Structural Durability:
The Proper Use of
Preservative Treated Wood

Tom Milton

Learning Objectives

At the end of this program, participants will be able to:

1. Identify what causes wood to deteriorate.
2. Where and how design features can protect wood and where treated wood must be used.
3. Identify what types of preservatives are available and suitable for various applications.
4. Learn how to use the AWPA Use Category System to specify treated wood products.

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**Structural Durability and the Use of Preservative Treated Wood**

- Durability and Service Life
- What Causes Wood to Deteriorate
- How to Protect Wood from Deterioration
- Where is PT Wood Required by the IBC
- Preservative Treated Wood
- What Types of Preservatives are Available
- How is Wood Pressure Treated
- How is Treating Quality Measured & Verified
- Specifying Treated Wood
- Use & Handling of Treated Wood

**Stave Church, Norway, 1500-1600 A.D.**

![Stave Church](image)

**200+ yr old Wood Frame Home**

![Wood Frame Home](image)

**Minnesota Study on Service Life**

- Steel: 20% >51 yrs
- Concrete: 35% >51 yrs
- Wood: 68% >51 yrs

![Bar Chart](image)
Minnesota Study on Service Life

Figure 9: Number of demolished buildings by reason for demolition

- Area redevelopment: 79
- Building's physical condition: 70
- Not suitable for anticipated use: 50
- Fire damage: 15
- Improvements to bring to code too expensive: 4
- Other: 4
- Socially undesirable use: 12
- Maintenance too expensive: 1
- Changing land values: 1

Wood Deterioration- 2 Categories

- Biotic (biological)
- Abiotic (nonbiological)

Nonbiological Deterioration

1) Weathering
   Cause: wetting/drying cycles (swelling and shrinkage), ultraviolet light, oxidation and leaching
   Solution: use coverings or water repellent and UV resistant finishes, eg- paints, stains, water repellents
### Nonbiological Deterioration

<table>
<thead>
<tr>
<th>Cause</th>
<th>Solution</th>
</tr>
</thead>
</table>
| 2) Thermal Decomposition (Fire)  
Cause: exposure to flame or high heat  
Solution: use fire retardant chemicals, protected assemblies and/or fire sprinklers | |
| 3) Mechanical Damage  
Cause: abrasion to wood surfaces, eg-flooring, stairs  
Solution: use high-specific gravity, edge grain, or chemically hardened woods | |
| 4) Chemical Decomposition (Pulping)  
Cause: caustic chemicals, such as strong bleach solutions  
Solution: avoid caustic chemicals | |

### Biological Deterioration

<table>
<thead>
<tr>
<th>Cause</th>
<th>Solution</th>
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</thead>
</table>
| 1) Insect Damage  
Cause: termites, borers, and carpenter ants  
Solution: use wood preservatives, barriers, termite baits, insecticides, keep wood dry | |
| 2) Marine Borer Damage  
Cause: shipworms and crustaceans  
Solution: wood preservatives and/or surface barriers | |
| 3) Bacterial damage  
Cause: bacteria in high-moisture conditions  
Solution: keep wood dry or use wood preservatives | |
| 4) Fungal damage  
Cause: stains, molds, & decay fungi  
Solution: keep wood dry or use wood preservatives | |

### Wood Fungi

<table>
<thead>
<tr>
<th>Cause</th>
<th>Prevention</th>
<th>Solution</th>
</tr>
</thead>
</table>
| 1) Sapstain Fungi  
Prevention: dry wood quickly or use anti-stain chemicals  
Sapstains affect appearance but not wood strength | |

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**Nonbiological Deterioration**

- **2) Thermal Decomposition (Fire)**
  - Cause: exposure to flame or high heat
  - Solution: use fire retardant chemicals, protected assemblies and/or fire sprinklers

- **3) Mechanical Damage**
  - Cause: abrasion to wood surfaces, eg-flooring, stairs
  - Solution: use high-specific gravity, edge grain, or chemically hardened woods

- **4) Chemical Decomposition (Pulping)**
  - Cause: caustic chemicals, such as strong bleach solutions
  - Solution: avoid caustic chemicals

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**Biological Deterioration**

- **1) Insect Damage**
  - Cause: termites, borers, and carpenter ants
  - Solution: use wood preservatives, barriers, termite baits, insecticides, keep wood dry

- **2) Marine Borer Damage**
  - Cause: shipworms and crustaceans
  - Solution: wood preservatives and/or surface barriers

- **3) Bacterial damage**
  - Cause: bacteria in high-moisture conditions
  - Solution: keep wood dry or use wood preservatives

- **4) Fungal damage**
  - Cause: stains, molds, & decay fungi
  - Solution: keep wood dry or use wood preservatives

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**Wood Fungi**

- **1) Sapstain Fungi**
  - Prevention: dry wood quickly or use anti-stain chemicals
  - Sapstains affect appearance but not wood strength
2) Mold Fungi
Prevention: keep wood surfaces dry or use mold inhibiting chemicals
Molds affect appearance but not wood strength

3) Wood Decay Fungi
(brown, white and soft rots)
Prevention: keep wood dry or use wood preservatives

Wood Fungi Growth Requirements
- Free water on cell walls
  - 40-80% MC optimum
  - < 19% MC prevents fungal growth
- Favorable temperature range
  - 50° F - 90° F optimum
- Oxygen
  - In situations without oxygen, wood lasts indefinitely, e.g. submerged logs,
- Digestible food source (i.e. wood)

Protecting Wood Products
To protect wood from biological deterioration:
- Dry wood to the MC it will eventually reach in service
- Keep wood dry during storage, transport, & construction
- Keep wood dry by using proper construction designs
  or
- Use naturally durable or preservative treated wood where conditions warrant
Protecting Wood Products

• Durability by design
• Durability by nature
• Durability by treatment

The Four D's of Wall Design

1. Deflection
2. Drainage
3. Drying
4. Durability

All Water Should Run To Daylight!

Source: QBI Building Practice Guide
St Cloud, MN Regional Airport Terminal

Liquid Movement - Capillary (Wicking)

Weep Holes
Wood Structure and Natural Durability

Figure 1. Major tissue types in a tree cross-section, and the principal driving forces of tree growth and annual ring formation.
Wood Structure and Natural Durability

Species that exhibit natural decay resistance in heartwood

• Cedar
• Redwood
• Cypress
• White oak
• Black locust

Preservatives Extend Wood’s Service Life

- Untreated Wood: 5 years
- Treated Wood: 30-50+ years
- Service life is increased by 5 to 10 times
- Provides annual savings of $7.5 billion in U.S.
- Conserves 6.5 billion board feet of lumber products annually
- Saves 226 million trees—equivalent to 435,000 new houses

Preservative Treated Wood Applications

• Residential
  • Decks
  • Fences
  • Landscaping timbers
  • Ramps
  • Gazebos
  • Outdoor Furniture
  • Planter boxes
  • Doghouses
  • Trellises
  • Sill plates, furring strips, sleepers
  • Shakes & shingles
  • Permanent wood foundations

• Agricultural
  • Tomato & grape stakes
  • Post frame structures
  • Stables & corrals
  • Fence posts

• Commercial
  • Walkways & bridges
  • Structural columns
  • Exterior stairways
  • Utility poles
  • Building poles
  • Piling (foundation & marine)
  • Guardrail posts
  • Sign posts
  • Retaining walls
  • RR Cross ties
IBC Section 2303.1.8 – Lumber, timber, plywood, piles and poles supporting permanent structures shall be treated according to the requirements of the American Wood-Protection Association (AWPA) for species, product, preservative and end use.

**Building Code Requirements for PT Wood**

**IBC Section 2304.11.2.1**

Where wood joists or the bottom of a wood structural floor are closer than 18” or wood girders when closer than 12” to exposed ground in crawl spaces...

**Section 2304.11.2.2**

Where wood framing members rest on concrete or masonry exterior foundation walls and are less than 8” from exposed ground.

**Section 2304.11.2.6**

Where wood siding, sheathing & wall framing on the exterior of a building are less than 6” to the ground.

**IBC Section 2304.11.2.3-Furring Strips**

Where wood furring strips or other wood framing members attach to the interior of exterior masonry or concrete walls below grade.

**IBC Section 2304.11.2.4-Sleepers & Sills**

Where sills and sleepers are on concrete or masonry, which is in direct contact with earth.
IBC Section 2304.11.2.5 – Girder Ends
Where the ends of wood girders entering exterior masonry or concrete walls have clearances of less than 0.5” on tops, sides and ends.

IBC Section 2304.11.2.7 – Posts or Columns
Where posts or columns supporting permanent structures are [themselves] supported by a concrete or masonry slab or footing that is in direct contact with the earth.

IBC Section 2304.11.3-Laminated Timbers
Where the portions of glued laminated timbers that form the structural supports of a building are exposed to weather and not protected from moisture.

2304.11.4.1-Posts or Columns. Posts and columns supporting permanent structures that are embedded in concrete that is in direct contact with the earth, embedded in concrete that is exposed to the weather, or in direct contact with the earth.

2304.11.4.2-Wood Structural Members. Wood structural members supporting moisture-permeable floors or roofs that are exposed to weather such as concrete or masonry slabs.
Building Code Requirements for PT Wood

IBC Section 2304.11.5
Supporting Members for Permanent Appurtenances
In geographical areas, where needed, wood members
which support buildings, balconies, decks or porches if
exposed to weather and without adequate cover protection.

IBC Section 2304.11.6
Termite Protection
In geographical areas
where hazard of termite
damage is known to be
very heavy, wood floor
framing.

Wood products need protection from
decay and insects when:
1. Exposed to high humidity or condensation
2. In direct contact with ground
3. In indirect contact with ground (concrete)
4. Exposed to water
5. Where termites are known to occur

American Wood Protection Association
- Founded in 1904
- International, nonprofit technical society
- Standards writing organization for the wood preserving industry in U.S.
- Provides a technical forum for industry, research and users.
- Protects consumers by ensuring uniform product performance.
- Referenced in all building codes.
- Updated Annually – Currently 2012 Edition
- Determines if a preservative is effective and can be listed in the standards
- Establishes how much preservative is needed (retention) depending upon the exposure and use.
- For more information visit: www.awpa.com

AWPA USE CATEGORY SYSTEM
- New AWPA Standard U1 (User Specifications for Treated Wood) replaces old “C” (commodity) Standards
- Simplifies specification for specifiers and users
- Standard U1 based on biodeterioration hazard to which the treated product will be exposed
- 5 Use Categories based on exposures & expected product performance.
- Categories range from weather protected (UC1 mild exposure/lowest risk) to salt water marine (UC5 severe exposure/highest risk).
- Separate Use Category for fire retardants.
AWPA Use Category System

Degree of protection needed depends upon:
- Geographic location
- Desired service life
- Structural vs. Nonstructural components
- Replacement difficulty
- Exposure severity (i.e., interior, exterior, above ground, ground contact, freshwater, or saltwater)

Specify With the AWPA Use Category System

Use Category 1 (UC 1)
- Interior construction
- Not in contact with ground or foundations
- Protected from weather
- Protected from interior sources of water
- Insect hazard only
  - e.g., interior construction and furnishings

Use Category 2 (UC 2)
- Interior construction
- Not in contact with ground
- Protected from weather
- Subject to dampness and occasional sources of water
- Decay fungi & insect hazard
  - e.g., interior construction, sill plates, furring strips
Use Category 3 (UC 3)
- Exterior construction,
- Above ground
- Decay fungi & insect hazard
- UC3A: Coated & rapid water runoff; e.g.—coated millwork, siding, and trim
- UC3B: Uncoated or poor water runoff; e.g.—decking, deck joists, railings, fence pickets, uncoated millwork

Use Category 4 (UC 4)
- Ground or fresh water contact; Exposed to all weather cycles
- Subject to fungal and insect hazards
- UC4A: Non-critical components, low decay areas; e.g.—fence, deck & guardrail posts, crossties and utility poles.
- UC4B: Critical components or difficult replacement, high decay areas. e.g.—permanent wood foundations, building poles, posts, crossties & utility poles.
- UC4C: Critical structural components, extreme decay potential; e.g.—land & fresh water piling, foundation piling, crossties & utility poles

Use Category 5 (UC 5)
- Wood used in salt or brackish water
- Exposed to marine borer attack
- Applications such as marine piles, docks, bridges, bulkheads, bracing
- UC5A-Northern waters, north of New Jersey, San Francisco
- UC5B-Waters between NJ and GA, South of San Francisco
- UC5C- Waters south of GA, Gulf Coast, Hawaii, & Puerto Rico

Use Category 5 - UC F
- Fire Retardant Treated Wood
- Above ground use only
- Two risk groups – Determined by weather exposure
- UCFA: Interior - Continuously protected from weather e.g.—roof sheathing, roof trusses, studs, joists, paneling.
- UCFB: Exterior - Exposed to weather or wetting; e.g.—vertical exterior walls, inclined roof surfaces or other construction which allows water to quickly drain
Specifying Treated Wood Products

Sill plates shall be treated in accordance with AWPA Standard U1 to the requirements of Use Category 2 (UC2)

Sill plates shall be treated with waterborne preservatives in accordance with AWPA Standard U1 to the requirements of Use Category 2 (UC2)

Sill plates shall be treated with waterborne preservatives in accordance with AWPA Standard U1, Commodity Specification A, to the requirements of Use Category 2 (UC2)

Sill plates shall be southern pine lumber, treated with waterborne preservatives in accordance with AWPA Standard U1, Commodity Specification A, to the requirements of Use Category 2 (UC2)

Sill plates shall be southern pine lumber, treated with inorganic boron (SBX) in accordance with AWPA Standard U1, Commodity Specification A, to the requirements of Use Category 2 (UC2)

How Are Preservatives Classified?

- By the type of carrier or solvent – creosote vs. oilborne vs. waterborne solutions
- By the preservative’s chemistry - organic (carbon) based vs. inorganic (metal) based compounds
- By the application process - pressure vs. non-pressure
- By the type of EPA Registration - restricted use vs. general use

Q: What makes a good preservative?
### Waterborne Preservatives

- Clean to the touch, paintable surfaces
- No odors, suitable for interior applications
- After re-drying, low permanent weight increase (1-2%)
- Low solution cost
- Water repellents, colorants, & mold inhibitors can be incorporated into solutions

### CCA

- Industry voluntarily modified EPA registered uses for CCA
- Effective Dec. 31, 2003 – CCA phased out for most consumer and residential applications
- CCA is still approved for industrial end use applications such as plywood, PWFs, highway construction, utility poles, piling and agricultural applications
- EPA does NOT recommend the removal of existing CCA structures

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**Table 2: Identification of Preservatives Approved for the Pressure Treatment of Southern Pine Wood Products**

<table>
<thead>
<tr>
<th>Preservative</th>
<th>Description</th>
<th>300</th>
<th>500</th>
<th>700</th>
<th>1200</th>
<th>1500</th>
<th>2300</th>
<th>3000</th>
<th>3500</th>
<th>6000</th>
<th>9000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waterborne, Copper Based</td>
<td>Preservative Formulation</td>
<td>300</td>
<td>500</td>
<td>700</td>
<td>1200</td>
<td>1500</td>
<td>2300</td>
<td>3000</td>
<td>3500</td>
<td>6000</td>
<td>9000</td>
</tr>
<tr>
<td>Acid Copper Chrome</td>
<td>Copper Chromate</td>
<td>300</td>
<td>500</td>
<td>700</td>
<td>1200</td>
<td>1500</td>
<td>2300</td>
<td>3000</td>
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<td>6000</td>
<td>9000</td>
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<tr>
<td>HMC Copper-Quinone</td>
<td>Copper Quinone</td>
<td>300</td>
<td>500</td>
<td>700</td>
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<td>2300</td>
<td>3000</td>
<td>3500</td>
<td>6000</td>
<td>9000</td>
</tr>
<tr>
<td>Artisan Copper-Quinone</td>
<td>Copper-Quinone</td>
<td>300</td>
<td>500</td>
<td>700</td>
<td>1200</td>
<td>1500</td>
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<td>3500</td>
<td>6000</td>
<td>9000</td>
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<tr>
<td>Artisan Copper-Quinone Accelerator</td>
<td>Copper-Quinone Accelerator</td>
<td>300</td>
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<td>700</td>
<td>1200</td>
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<td>9000</td>
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Source: Pressure Treated Southern Pine, 08-09 Edition, Southern Pine Council
Oilborne Preservatives

- No dimensional change to treated products
- Enhanced water repellency
- Soluble in light to heavy petroleum oils with varying viscosities and properties
- Treating solutions can be heated, enhancing penetration and allowing in-cylinder drying processes
- Low to high permanent weight increase

Oilborne Preservatives Include:
- Pentachlorophenol (Penta or PCP)
- Copper Naphthenate (CuN)
- Copper 8 Quinolinolate (Cu8)

Creosote Solutions

- Unique - act as both carrier and preservative
- Patented in 1836
- Excellent protection - fungi, insects, most marine borers
- Insoluble in water and leach resistant
- Excellent thermal stability
- Water repellent - enhances dimensional stability
- Used for industrial products including:
  RR Crossties, Marine piling, Bridge timbers

New Mold Protection Products

- Mold-Resistant Framing
  - FrameGuard®
  - BluWood®
  - QuanTIM™
- Factory-Applied Surface Coating (green, blue, purple) for Lumber, Plywood, Trusses, OSB
- Offers Added Resistance to Termites and Fungal Decay in Interior Applications.
- NOT a Substitute for Treated Wood!
After drying, incising etc, similar sizes and species of wood products are loaded onto trams and pushed into a large horizontal treating cylinder.

Cylinder door is closed and vacuum-pressure treating cycle begins.

Kiln drying after treatment (KDAT)

Specify KDAT: When PT framing lumber will be covered or enclosed, (and therefore difficult to re-dry), building codes require a moisture content of 19% or less. e.g. PWF lumber & plywood, UC 1 & UC 2

Quality Assurance

Verification of the treatment starts at the treating plant and involves drawing a representative sample (20) of increment cores from each charge for later analysis and recording

Analysis of increment core samples determines:

- Retention—the amount of preservative, retained in the wood, measured in pounds (of preservative) per cubic foot (of wood)
- Penetration—the depth of treatment, measured in inches or percent of sapwood
Reference design values for structural lumber can be found in the Design Values for Wood Construction Supplement of the National Design Specification® (NDS). Reference design values and adjustment factors apply to both untreated and pressure treated lumber, equally.

Exceptions and Adjustments for Pressure Treated Wood

Load duration factor, $C_D$
Cannot exceed 1.6 for structural members pressure treated with waterborne preservatives.

Wet Service Factor, $C_M$
Where moisture content of the wood will exceed 19% for an extended time, reference design values must be adjusted by the appropriate wet service factor, $C_M$, found in the NDS®.

Incising Factor, $C_i$
A reduction imposed on wood species that must be incised. $C_i$ reduces MOE by 5%, and bending, tension and compression allowable design stresses by 20%.

Design Values for Treated Wood

Retreatment of Field Cuts with Copper Naphthenate (2% Cu)

AWPA Standard M4
- CUPRINOL-Green #10
- WOLMANIZED-End Cut Solution
- JASCO- Termin-8, Copper-Green, Copper-Brown

Fasteners & Connectors for Pressure Treated Wood
- Hot dipped galvanized generally acceptable for above grade applications.
- Type 304 or 316 stainless steel is recommended for more severe exterior applications. SS required for PWF’s.
- HDG fasteners must meet ASTM A153 with 2 ounces zinc/sq ft.
- HDG connectors must meet ASTM A653, Class G185 with 1.85 ounces zinc/sq ft.
- Fasteners & connectors must be the same type of metal.
- Standard carbon steel or aluminum must not be in direct contact with PT wood.
- Electroplated galvanized hardware typically not acceptable by building codes.
- Hardware coated with proprietary anti-corrosion technologies may be acceptable.
- Carbon based preservatives and borates are less corrosive than copper based preservatives. Standard fasteners may be used, but exposure conditions may dictate coated fasteners.
- Always follow manufacturer’s recommendations.
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Information Sources

American Wood Protection Association: [www.awpa.com](http://www.awpa.com)
US Forest Products Lab: [www.fpl.fs.fed.us/](http://www.fpl.fs.fed.us/)
Forest Products Society: [www.forestprod.org](http://www.forestprod.org)
Western Wood Preservers Institute: [www.wwpinstitute.org](http://www.wwpinstitute.org)

Questions?

This concludes The American Institute of Architects Continuing Education Systems Course.

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