REPORT DOCUMENTATION PAGE

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12a. DISTRIBUTION/AVAILABILITY STATEMENT

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

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13. ABSTRACT (Maximum 200 words)

THIS DOCUMENT CONTAINS STANDARDS AND SPECIFICATION REQUIREMENTS FOR EXPANSION OF THE NORTH BOUNDARY LIQUID WASTE DISPOSAL EXPANSION. STANDARDS INCLUDED ARE THOSE OF THE: AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM); CORPS OF ENGINEERS; COLORADO DEPT. OF HIGHWAYS; AMERICAN PETROLEUM INST. (API); AMERICAN NATIONAL STANDARDS INSTITUTE INC. (ANSI) AND ALSO FEDERAL SPECIFICATIONS. CONSTRUCTION DIVISIONS WITHIN THE DOCUMENTS ARE: GENERAL REQUIREMENTS; SITE WORK; CONCRETE; METALS, STRUCTURAL AND MISC.; FINISHES; SPECIALITIES; SPECIAL CONSTRUCTION; MECHANICAL; ELECTRICAL. THIS DOCUMENT IS NOT COMPLETE ACCORDING TO THE TABLE OF CONTENTS.

14. SUBJECT TERMS

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TECHNICAL PROVISIONS

LIQUID WASTE DISPOSAL FACILITY
NORTH BOUNDARY EXPANSION
ROCKY MOUNTAIN ARSENAL
Commerce City, Colorado

FY 80

Project No. 34

Prepared for

U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
Omaha, Nebraska

Prepared by

BLACK & VEATCH
CONSULTING ENGINEERS
Kansas City, Missouri

LIST OF SPECIFICATION SECTIONS

DIVISION 6 - NOT USED

DIVISION 7 - NOT USED

DIVISION 8 - NOT USED

DIVISION 9 - FINISHES

- 9A Painting, General
- 9B Decorating Schedule (Interior Design Schedule)

DIVISION 10 - SPECIALTIES

- 10A Slurry Trench Ground Water Barrier

DIVISION 11 - NOT USED

DIVISION 12 - NOT USED

DIVISION 13 - SPECIAL CONSTRUCTION

- 13A Metal Buildings
- 13B Monitoring Wells - Alluvium
- 13C Denver Sand Monitoring Wells
- 13D Denver Sand Dewatering Wells (DW 36 to DW 54)
- 13E Dewater Wells
- 13F Recharge Wells

DIVISION 14 - NOT USED

ZERO ACCIDENTS

SECTION 2D
EXCAVATION AND BACKFILLING FOR WORKING SURFACE, SLURRY TRENCH

INDEX

1. APPLICABLE PUBLICATIONS. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto.

1.1. MILITARY STANDARDS (Mil. Std.).

MIL-STD-619B	Unified Soil Classification System for Roads, Airfields, Embankments and Foundations
MIL-STD-621A & Notices 1 & 2	Test Method for Pavement Subgrade, Subbase, and Base-Course Materials

1.2. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS.

D 1556-64 (R 1974)	Density of Soil in Place by the Sand-Cone Method
D 2167-66 (R 1977)	Density of Soil in Place by the Rubber-Balloon Method
D 2922-78	Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

2. GENERAL. This section covers the excavation and backfilling for the ground water barrier working surface area.

3. EXCAVATION.

3.1. GENERAL. All excavation of every description and of whatever substances encountered shall be performed to the depths indicated or as otherwise specified. During excavation, material suitable for backfilling shall be piled in an orderly manner a sufficient distance

from the slopes of the working surface area to avoid overloading and to prevent slides of cave-ins. All excavated materials not required or suitable for backfill shall be removed and wasted as indicated or as directed. Grading shall be done as shown on the drawings to prevent surface water from accumulating at the center line of the slurry trench installation. Water accumulating at low spots in the ditches at the edge of the working surface shall be removed by pumping or by other approved methods.

3.2. WORKING SURFACE AREA EXCAVATION. The area shall be as shown on the drawings to permit operation of slurry trench equipment and preparation of slurry trench backfill material. The sides shall be sloped as shown on the drawings to reduce sloughing effects. The elevation of the working surface shall be as shown on the drawings. However, the Contractor may construct, at no expense to the Government, a working surface to a level higher than the defined working surface for his own convenience providing it is approved by the Contracting Officer. There will be no payment for any additional excavation, fill, or slurry trench cutoff required as the result of constructing for the convenience of the Contractor, a higher level working surface than the defined working surface. In the event that the static ground water table is encountered at a depth of 1.0 foot or less below the stripped surface, the Contractor shall, at the direction of the Contracting Officer, raise the working surface by placing compacted fill to a height of 1.0 foot above the measured static ground water table. Wherever backfill is required to construct the working surface area, it shall be installed at 90 percent of the maximum density.

4. REMOVAL OF UTILITY LINES. When utility lines that are to be removed are encountered within the area of operations, the Contracting Officer shall be notified in ample time for the necessary measures to be taken to prevent interruption of the service.

5. BACKFILLING. The working surface area shall not be backfilled until the construction and installation of the slurry trench is completed in the immediate area at the consent of the Contracting Officer. The material excavated and stockpiled from the area may be used to backfill the area. Additional material may be required to achieve final grades as shown on the drawings and shall be obtained from the borrow areas indicated on the drawings.

5.1. BACKFILL MATERIALS AND REQUIREMENTS. The backfill material shall all be sound and free of injurious amounts of deleterious materials. The backfill material shall be free of stones larger than 6 inches or 1/2 the layered thickness, whichever is smaller in any dimension. Backfill material shall be deposited in layers not exceeding 12 inches. The degree of compaction shall be 85 percent of the maximum density obtained by the test procecure presented in MIL-STD-621, compaction

effort designation CE 55, or to a degree acceptable to the Contracting Officer.

5.2. FIELD TESTNG CONTROL. Testing shall be the responsibility of the Contractor at his expense and shall be performed by an approved commercial testing laboratory. When test results indicate that compaction is not as specified, the material shall be removed and replaced or recompacted to meet specification requirements at no expense to the Government. Subsequent tests on recompacted areas shall be performed to determine conformance with specification requirements.

5.2.1. Quality Controls. All quality control sampling and testing shall be performed by the Contractor in accordance with paragraph: CONTRACTOR QUALITY CONTROL of SECTION: SPECIAL PROVISIONS and as follows:

5.2.1.1. Density-Moisture Determinations. Tests for determination of maximum density and optimum moisture shall be performed by the Contractor in accordance with the requirements of MIL-STD-621, Method 100, compaction effort designation CE 55. Samples shall be representative of the materials to be placed. An optimum moisture-density curve shall be obtained for each principal type of material or combination of materilas encountered or utilized. Results of these tests shall be the basis of control for compaction. The above testing shall include Atterberg limits, grain size determinations and specific gravity.

5.2.1.2. Density Control. The Contractor shall control the density of the backfill by tests made in accordnace with ASTM D 1556, D 2167, or nuclear devices. Nuclear testing equipment and procedures shall conform to ASTM D 2922. Nuclear methods for determining in-place density and moisture may be used for 100 percent of tests on fill for the working surface area. A density test shall be made for each foot of fill for each 200 linear feet or less of working surface area. The Contractor shall make as many additional tests as he requires to obtain the specified density at all points. All tests results shall be furnished daily to the Contracting Officer. Density check tests may be made by the Government.

ZERO ACCIDENTS

SECTION 2G
GRAVEL SURFACING

INDEX

1. APPLICABLE PUBLICATIONS. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1.1. MILITARY STANDARD (Mil. Std.).

MIL-STD-621A & Notices 1 & 2	Test Method for Pavement Subgrade, Subbase, and Base-Course Materials

1.2. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS.

C 88-76	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
C 117-76	Materials Finer Than No. 200 (75 m) Sieve in Mineral Aggregates by Washing
C 131-76	Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
C 136-76	Sieve or Screen Analysis of Fine and Coarse Aggregates

D 75-71 (R 1978)	Sampling Aggregates
D 422-63 (R 1972)	Particle-Size Analysis of Soils
E 11-70 (R 1977)	Wire-Cloth Sieves for Testing Purposes

1.3. U.S. ARMY CORPS OF ENGINEERS HANDBOOK FOR CONCRETE AND CEMENT.

CRD-C 130-77	Scratch Hardness of Coarse Aggregate Particles

1.4. STATE OF COLORADO DEPARTMENT OF HIGHWAYS, STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION (1976).

703.03	Aggregate for Bases

2. DEGREE OF COMPACTION required under the paragraph: COMPACTION is expressed as a percentage of the maximum density obtained by the test procedure in MIL-STD-621, Method 100, compaction effort designation CE 55. This will be abbreviated hereinafter as percent CE 55 maximum density.

3. MATERIALS. Aggregates shall consist of crushed stone, crushed gravel, angular sand or other approved sound, durable materials processed and blended or naturally combined. Aggregates shall be durable and sound, free from foreign materials such as organic matter, lumps of clay and coatings. Disintegrated granite shall not be used for production of any aggregate and the processed aggregate shall contain not more than 2.0 percent by weight of disintegrated granite particles in that portion of the total sample larger than the No. 4 sieve and not more than 4.0 percent in any individual sieve size listed in the required aggregate gradation for that portion larger than the No. 4 sieve. A disintegrated granite particle is defined as a soft, crumbly particle of igneous rock having a visible crystalline grain size and consisting essentially of feldspar and quartz with lesser amounts of micas and/or amphiboles and pyroxenes. Generally, the rock particle will be stained by iron oxide and the feldspar grains will have a dull, highly fractured appearance. The individual mineral grains are so weakly bonded that the particle will crumble under moderate pressure. When tested by Test Method CRD-C 130 the particle would be classified as soft. The Contractor shall obtain materials that meet the requirements specified herein and that can be constructed to meet the gradation, compaction and smoothness requirements specified herein after placement. The material retained on

a No. 4 sieve shall be known as coarse aggregate; that passing the No. 4 sieve shall be known as binder material.

3.1. COARSE AGGREGATE conforming to the requirements specified above shall have a percentage of wear not to exceed 50 percent after 500 revolutions. When subjected to 5 cycles of the soundness test, in accordance with ASTM C 88 using magnesium sulfate, the loss in weight of coarse aggregate shall not exceed 18 percent. Coarse aggregate shall consist of crushed rock or crushed gravel having angular fragments uniform in density and quality. The amount of flat and elongated particles shall not exceed 30 percent. A flat particle is one having a ratio of width to thickness greater than 3, and an elongated particle is one having a ratio of length to width greater than 3. Crushed gravel shall conform to the requirements of Crushed Gravel or Coarse Aggregate below. The Contractor shall notify the Contracting Officer in writing stating which subparagraphs the crushed gravel shall conform to, and the selected paragraph requirements shall be mandatory for the entire job.

3.1.1. Crushed Gravel shall be manufactured from gravel particles 50 percent of which by weight are retained on the maximum size sieve listed in GRADATION below.

3.1.2. Coarse Aggregate retained on each sieve specified shall contain at least 50 percent by weight of crushed pieces having two or more freshly fractured faces with the area of each face being at least equal to 75 percent of the smallest midsectional area of the piece. When two fractures are adjacent, the angle between the planes of the fractures must be at least 30 degrees to count as two fractured faces.

3.2. BINDER MATERIAL shall consist of screenings, angular sand or other finely divided mineral matter processed or naturally combined with the coarse aggregate. The portion of any component, or of the completed course passing the No. 40 sieve shall be either nonplastic or shall have a liquid limit not greater than 25 and a plasticity index not greater than 5.

3.3. GRADATION requirements shall apply to the completed surface course. The maximum size of aggregate shall be not over 1/2 inch and the material shall be well graded within the limits specified for Class 6 aggregate in Section 703.03 of the State of Colorado Department of Highways Standard Specifications for Road and Bridge Construction. All the material furnished for the project shall conform to the designated gradations after placement and compaction.

Particles having a diameter less than 0.02 millimeter shall not exceed 3 percent of the aggregate weight in the completed course. The specified gradations represent the extreme limits which shall determine

suitability of aggregate for use from all sources of supply. The aggregate used in the work shall have a gradation within the limits designated, and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but shall be well graded from coarse to fine.

4. APPROVAL, SAMPLING AND TESTING. Sampling and testing shall be the responsibility of the Contractor and shall be performed at no additional cost to the Government. Sampling and testing shall be performed by an approved commercial testing laboratory, or by the Contractor subject to approval. Tests shall be performed at the frequency specified hereinafter. Copies of test results shall be furnished to the Contracting Officer as soon as tests are performed and in every case prior to placing subsequent construction over completed base course.

4.1. GENERAL. The Contractor shall select the source of materials and perform initial sampling and testing sufficiently in advance to not delay the work. The Contractor shall control his operations during production and placement of material, so that materials in the completed course will meet specified requirements. All quality control sampling and testing shall be performed by the Contractor in accordance with paragraph: CONTRACTOR QUALITY CONTROL in SECTION: SPECIAL PROVISIONS, and as specified herein. The Government may perform verification tests for final approval of materials in the completed course.

4.2. SAMPLES. All samples including those required and used by the Contractor for control of his operations, shall be representative of materials being placed. In addition, samples shall be taken from completed and compacted course. All samples shall be taken in conformance with ASTM D 75 unless otherwise approved or directed.

4.3. TESTS. The following tests shall be performed by the Contractor.

4.3.1. Sieve Analyses shall be made in accordance with ASTM C 117, C 136, and D 422. Sieves shall conform to ASTM E 11.

4.3.2. Wear (L.A. Abrasion) Test shall be made in conformance with ASTM C 131.

4.3.3. Soundness shall be determined in accordance with ASTM C 88 using magnesium sulfate.

4.3.4. Liquid-Limit and Plasticity-Index shall be determined in accordance with MIL-STD-621, Method 103.

4.3.5. Moisture-Density Determinations. The maximum density and optimum moisture shall be determined in accordance with MIL-STD-621, Method 100, compaction effort designation CE 55.

4.3.6. Field Density. Density shall be controlled in the field by the Contractor in accordance with MIL-STD 621, Method 106, or by approved nuclear devices, provided such devices operate to the satisfaction of the Contracting Officer. The minimum size sample hole for the density test shall be 0.075 cu ft for 1-inch maximum particle size and 0.100 cu ft for 2-inch maximum particle size. If nuclear devices are used, not less than 1 of every 5 consecutive field density tests shall be in accordance with MIL-STD 621, Method 106 to provide correlation.

4.3.7. Crushed Particles shall be determined by visual examination and measurement.

4.4. TESTING FREQUENCY.

4.4.1. Initial Tests. One of each of the following tests shall be performed on the proposed material prior to commencing construction to demonstrate that the proposed material will meet all specified requirements when furnished and after placing and compaction.

Sieve Analysis including 0.02 mm size material

L.A. Abrasion

Particle Shape

Crushed Particles, unless material is crushed quarried rock

Soundness

Liquid-Limit and Plasticity-Index

Moisture-Density Relationsihp

4.4.2. In-Place Tests. One of each of the following tests shall be performed on samples taken from the placed and compacted base course. Samples shall be taken for each 2,000 square yards of each layer of material placed in each area.

Sieve Analysis including 0.02 mm size material

Field Density and Moisture

Liquid-Limit and Plasticity-Index

Crushed Particles, unless the material is crushed quarried rock or unless otherwise approved

5. SUBMITTALS. In accordance with SECTION: SPECIAL PROVISIONS, the Contractor shall submit for approval, data as specified herein on the following:

5.1. CATEGORY I. None.

5.2. CATEGORY II.

Copies of test results

6. EQUIPMENT. All plant, equipment, tools and machines used in the performance of the work shall be subject to approval prior to commencement of work. This equipment shall be maintained in satisfactory working condition at all times.

7. OPERATION OF PITS OR QUARRIES. All work involved in the clearing, stripping, and excavating in opening or operation of pits or quarries shall be performed by the Contractor. Upon completion of the work, the pits or quarries on Government reservations shall be conditioned in such manner as to drain readily, and these areas shall be left in a condition that is satisfactory to the Contracting Officer in all respects. Pits or quarries on private lands shall be conditioned in agreement with local laws and authorities.

8. STOCKPILING MATERIAL. Prior to stockpiling of material, storage sites shall be cleared and leveled. Aggregates shall be stockpiled on designated cleared and leveled areas so as to prevent segregation. Aggregates and binders obtained from different sources shall be stockpiled separately.

9. WEATHER LIMITATIONS. Courses shall be constructed only when atmospheric temperature is above 35 degrees F. When the temperature falls below 35 degrees F., the Contractor shall protect, by approved methods, all areas of completed or partially completed gravel surface course against freezing.

10. PREPARATION OF SUBGRADE. Prior to constructing the gravel surface course, the previously constructed subgrade shall be cleaned of all foreign substances. The subgrade shall conform to SECTION: GRADING. Ruts or soft, yielding spots in the subgrade areas having inadequate

compaction, and deviations of the surface from requirements set forth therein shall be corrected to specification requirements prior to placing the gravel surface course. The finished subgrade shall not be disturbed by traffic or other operations and shall be maintained by Contractor in a satisfactory condition until base course is placed.

11. GRADE CONTROL. During construction the lines and grades including crown and cross slope indicated shall be maintained by means of line and grade stakes placed by the Contractor in accordance with SPECIAL PROVISIONS.

12. MIXING AND PLACING MATERIALS. The Contractor shall, as directed, make such adjustments in mixing or placing procedures or in equipment as are necessary to obtain grades within the allowable tolerance, to minimize segregation and degradation, to reduce or increase water content, and to insure meeting all requirements specified herein. Any areas, which after placement, do not conform to these specification requirements shall be removed and replaced with material as specified or remixed to meet specification requirements. One of the following mixing and placement methods may be used.

12.1. STATIONARY-PLANT METHOD. Coarse aggregates and binder materials shall be proportioned by weight or by volume in quantities so that the specified gradation, liquid-limit and plasticity-index requirements will be met. Adjustments of percentages of coarse aggregates and binder material shall be made by the Contractor when directed. Water in approved quantities, measured by weight or volume, shall be added during mixing. Mixing operations shall produce a uniform blend. Finished mixture shall be hauled to the area to be paved in approved pneumatic-tired vehicles. The material shall be placed in a uniform layer to required contour and grades, and to a loose depth that, when compacted, will produce a layer of the designated thickness. The material shall be placed uniformly on the subgrade from moving vehicles, spreader boxes or mechanical spreaders and brought to required contour and grades with blade graders.

12.2. TRAVELING PLANT METHOD. Coarse aggregates and binder materials shall be hauled to the area to be paved in approved pneumatic-tired vehicles and deposited in windrows of such proportions that specified gradation, liquid-limit and plasticity-index requirements will be met. The size of the windrow of combined material shall not exceed the rated capacity of the traveling plant. Adjustments in percentages of coarse aggregates and binder materials shall be made when directed. The materials shall be mixed by the traveling plant and deposited on subgrade in windrows of uniform cross section. Water in approved quantities shall be added during mixing. Mixing operations shall produce a uniform blend. The windrowed mixed material shall be spread by blade graders

and in a layer of uniform thickness to the required contour and grades and to a loose depth that, when compacted, will produce a layer of the designated thickness.

12.3. ROAD-MIX METHOD. Coarse aggregates and binder materials shall be hauled to the area to be paved in approved pneumatic-tired vehicles. Materials shall be spread in layers of uniform thickness from spreader boxes or moving vehicles. Coarse aggregate shall be placed in a layer of uniform thickness on subgrade without segregation of sizes, followed by placing thereon uniform layers of the other materials to such loose depths and proportions that, when mixed together and compacted, the finished layer will conform to specified gradation, liquid limit, plasticity index and designated thickness. The coarse aggregates and binder materials may be placed on the subgrade in windrows of such cross section proportions that, when mixed, spread and compacted, the layer will conform to specified gradation, liquid limit and plasticity index and to the thickness indicated. The windrowed material shall then be spread in a layer of uniform thickness. The material shall be mixed with approved equipment in such manner as not to disturb or mix material from the underlying subgrade into the overlying layer. Initial mixing shall continue until the mixture is uniform throughout, adding water by sprinkling to the extent necessary to prevent segregation during mixing. Mixing shall continue until the water is uniformly distributed throughout. Following this mixing procedure the mixture shall be leveled to the required contour and grades with blade graders.

13. LAYER THICKNESS. The compacted thickness of the gravel surface course shall be as indicated. When a compacted layer of 6 inches or less is specified, the material shall be placed in a single layer.

14. COMPACTION. The gravel surface course including shoulders shall be compacted with equipment as approved. Water content shall be maintained at optimum or at the percentage directed during compaction. In places not accessible to the rollers, the mixture shall be compacted with mechanical tampers. Compaction shall continue until the layer through the full depth is compacted to 100 percent of CE 55 maximum density. The Contractor shall make such adjustments in rolling or finishing procedures as may be required to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to insure a satisfactory gravel surface course. Unsatisfactory materials shall be reworked to produce a satisfactory material.

15. SHOULDERS. Where the pavement section includes shoulders constructed of gravel surface course, the gravel surface course portion of the shoulders shall be constructed in the same manner and simultaneously with the gravel surface course on the roadway. All requirements for

the gravel surface course shall apply to the shoulders. The tapered edge of the shoulders shall be constructed in such manner as the Contractor elects subject to the approval of the Contracting Officer, but the finished surface of the shoulders and tapered edges shall conform to the line, grade, and section shown on the drawings.

16. SMOOTHNESS. The surface of the layer shall show no deviations in excess of 3/8 inch when tested with a 10-foot straightedge applied both parallel with and at right angles to the centerline of the gravel surface course area. Deviations exceeding this amount shall be corrected by removing material and replacing with new material, or by reworking existing material and compacting.

17. THICKNESS CONTROL. The Contractor shall control his operations by measurements to insure placement of materials to the thickness specified. Thickness measurements shall be made by test holes at least 3 inches in diameter through the course. One depth measurement shall be made for each 500 square yards or part thereof of gravel surface course. Measurements may be made by the Government for verification of compliance; however, the Contractor shall not depend on such measurements for his control of operations. The completed thickness of the gravel surface course shall be within 1/2 inch plus or minus of the thickness shown on the drawings. Where the measured thickness is deficient by more than 1/2 inch, the Contractor shall correct such areas by scarifying, adding mixture of proper gradation, reblading and recompacting. The average job thickness shall be the average of the job measurements as specified above but within 1/4 inch of the thickness indicated.

18. MAINTENANCE. The gravel surface course shall be maintained in a satisfactory condition until accepted. Areas of gravel surface course damaged by freezing, rainfall or other weather conditions shall be corrected to meet specified requirements.

ZERO ACCIDENT

SECTION 10A
SLURRY TRENCH GROUND WATER BARRIER

INDEX

1. APPLICABLE PUBLICATIONS. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

1.1. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM PUBLICATIONS.

C 117-76	Materials Finer than No. 200 (75- M) Sieve in Mineral Aggregates by Washing
C 136-76	Sieve or Screen Analysis of Fine or Coarse Aggregates
C 143-74	Slump of Portland Cement Concrete

1.2. AMERICAN PETROLEUM INSTITUTE (API) STANDARD SPECIFICATIONS.

Code RP 13B (dated February 1971)	Standard Procedures for Testing Drilling Fluid
Spec 13A, Sections 3, 5, 6, and 7	Oil-Well Drilling Fluid Materials

2. DEFINITIONS. The terms used in these specifications are defined as follows:

2.1. SLURRY TRENCH is a a trench excavated in the existing overburden and/or fill by the slurry trench method of excavation and back-

filled with a specified material to form a ground water barrier wall which is practically impervious.

2.2. SLURRY TRENCH METHOD OF EXCAVATION consists of constructing an essentially vertical-walled trench and at the same time, keeping the trench filled with slurry. The basic purposes of the slurry in the trench are to provide support for the walls of the trench and to restrict the flow of ground water into the trench excavation.

2.3. SLURRY is a stable collodial suspension of pulverized bentonite in water.

2.4. BENTONITE is a ultrafine natural clay whose principal mineral constituent is sodium cation-based montomorillonite.

2.5. BACKFILL MATERIAL which is placed in the excavated slurry trench consists of a mixtures of slurry and select soil. The soil has the purpose of reducing the amount of bentonite required in the backfill, adds body to the slurry, and reduces the trench compressibility.

2.6. GROUND WATER LEVEL is the piezometric level of the ground water as determined from piezometers and wells penetrating the pervious deposits.

2.7. BEDROCK consists of relatively dense and low permeability clay stone, siltstone, and sandstone.

2.8. WORKING SURFACE is the top of the stripped natural ground or the surface of compacted fill on which the slurry trench shall be constructed. The elevation of the working surfaces shall be as shown on the drawings.

2.9. SLURRY TRENCH/MUD SPECIALIST is an engineer who has proven to have successful experience in slurry trench construction and is knowledgeable with all facets of the construction including: (1) the use, testing and control of bentonite as a slurry, (2) the proper mixing methods employed to mix the slurry and backfill material; (3) excavation and backfill operations, and (4) a thorough knowledge of construction methods and testing requirements needed for slurry trench construction.

3. SUBSURFACE CONDITIONS. The subsurface soils underlying the northern boundary slurry trench barrier extension consist of a mixture of alluvium, sand, silt, and clay. The subsurface soil profile as shown on the drawings was developed from borings and piezometers located in the vicinity of the slurry trench extension.

4. PATENTS ON SLURRY TRENCH METHOD. Patents exist which may be applicable to portions of the specified methods of constructing the slurry trench cutoff. One of these is under United States Patent No. 2,757,514 dated August 7, 1956, "Method of Forming an Impermeable Wall in the Terrain", in the name of Harold T. Wyatt, Arcadia, California, assignor to Cronese Products, Inc., a corporation of California (last known as Cronese-Terminal, Division of Pike Corporation, 12632 East Imperial Highway, Santa Fe Springs, California, 90670, U.S.A.) Contract General Provision 15, "Patent Indemnity" will apply.

5. QUALIFICATIONS FOR SLURRY TRENCH CONSTRUCTION. The Contractor shall submit evidence that he or his subcontractor is competent in slurry trench construction. This evidence will insure that the Contractor or his subcontractor will have sufficient competent personnel to carry out the operations specified and such personnel shall have experience in this type of construction. In particular, a slurry trench specialist employed by the Contractor shall be used to control the composition, mixing, placing, cleaning, and maintaining of the slurry. Credentials of the slurry trench specialist shall be submitted to the Contracting Officer for approval at least four weeks prior to the start of the slurry trench construction.

6. QUALITY CONTROL. The Government will perform quality assurance testing on both the slurry and backfill materials using the laboratory and equipment furnished by the Contractor. The Government testing shall in no way relieve the Contractor of the responsibility of performing testing necessary to meet the construction requirements. The Contractor shall provide the equipment and laboratory space to Government personnel on demand and these services shall be considred a subsidiary obligation of the slurry trench construction.

6.1. BENTONITE SLURRY PROPERTIES shall be tested by the Contractor twice daily on the slurry prior to placing of the bentonite slurry in the trenches. The following tests shall be performed: Methyleneblue aborption, viscosity, filtration, and density tests. At the time of placing backfill into the slurry filled trenches, the Contractor shall perform tests on the bentonite slurry consisting of filtration, density, sand content, and water analysis (as directed by Contracting Officer or his Representative). The slurry in the trenches shall be sampled at intervals of every 10 feet of depth and at a maximum 50-foot horizontal interval. These samples shall be taken twice each day and tested as required above. The sampling device used to collect samples will be subject to the approval of the Contracting Officer. The Contractor will be required to obtain samples for the Government at any time or location requested. Tests shall conform with the requirements of API Code RP 13B.

6.2. EXCAVATION DEPTH SOUNDINGS shall be made by the Contractor every ten (10) feet along the trench centerline and recorded. Soundings at each point shall consist of the following:

6.2.1. Measurement of the Depth to the Top of the Impermeable Bedrock.

6.2.2. Measurement of the Depth to the Bottom of the Excavation Immediately after Excavating.

6.2.3. Measurement of the Depth to the Bottom of the Excavation Immediately before Backfilling. Soundings shall be made with a weighted cable or similar device approved by the Contracting Officer or his duly authorized representative. The location of the top of bedrock shall be ascertained from inspection of cuttings and from the drive tube samples taken in accordance with paragraph: SAMPLES OF BEDROCK.

6.3. BACKFILL AT THE TIME OF PLACEMENT shall be sampled by the Contractor at the locations and times specified by the Contracting Officer. Samples for gradation tests shall be taken on the basis of one sample per 300 cubic yards. The gradation tests shall conform with the requirements of ASTM C 117-76 and C 136-76. Samples for slump cone tests shall be taken at least twice daily but not more than five times daily. The slump cone tests shall conform with the requirements of ASTM C 143-74. All sampling equipment and procedure shall be subject to the approval of the Contracting Officer. The slope of the in-place backfill shall be measured with soundings. Each set of soundings shall start at the toe of the backfill in the bottom of the trench and progress up the backfill slope to the ground surface at 30-foot horizontal intervals. A set of backfill slope soundings shall be made at maximum 50-foot horizontal intervals.

6.4. SAMPLES OF BEDROCK shall be taken of the bedrock material at a maximum 50-foot interval a minimum of one time by a 1-3/8-inch I.D. (or larger) drive tube sample with a minimum length of 3 inches. The samples shall be taken just prior to backfilling of the trench. After examining these samples, the Contracting Officer will either approve the termination of excavation at the sample points or require additional excavation. If additional excavation is required, then additional samples will be furnished by the Contractor as specified above.

6.5. EQUIPMENT FOR SLURRY TESTING shall be furnished and maintained by the Contractor and shall consist of the following to be used by qualified personnel, provided by the Contractor, who are trained to operate all equipment and who have a working knowledge of test procedures for slurry testing in accordance with applicable American Petroleum Institute (API) Standard Specifications:

1 Mold for slump test
1 Marsh funnel set
1 Standard filter press for low temperature test
(carbon dioxide cartridge pressurized systems)

1 Mud balance (direct reading of density)
1 Slurry sampler
1 Soil sampling tool and driving apparatus

6.6. REPORTS AND RECORDS prepared and submitted by the Contractor shall consist of the following:

6.6.1. A Profile of the trench bottoms as well as the backfill slopes and a description of the material encountered in the bottom (includes retention of all trench bottom samples, properly identified and labeled).

6.6.2. Results of all construction control testing done to meet specification requirements for the slurry and the backfill.

6.6.3. A Record of all admixtures utilized, their proportions and placement locations.

6.6.4. Slurry Mix Adjustments and placement location.

6.6.5. A Construction Log indicating delays encountered during slurry placement including the cause, location, and extent of delay.

6.6.6. A Record of Unusual Conditions of materials and construction problems encountered and dispositions made.

6.7. DOCUMENTATION of these reports and records as well as corrective action taken shall be furnished the Government daily or as directed by the Contracting Officer.

7. SLURRY TRENCH/MUD SPECIALIST.

7.1. SLURRY TRENCH/MUD SPECIALIST as defined in paragraph: Slurry Trench/Mud Specialists shall be employed by the Contractor. The duties and responsibilities of the Slurry Trench/Mud Specialist shall be solely limited to quality control for slurry trench construction. In accordance with requirements of paragraph: DEFINITIONS, the Slurry Trench/Mud Specialist shall be responsible for all testing and inspection of slurry trench construction to assure compliance with the contract requirements and record the inspections and tests of all operations. Inspection of slurry trench construction operations shall include

inspection of trench excavation for alinement, penetration, and verticality; backfill mixing; placement of backfill; and other associated operations. The Slurry Trench/Mud Specialist shall supervise the preparation, maintenance, and quality control of the slurry. He shall control the composition, mixing, placing, cleaning, and maintaining of the slurry.

8. MATERIALS.

8.1. BENTONITE shall be a sodium cation-base montmorillonite powder (Wyoming-type bentonite) that conforms to the standards set forth in API Spec 13A, Sections 3, 5, 6, and 7. No chemically-treated bentonite will be allowed. The Contractor shall furnish a statement from the supplier that the bentonite furnished complies with these Specifications, together with four (4) copies of the test report.

8.2. WATER for the construction site will be furnished by the Government at specified locations close to the construction site. The Contractor will be responsible for transport of the water from these sources to the construction site. The Government will furnish nominal 6-inch diameter irrigation pipe sufficient to construct a pipeline from the sources to the construction site for use during the project, if the Contractor chooses this method of water transport. The pipeline must be fabricated and operated in a manner that will prevent contamination of the water during movement from the sources to the construction site. When these sources of water are no longer needed, the pipeline will be dismantled and stockpiled by the Contractor at a location specified by the Government.

8.3. SLURRY for supporting the sides of the trench and that mixed with the backfill shall consist of a stable colloidal suspension of powdered premium grade natural bentonite in water. It is the responsibility of the Contractor that the slurry meets the necessary standards to insure a stable trench. The properties of the slurry used in all construction sequences will be controlled in accordance with API Code RP 13B and shall also conform to the following requirements:

8.3.1. Bentonite shall be protected from moisture during transit and storage.

8.3.2. Peptizing or Bulking Agents shall not be mixed with the slurry. Admixtures of the types used in the control of oil field drilling needs may be used to alter the characteristics of the slurry only as approved by the Contracting Officer.

8.3.3. At the Time of Introduction of the bentonite slurry into the trench, the following will apply:

8.3.3.1. The Slurry Density shall not be less than 64 pounds per cubic foot.

8.3.3.2. The Filtrate, or water loss, shall not be greater than 20 cc at 100 psi in 30 minutes.

8.3.3.3. The Viscosity shall not be less than 40 Marsh seconds at 65°F.

8.3.4. At any Time in the Slurry Trench or when the slurry is mixed with backfill material, the following will apply.

8.3.4.1. The Slurry Density shall not be less than 70 pounds per cubic foot nor greater than 85 pounds per cubic foot or as approved by the Contracting Officer. It shall be the responsibility of the Contractor to regulate the density, within the specified range, to maintain stability of the trench at all times. Mixture adjustments shall conform to the requirements in subparagraph: If Directed by the Contracting Officer.

8.3.4.2. If Directed by the Contracting Officer, the Contractor shall make the slurry denser or more viscous than the limits specified above. As directed, the Contractor shall use additional bentonite.

8.4. BACKFILL MATERIAL shall be composed of slurry and selected soils. Soils having excessive silt or clay content or organic content shall not be allowed. The soil shall have 90 to 100 percent passing the 1-1/2-inch sieve and 10 to 25 percent passing the No. 200 sieve.

8.4.1. Onsite Material which meet the above criteria may be used for backfill.

8.4.2. Offsite Material shall be furnished by the Contractor, and it will be his responsibility to supply material that will meet the backfill gradation requirements.

9. CONSTRUCTION OPERATIONS. Since the time available for constructing the slurry trench cutoff may be limited, the Contractor shall schedule his operations so as to work not less than one, eight-hour shift daily for six days a week during the construction of the slurry trench cutoff, unless reduced operations are authorized by the Contracting Officer. The Contractor shall have personnel, equipment, and materials ready to raise the slurry level at any time the water level rises within the limitations specified in Paragraph: SLURRY TRENCH EXCAVATION PROCEDURE and subparagraphs thereof. To this end, the Contractor shall have personnel on call to raise the slurry level at any time this occurs, weekends and/or holidays included.

10. LINES AND GRADES. The slurry trench cutoff and associated instrumentation shall be constructed to the elevations, lines, grades, and cross sections shown on the drawings, unless otherwise directed by the Contracting Officer. The Government reserves the right to modify the elevations, lines, grades, and/or cross sections as may be determined necessary by the Contracting Officer; if any such modifications are made, an equitable adjustment will be made in accordance with General Provision 3 "Changes".

11. EQUIPMENT. The Contractor shall furnish the necessary plant and equipment for efficiently excavating the trench; mixing and placing slurry; cleaning of slurry and trench bottoms; hauling, mixing, and placing backfill material; and for placing the impervious cap on the completed trench.

11.1. TRENCH EXCAVATION EQUIPMENT for excavating the slurry trenches shall consist of either a dragline, a backhoe, or a special mechanical slurry trench clamshell. The bucket used with the above equipment shall not be perforated. The bucket may be tapered and equipped with bottom side cutter teeth protruding no more than six inches on each side. The makeup of the bucket shall be such that ravelling of the sides of the trench is minimized and the width of the trench is maintained. The bucket used with a dragline shall be specially made for slurry trench excavation. It shall also have a minimum weight of 10,000 pounds. Regardless of the equipment type used it shall be capable of excavating the minimum required widths in a single pass of the excavating tool.

11.2. MIXING AND PLACING SLURRY for use in the trench shall be mixed in a colloidal continuous mixer. No slurry may be made in the trench. Mixing of water and bentonite shall continue until bentonite particles are fully hydrated and the resulting slurry is homogenous. The slurry plant shall include the necessary equipment such as a mixer capable of producing a colloidal suspension of bentonite in water, a mechanically agitated sump, pumps, valves, hoses, supply lines, and small tools, all as may be required to adequately supply slurry to the trench. Storage containment areas(s) having a minimum capacity of 1,000 gallons shall be provided to store initially mixed slurry to allow hydration time and to serve as a reserve in cases where substantial loss from the trench, through underlying pervious zones or other reasons, may occur. The slurry shall be occasionally agitated or recirculated in the storage ponds.

11.3. CLEANING OF SLURRY AND TRENCH BOTTOM EQUIPMENT shall include a vibratory shaker screen and a centrifugal sand separator. Equipment for investigating and treating the bottom of the trenches shall include the use of a crane, jet pipes, air lift pumps, vibrating shaker screen, probe pipes and necessary pipes, hoses and fittings.

11.4. MIXING AND PLACING BACKFILL EQUIPMENT needed for the mixing of backfill material shall be any type of light earthmoving or grading equipment such as bulldozers or blade graders. Placement of the backfill in the trench will initially require a clamshell bucket, tremie, or other equipment which will prevent dropping of the backfill through the slurry or other actions which could lead to segregation of backfill material. This is to be followed by use of any of the above mentioned (bulldozer or blade grader).

12. WORKING SURFACE. The working surfaces from which the slurry trench cutoffs are to be constructed shall be as defined in paragraph: DEFINITIONS, and will establish the top of the slurry trench cutoffs for the purpose of measurement for payment. However, the Contractor may construct, at no expense to the Government, a working surface to a level higher than the defined working surface for his own convenience providing it is approved by the Contracting Officer. There will be no payment for any additional excavation, fill, or slurry trench cutoff required as the result of constructing for the convenience of the Contractor, a higher level working surface than the defined working surface. In the event that the static ground water table is encountered at a depth of 1.0 foot or less below the stripped surface the Contractor shall, at the direction of the Contracting Officer, raise the working surface by placing compacted fill to a height of 1.0 foot above the measured static ground water table. The surface thus produced will provide a basis for measurement for payment.

13. SLURRY TRENCH EXCAVATION PROCEDURE.

13.1. THE CONTRACTOR shall excavate the slurry trench from the working surface as defined in paragraph: WORKING SURFACE. Excavation shall be carried to the full depth shown on the drawings or as directed by the Contracting Officer immediately at the point where excavation is started. The entire depth of excavation shall then be carried along the trench line. The toe of the slope of the trench excavations shall not precede the toe of their backfill slopes by more than 100 feet. The slurry trench shall be constructed without undue interruption until it is complete. If for some reason it is necessary for the slurry trench to be constructed in more than one continuous segment, some re-excavation of the previously constructed slurry trench will be necessary. This re-excavation shall consist of backfill and slurry removal 10 feet perpendicular to the slope of the backfill for the full depth of the slurry trench.

That portion of the slurry trench that is removed or overlapped shall be constructed at no expense to the Government. A minimum overlap length of five feet shall be made at any corner to obtain the continuous

full depth through the entire length of each side of the trench, unless the equipment used produces vertical end walls.

The slurry trench extension both in the easterly and westerly directions shall be tied into the existing trench as described above for re-excavation of previously constructed slurry trenchs.

Regardless of the method of construction, excavation of the slurry trench shall proceed in a manner which, when completed, provides for a continuous 30-inch minimum wide trench to the required depth at all points along the centerline of the excavation. The excavation shall be carried to a minimum depth as shown on the drawings. The Contracting Officer will make the decision as to the final trench grade during trench excavation.

13.2. SLURRY SHALL BE INTRODUCED into the trench at the time excavation begins. The level of the slurry in the open trench shall be maintained a minimum of one foot above the static water level as well as being maintained even with the top of the working surface at all times. Dilution of slurry by surface waters shall be prevented. The Contractor shall take all necessary precautionary measures to minimize damages to the work and to the equipment from both ground water and surface waters. The slurry shall be maintained at all times in a condition which meets the requirements set forth in paragraph: SLURRY, and subparagraphs thereof. To achieve this end, the slurry may require operations such as recirculation through shaker screens or the addition of approved additives.

13.3. STABILITY OF TRENCH DURING CONSTRUCTION shall be maintained at all times for its full depth. Stockpiles and excavated material shall be placed a minimum distance from the trench equal to 60 percent of the trench depth, measured from the work surface. For instance, if the trench depth is 20 feet below the working surface, spoil shall be placed no closer than 12 feet from the excavation. Slopes of stockpiles and excavation material shall be no steeper than 1V to 2H and no higher than 10 feet above the work surface. The working surface shall be sloped to drain surface water away from the trench.

13.4. STOCKPILING MATERIAL excavated from the slurry trenches that are suitable for part of the backfill mixture may be stockpiled nearby for subsequent processing.

13.5. SPOIL MATERIAL excavated from the slurry trenches that are not suitable for part of the backfill mixture or excess to the Contractors needs shall be placed in the stockpile or disposal areas or, if suitable, in areas requiring uncompacted fill.

13.6. CLEANING OF SLURRY, to maintain slurry density below the maximum allowable density (of 85 pcf), may be necessary. If necessary to maintain the properties of the slurry in the trench at the required levels specified in paragraph: SLURRY and subparagraphs thereof and to keep it clean and workable, the slurry in the trench shall be recirculated; and the suspended matter shall be separated by use of stilling ponds, screens, cyclones, or other appropriate equipment specified in paragraph: CLEANING OF SLURRY AND TRENCH BOTTOM EQUIPMENT or approved by the Contracting Officer.

14. TREATMENT OF TRENCH BOTTOM. Excavation shall proceed to a minimum depth as shown on the drawings, as specified in paragraph: SLURRY TRENCH EXCAVATION PROCEDURE above, to form a positive tie-in for the trench. Sediments that are deposited at the base of the trench before backfilling should be removed by air lift pumps, clamshell, or other suitable equipment as described in paragarph 11.3 above or as approved by the Contracting Officer. The Contractor shall submit in writing his proposed method and equipment to be used for removal of sediments deposited at the base of the trench to the Contracting Officer for approval. The base of the trench shall be sounded by the Contractor, in the presence of a representative of the Contracting Officer, to determine if sediment is present before backfilling operations can proceed.

15. BACKFILLING.

15.1. MIXING STOCKPILED MATERIAL from excavation and/or material from borrow shall be mixed and blended by windrowing, by disk harrowing, by bulldozing, by blading, or by other approved methods. Mixing and blending shall be performed in such a manner as to produce the required gradation of backfill as specified in paragraph: BACKFILL MATERIAL. This material when mixed with the slurry to attain the specified slump shall constitute the backfill used to fill the slurry trench. Excess slurry which may drain away from the mixing operations shall be allowed to drain back into the trench. The backfill material shall be thoroughly mixed into a homogeneous mass, free from large lumps or pockets of fines, sand, or gravel. Occasional lumps of up to 6 inches in their largest dimensions will be permitted. The backfill material, just prior to placing, shall have a consistency that has the appearance of a "wet concrete with a slump of 2 to 5 inches) and as approved by the Contracting Officer. To this end the materials may be sluiced with slurry during blending operations. Sluicing with water will not be permitted. When mixing the backfill, equipment such as bulldozer should not operate in a back and forth fashion paralleling the open slurry trench any closer than 15 feet of the edge. Any sloughing of the slurry trench walls or other damages as a result of operating equipment near the trench, shall be repaired or restored by the Contractor at no additional

cost to the Government. The Contractor shall construct a small dike (2 to 3 feet high) paralleling the slurry trench in order to keep the backfill from flowing into the trenches as a result of wave action created by the dozer mixing the backfill. Intermittent holes in the dike will be allowed so that excess slurry may flow back into the trenches.

15.2. PLACING OF THE BACKFILL shall be made so that no pockets of slurry are present in the completed slurry trench cutoffs. In order that this may be assured, the Contractor shall backfill continuously from the beginning of the trenches in the direction of the excavation to the end of the trenches. Placing operations shall proceed in such fashion that the top of the backfill below the surface of the slurry shall follow a reasonably smooth grade and shall not have hollows which may trap pockets of slurry during subsequent backfilling. To this end, the face of the backfill below the surface of the slurry may require rodding, and the Contractor shall have such equipment available at the job site. The backfill operation shall lag the trench excavation by a minimum of 30 feet. Free dropping of backfill material through the slurry will not be permitted. Initially, backfilling will proceed by lowering backfill to the bottom of the trenches with crane and clamshell bucket until the surface of the backfill rises above the surface of the slurry trenches at the end of the trenches. The remaining backfill may then be placed by bulldozer in such manner that the backfill enters the trenches by sliding down the forward face of the previously placed backfill. To accomplish this, the bulldozer operator shall pile sufficient backfill on the edge of the existing backfill to cause a sliding action down the face of the existing backfill. The backfill shall not be dropped or deposited in any manner that will cause segregation. An acceptable substitute for the initial placing of backfill by the use of a clamshell bucket shall be to begin excavation at a point outside of the limits of work which will provide a sufficient distance for the backfill face to form by dozing the backfill into the trench before the toe of the backfill reaches the point where the cutoff is required. No payment will be made for the portions of the trenches which lie outside of the limits of work.

15.3. MIXING AND PLACING BACKFILL DURING COLD WEATHER shall not be performed when the air temperature is below 20 degrees F unless otherwise approved by the Contracting Officer.

15.4. THE TOP OF ALL SLURRY TRENCHES shall be covered within three days after the backfill reaches the top of the slurry trench. The cover shall be a 3-foot thick layer of clay soil. Initial compaction shall be done by three complete coverages of a bulldozer or any crawler-type tractor or any other approved equipment. During the 10 days following the initial compaction, the area above the trench shall be compacted at

least two additional times at 5-day intervals by one complete coverage of compaction equipment, as defined in the preceding sentence, to develop and expose any possible depression areas and to speed up settlement. If any sink should develop within the backfill slurry trench area, it shall be repaired by placing and compacting additional clayey soil; and an equitable adjustment in contract price and time will be made in accordance with clause 3 "Changes" in General Provisions. If the Contracting Officer determines that the five passes required hereinabove have not produced the desired degree of compaction, he will direct that additional passes be made over the area; and an equitable adjustment in contract price and time will be made in accordance with clause 3 "Changes". A detail of the clay cap is shown on the drawings.

15.5. CLEANUP following completion of backfilling operations, shall consist of removing from the working surfaces all remaining excavated material and slurry. The slurry shall be disposed of within the disposal areas or in a location as otherwise approved by the Contracting Officer.

15.6. RECORDS AND CONTROLS shall be provided by the Contractor for all necessary equipment and personnel to ascertain that the mixing of the slurry and the construction of the slurry trench meet the specifications. The Contractor's required records are outlined in paragraph: RECORDS AND REPORTS. Construction quality control shall be the Contractor's responsibility; however, quality assurance testing may be performed by the Government as outlined in paragraph: QUALITY CONTROL.

16. MEASUREMENT. Measurement for payment for the "Slurry Trench Cutoffs" will be based on the area in square feet of slurry trench measured on a vertical plane through the centerline of the slurry trenches within the boundaries established by the working surfaces as defined in paragraph: Working Surface, the bottom of the excavated trenches as approved, and vertical lines at each end of the approved full depths of the excavated trenches. Measurement will be based on surveys and soundings taken at the site as directed and approved by the Contracting Officer.

17. PAYMENT. Payment for Slurry Trench measured as specified hereinbefore will be made at the contract unit price per square foot for Bid Item No. __, "Slurry Trench". Such price will include all costs of stripping, excavating by the slurry method of excavation, dragging and cleaning the trench bottom, stockpiling or spoiling excavated materials, obtaining backfill materials from borrow pits, if required, mixing, blending, placing and rodding the slurry trench backfill, and all other items incidental to the construction and completion of the Slurry Trench. No separate payment will be made for slurry materials including bentonite, additives, equipment and mixing, handling and cleaning the slurry,

for the ripping block, for diking around the open trench, and for overtime during continuous operations, for cleanup, and for assistance in the collection and maintaining records; such items being included in the price for "Slurry Trench". Payment for materials obtained from required excavations other than the slurry trench excavation itself will be paid for at the contract unit price for "Unclassified Excavation".

ZERO ACCIDENTS

SECTION 13B
MONITORING WELLS - ALLUVIUM

INDEX

1. APPLICABLE PUBLICATIONS. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto.

1.1. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS.

D 1785	PVC Pipe
C 136-71	Sieve or Screen Analysis of Fine or Coarse Aggregates

2. SCOPE. The work provided for herein consists of furnishing all plant, labor, fuels, lubricants, electric energy, materials, and equipment, and performing all operations required to construct and develop monitoring wells as indicated on the drawings and as specified herein.

3. QUALITY CONTROL. The Contractor shall establish and maintain quality control for all well construction and development to assure compliance with contract requirements and maintain records of his quality control for all construction operations, including but not limited to the following:

Drilling of wells
Installation of slotted pipe, riser pipe, and sand trap
Placement of gravel filter pack
Development of wells
Sieve analysis of gravel filter pack
Logging of borehole
Capping well

A copy of these records and tests, as well as the records of corrective action taken, shall be furnished the Government as directed by the Contracting Officer.

4. GENERAL.

4.1. LOCATION, spacing, and number of wells shall be as shown on the drawings, but may be changed by the Contracting Officer at no cost to the Government if field conditions warrant.

4.2. DEPTH AND DIAMETER OF WELL. Each well shall be installed to the depth as indicated on the drawings or as directed by the Contracting Officer or his representative. The well depth may vary up to 20 percent from those indicated on the drawings as directed by the Contracting Officer. The hole drilled for each alluvial monitoring well shall be 12 inches in diameter.

4.3. OBSTRUCTIONS ENCOUNTERED. The Contractor will be required to provide and use drills and equipment that are capable of removing cobbles up to 5 inches in diameter and drilling through claystone and sandstone bedrock. The presence of cobbles up to 5 inches in diameter encountered during drilling will not be considered as obstructions of sufficient reason for abandonment of a well. No payment will be made for any wells in which abandonment is determined to be necessary due to fault or neglect on the part of the Contractor.

5. SLOTTED PIPE for alluvial monitoring wells shall be fabricated entirely from Schedule 80 PVC pipe. Screens shall be mill slotted, with a slot width of 0.064 inches.

6. RISER PIPE AND SAND TRAP and fittings shall be of Schedule 80 PVC pipe, manufactured to ASTM D 1785.

7. GRAVEL FILTER PACK MATERIAL. Material for the gravel filter pack around the riser pipes, sand trap, and screens shall be rounded to subrounded, washed gravel composed of hard, tough, and durable particles free from adherent coatings. It shall contain no vegetable matter nor soft, friable, thin, or elongated particles in quantities determined deleterious. No more than 5 percent by weight of calcareous material shall be permitted. The gravel pack shall conform to the following gradation requirements when tested by ASTM C 136.

GRAVEL FILTER PACK MATERIAL

Sieve or Screen Size	Percent Passing
3/8 inches	100
No. 4	81-97
No. 6	64-80
No. 8	38-54
No. 14	0-14
No. 20	0

Materials shall be well graded between the limits specified above. All points on individual grading curves obtained from representative samples of gravel filter material shall lie between the boundary limits plotted on a mechanical analysis diagram. The individual grading curves within these limits shall not exhibit abrupt changes in slope denoting skip grading, scalping of certain sizes, or other irregularities which would be detrimental to the proper functioning of the gravel filter.

8. DRILLING.

8.1. GENERAL. The Contractor shall submit for review and approval by the Contracting Officer his proposed plan for drilling the wells. The plan shall take into account all the information furnished and all the restrictions imposed by the contract drawings and specifications. Wells shall be drilled by a proven method such as rotary, or bucket auger, which will ensure proper placement of the slotted pipe, riser pipe, and gravel pack. Methods which may reduce the yield of the well will not be permitted. The use of bentonitic-type drilling fluid is prohibited. Drilling fluid additives similar and equal to "Revert" and "Fastbreak," products of UOP Johnson Division, St. Paul, Minnesota 55104, may be used. Loss of a hole or well because of lack of material, inadequate or faulty equipment, or careless operating procedures will be considered cause for an abandoned well due to fault or neglect on the part of the Contractor.

8.2. DRILLING METHOD. The diameter of the hole shall be a minimum of 12 inches in diameter and shall permit the placement of the minimum thickness of gravel pack as specified hereinafter in paragraph, GRAVEL FILTER PACK PLACEMENT. If a drilling fluid is used (not a bentonite or other expansive clay system), it shall be a suspension of fine-grained soil or shall be an approved commercial product of a recognized manufacturer and shall have the characteristics of being readily removable from the gravel filter pack and the walls of the formation by developing methods as hereinafter specified in paragraph, DEVELOPMENT OF WELLS. If the walls of the hole require support during

drilling or development operations, a temporary casing similar to that specified in paragraph, TEMPORARY CASING, shall be placed so as to extend from the ground surface to at least three feet below the top of the gravel filter.

8.3. TEMPORARY CASING. If necessary, a temporary well casing of either iron or steel, new or used, may be used to support the sides of the entire hole during drilling and placement of screen, riser pipe, and gravel filter pack and to support the sides of the unbackfilled portion of the hole during development of the well. Any temporary casing shall have an inside diameter large enough to provide a 3-1/2-inch minimum filter thickness entirely around the well screen or riser pipe and shall have sufficient thickness to retain its shape and maintain a true section throughout its depth. The temporary casing shall be such as to permit its removal without interfering with the filter or riser pipe. Temporary casing shall be carried to a minimum of 4 feet below the bottom elevation of the well screen.

8.4. LOGGING OF BOREHOLE. Contractor will provide a driller's log to the Contracting Officer prior to installation of casing, screen, and filter pack.

9. INSTALLATION OF RISER PIPE, SAND TRAP, AND SLOTTED PIPE.

9.1. ASSEMBLY. All riser pipe, sand trap, and slotted pipe shall be in good condition before installation; and all joints and other accessory parts shall be securely fastened in place. Particular care shall be exercised to avoid damaging the sand trap, spacers, slotted pipe and riser pipe during installation and throughout all subsequent operations. The slotted pipe, sand trap, and riser pipe shall be centered in the well hole and held securely in place during placement of the filter by means of an approved method.

9.2. JOINTS. Sections of the PVC pipe shall be joined using an approved cement, and shall be drilled and pinned after cementing to ensure that joints are stable during installation. Either collared joints or couplings will be permitted.

9.3. SUBMITTALS. The Contractor shall submit for approval detailed shop drawings and catalog data of the slotted pipe, riser pipe, joints, and sand traps which he proposes to furnish in accordance with Section: GENERAL PROVISIONS.

9.4. INSTALLATION. The assembled slotted pipe, sand trap, and riser pipe shall be placed in the well hole in such a manner as to avoid jarrng impacts and to ensure that the assembly is not damaged or misplaced. Immediately after the installation of the well screen, sand trap, and riser pipe, the depth of the well shall be measured. The

riser pipe shall extend 1-1/2 feet above existing ground or fill surface and shall be capped after development.

10. GRAVEL FILTER PACK PLACEMENT. After the slotted pipe, sand trap, and riser pipe have been placed and alinement surveys are conducted, the gravel filter pack shall be tremied around the screen in such a manner as to ensure uniform placement around the screen as the tremie is raised. The gravel shall have a minimum thickness of not less than 3-1/2 inches between the outside of the casing and the outside of the gravel filter pack and shall be maintained a minimum of 2 feet above the screen throughout the development process. Material which may have entered the well screen and riser pipe shall be removed before development of the well is commenced.

11. DEVELOPMENT OF WELLS. Development of Denver Sand monitoring wells shall commence by surging with compressed air until the water entering the well is relatively free of sand and fines. Surging with air shall continue for a minimum of 4 hours. After the surging is completed, the well shall be pumped until all fines and drilling fluids are removed from the well. Such pumping shall continue for not less than 4 hours at a rate compatible with reasonable drawdown as directed, or until water is relatively sand free. Upon completion of initial development, each well shall be subjected to a 4-hour pump test. The pump shall be complete with gasoline, diesel, or electric motor of adequate size. The pumping shall be conducted as directed. The following test measurements will be made by the Contracting Officer with the cooperation and assistance of the Contractor:

Time of observation
Depth of water in well before, during, and after pumping
Flow in gpm
The depth of sand in well before and after pumping

The pumping shall be at the maximum rate possible consistent with the requirements that a minimum of 3 feet of water above the bottom of the pump bowl shall be maintained at all times, and that the entrance velocities through the open area of the screen below the pumping water surface in the well shall not exceed 0.1 foot per second. Test pumping of a well will be permitted concurrently with drilling, development, or pumping of any other well.

12. CAPPING WELLS. After development is completed, the riser pipe shall be capped with a 4-inch cap installed on the conductor casing to protect the well opening.

13. PLUGGING ABANDONED WELLS. The well screen and riser pipe may be salvaged from wells abandoned. Wells abandoned shall be plugged by first drilling or jetting a hole to the bottom of the screen and then

injecting a neat cement grout into the hole through the jet pipe or drill stem as the screen is removed from the hole. The neat cement grout mix shall consist of one bag (94 pounds) of cement to 5 gallons of water and shall be injected at a maximum pressure of 10 psi.

14. MEASUREMENT AND PAYMENT.

14.1. MEASUREMENT.

14.1.1. Drilling Wells will be measured for payment by the linear foot to the nearest 1/10 foot from the bottom of the hole to the ground surface.

14.1.2. Well Screen will be measured for payment by the linear foot to the nearest 1/10 foot from the top to the bottom of each well screen acceptably installed.

14.1.3. Riser Pipe. Acceptably installed riser pipe will be measured for payment by the linear foot to the nearest 1/10 foot from the specified top elevation to the bottom of the riser pipe.

14.1.4. Sand Trap. Installed sand trap will be measured for payment by the satisfactorily completed unit.

14.1.5. Gravel Filter Pack will be measured for payment by the linear foot of material satisfactorily installed to the dimensions shown on the drawings. No extra compensation will be allowed for any material placed outside of the 1-foot diameter shown on the drawings. Payment will be made at the contract unit price for "Gravel filter pack," which payment shall constitute full compensation for furnishing all plant, labor, materials, and equipment; for withdrawing the temporary casing, and for performing all operations necessary for placing the gravel filter pack.

14.1.6. Development of Wells will be measured for payment by the hour, measured to the nearest 15 minutes, for well development performed as specified in paragraph, DEVELOPMENT OF WELLS. Measured time will begin when the Contractor actually begins jetting operations and will end either when the well has been successfully developed or when the Contracting Officer directs that the well be abandoned. Time spent removing material from the bottom of the well and in making required measurement will be included in the measured time, but time spent in installing and removing pumping equipment or in sealing the top of the riser pipe will not be included in the measured time.

14.1.7. Plugging Abandoned Wells as specified in paragraph, PLUGGING ABANDONED WELLS, will be measured for payment by the linear foot to the nearest 1/10 foot from the bottom of the well boring to the top elevation of the well.

14.2. PAYMENT.

14.2.1. Drilling Wells. Payment at the contract unit price for "Drilling Wells" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations necessary to drill the wells, remove drilling fluid, furnish and install temporary casing, assist the Contracting Officer on the job in securing samples for logging the hole, and all other operations incidental to drilling the wells.

14.2.2. Well Screen. Payment at the contract unit price for "Well Screen" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations necessary to install the well screens, including joining the screens to the riser pipe, furnishing and installing the welding couplings and bottom plates, and all other operations incidental to installing the well screens.

14.2.3. Riser Pipe. Payment at the contract unit price for "Riser Pipe" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for joining the pipe sections, and performing all other operations necessary to install the riser pipe.

14.2.4. Sand Trap. Payment made at the contract unit price for "Sand Trap" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for joining the screen and sand trap sections and performing all other operations necessary to install the sand trap.

14.2.5. Gravel Filter Pack. Payment made at the contract unit price for "Gravel Filter Pack" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations as delinearted in the last sentence of 14.1.5, Gravel Filter Pack.

14.2.6. Development of Wells. Payment at the contract unit price for "Well Development" shall constitute full compensation for furnishing all plant, labor, fuels, lubricants, electric energy, materials and equipment, and for performing all operations necessary to develop the wells.

14.2.7. Abandoned Wells.

14.2.7.1. Lack of Compliance. No payment will be made for "Drilling Wells," "Well Screen," "Riser Pipe," "Sand Trap," "Gravel Pack," "Well Development," or backfilling and/or plugging any wells which are ordered abandoned due to failure to meet requirements of paragraph, DEVELOPMENT OF WELLS, where there is evidence that the Contractor failed to comply with requirements of the plans and specifications and/or Contracting Officer's directives.

14.2.7.2. Failure of Well to Meet Standards. Any wells which are abandoned due to producing excessive amounts of sand or filter material and which have been installed in full compliance with the plans and specifications and/or Contracting Officer's directives will be paid for at the applicable contract unit prices for "Drilling Wells," "Gravel Pack," and "Well Development." The stage of completion at the time of abandonment shall determine which items are applicable for payment.

14.2.7.3. Plugging Abandoned Wells. Payment made at the contract unit price for "Plugging Abandoned Wells" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations necessary to plug abandoned wells, as required by paragraph, PLUGGING ABANDONED WELLS.

No payment will be made for plugging any well abandoned as a result of fault or negligence of the Contractor. If no wells are abandoned, no plugging will be required; and the Contractor will not receive any pay whatsoever for this item, even though he may have put some of his indirect cost into the price bid for it.

ZERO ACCIDENTS

SECTION 13C
DENVER SAND MONITORING WELLS

INDEX

1. APPLICABLE PUBLICATIONS. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto.

1.1. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS.

D 1785 PVC Pipe

2. SCOPE. The work provided for herein consists of furnishing all plant, labor, fuels, lubricants, electric energy, materials and equipment, and performing all operations required to construct and develop Denver Sand monitoring wells as indicated on the drawings and as specified herein.

3. QUALITY CONTROL. The Contractor shall establish and maintain quality control for all well construction and development to assure compliance with contract requirements and maintain records of his quality control for all construction operations, including but not limited to the following:

Drilling of wells
Installation and grouting of conductor casing
Installation of slotted pipe, riser pipe, and sand trap
Development of wells
Logging of borehole
Capping well

A copy of these records and tests, as well as the records of corrective action taken, shall be furnished the Government as directed by the Contracting Officer.

4. GENERAL.

4.1. LOCATION, spacing, and number of wells shall be as shown on the drawings, but may be changed by the Contracting Officer's representative at no cost to the Government if field conditions warrant.

4.2. DEPTH AND DIAMETER OF WELL. Each well shall be installed to the depth as indicated on the drawings or as directed by the Contracting Officer or his representative. The well depth may vary up to 15 percent from those indicated on the drawings as directed by the Contracting Officer. Each well shall be drilled to a diameter of 6 inches below the conductor casing. The hole in which the conductor casing is installed shall be drilled to a diameter of 12 inches.

4.3. OBSTRUCTIONS ENCOUNTERED. The Contractor will be required to provide and use drills and equipment that are capable of removing cobbles up to 5 inches in diameter and drilling through sandstone, siltsone, and claystone bedrock. The presence of cobbles up to 5 inches in diameter encountered during drilling will not be considered as obstructions of sufficient reason for abandonment of a well. No payment will be made for any wells in which abandonment is determined to be necessary due to fault or neglect on the part of the Contractor.

5. CONDUCTOR PIPE for Denver Sand monitoring wells shall be Schedule 40 PVC, 6 inches in diameter.

6. SLOTTED PIPE for Denver Sand monitoring wells shall be fabricated entirely from 4-inch Schedule 80 PVC pipe. Screens shall be mill slotted, with a slot width of 0.064 inches.

7. RISER PIPE AND SAND TRAP and fittings shall be of Schedule 80 PVC pipe, manufactured to ASTM D 1785.

8. DRILLING.

8.1. DRILLING METHOD. The Contractor shall submit for review and approval by the Contracting Officer his proposed plan for drilling the wells. The plan shall take into account all the information furnished and all the restrictions imposed by the contract drawings and specifications. Wells shall be drilled by the rotary or reverse rotary or bucket auger method down to the conductor casing depth. Below the conductor casing, wells shall be drilled by the air rotary method with foam as necessary. The use of bentonitic-type drilling fluid is encouraged for drilling the conductor casing hole but will not be permitted below the conductor casing. Loss of a hole or well because of lack of material, inadequate or faulty equipment, or careless operating procedures will be considered cause for an abandoned well due to fault or neglect on the part of the Contractor. The diameter of the hole for the conductor

casing shall be 12 inches. The diameter of the hole below the conductor pipe shall be 6 inches.

8.2. TEMPORARY CASING. If necessary, a temporary well casing of either iron or steel, new or used, may be used to support the sides of the entire hole during drilling, and during placement and cementing of the conductor casing. Any temporary casing shall have an inside diameter large enough to provide a 3-inch minimum cement thickness entirely around conductor pipe and shall have sufficient thickness to retain its shape and maintain a true section throughout its depth. The temporary casing shall be such as to permit its removal without interfering with the filter or riser pipe. Temporary casing shall be carried to a minimum of 4 feet below the bottom elevation of the well screen.

8.3. LOGGING OF BOREHOLE. Contractor will provide a driller's log to the Contracting Officer prior to installation of casing, screen, and filter pack.

9. INSTALLATION OF CONDUCTOR PIPE. The conductor pipe shall be placed in the well hole in such a manner that it remains vertical, and so that the 2 1/2-inch minimum thickness of cement grout can be placed around the casing. Centering guides shall be used. After the conductor casing is placed in the hole, the annular space between the outside of the casing and the borehole wall shall be cemented using a displacement method, forcing grout into the annular space from the bottom of the conductor casing upward to ground surface. Cement used for seal shall be a cement grout containing bentonite clay in an amount no greater than 5 pounds clay per 94-pound sack of cement. Water content shall be the minimum necessary to place mixture used. The cement mixture shall be thoroughly mixed to a uniform consistency and shall contain no aggregate. No further work on the well shall be undertaken for at least 12 hours or until the cement grout has set. The Conductor casing and cement seal will extend to within 5 feet of the top of the sand layer or zone to be monitored. The exact depths will be specified in the field by the Contracting Officer.

10. INSTALLATION OF RISER PIPE, SAND TRAP, AND SLOTTED PIPE.

10.1. ASSEMBLY. All riser pipe, sand trap, and slotted pipe shall be in good condition before installation; and all joints and other accessory parts shall be securely fastened in place. Particular care shall be exercised to avoid damaging slotted pipe, sand trap, and riser pipe during installation and throughout all subsequent operations.

10.2. JOINTS. Sections of the PVC pipe shall be joined using an approved cement, and shall be drilled and pinned after cementing to ensure that joints are stable during installation. Either collared joints or bell couplings will be permitted.

10.3. SUBMITTALS. The Contractor shall submit for approval detailed shop drawings and catalog data of the slotted pipe, riser pipe, joints, and sand traps which he proposes to furnish in accordance with Section: GENERAL PROVISIONS.

10.4. INSTALLATION. The assembled slotted pipe, sand trap, and riser pipe shall be placed in the well hole in such a manner as to avoid jarrng impacts and to ensure that the assembly is not damaged or misplaced. Immediately after the installation of the well screen, sand trap, and riser pipe, the depth of the well shall be measured. The riser pipe shall extend 1-1/2 feet above existing ground or fill surface and shall be capped after development.

11. DEVELOPMENT OF WELLS. Development of Denver Sand monitoring wells shall commence by surging with compressed air until the water entering the well is relatively free of sand and fines. Surging with air shall continue for a minimum of 4 hours. After the surging is completed, the well shall be pumped until all fines and drilling fluids are removed from the well. Such pumping shall continue for not less than 4 hours at a rate compatible with reasonable drawdown as directed, or until water is relatively sand free. Upon completion of initial development, each well shall be subjected to a 4-hour pump test. The pump shall be complete with gasoline, diesel, or electric motor of adequate size. The pumping shall be conducted as directed. The following test measurements will be made by the Contracting Officer with the cooperation and assistance of the Contractor:

Time of observation
Depth of water in well before, during, and after pumping
Flow in gpm
The depth of sand in well before and after pumping

The pumping shall be at the maximum rate possible consistent with the requirements that a minimum of 3 feet of water above the bottom of the pump bowl shall be maintained at all times, and that the entrance velocities through the open area of the screen below the pumping water surface in the well shall not exceed 0.1 foot per second. Test pumping of a well will be permitted concurrently with drilling, development, or pumping of any other well.

12. CAPPING WELLS. After development is completed, the riser pipe and conductor pipe shall be cut to the same level and a 6-inch cap installed on the conductor casing to protect the well opening as indicated on the drawings.

13. PLUGGING ABANDONED WELLS. The well screen and riser pipe may be salvaged from wells abandoned. Wells abandoned shall be plugged by first drilling or jetting a hole to the bottom of the screen and then injecting a neat cement grout into the hole through the jet pipe or drill stem as the screen is removed from the hole. The neat cement grout mix shall consist of one bag (94 pounds) of cement to 5 gallons of water and shall be injected at a maximum pressure of 10 psi.

14. MEASUREMENT AND PAYMENT.

14.1. MEASUREMENT.

14.1.1. Drilling Wells will be measured for payment by the linear foot to the nearest 1/10 foot from the bottom of the hole to the ground surface.

14.1.2. Well Screen will be measured for payment by the linear foot to the nearest 1/10 foot frm the top to the bottom of each well screen acceptably installed.

14.1.3. Riser Pipe. Acceptably installed riser pipe will be measured for payment by the linear foot to the nearest 1/10 foot from the specified top elevation to the bottom of the riser pipe.

14.1.4. Sand Trap. Installed sand trap will be measured for payment by the satisfactorily completed unit.

14.1.5. Gravel Filter Pack will be measured for payment by the linear foot of material satisfactorily installed to the dimensions shown on the drawings. No extra compensation will be allowed for any material placed outside of the 1 foot-4 inch diameter shown on the drawings. Payment will be made at the contract unit price for "Gravel filter pack," which payment shall constitute fullcompensation for furnishing all plant, labor, materials, and equipment; for withdrawing the temporary casing, and for performing all operations necessary for placing the gravel filter pack.

14.1.6. Development of Wells will be measured for payment by the hour, measured to the nearest 15 minutes, for well development performed as specified in paragraph, DEVELOPMENT OF WELLS. Measured time will begin when the Contractor actually begins jetting operations and will end either when the well has been successfully developed or when the Contracting Officer directs that the well be abandoned. Time spent removing material from the bottom of the well and in making required measurement will be included in the measured time, but time spent in installing and removing pumping equipment or in sealing the top of the riser pipe will not be included in the measured time.

14.1.7. Plugging Abandoned Wells as specified in paragraph, PLUGGING ABANDONED WELLS, will be measured for payment by the linear foot to the nearest 1/10 foot from the bottom of the well boring to the top elevation of the well.

14.2. PAYMENT.

14.2.1. Drilling Wells. Payment at the contract unit price for "Drilling Wells" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations necessary to drill the wells, remove drilling fluid, furnish and install temporary casing, assist the Contracting Officer on the job in securing samples for logging the hole, and all other operations incidental to drilling the wells.

14.2.2. Well Screen. Payment at the contract unit price for "Well Screen" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations necessary to install the well screens, including joining the screens to the riser pipe, furnishing and installing the welding couplings and bottom plates, and all other operations incidental to installing the well screens.

14.2.3. Riser Pipe. Payment at the contract unit price for "Riser Pipe" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for joining the pipe sections, and performing all other operations necessary to install the riser pipe.

14.2.4. Sand Trap. Payment made at the contract unit price for "Sand Trap" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for joining the screen and sand trap sections and performing all other operations necessary to install the sand trap.

14.2.5. Gravel Filter Pack. Payment made at the contract unit price for "Gravel Filter Pack" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations as delinearted in the last sentence of 14.1.5, Gravel Filter Pack.

14.2.6. Development of Wells. Payment at the contract unit price for "Well Development" shall constitute full compensation for furnishing all plant, labor, fuels, lubricants, electric energy, materials and equipment, and for performing all operations necessary to develop the wells.

14.2.7. Abandoned Wells.

14.2.7.1. Lack of Compliance. No payment will be made for "Drilling Wells," "Well Screen," "Riser Pipe," "Sand Trap," "Gravel Pack," "Well Development," or backfilling and/or plugging any wells which are ordered abandoned due to failure to meet requirements of paragraph, DEVELOPMENT OF WELLS, where there is evidence that the Contractor failed to comply with requirements of the plans and specifications and/or Contracting Officer's directives.

14.2.7.2. Failure of Well to Meet Standards. Any wells which are abandoned due to producing excessive amounts of sand or filter material and which have been installed in full compliance with the plans and specifications and/or Contracting Officer's directives will be paid for at the applicable contract unit prices for "Drilling Wells," "Gravel Pack," and "Well Development." The stage of completion at the time of abandonment shall determine which items are applicable for payment.

14.2.7.3. Plugging Abandoned Wells. Payment made at the contract unit price for "Plugging Abandoned Wells" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations necessary to plug abandoned wells, as required by paragraph, PLUGGING ABANDONED WELLS.

No payment will be made for plugging any well abandoned as a result of fault or negligence of the Contractor. If no wells are abandoned, no plugging will be required; and the Contractor will not receive any pay whatsoever for this item, even though he may have put some of his indirect cost into the price bid for it.

ZERO ACCIDENTS

SECTION 13D
DENVER SAND DEWATERING WELLS (DW-36 TO DW-54)

INDEX

1. APPLICABLE PUBLICATIONS. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto.

1.1. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS.

D 1785	PVC Pipe
C 136-71	Sieve or Screen Analysis of Fine or Coarse Aggregates

2. SCOPE. The work provided for herein consists of furnishing all plant, labor, fuels, lubricants, electric energy, materials and equipment, and performing all operations required to construct and develop Denver Sand dewatering wells as indicated on the drawings and as specified herein.

3. QUALITY CONTROL. The Contractor shall establish and maintain quality control for all well construction and development to assure compliance with contract requirements and maintain records of his quality control for all construction operations, including but not limited to the following:

Drilling of wells
Installation and grouting of conductor casing
Installation of slotted pipe, riser pipe, and sand trap
Placement of gravel filter pack
Development of wells
Sieve analysis of gravel filter pack
Logging of borehole

A copy of these records and tests, as well as the records of corrective action taken, shall be furnished the Government as directed by the Contracting Officer.

4. GENERAL.

4.1. LOCATION, spacing, and number of wells shall be as shown on the drawings, but may be changed by the Contracting Officer's representative at no cost to the Government if field conditions warrant.

4.2. DEPTH AND DIAMETER OF WELL. Each well shall be installed to the depth as indicated on the drawings or as directed by the Contracting Officer or his representative. The well depth may vary up to 15 percent from those indicated on the drawings as directed by the Contracting Officer. Each well shall be drilled to a diameter of 10 inches below the conductor casing. The hole in which the conductor casing is installed shall be drilled to a diameter of 16 inches.

4.3. OBSTRUCTIONS ENCOUNTERED. The Contractor will be required to provide and use drills and equipment that are capable of removing cobbles up to 5 inches in diameter and drilling through sandstone, siltsone, and claystone bedrock. The presence of cobbles up to 5 inches in diameter encountered during drilling will not be considered as obstructions of sufficient reason for abandonment of a well. No payment will be made for any wells in which abandonment is determined to be necessary due to fault or neglect on the part of the Contractor.

5. CONDUCTOR PIPE for Denver Sand dewatering wells shall be Schedule 40 PVC, 10 inches inside diameter.

6. SLOTTED PIPE for Denver Sand dewatering wells shall be fabricated entirely from 4-inch Schedule 80 PVC pipe. Screens shall be mill slotted, with a slot width of 0.064 inches.

7. RISER PIPE AND SAND TRAP and fittings shall be of Schedule 80 PVC pipe, manufactured to ASTM D 1785.

8. GRAVEL FILTER PACK MATERIAL. Material for the gravel filter pack around the riser pipes, sand trap, and slotted pipe shall be rounded to subrounded, washed sand and gravel composed of hard, tough, and durable particles free from adherent coatings. It shall contain no vegetable matter nor soft, friable, thin, or elongated particles in quantities determined deleterious. No more than 5 percent by weight of calcareous material shall be permitted. The gravel pack shall conform to the following gradation requirements when tested by ASTM C 136.

GRAVEL FILTER PACK MATERIAL

Sieve or Screen Size	Percent Passing
3/8 inches	100
No. 4	64-80
No. 8	38-54
No. 14	0-14
No. 20	0

Materials shall be well graded between the limits specified above. All points on individual grading curves obtained from representative samples of gravel filter material shall lie between the boundary limits as defined by smooth curves drawn through the tabulated grading limits plotted on a mechanical analysis diagram. The individual grading curves within these limits shall not exhibit abrupt changes in slope denoting skip grading, scalping of certain sizes, or other irregularities which would be detrimental to the proper functioning of the gravel filter.

9. DRILLING.

9.1. DRILLING METHOD. The Contractor shall submit for review and approval by the Contracting Officer his proposed plan for drilling the wells. The plan shall take into account all the information furnished and all the restrictions imposed by the contract drawings and specifications. Wells shall be drilled by the rotary or reverse rotary method down to the conductor casing depth. Below the conductor casing, wells shall be drilled by the air rotary method with foam as necessary. The use of bentonitic-type drilling fluid is encouraged for drilling the conductor casing hole (16-inch diameter) but will not be permitted below the conductor casing. Loss of a hole or well because of lack of material, inadequate or faulty equipment, or careless operating procedures will be considered cause for an abandoned well due to fault or neglect on the part of the Contractor. The diameter of the hole for the conductor casing shall be 16 inches. The diameter of the hole below the conductor pipe shall be approximately 10 inches and shall permit the placement of the 3-inch thickness of gravel pack in the annular space between the casing and the wall of the well bore.

9.2. TEMPORARY CASING. If necessary, a temporary well casing of either iron or steel, new or used, may be used to support the sides of the entire hole during drilling, and during placement and cementing of the conductor casing. Any temporary casing shall have an inside diameter large enough to provide a 3-inch minimum cement thickness to retain its shape and maintain a true section throughout its depth.

9.3. LOGGING OF BOREHOLE. Contractor will provide a driller's log to the Contracting Officer prior to installation of casing, screen, and filter pack.

10. INSTALLATION OF CONDUCTOR PIPE. The conductor pipe shall be placed in the well hole in such a manner that it remains vertical, and so that the 3-inch minimum thickness of cement grout can be placed around the casing. Centering guides shall be used. After the conductor casing is placed in the hole, the annular space between the outside of the casing and the borehole wall shall be cemented using a displacement method forcing grout into the annular space from the bottom of the conductor casing upward to ground surface. Cement used for seal shall be a cement grout containing bentonite clay in an amount no greater than 5 pounds clay per 94-pound sack of cement. Water content shall be the minimum necessary to place mixture used. The cement mixture shall be thoroughly mixed to a uniform consistency and shall contain no aggregate. No additional work on the well shall be undertaken for at least 12 hours or until the cement grout has set.

11. INSTALLATION OF RISER PIPE, SAND TRAP, AND SLOTTED PIPE.

11.1. ASSEMBLY. All riser pipe, sand trap, and slotted pipe shall be in good condition before installation; and all joints and other accessory parts shall be securely fastened in place. Particular care shall be exercised to avoid damaging the slotted pipe, sand trap, spacers, and riser pipe during installation and throughout all subsequent operations. The slotted pipe, sand trap, and riser pipe shall be centered in the well hole and held securely in place during placement of the filter by means of an approved method.

11.2. JOINTS. Sections of the PVC pipe shall be joined using an approved cement, and shall be drilled and pinned after cementing to ensure that joints are stable during installation. Either collared joints or bell couplings will be permitted.

11.3. SUBMITTALS. The Contractor shall submit for approval detailed shop drawings and catalog data of the slotted pipe, riser pipe, joints, and sand traps which he proposes to furnish in accordance with Section: GENERAL PROVISIONS.

11.4. INSTALLATION. The assembled slotted pipe, sand trap, spacers, and riser pipe shall be placed in the well hole in such a manner as to avoid jarrng impacts and to ensure that the assembly is not damaged or misplaced. Immediately after the installation of the well screen, sand trap, and riser pipe, the depth of the well shall be measured. The riser pipe shall have a top elevation as indicated on the drawings and shall be capped after development.

11.5. ALINEMENT. Each completed well shall be straight and plumb. Immediately before placing the gravel pack and with top of riser fastened securely in a vertical and horizontal position, alinement surveys shall be conducted by the Contractor in the presence of the Contracting Officer or his representative. Excessive misalinement shall be corrected before placing gravel pack.

11.6. PLUMBNESS TESTS. Plumbness surveys will be performed by the Contracting Officer's representative and will consist of a plumb line run from the top of the well to the bottom of the well. A variation of 20 inches per 100 feet will be permitted in the combined length of screen, sand trap, and riser pipe of the well. Advance notice of at least one day of the approximate time of readiness for the plumbness survey shall be given by the Contracting Officer to avoid delay to the Contractor.

12. GRAVEL FILTER PACK PLACEMENT. After the slotted pipe, sand trap, and riser pipe have been placed and alinement surveys are conducted, the gravel filter pack shall be tremied around the screen in such a manner as to ensure uniform placement around the screen as the tremie is raised. The gravel filter pack material shall be placed in one continuous run. The gravel shall have a minimum thickness of not less than 1-3/4 inches between the outside of the screen and the borehole wall. The gravel pack shall extend to within 1 foot of the top of the conductor casing. The principal purpose of the gravel pack for the Denver Sand dewatering wells is to prevent caving of shale into the borehole by providing support of the borehole walls.

13. DEVELOPMENT OF WELLS. Development of Denver Sand dewatering wells shall commence by surging with compressed air until the water entering the well is relatively free of sand and fines. Surging with air shall continue for a minimum of 4 hours. After the surging is completed, the well shall be pumped until all fines and drilling fluids are removed from the well. Such pumping shall continue for not less than 2 hours at a rate compatible with reasonable drawdown as directed. If at the completion of the 2 hour minimum pumping, the total amount of sand entering the well is in excess of 2 to 5 ppm of sand, as determined from soundings in the well and collection of samples in a tank, shall be repeated and the well pumped again. Development of the well shall be continued until material entering the well during pumping is less than the amount specified above unless otherwise directed by the Contracting Officer. Wells which continue to produce an excessive amount of sand or filter material during pumping shall be abandoned as directed by the Contracting Officer. Wells abandoned shall be plugged in accordance with the provisions of paragraph, PLUGGING ABANDONED WELLS. If, after completion of this initial surging and pumping, there is more than 0.5 foot of material in the bottom of the well, such material shall be removed. The Contractor shall provide an approved means for accurately

determining the water level in the well under all conditions and furnish and install a calibrated instrument of standard design for the purpose of measuring the discharge from the well. He shall also provide an approved sounding device for measuring the depth of sand in the well. The pump discharge shall be conducted in an approved manner so as not to interfere with other construction in the area. The Contractor shall furnish an approved tap and valve in the discharge line and a suitable baffled tank or other Government-approved device into which the well discharge shall be pumped to determine whether sand or other material is being pumped out of the well. The Contractor shall cooperate with and assist the Government's representative in measuring water elevations, sand in the well before and during pumping, and the amount of sand in the pump discharge. Upon completion of initial development, each well shall be subjected to a 4-hour pumping test. The pump shall be complete with gasoline, diesel, or electric motor of adequate size. The pumping and sand infiltration tests shall be conducted as directed. The following test measurements will be made by the Contracting Officer with the cooperation and assistance of the Contractor:

Time of observation
Depth of water in well before, during, and after pumping
Flow in gpm
The depth of sand in well before and after pumping
Amount of sand pumped out of well and collected in tank

The pumping shall be at the maximum rate possible consistent with the requirements that a minimum of 3 feet of water above the bottom of the pump bowl shall be maintained at all times, and that the entrance velocities through the open of the screen below the pumping water surface in the well shall not exceed 0.1 foot per second. Test pumping of a well will be permitted concurrently with drilling, development, or pumping of any other well. In the event that sand or other material infiltrates into the well as a result of the pumping test, the following procedures shall be followed:

If the total rate of sand infiltration into the well during the last hour of the pumping test is more than 2 to 3 ppm of sand, the well shall be surged by manipulation of the test pump for 60 minutes, after which the test pumping shall be resumed and shall be continued at the constant rate specified above until the sand infiltration rate is reduced to less than 2 to 5 ppm of sand but not for more than a total of 8 hours. If at the end of 8 hours of pumping the rate of infiltration of sand is more than 5 ppm of sand, the well shall be abandoned as directed by the Contracting Officer, except that the Contractor may, if he so elects and at no additional cost to the Government, continue the test pumping and perform such other approved remedial work as he considers desirable. If, after such additional test pumping and other remedial measures, the sand infiltration rate of a well is reduced to not more

than 2 to 5 ppm of sand, the well will be accepted. Plugging of wells abandoned shall be in accordance with paragraph, PLUGGING ABANDONED WELLS. Upon completion of the pumping test, any sand or filter material in the bottom of the well shall be removed by pumping or with a piston-type bailer. If the pumping equipment is removed from the well when pumping is completed, the top of the riser shall be immediately sealed in an approved manner. The well shall be kept sealed at all times except during pumping or cleaning operations or during measurement of the water level in the wells.

14. CAPPING WELLS. After development is completed, the gravel pack shall be brought back up to within 1 foot of the top of the conductor casing. A hole shall be cut in the center of a 10-inch PVC cap such that the 4-inch riser pipe will extend through the cap. A cap shall also be provided for the 4-inch riser pipe.

15. PLUGGING ABANDONED WELLS. The well screen and riser pipe may be salvaged from wells abandoned. Wells abandoned shall be plugged by first drilling or jetting a hole to the bottom of the screen and then injecting a neat cement grout into the hole through the jet pipe or drill stem as the screen is removed from the hole. The neat cement grout mix shall consist of 1 bag (94 pounds) of cement to 5 gallons of water and shall be injected at a maximum pressure of 10 psi.

16. MEASUREMENT AND PAYMENT.

16.1. MEASUREMENT.

16.1.1. Drilling Wells will be measured for payment by the linear foot to the nearest 1/10 foot from the bottom of the hole to the ground surface.

16.1.2. Well Screen will be measured for payment by the linear foot to the nearest 1/10 foot frm the top to the bottom of each well screen acceptably installed.

16.1.3. Riser Pipe. Acceptably installed riser pipe will be measured for payment by the linear foot to the nearest 1/10 foot from the specified top elevation to the bottom of the riser pipe.

16.1.4. Sand Trap. Installed sand trap will be measured for payment by the satisfactorily completed unit.

16.1.5. Gravel Filter Pack will be measured for payment by the linear foot of material satisfactorily installed to the dimensions shown on the drawings. No extra compensation will be allowed for any material placed outside of the 1 foot-4 inch diameter shown on the drawings. Payment will be made at the contract unit price for "Gravel

filter pack," which payment shall constitute fullcompensation for furnishing all plant, labor, amterials, and equipment; for withdrawing the temporary casing, and for performing all operations necessary for placing the gravel filter pack.

16.1.6. Development of Wells will be measured for payment by the hour, measured to the nearest 15 minutes, for well development performed as specified in paragraph, DEVELOPMENT OF WELLS. Measured time will begin when the Contractor actually begins jetting operations and will end either when the well has been successfully developed or when the Contracting Officer directs that the well be abandoned. Time spent removing material from the bottom of the well and in making required measurement will be included in the measured time, but time spent in installing and removing pumping equipment or in sealing the top of the riser pipe will not be included in the measured time.

16.1.7. Plugging Abandoned Wells as specified in paragraph, PLUGGING ABANDONED WELLS, will be measured for payment by the linear foot to the nearest 1/10 foot from the bottom of the well boring to the top elevation of the well.

16.2. PAYMENT.

16.2.1. Drilling Wells. Payment at the contract unit price for "Drilling Wells" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations necessary to drill the wells, remove drilling fluid, furnish and install temporary casing, assist the Contracting Officer on the job in securing samples for logging the hole, and all other operations incidental to drilling the wells.

16.2.2. Well Screen. Payment at the contract unit price for "Well Screen" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations necessary to install the well screens, including joining the screens to the riser pipe, furnishing and installing the welding couplings and bottom plates, and all other operations incidental to installing the well screens.

16.2.3. Riser Pipe. Payment at the contract unit price for "Riser Pipe" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for joining the pipe sections, and performing all other operations necessary to install the riser pipe.

16.2.4. Sand Trap. Payment made at the contract unit price for "Sand Trap" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for joining the screen and sand trap sections and performing all other operations necessary to install the sand trap.

16.2.5. Gravel Filter Pack. Payment made at the contract unit price for "Gravel Filter Pack" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations as delinearted in the last sentence of 14.1.5, Gravel Filter Pack.

16.2.6. Development of Wells. Payment at the contract unit price for "Well Development" shall constitute full compensation for furnishing all plant, labor, fuels, lubricants, electric energy, materials and equipment, and for performing all operations necessary to develop the wells.

16.2.7. Abandoned Wells.

16.2.7.1. Lack of Compliance. No payment will be made for "Drilling Wells," 'Well Screen," "Riser Pipe," "Sand Trap," "Gravel Pack," "Well Development," or backfilling and/or plugging any wells which are ordered abandoned due to failure to meet requirements of paragraph, DEVELOPMENT OF WELLS, where there is evidence that the Contractor failed to comply with requirements of the plans and specifications and/or Contracting Officer's directives.

16.2.7.2. Failure of Well to Meet Standards. Any wells which are abandoned due to producing excessive amounts of sand or filter material and which have been installed in full compliance with the plans and specifications and/or Contracting Officer's directives will be paid for at the applicable contract unit prices for "Drilling Wells," "Gravel Pack," and "Well Development." The stage of completion at the time of abandonment shall determine which items are applicable for payment.

16.2.7.3. Plugging Abandoned Wells. Payment made at the contract unit price for "Plugging Abandoned Wells" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations necessary to plug abandoned wells, as required by paragraph, PLUGGING ABANDONED WELLS.

No payment will be made for plugging any well abandoned as a result of fault or negligence of the Contractor. If no wells are abandoned, no plugging will be required; and the Contractor will not receive any pay whatsoever for this item, even though he may have put some of his indirect cost into the price bid for it.

ZERO ACCIDENTS

SECTION 13F
RECHARGE WELLS

INDEX

1. APPLICABLE PUBLICATIONS. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto.

1.1. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS.

A 53-78	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
A 120-78	Pipe, Steel, Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless
A 135-73a	Electric-Resistance - Welded Steel Pipe
A 139-74	Electric Fusion (Arc) - Welded Steel Pipe (Sizes 4 in. and over)
C 136-76	Sieve or Screen Analysis of Fine or Coarse Aggregates

1.2. AMERICAN PETROLEUM INSTITUTE (API) STANDARD SPECIFICATIONS.

5L	Specification for Line Pipe
5LX	Specification for High-Test Line Pipe

2. QUALITY CONTROL. The Contractor shall establish and maintain quality control for all well construction and development to assure compliance with contract requirements and maintain records of his quality control for all construction operations, including but not limited to the following:

Drilling of wells
Installation of well screen, riser pipe and sand trap
Placement of gravel filter pack
Development of wells
Sieve analysis of gravel filter pack
Logging of borehole
Capping well

A copy of these records and tests, as well as the records of corrective action taken, shall be furnished the Government as directed by the Contracting Officer.

3. GENERAL.

3.1 LOCATION. The location, spacing, and number of wells shall be as shown on the drawings, but may be changed by the Contracting Officer at no cost to the Government if field conditions warrant.

3.2 DEPTH AND DIAMETER OF WELL. Each well shall be installed to the depth as indicated on the drawings. The well depth may be increased up to 20 percent from those indicated on the drawings at the direction of the Contracting Officer. The hole drilled for each ~~dewater~~ recharge well shall be a minimum of 16 inches in diameter.

3.3 OBSTRUCTIONS ENCOUNTERED. The Contractor will be required to provide and use drills and equipment that are capable of removing cobbles up to 5 inches in diameter and drilling through claystone and sandstone bedrock. The presence of cobbles up to 5 inches in diameter encountered during drilling will not be considered as obstructions of sufficient reason for abandonment of a well. No payment will be made for any wells in which abandonment is determined to be necessary due to fault or neglect on the part of the Contractor.

4. WELL SCREENS for recharge wells shall be fabricated entirely from 304 stainless steel. Screens shall have a No. 60 (0.060 inch) slot width and shall be 12 inches in inside diameter. Well screens shall be wrapped, continuous slot screens, commercially manufactured, and of demonstrated structural ability for gravel wall wells to a depth of 40 feet. Screen openings shall be "V" shaped, being larger on the inside surface of the well screen.

5. RISER PIPE AND SAND TRAP shall be longitudinally welded steel line pipe. It shall be 12 inches in diameter as shown on drawings, and a minimum of 0.330 inches in wall thickness and shall meet one of the following applicable specifications (most current edition) for steel pipe: API 5L, API 5LX, ASTM A 53, ASTM A 120, ASTM A 135, or ASTM A 139.

6. GRAVEL FILTER PACK MATERIAL. Material for the gravel filter pack around the riser pipes, sand trap, and screens shall be rounded to subrounded, washed gravel composed of hard, tough, and durable particles free from adherent coatings. It shall contain no vegetable matter nor soft, friable, thin, or elongated particles in quantities determined deleterious. No more than 5 percent by weight of calcareous material shall be permitted. The gravel pack shall conform to the following gradation requirements, when tested by ASTM C 136, test method for "Sieve or Screen Analysis of Fine and Coarse Aggregates."

GRAVEL FILTER PACK MATERIAL

Sieve or Screen Size	Percent Passing
3/8 inch	100
No. 4	81-97
No. 6	64-80
No. 8	38-54
No. 14	0-14
No. 20	0

Materials shall be well graded between the limits specified above. All points on individual grading curves obtained from representative samples of gravel filter material shall lie between the boundary limits as defined by smooth curves drawn through the tabulated grading limits plotted on a mechanical analysis diagram. The individual grading curves within these limits shall not exhibit abrupt changes in slope denoting skip grading, scalping of certain sizes, or other irregularities which would be detrimental to the proper functioning of the gravel filter.

7. DRILLING.

7.1. GENERAL. The Contractor shall submit for review and approval by the Contracting Officer his proposed plan for drilling the wells. The plan shall take into account all the information furnished and all the restrictions imposed by the contract drawings and specifications. Wells shall be drilled by a proven method such as rotary, reverse rotary, or auger, which will ensure proper placement of the well screen, riser pipe, and gravel pack. Methods which may reduce the yield of the well will not be permitted. The use of bentonitic-type drilling fluid is prohibited. Drilling fluid additivies similar and equal to "Revert" and "Fastbreak," products of UOP Johnson Division, St. Paul, Minnesota 55104, may be used. Loss of a hole or well because of lack of material, inadequate or faulty equipment, or careless operating procedures will be considered cause for an abandoned well due to fault or neglect on the part of the Contractor.

7.2. DRILLING METHOD. The diameter of the hole shall be a minimum of 24 inches and shall permit the placement of the minimum thickness of gravel pack as specified hereinafter in paragraph, GRAVEL FILTER PACK PLACEMENT. If a drilling fluid is used (not a bentonite or other expansive clay system), it shall be a suspension of fine-grained soil or shall be an approved commercial product of a recognized manufacturer and shall have the characteristics of being readily removable from the gravel filter pack and the walls of the formation by developing methods as hereinafter specified in paragraph, DEVELOPMENT OF WELLS. If the walls of the hole above the top of the gravel filter require support during development operations, a temporary casing similar to that specified in paragraph, TEMPORARY CASING, shall be placed so as to extend from the ground surface to at least three feet below the top of the gravel filter.

7.3. TEMPORARY CASING. If necessary, a temporary well casing of either iron or steel, new or used, may be used to support the sides of the entire hole during drilling and placement of screen, riser pipe, and gravel filter pack and to support the sides of the unbackfilled portion of the hole during development of the well. Any temporary casing shall have an inside diameter large enough to provide a 5-1/2-inch minimum filter thickness entirely around the well screen or riser pipe and shall have sufficient thickness to retain its shape and maintain a true section throughout its depth. The temporary casing shall be such as to permit its removal without interfering with the filter or riser pipe. Except where the reverse rotary method is used, temporary casing shall be carried to a minimum of four feet below the bottom elevation of the well screen.

7.4. LOGGING OF BOREHOLE. Contractor will provide a driller's log to the Contracting Officer prior to installation of screens and casings.

8. INSTALLATION OF RISER PIPE, SAND TRAP, AND SCREEN.

8.1. ASSEMBLY. All riser pipe, sand trap, and screen shall be in good condition before installation; and all joints and other accessory parts shall be securely fastened in place. Particular care shall be exercised to avoid damaging the screen, sand trap, spacers, and riser pipe during installation and throughout all subsequent operations. The screen, sand trap, and riser pipe shall be centered in the well hole and held securely in place during placement of the filter by means of an approved method. Spacers will not be permitted on the well screen.

8.2. JOINTS. Sections of the steel riser pipe, stainless steel well screen, and sand trap shall be joined by butt welding. The joints shall be designed and constructed to support the weight of the screen and/or pipe as it is lowered into the hole.

8.3. SUBMITTALS. The Contractor shall submit for approval detailed shop drawings and catalog data of the well screen, riser pipe, joints, and sand traps which he proposes to furnish in accordance with Section: SPECIAL PROVISIONS.

8.4. INSTALLATION. The assembled screen, sand trap, and riser pipe shall be placed in the well hole in such a manner as to avoid jarring impacts and to ensure that the assembly is not damaged or misplaced. Immediately after the installation of the well screen, sand trap, and riser pipe, the depth of the well shall be measured. The riser pipe shall have a top elevation as indicated on the drawings and be sealed in an approved manner after development.

8.5. ALINEMENT. Each completed well shall be straight and plumb. Immediately before placing the gravel pack and with top of riser fastened securely in a vertical and horizontal position, alinement and plumbness surveys shall be conducted by the Contractor in the presence of the Contracting Officer or his representative. Excessive misalinement or deviation from plumb shall be corrected before placing gravel pack.

8.6. PLUMBNESS TESTS will be performed by the Contracting Officer or his representative and will consist of a plumb line run from the top of the well to the bottom of the well. A variation of 20 inches/100 feet will be permitted in the combined length of screen, sand trap, and riser pipe of the well. Advance notice of at least one day of the approximate time of readiness for the plumbness survey shall be given by the Contracting Officer to avoid delay to the Contractor.

9. GRAVEL FILTER PACK PLACEMENT. After the screen, sand trap, and riser pipe have been placed and plumbness and alinement surveys are conducted, the gravel filter pack shall be tremied around the screen in such a manner as to ensure uniform placement around the screen as the tremie is raised. The gravel filter pack material shall be placed in one continuous run. The gravel shall have a minimum thickness of not less than 5-1/2 inches between the outside of the screen and the outside of the gravel filter pack and shall be maintained a minimum of 2 feet above the screen throughout the development process. Material which may have entered the well screen and riser pipe shall be removed before development of the well is commenced.

10. DEVELOPMENT OF WELLS shall consist of simultaneously pumping with air to create flow from the well and operating a horizontal water jet inside the well screen in such a manner that high velocity streams of water shoot out through the screen openings to achieve a stable well of maximum efficiency. The static water surface in the well shall not be lowered below the top of the screen during development operations. By slowly rotating and gradually raising the jetting tools, the entire surface of the screen shall be covered by the jetting action. The tool

shall be rotated at a rate of one-half revolution in 15 seconds and returned at the same rate for a period of 2 minutes. The tool shall then be raised in increments of 6 inches and again rotated. At the same time the jetting operation is in progress, the well shall be air pumped at a rate not less than 1.25 times the gpm entering the well through the jetting tool and sufficient to remove the fine material entering the well or as directed by the Contracting Officer. The jetting tool shall consist of an attachment fitted with four evenly spaced horizontal nozzles having 1/4-inch orifices set in a ring having a diameter approximately 1 inch less than the diameter of the screen. Only clear water shall be used in the jetting operation. The pump used in the jetting operations shall be a high pressure pump of sufficient capacity to pump approximately 80 gpm and obtain an approximate nozzle velocity of 150 feet per second. Air shall be supplied by an air compressor of suitable capacity. Jetting shall begin at the bottom of the screen and proceed upward to the top of the screen which shall constitute one jetting cycle. A minimum of three jetting cycles is required. Sand remaining in the well shall be removed at the end of each jetting cycle or as directed by the Contracting Officer. After the jetting and cleaning cycles are completed, the well shall be pumped until all fines and drilling fluids are removed from the well. Such pumping shall continue for not less than 2 hours at a rate compatible with reasonable drawdown as directed. If at the completion of the 2-hour minimum pumping, the total amount of sand entering the well is in excess of 2 to 5 ppm of sand, as determined from soundings in the well and collection of samples in a tank, the jetting and cleaning cycles shall be repeated and the well pumped again. Development of the well shall be continued until material entering the well during pumping is less than the amount specified above unless otherwise directed by the Contracting Officer. Wells which continue to produce an excessive amount of sand or filter material during pumping shall be abandoned as directed by the Contracting Officer. Wells ordered abandoned shall be plugged in accordance with the provisions of paragraph, PLUGGING ABANDONED WELLS. If, after completion of this initial jetting and pumping, there is more than 0.5 of a foot of material in the bottom of the well, such material shall be removed. The Contractor shall provide an approved means for accurately determining the water level in the well under all conditions and furnish and install a calibrated instrument of standard design for the purpose of measuring the discharge from the well. He shall also provide an approved sounding device for measuring the depth of sand in the well. The pump discharge shall be conducted in an approved manner and so as not to interfere with other construction in the area. The Contractor shall furnish an approved tap and valve in the discharge line and a suitable baffled tank or other Government-approved device into which the well discharge shall be pumped to determine whether sand or other material is being pumped out of the well. The Contractor shall cooperate with and assist the Contracting Officer's representative in measuring water elevations; sand in the

well, before and during pumping; and the amount of sand in the pump discharge. Upon completion of initial development, each well shall be subjected to a two hour pumping test. The pump shall be complete with gasoline, diesel, or electric motor of adequate size. The pumping and sand infiltration tests shall be conducted as directed. The following test measurements will be made by the Contracting Officer with the cooperation and assistance of the Contractor:

Time of observation
Depth of water in well before, during, and after pumping
Flow in gpm
The depth of sand in well before and after pumping
Amount of sand pumped out of well and collected in tank

The Contractor shall test each well by pumping continuously for a minimum of 2 hours. The pumping shall be at the maximum rate possible consistent with the requirements that a minimum of 3 feet of water above the bottom of the pump bowl shall be maintained at all times, and that the entrance velocities through the open area of the screen below the pumping water surface in the well shall not exceed 0.1 foot per second. Test pumping of a well will be permitted concurrently with drilling, development, or pumping of any other well. In the event that sand or other material infiltrates into the well as a result of the pumping test, the following procedures shall be followed:

If the total rate of sand infiltration into the well during the last hour of the 2 hour pumping test is more than 2 to 5 ppm of sand, the well shall be surged by manipulation of the test pump for 60 minutes, after which the test pumping shall be resumed and shall be continued at the constant rate specified above until the sand infiltration rate is reduced to less than 2 to 5 ppm of sand but not for more than a total of 8 hours. If at the end of 8 hours of pumping the rate of infiltration of sand is more than 2 ppm of sand, the well shall be abandoned as directed by the Contracting Officer, except that the Contractor may, if he so elects and at no additional cost to the Government, continue the test pumping and perform such other approved remedial work as he considers desirable. If, after such additional test pumping and other remedial measures, the sand infiltration rate of a well is reduced to not more than 2 to 5 ppm of sand, the well will be accepted. Plugging of wells ordered abandoned shall be in accordance with the provisions of paragraph, PLUGGING ABANDONED WELLS. Upon completion of the pumping tests, any sand or filter material in the bottom of the well shall be removed by pumping or with a piston-type bailer. The well riser pipe shall then be filled to its top with clear water; the rate at which the water in the riser pipe falls shall be observed and recorded as directed. If the pumping equipment is removed from the well when pumping is completed, the top of the riser shall be immediately sealed in an approved manner.

The well shall be kept sealed at all times except during pumping or cleaning operations or during measurement of the water level in the wells.

11. PLUGGING ABANDONED WELLS. The well screen and riser pipe may be salvaged from wells abandoned. Wells abandoned shall be plugged by first drilling or jetting a hole to the bottom of the screen and then injecting a neat cement grout into the hole through the jet pipe or drill stem as the screen is removed from the hole. The neat cement grout mix shall consist of one bag (94 pounds) of cement to 5 gallons of water and shall be injected at a maximum pressure of 10 psi.

12. MEASUREMENT AND PAYMENT.

12.1. MEASUREMENT.

12.1.1. Drilling wells will be measured for payment by the linear foot to the nearest 1/10 foot from the bottom of the hole to the ground surface.

12.1.2. Well screens will be measured for payment by the linear foot to the nearest 1/10 foot from the top to the bottom of each well screen acceptably installed.

12.1.3. Riser pipe. Acceptably installed riser pipe will be measured for payment by the linear foot to the nearest 1/10 foot from the specified top elevation to the bottom of the riser pipe.

12.1.4. Sand trap. Installed sand trap will be measured for payment by the satisfactorily completed unit.

12.1.5. Gravel filter pack will be measured for payment by the linear foot of material satisfactorily installed to the dimensions shown on the drawings. No extra compensation will be allowed for any material placed outside of the 1 foot-4 inch diameter shown on the drawings. Payment will be made at the contract unit price for "Gravel filter pack," which payment shall constitute full compensation for furnishing all plant, labor, materials, and equipment; for withdrawing the temporary casing, and for performing all operations necessary for placing the gravel filter pack.

12.1.6. Development of wells will be measured for payment by the hour, measured to the nearest 15 minutes, for well development performed as specified in paragraph, DEVELOPMENT OF WELLS. Measured time will begin when the Contractor actually begins jetting operations and will end either when the well has been successfully developed or when the Contracting Officer directs that the well be abandoned. Time

spent removing material from the bottom of the well and in making required measurement will be included in the measured time, but time spent in installing and removing pumping equipment or in sealing the top of the riser pipe will not be included in the measured time.

12.1.7. Plugging abandoned wells, as specified in paragraph, PLUGGING ABANDONED WELLS, will be measured for payment by the linear foot to the nearest 1/10 foot from the bottom of the well boring to the top elevation of the well.

12.2. PAYMENT.

12.2.1. Drilling wells. Payment at the contract unit price for "Drilling Wells" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations necessary to drill the wells, remove drilling fluid, furnish and install temporary casing, assist the Contracting Officer on the job in securing samples for logging the hole, and all other operations incidental to drilling the wells.

12.2.2. Well screen. Payment at the contract unit price for "Well Screen" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations necessary to install the well screens, including joining the screens to the riser pipe, furnishing and installing the welding couplings and bottom plates, and all other operations incidental to installing the well screens.

12.2.3. Riser pipe. Payment at the contract unit price for "Riser Pipe" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for joining the pipe sections, and performing all other operations necessary to install the riser pipe.

12.2.4. Sand trap. Payment made at the contract unit price for "Sand Trap" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for joining the screen and sand trap sections and performing all other operations necessary to install the sand trap.

12.2.5. Gravel filter pack. Payment made at the contract unit price for "Gravel Filter Pack" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations as delineated in the last sentence of 12.1.5., Gravel Filter Pack.

12.2.6. Development of wells. Payment at the contract unit price for "Well Development" shall constitute full compensation for furnishing all plant, labor, fuels, lubricants, electric energy, materials and equipment, and for performing all operations necessary to develop the wells.

12.2.7. Abandoned wells.

12.2.7.1. Lack of compliance. No payment will be made for "Drilling Wells," "Well Screen," "Riser Pipe," "Sand Trap," "Gravel Pack," "Well Development," or backfilling and/or plugging any wells which are ordered abandoned due to failure to meet requirements of paragraph, DEVELOPMENT OF WELLS, where there is evidence that the Contractor failed to comply with requirements of the plans and specifications and/or Contracting Officer's directives.

12.2.7.2. Failure of well to meet standards. Any wells which are abandoned due to producing excessive amounts of sand or filter material and which have been installed in full compliance with the plans and specifications and/or Contracting Officer's directives will be paid for at the applicable contract unit prices for "Drilling Wells," "Gravel Pack," and "Well Development." The stage of completion at the time of abandonment shall determine which items are applicable for payment.

12.2.7.3. Plugging abandoned wells. Payment made at the contract unit price for "Plugging Abandoned Wells" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations necessary to plug abandoned wells, as required by paragraph, PLUGGING ABANDONED WELLS.

No payment will be made for plugging any well abandoned as a result of fault or negligence of the Contractor. If no wells are abandoned, no plugging will be required; and the Contractor will not receive any pay whatsoever for this item, even though he may have put some of his indirect cost into the price bid for it.

ZERO ACCIDENTS

SECTION 13E
DEWATER WELLS

INDEX

1. APPLICABLE PUBLICATIONS. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto.

1.1. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS.

A 53-78	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
A 120-78	Pipe, Steel, Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless
A 135-73a	Electric-Resistance - Welded Steel Pipe
A 139-74	Electric Fusion (Arc) - Welded Steel Pipe (Sizes 4 in. and over)
C 136-76	Sieve or Screen Analysis of Fine or Coarse Aggregates

1.2. AMERICAN PETROLEUM INSTITUTE (API) STANDARD SPECIFICATIONS.

5L	Specification for Line Pipe
5LX	Specification for High-Test Line Pipe

2. QUALITY CONTROL. The Contractor shall establish and maintain quality control for all well construction and development to assure compliance with contract requirements and maintain records of his quality control for all construction operations, including but not limited to the following:

Drilling of wells
Installation of well screen, riser pipe and sand trap
Placement of gravel filter pack
Development of wells
Sieve analysis of gravel filter pack
Logging of borehole
Capping well

A copy of these records and tests, as well as the records of corrective action taken, shall be furnished the Government as directed by the Contracting Officer.

3. GENERAL.

3.1 LOCATION. The location, spacing, and number of wells shall be as shown on the drawings, but may be changed by the Contracting Officer at no cost to the Government if field conditions warrant.

3.2 DEPTH AND DIAMETER OF WELL. Each well shall be installed to the depth as indicated on the drawings. The well depth may be increased up to 20 percent from those indicated on the drawings at the direction of the Contracting Officer. The hole drilled for each dewater well shall be a minimum of 16 inches in diameter.

3.3 OBSTRUCTIONS ENCOUNTERED. The Contractor will be required to provide and use drills and equipment that are capable of removing cobbles up to 5 inches in diameter and drilling through claystone and sandstone bedrock. The presence of cobbles up to 5 inches in diameter encountered during drilling will not be considered as obstructions of sufficient reason for abandonment of a well. No payment will be made for any wells in which abandonment is determined to be necessary due to fault or neglect on the part of the Contractor.

4. WELL SCREENS for dewatering wells shall be fabricated entirely from 316L stainless steel. Screens shall have a No. 60 (0.060 inch) slot width and shall be 6 inches in inside diameter. Well screens shall be wrapped, continuous slot screens, having "V" shaped openings. The screen opening shall be larger on the inside surface of the well screen. The screen shall be a commercially manufactured screen of demonstrated structural ability for gravel wall dewatering wells to a depth of 40 feet and shall be of a type which has been successfully used in similar installations.

5. RISER PIPE AND SAND TRAP shall be longitudinally welded steel line pipe. It shall be 6 inches in diameter as shown on drawings, and a minimum of 0.28 inches in wall thickness. It shall meet one of the following applicable specifications (most current edition) for steel pipe: API 5L, API 5LX, ASTM A 53, ASTM A 120, ASTM A 135, or ASTM A 139.

6. GRAVEL FILTER PACK MATERIAL. Material for the gravel filter pack around the riser pipes, sand trap, and screens shall be rounded to subrounded, washed gravel composed of hard, tough, and durable particles free from adherent coatings. It shall contain no vegetable matter nor soft, friable, thin, or elongated particles in quantities determined deleterious. No more than 5 percent by weight of calcareous material shall be permitted. The gravel pack shall conform to the following gradation requirements, when tested by ASTM C 136, test method for "Sieve or Screen Analysis of Fine and Coarse Aggregates."

GRAVEL FILTER PACK MATERIAL

Sieve or Screen Size	Percent Passing
3/8 inch	100
No. 4	81-97
No. 6	64-80
No. 8	38-54
No. 14	0-14
No. 20	0

Materials shall be well graded between the limits specified above. All points on individual grading curves obtained from representative samples of gravel filter material shall lie between the boundary limits as defined by smooth curves drawn through the tabulated grading limits plotted on a mechanical analysis diagram. The individual grading curves within these limits shall not exhibit abrupt changes in slope denoting skip grading, scalping of certain sizes, or other irregularities which would be detrimental to the proper functioning of the gravel filter.

7. DRILLING.

7.1. GENERAL. The Contractor shall submit for review and approval by the Contracting Officer his proposed plan for drilling the wells. The plan shall take into account all the information furnished and all the restrictions imposed by the contract drawings and specifications. Wells shall be drilled by a proven method such as rotary, reverse rotary, or auger, which will ensure proper placement of the well screen, riser pipe, and gravel pack. Methods which may reduce the yield of the well will not be permitted. The use of bentonitic-type drilling fluid is prohibited. Drilling fluid additivies similar and equal to "Revert" and "Fastbreak," products of UOP Johnson Division, St. Paul, Minnesota 55104, may be used. Loss of a hole or well because of lack of material, inadequate or faulty equipment, or careless operating procedures will be considered cause for an abandoned well due to fault or neglect on the part of the Contractor.

7.2. DRILLING METHOD. The diameter of the hole shall be a minimum of 16 inches and shall permit the placement of the minimum thickness of gravel pack as specified hereinafter in paragraph, GRAVEL FILTER PACK PLACEMENT. If a drilling fluid is used (not a bentonite or other expansive clay system), it shall be a suspension of fine-grained soil or shall be an approved commercial product of a recognized manufacturer and shall have the characteristics of being readily removable from the gravel filter pack and the walls of the formation by developing methods as hereinafter specified in paragraph, DEVELOPMENT OF WELLS. If the walls of the hole above the top of the gravel filter require support during development operations, a temporary casing similar to that specified in paragraph, TEMPORARY CASING, shall be placed so as to extend from the ground surface to at least three feet below the top of the gravel filter.

7.3. TEMPORARY CASING. If necessary, a temporary well casing of either iron or steel, new or used, may be used to support the sides of the entire hole during drilling and placement of screen, riser pipe, and gravel filter pack and to support the sides of the unbackfilled portion of the hole during development of the well. Any temporary casing shall have an inside diameter large enough to provide a 4-1/2-inch minimum filter thickness entirely around the well screen or riser pipe and shall have sufficient thickness to retain its shape and maintain a true section throughout its depth. The temporary casing shall be such as to permit its removal without interfering with the filter or riser pipe. Except where the reverse rotary method is used, temporary casing shall be carried to a minimum of four feet below the bottom elevation of the well screen.

7.4. LOGGING OF BOREHOLE. Contractor will provide a driller's log to the Contracting Officer prior to installation of screens and casings.

8. INSTALLATION OF RISER PIPE, SAND TRAP, AND SCREEN.

8.1. ASSEMBLY. All riser pipe, sand trap, and screen shall be in good condition before installation; and all joints and other accessory parts shall be securely fastened in place. Particular care shall be exercised to avoid damaging the screen, sand trap, spacers, and riser pipe during installation and throughout all subsequent operations. The screen, sand trap, and riser pipe shall be centered in the well hole and held securely in place during placement of the filter by means of an approved method. Spacers will not be permitted on the well screen.

8.2. JOINTS. Sections of the steel riser pipe, stainless steel well screen, and sand trap shall be joined by butt welding. The joints shall be designed and constructed to support the weight of the screen and/or pipe as it is lowered into the hole.

8.3. SUBMITTALS. The Contractor shall submit for approval detailed shop drawings and catalog data of the well screen, riser pipe, joints, and sand traps which he proposes to furnish in accordance with Section: SPECIAL PROVISIONS.

8.4. INSTALLATION. The assembled screen, sand trap, and riser pipe shall be placed in the well hole in such a manner as to avoid jarring impacts and to ensure that the assembly is not damaged or misplaced. Immediately after the installation of the well screen, sand trap, and riser pipe, the depth of the well shall be measured. The riser pipe shall have a top elevation as indicated on the drawings and be sealed in an approved manner after development.

8.5. ALINEMENT. Each completed well shall be straight and plumb. Immediately before placing the gravel pack and with top of riser fastened securely in a vertical and horizontal position, alinement and plumbness surveys shall be conducted by the Contractor in the presence of the Contracting Officer or his representative. Excessive misalinement or deviation from plumb shall be corrected before placing gravel pack.

8.6. PLUMBNESS TESTS will be performed by the Contracting Officer or his representative and will consist of a plumb line run from the top of the well to the bottom of the well. A variation of 20 inches/100 feet will be permitted in the combined length of screen, sand trap, and riser pipe of the well. Advance notice of at least one day of the approximate time of readiness for the plumbness survey shall be given by the Contracting Officer to avoid delay to the Contractor.

9. GRAVEL FILTER PACK PLACEMENT. After the screen, sand trap, and riser pipe have been placed and plumbness and alinement surveys are conducted, the gravel filter pack shall be tremied around the screen in such a manner as to ensure uniform placement around the screen as the tremie is raised. The gravel filter pack material shall be placed in one continuous run. The gravel shall have a minimum thickness of not less than 4-1/2 inches between the outside of the screen and the outside of the gravel filter pack and shall be maintained a minimum of 2 feet above the screen throughout the development process. Material which may have entered the well screen and riser pipe shall be removed before development of the well is commenced.

10. DEVELOPMENT OF WELLS shall consist of simultaneously pumping with air to create flow from the well and operating a horizontal water jet inside the well screen in such a manner that high velocity streams of water shoot out through the screen openings to achieve a stable well of maximum efficiency. The static water surface in the well shall not be lowered below the top of the screen during development operations. By slowly rotating and gradually raising the jetting tools, the entire surface of the screen shall be covered by the jetting action. The tool

shall be rotated at a rate of one-half revolution in 15 seconds and returned at the same rate for a period of 2 minutes. The tool shall then be raised in increments of 6 inches and again rotated. At the same time the jetting operation is in progress, the well shall be air pumped at a rate not less than 1.25 times the gpm entering the well through the jetting tool and sufficient to remove the fine material entering the well or as directed by the Contracting Officer. The jetting tool shall consist of an attachment fitted with four evenly spaced horizontal nozzles having 1/4-inch orifices set in a ring having a diameter approximately 1 inch less than the diameter of the screen. Only clear water shall be used in the jetting operation. The pump used in the jetting operations shall be a high pressure pump of sufficient capacity to pump approximately 80 gpm and obtain an approximate nozzle velocity of 150 feet per second. Air shall be supplied by an air compressor of suitable capacity. Jetting shall begin at the bottom of the screen and proceed upward to the top of the screen which shall constitute one jetting cycle. A minimum of three jetting cycles is required. Sand remaining in the well shall be removed at the end of each jetting cycle or as directed by the Contracting Officer. After the jetting and cleaning cycles are completed, the well shall be pumped until all fines and drilling fluids are removed from the well. Such pumping shall continue for not less than 2 hours at a rate compatible with reasonable drawdown as directed. If at the completion of the 2-hour minimum pumping, the total amount of sand entering the well is in excess of 2 to 5 ppm of sand, as determined from soundings in the well and collection of samples in a tank, the jetting and cleaning cycles shall be repeated and the well pumped again. Development of the well shall be continued until material entering the well during pumping is less than the amount specified above unless otherwise directed by the Contracting Officer. Wells which continue to produce an excessive amount of sand or filter material during pumping shall be abandoned as directed by the Contracting Officer. Wells ordered abandoned shall be plugged in accordance with the provisions of paragraph, PLUGGING ABANDONED WELLS. If, after completion of this initial jetting and pumping, there is more than 0.5 of a foot of material in the bottom of the well, such material shall be removed. The Contractor shall provide an approved means for accurately determining the water level in the well under all conditions and furnish and install a calibrated instrument of standard design for the purpose of measuring the discharge from the well. He shall also provide an approved sounding device for measuring the depth of sand in the well. The pump discharge shall be conducted in an approved manner and so as not to interfere with other construction in the area. The Contractor shall furnish an approved tap and valve in the discharge line and a suitable baffled tank or other Government-approved device into which the well discharge shall be pumped to determine whether sand or other material is being pumped out of the well. The Contractor shall cooperate with and assist the Contracting Officer's representative in measuring water elevations; sand in the

well, before and during pumping; and the amount of sand in the pump discharge. Upon completion of initial development, each well shall be subjected to a two hour pumping test. The pump shall be complete with gasoline, diesel, or electric motor of adequate size. The pumping and sand infiltration tests shall be conducted as directed. The following test measurements will be made by the Contracting Officer with the cooperation and assistance of the Contractor:

Time of observation
Depth of water in well before, during, and after pumping
Flow in gpm
The depth of sand in well before and after pumping
Amount of sand pumped out of well and collected in tank

The Contractor shall test each well by pumping continuously for a minimum of 2 hours. The pumping shall be at the maximum rate possible consistent with the requirements that a minimum of 3 feet of water above the bottom of the pump bowl shall be maintained at all times, and that the entrance velocities through the open area of the screen below the pumping water surface in the well shall not exceed 0.1 foot per second. Test pumping of a well will be permitted concurrently with drilling, development, or pumping of any other well. In the event that sand or other material infiltrates into the well as a result of the pumping test, the following procedures shall be followed:

If the total rate of sand infiltration into the well during the last hour of the 2 hour pumping test is more than 2 to 5 ppm of sand, the well shall be surged by manipulation of the test pump for 60 minutes, after which the test pumping shall be resumed and shall be continued at the constant rate specified above until the sand infiltration rate is reduced to less than 2 to 5 ppm of sand but not for more than a total of 8 hours. If at the end of 8 hours of pumping the rate of infiltration of sand is more than 2 ppm of sand, the well shall be abandoned as directed by the Contracting Officer, except that the Contractor may, if he so elects and at no additional cost to the Government, continue the test pumping and perform such other approved remedial work as he considers desirable. If, after such additional test pumping and other remedial measures, the sand infiltration rate of a well is reduced to not more than 2 to 5 ppm of sand, the well will be accepted. Plugging of wells ordered abandoned shall be in accordance with the provisions of paragraph, PLUGGING ABANDONED WELLS. Upon completion of the pumping tests, any sand or filter material in the bottom of the well shall be removed by pumping or with a piston-type bailer. If the pumping equipment is removed from the well when pumping is completed, the top of the riser shall be immediately sealed in an approved manner. The well shall be kept sealed at all times except during pumping or cleaning operations or during measurement of the water level in the wells. Past groundwater investigations along the dewatering well alinement indicate an expected yield of about 1.5 to 6 gpm per foot of draw down.

11. PLUGGING ABANDONED WELLS. The well screen and riser pipe may be salvaged from wells abandoned. Wells abandoned shall be plugged by first drilling or jetting a hole to the bottom of the screen and then injecting a neat cement grout into the hole through the jet pipe or drill stem as the screen is removed from the hole. The neat cement grout mix shall consist of one bag (94 pounds) of cement to 5 gallons of water and shall be injected at a maximum pressure of 10 psi.

12. MEASUREMENT AND PAYMENT.

12.1. MEASUREMENT.

12.1.1. Drilling wells will be measured for payment by the linear foot to the nearest 1/10 foot from the bottom of the hole to the ground surface.

12.1.2. Well screens will be measured for payment by the linear foot to the nearest 1/10 foot from the top to the bottom of each well screen acceptably installed.

12.1.3. Riser pipe. Acceptably installed riser pipe will be measured for payment by the linear foot to the nearest 1/10 foot from the specified top elevation to the bottom of the riser pipe.

12.1.4. Sand trap. Installed sand trap will be measured for payment by the satisfactorily completed unit.

12.1.5. Gravel filter pack will be measured for payment by the linear foot of material satisfactorily installed to the dimensions shown on the drawings. No extra compensation will be allowed for any material placed outside of the 1 foot-4 inch diameter shown on the drawings. Payment will be made at the contract unit price for "Gravel filter pack," which payment shall constitute full compensation for furnishing all plant, labor, materials, and equipment; for withdrawing the temporary casing, and for performing all operations necessary for placing the gravel filter pack.

12.1.6. Development of wells will be measured for payment by the hour, measured to the nearest 15 minutes, for well development performed as specified in paragraph, DEVELOPMENT OF WELLS. Measured time will begin when the Contractor actually begins jetting operations and will end either when the well has been successfully developed or when the Contracting Officer directs that the well be abandoned. Time spent removing material from the bottom of the well and in making required measurement will be included in the measured time, but time spent in installing and removing pumping equipment or in sealing the top of the riser pipe will not be included in the measured time.

12.1.7. Plugging abandoned wells, as specified in paragraph, PLUGGING ABANDONED WELLS, will be measured for payment by the linear foot to the nearest 1/10 foot from the bottom of the well boring to the top elevation of the well.

12.2. PAYMENT.

12.2.1. Drilling wells. Payment at the contract unit price for "Drilling Wells" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations necessary to drill the wells, remove drilling fluid, furnish and install temporary casing, assist the Contracting Officer on the job in securing samples for logging the hole, and all other operations incidental to drilling the wells.

12.2.2. Well screen. Payment at the contract unit price for "Well Screen" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations necessary to install the well screens, including joining the screens to the riser pipe, furnishing and installing the welding couplings and bottom plates, and all other operations incidental to installing the well screens.

12.2.3. Riser pipe. Payment at the contract unit price for "Riser Pipe" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for joining the pipe sections, and performing all other operations necessary to install the riser pipe.

12.2.4. Sand trap. Payment made at the contract unit price for "Sand Trap" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for joining the screen and sand trap sections and performing all other operations necessary to install the sand trap.

12.2.5. Gravel filter pack. Payment made at the contract unit price for "Gravel Filter Pack" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations as delineated in the last sentence of 12.1.5., Gravel Filter Pack.

12.2.6. Development of wells. Payment at the contract unit price for "Well Development" shall constitute full compensation for furnishing all plant, labor, fuels, lubricants, electric energy, materials and equipment, and for performing all operations necessary to develop the wells.

12.2.7. Abandoned wells.

12.2.7.1. Lack of compliance. No payment will be made for "Drilling Wells," "Well Screen," "Riser Pipe," "Sand Trap," "Gravel Pack," "Well Development," or backfilling and/or plugging any wells which are ordered abandoned due to failure to meet requirements of paragraph, DEVELOPMENT OF WELLS, where there is evidence that the Contractor failed to comply with requirements of the plans and specifications and/or Contracting Officer's directives.

12.2.7.2. Failure of well to meet standards. Any wells which are abandoned due to producing excessive amounts of sand or filter material and which have been installed in full compliance with the plans and specifications and/or Contracting Officer's directives will be paid for at the applicable contract unit prices for "Drilling Wells," "Gravel Pack," and "Well Development." The stage of completion at the time of abandonment shall determine which items are applicable for payment.

12.2.7.3. Plugging abandoned wells. Payment made at the contract unit price for "Plugging Abandoned Wells" shall constitute full compensation for furnishing all plant, labor, materials and equipment, and for performing all operations necessary to plug abandoned wells, as required by paragraph, PLUGGING ABANDONED WELLS.

No payment will be made for plugging any well abandoned as a result of fault or negligence of the Contractor. If no wells are abandoned, no plugging will be required; and the Contractor will not receive any pay whatsoever for this item, even though he may have put some of his indirect cost into the price bid for it.

ZERO ACCIDENTS

SECTION 15F
PRESSURE VESSELS FOR STORAGE OF COMPRESSED GASES

1. APPLICABLE PUBLICATIONS: The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto:

1.1 FEDERAL SPECIFICATIONS (Fed. Spec.):

TT-E-489F & Int. Am-1	Enamel, Alkyd, Gloss (for Exterior and Interior Surfaces)
TT-P-86G	Paint, Red-Lead-Base, Ready-Mixed

1.2 MILITARY SPECIFICATION (Mil. Spec.):

MIL-P-27401C	Propellant Pressurizing Agent, Nitrogen

1.3 AMERICAN NATIONAL STANDARDS INSTITUTE, INC. (ANSI) STANDARDS:

B16.5-1977	Steel Pipe Flanges & Flanged Fittings
B16.20-1973	Ring-Joint Gaskets and Grooves for Steel Pipe Flanges
B31.3a-1978, B31.3-1976, & B31.3b-1978,	Petroleum Refinery Piping

B31.2-1968	Fuel Gas Piping
B31.8-1975	Gas Transmission and Distribution Piping

1.4 AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS:

A 36-77a	Structural Steel
A 182-78	Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Services
A 193-78a	Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
A 194-78	Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
A 312-77	Seamless and Welded Austenitic Stainless Steel Pipe
A 320-77a	Alloy Steel Bolting Materials for Low-Temperature Service
A 370-77	Methods and Definitions for Mechanical Testing of Steel Products
A 376-77	Seamless Austenitic Steel Pipe for High-Temperature Central-Station Service
A 403-77	Wrought Austenitic Stainless Steel Piping Fittings
E 109-63 (R 1976)	Dry Powder Magnetic Particle Inspection
E 165-65	Liquid Penetrant Inspection Method

1.5 AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME) PUBLICATIONS:

Boiler and Pressure Vessel Code and Interpretations:

Section II	Material Specifications, Part A -- Ferrous Materials (1977; Addenda: Summer and Winter 1977; Summer and Winter 1978; Summer 1979)
Section V	Nondestructive Examination: (1977; Addenda: Summer and Winter 1978; Summer 1979)
Section VIII	Pressure Vessels, Division 1 (1977; Addenda: Summer and Winter 1977; Summer and Winter 1978; Summer 1979)
Section IX	Welding and Brazing Qualifications (1977; Addenda: Summer and Winter 1977; Summer and Winter 1978; Summer 1979)

1.6 UNIFORM CLASSIFICATION COMMITTEE (UCC) PUBLICATION:

Uniform Freight Classification 13, Ratings, Rules and Regulations (May 26, 1978, and Supplements 1, June 2, 1978; 5, Nov 13, 1978; 8, Jan 22, 1979; 10, Mar 21, 1979; 11, May 21, 1979; 12, May 22, 1979; 16, Jul 2, 1979; 16A, Jul 6, 1979; 17, Jul 20, 1979; 18, Aug 20, 1979).

2. QUALITY CONTROL provisions of Division 1, General Requirements, apply to this section. Unless otherwise specified herein, requirements for supervision, inspection, sampling, testing, approval, directing, authorizing, and other requirements of similar import shall be the responsibility of the Contractor Quality Control representative. Approvals, except those required for field installation, field applications, and field tests shall be obtained before delivery of materials or equipment to the project site.

3. GENERAL. The vessel shall be welded cylinder or sphere, or seamless cylinder, or cylinder of multiple layer or banded construction, and shall be designed, fabricated, tested, and cleaned in conformance with requirements herein and the applicable drawings. Vessel shall be suitable for stationary, aboveground installation, exposed to atmospheric elements. Only minimum requirements are specified herein. Additional measures as necessary shall be taken in the design, fabrication, inspection, and testing to produce vessels that will pass the hydrostatic test

satisfactorily without damage to the vessel. Where requirements set forth in this specification depart from requirements or alternatives contained in any documents referenced herein, requirements contained in this specification will govern.

3.1. CAPACITIES of the vessel shall be not less than 5,000 gallons.

3.2. IDENTIFICATION plate plainly stamped in letters not less than 3/8-inch high shall be permanently attached to the vessel or vessel assembly structure at a conspicuous location. Attachment to the shell or head portions or around the nozzle openings of the vessel shall be by a band clamp. Stamping shall show the serial number, symbols of the manufacturer, specification number, date of manufacture, design pressure, test pressure, and water volume capacity in cubic feet to the nearest tenth.

4. SHOP DRAWINGS shall be submitted in conformance with the SPECIAL PROVISIONS. The shop drawings shall show the locations of weld seams, sizes, and types of welds, piping arrangements, nozzle reinforcement, method of nozzle attachment, plate and head thicknesses, vessel weights, details of gas-relief holes in multiple-layer shells, manways and details of drains and vents if required for cleaning of the vessels, details required for fabrication of the vessels, and a complete list of materials. Design calculations for the vessels and manifolds shall be submitted with the shop drawings showing the chemical composition and mechanical properties of the steels used, including reference to the ASME Code Case Interpretation if applicable.

5. QUALIFICATION OF FABRICATOR. The vessels shall be the product of a fabricator with at least 5 years of experience in the fabrication of pressure vessels of the design submitted, and of comparable size, pressure, construction, and service, or of a fabricator with 5 years' experience in the fabrication of pressure vessels of comparable size, pressure, construction, and services, and licensed by a fabricator with 5 years experience in the fabrication of pressure vessels of the design submitted. A list shall be submitted of high-pressure vessels constructed by the fabricator showing size, pressure, type of material, and date of acceptance by the customer. No fabricator will be considered qualified unless proof is submitted of successful fabrication of pressure vessels as outlined above.

6. WORKMANSHIP QUALIFICATION. The welding procedures and techniques for fabrication of the vessel shall be submitted prior to the start of fabrication.

6.1 QUALIFICATION OF PIPE WELDERS: Before assigning any welder to work on piping fabrication, the Contracting Officer shall be furnished

certified copies of performance qualification test records indicating that the welders have passed qualification tests in conformance with the appropriate QUALIFICATION subdivision of ANSI B31. Where such test records are not furnished, qualification tests shall be performed, and witnessed by the Contracting Officer or his representative. Each welder shall be qualified for the position and the type of material assigned. Requalification tests shall be required when the work of the welder creates a reasonable doubt as to his proficiency. Welders failing a requalification test shall not be permitted to work under this contract.

6.2. PROCEDURE FOR WELDING VESSELS. Vessel welding procedure shall conform to the requirements of Section IX of the ASME Code and to requirements specified below. Information required by recommended Form OW-483 of Article IV Welding Data, Section IX shall be submitted for approval.

6.2.1. Separate Qualification Tests shall be made on the maximum joint thickness of each material and each procedure used in production of double-welded butt joints and single-welded joints. Procedures qualified for thicknesses greater than those used in production of this specific contract shall be acceptable without requalification. The joint design used in the test plates shall be the same as for the joints used in production. A requalification test shall be made for any change in the nominal weld metal composition and for changes in any of the essential variables listed in paragraph OW-250 of Article II of Section IX of the ASME Code. A separate qualification test shall be made for each joint design. For multiple-layer or banded vessels, the tension and guided bend tests shall be performed on the inner-shell and outer-layer thicknesses. For girth welds between multiple-layer shells and heads, the test specimen shall include head material as well as layered shell material.

6.2.2 In Addition to the Tests Specified in Article II, Section IX of the ASME Code, the procedure qualification test plates shall be radiographed following the same heat-treating procedure used in production. Using the radiographic procedures specified for production welds, the radiographs shall conform to requirements herein.

6.2.3 Weld Layer Thickness: The individual layer thickness of production welds shall not exceed 1.1 times that of the individual layer thickness deposited in the performance qualification.

6.2.4 Continuity of Backing Ring: Backing rings shall be permitted only for circumferential weld joints which, due to access limitations, cannot be welded from both sides. If a backing bar, strap, or ring is used on the inside of the single-butt weld joints, the ends of the backing bar shall be welded to produce a continuous backing element.

6.3 PERFORMANCE QUALIFICATION OF VESSEL WELDERS AND WELDING OPERATORS: Before assigning any welder or welding operator to work on vessel fabrication, the Contracting Officer shall be furnished certified copies of the performance qualification test records for each welder and welding operator. Such qualification must be based either on the basis of radiographic or mechanical tests of his performance test specimens in accordance with the appropriate requirements of Article II, Section IX of the ASME Code. The Contracting Officer or his representative shall have the right at any time to call for and witness tests of the ability of any welder or welding operator when there is a reason to question a welder's ability to make welds in accordance with these specifications. Such a retest may include both radiographic and mechanical tests at the Contracting Officer's option.

7. MATERIALS shall conform to the respective specifications and other requirements specified below:

7.1 BOLTS, STUDS, AND NUTS FOR FLANGES. Bolts and studs for flanges for stainless-steel manifolds shall be strain-hardened and shall conform to ASTM A 320, Grade B8 or equivalent age-hardened material. Nuts shall conform to ASTM A 194, Grade 4, and shall be hexagonal American Standard Heavy Series. For manways and for other than stainless-steel flanges, bolts and studs shall conform to ASTM A 193, Grade B7, and nuts shall conform to ASTM A 194, Grade 2H.

7.2 FLANGE GASKETS. Gaskets for ring-type joint flanges shall be octagonal, fully annealed stainless-steel ring-type gaskets with dimensions conforming to ANSI 16.20. Gaskets for helium service shall be oval type.

7.3 SUPPORTS AND ATTACHMENTS. Structural steel for supports or structural attachments shall conform to the material used for fabrication of the vessel or to ASTM A 36.

7.4 VESSELS shall be constructed of steels which have been previously used successfully in production by the vessel fabricator in the fabrication of pressure vessels. In addition, no steel shall be used which does not meet the following minimum requirements at room temperature: elongation in 2 inches, minimum 15 percent; reduction of area, minimum 40 percent. Where heat treatment is employed, reheat treatment will be permitted. Supporting information shall be furnished attesting to the chemical composition and mechanical properties based on test results of the steel used for the design of the vessels. Where ASME Code Case Interpretations are applicable to the material from which the pressure vessels are fabricated, the requirements of the Code Case Interpretations shall be adhered to except as modified in this specification.

7.5 ELECTRODES AND FLUXES shall be dry and shall be so stored as to obviate contamination and deterioration by moisture. A drying oven or heater shall be used as necessary to remove moisture.

8. DESIGN AND FABRICATION of the vessels shall conform to requirements of Section VIII, Division 1 of the ASME Code, except as modified herein.

8.1. DESIGN PRESSURE. The vessels shall be designed for a pressure of 250 psig.

8.2. TEMPERATURE. The vessels shall be designed for a temperature range of plus 120 degrees F to minus 40 degrees F.

8.3. NOZZLES OR OUTLETS.

8.3.1. Nozzles or Outlets for Welded Monobloc, Multiple-Layer, and Banded Vessels shall be two in number, one at each end on the longitudinal centerline, for connection to the piping or manifold and for inspection purposes and shall have a minimum diameter of 2 inches. Nozzles and outlets shall conform to paragraph UW-16: Minimum Requirements for Attachment Welds, figures UW-16.1, q-1, q-2, q-3, or q-4, as applicable, or to paragraph UG-38: Flue Openings in Formed Heads, paragraph a of Section VIII of the ASME Code, and shall be fully reinforced regardless of size. Flanged outlets shall conform to ANSI B16.5 or to Appendix II, paragraph UA-45, Rules for Bolted Flanged Connections of Section VIII of the ASME Code. Nozzles or outlets shall be suitable for the pressure specified for the vessels. Material for nozzles, outlets and flanges preferably shall be the same as that of the vessel but may be of any other suitable material.

8.3.2 Nozzles or Outlets for Seamless Vessels conform to requirements below.

8.4 ACCELERATION FORCES. The entire vessel assembly including connections, and supports shall be designed to resist shipping acceleration forces and earthquake force.

8.5 STRUCTURAL ATTACHMENTS. Permanent structural attachments shall not be welded to vessel parts subject to pressure stress unless approval is obtained. To receive approval consideration, such welds shall be full penetration and shall have weld layers inspected progressively by the magnetic particle method. No welding shall be performed after final stress relief and/or hydrostatic testing.

8.6 SHELL AND HEAD THICKNESS shall be calculated in conformance with Subsection A -- General Requirements of Section VIII of the ASME Code except that the maximum allowable stress at the design pressure of

the vessel shall not exceed one-third the minimum tensile strength of the steel used.

8.7 JOINT EFFICIENCY not greater than 1.00 shall be used for butt-welded seams that are fully radiographed. For a single butt joint with backing strip which is fully radiographed, the maximum allowable joint efficiency shall not exceed that permitted in paragraph UW-12, Joint Efficiencies of Section VIII of the ASME Code.

8.7.1 A Joint Efficiency Not Greater Than 0.95 shall be used for the staggered butt-welded longitudinal seams of multiple layer or banded vessels provided the welds in the inner shell and adjacent layer are fully radiographed and the finished weld in each of the subsequent layers is fully magnetic-particle inspected and is 9/32-inch or less in thickness. A penetrameter thickness not more than one percent of the total wall thickness being radiographed shall be used when radiographing the adjacent layer.

8.7.2 A Joint Efficiency Not Greater Than 0.85 shall be used for butt-welded seams that are spot examined by radiography. For a single butt joint with a backing strip which is spot examined by radiography the maximum allowable joint efficiency shall not exceed that permitted in paragraph UW-12, of Section VIII of the ASME Code.

8.7.3 A Joint Efficiency Not Greater Than 0.70 shall be used for butt-welded seams that are not spot-examined by radiography.

9. SPECIAL REQUIREMENTS.

9.1 MULTIPLE-LAYER OR BANDED VESSELS.

9.1.1 Longitudinal Welded Seams in individual layers shall be spaced around the cylinder so that no weld in one layer is offset circumferentially by less than 3 inches or 10 degrees, whichever is less, from the intersection of a radial plane passing through the axis of the cylinder with any other layer longitudinal weld.

9.1.2 Thickness of Circumferential Welds for attaching heads or flanges and the combined thickness of circumferential welds for layers shall not be less than the minimum required thickness of a hemispherical head divided by the efficiency of the head to shell joint.

9.1.3 Longitudinal Seam Welds on the inner shell and all intermediate layers shall be ground flush before the application of the next layer.

9.1.4 Slag shall be removed after each weld layer in both longitudinal and circumferential weld joints, and each layer of the weld

shall be visually inspected for undercut, lack of fusion, irregularity of weld deposit, slag inclusions, and porosity. Corrections shall be made before the next weld layer is deposited.

9.1.5 Post Weld Heat Treatment shall be accomplished in accordance with Parts UCS and UHT, Section VIII of the ASME Code. Heads shall be stress-relieved after forming operations and attachments by welding having been completed and before assembly to the vessel. The inner shell shall be stress-relieved after completion of the longitudinal welds. Post-weld heat treatment of the complete vessel is not required.

9.1.6 Where the Thickness of the inner shell is less than one-half the required head thickness and layers are 3/8-inch thick or less, the vessel shall conform to the following:

9.1.6.1 Multiple-Layer Shells in which the layers are welded circumferentially shall have holes drilled radially from the outside of the vessel to the inner shell. The holes shall be of sufficient size and spacing to provide adequate gas relief between the layers and shall not penetrate the inner shell of the vessel. Shop drawings shall show such holes in detail.

9.1.6.2 Tightness of Layers. After the longitudinal seam of each layer has been welded, the layer shall be hammer-tested for contact with the layer underneath. A loose area greater than 12-inches circumferentially and 24-inches longitudinally will not be accepted. A maximum single radial pay of 0.120 square inch between any 2 layers as measured at the ends of the shell sections at right angles to the vessel axis will be acceptable. A gap of 0.060 inch shall be limited to a length of 4-inches; a gap of 0.040 inch shall be limited to 6-inches; a gap of 0.020 inch shall be limited to 12-inches. In event of more than one loose area circumferentially in any 24-inch length, the total of such areas shall not exceed the area prescribed by the above limits.

9.1.7 Where the Thickness of the Inner Shell is greater than 1/2 the required head thickness, the vessel shall conform to one of the following requirements, as applicable.

9.1.7.1 The Tightness of Layers having a nominal thickness of 3/8 inch and under shall be established in accordance with the requirements in paragraph Tightness of Layers.

9.1.7.2 The Tightness of Vessels with layers over 3/8-inch nominal thickness in which the inner layer is expanded to the outer layer shall be determined by demonstrated elastic behavior as substantiated by pressure volume curve during repressurization after expansion to a significant pressure to demonstrate that the layers act together.

9.1.7.3. The Tightness of Vessels with layers over 3/8-inch nominal thickness in which the outer layer or layers are shrunk over the inner layer or layers shall be determined by measuring the diameter or circumference of the layers in the cold condition to show that there is sufficient interference between the layers to demonstrate that the layers act together.

9.2. SEAMLESS CYLINDERS shall conform to the following requirements and shall be of a type and size suitable for manifolding together to meet the gaseous-storage-volume requirements. All seamless cylinders shall have 2 outlets, one at each end on the longitudinal centerline; each outlet shall be a minimum of 2 inches in diameter for connection to the piping or manifold and for inspection purposes. The vessel connections for seamless vessels shall be adapted for and connected to ANSI B16.5, steel pipe flanges. Connections shall be suitable for the pressure specified for the vessels. All seamless cylinders after fabrication shall be normalized or liquid-quenched and tempered.

10. INSPECTION AND REPAIR OF DEFECTS.

10.1. PERSONNEL QUALIFICATIONS. Radiographic, liquid penetrant and magnetic particle inspections of butt welded pipe joints and welded vessels listed below shall be performed by personnel qualified in accordance with applicable portion of Section V of the ASME Boiler and Pressure Vessel Code as appropriate. Results of all tests shall be certified to the Contracting Officer by the reviewing inspector.

10.2. RADIOGRAPHY OF BUTT-WELDED PIPE JOINTS. Butt-welded pipe joints shall be radiographed 100 percent. Radiographic technique and interpretation shall conform to Section 336.4, Examination Methods of ANSI B31.3, except as herein modified. The negatives and the interpretation report shall be submitted for examination within 24 hours after taking the radiographs. Unacceptable areas of joints shall be cut out, remade, and reradiographed to the satisfaction of the Contracting Officer. The negatives shall be accessible for examination by representatives of the Government.

10.3. RADIOGRAPHY OF WELDED VESSELS. The extent of radiography performed shall be in accordance with paragraph UW 12 Joint Efficiency, of Section VIII of the ASME Code and shall be based upon the joint efficiencies used for design purposes. Radiographic technique and interpretation thereof shall conform to paragraph UW 51, Technique for Radiographic Examination of Welded Joints of Section VIII of the ASME Code. The radiographic film shall be the type designated as "fine grain" similar or equal to Kodak AA, Dupont NDT 75, or GAF 1600 or "extra-fine" similar or equal to Kodak M or T, Dupont NDT 55 or GAF 400. The radiographic negatives and the interpretation shall be submitted to the Contracting Officer's representative for approval at the fabricator's plant. Unacceptable welds shall be repaired and re-radiographed

in accordance with paragraph UW-51. Technique for Radiographic Examination of Welded Joints of Section VIII of the ASME Code. Upon approval, the negatives shall be returned to and filed by the fabricator as required by this section of the ASME Code. During the 5-year storage period of negatives, the files shall be accessible to representatives of the Government for reference.

10.4 MAGNETIC PARTICLE INSPECTION. Except for the inside surface of the closing girth seam, the accessible surfaces of all welds including all layers of multiple-layer or banded vessels shall be magnetic particle inspected during fabrication in accordance with ASTM Methods E 109, using d.c. direct probe only. In addition, inspection of accessible outside surface of welds shall be made after hydrostatic testing. The swaged ends of seamless vessels shall be magnetic particle inspected after forming and heat treatment. In addition, magnetic particle inspection shall be performed in accordance with applicable ASME Code Cases. Cracks shall be repaired. Linear defects, except linear inclusions not exceeding 1/4-inch for thicknesses up to 3/4-inch, 1/3-inch for thicknesses 3/4-inch to 2-1/4-inches, and 3/4-inch for thicknesses over 2-1/4-inches, shall be repaired.

10.5 INSPECTION FOR LAMINATIONS. Laminations found at edges of plates shall be chipped or ground out to the depth of the lamination or 1/2 inch, whichever is less, and the resulting groove shall be repaired by welding. Linear defects 3 inches or less in length which are parallel to the plate surface shall not be considered as laminations and are acceptable. Linear defects over 3 inches in length which are parallel to the plate surface shall be considered as laminations and shall be repaired.

10.6 DYE PENETRANT INSPECTION. Piping and seal welds shall be liquid penetrant inspected at the root and final weld layers. Cracks and linear indications except minor inclusions shall be eliminated. The inspection procedure shall be in conformance with ASTM E 165.

10.7 REPAIR OF DEFECTS. Defects shall be repaired in accordance with approved procedures. Wherever a defect is removed and repair by welding is not required, the affected area shall be blended into the surrounding surface so as to avoid sharp notches, crevices, or corners. After a defect is thought to have been removed and prior to making repairs, the area shall be examined by suitable methods to insure that the defect has been eliminated. After repairs have been made, the repaired area shall be reexamined by the same methods that were originally required for the area. Any indication of a defect shall be regarded as a defect unless re-evaluation by nondestructive methods and/or by surface conditioning shows that no unacceptable defect is present.

11. TESTING.

11.1 NOTCHED-BAR IMPACT TESTS FOR MATERIAL. Materials for shells, heads, nozzles, and other vessel parts subject to stress due to pressure shall be impact tested at minus 40 degrees F in accordance with the requirements of paragraph UG 84, Charpy Impact Tests of Section VIII of the ASME Code with the following modifications:

11.1.1 Impact Specimens.

11.1.1.1 Test Plates for Welded Vessels. In addition to the requirements of subparagraph UG-84(b) (1) under Charpy Impact Tests, one set of impact specimens shall be taken from the head to shell weld with the notch in the adjacent head metal in the heat-affected zone. The test specimens shall be taken from the mid-length of the test plates.

11.1.1.2 Multiple-Layer Plate Material: For plates used in multiple-layer vessels and which are 3/8-inch or less in thickness, exclusive of the inner shell, the requirements for testing plates shall be met by testing at least one set of impact specimens for each two feet of cylindrical length of each vessel.

11.1.1.3 Seamless Vessels: The requirements in paragraph UG-84, Charpy Impact Tests for testing impact specimens shall be met by testing one set of specimens from a test sample of the lot it represents. A lot shall consist of a maximum of six vessels having the same inside diameter and wall thickness in a heat-treat furnance charge from the same heat of steel. The test sample shall be at least 24-inches long and shall be subjected to the same working, normalizing or quenching, and tempering and shall be heat-treated with the lot of production vessels. The impact test specimens shall be cut from the central 12 inches of the test sample.

11.1.2 In Lieu of the Requirements in paragraph UG-84, Charpy Impact Tests, each specimen of the set of three 10-mm by 10-mm specimens shall have a specified minimum impact value of 15 foot-pounds for material thickness of 1/2-inch or greater. For thinner material a similar specimen shall be used except that the dimension along the axis of the notch and the specified minimum impact value shall be reduced to the largest possible of

7.5 mm and 12.5 foot-pounds
5.0 mm and 10 foot-pounds
2.5 mm and 5 foot-pounds

If the value of only one of the specimens is less than the specified value, a retest will be permitted in which case all three retest specimens shall have an impact value of not less than the specified value.

11.1.3. Additional Tests of Welded and Seamless Vessels.

11.1.3.1. In Addition, the materials and weld metal shall be tested at plus 50 degrees F and shall meet the following:

11.1.3.1.1. Specimens shall be in accordance with ASTM A 370, Figure 11, Type A, designation V-notch specimens.

11.1.3.1.2. Minimum Values shall be as given below:

Size of specimen	Base metal and heat-affected zone	Weld Metal
10 mm x 10 mm	30	25
10 mm x 7.5 mm	25	20
10 mm x 5 mm	20	16
10 mm x 2.5 mm	10	8

If the value of only one of the specimens is less than the specified value, a retest will be permitted, in which case all three retest specimens shall have an impact value of not less than the specified value.

11.1.3.2. For Welded Vessels, one set of Charpy tests shall be made with the notch located in the base metal at least 2 inches from the weld, one set with the notch located in the heat-affected zone of the shell, and one set with the notch located in the weld metal.

11.1.3.3. For Seamless Vessels, the tests shall be performed on the base metal only in the same quantities as required above in the Seamless Vessels subparagraphs.

11.2. MECHANICAL PROPERTY TESTS.

11.2.1. Welded Vessels. Two tension tests and one bend test shall be made from each parent plate as rolled from a slab or ingot. Plates which are quenched and tempered by the steel supplier shall be tested by performing one bend test from each parent plate as rolled from a slab or ingot, and two tension tests from each plate as heated-treated. In addition, one tension test shall be made on each quenched and tempered plate used for vessel shells and heads when the heat-treatment is performed by the fabricator.

11.2.2. Seamless Vessels.

11.2.2.1. One Tension Test shall be made from the test sample for each lot as described for seamless vessels in the Impact Specimens paragraph. The test specimens shall be taken from the central 12 inches of the test sample.

11.2.2.2. One Flattennng Test in accordance with Specification SA-372 of Section II, Part A of the ASME Code shall be made from a test ring cut from the parent vessel tube and heat treated with each vessel, from the test sample for each lot as described in the Impact Specimens paragraph for seamless vessels, or from a prolongation of each vessel after heat treatment.

11.3. HYDROSTATIC TESTING shall be performed after fabrication and heat treatment. Pressure vessels and manifolds shall be hydrostatically tested in accordance with paragraph UG-99, Standard Hydrostatic Test of Section VIII of the ASME Boiler and Pressure Vessel Code, except that the test pressures shall be at least 1.6 times the design pressure and the holding time at test pressure shall not be less than six hours.

11.4. TEST REPORTS shall be submitted to show that each vessel has been inspected and tested in accordance with requirements herein. The tests will be witnessed by the Contracting Officer or his representative.

12. CLEANING.

12.1. INTERNAL CLEANING. The internal surfaces of each vessel shall be cleaned until the permissible contamination limits are complied with and then shall be dried and protected. Cleaning procedures as necessary to comply with the permissible contamination limits shall be employed. Cleaning, except during fabrication, shall be performed at the place of manufacture or at the installation site, at the Contractor's option. Cleaning during fabrication shall be performed at the place of manufacture. Inspection and tests will be witnessed by the Contracting Officer or his representative at time of final acceptance.

12.2. QUALIFICATION FOR PERFORMING CLEANING. A certified record of satisfactory cleaning of similar vessels or a record certifying not less than 2 years' experience in chemical cleaning to similar standards and for similar service shall be submitted for approval. No organization performing the cleaning will be considered qualified unless such proof of cleaning experience is submitted.

12.3. CONTAMINATION LIMITS. Permissible contamination limits for the vessels and manifolds shall not exceed the following:

12.3.1. No Hydrocarbon as evidenced by Inspections Nos. 2 and 3.

12.3.2 Five Milligrams of solids and fibrous particles per square foot as measured in the effluent on the final rinse or not exceeding 10 p/m by weight of sample.

12.3.3. No Particles greater than 150 micron size.

12.3.4. No Fibers greater in size than 150 micron diameter by 1,000 micron length.

12.4. DEFINITIONS. For purposes of this specification the following definitions shall apply:

12.4.1. Nominal Rated Filters. The nominal rating describes the filter efficiency and specifies the removal of 98 percent by weight of particles whose two smallest dimensions are greater than the openings in the filter media. Filters made by powder metallurgy processes shall not be used.

12.4.2. Clean Water is color-free water containing no visible suspended particles or hydrocarbons.

12.4.3. Dry Air is oil-free air which has been processed through a dehydrator so that the dew point is minus 63.5 degrees F at one atmosphere or a maximum of 26.3 p/m water vapor by volume.

12.4.4. Nitrogen in use shall conform to Mil. Spec. MIL-P-27401, and have been filtered through a 40-micron absolute rated filter with an element constructed of stainless steel dutch twill weave. The filter shall be cleaned so as not to contaminate the system in excess of the filter rating.

12.4.5. Hydrocarbon is any combustible compound containing carbon and hydrogen.

12.4.6. Solid Particle is any solid material which cannot be classified as a fiber. The size of a solid particle shall be determined by the longest dimension.

12.4.7. Fiber is a threadlike structure composed of any material.

12.4.8. White Metal has a surface of a gray white, uniform metallic color. The surface, when viewed without magnification, shall be found free of visible mill scale, rust, corrosion, oxides, paint, or other foreign matter.

12.5. CLEANING PROCEDURES shall be as follows, and additional procedures of the Contractor's choice shall be employed as necessary to comply with the permissible contamination limits.

12.5.1. Cleaning During Fabrication. During vessel fabrication, surfaces and welds of vessels and manifolds which will be exposed to gas shall be thoroughly cleaned to white metal. Wire brushes used on stainless steel shall be of stainless steel. Descaling may be accomplished prior to welding of the final seam. When performed after cleaning, strees-relieving shall be performed using an inert gas within the vessel.

12.5.2. After Cleaning, the surfaces shall be treated to inhibit rust.

12.6. DRYING of the vessels shall be by heating or vacuum evacuation. Manifolds shall be dried by purge with gaseous nitrogen or dry air at a minimum of 140 degrees F. The vessels and manifolds shall be considered dry when the dew point apparatus shows that the purging medium has a dew point no higher than the dew point of the influent gas which is not above minus -63.5 degrees F at one atmosphere or 26.3 p/m water vapor by volume. If vacuum evacuation is used, the vessel shall be considered dry when the pressure is maintained at 0.5-inch of mercury absolute for a minimum of 5 minutes at a temperature of 60 degrees F or higher temperature or at such lower pressure which is 96 percent of the vapor pressure of water for the vessel temperature. For example, for a vessel at 40 degrees F, a pressure of 0.238 inch of mercury absolute shall be maintained for 5 minutes. The dry gas used for purging and drying shall be filtered through a 10-micron nominal rated filter.

12.7. TESTING OF CLEANED VESSELS AND MANIFOLDS.

12.7.1. Test Prior to Cleaning. Testing required prior to shipment from the vendor, or prior to installation, shall be completed, if possible, prior to the cleaning specified above.

12.7.2. Tests During or After Cleaning. Tests during or after cleaning shall be conducted so as not to contaminate the vessels or manifolds. Should testing contaminate the vessels and manifolds, recleaning shall be performed.

12.8. INSPECTION. Each vessel shall be insepcted by the Contractor for compliance with the permissible contamination limits. The results of such inspections shall be certified by the Contractor and will be witnessed and approved by the Contracting Officer or his representative. Inspections in the order listed below, tests, and sampling shall be performed by the Contractor. Any vessel or manifold which is rejected in any one of these inspection procedures shall be recleaned or reworked to the extent necessary to meet the requirements.

12.8.1 Inspection No. 1, Final Rinse: During the final rinse and prior to the drying operation, a 1-liter sample of the effluent shall be examined by the Millipore method or equivalent method. For this purpose, the rinse shall be performed using a pressure spray nozzle on interior surfaces of the component to insure dislodgement of particles. Effluents containing contamination in excess of the permissible contamination limits shall be cause for recleaning and reinspection.

12.8.2. Inspection No. 2, Visual: Vessels and manifolds shall be examined for evidence of corrosion products including rust, metal chips, scale, weld scale, oil, grease, paints, preservatives, decals, or other foreign matter. Special devices such as inspection mirrors or borescopes shall be used to visually examine inaccessible areas of vessels or manifolds. Contamination in excess of the permissible contamination limits shall be cause for recleaning and reinspection.

12.8.3 Inspection No. 3, Ultraviolet Light. Visual inspection with the aid of an ultraviolet light shall be accomplished on all accessible surfaces to determine the presence of petroleum-type hydrocarbons. Wipe pads shall also be inspected by ultraviolet light. Inspectors shall be qualified to use the ultraviolet light. Contamination in excess of the permissible contamination limits shall be cause for recleaning and reinspection. The ultraviolet light used for this inspecton and light-intensity meter shall conform to the following:

12.8.3.1. Light Source shall be 100-watt spot mercury and bulb 2500 to 3700 Angston units.

12.8.3.2. Transformer shall meet the recommendations of the bulb manufacturer.

12.8.3.3. Filter shall be approximately 5 inches in diameter, convex and round.

12.8.3.4 Bulb shall be replaced when intensity of ultraviolet light through filter is less than 550 microwatts per

square centimeter when measured 24 inches from the outside surface of the filter, or after 500 hours of use whichever occurs first.

12.8.4. Inspection No. 4, Wipe Test. The wipe test shall be made at each end of each cleaned section of pipe and on interior surfaces of vessels and manifolds which are accessible with a probe. Clean filter paper shall be used. Interior surfaces are to be wiped on a random basis or as indicated by the results of Inspection No. 2. The test shall consist of a linear movement of the filter paper over a distance approximately two feet long when large areas are being tested. Smaller areas, such as manifold ends, shall receive a full circular wipe. The filter paper shall then be examined under clean room conditions. Contamination in excess of the pemissible contamination limits shall be cause for recleaning and reinspection.

13. SEALING.

13.1. Seals. The vessels and manifolds shall be sealed immediately after it is determined that they are clean in accordance with the cleaning inspections. Seals shall be tight enough to prevent contamination and shall be protected so that they will not be broken or warped. Tape for sealing procedures shall not leave any residue on connections when removed.

13.2. FLANGED OPENINGS shall be sealed with a suitable full-face blank gasket 1/8 inch thick or disk at least 1/16 inch thick consisting of Teflon or other nonflammable, noncontaminating material and a bolted blank flange of aluminum or corrosion-resisting steel at least 1/4-inch thick. Stainless-steel bolts shall be used in contact with stainless steels. Cadmium-plated bolts may be used in contact with aluminum but shall not be used in contact with stainless steels. A bolt correctly torqued to correspond to particular blank flange and gasket design shall be placed in each bolt hole. Gaskets and flanges shall be cleaned as required herein.

13.3. THREADED OPENINGS shall be sealed with appropriately cleaned caps or plugs made of corrosion-resisting steel.

14. CERTIFICATE of inspection indicating conformance to requirements herein shall be attached to each item. The certificate shall show the date of inspection and the signature of the Contractor's inspector.

15. PRESSURIZING. The vessels shall be pressurized to 15 lb/in^2g with nitrogen immediately following the cleaning inspections and sealing of the vessels. The vessels shall be maintained at positive pressure up to and during the time of final acceptance by the Contracting Officer. All vessels shall be equipped with a shut-off valve and gage for pressurizing. The gage shall be capable of reading from 0 to 5

lb/in^2g in 1-pound increments and to a pressure as high as the fabricator elects to pressurize. A protective metal cover shall be provided around the gage and valving. Complete loss of pressure shall be cause for reinspection and recleaning as necessary to meet the permissible contamination limits by and at the expense of the Contractor.

16. PAINTING.

16.1. EXTERIOR SURFACES of all vessels, including supports but excluding stainless-steel surfaces, shall be cleaned and painted in the shop. Abraded or corroded spots shall be wire brushed and touched up with the same material as the paint coat.

16.2. CLEANING AND PREPARATION OF SURFACES. Exterior surfaces shall be cleaned before applying paint. Oil, grease, dirt, loose dust, loose mill scale, and other foreign substances shall be removed. The removal of oil and grease shall be accomplished before mechanical cleaning is started, using mineral spirits or other paraffin-free solvents having a flash point higher than 100 degrees F. Clean cloths and clean fluids shall be accomplished by means of emulsions, steam, flame-cleaning, high-speed power wire brushing, blast-cleaning, or other approved methods. The use of chipping tools that produce cuts, burrs, and other forms of excessive roughness will not be permitted. Tight mill scale that cannot be removed by applying a sharp knife to any edge and minor amounts of residual rust not removable except by thorough blast cleaning will be permitted.

16.3. PAINTING OF SURFACES. A primer coat of red lead paint conforming to Fed. Spec. TT-P-86 shall be applied to the exterior surfaces of the vessel. The vessel shall be finished with two coats of enamel conforming to Fed. Spec. TT-E-489 gray, No. 16251. Paint shall be applied under dry and dust-free conditions when the ambient temperature is not below 40 degrees F. Painting shall be done so as to produce an even film of uniform thickness. Edges, corners, crevices, and joints shall be thoroughly cleaned and painted.

17. PREPARATION FOR DELIVERY. In addition to sealing and pressurizing the vessels and sealing the manifolds, the vessels and manifolds shall be prepared as follows:

16.1. PACKING shall conform to Uniform Freight Classification Rules or the regulations of other common carriers as applicable to the mode of transportation.

16.2. PHYSICAL PROTECTION. Adequate measures shall be taken to insure no damage to the vessels or components during shipment. Cushioning, blocking, bracing, and bolting shall be such as to insure safe delivery of the component. The vessels shall be protected to withstand

an acceleration force of 3g. in any direction during transportation. Temporary supports, blocking and bracing, or isolation mounts may be used to meet this requirement, and if so, shall be clearly marked for removal during installation.