Cooling Tower wood structure

GENERAL INSPECTION PROCEDURE
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Since the actual framing or structural members in a tower support all other components, the structure is considered to be of primary importance.

The framing consists of vertical columns, horizontal girts, running both the length and width of the tower and diagonal members (or bracing). Fasteners such as bolts, castings and special connectors join the framing members.

Excluding fires, explosions, wind damage and mechanical damage, deterioration of framing members is usually due to fungal attack or chemical attack.

Chemical attack usually occurs due to the failure to control water treating chemicals. The combination of high pH and excessive chlorination will deteriorate wood rather rapidly. Generally, chlorination in excess of 1 ppm free residual is dangerous because it makes the wood more susceptible to fungal attack. It can also cause a loss of lignin, resulting in a fuzzy, cottony surface on the wood.

These loosened cellulose fibers may accumulate on sump screens in a thick mat, requiring frequent cleaning. The wood also assumes an eroded, bleached appearance. The wood will continue to lose cross section until the chlorine is reduced to a proper amount. In treated wood, this loss of cross section also means a loss of preservative chemical in the eroded areas.

Some operators link algae and slime with fungi. There is no evidence that either growth has any bearing on fungal activity in the wood. Actually, a light growth of algae in cooling tower areas exposed to direct sunlight often indicates the operator is not over-chlorinating and may be taking better care of water treating procedure than one whose tower is devoid of any signs of algae.

Investigation has also disproven the idea that some erosion of wood is due to falling water. Erosion of sound wood by water flow is very negligible. However, decayed or chemically attacked wood can be eroded.

Another form of wood deterioration (sometimes confused with chemical attack) can occur in outer areas of the tower, such as louver and hot water basin perimeters subject to alternate wetting and drying. The evaporation of water results in the buildup of salt deposits in the wood fibers, which will eventually cause them to rupture. The fibers loosen and separate into a wool-like mass mixed with salt crystals, which can be easily freed with the fingers. This is a mechanical action, not chemical.

In the past, fungal attack has increased maintenance costs for cooling towers more than any other factor. Today, principal users of cooling towers specify all wood components be pressure treated after fabrication and before erection. This has greatly reduced fungal attack in these treated towers.

The internal rots (white and brown) are insidious because there is no outward indication of decay. These types of decay can only be found by sounding or probing the wood.

The soft rot starts on the outside and is characterized by a softening of the surface of the wood. In the flooded area, the flow of water washes away the softened fibers and gradually decreases the wood member in size. In fairly advanced decay, the wood can be broken across grain with very little irregularity or splintering. The wood darkens with the advance of the decay.

In the hot vapor zone, the soft rot attack progresses with deepening softness. Since there is no flow of water, little erosion may take place.

### Types of Fungal Attack Found In Cooling Towers

1. **White Rot** - Occurs in the hot vapor zone, but seldom in the flooded areas. (See Figures 3 and 9.)

2. **Brown Cubical Rot** - Occurs in the hot vapor zone (can be associated with wood attacked by iron corrosion products, or “iron rot”), but seldom in the flooded area. (See Figure 8.)

3. **Soft or Surface Rot** - Usually occurs in the flooded zone, but may occur in unusually wet vapor zones. (See Figures 1, 2, 4, and 6.)
The soft rot is obvious and rather easily observed by the extent of deterioration. However, the internal rots are dangerous, because there is no indication of deterioration until the wood falls under load.

Post-treatment can be applied to cooling towers to control fungal attack, but the effectiveness of the treatment depends upon application in the early stages of infection. However, if internal rot in either advanced or incipient stages exists deep in the heavier members, a surface application of toxic materials cannot be expected to penetrate deep enough to be effective.

Wood deterioration which goes unnoticed and unchecked may be discovered when components fail under load.

Deteriorated members in the vicinity of mechanical equipment may sag, throwing mechanical equipment out of line or may fail, causing the mechanical equipment to fall. Pipe supports may also sag or fail.

Fan deck floors and hot water distribution basins floors may sag or give way. When this occurs, sound components in the path of the failing objects can be damaged or destroyed.

Operating and maintenance personnel often uncover such deterioration by accident—by putting a foot through a fan deck or having a beam crumble beneath them during routine maintenance. There have even been actual cases of complete cooling tower collapse due to wood deterioration. These are extreme cases and, fortunately, are very few in number. The collapse of these cooling towers could have been prevented if periodic inspections had been performed.

Deteriorated members should be replaced with pressure treated wood.

Generally, a partial or piecemeal replacement is unsatisfactory for the following reasons:

1. The resistance to fungal attack of individual pieces of wood varies considerably even when the pieces are from the same tree. One wood member may show large areas of rot while an adjacent member shows no rot whatsoever.

2. The assumed undamaged member, when in the presence of greatly deteriorated members, has probably been infected and is in some stage of incipient decay. Incipient decay in the early stages can only be detected by extensive laboratory tests.

3. Incipient decay gradually extends and develops more advanced decay.

4. If only the badly deteriorated members are removed from the tower and those members with incipient decay remain, the tower operator will be faced with a continuing maintenance problem.

5. There will be increased labor costs and tower down time. Frequently, the operator will find it necessary to remove recently installed sound wood members in order to remove older members which have no noticeable deterioration.

Consider the Following When Determining the Extent of Damage and Recommended Replacements:

1. Are the deteriorated members confined to a relatively small area?

2. What do these deteriorated members support?

3. Will it be necessary to remove other components and framing in order to replace the badly deteriorated members?

A single area of rot is enough to condemn the whole piece of wood. Cutting out decayed spots and splicing to the same member is poor practice. Where obvious decay exists, incipient decay almost surely extends far beyond. The decay may also pass from one member to another at the joints.

If rot is scattered, generally throughout the plenum, it may be advisable to replace the whole plenum structure at one time rather than just remove the worst pieces. This may be most economical in the long run due to the labor involved.

If the rot seems to be confined to the upper framing area, but is scattered throughout the area, it is advisable to remove the complete framing in the upper area down to the column splices. This same practice would apply if rot is scattered throughout the lower areas—complete replacement is advisable from the base of the columns up to the column splices. Generally, in either case, it will be necessary to follow later with replacements of the remaining upper or lower sections. If only minimal repairs can be afforded, particular attention should be given to the load bearing members supporting mechanical equipment and piping.
In a badly infected older tower, it is recommended that a fairly clean sweep of all wood components in the area be made. For example, the fan deck flooring may appear to be in serviceable condition, but all of the framing immediately below it is in poor condition. Generally, it is not economical to remove fan cylinders, mechanical equipment, etc. to gain access to the framing and supports and to reuse the old floor. It is also not economical to replace deteriorated flooring and reuse the flooring supports. Where advanced fungal deterioration is present in one member, the joining and adjacent members are probably infected also. Eventually, they will deteriorate and their replacement alone will be much costlier than their replacement in conjunction with the other work at one time.

Even new pressure treated wood placed in contact with infected wood will have a shorter service life, because it is in immediate and continuous contact with a source of infection.

Usually, framing members in the hot vapor zone (plenum) require replacement more frequently than framing members in the flooded area. Wood framing in the flooded area is usually only subject to the slower progressing soft rot. One exception to this is the possible occurrence of internal rot immediately beneath the hot water basins in crossflow towers, where there is not a continuous flow of water across certain areas. These areas include the underside of the fan deck flooring away from the nozzles, tops of columns and other members on transverse column lines that are subjected only to occasional splash from the nozzles, but are continually subjected to a hot, moist atmosphere.

Since fungal spores are continuously present in air and water everywhere, chances of infection are always present. A cooling tower takes in tremendous amounts of air, which is continuously washed by the circulating water. Deterioration and production of spores in one area of the tower can be carried by both air and water to all areas. Infection and deterioration will take place in any area of the tower where optimum temperatures and humidity occur.

Generally, temperatures in the average cooling tower range from relatively cool at low levels to hot at upper levels. Depending on the temperature differential and such factors as air currents and eddies, optimum conditions for fungi propagation may occur at one or more levels. Other factors, such as channeling of water and consequent variation in air flow, which affect temperatures both vertically and horizontally, make this unpredictable.
General Inspection Procedures

1. Fill and eliminators should be removed from the area to be inspected.

2. All structural members and joints should be inspected, giving special attention to heavily loaded columns (e.g., those supporting mechanical equipment and distribution piping), girts and joists at the hot water basin and fan deck levels.

3. Check wood members for decay by visual inspection. Surface appearance, when normal, indicates the absence of harsh chemicals and surface type rot. Bleached, shredded or grooved surfaces are generally associated with chemical action, but are often the result of chemical and biological forces working together. A cross-checked surface is almost always the result of fungal attack. Cross-checks are small cracks which occur across the wood grain. Loss of dimension is a result of deterioration. The amount of loss is an indication of the severity of attack, but it is not possible to determine the cause by visual inspection alone.

4. Check for internal rot by sounding and probing the members. Internal rot can be found by thumping the members with a mallet or hammer. If the sound is a dull thud, the next step is to probe the wood with a screw driver or similar tool to check for internal damage. Internal decay may be white rot or brown cubicle rot, and is usually isolated and spotty. Soft rot, which is more visible than internal rot since it only affects the outer wood surfaces, sometimes leaves a skin of treated wood on the outside and can only be detected by probing. Surface deterioration around corroded steel is probably "iron rot" which is primarily chemical attack and not decay. Deterioration of wood is usually accompanied by a distinct change of internal color. The depth of discoloration established by probing is another measure of the extent of deterioration.

5. Check for broken or missing bolts, deteriorated FRP diagonal connectors and excessively corroded anchor castings.

6. Check for through splits passing through the bolt holes in splice blocks or the ends of structural members.

7. Check for column bow over 3/16" in a six foot story. Check for splits or breaks in the columns.

8. Check for girt or joist deflection exceeding 1/2" in a six foot span. Check for splits or breaks in the members.

9. Check the fan deck and hot water basin for general structural condition (e.g. sagging joists, girts or decking members).
Samples of Lumber Deterioration

Soft Rot

Samples of Untreated Redwood
3/8" x 3" Eliminator Blades

Figure 1
This sample shows typical cross-checking, erosion and bleached appearance of advanced soft rot. Notice the left side (which is actually the lower end) has brash fracture without splintering.

Cross-checking and light color is usually more evident after the sample has dried out.

Figure 2
This sample also shows cross-checking and erosion, which is typical of soft rot. In addition, the removal of an outside section of the wood reveals internal white rot with its typical light colored loose, cellulose fibers, resulting from the selective destruction of lignin. Eventually, the cellulose may also be destroyed.
White Rot
Sample of Untreated Redwood
1 1/2" x 6" Girt

Figure 3
The surface of the wood is deceptive since it appears sound; however, it gives readily under pressure of fingers.

Breaking off part of the outer shell shows white rot is destroying the wood. In this sample, the rot has advanced so far as to leave only the fibrous cellulose. A girt in this condition will not support a person’s weight.
Soft Rot and Excessive Chlorination

Samples of Untreated Redwood
3/8" x 1 1/2" Splash Bars

Figure 4
This sample shows cross-checking and the eroded surface of soft rot.

Figure 5
This sample has a fuzzy and eroded surface typically resulting from excessive chlorination in water treating procedures. The chlorine has destroyed lignin and freed cellulose fibers. In such cases, the loose fibers may build up on sump screens in a thick mat, requiring periodic cleaning of screens. Chlorine damage also makes wood more susceptible to decay.

Figure 6
This is a sample of cross checking caused by soft rot.

Figure 7
This is a sample of new redwood shown for comparison. Notice that the saw marks show clearly.
Brown Cubical Rot

Sample of Untreated Redwood
2" x 4" Girt

Figure 8
The outer surface of this sample was smooth and gave no indication of the decay within until broken by a hammer blow. The cellulose has been destroyed, causing the lignin to shrink and contract into the rough cubical formation, giving this type of decay its name. The remaining lignin is easily powdered to brown dust.
White Rot
Sample of Untreated Redwood
1 1/2” x 4” Girt

Figure 9
Here again, the sound unmarked shell surrounds an Interior completely converted to a mass of cellulose fiber. Examples of this type, when present in a cooling tower, are easily found by pressing or squeezing the wood.

In the stages before the entire interior of the wood member has been degraded, a smaller decayed area may be closer to one side than the other.

All sides of a member should be checked when internal rot is suspected. One side or edge may give under pressure while the others seem solid.