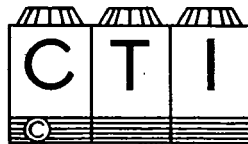


COOLING TOWER INSTITUTE

WOOD MAINTENANCE

FOR

WATER-COOLING TOWERS



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INTRODUCTION

The gradual depreciation and ultimate failure of wood in water-cooling towers has long been recognized. As early as 1948 cases of moderately severe deterioration had been reported, but not until 1950 were cases of unusually rapid deterioration of redwood brought fully to the attention of the industry. In that year, redwood lumber mills and cooling tower manufacturers learned that serious deterioration was occurring in redwood cooling towers in the Gulf Coast area. Samples of affected wood from these towers were examined by several redwood suppliers, several cooling tower manufacturers, the California Redwood Association and the Institute of Paper Chemistry. Similar samples were referred to the U.S. Department of Agriculture, Forest Products Laboratory.

These samples, and reports from cooling tower users, showed that different types of deterioration were occurring and that, although they could be classified in general categories of decay and chemical attack, the *specific* causes for the rapid deterioration were not immediately identifiable. Typical wood destroyers, including termites, were found to be present in some samples, but it was thought that some other form of attack was principally responsible for the rapidity and severity of the surface degradation.

To analyze the problem and decide on a program by which it could be approached and solved, representatives of the Cooling Tower Institute and the California Redwood Association met on July 25, 1950. The differing opinions about the primary causes of deterioration indicated that considerable field work would have to be done and that finding the answers would require a long-range project with the co-operation of cooling tower users. A group of tower users met with CTI and CRA representatives on July 27, 1950, and all agreed to work together in an effort to answer the problem. U.S. Department of Agriculture, Forest Products Laboratory provided extremely valuable consultation, guidance, and encouragement in formulating the basic program established.

The program was divided into two sections. One included the study and analysis of deterioration of redwood lumber in operating cooling towers. The other involved the observation of the effect of preservative treatments on four species of wood. The field studies were started in June of 1951, and periodic reports have been issued following routine inspections described herein. Definite trends, permitting certain conclusions and recommendations have become evident and are presented in this report.

OBJECTIVES OF PROGRAM

The program was undertaken to achieve these specific objectives:

- A. To define the problem by identifying the different types of deterioration observed in cooling towers which would lead to better understanding of the deterioration mechanism; to determine specific measures for controlling each type.
- B. To assess the effect of such variables as cooling tower operating conditions, design,

age, type of service and geographical location on the type and extent of deterioration observed; to test under actual field operating conditions the conclusions derived from the primary study of the specific chemistry of wood deterioration.

- C. To investigate the effectiveness of commercial wood preservatives in protecting cooling tower lumber against deterioration.

FIELD PROGRAM

COOLING TOWER STUDY

A total of 103 towers were selected for study, located in an area extending across the Gulf Coast from Brownsville, Texas, to Baton Rouge, Louisiana. The installations included power, chemical and rubber plants and petroleum refineries. The towers served shell-and-tube heat exchangers, open water box coolers, barometric condensers, and other types of commonly used cooling devices. Included in the study sample were atmospheric, forced draft and induced draft towers (counterflow and crossflow) ranging from 2 to 30 years in age at the beginning of the program. The water circulated in the towers was treated by a variety of methods although, in some cases, untreated water was used. Each tower was inspected in 1951, 1952, 1954, 1956, 1958, and 1961.

To identify the causes of the deterioration of the lumber, samples of deteriorated wood were removed from operating cooling towers and analyzed chemically by the Institute of Paper Chemistry and the U.S. Department of Agriculture, Forest Products Laboratory.

Over the duration of the study period many towers lost their statistical value because of extensive repair, total destruction or obsolescence. Repaired towers were kept in the program to obtain supplemental information. Of the original sample, 81 towers were inspected in 1961, of which 33 were still operating without major modifications.

TEST PANEL STUDY

Seven hundred forty-five panels were installed during the summer of 1951 in 21 operating towers selected from the group of 103 towers in the wood maintenance study. Tower designs included atmospheric, forced draft and induced draft. They were inspected annually during the period from 1952 through 1956, in 1958 and 1961. In each tower, 4 or 5 test panels of each species were placed on the lowest layer of the filling in the flooded section, and 4 or 5 of each species were placed on or in the drift eliminators in the moist non-flooded section. This resulted in a total of 18 to 20 panels in the filling and 18 to 20 panels in the eliminator section in each tower. All of the test panels were placed in one cell (not an end cell) or in two adjoining back-to-back cells in the case of back-to-back towers. Locations were selected over the entire cell area in order to encounter various temperatures and any other variations which might exist. Panels were held in place by gravity or copper wire.

Panel Description

Test panels were constructed of the following four lumber species:

California Redwood: Clear All Heart, graded by CRA

Douglas Fir: Clear All Heart, graded by CRA
Western Red Cedar: Clear grade, as defined by WCLIB Std. Rules #14, Revised Nov. 1, 1948
Southern Yellow Pine: B and Better, as defined by SPIB, Sec. II, Item 115 B Finish

These species were chosen because of their commercial availability in suitable grades for cooling tower construction.

Each panel consisted of 9 slats, each $\frac{5}{16} \times 1\frac{3}{4} \times 18$ inches, all of the same species, with one slat an untreated "control" piece, the other 8 treated with different commercial preservatives. The 8 preservatives used were selected on the basis of commercial availability and general usage.

The slats were nailed into grids using untreated redwood binder cleats with approximately $\frac{5}{8}$ inch clearance between slats. Nails were $1\frac{1}{2}$ inch brass, clinched over on the back side of the panel. Over-all nominal dimensions of the average panel, including the binder cleats, were $1 \times 18 \times 24$ inches (see Figure 1).

The species used in each panel was identified by notches on the binder at the end of the panel where the untreated slat was secured, as follows: 1 notch for redwood, 2 for fir, 3 for cedar, and 4 for pine. Counting from the notched end the respective treatments were always in the same sequence: (1) untreated, (2) acid copper chromate, (3) ammoniacal copper arsenite, (4) chromated copper arsenate, (5) pentachlorophenol, (6) copper naphthenate, (7) creosote, (8) chlorinated paraffin, (9) fluoride chrome arsenate phenol.

Two panels of each species are in dry, protected storage for a control check.

In 1958 the test panels were tagged with numbered monel strips to facilitate their identification upon future inspections or upon removal, and diagrams were made to show the location of each panel by number. Due to loss from tower repairs and for other reasons, in 1961 there were 468 test panels remaining in the study.



Fig. 1 Treated wood test panel.

Preservative Description

Complete data on preservatives used in the test panels are given in the following table:

Slat No.	Treatment	Retention, Lb. per Cu. Ft.			
		Redwood	Douglas Fir	Cedar	Pine
1	Untreated control	—	—	—	—
2	Acid Copper Chromate, ACC (Celcure) Copper sulfate, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ 50% Sodium dichromate, $\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$ 48.3% Chromic acid, CrO_3 1.70% (calculated as equiv. to 2.5% sodium dichromate) Concentration: 1.74 total salt by analysis	0.722	0.729	0.68	0.721
3	Ammoniacal Copper Arsenite, ACA (Chemonite) Copper hydroxide, $\text{Cu}(\text{OH})_2$ 58% Arsenic trioxide, As_2O_3 39% Ammonia 3% Acetic acid, CH_3COOH trace	0.74	0.64	0.69	0.55
4	Chromated Copper Arsenate, CCA (Erdalith, Greensalt) Sodium dichromate, $\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$ 56% Copper sulfate, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ 33% Arsenic acid, H_3AsO_4 11% Concentration: redwood, 1.6%; fir, 1.7%; cedar, 1.8%; pine, 1.5%.	0.63	0.40	0.58	0.53
5	Pentachlorophenol Oil carrier was No. 2 fuel oil having the following properties: API gravity @ 60F — 27 Penta solvency — over 10% Distillation — 50% over at 515F Flash point, Pensky-Marten closed cup — 220F (Oil complies with AWWA specifications P9) Concentration: 4.91% penta by analysis	11.0	11.3	11.0	9.4
6	Copper Naphthenate Same oil carrier as for the pentachlorophenol Concentration: 0.49% copper by analysis	9.6	10.3	9.0	9.35
7	Creosote Grade #1, meeting AWWA specification P1. Analysis as follows: Water — 0.3% Specific gravity @ 100F — 1.068 Insoluble in benzol — 0.63% Coke residue — 2.38% Distillation up to: 210C 0.3% 315C 64.8% 235C 8.3% 355C 84.3% 270C 42.7% Residue 15.5%	13.0	12.4	10.95	10.2
8	Chlorinated Paraffin No oil carrier was used. Mix was 95% Chlorofin 42 and 5% paraffin	9.0	9.5	9.0	12.4
9	Fluoride Chrome Arsenate Phenol, FCAP (Tanalith, Wolman salts) Sodium fluoride, NaF 25% Sodium arsenate, Na_2HAsO_4 25% Sodium chromate, Na_2CrO_4 38% Dinitrophenol, $(\text{NO}_2)_2 \cdot \text{C}_6\text{H}_3 \cdot \text{OH}$ 12% Concentrations: redwood, 1.2%; fir, 1.4%; cedar, 1.5%; pine, 1.0%.	0.34	0.37	0.37	0.36

INSPECTION PROCEDURE

All the inspections, from the beginning of the study, were conducted by one man, the CTI Field Engineer, which made possible accurate comparative grading.

The towers and panels were inspected in operation, to determine the strength of the saturated lumber. This was important because drying of deteriorated lumber usually strengthens it, and also hardens the surfaces, making comparative grading difficult.

The inspections included the following observations:

Visual: The appearance of the lumber and the depth to which loose or punky material could be scraped off with a dull instrument.

Strength: The breaking strength of drift eliminator boards and fill-deck splash bars was tested by hand to determine brashness. Also the softening of the surface and the depth of penetration of a sharp-pointed probe were noted as an indication of strength.

Touch: Whether the original saw marks could still be felt on the surface of the lumber, and if the surface was fibrous or crumbly.

Probe: The ease with which a probe penetrated heavier members and the depth of this penetration. Also the type fracture made on breaking out was used as an indication of the type of deterioration or its absence in the interior.



Fig. 2
Removing test panel from lower fill.



Fig. 3
Inspection of framing in plenum area of crossflow tower.

These observations were made in the typical tower as follows:

First, the louvers were examined and then entrance made through the louvers to the bottom of the filling, and fill test panels (Figure 2). Then from the stairs the outside casing was examined. Entrance was then gained through the trap door in the fan deck to the plenum chamber which was examined closely with special attention given to framing joints and exposed end-grain material (Figure 3). Next, the drift eliminators, drift eliminator supports, and eliminator panels were inspected (Figure 4). Then entrance was made through the drift eliminators to the distribution system and the top sections of the filling. The fan deck, from the underside, the inside casing, and the partition walls in the plenum area and below were then graded.



Fig. 4
Panel inspection in drift eliminator section of counterflow tower.