

DEPARTMENT OF THE NAVY  
NAVAL FACILITIES  
ENGINEERING COMMAND  
GUIDE SPECIFICATION

0173  
NFGS-02734 (March 1984)  
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Superseding  
TS-02581 (September 1978)

SECTION 02734

ROTARY-DRILLED WATER WELL

(B)

(A)

PART 1 - GENERAL

1.1 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. (C)

1.1.1 Federal Specification (Fed. Spec.):

GG-G-76E Gages, Pressure and Vacuum, Dial Indicating (for  
& Am 1 Air, Steam, Oil, Water, Ammonia, Chloro-Fluoro  
Hydrocarbon Gases, and Compressed Gases)

1.1.2 American National Standards Institute (ANSI) Publication:

B2.1-68 Pipe Threads (Except Dryseal)

1.1.3 American Society for Testing and Materials (ASTM) Publications:

A 53-83 Pipe, Steel, Black and Hot-Dipped, Zinc-Coated  
Welded and Seamless

A 120-83 Pipe, Steel, Black and Hot-Dipped Zinc-Coated  
(Galvanized) Welded and Seamless, for Ordinary  
Uses

B 88-83 Seamless Copper Water Tube

C 150-83 Portland Cement  
(Rev. A)

C 494-82 Chemical Admixtures for Concrete

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1.1.4 American Water Works Association (AWWA) Publications:

- C 206-82            Field Welding of Steel Water Pipe
- C601-81            Disinfecting Water Mains
- C700-77            Cold Water Meters - Displacement Type
- C701-78            Cold-Water Meters - Turbine Type for Customer Service
- C702-78            Cold-Water Meters - Compound Type

1.1.5 U.S. Environmental Protection Agency (EPA) Publication:

- 570/9-75-001      Manual of Water Well Construction Practices

1.2 SUBMITTALS:

1.2.1 Shop Drawings: Shop drawings or catalog cuts showing well components and details of well casings, well screens, air lines, and gages. Shop drawings or catalog cuts shall be accompanied by a cross section showing the relative size, location, and spacing of the well components such as the hole size, outer casing, [inner casing,] [well screen,] [gravel filter,] air line and gage, and grout. (D)

1.2.2 Certificates of Compliance: (D)

- a. Casings
- b. Cement
- c. Air piping
- d. Air gage
- e. Drilling mud
- f. Water meter
- [g. Screens]
- [h. Gravel]

1.2.3 Recommendation and Data Submittal: Upon completion of test hole, provide recommendations for permanent wells and submit data obtained [at each well site], in triplicate. Include with the recommendations the appropriate depth, details of construction, length and location of screens, screen openings, gravel size, grout, and an estimation of the quantity of water that can be obtained from each water-bearing stratum and from each completed well. Submit electric log, a drillers log drawn to scale with coarseness and fineness modulus of each strata, time penetration log (time to drill through each formation), [caliper log] [natural-gamma log], and sieve analysis to substantiate recommendations. (E)

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1.2.4 Certified Data:

- a. Pump test
- b. Water analysis
- c. Plumbness and alignment test

1.3 DELIVERY, STORAGE, AND PROTECTION: Deliver materials in an undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact. Replace defective or damaged materials with new materials.

1.4 DESCRIPTION OF WORK: The work includes providing a test hole, a permanent rotary drilled water well, sampling, testing, [abandoning existing wells,] and incidental related work. Provide each system complete and ready for operation. Each system, including equipment, materials, installation, and workmanship shall be in accordance with the EPA Manual of Water Well Construction Practices, except as modified herein. In the manual referred to herein, the advisory provisions shall be considered mandatory, as though the word "shall" has been substituted for the word "should" wherever it appears. Reference to the "Project Representative" and the "Owner" shall be interpreted to mean the Contracting Officer. Other applicable requirements are included under Section 01560, "Environmental Protection."

PART 2 - PRODUCTS

2.1 MATERIALS: Shall conform to the respective specifications and other requirements as specified herein.

2.1.1 Casings: ASTM A 120 or ASTM A 53; [black steel pipe] [zinc-coated steel pipe] outer casing, \_\_\_\_\_ nominal diameter, \_\_\_\_\_ wall thickness, [black steel pipe] [zinc-coated steel pipe] inner casing, \_\_\_\_\_ nominal diameter, \_\_\_\_\_ wall thickness. Provide casings with [screwed] [or] [welded] joints. (F,J)

2.1.2 Well Screens: Type 304 or 316 stainless steel, \_\_\_\_\_ inside diameter, \_\_\_\_\_ type. Provide screens with adequate strength to resist external forces, both during and after installation. Length shall be [\_\_\_\_\_] [as required to provide the quantity of water specified]. Water velocity through openings shall not exceed 0.1 feet per second. Determine the well screen openings from an analysis of the sand in the water-bearing strata. Provide joints of the same material as the screen, with either threaded rings or butt-type welding rings. (G)

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2.1.3 Filter Gravel: Provide clean, round, hard, water-worn [quartz or granite] [ ] with less than 5 percent feldspar, no fossils, carbonate, or organics, and of proper size and gradation to allow free flow of water in the well and prevent the infiltration of sand. Gravel size will be selected by the Government, based upon the analysis of the sand in the water-bearing strata. Sterilize gravel with 20 ppm of free available chlorine for a minimum of 2 hours before using. (H)

2.1.4 Grout: Provide neat cement grout, Type I or II portland cement conforming to ASTM C 150, and water. The mixed grout shall contain no more than 7 gallons of water per bag (1.0 cubic foot or 94 pounds).

2.1.4.1 Admixtures: ASTM C 494.

2.1.5 Air Line: ASTM B 88, Type K, copper tube, \_\_\_\_\_ inch diameter.

2.1.6 Air Gage: Fed. Spec. GG-G-76, Class 1, Style X, 4 1/2-inch, brass case, bronze tube, calibrated in feet of water.

2.1.7 Water Meter: AWWA C700 displacement type, C701 turbine type, or C702 compound type.

2.1.8 Drilling Mud: A fluid composed of water and bentonite clay, readily thinned with commercial mud thinners or biodegradable polymer mud which will break down naturally. The specific gravity and the character of the mud-laden fluid shall be such that the production of the aquifers will not be impaired.

2.1.9 Auxiliary Equipment: Provide discharge piping to dispose of pumped water during developing and testing of well. Locate the discharge piping a sufficient distance from each well to prevent flooding of the site and flow back into the well, as approved by the Contracting Officer.

### PART 3 - EXECUTION

3.1 TEST HOLE: Drill a test hole at the well site before construction of the permanent well is started. Test hole shall be of sufficient size to obtain information required for the construction of the permanent well, but shall be not less than \_\_\_\_\_ inches. The location, size of well, and method of drilling must be approved before work is started. Test hole shall be not less than \_\_\_\_\_ feet deep. Keep (I)

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an accurate log and record of material drilled through and the depths at which changes in formation occur. Do not construct permanent well until data submitted for test hole has been analyzed and approved by the Contracting Officer. Should the data obtained from any test hole indicate unfavorable conditions, exploration shall be continued at other locations approved by the Contracting Officer until a suitable well site is located. In the event additional test holes are required and approved, the contract price and time for completion will be adjusted in accordance with the contract. A test hole may be incorporated into the finished construction provided it meets the requirements for a finished well. Seal test holes not used in finished construction as recommended in Article 56 of the EPA Manual of Water Well Construction Practices and as approved by the Contracting Officer.

3.2 WELL CONSTRUCTION: The depth of the permanent well and number of screens provided shall be adequate to produce a guaranteed capacity of \_\_\_\_\_ gallons per minute of clear, potable water. Methods of construction include using drilling mud for conventional fluid rotary drilling or reverse circulation drilling. Drilling mud shall be prechlorinated with 20 ppm free available chlorine for a minimum of 2 hours.

3.2.1 Drilling: Drill a hole \_\_\_\_\_ inches in diameter to a minimum depth of \_\_\_\_\_ feet and to additional depths as required to produce the flow capacity required. (J)

3.2.2 Outer Casing, [Inner Casing,] and Well Screen: Install the outer casing concentrically in the drilled hole and extend the casing down to a minimum depth of \_\_\_\_\_ feet. [Provide welded joints in accordance with AWWA C206.] [Provide threaded joints in accordance with ANSI B2.1.] [Fill the void between the outer casing and the drilling hole with neat cement grout to seal the outer casing to the wall of the drilled hole.] [Install the inner casing and well screens concentrically in the outer casing and drill hole. Fill the void between the outer casing and the inner casing with neat cement grout to seal the inside wall of the outer casing to the outside wall of the inner casing.] Provide centralizers at the bottom of the casing and at other critical grouting points such as zones of unsuitable water quality. Grout casing from the bottom upward to effectively seal the annular void. Inject grout using a tremie pipe sealed to the well casing at the surface. Provide sufficient screens at the water bearing layer to be developed to secure available flow. Seal the bottom of the deepest screen with a threaded or welded plug, consisting of the same material and thickness as the screen body, or a welded plate, consisting of the same material and thickness as the screen body or casing. (K)

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3.2.3 Well Development: Set the casing[s] and allow the neat cement grout to harden a minimum of 72 hours prior to well development. Provide well development in accordance with Article 52 of the EPA Manual of Water Well Construction Practices, except explosives will not be permitted. Furnish pumps, compressors, plungers, bailers, and other equipment required to fully develop the well for the maximum yield of water per foot of drawdown and to limit sand intrusion during the life of the well. Underream the sand strata to a diameter 16 inches greater than the outside diameter of the casing attached to the well screens. Extend the underream continuously through the entire depth of the water bearing strata. Pump the well free of sand, mud, drillings, and other foreign matter. Maximum sand concentration at the completion of well development shall be 2.0 ppm.

3.2.4 Gravel Envelope: Following completion of the underream, fill the entire annular space between the screen and the outside wall of the underreamed hole with gravel. The gravel envelope shall extend from a point equal in distance to 2.5 times the largest diameter of the underreamed hole below the lowest screen and the same distance above the highest screen. Disinfect and place the gravel with a tremie pipe in accordance with Articles 54 and 50 of the EPA Manual of Water Well Construction Practices. Control speed of gravel placement to prevent bridging and to allow for settlement of the gravel. Equipment and methods required to place the gravel shall be approved by the Contracting Officer prior to commencement of work.

3.2.5 Disinfection: Disinfect well, equipment, and material in accordance with Article 54 of the EPA Manual of Water Well Construction Practices and as specified herein. Portions of the well above the water level shall be maintained in a wet condition with a minimum of 50 ppm of free available chlorine for a period of not less than 30 minutes. A stock chlorine solution sufficient to produce 50 ppm of free available chlorine throughout the water in the well shall be added to the well at different water level intervals from top to bottom and then agitated to distribute the chlorine solution evenly throughout the well. The chlorine shall remain in the well for a minimum of 12 hours. After the 12-hour period, pump the well free of chlorine. Disinfect piping in accordance with AWWA C601.

3.2.6 Sanitary Seal: Provide a sanitary seal for the well to prevent contamination until the pump foundation and pump are installed on the well.

3.2.7 Abandoning Existing Wells: Abandon and seal existing wells in accordance with Article 56 of the Manual of Water Well Construction Practices and [as specified herein. Sealing shall consist of a permanent bridge neat cement seal directly above the lowest aquifer, intermediate neat cement seals between water bearing formations, and uppermost aquifer neat cement seal placed above the uppermost aquifer and the top of the well. Provide disinfected aquifer fill materials consisting of sand and gravel between sealed layers] [as indicated].

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3.3 WASTE DISPOSAL: Dispose of waste materials and soil removed from the drilled holes [by removal from the limits of Government property] [by deposition on Government property, as directed by the Contracting Officer] [as indicated].

3.4 FIELD SAMPLING AND TESTING:

3.4.1 Material Samples: During drilling of test hole, take samples of materials found in each soil stratum. Preserve samples in approved containers furnished by the Contractor. In addition, take samples at 5-foot intervals below the static water level to ensure that changes in sand size are noted. Label samples to show depth below ground surface and thickness of the stratum from which the samples were obtained. Describe water-bearing strata in detail as to whether material is loose or compact, the color of material, and if gravel, whether it is water worn or angular. The presence of clay must be noted. Provide a sieve analysis for soil samples in each soil stratum.

3.4.2 Water Quality Determination: During drilling of test hole, collect, and have analyzed by a Government-approved testing laboratory, representative water samples from water-bearing strata to accurately show the quality of water from each stratum. Perform water sampling in accordance with Article 45 of the EPA Manual of Water Well Construction Practices. Include bacteriological and physical-chemical analysis, and further include field and routine analysis data contained in Parts I and III of DD Form 710, Physical and Chemical Analysis of Water, which accompanies this specification. In addition, analyze the water for any additional suspected minerals or contaminants which would make it unfit for human consumption, such as nitrate, fluoride, and mercury.

3.4.3 Electric Log: Upon completion of test hole, furnish a complete electric log indicating spontaneous potential through the use of long and short normal resistivity logging of formations.

*gamma ray - neutron log and*

3.4.4 Pump Test: Upon completion of permanent well, provide a temporary pump, meter, air gage, and air line in the well for measuring the flow and drawdown. The temporary pump shall have a capacity of not less than \_\_\_\_\_ gallons per minute. After determining the static water level in the well, begin pumping at a rate equal to 60 percent of the guaranteed capacity rate and check the drawdown at 15-minute intervals until drawdown stabilizes. Measure drawdown using the air line method. Continue pumping at that rate for 2 hours and check the water level at 30-minute intervals. Increase pumping rate in uniform increments of 20 percent of the guaranteed capacity rate and repeat described procedure at each increment of increased rate until the capacity of the well is

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determined or the 160 percent increment of the guaranteed capacity rate is reached. The capacity of the well shall be the flow obtained at a drawdown level 10 feet above the top of the uppermost screen. After determining the safe maximum yield of the well, conduct a continuous 24-hour pump test at that rate and check the drawdown at hourly intervals. Provide pipe and ditches to drain the water from the well site. Submit water disposal methods to the Contracting Officer for approval. Furnish a complete written log of the pump test, showing static water level, pumping rate, and drawdown at the specified intervals. Remove air line at completion of pump test. At the end of the 24-hour test and disinfection procedure, submit water samples to an approved testing laboratory for complete chemical and bacteriological analysis. Furnish additional samples as required by Contracting Officer.

3.4.5 Well Plumbness and Alignment Test: Upon completion of the permanent well, provide a well plumbness and alignment test using a plummet in accordance with Article 51 of the EPA Manual of Water Well Construction Practices. Perform the test on the entire depth of the well. The plumb or dummy shall move freely through the entire depth of the well. The well shall not vary from the vertical in excess of two-thirds of the smallest inside diameter of that part of the well being tested per 100 feet of depth. Correct defects in plumbness and alignment, and repeat test until the work is in compliance with contract requirements.

\*\*\* END OF SECTION \*\*\*

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PHYSICAL AND CHEMICAL ANALYSIS OF WATER					SAMPLE NO.	
FROM: (Station or unit)					DATE	
TO: (Name and location of laboratory)						
SAMPLE FROM (Location of sampling point)						
COLLECTED BY		DATE	HOUR	SOURCE (Designate ground, surface, run, treated)		
REASON FOR EXAMINATION			EXAMINATION REQUESTED BY			
NOTE: All results reported in parts per million unless otherwise noted except for pH, temperature, and specific conductance. One liter of potable water is assumed to weigh one kilogram.						
I. FIELD ANALYSIS			III. ROUTINE LABORATORY ANALYSIS			
1. pH	TEMPERATURE		(CHECK ONE)			
	°F	°C	REQUESTED		NOT REQUESTED	
ITEM		PPM	1. COLOR			
2. CARBON DIOXIDE (CO <sub>2</sub> )			2. TURBIDITY			
3. DISSOLVED OXYGEN (O <sub>2</sub> )			3. ALKALINITY (CaCO <sub>3</sub> )			
4. HYDROGEN SULFIDE (H <sub>2</sub> S)			P		MD	
5. CHLORINE DEMAND (Cl <sub>2</sub> )			4. TOTAL HARDNESS (CaCO <sub>3</sub> )			
FIELD ANALYSIS BY			5. NON-CARBONATE HARDNESS (CaCO <sub>3</sub> ) (By Computation)			
DATE OF ANALYSIS			6. CARBONATE HARDNESS (CaCO <sub>3</sub> ) (By Computation)			
II. SPECIAL LABORATORY ANALYSES			7. TOTAL DISSOLVED SOLIDS			
Check (X) individual items to be included in the Special Analyses. Request determination only of those substances suspected of being present in significant amounts.						
(X)	ITEM	PPM	8. SPECIFIC CONDUCTANCE (Microhm/cm)			
	1. As		ITEM		PPM	
	2. Se		9. CALCIUM (Ca)			
	3. Pb		10. MAGNESIUM (Mg)			
	4. B		11. SODIUM (Na) AND POTASSIUM (K)			
	5. Cu		12. HYDROXIDE (OH) <sup>*</sup>			
	6. Zn		13. BICARBONATE (HCO <sub>3</sub> ) <sup>*</sup>			
	7. Cr (Hexavalent)		14. CARBONATE (CO <sub>3</sub> ) <sup>*</sup>			
	8. PO		15. SULFATE (SO <sub>4</sub> )			
	9. Cd		16. CHLORIDE (Cl)			
	10. CN		17. NITRATE (NO <sub>3</sub> )			
	11. Phenolic Compounds (FPB)		18. IRON (Fe) TOTAL			
	12. Others (Specify)		19. MANGANESE (Mn)			
	13.		20. SILICA (SiO <sub>2</sub> )			
	14.		21. FLUORIDE (F)			
	15.		*State whether determined or computed from P and MD alkalinity.			
	16.					
REMARKS (Such as unusual appearance, taste, odor, etc.)						
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LABORATORY ANALYSIS BY					DATE OF ANALYSIS	

GENERAL NOTES

1. This guide specification shall not be referenced but is to be used as a manuscript in preparing project specifications. Edit and modify this guide specification to meet project requirements. Where "as shown", "as indicated", "as detailed", or words of similar import are used, include all appropriate requirements in the project specification and on the project drawings.
2. The capital letters in the right hand margins indicate that there is a technical note pertaining to that portion of the guide specification. Do not include these letters in the project specification.
3. Where numbers, symbols, words, phrases, clauses, or sentences in this specification are enclosed in brackets [], a choice or modification must be made; delete inapplicable portion. Delete publications not referenced in the project specification. Where blank spaces occur, insert appropriate data. Delete inapplicable paragraphs.
4. CAUTION: Coordination of this section with other sections of the specification and with the drawings is mandatory. If materials or equipment are to be furnished under this section and installed under other sections or on the drawings, state that fact clearly for each occurrence. Review the entire specification to ensure that language is included to provide complete and operable systems and equipment.
5. Specifications should not repeat information shown on the drawings. Drawings only should indicate dimensions of construction, quantities, location, and capacity of equipment. Specifications should supplement the drawings by specifying the quality of materials and workmanship, method of installation, equipment functions, and testing required for the project.
6. Do not include Table of Contents, General Notes, and Technical Notes in this section in any submittal.
7. If consolidated well is indicated, delete well components which are not used such as inner casing, well screen, and gravel. Drawings should include the following and any other information necessary to indicate layout and general configuration of the well.

Diameter of drilled hole

Casing sizes - outside casing, inside casing

Well screen size

Minimum depth of outer casing and minimum depth of well screen

Limits of gravel envelope around inside casing and screens

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Limits of neat cement grout around outer casing

Location of air line and altitude gage

Type of cap, cover, or seal required at top of well

Required well capacity in gallons per minute

8. Suggestions for improvement of this specification will be welcomed; fill in and mail the attached DD Form 1426. Send original of DD Form 1426 to the preparing activity, with a copy to:

COMMANDER  
Naval Facilities Engineering Command  
Code 04M2B  
200 Stovall Street  
Alexandria, VA 22332

TECHNICAL NOTES

- A. This guide specification covers the requirements for rotary-drilled water wells (consolidated or unconsolidated) using conventional fluid rotary drilling or reverse circulation drilling.
- B. Specification, section, and page numbers shall be centered at the bottom of each page of this section.

EXAMPLE:

05-76-1776  
02734-1

- C. Paragraph 1.1: The latest issue of these publications must be used if they meet the requirements of the project under design. If the latest issue of the referenced publication does not meet project requirements, resolve the problem in the most efficient way; reference the listed publication issue, incorporate data in project specification or do whatever is appropriate. Immediately complete DD Form 1426 in duplicate to the EFD specifications branch.
- D. Paragraphs 1.2.1 and 1.2.2: Edit the submittal requirements based on the type of well (consolidated or unconsolidated). If the specification is written for a consolidated well, delete the well components which are not normally required in consolidated formations, such as inner casing, well screen, and gravel fill.

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- E. Paragraph 1.2.3: Natural-gamma logging records the amount of natural-gamma radiation emitted by earth materials. Caliper logging records the average borehole diameter. Verify that natural-gamma logging and caliper logging are required in the geographical region of the project.
- F. Paragraph 2.1.1: Delete the requirements for inner casings if the specification is written for a consolidated well and it is known that inner casings are not required. Approximate well casing size should be two sizes larger than the nominal diameter of the pump. Under no circumstances should the well casing size be less than one nominal size larger than the pump bowls. Zinc coating of casing may be omitted where water is not severely corrosive or where casing size is beyond the range of economical zinc coating. Welded joints are recommended for pipe larger than 20 inches in diameter, as well as for smaller pipe where necessary, to obtain proper clearance and maintain uniform grout thickness.
- G. Paragraph 2.1.2: Delete the requirements for well screens if the specification is written for a consolidated well and it is known that well screens are not required. If the specification is written for an unconsolidated well, include appropriate data for the well screen such as inside diameter and type, e.g., perforated tube, continuous or noncontinuous slot, shutter, bar, or wire wound. Well screen efficiency and strength shall be considered in screen selection. Generally, screens should have long, narrow, continuous, horizontal slots larger on the inside than on the outside for optimum efficiency. Longer screens are required where slots are noncontinuous. Screen open areas and efficiencies are more limited in perforated, slotted, shutter, and bar screens. Shutter type screens are particularly appropriate for deeper wells, where additional strength is required. Perforated pipe base screens are appropriate in special cases where it may be necessary to drive or spud the screen into the ground.
- H. Paragraph 2.1.3: Quartz and granite are common filter gravel materials, however, verify the type of filter materials locally available. Delete the requirements for gravel if the specification is written for a consolidated well and gravel is not required. The type and size of gravel depends on the formation to be developed. The gravel size should not be specified but should be recommended by the Contractor and determined by the Contracting Officer based on analysis of sand in the water-bearing strata.

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- I. Paragraph 3.1: If the test hole is to be used as a permanent project well, it shall meet the requirements and characteristics as set forth for the permanent well. Specify minimum diameter and minimum depth of the test well. The minimum test hole diameter for logging with electric logs is 6 inches.
- J. Paragraph 2.1.1 and 3.2.1: In unconsolidated formations where inner casings are required, the inside diameter of the outer casing shall be a minimum of 3.0 inches larger than the outside diameter of the inner casing, and the diameter of the drill hole shall be slightly larger than the outside diameter of the outer casing. In consolidated formations where inner casings are not required, the drill hole shall be a minimum of 3.0 inches larger in diameter than the outside diameter of the outer casing.
- K. Paragraph 3.2.2: When inner casings are not required, use first optional wording. When inner casings are required, delete first optional wording and use second optional wording.
- L. Paragraph 3.4.4: The temporary pump capacity shall be a minimum of 160 percent of the guaranteed capacity rate.

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**INSTRUCTIONS:** In a continuing effort to make our standardization documents better, the DoD provides this form for use in submitting comments and suggestions for improvements. All users of military standardization documents are invited to provide suggestions. This form may be detached, folded along the lines indicated, taped along the loose edge (*DO NOT STAPLE*), and mailed. In block 5, be as specific as possible about particular problem areas such as wording which required interpretation, was too rigid, restrictive, loose, ambiguous, or was incompatible, and give proposed wording changes which would alleviate the problems. Enter in block 6 any remarks not related to a specific paragraph of the document. If block 7 is filled out, an acknowledgement will be mailed to you within 30 days to let you know that your comments were received and are being considered.

**NOTE:** This form may not be used to request copies of documents, nor to request waivers, deviations, or clarification of specification requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

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