Designation: ~~D4778 – 10~~ D4778 – 15

Standard Test Method for
Determination of Corrosion and Fouling Tendency of Cooling Water Under Heat Transfer Conditions[1]

This standard is issued under the fixed designation D4778; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method provides directions for fabricating and operating a test apparatus to simultaneously monitor the corrosion and fouling tendency of real and pilot cooling water systems under heat transfer conditions.

1.2 Interpretation of the results of this test method must be left to the investigator. Many variables are involved which may not be easily controlled or fully understood. Variations in design and operating conditions may produce results that are not comparable from unit to unit.

1.3 The values stated in inch-pound units are to be regarded as ~~the~~ standard. The values given in parentheses are mathematical conversions to SI units that are provided for information ~~only.~~only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]
D1129 Terminology Relating to Water
D2331 Practices for Preparation and Preliminary Testing of Water-Formed Deposits
D2777 Practice for Determination of Precision and Bias of Applicable Test Methods of Committee D19 on Water
G1 Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens
G16 Guide for Applying Statistics to Analysis of Corrosion Data

3. Terminology

3.1 ~~*Definitions—*~~*Definitions:* ~~For definitions of terms used in this test method, refer to Terminology D1129.~~

3.1.1 For definitions of terms used in this standard, refer to Terminology D1129.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *corrosion, n*—the deterioration of the metal by reaction with its environment.

3.2.2 *fouling, n*—deposition of organic matter or inorganic matter, or both, on heat transfer surfaces that result in the loss of heat transfer efficiency.

3.2.3 *heat flux, n*—heat transfer per unit area per unit time.

4. Summary of Test Method

4.1 Water from the system to be tested flows across a heated tube of the desired metallurgy at a constant flow rate and heat flux. Corrosion rate is determined by weight loss while fouling tendency is determined by the deposit weight.

5. Significance and Use

5.1 Deposits on heat transfer surfaces reduce efficiency of the heat exchanger affected. A method for easily determining the corrosion and fouling tendency of a particular water under heat transfer conditions will allow the evaluation of changes in the various system variables such as heat flux, flow velocity, metallurgy, cycles-of-concentration, and treatment schemes on heat exchanger performance.

6. Apparatus (Fig. 1)

6.1 *Test Specimen*—A metal tube of ⅜ or ½ in. (9.5 or 12.5 mm) outside diameter with sufficient inside diameter to snuggly accommodate the cartridge heater. The tube should be cut to a length sufficient to extend ½ in. (12.5 mm) from each end of the test assembly. If both corrosion and deposition are to be determined, metallurgy of the test specimen should match that of the heat exchanger being modeled.

6.2 *Cartridge Heater*—A ¼ or ⅜ in. (6.2 or 9.5 mm) diameter. Heated surface should be 4 to 8 in. (10 to 20 cm) long with a minimum power rating sufficient to provide 110 % of the heat load required (see Eq 7, 8.2.2). The heater should have an unheated section of sufficient length to allow the center of the heated section to be placed consistently in the center of the test specimen.

6.3 *Power Controller*—A device to set and control the power to the heater, such as a variable transformer, is used to adjust the heat flux in order to maintain the surface temperature of the test specimen consistent with the heat exchanger being modeled. The power controller should be rated to maintain at least 120 %, but not more than 400 % of the power required.

6.4 *Flow Control*—A flow meter or a flow control device such as an orifice, or both, is recommended to maintain a consistent flow rate during the test period.
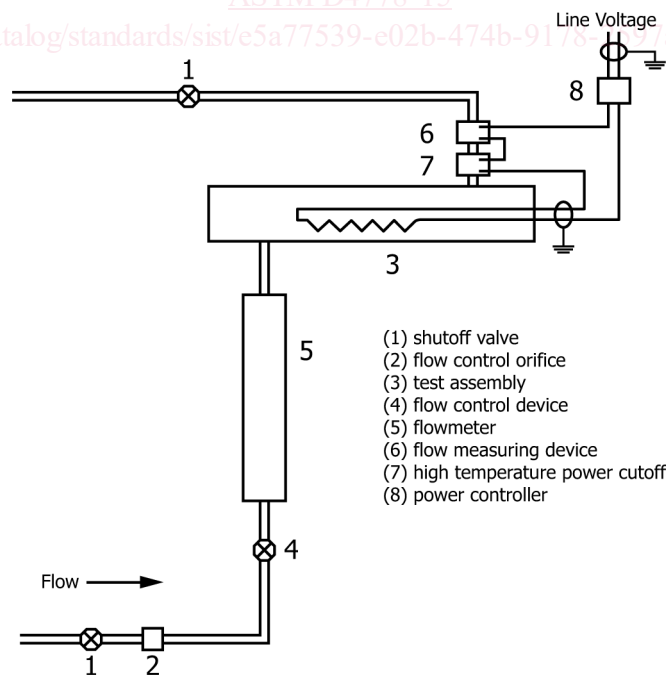
6.5 *Safety Equipment*—A pressure or flow sensor/controller is necessary to cut power to the heater in the event of a flow interruption. A high temperature cutoff is recommended for added protection.

6.6 *Test Assembly*—See Fig. 2.

(1) shutoff valve
(2) flow control orifice
(3) test assembly
(4) flow control device
(5) flowmeter
(6) flow measuring device
(7) high temperature power cutoff
(8) power controller

NOTE 1—All pipe is threaded 1 in. (25 mm) PVC. Heater should be fused and grounded in accordance with local electrical codes.
FIG. 1 Test Apparatus and Parts List
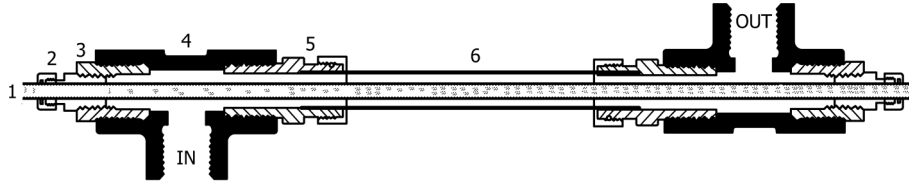
Parts List:
(1) test specimen

(2) tube fitting; nylon (no metal parts)
(3) reduci ng bushing, PVC
(4) tee, 1 in. (25 mm) PVC
(5) tube fitting, 1 in. (25 mm) tube by 1 in.
 (25 mm) male pipe thread stainless steel

(6) acrylic tube, 10 in. (25 cm) long by 1 in. (25 mm)
 outside Diameter
(7) Cartridge type heater (not shown)

FIG. 2 Test Assembly and Parts List

7. Materials

7.1 *Vapor Phase Inhibitor Paper—~~envelopes~~Envelopes* constructed of vapor phase inhibitor paper.

8. Procedure

8.1 *Installation of Test Device:*

8.1.1 Placement of the test device with respect to the cooling water system is an important factor in monitoring fouling and corrosion in interpreting the test results. Fouling and corrosion are both affected by temperature. In the case of corrosion, the higher the water temperature, the greater will be the corrosivity of the water. Fouling, however, is a far more complex phenomenon, involving one or more of several types of foulants, namely, particulate matter, precipitates, biomass, corrosion products, and contamination. There are five phases involved in the fouling phenomenon: initiation, attachment, removal, transport, and aging.

8.1.2 Several of the foulants are temperature sensitive. Precipitates, such as calcium carbonate, tend to precipitate more rapidly as temperatures increase. Most biomasses, on the other hand, would agglomerate more rapidly at temperatures between 90 and 105°F (32.2 and 40°C).

8.1.3 The test device may be installed to take its inlet water from one of three locations: cold water supply to a heat exchanger, a heat exchanger outlet, or warm water return to the cooling tower. The choice of location is a function of the type of fouling problem(s) experienced with the particular system. No matter where it is placed, the fouling conditions in the test device should simulate the plant equipment as closely as possible. Specifically, the surface or interface temperature and the shear stress of the water film against the heated surface in the test device should be the same as in the plant equipment being monitored.

8.2 *Determination of Setup Conditions:*

8.2.1 Calculate plant heat exchange conditions as follows:

$$V_p = 0.408 \left(F_p\right) P / \left(D^2 N\right) \tag{1}$$

where:

V = water velocity, ft/s,
p = process,
F = water flow rate, gal/min,
P = number of passes,
~~D = number of tubes in process heat exchanger, in., and~~
$\underline{D}$ = inside diameter of tubes in process heat exchanger, in., and
N = number of tubes in process heat exchanger.

$$\left(q/A\right)_p = 1910 \left(T_o - T_i\right) \left(F_p\right) / \left(DLN\right) \tag{2}$$

where:

q/A = heat flux on inner tube, Btu/h/ft^2,
p = process,
T = temperature,° F,
o = outlet water,
i = inlet water,
F = water flow rate, gal/min,
D = inside diameter of tube in process heat exchanger, in.,
L = length of heater section, ft, and