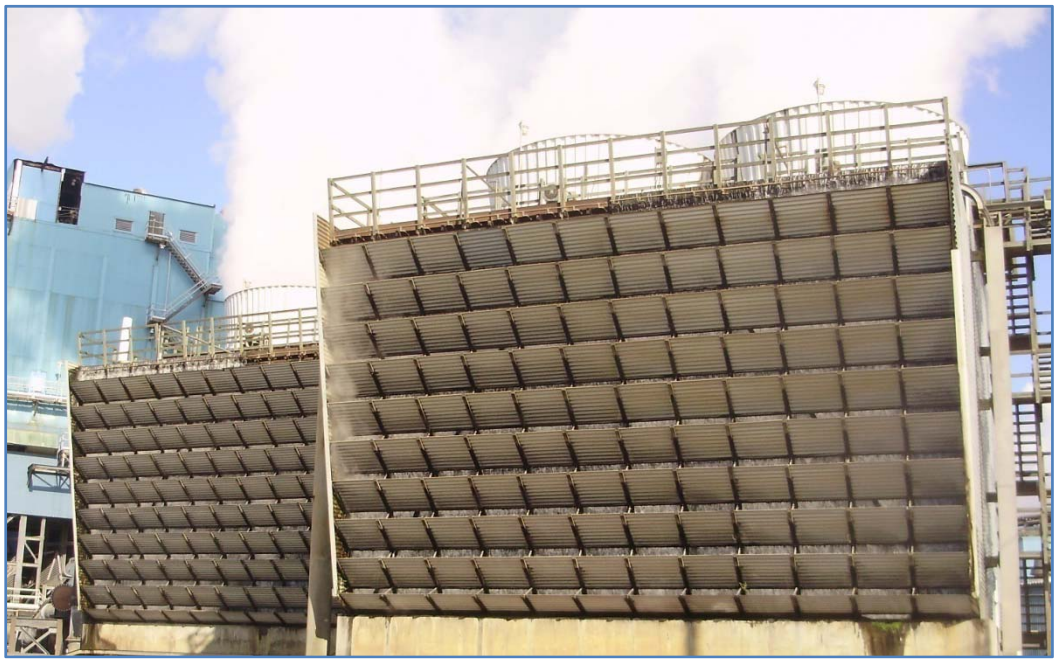
Inspection Report

Central Plant Cooling Tower



For

[redacted]

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General Overview

The main plant cooling tower which provides condenser water for the majority of the [redacted] was inspected in response to a request from operations to investigate some vibration and balance issues on the four fans. The cooling tower was originally built by The Marley Cooling Tower Company utilizing wood splash fill and was upgraded in the mid-nineties to the current design that utilizes PVC splash bar fill material. The cooling tower consists of four single fan cells; all four cells utilize eighteen feet of air travel. The cooling tower was made available for both an exterior and internal inspection, annotations were recorded in an effort to gain a better understanding on the overall condition of the tower and prepare a scope of work for the repair and refurbishment of the deteriorated areas. Repairs are listed with respect to the damage that was found during inspection; the cooling tower was completely shut down during inspection. A schematic of the tower's layout is located in figure 1.

Cooling Tower Equipment Survey

Model:	*Marley Series 600 Double Cross flow Model# 652-4-02*
Serial #:	*NA*
Design Flow	*NA*
Fan Motors:	*Reliant Electric 1785 RPM 150 HP Frame: 445T Type: TEFC*
Gear Box:	*Marley 32.2 Double Reduction Ratio 11.18:1*
Fan Assembly:	*Marley Fiberglass HP-7000 24' diameter / 8 blades Pitch Setting 23°*
Drive Shafts:	*Stainless Steel drive shaft Marley 301 Series*
Fan Stacks:	*10' tall velocity recovery fiberglass*
Nozzles:	*Marley Spiral Target Cross flow Nozzles*
Valves:	*Marley flow control valve, Part # 79-41919.1, Rated : 25 psi*
Vibration Switch:	*Metrix Vibralert*

Table 1: Cooling Tower Equipment Survey

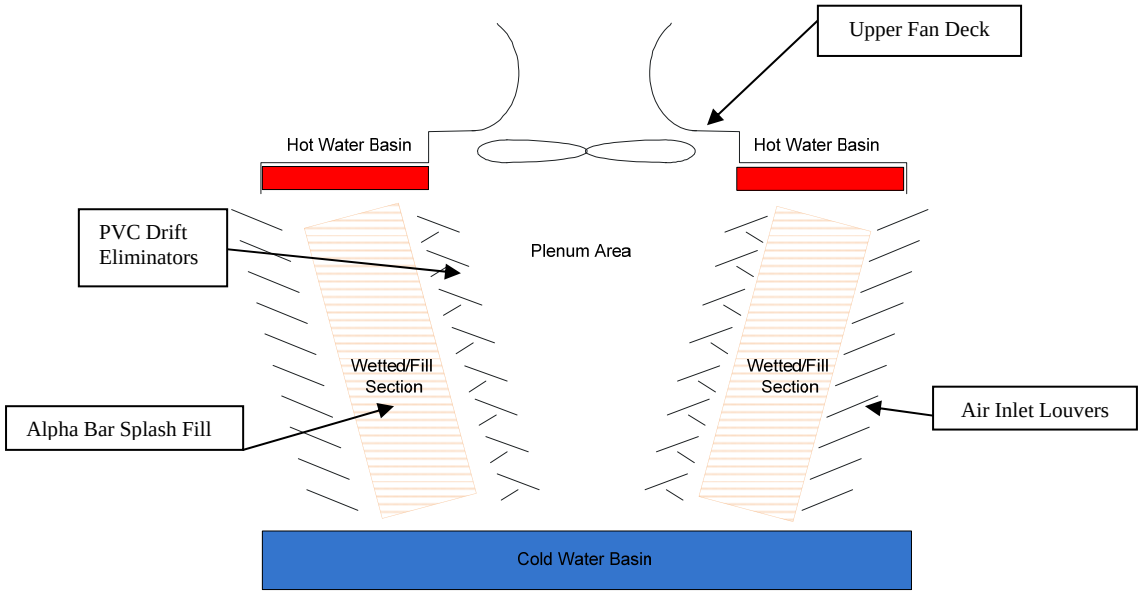

Figure 1:Cross flow basic schematic

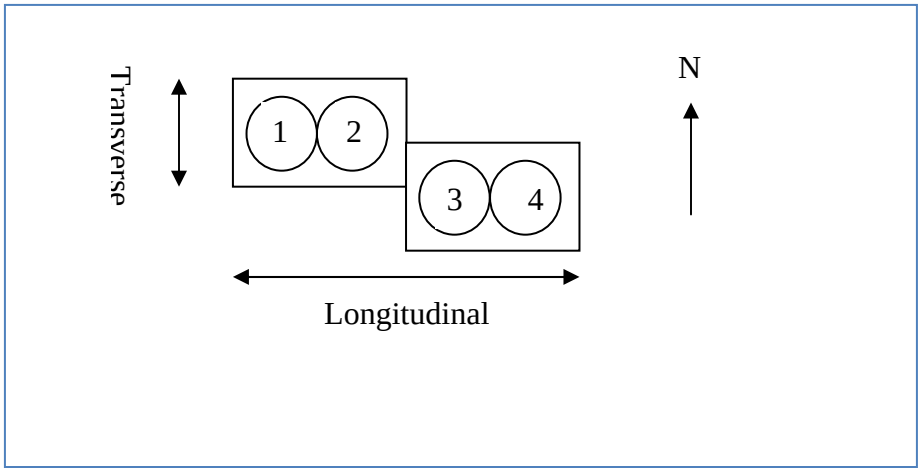

Figure 2: Cooling Tower orientation and nomenclature

EXTERIOR STRUCTURE AND COMPONENTS

Casing

The casing material on the central plant cooling tower is composed of 4.2 inch corrugated fiberglass reinforced plastic. This material is a common product used in cooling towers and has replaced the compressed asbestos board that was originally installed on the tower. The tower was in operation at the time of inspection, which provided an opportunity to identify casing leaks. Many leaks have developed in areas that have ripped or split from normal wear and tear. It is recommended to replace the four end walls with a much heavier twelve ounce casing material which will be more resistant to tearing and splitting. Images of the end walls and damaged casing sections are located in figure three.

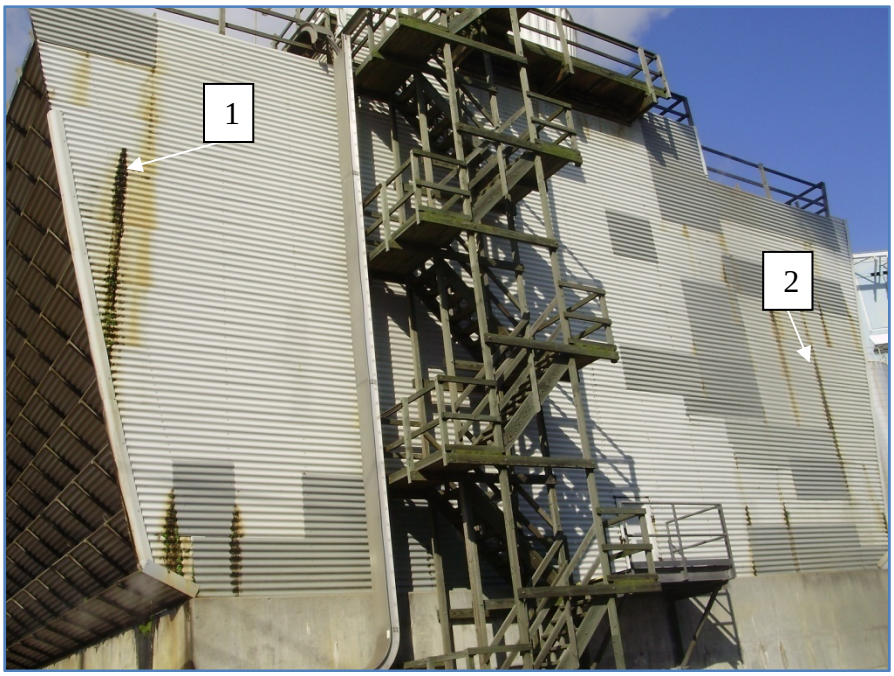

Figure 3: Exterior casing- Detail points one and two reference leaks on the end wall casing panels, many holes have been patched over the years but leaks have developed in many of the wetted section.

Air Intake Louvers

The intake louvers are comprised of a twelve ounce piece of FRP panel supported by a redwood support with a PVC tension arm. All of the intake louvers were inspected and found to be in good condition. Approximately six leaks were found within the louver assemblies and the interface with the end wall. It is recommended to fix the small amount of leaks at the next available opportunity.

Stairway

The stairway is a free standing design that is composed of structural Douglas fir components and 304 stainless steel fasteners. Inspection found no major damaged areas of the stairway and the treatment appeared to be sufficient at minimizing deterioration of the structural members. No immediate concerns were noted with respect to the material of the stairway system. A small set of switch back stairs was found in poor condition at the west side of the cooling tower cells one and two. It is recommended to replace this small section of rotted stairway at the next available opportunity.

Fan Deck

The Plywood fan deck is composed of 1-1/8" tongue and grooved four by eight treated material that is installed in the longitudinal direction of the cooling tower. The support structure for the decking is two by six joists orientated in the transverse direction of the tower. The structural condition of the fan deck joists was found to be average at inspection with a few rotted joists found at inspection. Numerous areas of the fan deck were found to be delaminating and deterioration was noticed on the surface. It is our recommendation to remove the existing plywood material and replace with either new plywood or pultruded fiberglass decking. Damaged 2"x6" fan deck joist should be replaced at this time. Images of the fan deck and support structure are located in figures four and five.

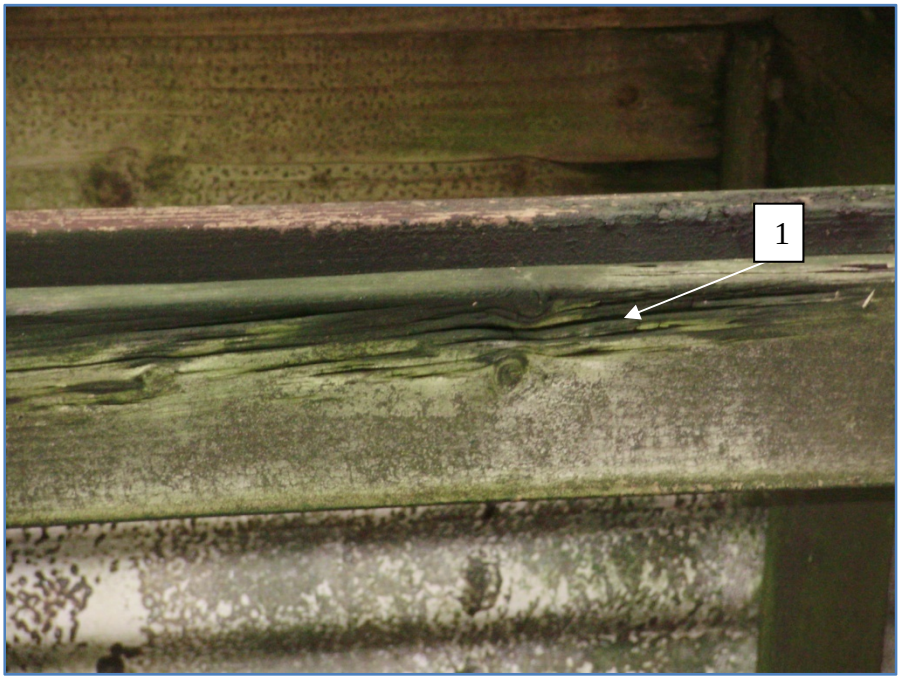

Figure 4: Top Deck- The underside of the cooling tower fan deck, inspection from the plenum area found a few joist members with fungal rot Detail point one references rot striations in a 2" x 6" joist member in cell number four.

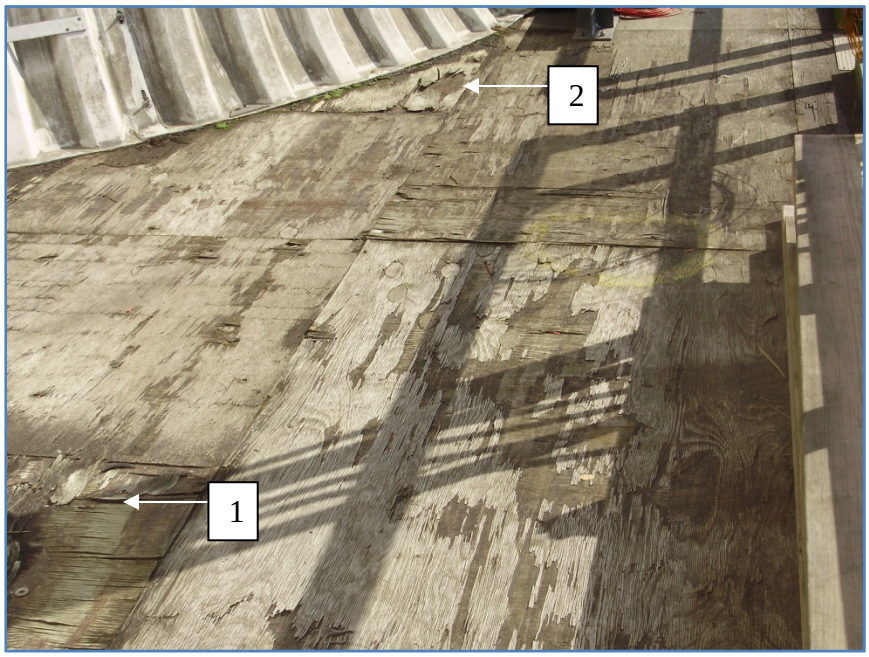

Figure 5: Top Deck- The top deck was found with a large amount of delaminating plywood material across the four cells.. Detail point one and two refer to a couple of areas that have started to peel back from the panels.

Handrail

The perimeter handrail consists of four by four pressure treated redwood posts capped with two by four hand and knee rails. The handrail and toe boards are attached to four by four column posts with stainless steel hardware. The entire handrail and toe rail was inspected and found to be in good condition. There were no immediate concerns identified with the handrail at inspection.

Fan Stack

The fan stacks are ten foot tall fiberglass velocity recovery stacks with a diameter of twenty four feet. The stack is constructed from fiberglass with stainless steel connecting hardware. The fan stack was inspected from both the exterior and interior of the unit. Loose hardware was identified on all four fan stacks which is a result of the movement in the fan assemblies. Recommendation is to tighten all loose hardware and replace any missing parts at the next available opportunity.

INTERIOR STRUCTURE AND COMPONENTS

Columns

The columns consist of four by four pressure treated redwood. The columns are spaced on four foot longitudinal and eight foot centers in the transverse direction. The interior columns were visually inspected throughout the tower structure and verified with a sound test. The posts were found to be in good condition with no signs of delignification or internal fungal rot. An image of the structural posts is located in figure six.

Figure 5: Cell #2 columns-The columns were inspected in upper and lower sections of the plenum and were found to be in good condition.

Bracing

The bracing consists of four by four pressure treated redwood members orientated in both the transverse and longitudinal directions of the cooling tower. The purpose of the diagonal braces is to provide structural rigidity from loads in the horizontal direction such as wind loads. The majority of the braces were found to be in good condition with the exception of six braces that were identified in cell number four.

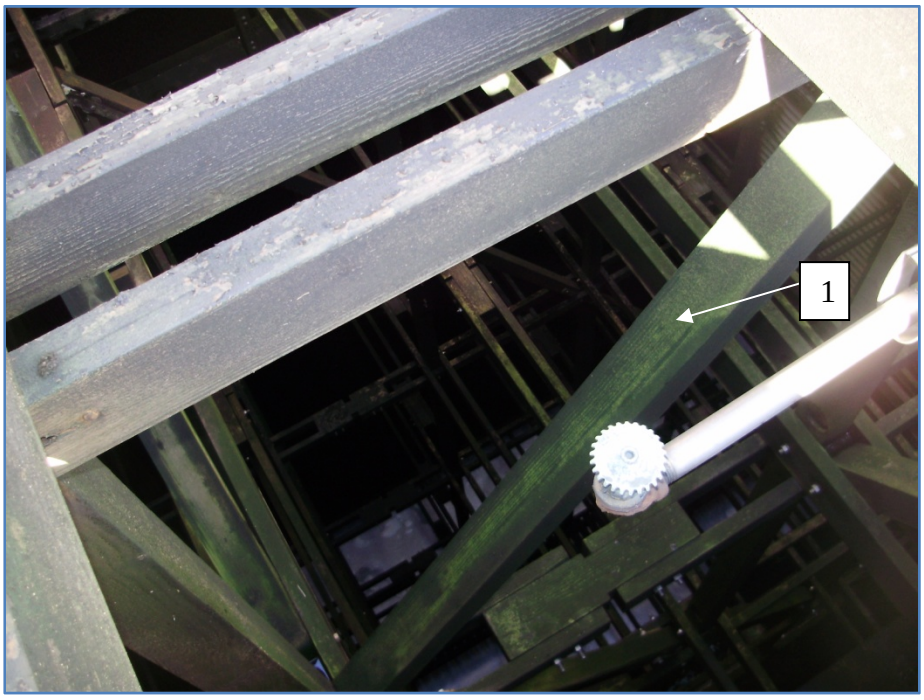

Figure 7: Internal diagonal brace: Detail point one refers to a brace that has started to show signs of surface rot

Structural Ties

The structural tie lines consist of two by four inch treated redwood lumber. The tie lines are orientated in both the transverse and longitudinal directions of the tower and placed at each vertical level on six foot centers. Approximately (10) double tie lines were found to be affected by internal fungus in cells three and four. Cells one and two showed no significant signs of damage within the tie line members and all of the associated hardware was secure. It is recommended to replace the damaged tie lines in cells three and four at the next available opportunity.

Figure 8: Structural Tie Line- Detail point one refers to a two by four tie line member that has deteriorated from biological rot.

Hardware

The hardware in the cooling tower is composed of 304 stainless steel bolts and nails. A good portion of the plenum hardware was checked for defects and corrosion, all of it was found in good condition. The base anchor castings were inspected and showed no signs of deterioration, overall the hardware was found to be satisfactory throughout the tower.

Partition Walls

The partition wall is composed of four foot by eight foot ¾" treated Douglas fir plywood. The partition wall is connected to the transverse columns with stainless steel serrated nails. The partition walls were visually inspected and mechanically checked for material strength. All of the partition wall material was found in good condition.

Hot water basins / Hot water decks

The distribution system consists of a plywood deck that is supported by two by six support joists connected to the structural redwood posts. The decking has nozzle orifices bored on one foot centers and utilizes Marley's standard spiral target cross flow nozzles. Each cell has two Marley flow control valves that feed into a distribution box, evenly distributing the water to maintain a head pressure on the nozzles. Defective valves were found on the south sides of cell numbers one and four. These damaged valves allow water to overflow the basin walls blocking air flow at the louver face and permit condensed water to enter the plenum area. Approximately (7) two by twelve basin curb walls were found to be extremely decayed on cells three and four. The distribution decking material and support joists were inspected from both the outer face of the tower and inside the plenum. All of the basin decking was found in favorable condition with no split or broken joists identified. Recommendation is to replace the damaged curb boards and broken valves at the next available opportunity. An image of the distribution deck is located in figure nine.

Figure 8: Distribution Deck – two broken flow control valves were found on the tower distribution system. Detail point one refers to the outer curb wall that is engulfed in water. This mass of water restricts airflow through the cooling tower and hinders efficiency.

Drift Eliminators

The purpose of the drift eliminators is to minimize the condensed water droplets that leave the exhaust stack of the unit. Drift eliminators are typically composed of a series of channels made from wood or plastic oriented in a pathway that allows air to escape but captures condensed droplets of water. High efficiency PVC drift eliminators are installed throughout the four cells of the cooling tower. The drift eliminators sit in the plenum section of the tower between the fill material and centerline of the tower. The drift eliminators were inspected and found to be in average condition with noticeable amounts of foulants present on the channel blades.

Fill Material

The cooling tower fill material is composed of fiberglass hanger material that supports offset Marley wood "Alpha Bar" splash media. All four cells are built with eighteen feet of air travel with the fill set on four inch by eight inch spacing. The fill was removed and inspected and found to be in good condition. The redwood fill supports were checked from the first set of drift eliminators and proved to be in good structural condition with no signs of bending or overloading. The fill material on all four cells was found to be in good condition with no immediate concerns recorded at inspection.

Figure 10: Splash fill material- The fill material was found to be in relatively good condition with no collapsed or significantly damaged sections found at inspection.

MECHANICAL EQUIPMENT AND COMPONENTS

Fan

The existing fans are Marley twenty four foot diameter, eight bladed fiberglass fans. The tip clearance was checked on all four fan assemblies and found to be satisfactory. The fans have been in operation for over fourteen years and have started to display a significant amount of wear. The fiberglass UV coating has deteriorated on all four fan assemblies and the fiberglass bonding fabric is exposed on numerous areas of all the fan blades. The pitch angles were measured on all of the fan blades and were found to be inconsistent but not detrimental to operation. The leading edge on all of the fans was found to be significantly deteriorated, this is the result of water entering the plenum section from either failed drift eliminators or overflow from the broken valves. The most compelling observation made was the noticeable sway in the tower structure at the frequency of the fan speed. This horizontal motion is attributed to the fan assemblies being out of balance due to wear and tear. Based on the current condition of the fan blade assemblies and the noticeable unbalanced operation it is our recommendation to replace all four fans with new Hudson aftermarket Tufflite III fan assemblies. Images of the fan assemblies are located in figure eleven.

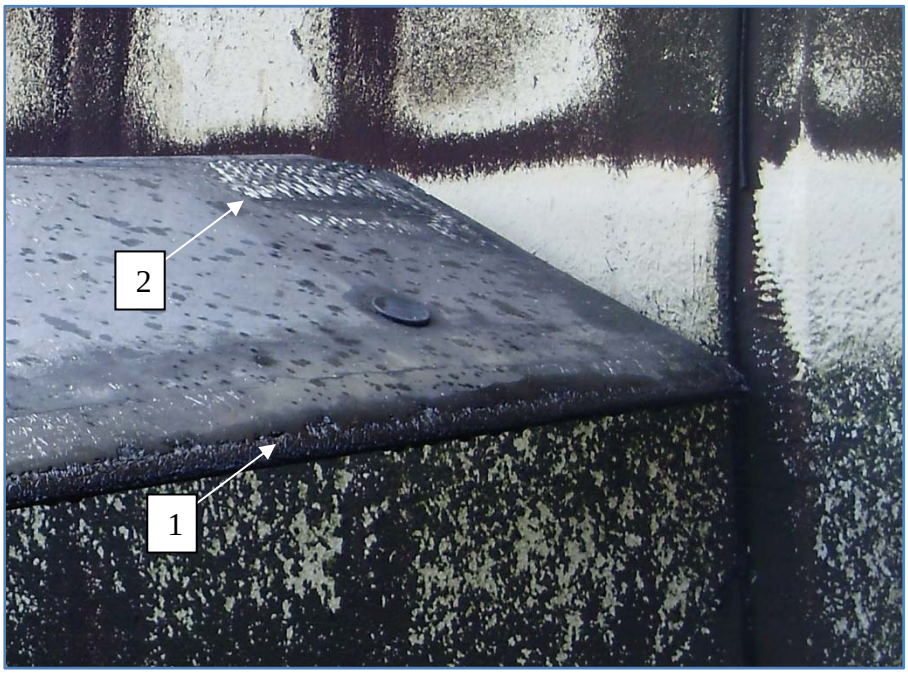

Figure 11: Fan Blade- The fan blades were found with a considerable amount of wear and pitting in the fiberglass. Detail point one refers to pitting on the leading edge of the fan blade that is caused by water droplets invading the plenum. Detail point two references a section of the fan blade wear the UV barrier has worn away and the fiberglass mesh is visible

Motors

The motors on the cooling towers are single speed one hundred and fifty horsepower motors. Each motor is totally enclosed, fan cooled (TEFC) and all look to be in good condition. The motors were in operation during inspection and the opportunity was available to inspect with the units down. All of the motors appeared to be in satisfactory condition, one inquiry at inspection was the status of the vibration switches and the operating condition. It is recommended to check the status on all four vibration cut out switches.

Drive Shaft

The flexible drive shafts are original Marley 301 series with a yoke and flange coupling design. All of the fan cells have stainless steel drive shafts; all four were checked for misalignment with only cell number one displaying values out of specification. This misalignment can be labeled as one of the sources for the vibration at motor speed on cell number one. All of the shaft guards were checked and found to be properly fastened. Recommendation is to realign the drive shaft in cell number one verifying the proper gap settings and alignment with a 360° sweep measurement.

Gear Reducer

The existing Marley 32.2 gears are spiral bevel double reduction gears providing a 11.18:1 ratio. The gears are in good condition and have been well maintained over the years. The input oil seal on the gearbox in cell number one was found to have a significant leak. It is our recommendation to have the seal replaced at the next available opportunity.

Summary

The main plant cooling tower is in good condition with respect to the age of the material and the relatively aggressive operating schedule it follows. The majority of the tower structure was found in sound condition and revealed no issues warranted of urgent attention. Consideration should be placed on making the repairs to the end walls and structural members to keep the unit in favorable condition. The four fan assemblies are a going concern based on the significant wear that has been noticed. All four fan assemblies should be replaced with new assemblies that are designed for this application (Hudson, Marley or Howden). The broken valves should be replaced as soon as possible in an effort to eliminate inefficiencies and prevent deterioration of the fan blades after replacement.

Recommendations/ Scope of Work

All lumber to be #1 Structural Redwood

1.) Remove and Replace approximately (15) damaged double tie lines in cells three and four

2.) Remove existing fan deck and replace approximately (11) damaged fan deck joists on all four cells. Replace fan deck with either 1-1/8" tongue and groove plywood or SAFEDECK fiberglass decking.

3.) Remove and replace (7) 2" x 12" curb boards on cells three and four.

4.) Remove and replace (12) damaged diagonal braces in cells three and four

5.) Replace all four fan assemblies with new adjustable pitch fan assemblies. All fans should be properly sized with consideration placed on input motor horsepower and current gearbox ratio. Fan pitch should be set to draw maximum amperage from drive motors.

6.) Realign the drive shaft in cell number one to a tolerance of ±.003" at 360°.

7.) Tighten the hardware on all four fan stacks applying thread lock to minimize future back out.

8.) Remove all four end walls and inspect perimeter columns thoroughly, replace end wall with new twelve ounce 4.2 corrugated FRP casing.

Works Cited

1.) James L. Willa. "IRON ROT – THE “NEW” NEMESIS”, Cooling Tower Institute February 1995: 7.

2.) Herro, Harvey M.,Port, Robert D. The Nalco Guide to Cooling Water System Failure Analyses. New York, New York: McGraw-Hill, Inc., 1993