REMR Technical Note OM-MS-1.8

REMR Management System for Emptying and Filling Valves

Purpose

To develop a uniform procedure to describe the current condition of emptying and filling valve structures and to develop guidelines for the maintenance and repair of these structures.

Background

A series of REMR Management Systems is being developed to assist the U.S. Army Corps of Engineers in planning and budgeting for maintenance and rehabilitation of their facilities. Methods for life-cycle cost comparisons of maintenance and rehabilitation alternatives and a more effective means for monitoring the condition of facilities are important aspects of these computerized maintenance management systems. (See REMR Technical Note OM-MS-1.1).

Overview

A REMR Management System is currently under development for emptying and filling valves. As with previous REMR Management Systems, it will contain standardized inspection and condition rating procedures, life-cycle/cost-analysis routines, and data storage and handling capabilities. This technical note summarizes two separate management systems, one for tainter valves and another for butterfly valves.

Condition Index Rating

A Condition Index (CI) is a numerical measure of the current state of a structure. The CI ranges from a low of 0 to a high of 100. The numbers are designed to capture a "snapshot" of a structure's condition and are indicative to some extent of a structure's need for repairs or further engineering analyses. The CI calculation is based primarily on objective field measurements, with some dependence on subjective observations of problems. See Tables 1 and 2.

Under previously developed rating systems, the field inspection was based on data that were obtainable from the top of the lock structure or from a boat to keep the lock in an operating mode, while still obtaining quantitative and applicable information. Because a valve structure is completely or partially

Table 1
Distresses in Tainter Valves

Distress	Description
Anchorage assembly deterioration	Movement of embedded anchorage system and damaged components
Trunnion assembly wear	Displacement between pin and bushing
Seal condition	Condition of seals in place
Corrosion	Loss of steel due to interaction with the environment
Cavitation/erosion/abrasion	Jagged pitting
Lifting bracket bushing wear	Displacement between pin and bushing on the lifting bracket
Cracking (dry inspection only)	Breaks in structural steel components
Noise/jump/vibration (wet inspection only)	Abnormal noise, jumping, or vibration during valve operation

Table 2
Distresses in Butterfly Valves

Distress	Description
Axle assembly wear	Displacement between the axle and bushing
Seal condition	Condition of seals in place
Corrosion	Loss of steel due to interaction with the environment
Lifting bracket operating mechanism wear	Displacement between the pin and bushing on the lifting bracket
Cracking (dry inspection only)	Breaks in structural steel components
Noise/jump/vibration (wet inspection only)	Abnormal noise, jumping, or vibration during valve operation

submerged during operation, a decision was made to incorporate both a dewatered (dry) and a submerged (wet or diver) inspection into the valve inspection procedure.

In addition to being difficult to access, there are many different types of valve structures. Two primary types are tainter and butterfly valves which are structurally very different from each other. Within each type there are also several variations. For example, butterfly valves can be round or rectangular with either vertical or horizontal axes. Tainter and reverse tainter valves dam the water on opposite sides of their skin plates, requiring different anchorage designs. To accommodate these structural variations, separate inspection forms and rating rules were developed for tainter and butterfly valves.

The CI includes both a safety and serviceability consideration. A series of critical measurements of the distresses in Table 1 for tainter valves and in Table 2 for butterfly valves are made on each valve to quantify the CI. The measurements are related to the CI by a number of rules established by Corps experts. As an example, a movement, X , of 0.001 in. could be measured for the anchorage assembly deterioration distress for tainter valves. If the experts determined the limiting value of this movement, X_{max}, to be 0.005 in. (X/X_{max} = 0.2), Figure 1 would give a CI near 83.

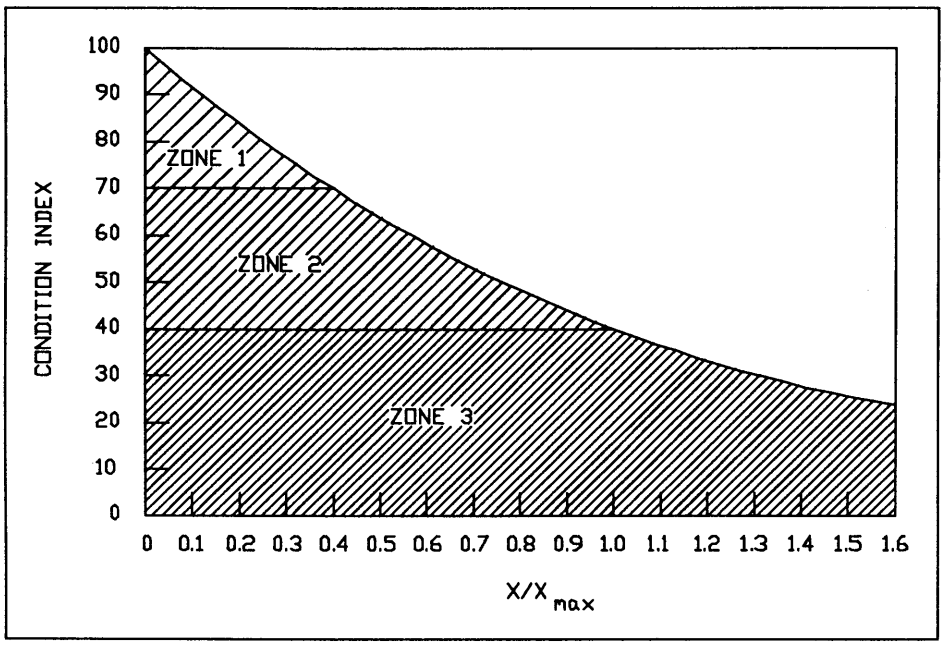

Figure 1. CI related to X/X_{max}

Some of the distresses listed in these tables are specific to the type of inspection procedure. A wet inspection is not as thorough as a dry inspection. Wet inspections may make use of measurement projection when the diver cannot gather the needed information. (A measurement projection is an estimated wear value based on historical data.) The CI based upon measurement projection carry less weight than those based upon actual measurement. The CI for the individual distresses are combined by a weighted average to give the overall condition of the gate.

Structural Considerations

Many factors were taken into account by the experts as they formulated the CI rules. A primary consideration is structural safety. Observations of potential structural problems are difficult to quantify and are usually not accounted for in a simple structural analysis. As an example, excessive material loss on the strut arms may indicate a potential safety problem. Only a

more detailed inspection may indicate the severity of the problem. In addition to functional and operational factors, the experts took such structural factors into account when setting limiting values and weight factors. The experts identified a subset of distresses as having a more significant impact on safety than others. The subsets of structural distresses for each valve type are listed in Tables 3 and 4.

Table 3
Structural Distresses for Tainter Valves

Structural Distress	Brief Description
Anchorage assembly deterioration	Embedded steel movement and concrete and steel deterioration
Corrosion - Strut arm and bracing material loss	Loss of strut arm and bracing steel
Corrosion - Segmental girder material loss	Loss of segmental girder steel
Cracking - Strut arms and bracing (dry inspection)	Breaks in strut arms and bracing
Cracking - Segmental girder (dry inspection)	Breaks in segmental girder
Jumping (wet inspection)	Abnormal gate jumping

Table 4
Structural Distresses for Butterfly Valves

Structural distress	Brief Description
Corrosion - End plate material loss	Loss of end plate steel
Cracking - End plates (dry inspection)	Breaks in the end plates
Jumping (wet inspection)	Abnormal gate jumping

Maintenance and Repair Analysis

After the distresses have been identified, several different maintenance and repair solutions will be formed. The consequences of each solution will be obtained by calculating a new CI that reflects the as-repaired structure. Life-cycle cost information about the solution will provide a preliminary evaluation of a maintenance plan.

Reference

Greimann, L., Stecker, J., and Veenstra, J. (1993). "Condition rating procedures for tainter and butterfly valves," Technical Report REMR-OM-14, U.S. Army Construction Engineering Research Laboratory, Champaign, IL.