

Standard Recommended Practice

Initial Conditioning of Cooling Water Equipment

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Foreword

This NACE standard recommended practice has been prepared to provide a series of procedures for protecting cooling water equipment from initial corrosion that often occurs prior to cooling water exposure. Implementation of these procedures should increase the life expectancy of the equipment.

The procedures outlined in this standard are primarily intended for low-carbon (e.g., mild) steel equipment, but also apply to all other metals and their alloys commonly used in cooling water systems. This standard was prepared to assist individuals involved in the specification, construction, fabrication, and operation of cooling water systems by revealing a potentially serious problem and by identifying an effective solution common to (1) new equipment installed in existing systems or (2) completely new systems. The recommended procedures presented in this standard in no way preclude the use of other procedures presented as options for conditioning cooling water equipment prior to its exposure to cooling water. Many water treatment companies can provide other acceptable procedures.

This standard was originally prepared by NACE Task Group T-7A-5 in 1982, reaffirmed in 1985, and revised by Task Group T-7A-20, a component of Unit Committee T-7A on Cooling Water, in 1995. The task groups were composed of representatives from the refinery, petrochemical, chemical, and water treatment industries. This standard is issued by NACE International under the auspices of Group Committee T-7 on Corrosion by Waters.

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Section 1: General

1.1 This standard describes procedures for increasing the life expectancy of cooling water equipment through the application of chemical conditioning techniques prior to cooling water exposure. These initial conditioning techniques involve two steps: (1) the thorough cleaning of metal surfaces, and (2) the development of a protective film on the metal surfaces. This standard outlines various available methods, recommends specific procedures, and provides performance evaluation methods. Initial conditioning applies to all metals but is directed primarily toward low-carbon (e.g., mild) steel equipment, because low-carbon steel has lower resistance to corrosion and fouling reactions than most other metals or alloys. Initial conditioning applies to pipelines, heat exchangers with water on the tube or shell side, and any equipment that will be contacted by cooling water.

1.2 Commonly used cooling water corrosion inhibitors require clean surfaces to form protective films. If these surfaces are contaminated by rust, oil, grease, or dirt, the protective film cannot be established effectively. Often, if contaminants are present, excessive inhibitor levels may be required, and a build-up of corrosion/corrosion inhibitor reaction products may occur, resulting in loss of heat transfer, premature failures, or high maintenance costs. Dirty surfaces can result in severe pitting and localized corrosion.

1.3 Some metals, such as titanium or austenitic stainless steels, may not require initial conditioning to establish a specific passive protective film because they are either

self-passivating or the cooling water treatment program can provide protection at normal treatment levels. A distinction should be made between true passivation (i.e., inherent in the nature of the alloy) and inhibition phenomena in the more general sense of laying down a protective inhibitor film. Most alloys will benefit from a cleaning procedure or a cleaning/conditioning procedure, in which the type of protection conforms to the latter definition. The words "inhibition" or "inhibiting" will be used in a general sense in this standard to refer to either of these two mechanisms.

1.4 It is not the purpose of this standard to evaluate different chemicals or techniques, but rather to present effective and economical procedures for extending equipment life and improving its performance.

1.5 Initial conditioning may be applied to an entire cooling water system, a portion of a system, or an individual heat exchange unit, regardless of what treatment may be used later. Initial conditioning is applicable to both new and recently cleaned cooling water equipment.

1.6 The most effective protection results when the interval between inhibition and initial water contact for normal service is short. As this interval increases, protection becomes more difficult, because the equipment often develops barriers such as rust, which interfere with the process. The ideal time for initial conditioning is during hydrotesting.

Section 2: Pretreatment Inspection

2.1 Equipment should be inspected prior to initial conditioning to determine whether cleaning is essential and which procedure for cleaning should be used. Inspection techniques such as fiber-optics may prove helpful.

2.2 An inspection should be made to determine the presence of oils, greases, corrosion products, and any other barriers that may interfere with protective film formation during the conditioning procedure.

2.3 If metal surfaces show the presence of visible corrosion products or other deposits such as scale, foulants, or copper-plated surfaces, an appropriate cleaning procedure should be implemented.

2.4 If metal surfaces show the presence of any visible amounts of corrosion products or oils and greases from fabrication, the cleaning procedures in Section 3 of this standard should be used.

2.5 Service companies may have technical services, proprietary formulations, and specific recommendations for initial conditioning to assist in achieving favorable results. Proprietary formulations usually contain a blend of several chemicals and can combine the cleaning and inhibiting actions. Any discussion of the merits of specific formulations, however, is beyond the scope of this standard. Compatibility of the materials of construction with cleaning and corrosion-inhibiting chemicals can often be determined by contacting a consultant or service company.

Section 3: Chemicals and Procedures

3.1 The chemicals and procedures outlined in this section are guidelines to be used, depending on the type of equipment, equipment examination, equipment location, and type of treatment program. Initial conditioning procedures always include steps that may be performed separately or at the same time. Typical cleaning and inhibiting chemicals are listed below.

3.1.1 A cleaning-inhibiting product such as an alkaline polyphosphate formulation, which may contain the following: 90% sodium tripolyphosphate or tetrasodium pyrophosphate and 10% nonionic, low-foaming surfactant.

3.1.2 A cleaning solution composed of water-soluble degreasing chemicals that are nonionic, low-foaming, neutral pH surfactants, such as the one described in Paragraph 3.1.1.

3.1.3 A cleaning solution composed of a mineral acid such as hydrochloric or an organic acid such as ammoniated citric with an appropriate acid inhibitor that can be used for derusting low-carbon steel equipment.

3.1.4 When copper or copper alloys compose a significant portion (greater than 10%) of the system, consideration should be given to the use of azole-based inhibitors (benzotriazole, tolyltriazole, mercaptobenzothiazole) as a component of the inhibiting solution, to prevent plating of copper onto steel components, and to provide protection to copper and copper alloys.

3.1.5 When stainless steel components are involved, hydrochloric acid or solutions containing greater than 100 ppm concentration of chlorides should be avoided, because of their tendency to initiate and promote pitting and stress corrosion cracking on certain stainless steel alloys. ASTM⁽¹⁾ A 380⁽²⁾ provides cleaning guidelines for stainless steels.

3.2 New equipment: This procedure should be used when the equipment is new and has not been in prior service, or for individual units such as tube bundles, that have not been installed.

3.2.1 The selected cleaning step of the initial conditioning procedure depends on several factors. These include knowledge of all the metallurgy to be

contacted by cooling water, and the results of the inspection as detailed in Section 2.

3.2.2 For a combination mild cleaning and inhibition of low-carbon steel equipment, an alkaline polyphosphate surfactant, such as the one described in Paragraph 3.1.1, should be used. A 1 to 2% solution at a pH of 7 to 8 is generally circulated for four to six hours at a temperature of 60 to 70°C (140 to 160°F).

3.2.3 For copper or copper-alloy equipment, a neutral cleaner with an azole-based inhibiting chemical, such as those described in Paragraph 3.1.4, should be used. A 0.1% solution at a pH between 7 and 8 should be circulated for four to six hours at a temperature of 40 to 50°C (100 to 120°F).

3.3 Used or stored equipment: Any equipment that has been in prior service should be examined to determine whether it is sufficiently clean for inhibiting or whether additional cleaning is necessary. When acceptably clean, guidelines listed in Paragraph 3.2 should be applied.

3.4 Complete system conditioning: Initial conditioning of the entire cooling system should include a combination of cleaning and inhibition either as separate steps or simultaneously. When the system is new, initial conditioning should be performed, preferably at the time of hydro-testing. The treatment solution should be circulated with the system pumps at ambient temperatures until the equipment has received a protective film (see Section 4). Inhibitor concentration is generally maintained at a level of 0.01% or higher. If the system has been in operation for any period of time and contains appreciable amounts of corrosion products, an expert in cleaning should be consulted for proper cleaning techniques before conditioning. If more than one type of metal is present, special consideration and cleaning procedures are needed to prevent plating and subsequent severe corrosive conditions.

3.4.1 For low-carbon steel systems, an alkaline polyphosphate, such as the one described in Paragraph 3.1.1, should be used at a dosage of 0.01% or higher at a pH of 7 to 8 and should be circulated for four days, or until the protective film has formed. Higher concentrations for a shorter time can be used effectively. Alternate corrosion inhibitors may include silicates, zinc, molybdates, or nitrites, among others.

⁽¹⁾ American Society for Testing and Materials (ASTM), 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959.

⁽²⁾ ASTM A 380 (latest revision), "Standard Practice for Cleaning and Descaling Stainless Steel Parts, Equipment, and Systems" (West Conshohocken, PA: ASTM).

3.4.2 When copper or copper alloys are used with low-carbon steel, a neutral cleaner with an azole-based inhibiting chemical, such as those described in Paragraphs 3.1.2 and 3.1.4, should be used. Azoles

are typically employed at pH 7 to 8 at 0.01% concentration. The solution should be circulated for four days, or until the protective film has formed.

Section 4: Initial Conditioning Evaluation

4.1 To assure that cleaning and inhibition have been effective, several critical representative exchangers should be examined immediately after completion of conditioning. Slightly rusted corrosion specimens can be inserted prior to initial conditioning to monitor the effectiveness of the cleaning and inhibition.

4.2 Depending on which chemical is used for inhibition, a protective film may be evident and, in the case of low-carbon steel, usually appears as a dull iridescent coating.

4.3 There should be no visible rust on low-carbon steel surfaces. If rust is present, it indicates incomplete

cleaning and/or protection and a need to repeat the procedure.

4.4 If individually examined components reveal the presence of corrosion products, general dirt, or debris, there is a need for extensive examination of the entire system. The initial conditioning procedure should be repeated on partially protected components or on the entire system.

4.5 The use of photographs and records is particularly useful and important for recording the appearance of equipment before and after initial conditioning.

Section 5: Precautions

5.1 It is important that each step of the initial conditioning program be properly conducted to ensure satisfactory application. Important precautions for ensuring satisfactory performance are as follows:

5.1.1 Corrosion inhibitors require clean metal surfaces for proper film formation and metal protection.

5.1.2 Circulating is preferable to soaking. Both insufficient time and low temperature in either procedure frequently result in incomplete cleaning and film formation.

5.1.3 If an alkaline polyphosphate formulation is used, extended periods of contact can be satisfactory, but only at ambient temperatures and moderate levels of water hardness (e.g., at least 100 ppm hardness as calcium carbonate). Should this solution be removed, the protection must be continued with corrosion inhibitors after initial conditioning.

5.1.4 Care should be exercised when using polyphosphate solutions in systems containing galvanized components. Alkaline silicate compositions may deserve consideration.

5.1.5 The initial conditioning must be compatible with the planned cooling water treatment program and corrosion and deposit inhibitors to be used.

5.1.6 The use of any chemical in sufficient concentrations may cause an environmental hazard. Before using an environmentally sensitive chemical, it must be ascertained that appropriate facilities for proper disposal of spent solutions are in place and functional.

5.2 The initial conditioning procedures establish ideal conditions only for subsequent cooling water corrosion inhibitor treatment. It should be recognized that proper control of pH and concentration of the inhibitor is essential in maintaining effective protection. The initial conditioning procedure, when properly performed and followed by an effective treatment, adds substantially to the life expectancy of the equipment and to more efficient heat transfer, particularly for low-carbon steel components.

5.3 As with any chemical, all persons who may be involved with this procedure must use appropriate protective clothing and safety equipment to prevent any injury. Safety instructions must be given to all personnel.