

COOLING TECHNOLOGY INSTITUTE

Internal Plant Cooling Water Reuse



July 2008

WTG-155(08)

FOREWORD

This Cooling Technology Institute (CTI) publication is published as an aid to cooling tower purchasers and designers. It may be used by anyone desiring to do so, and efforts have been made by CTI to assure the accuracy and reliability of the data contained herein. However, CTI makes no warranty of fitness for particular purpose or merchantability nor any other warranty expressed, implied or statutory. In no event shall CTI be liable or responsible for Incidental, Consequential or Commercial losses or damage of any kind resulting from this publication's use; or violation of any federal, state, or municipal regulation with which this publication may conflict or for the infringement of any patent resulting from the use of this publication.

All CTI codes and standards are copyrighted with all rights reserved to CTI. The reproduction of any part of this or any other CTI code or standard is a violation of Federal Law. One must recognize and appreciate commitment by a number of volunteer members who donate their time to develop and update CTI codes and standards. The monies spent for code development, administrative staff support and publication are essential and constitute a substantial drain on CTI. The purchase price of these documents helps to offset these costs. Reproduction and distribution by others, in addition to being unethical, undermines this system and constitutes a further financial drain on CTI. When copies are needed, you are requested to call or write the Cooling Technology Institute, P.O. Box 73383, Houston, Texas 77273, (281) 583-4087. Please request that your associates buy the required codes and standards rather than copy them. Your cooperation in this matter is greatly appreciated.

Nothing contained herein is to be construed as granting any right for the manufacture, sale or use in connection with any method, apparatus, or product covered by letters patent, nor as insuring anyone against liability for infringement of letters patent.

This guideline document summarizes the best current state of knowledge regarding the specific subject. This document represents a consensus of those individual members who have reviewed this document, its scope and provisions. It is intended to aid all users or potential users of cooling towers.

Approved by the CTI Executive Board.



This document has been reviewed and approved as part of CTI's Five Year Review Cycle. This document is again subject to review in 2013.

Approved by the
CTI Executive Board

Copyright 2008
by Cooling Technology Institute
Printed in U.S.A.

WTG-155(08)

Table of Content

Section/Title	Page
1. Introduction	5
Mission Statement	5
What is Internal Plant Cooling Water Reuse?	5
Why Reuse?	5
2. The Steps to an Internal Plant Water Reuse Project	5
3. Internal Plant Cooling Water Reuse Audit Process	7
4. Physical Processes, Chemical Processes, and Water Component Measurement	8
Physical and Chemical Processes	9
Membrane Filtration	11
Other Processes and Procedures	12
Analytical Instrumentation for Monitoring Reuse Water Quality	13
Turbidity and Suspended Solids	14
5. Impact of Reuse Waters on Cooling System Materials of Construction, Water Chemistry and Chemical Control	15
Cooling System	15
Materials Under Consideration	15
Cooling System Heat Exchangers	15
Considerations for Cooling Tower Fill	15
Cooling System Chemistry and Control	15
6. Summary	16
Appendices	
A Water Chemistry Evaluation with Software Tools	16
B References From Cooling Technology Institute Publications	19
Figures and Tables	
Fig. 1 Internal Plant Cooling Water Reuse Design Process Flow	6
Table 1	17
Table 2 Example Ion Pairs Used to Estimate Free Ion Concentrations	18

Internal Plant Cooling Water Reuse

SECTION 1. INTRODUCTION

Mission Statement

The purpose of this document is to provide general guidelines to plant owners and operators for water conservation through internal plant cooling water reuse.

What is Internal Plant Cooling Water Reuse?

Internal plant water reuse is the use of any previously used water stream existing within the plant facilities, with or without water treatment, in water consuming units, such as evaporative cooling systems, boilers, and/or process operations. When such a water source is used as makeup water for the cooling system, it is Cooling Water Reuse. The main objective of water reuse is to reduce fresh water intake and wastewater discharge.

Why Reuse?

Industry has historically given water reuse projects low priority for a number of reasons. Most important of these is that new plants have typically been sited near abundant and inexpensive sources of fresh water. Also, the logistics of retrofitting plant piping to take advantage of reuse opportunities are often complex and expensive.

In the past few years several changes have taken place that make water reuse more attractive:

- Increased regulatory activity around treatment of wastewater before discharge
- Curtailed good quality water supply to industry to meet higher priority drinking water needs
- Unusual weather patterns which have reduced water supplies drastically in some areas for several years
- Rapid escalation of costs for developing new water supplies and expanding existing supplies
- Deterioration or contamination of existing water supplies in heavily industrialized areas

Industry can no longer assume that good quality water will always be available in unlimited quantities. It is likely that industry will invest more capital and spend more operating dollars for water in the future. As this happens the economic justification for water reuse will increase.

SECTION 2. THE STEPS TO AN INTERNAL PLANT WATER REUSE PROJECT

A flowsheet depicting a typical water reuse project process is shown in Figure 1:

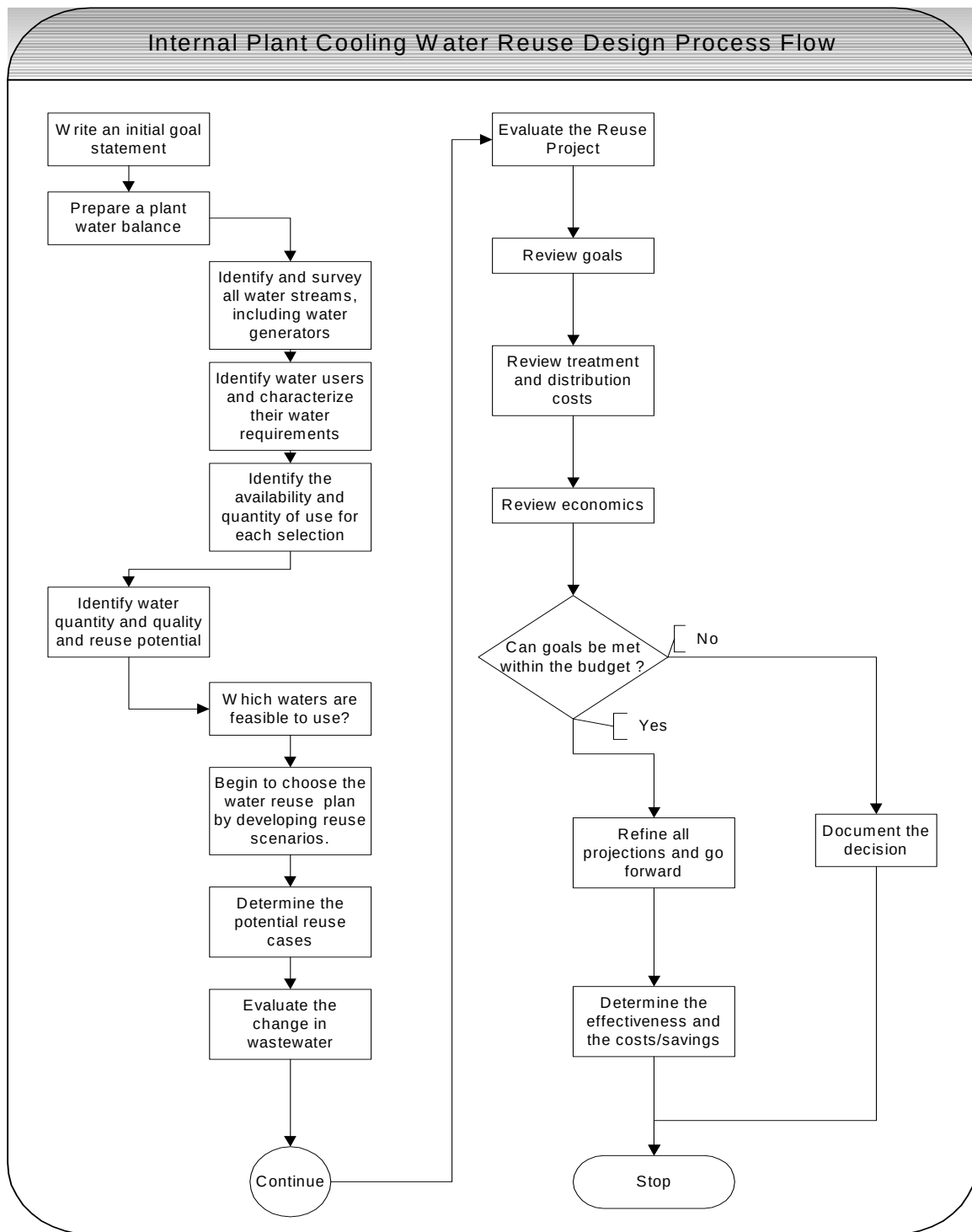


Figure 1

Like any process modification made within an operating plant, every water reuse plan must be technologically feasible and economically justified. A combined engineering and economic evaluation of each proposal should proceed as follows:

- Develop the concept showing how the reuse can be achieved
- Estimate the investment required and the costs involved with the proposed plan
- Compare the proposal against alternative course of action (or inaction)
- Choose the best alternative based on a common measure of profitability, such as net return on investment or net present value

When in doubt on how to proceed with a project, refer to your corporate project implementation guidelines

General Reuse Project Guidelines

Before proposals can be made to save water, one must know in as much detail as possible, where and how water is currently being used on the site. If the site has critical water issues that may impact future continuity of operation, it is essential to conduct a site water balance. This entails determining all site water uses down to the 5-10 gpm range. Most water reuse projects will not require this level of detail, but the more data that is available the more likely that the reuse project will be successful.

Along with the quantity of the water being used on the site, one must also know the quality (degree of contamination) of all the water streams. Streams that are highly contaminated can be eliminated from further consideration. Some of the common sources of water for reuse in a typical industrial plant are:

- Once-through cooling water (water that is pumped from its source through one set of heat exchangers before being discharged).
- Wastewater from water treatment equipment (filter backwash, softener rinse, reverse osmosis unit reject, etc.)
- Biological wastewater treatment plant effluent
- Process condensates
- Captured stormwater

A few examples of reuse opportunities are:

- Replacing once through water use with a closed loop chilled water system or an open recirculating cooling tower system

- Using reject from a reverse osmosis unit (where the makeup has been pre-softened) to supplement boiler feedwater
- Using biotreater effluent as makeup to a cooling tower system

There are, of course, many more options to consider. Through careful analysis of the water balance, combined with a feel for process needs and limitations, a logical network of interconnecting water use and reuse systems can be developed. No matter what kind or how much water reuse is proposed, it is almost certain that additional treatment of the water will be required at some point in the system. This could take place at the wastewater discharge from a specific user, in the recycle water loop, or, at final waste treatment. Making sure the proper treatment options are selected (see Section 4) is the most important step in providing a working water reuse system. Some of the more important items to consider when reviewing treatment options are:

- Can concentrated wastes be isolated and treated at the source?
- Will the effluent be compatible to existing final waste treatment processes and be able to meet existing discharge permit limits?
- Can dependable, accepted waste treatment unit operations be used, or, will more sophisticated or less proven technology be called for?
- Will additional chemical treatment be necessary to reduce corrosion, scaling, or fouling tendencies in the recycle system?
- How will the solid wastes generated in the recycle/waste treatment process be handled? Disposed of? Recovered?

A water/wastewater treatment consultant (along with your current water treatment chemical supplier) can assist in selecting the best treatment programs and in developing proposed process flowsheets.

At this point of the study, enough data should be in hand to proceed with the evaluation of the proposed water reuse alternatives according to your corporate project guidelines.

3. INTERNAL PLANT COOLING WATER REUSE AUDIT PROCESS

It is important to maintain a water reuse program through careful monitoring and control. Although operating areas must continue to be responsible for their own water consumption and wastewater discharge, a specific person or plant

group should be given site monitoring and control authority. Deviations in normal water use patterns should be investigated as soon as they appear. New water use requirements should be analyzed thoroughly using the same criteria set forth in the original conservation program.

SECTION 4. PHYSICAL PROCESSES, CHEMICAL PROCESSES, AND WATER COMPONENT MEASUREMENT

When used water requires treatment before reuse, physical and chemical treatment processes can prepare the water for reuse. The following table lists the processes used and the types of contaminants each process treats. After the table each process is discussed and explained. Discussions of types of analytical instrumentation for monitoring the reused water quality follow the discussions of the processes.

Physical Or Chemical Process	Water Component or Contaminant Removed					
	Debris	Suspended Solids	Dissolved Solids	Macro-molecules	Oxidiz-able Material	Organics
Mechanical screening	X					
Filtration: sand, multimedia and other		X				
Centrifugal separation		X				
Clarification: conventional, Lamella, and tube settler		X				
Lime softening		X	Calcium, Magnesium, Phosphate, some silica, others			Some
Granulated activated carbon		X Secondary		Some		X Others
Manganese Greensand		X Secondary	Iron and Manganese and H ₂ S			
Birm		X Secondary	Iron and Manganese			
Ion exchange		X Secondary	X			
Microfiltration		X Secondary		X		Some
Ultrafiltration				X		Some
Nanofiltration			Some	X		Some
Reverse osmosis			X	X		Some
Oxidation					X	Some
Biological treatments: activated sludge, trickling filters, others		X Secondary		Some	Some	X
Degasification/Air Stripping			HCO ₃ ⁻ with pH adjustment			Some
API, Oil/water or physical separation						X