depth of injection points.

Originally the plan had been to inject 7 points at a depth of 4.3 m (14 ft) and 7 points at 5.2 m (17 ft). A lockup row of 6 points would be at 4.7 m (15.5 ft).

This pattern was not used because: (1) points 1 and 7 at the edges of the tank floor were found to be solid grout. This indicated good penetration of grout at this level, and (2) it was not feasible to dig the working pit any deeper with the equipment available.

The pattern used consisted of 7 points at 4.3 m (14 ft) and 6 points 4.6 m (15 ft). Due to return of grout out of the hole around the drill, the crew was unable to advance in one-foot increments as had been done in making the wall. To get penetration they had to drill the full length of the hole and seal the mouth of the hole around the drill pipe with rags. This did not permit very high pumping pressures. Better results have been obtained by using a packer (a type of packing gland). Figure 5 shows a graphic representation of the finished grout.

FIGURE 4
INJECTION POINTS

FIGURE 5
GRAPHIC ILLUSTRATION OF FINISHED GROUT

EQUIPMENT

All the grouting equipment used was pneumatically driven. The mixing and pumping equipment was mounted on a small trailer. The trailer contained two complete mixing and pumping systems. Auxiliary pumps could also be controlled from the trailer. A schematic of a mixing system is shown in Figure 6. Grout was normally pumped at 15-23 liters per minute (4-6 gal./min) at pressures ranging from 50-90 pounds per square inch gauge. At higher pressures (120-140 psig) the rate was slower, about 11 liters/minute (3 gal./min).

Grout was injected with an air powered drill. One-inch drill pipe and bits were used.

FIGURE 6
EQUIPMENT SYSTEM

EXCAVATION OF TANK CENTER

In excavating the center of the simulated tank, observations were made of the grout flow pattern and the different sediments encountered in the test area. The sediment and grout was removed by the use of shovels and a mobile vacuum truck. The excavation was started October 1, 1976 and finished on October 25, 1976.

The first grout appeared at the 1.7 m (5 1/2 ft) level. At this depth the grout horizontal penetration was so great that it flowed across the opening of the tank and sealed it off. Piercing the grout required considerable effort. After much pounding, a 61 cm (2 ft) diameter hole was opened through this layer. With an extension of the vacuum hose, the hole was extended to the 3.1 m (10 ft) depth. By undercutting the grout plume, the diameter of the hole was enlarged to approximately 2.12 m (7 ft) by breaking off large chunks of grout. A clay lense 1.3 cm (1/2 in.) thick located at the 1.9 m (6 ft 3 in.) depth probably accounts for the lateral spread of the grout. The sediment 46 cm (1 1/2 ft) below the lense showed a wet coarse to medium sand with small pebbles that contained some grout. Ammonia odor was detected indicating some penetration of the grout. The sand below 2.35 m (7 ft 8 in.) appeared dry, this was removed until grout was encountered at the 3.1 m (10 ft) depth. The hole was then widened to 2.6 m (8 1/2 ft) diameter and 3.26 m (10 ft 8 in.) depth for preparation of the leak test.

The grout formation and sediment layers are identified in Figure 7. The drawing shows how the grout flowed in the sediments, these were identified in excavation of the center of the tank and in the excavation of the outer wall. Grout penetration was identified by smell and color. The odor of ammonia was very evident when grout was present. The use of phenolphthalein solution turned a grouted area pink. The use of this solution on the excavated outer wall showed that the silt lense present in the sediment effected the flow of the grout (Figure 8).

LEAK DETECTION

In order to identify a leak in a specific location of the grouted tank a Battelle-Northwest leak detection system was set up around the perimeter of the grouted area. The BNW electrode DC potential system had been tested in the tank farm and underground waterlines to detect for leaks. This system has detected leaks as low as 19 liters (5 gals.) in past tests. It measures the potential differences in millivolts changes in the sediment around the area to be tested. It was expected that a continuous leak would produce changes which were easily observed.

FIGURE 8

SILT LENSE AND GROUT - IN OUTER WALL

The system consisted of eight electrodes set in the ground at various depths, these were individually wired to a 1268 Data Logger. Base readings were taken prior to water addition, and readout was set on a ten minute cycle. An arrangement of the electrodes shown in Figure 9. On October 29, 1976 water was added to the simulated tank, visual observation confirmed that a leak existed. A drop of 10.2 cm (4 in.) from a reference point .95 cm (3/8 in.) rod positioned at the top of the tank in 30 minutes was noted. In eight days all the water had drained out of the tank. The readouts on the DC system were continued during this period. The difference in the field potential changes were not as great as expected from the visually observed leak. This could be attributed to the presence of water in the grout.

Figure 10 is a plot of water level change as a function of time. The solid line of the graph represents the drop of water level in the grout hole after its initial filling October 29, 1976. The leak resulted in approximately a 10.2 cm (4 in.) drop in water level per day after it had reached steady state. This is about 26.5 liters (7 gals.) per hour. The hole was allowed to go dry and then sealed with an asphalt emulsion. After refilling with water, the leak rate was down to about 5.3 liters (1.4 gals.) per hour as shown by the dotted line on the graph.

Examination of the data indicates that most of the flow was through the floor of the tank. The differences in the field potential changes were not as great as expected. There was no confirmation of water leaking through the vertical walls.

RESULTS AND CONCLUSIONS

The technique of encompassing an underground tank with a sodium-silicate grout was demonstrated.

- (a) Vertical grouting was not effective at depths less than 0.9 m (3 ft). At depths less than 0.9 m (3 ft) the drill hole would not seal and the grout would not penetrate.
- (b) Some difficulty was observed with the drilling operation when passing through gravel layers. Penetration of extensive layers of cobble may not be feasible with this technique.
- (c) Horizontal grouting was not as successful as vertical grouting due to the failure of the drill holes to seal. This technique would be improved by the use of a packer.

FIGURE 9

BATTELLE-NORTHWEST LEAK DETECTION SYSTEM

FIGURE 10
GRAPH OF LEAK RATE

- (d) Return of liquid to the surface was observed during vertical and horizontal injection. This would be unacceptable in a potentially contaminated area unless injection techniques could be improved to eliminate this problem.
- (e) The test did not meet the final criteria of a complete containment but did show that sediments in the 200 Areas will readily accept a silicate grout in great volumes.
- (f) Improved injection techniques into silt and clay layers, plus a method of identifying grout flow could improve performance to encompass an underground tank.

RECOMMENDATIONS ON FUTURE WORK

Future work on encompassing waste tanks should include:

- (a) Close liaison with experienced vendors.
- (b) Lab tests to note leaching, moisture penetration, strength, and durability with time of affixed sediments.
- (c) Methods of measuring coverage, e.g., neutron activation.
- (d) Effects of microorganisms, plant growth, and animals on affixed sediments.
- (e) Continued attention to ongoing field studies as well as new field studies to optimize types and concentrations of affixants, additives, methods of injection (e.g., vibratory driller), use of double-injection (e.g., sodium silicate - calcium-chloride formamide followed by asphalt emulsion).
- (f) Pressure measurement techniques to insure no undue pressure exerted on tanks.
- (g) Field tests to monitor time-dependent changes in Transport Factors for affixed areas versus unaffixed areas.

APPENDIX

PROCEDURESGrout Preparation

Two separate component grout solutions were prepared. One with water, sodium silicate and penechem and the other with formamide, calcium chloride, water and vanadium pentoxide. The desired gel time was 20 to 30 minutes. The following procedure was used:

Tank No. 1

1. Turn on agitator. Do not turn off until the tank is empty.
2. Fill tank to 378 liter (100 gal.) mark with water.
3. Add vanadium pentoxide tracer (optional -0.9 g used in test).
4. Add 53 liters (14 gal.) of formamide.
5. In a bucket dissolve 4.1 kilograms (9 lbs) calcium chloride into about 19 liters (5 gal.) of water. (The amount of calcium chloride required is determined from the grout temperature and the desired gel time. Increasing the amount of calcium chloride or increasing the temperature decreases the gel time. The gel time of a small sample from each batch is recorded.)
6. Slowly add the calcium chloride solution to the formamide solution.
7. Add sufficient water to bring the volume to 530 liters (140 gal.)

Tank No. 2

1. Turn on agitator.
2. Fill the tank to the 265 liter (70 gal.) mark with water.
3. Add sodium silicate, fill to the 530 liter (140 gal.) mark.
4. Add one cup of penechem. (Penechem is a dispersent used by the Pressure Grout Company to increase the penetration of the grout in tight soils, i.e., high silt content. Penechem works by reducing the surface tension of the grout. Penechem is the private formulation of the Pressure Grout Company and is not commercially available.

Preparation of Bentonite Slurry

A slurry of bentonite is prepared in a mixer by adding approximately 227 g (1/2 lb) of bentonite for each 3.7 liters (1 gal.) of water.

Bentonite is used to lubricate the drill pipe when it binds. Binding is usually caused by gravel layers.

The slurry must be injected after injection of the ground and before the drill is advanced. If bentonite is injected first, it will seal the hole and prevent penetration of the grout. Eleven liters (3 gal.) of slurry is sufficient.

Techniques of Injection

Jetting

Pumping a liquid through a pipe so that the pipe can be pushed into the soil is referred to as jetting. Advancement of the point by this method is rapid and relatively easy. It is well adapted for use in sandy and unpacked soils. Advancement by this technique into gravel or packed layers usually is not feasible.

Procedure

1. Water is pumped through the pipe while the same time pipe is moved up and down.
2. When the desired depth is reached, the water is turned off.
3. Wait 15 to 20 minutes to allow the mud to seal around the pipe.
4. Pump the calculated amount of grout for that depth.
5. Advance the pipe while pumping grout to the next depth. Pump the required amount of grout for that depth.

Injection by a Rotating Drill

A rotating drill is usually capable of penetrating gravel and hard packed silt layers. Pressure Grout Company used 2.54 cm (1 in.) drill pipe to grout the soil. The drill pipe was rotated by a hand-held air powered drill. Grout was pumped to the pipe through a swivel fitting.

Vertical Injection

Personnel of Pressure Grout Company used the following for vertical injections.

1. Drill pipe was jetted down to 1.2 m (4 ft) with water. (Jetting makes a smaller hole around the pipe than drilling.)
2. A pneumatic drill was attached to the pipe. Mud in the hole was allowed to seal around the pipe. (15 to 20 minutes)
3. After the hole was sealed, 106 liters (28 gal.) of grout were pumped in. (By experience this will produce a 0.9 m (3 ft) diameter sphere of grouted soil assuming 26 percent void space.)
4. When the required amount of grout has been pumped, the drill is advanced one foot. Advancement of the drill is by simultaneously pumping grout and rotating the drill. To prevent binding or clogging of the bit the drill is supported rather than forced into the ground.
5. Upon reaching the next depth 58 liters (14 gal.) of grout were pumped (26 percent of 0.9 m [3 ft] diameter, 0.3 m [1 ft] thick disk).
6. Step 5 is repeated until the desired depth is reached.
7. At times a floc will form in the grout. This plugs the soil and causes the grout to flow out the top of the hole. Rotation of the drill will breakup the floc and stop the return.
8. Layers of gravel cause the drill bit to bind. A bentonite slurry is used to lubricate the outside of the drillpipe. After injecting the grout, the drill is pulled up 15 to 30 cm (6-12 in.). Eleven liters (3 gal.) of a bentonite slurry are injected into the hole while the drill is intermittantly rotated. As bentonite also seals the soil, the drill must not be advanced until grout is coming out the bit. This is determined by flow-meter readings and the volume of the hose.
9. If the point doesn't "take" grout at a particular level, the drill is advanced to the next depth. An additional amount of grout equal to the amount that returns to the surface is pumped at the new level.
10. Upon completion of the grouting, the amount of grout is plotted against its depth and position to determine void areas. If a void is larger than one location, an attempt should be made to regrout that point.

Horizontal Injection

Horizontal grouting used the same basic technique as vertical grouting. This procedure was modified due to a large return of grout out the hole caused by difficulty in sealing the hole. Due to the low hydrostatic head, the grout tends to wash the mud out of the hole. This prevents a seal from forming on the pipe. Because of this problem, the hole was drilled the full length and the space around the pipe at the mouth of the hole was packed with rags. This type of seal was not as effective as the mud seal formed in vertical grouting as only low pumping pressures could be used (10-15 psig). It is likely that a packer would have created a better seal. A packer had not been brought as a need for it had not been anticipated.

PRESSURE GROUT COMPANY'S REPORT AND RECOMMENDATIONS

The following report was submitted to Atlantic Richfield Hanford Company on October 4, 1976 by Mr. E. D. Graf, prior to testing the tank for water leakage. Mr. Graf and Mr. H. Thayer of Kaiser Engineering were present during the leak test performed on October 29, 1976.

125 South Linden Avenue • South San Francisco, CA 94080 • 415/871-2244

ATLANTIC RICHFIELD HANFORD COMPANY
Richland, Washington

CHEMICAL GROUTING OF EXPERIMENTAL TANK IN SUBSURFACE SLLDIMENT

ARHCO PURCHASE ORDER NO. W6C-BBB-17559

PURPOSE:

With chemical grout construct an experimental "tank" in subsurface sands. Tank to be 10' inside diameter by 10' deep with the bottom formed by horizontal injection technique. After completion of injection the tank will be excavated and tested for permeability by ARHCO.

EQUIPMENT:

All equipment used was pneumatically operated. Grout unit consisted of four mixing tanks, two pairs of proportioning transfer pumps, and two reciprocating injection pumps. All grout was injected through pneumatic drills. A water truck was provided by ARHCO together with a tank trailer for silicate storage.

PERSONNEL:

Grouting personnel on job consisted of 1 foreman, 1 equipment operator, and 1 grout laborer.

MATERIAL:

Chemical grout material was a mix of sodium silicate, formamide, calcium chloride, and penechem with a gel time of approximately one-half hour. Mix records indicate the range of mixes used to facilitate the work. The materials, as used, were injected as a pure solution (no particles in suspension) with a viscosity of 3 to 6 centipoises.

SITE CONDITIONS:

The site was a sandy open field in the 200 West area. Based on injection records and the "feel" of the drills, the top four feet was a silty sand containing too much silt to allow penetration of the grout under surface conditions. Underlying the silty sand to the maximum injection depth of 17 feet the soil was felt to be stratified deposits of fine sands to coarse sands and some gravel.

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GROUTING PLAN:

"Tank walls" were injected vertically in three stages: first stage consisted of 20 injection points on a 13' diameter circle (inner row); second stage consisted of 30 injection points on an 18' diameter circle (outside row); and, third stage consisted of 25 injection points on a 15½' diameter circle (middle row) as a lockup.

In all three stages injection of grout began 4' below grade and advanced in one foot increments to 16' below grade. Quantities pumped were calculated to form a theoretical cylinder 3' diameter and 14' long at each point. Procedure used was to grout alternate points and then "locking up" with intermediate points.

Upon completion of the vertical injections a pit was dug exposing the north face of the grout tank to a depth of 16'. Two inch vertical pipe braces were installed and tied back by ARHCO for wall stability when excavated. The tank bottom grouting was accomplished in the pit in two stages: first stage, 7 injection points at 14' below grade; and, second stage, 6 injection points at 15' below grade.

In both stages points were drilled through grouted sides of "tank" and injections began upon reaching ungrouted center and continued in 1' increments until reaching the grouted sand on the far side.

GROUT TAKE OBSERVATIONS:

Total quantity pumped in the tank walls was 11,880 gallons and the tank bottom was 840 gallons.

Combined quantity for Stages 1 and 2 in the tank walls was 10,689 gallons while Stage 3 took only 840 gallons, indicating a good lockup between the first and second stages.

For the most part, grouting proceeded as planned with the exception being in the north half at the four foot level. Penetration of the sands in this area was accomplished by jetting to that 4' level at approximately 6" o.c.

The horizontal injection required drilling the full length and then sealing off the point at the face and pumping under pressure.

It is our opinion that the tank is injected as well as could possibly be done, particularly in view of the grout "takes" and the face exposed by the excavation of the working pit. We feel that the only possible "holes" would be silt or clay pockets or the silty sands in the top few feet where we are unable to develop enough pressure for successful penetration.

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CONCLUSIONS:

As requested in the purchase order, following are answers to particular questions:

- (1) Detailed mix records and quantities were submitted daily and are on file. Regarding the method of grout injection, of importance is that the advancing point injection technique was used to minimize effects of the stratification.
- (2) Pressure gauges with deep diaphragm gauge protectors were maintained at the point of injection. Pumping logs, on file, record these pressures at each point of injection. Quantities of grout at each point were pre-calculated and measured through standard meters at the pump.
- (3) Conclusions and recommendations for pressure grouting as a method of encompassing underground tanks:
 - A. This method should be a viable and effective method of substantially reducing permeability of subsurface soils around underground tanks based on the soil conditions at the tank site. The method would not be recommended for silt or clay soils with our current injection technology.
 - B. Some concern has been voiced regarding the danger to the steel underground tanks themselves due to the grouting pressures. With proper injection procedures and techniques it is inconceivable that the tanks could be damaged. Factors of importance to preclude tank damage are as follows:
 - a. All grouting to proceed from immediately adjacent to the tank outward.
 - b. Combining the factor of gel time and pumping rate the effective area of a hydraulic piston working in the soil against the tank will be held to a minimum. Pressures that are theoretically unsafe must be used for economic injection. However, by controlling the size of the hydraulic piston against the tank there is no danger of collapsing the tank.
 - c. A third factor is the safety valve effect of the natural bedding of the soil combined with the weakness of the soil relative to the strength of the tank. If a hydraulic piston were to develop, the primary area of pressure would be in the vertical direction due to horizontal bedding of the soils. Theoretically 1 to 2 p.s.i. per foot of depth will lift the soil mass above the grout. This pressure is far less than that required to collapse a tank.

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C. Our most important recommendation is the absolute necessity of engaging a contractor thoroughly experienced in this type of work for future work. Chemical grouting methods and techniques have not been quantified. The subtle variations of technique that were used in doing this test project are only learned by years of experience on a wide variety of problems and by observing a number of unfortunate failures. Because of the nature of the work we used one of our best foremen, a university graduate with almost eight years of experience in this field, and even then he was faced with problems on which he needed assistance from more experienced people in the office.

Edward D. Graf

October 7, 1976

COST CALCULATIONS

COST BREAKDOWN

A cost basis developed for the work in constructing a grouted impermeable wall and floor around a 22.5 m (75 ft) tank or tank farm can be based on the cost of this test. The material and man hours for this test was as follows.

Sodium Silicate	11,578 liters (3,055 gals.)
Formamide	2,467 liters (651 gals.)
	<hr/> 14,045 liters (3,706 gals.)
Calcium Chloride	20.2 kg (445 lbs)
Total Man/Hours	290
TOTAL COST OF CONTRACT - \$37,674.00	

An approximate estimate made for grouting an individual waste tank is as follows.

Individual Tank

Total Material	
Sodium Silicate	792,110 liters (209,000 gals.)
Formamide	168,181 liters (44,375 gals.)
	<hr/> 960,291 liters (253,375 gals.)
Calcium Chloride	1,376 kg (30,300 lbs)
Chemical Cost	\$593,000
Labor 7,180 man/hours @\$15.00 IME	\$108,000
Equipment and Miscellaneous	<hr/> \$105,000
TOTAL COST	\$796,000/Tank

The above cost is based on a 2.1 m (7 ft) grout barrier for the wall and the same thickness for the floor.

COST ESTIMATE GROUTING OF T-TANK FARM

T-Tank Farm contains 16 tanks on approximately 30 m (100 ft) centers. The farm is approximately 120 m (400 ft) X 120 m (400 ft) square.

Based on our calculations the approximate cost would be nine million dollars. A breakdown would be as follows.

Material		Dollars
Sodium Silicate	9.85 X 10 ⁶ liters (2.6 X 10 ⁶ gals.)	3.5 X 10 ⁶
Formamide	2.06 X 10 ⁶ liters (5.44 X 10 ⁵ gals.)	3.8 X 10 ⁶
Calcium Chloride	16,800 kg (3.7 X 10 ⁴ lbs)	6.3 X 10 ⁴
SUB TOTAL		7.4 X 10 ⁶
Labor		1.3 X 10 ⁶
Equipment		1.0 X 10 ⁵
TOTAL		8.8 X 10 ⁶

The above totals approximately nine million dollars does not include excavation and shop hookup for grouting pits and other contingencies.

FIGURE 11
GROUTING EQUIPMENT

FIGURE 12

GROUT HOLES

FIGURE 13

TANK EXCAVATION START

FIGURE 14

TANK EXCAVATION - COMPLETE

FIGURE 15

LEAK TEST OF GROUT