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U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

WASHINGTON

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Letter Circular LC 744

Superseding LC 337

PAINTING STEEL POTABLE WATER TANKS

I. INTRODUCTION

The Bureau receives numerous requests from the public for information on protective coatings for the interior of steel water tanks, particularly those holding drinking water. In recent years, and especially since Pearl Harbor, a considerable amount of investigational work has been done on the subject by the Army Engineer Corps, The Bureau of Ships, Navy Department, and the New York Club of the Federation of Paint and Varnish Production Clubs.

The purpose of this letter circular is to present this information in one publication, so that it will be readily available to answer inquiries from the public.

The Bureau is not qualified to answer inquiries concerning the toxicity of various paints and pigments. Questions of this nature should be directed to the U. S. Public Health Service, Federal Security Agency, Washington 25, D. C. This letter circular has been reviewed by that agency.

II. PREPARATION OF THE SURFACE

Regardless of the type of coating to be used or the method of application, all investigators agree that the steel must be clean and dry before the coating is applied. This problem of cleaning the metal can not be overemphasized. The best coating will fail in performance if the metal is not cleaned properly. In this connection, War Department, Corps of Engineers, Tentative Specification No. T-1184E, Finishing, Treating and Painting, December 28, 1943, gives the following directions for the preparation of steel surfaces prior to painting:

"Steel surfaces shall be thoroughly cleaned of all scale, rust, dirt, oil, casting sand, slag or other foreign substances by pickling, sandblasting or other approved methods. As soon after cleaning as practicable, and prior to formation of any form of corrosion from atmospheric moisture or other causes, all surfaces to be painted shall be thoroughly treated with a chemical rust inhibitor having the following composition:

Orthophosphoric acid (75 percent H_3PO_4) - 12 gallons (one carboy
Chromium sulfate (water soluble) - - - - - 25 pounds
Monobutyl phenyl phenol sodium sulfonate
(detergent) - - - - - - - - - - - - - - - - 1 1/2 gallons
Ethylene glycol monoethyl ether (cello-
solve) - - - - - - - - - - - - - - - - - - 6 gallons

Water to make - 160 gallons

These quantities are not mandatory, but the above proportions of ingredients shall be adhered to. The rust inhibitor shall be applied either by brush or dipping. Not less than one hour after application of the inhibitor, residue on the surface shall be removed by thorough wiping with damp cloths or by flushing with hot water after which the surface shall be thoroughly dried."

III. COATINGS FOR THE INTERIOR OF THE TANKS

(a) Baked thermosetting phenolic resin.- As regards a paint coating for the inside of drinking water tanks, one of the most satisfactory tested at Fort Belvoir, Virginia, was a baked thermosetting phenolic resin applied in multiple coats. An experienced contractor baked the phenolic coating on new tanks. War Department Corps of Engineers Specification T-1690A, "Protective Coating Systems (for the Interior of Potable Water Tanks)", dated December 3, 1943, was written for this system.

(b) Zinc dust-zinc oxide-varnish base paint.- However, an alternate specification was needed for potable water tanks which would be finished in the field where baking may not be possible (portable infrared baking units are sometimes available for this purpose). As a result of intensive work of the New York Production Club[1] and pigment producers under the direction of

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[1] "A suitable coating for the interior of Army drinking water tanks", by Edward C. Haines, "Official Digest", No. 230, November 1943, page 405.

Captain H. H. Black at Fort Belvoir, two paints were developed. These paints are described in War Department Corps of Engineers Specification T-1715A, "Protective Coating Materials and Application (for the Interior of Potable Water Tanks)", dated June 2, 1943. Type I paint is a zinc dust-zinc oxide paint weighing not less than 20 pounds per gallon and containing between 73 and 77 percent pigment by weight. The pigment is 80 percent zinc dust and 20 percent zinc oxide. The vehicle is an unmodified para-phenyl-phenol-formaldehyde resin varnish, and the nonvolatile portion is composed of 25 gallons of linseed oil to 100 pounds of the resin.

There is evidence that if the oil in this paint were equal parts of linseed oil and tung oil, the paint would probably be improved, especially if the tank were to hold hot water (160° to 180° F). During present world war conditions, it is realized that tung oil must be conserved; the same statement applies to phenolic resins. About the best alternate vehicle during the emergency would be a high-grade spar varnish. There is also evidence that if the ratio of pigment to vehicle were increased in this paint, still better results would be obtained.

(c) Iron oxide-varnish base paint.- Type II paint in the above-mentioned specification of the Engineer Corps is an iron oxide paint weighing not less than 10.6 pounds per gallon, and containing between 32 and 37 percent of pigment by weight. The pigment is iron oxide containing a minimum of 86 percent Fe_2O_3. The nonvolatile portion of the vehicle contains 25 gallons of tung oil to 100 pounds of the same type of phenolic resin. Either Type I or Type II paints may be used as specified and the specification just cited should be consulted for details.

In applying these paints, the Army Specification requires that they be applied to the clean steel, treated with the chemical rust inhibitor previously quoted from Army Specification T-1184E. All interior surfaces of the tank should be given 2 coats of paint. The first coat of paint should be applied within 5 hours after completion of cleaning and rust inhibiting. All paint, when applied, should provide a satisfactory film and a smooth even surface, suitable for proper application and adhesion of the subsequent coat. All painting should be done in a neat, thorough, and workmanlike manner. In no case should paint be applied to surfaces upon which there is frost, or condensed moisture, nor during rainy weather unless the surface being painted is amply protected against the effect of the weather. While the painting is being done, the temperature of the atmosphere in contact with the paint surface should be maintained at or above 50° F. Also, all paint, should be approximately the same temperature as that of the surface on which it is to be applied. All paint should be applied by brushing unless otherwise specified.

First Coat.- For the first coat the packaged material should be thoroughly mixed and thinned with not more than 1/2 pint of mineral spirits per gallon of paint. The packaged paint, so thinned, should be applied at a spreading rate of 350 to 500 square feet per gallon. The tank should then be ventilated at a temperature between 65 and 85 degrees F for 24 to 36 hours. The paint should be allowed to dry no longer than is necessary to permit application of the second coat without damage to the first coat. In no case should the first coat be allowed to dry to complete hardness before application of the second coat.

Second Coat.- The packaged paint should be thoroughly mixed and tinted as follows:

Type I paint should be tinted by thoroughly mixing 3 ounces of burnt umber paste-in-oil into each gallon of paint. Type II paint should be tinted by thoroughly mixing 3 ounces of lampblack paste-in-oil into each gallon of paint. The paint then should be applied at a spreading rate of 325 to 450 square feet per gallon. If necessary it may be thinned with not more than 1/2 pint of mineral spirits per gallon of paint. The tank should then be ventilated at a temperature between 65 and 85° F for at least 12 hours and then at a temperature between 130 and 170° F for 24 to 36 hours.

The zinc dust-zinc oxide paint referred to as Type I in the Corps of Engineers Specification T-1715A (or at least one similar to it) had given good results in some previous tests made on the Montgomery Dam, Ohio River, by the Army Engineers.

The importance of proper cleaning and phosphate treatment of the steel surface prior to the application of this paint deserves repetition and special emphasis.

The practice of the Navy Department ("Appendix 6, Instructions for Painting and Cementing Vessels of the United States Navy"), in painting the interior of steel tanks to hold drinking water, is to apply either 2 coats of varnish, Formula No. 93, baked at 225° F for 2 hours, or 1 coat of white plastic, Formula No. 91, if water is not to be heated to over 150° F, or 2 coats of Gilsonite paint, Formula 92. The varnish is a 25-gallon, unmodified phenolic resin varnish (Navy Specification 52-V-17) containing equal parts of linseed oil and tung (China wood) oil.

However, the Bureau of Ships has done a considerable amount of experimental work with the zinc dust-zinc oxide paint and has a specification (52-P-67) covering this type of paint for the interior of tanks for potable water. Thus it is believed that considering all the available information, this appears to be the preferred paint for the purpose.

In procuring the zinc dust-zinc oxide paint, it is recommended that the buyer specify it to be packaged in either two-compartment containers or in separate containers; the zinc oxide base paint in the lower compartment and the dry zinc dust in the upper. For example, the Navy Department requires one package to hold the zinc oxide base paint and a separate package for the correct amount of zinc dust.

Mixing Instructions (for approximately 5 gallons of paint).- To one gallon of the zinc oxide base paint add the zinc dust in increments of 2 1/2 to 5 pounds and mix with a paddle until free of lumps and no dry particles of zinc dust are noted; continue until all the zinc dust has been added. Add remaining paint in increments of 1/2 gallons, mixing after each addition until homogeneous.

It is recommended that the zinc dust be mixed with the zinc oxide base paint one or two hours prior to use. Mix only enough for the job to be done. Do not store mixed paint.

(d) Aluminum Paint.- In addition to the paints cited, other types of paints have been used satisfactorily in tanks to hold fresh water. For example, three coats of aluminum paint have given good service. The paint consists of two pounds of aluminum paste mixed uniformly with one gallon of a high-grade phenolic resin spar varnish.

(e) Coal tar base coatings.-

(1) Hot-applied coal tar base enamels when properly applied can be expected to give longer service than most cold-applied type coatings. However, the application of this type of material to form well-bonded, uniform, and continuous coatings necessary for proper protection is difficult and should not be entrusted to inexperienced operators. The enamel is applied by mopping or flowing the molten material (the average working temperatures of commercial enamels are between 385 to 450° F) onto the surface to be protected. Enamels are usually applied 1/16 to 3/32 inch thick to surfaces previously cleaned and primed with a primer furnished by the manufacturer for use with the enamel. Enamels used on surfaces exposed to normal atmospheric temperature fluctuations should be of the "low susceptibility" or "plasticized" type. Enamels of this type can be procured under either "American Water Works Association Standard Specification (7A-5-1940, 7A-6-1940) for Coal-Tar Enamel Protective Coatings for Steel Water Pipe", April 25, 1940, or Navy Department, Bureau of Yards and Docks Specification for Bituminous Coating of Steel Surfaces, No. 34Yb, April 1943.

(2) Cold-applied thixotropic type coal tar base paints, because of the thickness to which they can be applied, and also their low susceptibility to temperature changes, are more suitable as protective coatings than paints formulated from straight-run coal tars dissolved in volatile solvents. Although heavy-bodied, this type of coating can readily be applied by brushing, and it has the added advantage that (when applied up to 1/6 inch thick) it does not flow or sag while still wet (on vertical metal surfaces). A paint of this type conforming to paragraph 1-05, Coal-Tar-Base Paint, of Navy Department, Bureau of Yards and Docks Specification 34Yb should not loosen, check, crack, peel, run, sag or otherwise lose its protective value when exposed to atmospheric temperatures between -10° and plus 140° F nor be adversely affected when struck by hard objects. Oil-base paints should not be used under or directly over this type of coating.

Before any coal tar base protective coating is used on the interior of tanks holding water intended for human or animal consumption, information should be obtained from the manufacturer of the coating regarding the effect of the particular coating on the potability of the water.

Caution: Particular attention is called to the danger to workmen in applying paints in unventilated places. Tanks being painted on the inside should always have forced ventilation and workmen should wear suitable protective respirators.

III. PAINTING THE EXTERIOR OF STEEL TANKS

The same procedure used in painting structural steel should be followed in painting the exterior of steel water tanks. The importance of having a clean dry surface is again emphasized. Linseed oil paints are suggested for the exterior of the tanks, and two coats of a rust-inhibitive priming paint followed by two coats of finish-coat paint are recommended. The priming paint should be designed for priming steel, for example red lead, lead chromate, zinc chromate, blue lead, zinc dust-zinc oxide-iron oxide, etc. Federal Specification TT-P-86, Amendment-1, covers a satisfactory red lead paint for the purpose, and TT-P-20, Amendment-1, covers a satisfactory blue lead paint. For finish coats, aluminum paint (2 pounds of aluminum paste mixed with one gallon of a long-oil, exterior spar varnish), graphite paint (Federal Specification TT-P-27), iron oxide red and brown paints (Federal Specification TT-P-31a), zinc dust-zinc oxide paint (Federal Specification TT-P-641, Type I), etc., may be used. The importance of allowing each coat of paint to dry hard and firm before another coat is applied is emphasized.

IV. SPECIFICATIONS

Requests for copies of Corps of Engineers Specifications should be directed to Office of Chief of Engineers, Engineering Division, Publications Unit, War Department, Washington 25, D. C. Requests for copies of Bureau of Yards and Docks Specifications should be directed to the Bureau of Yards and Docks, Navy Department, Washington 25, D. C. Requests for Navy "52" Series Specifications (52-P-67) should be directed to the Bureau of Supplies and Accounts, Navy Department, Washinton 25, D. C. Federal Specifications (FS) may be purchased for 5 cents each (do not send postage stamps) from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. The address of the American Water Works Association is 22 East 40th Street, New York, N. Y.