

 DESIGN PRACTICES	WATER POLLUTION CONTROL WATER REUSE PROPRIETARY INFORMATION - For Authorized Company Use Only	Section	Page
		XIX-B	1 of 34
		December, 2002	

Changes shown by ↗

CONTENTS

Section	Page
Scope	3
References	3
Definitions	3
BACKGROUND	4
GUIDELINES FOR WATER REUSE PROGRAM DEVELOPMENT	4
SUMMARY	4
WATER REUSE JUSTIFICATION	4
Reduce Raw Water Costs or Overcome Water Supply Limitation	4
Reduce Wastewater Treatment Cost and Lower Tax for Treated Effluent Discharge	4
Reduce or Eliminate Wastewater Treatment Facilities Expansion	4
Better Meet Environmental Regulations	5
WATER REUSE STUDY	5
Conduct Water Balance	5
Identify Potential Reuse Opportunities	5
Prioritize Reuse Options	6
Further Evaluate the Most Attractive Options	6
Confirm Incentives for the Most Attractive Options	7
Conduct Lab, Pilot, or Field Test	8
Hazard Identification & Risk Assessment	8
Implementation	8
WATER REUSE BY PROCESS AREA	9
WATER TREATMENT/STEAM GENERATION	9
Reduction	9
Reuse	9
COOLING TOWER	10
Reduction	10
Reuse	10
DESALTING	11
STRIPPED SOUR WATER (SSW)	12
Reuse	12
POWERFORMER	12
MTBE UNIT	12
WET GAS SCRUBBER	13
WASTEWATER	13
Treatment for Water Reuse	13

Section XIX-B	Page 2 of 34	<i>WATER POLLUTION CONTROL</i> WATER REUSE PROPRIETARY INFORMATION - For Authorized Company Use Only	 DESIGN PRACTICES
December, 2002			

TYPICAL WATER QUALITY PARAMETERS CHANGED BY TREATMENT	13
TREATMENT AND REUSE ISSUES	14
TREATMENT FOR DISSOLVED SOLIDS REMOVAL	15
Municipal Wastewater Effluent Treatment and Reuse	15
Cooling Tower Blowdown Treatment and Reuse	15
Refinery Wastewater Effluent Treatment and Reuse	16
CATIONS AS IONS, PPM.....	25
ANIONS AS IONS, PPM.....	25

FIGURES

Figure 1 Water Reuse Application Decision Tree	17
--	----

TABLES

Table 1 Water Consumers and Wastewater Producers in Refineries.....	18
Table 2 Water Chemistry Analysis Parameters	19
Table 3 Water Reuse Already Practiced at ExxonMobil.....	22
Table 4 Water Reuse Matrix.....	23

APPENDICES

A REUSE IN DEMIN PLANT.....	24
B QUALITIES OF RECLAIMED MUNICIPAL WASTEWATER USED AT XOM FACILITIES	25
C COOLING TOWER BASIN WATER QUALITY LIMITS	26
D HYDROGEN SULFIDE DISTRIBUTION IN DESALTER VERSUS PH.....	27
E MTBE WASTEWATER COMPOSITION	28
F STRIPPED SOUR WATER ANALYSES	29
G DISSOLVED SOLIDS REMOVAL PROCESS	30
H AUGUSTA SCREENING STUDY: CTBD TREATMENT AND REUSE TO DEMIN.....	31
I AUGUSTA SCREENING STUDY: CTBD TREATMENT AND REUSE TO DEMIN.....	32

Revision Memo

12/02 Moved Tables 3 – 7 and all Figures to Appendices



 DESIGN PRACTICES	WATER POLLUTION CONTROL WATER REUSE PROPRIETARY INFORMATION - For Authorized Company Use Only	Section	Page
		XIX-B	3 of 34
		December, 2002	

SCOPE

The objective of this section is to provide guidelines to: 1) justify water reuse programs, 2) conduct a water reuse study and 3) implement water reuse options. This document provides the framework for a water reuse study and introduces the issues involved in each stage of the process. The first section includes guidelines for developing a water reuse program. The subsequent sections address water reuse opportunities by process unit. Water reduction opportunities are discussed as well as wastewater streams that have been successfully reused or technically evaluated for reuse. Critical parameters for that reuse are discussed. As new opportunities for water reuse are evaluated, they will be added to subsequent updates of the DP.

In general, calculation procedures are not provided. Blending of water streams to determine pH and scaling potential are time consuming calculations and are generally performed by computer. A third party water chemistry computer program has been licensed to ExxonMobil and is available for use in evaluation of water reuse options. ExxonMobil Research and Engineering (EMRE) should be contacted for information on obtaining and running the program. Alternatively, EMRE can be used as a resource to run the program. Since water reuse generally involves an operating change, experts in the affected process areas, water treating areas, materials, and safety should be consulted during evaluation of a reuse option. The final section gives a brief introduction to treatment for reuse.

REFERENCES

1. EE.102E.78, "Cooling Tower Water Treatment Guidelines - Second Edition," E. I. Wolfe, 1978.
2. Meller, Floyd H., "Electrodialysis (ED) & Electrodialysis Reversal (EDR) Technology," Ionics Incorporated, March 1984.
3. EE.2E.86, "New Guide to Boiler Water Treatment," E. I. Wolfe, R. J. Franco, K. R. Walston, January 1986.
4. Raycheba, John M. T., "Membranes Technology Reference Guide," Ontario Hydro, 1990.
5. EE.50E.94, "Guidelines for Sour Water Reuse for Desalting," C. P. Feerick, C. M. Schinner, E. D. Carlson, 1994.
6. 95 GCD 88, "Water Reuse Workshop Follow-up: Guidelines for Water Reuse Program Development," E. Kang, June 29, 1995.

DEFINITIONS

Anion - A negatively charged ion resulting from the dissociation of salts, minerals or acids in water.

Blowdown - The amount of water purged from a recycling system in order to maintain contaminant levels within a specified range.

Cation - A positively charged ion resulting from the dissociation of salts, minerals or acids in water.

Conductivity - The ability of a solution to conduct electrical current, commonly expressed in microsiemens/cm or micro mhos/cm.

Electrodialysis (ED) - A process in which ions are transferred through membranes from a less concentrated to a more concentrated solution as a result of the passage of direct electric current.

Electrodialysis Reversal (EDR) - An electrodialysis process in which the polarity of the electrodes is reversed on a prescribed time cycle thus reversing the direction of ion movement in a membrane stack.

Hardness - A quality of water defined by the amount of calcium and magnesium present.

Recycle - The reuse of wastewater in the process from which it originated.

Reduction - The modification of a process that lowers the amount of wastewater produced.

Reuse - Routing or cascading wastewater from one process unit to another.

Reverse Osmosis (RO) - The process by which pressure is applied to the more concentrated solution so that the solvent flows through the semi-permeable membrane into the less concentrated solution.

♦ **Silt Density Index (SDI)** - A measure of how likely or rapidly a colloid-containing solution will foul or plug a filter or membrane.

Total Dissolved Solids (TDS) - The material residue from the filtrate that is left in the vessel after evaporation and subsequent drying in an oven at 356°F (180°C).

Total Suspended Solids (TSS) - The material residue left after evaporation and subsequent drying (at 217-221°F [103-105°C]) of the portion of the sample retained on the filter.

Section XIX-B	Page 4 of 34	<i>WATER POLLUTION CONTROL</i> WATER REUSE PROPRIETARY INFORMATION - For Authorized Company Use Only	 DESIGN PRACTICES
December, 2002			

PROPRIETARY INFORMATION - For Authorized Company Use Only

BACKGROUND

Water reuse is not a novel concept. It has been around for more than 25 years. Water reuse can result in a significant reduction in the volume of water (raw and discharged wastewater) used/generated at a refinery or chemical plant. Interest in water reuse is increasing for two main reasons: the availability and rising cost of raw water and its treatment and the rising cost of wastewater treatment. Increasingly stringent effluent water quality requirements and other new regulations are resulting in the need for additional investment in control/treatment of wastewater. To minimize this investment, a long term water management plan including reduction, recycle, and reuse should be implemented.

GUIDELINES FOR WATER REUSE PROGRAM DEVELOPMENT

SUMMARY

The Water Reuse Management Process can be broken down into 8 major steps:

- Conduct a Water Balance
- Identify Potential Reuse Opportunities
- Prioritize Potential Reuse Options
- Further Evaluate the Most Attractive Options
- Confirm Incentives for the Most Attractive Options
- Conduct Lab, Pilot, or Field Test, if necessary
- Hazard Identification & Risk Assessment of Water Management Project
- Implementation

These steps are illustrated in a decision tree ([Figure 1](#)) and are described in the subsequent sections.

WATER REUSE JUSTIFICATION

In general, cost reduction policies will promote conservation/recycle projects and wastewater minimization. Limited freshwater supply, more stringent environmental regulations and increasing costs will drive conservation and reuse. The following describes four potential justifications for water reuse projects.

Reduce Raw Water Costs or Overcome Water Supply Limitation

Public demand for water continues to grow, while supplies dwindle. In some areas, aquifers are being depleted and communities are switching to surface water supplies. Municipalities that control water resources may seek to reduce water usage by increasing the cost of water, or limiting the supply. Refineries and chemical plants that purchase raw water, such as locations that use surface water supplies, may be affected by these measures. Generally, most of the raw water requires treatment which can be as simple as clarification or as complex as ion exchange. Water reuse provides a means to reduce the cost of both raw water procurement and treatment by reducing the amount used.

Reduce Wastewater Treatment Cost and Lower Tax for Treated Effluent Discharge

In addition to wastewater treatment costs, certain locations are taxed based on treated effluent rate. Reducing, recycling, or reusing water upstream of the wastewater treatment plant (WWTP) results in savings of wastewater treatment and discharge costs in addition to the savings realized for raw water consumption.

Reduce or Eliminate Wastewater Treatment Facilities Expansion

Environmental regulations are likely to result in modification or expansion of WWTP's in the near or long term. A decrease in the hydraulic, organic, and/or total dissolved solids (TDS) loadings to the WWTP may decrease, delay, or eliminate this investment. Furthermore, process water treating facilities such as sour water strippers and wastewater benzene strippers (used in the U.S. to satisfy regulatory requirements) may be operating at or close to their design capacities. It may be necessary to accommodate additional process water from future projects. Debottlenecking these units may be feasible via water reuse.

	WATER POLLUTION CONTROL		Section	Page
	WATER REUSE		XIX-B	5 of 34
	DESIGN PRACTICES		December, 2002	

PROPRIETARY INFORMATION - For Authorized Company Use Only

Better Meet Environmental Regulations

Reduction in the hydraulic load to the WWTP may result in improved operation of the plant as well as reduction in mass loading of contaminants. However, the potential disadvantages of water reuse are increased TDS levels, such as metals, and possibly increased concentration of organics in the raw wastewater due to lower wastewater flow rates. This in turn may increase the toxicity in the wastewater discharged. The increased TDS level can be partially alleviated by segregating high dissolved solids streams such as demin or ballast water, or by removal of dissolved solids from selected streams upstream of the WWTP. Improved WWTP operation due to lower flow rates may result in no increase in organics in treated wastewater.

WATER REUSE STUDY

Conduct Water Balance

The first step in a water reuse study is to generate a water balance around the entire refinery/chemical plant. An overall water balance must identify water sources to the refinery or chemical plant, wastewater produced, and process water evaporation rates. The water balance is then developed further to identify water consumers and individual wastewater producers. Users and producers will be matched in the next step, identifying potential reuse options.

1. Water Sources

There are four primary sources of water:

- Raw Water
- Water in Crude
- Ballast Water
- Stormwater

Raw water, such as municipal water, onsite well water, or surface water are common sources of water which are metered. Water in the crude can be estimated based on changes in crude tank levels during crude water draw-off, or may already be measured for auditing purposes. Ballast water can be estimated from changes in ballast tank levels. Stormwater flow rates are seasonal and vary significantly from location to location. They can be estimated from yearly rainfall amounts and site area and runoff coefficients. In addition, a minor source of water at chemical plants is that produced by chemical reactions.

2. Wastewater and Evaporation

Wastewater can be divided into major categories as follows:

- Utility Wastewater (boiler blowdown, cooling tower blowdown, water treating wastewater)
- Process Wastewater (stripper waters, desalters, process wash waters, etc.)
- Stormwater (stormwater may already be included in wastewater rates)

To complete the balance, one must estimate the evaporation rate, which is primarily from the cooling tower and wet gas scrubber. Steam losses and evaporation from wastewater treatment plant basins or lagoons can also be significant. Total wastewater flow rates are generally available as they are required for environmental compliance reporting.

3. Identify Water Consumers and Wastewater Producers

Once an overall balance is achieved, individual water consumers and wastewater producers should be identified. A list of potential consumers and producers for a refinery is provided in [Table 1](#). While it is nearly impossible to identify every consumer and producer, major ones should be identified along with an estimate of their flow rates. Note that some wastewaters are cascaded from one unit to another unit. Therefore, be cautious not to repeat the same stream more than once. When conducting the facility water balance, portable ultrasonic flowmeters can be used to quantify flow through pipes that do not have permanent, dedicated flowmeters.

Identify Potential Reuse Opportunities

1. Types of Reuse

There are several categories of water reuse, listed below in approximate order of increasing cost of implementation.

- Reduction
- Recycle within the unit
- Reuse
 - Direct or cascade reuse
 - Segregation and reuse
 - Treatment and reuse (including treated WWTP effluent)

Section XIX-B	Page 6 of 34	WATER POLLUTION CONTROL WATER REUSE	ExxonMobil DESIGN PRACTICES
December, 2002		PROPRIETARY INFORMATION - For Authorized Company Use Only	

Reduction of the amount of water used in a process generally results in an increase in the contaminant level and the temperature of the effluent wastewater. If this is acceptable from a process, safety, and materials standpoint, it can be used to lower raw water usage. A typical large reduction in raw water usage is obtained by increasing the cooling tower cycles.

Recycle is the reuse of wastewater in the process from which it originated. Examples of this are return of sample coolers to the cooling tower or a pump-around on a water scrubber tower. A purge stream off of the recycle loop is needed to control the level of contaminants. Other measures, such as heat removal, chemical treatment, or contaminant removal may also be required.

Reuse is the routing or cascading of wastewater from one unit to another. For example, stripped sour water can be reused in the desalter. The advantage of reuse over recycle is that contaminant build-up is less likely. Each process has minimum water quality requirements. If the quality of the wastewater from a process meets the minimum water quality requirements of another process, it can be reused directly. If not, segregation of certain wastewaters from a combined stream or treatment of the wastewater before reuse may be necessary.

2. Concentrate on Major Wastewater Producers and Water Consumers

As with the water balance, when identifying potential water reuse opportunities, concentrate on major water users and wastewater producers. The effort needed to evaluate high or low flow streams is usually the same but the incentives for higher flow streams will generally be higher. Also, consider reduction and recycle before reuse as these are generally less expensive to implement.

3. Consider General Water Quality Parameters When Available

To the extent they are known, consider general water quality parameters when identifying potential reuse options. Parameters such as pH, pressure, temperature, oxygenated or reduced state, oil content, suspended solids content, and dissolved solids content may be known and can be used as a first pass in matching water sources to users. A list of water chemistry analysis parameters along with methods of analysis can be found in [Table 2](#). If these qualities are not known, potential matches based on water flow rate should be identified for later investigation of water quality. Parameters, such as pressure or pH may be altered at relatively low cost. Wastewater can also be blended with the current water source to affect contaminant levels or meet flow rate requirements.

4. Practiced Water Reduction Options

A list of reuse options already being practiced at ExxonMobil is included in [Table 3](#). These should be considered in an evaluation of potential reuse options. Site specific review of these options is still needed as wastewater composition can vary significantly from one location to another. For example, stripped sour water has been identified as a potential for reuse to the cooling tower at Antwerp. However, stripped sour water may contain phenols or ammonia at levels that make it undesirable for this use at other locations. In addition, the TDS level in stripped sour water can vary significantly, for example, from 18 ppm at Antwerp to over 1,400 ppm at Benicia.

Prioritize Reuse Options

1. Develop Cost/Benefit Analysis

The number of water reuse options evaluated in detail will depend on the water reuse goals and resources available. In order to prioritize the options identified, each option should be categorized qualitatively as resulting in a low, medium, or high water reduction and requiring low, medium, or high investment. Consider preparing a table as follows:

WATER REUSE OPTION	WATER REDUCTION	INVESTMENT
Option 1	Low	High
Option 2	High	Low
Option 3	Medium	Low

Since the water reuse options have not been determined to be feasible yet, a more detailed evaluation of the cost and benefit of each option is not warranted.

2. Prioritize Options and Select Those to be Worked Further

Prioritize the options from high water reduction and low investment to low water reduction and high investment. Depending on the water reduction goal and the resources available, select the number of options to be worked in detail.

Further Evaluate the Most Attractive Options

1. Identify Receiving Process Constraints

Determine the contaminants of concern for the receiving process and set the maximum level for each one. The limiting contaminant level may be the current operating level. However higher levels may be tolerable and should be considered. Consulting with process, safety, and materials specialists is recommended in setting these limits. Consideration should be given to the following:

	WATER POLLUTION CONTROL		Section	Page
	WATER REUSE		XIX-B	7 of 34
	DESIGN PRACTICES		December, 2002	

PROPRIETARY INFORMATION - For Authorized Company Use Only

- **Potential Catalyst Poisons:** If the receiving process is a catalytic one, water which contacts hydrocarbon feed in the process can transfer contaminants to the hydrocarbon stream, which may be poisonous to the catalyst.
- **Treatment Chemicals Compatibility:** Boilers, cooling towers, desalters, etc., receive chemical treatment. The chemical treatment vendor should be consulted regarding compatibility of their treatment with the new makeup water composition or any treatment chemicals from the wastewater source.
- **Materials:** Contaminants such as ammonia and chloride or oxygenated water may cause corrosion. The materials engineer should be consulted regarding any increased potential for corrosion due to the reuse.
- **Safety:** Reuse may cause increases in hydrogen sulfide or ammonia levels or changes in pH resulting in volatilization of these compounds. This and other safety concerns should be identified and reviewed with the safety engineer.
- **Product Contamination:** When reuse water comes in direct contact with the product (e.g., scrubbers or direct contact coolers), contaminants from the water can be transferred to the product.

2. Obtain Water Analysis

To determine water reuse feasibility, accurate and complete water analyses are recommended. Past data, if representative of current operation, can be used to minimize analytical costs. Otherwise, new water analyses should be obtained. A list of parameters to be analyzed, if they are believed present, is listed in [Table 2](#). Acceptable methods of analysis are also included. Even if certain parameters are not limiting in the receiving process, all parameters should be analyzed. A complete analysis of the water allows the reuse option to be accurately assessed by hand calculation or simulated through water chemistry modeling. Electrochemical balancing of the water ensures that no major contaminants in the wastewater have been overlooked.

3. Computer Modeling of Reuse

Unless contaminants are being removed by treatment, water reuse results in an increase in the concentration of contaminants in the affected water streams. This can result in formation of solids, free hydrocarbon, or evolution of gases, which generally has a negative effect on the process. Blending of water streams results in new water compositions and generally changes the pH or scaling potential of the water. This may have process or materials implications. Simulation of reuse options using computer modeling that predicts the water chemistry is recommended to ensure that the reuse option identified is feasible. As a result of the modeling, a limitation of the extent of reuse, pH adjustment, or other treatment may be identified. Modeling will help identify the need for further analyses or pilot testing. Modeling will also help define the operating limits of the reuse option, thereby reducing the risk in implementation.

The Environmental Simulation Program (ESP) is a state-of-the-art program (licensed to ExxonMobil) that predicts both inorganic and organic water chemistry including pH, formation of solids (scaling), and evolution of gases. ESP also has the capability to model unit operations, such as:

- Stripping
- Mixing
- Splitting
- Neutralization
- Heat Exchange
- Reactors

Confirm Incentives for the Most Attractive Options

Once the technical feasibility of the reuse options has been established, screening quality cost estimates for each option should be generated. This will allow re-prioritization of the reuse options on a quantitative basis.

The implementation cost may include:

- Capital Investment (screening quality)
- Operating Cost (chemicals, utilities, etc.)

The savings may arise from:

- Operations
 - Wastewater treatment cost
 - + Chemicals
 - + Utilities
 - + Sludge disposal
 - + Discharge fees (hydraulic and/or mass)
 - Raw water cost
 - + Purchase

Section XIX-B	Page 8 of 34	<i>WATER POLLUTION CONTROL</i> WATER REUSE PROPRIETARY INFORMATION - For Authorized Company Use Only	 DESIGN PRACTICES
December, 2002			

PROPRIETARY INFORMATION - For Authorized Company Use Only

+ Treatment

- Capital
 - Deferred investment due to debottlenecking
 - Reduced scope of investment

Conduct Lab, Pilot, or Field Test

The objective of testing is to confirm an operable, reliable, and safe reuse operation. Depending on the reuse option, lab or pilot testing may be appropriate. In some cases, however, if process conditions can not be reproduced in the lab or in the pilot test, a full scale test may be necessary. The field test plan should include the following activities:

- Schedule and responsibilities
- Review of chemical treatment with applicable process specialists and the vendor
- Design Specification preparation and equipment installation (if necessary)
- Risk assessment and SOC/OIC (Safe Operating Committee/Operations Integrity Committee) Review
- Baseline data collection, sampling, and analyses
- Sampling and monitoring during the test

Monitoring should include:

- Critical Process Parameters
- Corrosion Monitoring
- Fouling (i.e., pressure drop or loss of heat duty)
- Chemical Treatment Verification

Hazard Identification & Risk Assessment

Consistent with the goals of Operations Integrity Management Systems (OIMS), a hazard identification and risk assessment should be conducted before implementing any process change. The purpose of this risk assessment is to review potential reliability, safety, and environmental issues, and to identify mitigating steps if necessary. The reliability of the reuse water source and potentially a backup source for periods during which the reuse water source unit is shutdown must be considered. If the water reuse option is field tested before implementation, the risk assessment should be performed before the field test.

1. Identify Hazards

Consider the following areas when identifying the hazards:

- Environmental
- Materials
- Safety

2. Risk Assessment Methodology

- Identify Potential Impact or Consequence
- Rate the Probability of Occurrence Before Mitigation
- Identify Mitigation & Prevention Methods
- Rate the Probability of Occurrence After Mitigation

Implementation

The final step is permanent implementation of the reuse. A typical project will require:

- Process Basis or Design Basis Memorandum
 - Cost Estimate (Class V and Class III or IV)
 - Cost Reduction Task Force Review
- Design Specification
 - Cost Estimate (Class II)
 - HAZOP and SOC/OIC Review
- Appropriation of Capital/Expense

 DESIGN PRACTICES	WATER POLLUTION CONTROL WATER REUSE	Section	Page
		XIX-B	9 of 34
	PROPRIETARY INFORMATION - For Authorized Company Use Only	December, 2002	

- Detailed Engineering & Project Implementation
 - Construction
 - Start-up

WATER REUSE BY PROCESS AREA

A matrix of water reuse options already practiced or evaluated is shown in [Table 4](#). These options are discussed further in the sections below. As discussed in the above Guidance section, all water reuse options must be evaluated on a site specific basis. Success at one location does not guarantee success at another unless the water chemistry and other process issues are considered. A site specific evaluation includes analysis, modeling, consulting with water chemistry, process, materials, and safety experts, lab, pilot, or field testing, and a risk assessment.

WATER TREATMENT/STEAM GENERATION

Water treatment is defined as the process used to pretreat water for steam generation. Water treatment processes may include clarification/lime softening, filtration, ion exchange, and possibly reverse osmosis. Wastewaters generated in these processes are filter backwashes, ion exchange regeneration wastewaters, and reverse osmosis reject waters. In steam generation, blowdown water is generated to control boiler water chemistry, e.g., dissolved solids concentrations.

Reduction

Methods for reducing water treatment wastewaters are:

- Implement operator training programs emphasizing wastewater minimization.
- Increase ion exchange resin inspection programs. Perform annual filter and resin bed inspections to correct uneven flow application or insufficient backwash cleaning. Sample and analyze media or resin to determine state of degradation.
- Review backwash or regeneration sequences to ensure all stages have been optimized for flux rate, duration, or chemical strength.
- Add filter instrumentation (TSS/turbidity monitors, backwash cycle times, automatic backwash system).
- Monitor and automate ion exchange regeneration cycles by installing continuous analyzers (conductivity) and flow instrumentation.
- For new facilities, consider countercurrent (versus co-current) regeneration.

Reuse

Methods of reuse within the water treating process are reuse of filter backwash to the clarifier, cation/anion/mixed bed backwash to the clarifier, strong base anion final rinse to demin feed tank (clearwell), and mix bed final rinse to demin feed tank. [Appendix A](#) shows these reuse options as part of a water treatment flow schematic. Water chemistry considerations for each of these reuse options are discussed below:

Backwashes to the Clarifier: Filter and ion exchange backwashes can be recycled to the clarifier instead of routed to wastewater. Source water for the backwashes is generally filtered water. The backwash waters are contaminated with suspended solids, which are then flocculated and removed in the clarifier. Usually a sump is needed to equalize flows for a steady recycle to the clarifier. The resin bed backwashes may not be at neutral pH, so the buffering capacity of the raw water should be checked to ensure the blended water pH is within acceptable limits.

Final Rinse to the Clearwell: Ion exchange regeneration is made up of several steps, including acid regeneration of the cation beds and caustic regeneration of the anion beds. The spent regenerants containing dilute acid or caustic are sent to a neutralization tank. These waters are too high in dissolved solids for reuse and are routed to the wastewater treatment plant. In some cases, this wastewater can be routed directly to the effluent since it does not contain any hydrocarbon. Following these washes the beds are rinsed with feed water. Due to the presence of residual acid or caustic, the rinses are also sent to the neutralization tank. The final rinse of the strong base anion or mixed bed removes residual dissolved solids from the process. When the final rinse conductivity drops below the raw water conductivity, the rinse water can be reused by recycling to the demin feed tank (clearwell).

High Pressure Boiler Blowdown to Low Pressure Boilers: Reuse is also possible in steam generation. As mentioned above, blowdown is generated to maintain water chemistry (e.g., dissolved solids at levels that will not produce scaling). This amount of water, as well as steam or condensate lost from the system, must be replaced by makeup boiler feed water. Dissolved solids limits in a high pressure boiler are lower than in a low pressure boiler. As a result, high pressure boiler blowdown water can be reused as makeup water to a lower pressure boiler, assuming internal boiler chemical compatibility between the two systems.

Low Pressure Boiler Blowdown to Cooling Towers: Low pressure boiler blowdown is relatively free of organics and oil, it is a potential stream for reuse as cooling tower makeup. This option is discussed in greater detail under the cooling tower section.

Tertiary Treated Municipal Wastewater as Boiler Feedwater: In some cases, alternative water sources such as tertiary treated municipal wastewater or treated groundwater can be further treated to boiler feedwater quality. At the Torrance refinery, tertiary



Section XIX-B	Page 10 of 34	WATER POLLUTION CONTROL WATER REUSE PROPRIETARY INFORMATION - For Authorized Company Use Only	ExxonMobil DESIGN PRACTICES
December, 2002			

PROPRIETARY INFORMATION - For Authorized Company Use Only

treated municipal wastewater is treated via ultrafiltration and reverse osmosis and fed to existing high pressure boiler pretreatment facilities. In any such case, boiler quality demands and source water qualities must be carefully evaluated to ensure compatibility. Appendix B indicates quality data for reclaimed municipal wastewater used at the Torrance, Jurong, and Singapore PACT refineries.

COOLING TOWER

Total dissolved solids levels are maintained in the cooling water system by purging a certain amount of the cooling water. This is the cooling tower blowdown (CTB) and is usually the largest single wastewater stream. The CTB plus evaporation water must be made up in the cooling tower system with makeup water.

Reduction

The first consideration for cooling tower water management is CTB reduction through maximizing cooling tower cycles of concentration. Increasing cooling tower cycles may be limited by uncontrolled blowdown. In this case, in order to increase cycles, sources of uncontrolled blowdown must be located and recycled back to the cooling tower. If, however, there is a controlled blowdown stream, then this stream can be reduced to increase cooling tower cycles. The maximum cycles are based on makeup water quality and the current cooling water chemical treatment program. [Appendix C](#) lists constituents of concern for the cooling tower and guideline concentration limits for these constituents in the cooling tower basin. As a first pass, cycles of concentration can be increased until one of these limits is met. Computer modeling with site specific analyses should be used to confirm the level of concentration is acceptable. The site's cooling tower chemical vendor should also be consulted before increasing cycles or using reuse waters for cooling tower makeup. The cooling tower chemical vendor should assist in modifying chemical dosages, if applicable, and identifying critical control parameters.

While some parameters are of concern due to fouling or scaling potential, chloride is of concern for materials reasons. Generally, chloride restrictions are placed on stainless steel equipment to prevent chloride stress corrosion cracking, and pitting. The chloride limit depends on a variety of factors including temperature, pH, stress level, and oxygen concentration. Chloride stress corrosion cracking rarely occurs below 126°F (52°C) and 250 wppm (mg/L) chloride and for operating velocities of greater than 7.9 ft/s (2.4 m/sec) (when chloride levels are between 50 to 500 wppm [mg/L]). Many refineries are able to successfully operate their cooling tower with higher chloride content depending on levels of other ions in the water. Local materials experts should be consulted regarding the materials and conditions in the refinery in order to determine if higher chloride levels can be tolerated. A limit of 500 wppm (mg/L) on chlorides may also be set by the typical stabilized phosphate treatment system because the chemicals cannot prevent pitting corrosion of carbon steel at higher levels. It may, however, be possible for the chemical treatment vendor to adjust the chemical levels to allow for a higher chloride limit.

Routine maintenance inspection and continuous on-line monitoring should be used to ensure acceptable operation, especially when concentration limits are approached. Routine maintenance inspection includes corrosion coupons, test heat exchangers, and biofouling monitors and provides comprehensive information on corrosion and fouling. Low corrosion and fouling indicate that the amount of contaminants are acceptable for site operation. By using continuous on-line monitoring of cooling tower water conductivity, blowdown cycles can be controlled and blowdown minimized.

Reuse

High water requirements/wastewater production and less stringent makeup water criteria than boilers and some process stream water washes make the cooling tower a prime candidate for water reuse. However, reusing water to the cooling tower must be carefully evaluated as fouling in the cooling tower circuit can adversely affect the entire refinery. As mentioned above, a list of parameters and their concentration limits for the cooling tower basin water are found in [Appendix C](#). These levels are guidelines. Computer modeling using actual water analyses and reviewing present chemical treatment program limits will determine site specific limits. If modeling and site chemical program review show that the reuse is acceptable, a field test should be considered. Baseline and field test monitoring of heat exchanger performance and corrosion coupons should be performed.

Stripped Sour Water (SSW) is an excellent candidate for cooling tower makeup. SSW generally has low total dissolved solids (TDS) when pH adjustment is not carried out in the stripping process. SSW is also typically low in metals content and suspended solids. However, in some refineries, high concentrations of hydrocarbons, hydrogen sulfide, ammonia, phenols, or dissolved organics may be present in the SSW and can cause problems such as heat exchanger fouling, odor, and corrosion when reuse to the cooling tower is implemented. The limits listed in [Appendix C](#) should be adhered to when considering reuse of SSW to the cooling tower.

Computer modeling has shown that low pressure boiler blowdown is another source for makeup to the cooling tower. Low pressure boiler blowdown is known to be low in dissolved solids and relatively free of organics and oil. The sludge conditioner used in the boiler treatment may inhibit the function of dispersants used in the cooling water. This potential concern should be checked with the chemical treatment vendor.

Reuse of wastewater treatment (WWT) effluent as cooling tower makeup has been of interest for many years. However, contaminant levels, especially BOD and ammonia, in the treated wastewater have prevented its use. More efficient/consistent WWT, generally required today to meet stringent effluent criteria, as well as better water chemistry predictive tools, have improved the potential for wastewater effluent reuse. Although the quality of wastewater has improved, there are some considerations that must be addressed before implementing this option. Continuous biocide addition (chlorination) of the feed water to the tower is necessary. If the WWT effluent is blended to the cooling tower water return (CWR) line, additional chlorination should be injected at the CWR line. 