

**Effects of Disinfection of
Newly Constructed Polyethylene Water Mains**

PPI TR-34

2025



Foreword

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The intent of this technical report is to provide information on the effect of chlorine disinfection on the durability of PE piping for water systems. The testing reported herein was conducted on several pipe sizes and on resins in the form of plaques in accordance with the various test methods employed. The investigations were done in two separate studies. The first study focused on PE2306, PE3406, and PE3408 compounds and the second study was conducted with a PE4710 compound.

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TR-34 was first issued in 2001, and revised in June 2025

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1. Introduction

Disinfecting water mains has been a common industry practice for many years. The first AWWA standard covering this practice was approved in September 1947 (as 7D.2-1948). In 1986, the designation of the standard was changed to AWWA C651; the revision used in Study 2 is ANSI/AWWA C651-23. The standard describes methods of disinfecting newly constructed potable water mains; mains that have been removed from service for planned repairs or for maintenance that exposes them to contamination; mains that have undergone emergency repairs due to physical failure; and mains that, under normal operation, continue to show the presence of coliform organisms.

Because the chlorine disinfection process puts pipe in contact with a strong oxidizer, a task group was formed in June 1993 for Study 1 of this report, within the PPI Technical Committee to investigate possible effects of disinfection on the durability of PE piping in potable water service. Study 2 was started by a PPI task group convened in 2023 to update TR-34 with test information on the current generation PE4710 materials. While C651 covers all piping materials used in potable water service, this investigation was confined to polyethylene systems following ANSI/AWWA C901 and ANSI/AWWA C906. Chlorine was the only disinfection agent investigated. This report is not to be construed as an indicator of the long-term performance of polyethylene pipe in general, or in the specific user's environment and operating conditions.

2. Scope

This report aims to investigate and quantify the effects on the durability of PE piping caused by disinfection per ANSI/AWWA C651. Exposure times and concentration levels were chosen to be consistent with the requirements of the standard. Note that the disinfection practices outside the constraints used in this study (i.e., exposure time, etc.) may yield different results (e.g., if a contractor leaves a pipe full of concentrated disinfectant for 6 months). For continuous chlorine exposure of potable water applications, PPI TN-43 should be referred to.

3. Methods of Chlorination

At the time of Study 1, three methods of chlorination were explained in ANSI/AWWA C651: tablet, continuous feed, and slug. A brief description of the methods is provided; for more details, see ANSI/AWWA C651.

- The tablet method is intended to give an average chlorine dose of approximately 25 mg/L, and precautions shall be taken to ensure that air pockets are eliminated and the water shall remain in the pipe for at least 24 hours. If the water temperature is less than 41°F (5°C), the water shall remain in the pipe for at least 48 hours;

- The continuous feed method is intended to give a 24 hour residual of not less than 10 mg/L;
- The slug method is intended to give a 3 hour exposure of not less than 50 mg/L free chlorine. Residual free chlorine in the slug method, shall be measured as it moves through the main. If at any time it drops below 50 mg/L, the flow shall be stopped, chlorination equipment shall be relocated at the head of the slug, and, as flow is resumed, chlorine shall be applied to restore the free chlorine in the slug to not less than 100 mg/L.

It should be noted that the tablet method is not recommended for HDPE pipe in ANSI/AWWA C651-23 but the continuous feed and slug methods are recommended.

4. Industry Practice

Prior to conducting Study 1, to compare actual industry practice with AWWA C651 recommendations, a task group member conducted an informal survey of numerous City Water Departments. The survey was geographically broad and included utilities in Seattle (WA), Fresno (CA), Chicago (IL), Minneapolis (MN), San Antonio (TX), Savannah (GA) and Augusta (ME). It was learned that chlorine was by far the disinfectant of choice. All three methods described in 1997 version of C651 (tablet, continuous feed, and slug) were used with the tablet method being the most popular because it required no additional equipment.

For the tablet method, AWWA C651-97 recommends the use of an average chlorine content of 25 mg/L for at least 24 hours. The utilities surveyed stated concentrations ranging from 25-150 mg/L for durations from 24 to 72 hours. Preferably, disinfection should be carried out overnight, however, not on a day before the weekend or holidays.

In the continuous feed method, the chlorine may be added as dissolved calcium hypochlorite, sodium hypochlorite, liquid chlorine or dissolved chlorine gas. Several opinions were given that dissolved chlorine gas offered the “best” disinfection; however, environmental concerns and regulations have made this option less desirable. The water utilities that were interviewed use concentrations ranging from 25-60 mg/L for durations of 24-72 hours.

In the slug method, a heavily concentrated slug of chlorine is added to the main and slowly forced through the system. The concentration of the slug is monitored and more chlorine is added if the free chlorine residual drops below 50 mg/L. Several of the utilities use this method at concentrations of 300-500 mg/L. Disposal and treatment of the heavily chlorinated water can become a problem with this procedure.

5. Test Results

To evaluate the effects of chlorine exposure on PE water pipe during typical disinfection, physical properties of selected PE pipe samples were studied in two separate studies. Study 1 included PE2306, PE3406, and PE3408 materials.

Study 2 focused on PE4710 material and was conducted by TRI Environmental. Since the studies were conducted in different time frames the test conditions differ. However, in both studies, properties of pipe specimens exposed to chlorine were compared to properties of the same specimens that were not exposed to chlorine. Details of test methods and the results of these tests are presented herein.

5.1 Quick Burst

Test Objective: *Quick burst test was only conducted in Study 1 to determine if the chlorine exposure had a detrimental effect on the burst strength of the pipe. Based on the results of Study 1, the task group members for Study 2 decided that the high temperature, sustained pressure test (see Sec. 5.2) was a more appropriate test.*

Testing in Study 1 was conducted on pipe specimens filled with a 185 mg/L chlorine water solution and conditioned for 72 hours at room temperature. Control specimens were also tested. The controls were not filled with tap water until tested.

Test Method: Quick burst testing was then conducted in accordance with ASTM D1599, "Standard Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings." Several specimens were prepared from each sample. The specimens were 18" in length and sealed at each end with Swagelok fittings. For each sample, half the specimens were filled with water containing chlorine at 185 mg/L, and the other half were not filled until testing. The specimens exposed to chlorine were then placed on a sealed manifold for 72 hours. The control specimens were conditioned in the same room as the chlorine specimens for the same time period. *The Test Samples are described below:*

- Sample 1: ½" SDR 11.5 PE2306, ASTM D2239
- Sample 2: ½" SDR 11.5 PE3408, AWWA C901
- Sample 3: ¾" SDR 9 PE3406, ASTM D2737
- Sample 4: ¾" SDR 9 PE3408, ASTM D2737
- Sample 5: ¾" SDR 9 PE3408, ASTM D2737