11.0 COOLING SYSTEM

11.1 PROCESS DESCRIPTION

One natural draft cooling tower (approximately 330'D x 550'H) supplies the entire plant (process and utility areas) with a design circulation rate of 252,000 gpm of cooling water. Cooling water is supplied to the plant at 88°F and returned at 108°F, placing a design heat load of 2.52×10^9 Btu/hr on the tower. Seven (7) 2300 HP motor-driven vertical pumps (six operating, one spare), with a design capacity of 42,000 gpm each, supply the estimated 70 psi differential pressure required for circulation. Since water quality is essential for controlling scale in cooling equipment and the tower, solids levels are controlled 3.0 cycles of concentration. The blowdown rate is controlled to 0.9 percent as described in the Water Management Section (Volume 3 Section 12.0). Make-up is approximately 3.0 percent of circulation rate. Water, clarified to remove suspended solids is used as make-up water. Evaporation rate for a natural draft tower is estimated at 2.0 percent, and wind losses at 0.1 percent. Organics are controlled in the circulation water and tower by chlorine addition.

11.2 FLOWSHEET

No flowsheets were prepared for the cooling water system.

11.3 MATERIAL BALANCE

UNIT	IDENTIFICATION	CASE 13 PROCESS CW REQUIREMENTS
11	Gas Cooling	6400 gpm
12	Rectisol	13600 gpm
16	Phenosolvan	1150 gpm
17	Ammonia Recovery	15600 gpm
18	Sulfur Recovery	1680 gpm
84	MEOH Synthesis	7100 gpm
86	Mobil MTG	17650 gpm
87	Gasoline Fractionation	1870 gpm
88	HF Alkylation	798 gpm
89	Heavy Gasoline Treater	111 gpm
*	Process Drivers W/Condensing Steam Turbines	38154 gpm
Total Process CW Requirements		104,113 gpm
Design Rate (1.15 x Total)		119,730 gpm

11.3 MATERIAL BALANCE (Continued)

UNIT	IDENTIFICATION	CASE 13 UTILITY CW REQUIREMENTS
40	Oxygen Plant	72218 gpm
41	Air & Nitrogen System	1320 gpm
47	Power Generation	41424 gpm

Total Utility CW Requirements		114,962 gpm
Design Rate (1.15 x Total)		132,206 gpm
Make-up		7,310 gpm
Losses evaporation	(5040 gpm)	
Blow down	(2270 gpm)	

Total (Normal) Circulation Rate --------- 219,075 gpm
Total (Design) Circulation Rate --------- 251,936 gpm

11.4 ACCOMPLISHMENTS AND DECISIONS MADE AND FINALIZED

Three studies were produced during this phase of the project. Several other studies were conducted for "in-house" work. Volume 11 contains the following studies:

- Air/Water Cooling Breakpoint (Vol. 11, Book A, Section 2.4)
- Comparison of Mechanical and Natural Draft Cooling Towers (Vol. 11, Book C, Section 4.2.14)
- Comparison of Cooling Ponds, Natural Draft, and Force Draft Towers (Vol. 11, Book C, Section 4.2.14)

From the above studies and general design work the below key decisions were made. Major issues relevant to the decisions are also discussed.

1. The Air/Water Cooling Breakpoint was determined for the Gas Cooling Unit. Air coolers proved to be the most economic choice in this unit for gas-side exit temperatures of 115°F and higher. This evaluation considered installed capital, operating cost, and operational constraints, i.e., cooling water scaling at higher temperatures, etc.

2. The Air/Water Cooling Breakpoints for other units has been assumed to coincide with the breakpoint for gas cooling. Other large heat loads should be reviewed when detail design work is resumed.

11.4 ACCOMPLISHMENT AND DECISIONS MADE AND FINALIZED (Continued)

3. The comparison between Force Draft Towers and Natural Draft Towers has been studied several times. Many factors control the final economic evaluation. When evaluated on an evaluated cost basis, Natural Draft Towers are slightly cheaper than Force Draft Towers. This study was based on Case 7R, but is assumed to hold for Case 13. Note that Plume (Fog) abatement is not included with Force Draft Towers. (See below)

4. Cooling Tower Fog is an environmental concern when Force Draft Towers are used. The Plant location (Ohio - valley) and winter weather could accent this concern. In light of this, several tower vendors were asked to present possible solutions to the Plume (Fog) problem. These appear below:

   o Use a wet/dry tower system. Moist air is discharged above the dew point.

   o Use a standard force draft tower with an extended stack.

   o Use a round force draft tower which gives more rise to the Plume than long sectional towers. The real benefit of this approach is unknown.

   o Locate tower so that natural winds will blow Plume away from plant. Winter wind patterns may preclude this option.

   The tower vendor would not recommend any one option over another nor would they estimate percent additional cost of each option.

   Due to the apparent economic superiority of the Natural Draft Towers, Plume abatement was not considered a major problem , i.e., Natural Draft Tower release the Plume at heights greater than 550 ft.

5. The optimum return water (cold side) temperature was studied in conjunction with the cooling pond study. This study considered both economics and plant operation. The conclusion was that 85°F was not optimum for any of the tower systems under review. The study was based on 7R10, and is assumed to hold for Case 13. Natural Draft Towers optimized at 88°F as did the study case pond, Force Draft Towers optimized at 86.5°F. As a result of this study, Case 13 is "Designed" based on Natural Draft Towers cooling to 88°F rather than the feasibility study limit of 85°F.

11.4 ACCOMPLISHMENT AND DECISIONS MADE AND FINALIZED (Continued)

6. A decision was made to use one Natural Draft Tower in lue of two as per the feasibility study. The heat load for Case 13, approximately 2.5 x 10^9Btu/hr can be cooled by one large tower. Several studies showed one large tower to be cheaper than 2 towers handling 50 percent each of the heat load. This single tower will handle both process and utility loads. The on stream factor for one tower or two towers (one for process, one for utilities) is assumed to be equal, i.e., the feasibility plant could not operate without both towers.

7. Cooling ponds were researched and studied in sufficient detail to evaluate the pond along side cooling towers. The studies completed to date concluded the following.

   - The evaluated cost of cooling pond water treatment is in the same order of magnitude as a single Natural Draft Tower loaded to 2.5 x - 10^9Btu/hr. The study showed the pond cost to be highly design specific. The pond design currently used for Case 13 is based on the cooling ponds at Union Carbide's Seadrift Facility. This pond design saved approximately five million in evaluated cost over the single Natural Draft Tower.

   - Operating information gained at the Union Carbide Facility indicated that water treatment cost for a pond system may be as much as an order of magnitude less than a sister plant with cooling towers. The sister plant, with towers, spends approximately one (1) million dollars per year for water treatment while the Seadrift Facility, with ponds, spends about 100,000 dollars per year. The heat load of the Union Carbide Plant and Case 13 are quite close.

   - The cooling ability of the pond has been approximated from many sources. Correlation of this data to the Tri-State plant location indicate the Tri-State heat load, Case 13, can be cooled to 88°F with a pond 600-700 acres in size.

11.5 CURRENT STATUS

Plant cooling water requirements have been estimated by factoring from similar units designed by Fluor. A study to determine the air/water cooling break even point was conducted on the large heat exchangers in the gas cooling section. The results of this study have not been incorporated into the plant as a whole, therefore, the cooling water estimates should be reviewed to determine if the application of air cooling can be expanded.

The Case 13 design estimate duty for the cooling water system is 2.52 x 10^3Btu/hr. This value was roughly half of the 6.0 x 10^9Btu/hr duty on which the cooling pond/cooling tower study was based. This study indicated that an optimum cooling system for a duty of 6.0 x 10^9Btu/hr consisted of two natural drafter cooling towers, cooling water from 108°F to 88°F.

Vertical pumps with motor drivers are used to circulate the cooling water for Case 13. Horizontal pumps would require the construction of a pump pit and would therefore require greater capital expenditure than vertical pumps, and turbine driven vertical pumps have inherent operational problems due to the required right angle coupling between the turbine and the pump driver. The selection of vertical pumps with motor drivers has not been verified by an economic study.

Appendix A of this section contains the cooling pond trip report. This report answers many questions about operational problems concerning cooling ponds.

11.6 LICENSORS AND EVALUATIONS

In general, the cooling tower itself will be supplied by some vendor not yet selected, but the complete cooling water system will be designed by an engineering contractor. In the event it is decided to further evaluate a cooling pond, a consultant specialist would be employed to assist in sizing the pond, selecting a cold temperature, and selection of the overall design conditions. The engineering contractor would then carry out the design based on the selected design basis.

11.7 APPENDIX A - Cooling Pond Trip Report

Note: Attachments referred to in this report are not included. Refer to the Fluor design files.

TRI-STATE SYNFUELS COMP...
Indirect Co l Liquefaction Plant
Western Kentucky

FLUOR EN... EERS AND CONSTRUCTORS, INC.
Contract 836604

UCC COOLING POND VISIT REPORT

March 23, 1982

by

Cyrus Rhee

Introduction

On February 23, 1982, a team consisting of Bob Jones Jr. (Tri-State), Roger Fincher (Tri-State), and Cyrus Rhee (Fluor) visited UCC (Union Carbide Corporation) polyolefins plant at Seadrift, Texas. The following outline describes the plant visit.

The purpose of the visit was to see their cooling ponds and to learn about UCC operating experience and design knowledge on cooling ponds by discussing with knowledgeable plant personnel.

We were greeted by four (4) UCC personnel, Richard Good (Energy systems department head), Robert Wright (Principal Engineer involved with original pond design), Kenneth Baldree (Chief Operator, utility systems), and Tom (Operator, environmental systems).

The UCC people were very cooperative, open minded, informative, and willing to discuss all aspects of this subject. We received valuable information, knowledge, and reference materials.

General

The Seadrift plant has utilized cooling ponds since early 1950, beginning of plant operation.

The original cooling water flow design of 60,000 GPM (204.3 acres cooling surface) has been expanded in three increments with some minor modifications to the present capacity of 390,000 GPM (606.3 acres cooling surface).

Attachments, articles 1 and 2, discuss the historical background of the original pond design and operating experience, and the present situation after several expansions.

Although, cooling ponds are the major supply of cooling water to the Seadrift plant, it is important to mention that there are several closed loop cooling towers supplying cooling water to some critical users; when users required better quality water and lower cooling water temperature than that of the water from the pond, or users are located at the remote area (e.g., oxygen plant).

Discussion

The discussion with UCC personnel was very informative. We found that UCC people were very knowledgeable and resourceful on design and operation of cooling ponds.

The following are UCC statements on specific questions asked by us:

I. General Pond Information

A. Pond size, dimension, depth

Total surface area for six (6) basins is 606.3 acres. Figure 1, attached, gives dimensions of each pond. The depth of the ponds is nine (9) feet average water level plus the free-board.

B. Pond flow rates

Total design flow rate is 390,000 GPM, 60,000 GPM from No. 6 Basin and 70,000 GPM from No. 1 Basin.

C. Pond temperatures

(1) During hot summer months, maximum cooling water return temperature is 42°C (107.6°F). Maximum cooling water supply temperature is between 34°C (93.2°F) and 35°C (95°F), occasionally, it reaches as high as 37°C (98.6°F) at still air condition.

(2) UCC stated that September is the worst month for the cooling ponds.

D. Any supplemental cooling

There is no supplemental cooling for the cooling ponds.

E. Equilibrium temperature of other (nonheat load) ponds

UCC stated that the temperature of river water (cooling pond supply) is between 27°C (80.6°F) and 32°C (89.6°F). Experience showed that the equilibrium temperature of other nonheat load pond (boiler feed water supply pond) is 1.5°C (2.7°F) above the river water temperature. Also, UCC stated that the cooling water supply temperature is usually within 9°F of the wet bulb temperature or within 3.6°F above the equilibrium temperature.

II. Pond Construction Information

A. Details of dike design, covering slope, free-board

(1) Banks for all basins originally did not have the liner. The low-level of the water, caused by the drought, revealed that bank erosion is a critical factor. Therefore, all banks are now lined with concrete (see attached Figure 2, 3, and 4, for details).

Wave action, especially during a hurricane, still eroded voids behind the concrete liners. Those places have been repaired with scrap concrete pieces removed from the plant. It was visibly clear to us that many repairs were made for all banks with rip-rap concrete liners.

(2) There are no flow distribution baffles in all ponds except the baffle at the inlet of Basin No. 5 and No. 6 and the pump intake for Basin No. 1.

These baffles are wooden boards or steel pilings. Occasionally, UCC experienced baffle failures during a hurricane.

B. Pond bottom design, liner, seepage

UCC stated that the soil condition at Seadrift is impervious and ideal for the construction of ponds (see attached Table 1, log of boring). The bottom of ponds were only provided with four (4) feet of clay liner.

C. Dike repairs, type frequency/magnitude cost

See item II, A.

III. Design Parameters for UCC Ponds

A. Meteorological data

(1) Usually, relative humidity is nearly 100 percent.

(2) The annual rainfall is 37 inches. It is equal to an annual evaporation of cooling basin.

B. Cycle of cooling water

(1) The continuous fresh water makeup is provided from the river. The makeup system is designed to supply 24,000 GPM. The normal makeup rate is between 11,000 - 12,000 GPM. It is equivalent to 11,000 - 18,000 acre-ft per year total.

(2) The continuous blowdown to canal is maintained to keep the cycle of concentration at about 1.5.

Since the makeup water has scaling characteristics, they must control the blowdown closely to monitor TDS level to reduce scaling.

(3) No further chemical treatment of the blowdown water is required, since there are no chemical treatment of cooling water for pH, corrosion, and scaling control except bacteria.

C. Cooling water intake structure/pumps

The concrete intake structures are utilized to accomodate verticle sump pumps. At the inlet of the structure, bar screens and gates are installed to remove big objects and isolation purposes. Also, there are traveling screens with the backwash and shocker to remove small objects.

The injection of acrolein slimicide is done at the intake structure to have a good mixing of chemical.

D. Cooling water discharge structure

There is no structure. The pumped cooling water is distributed via big reinforced concrete pipes to users.

IV. Operating Information

A. Analysis of pond water

The analysis of the makeup and cycle water (circulating) is attached (see Table 2).

B. Analysis of makeup water

See item IV, A.

C. Cooling water treatment

There are no chemical treatments for controlling pH, corrosion, and scaling except slime and bacteria.

(1) Filtering to avoid suspended solids

There are no filtration facilities provided to remove suspended solids except the removal of small objects by traveling screens and local filtration at users in limited basis. It appeared to me that the water in the ponds has turbidity and was gray color. It may require some filtration to remove slime and turbidity.

(2) Any algae growth/plant growth/how controlled?

UCC controls the growth of plant and algae by monitoring the level of dissolved oxygen, TOC, and using biocide. Originally, chlorine was used, but they switched to acrolein slimicide to control slime and bacteria.

Acrolein is injected at the rate to give 0.7 ppm concentration in the pumping structure for two hours per day, three times a week.

(3) Any plant runoff inflow/treatment?

Plant runoff is not allowed to flow into cooling ponds.

(4) Dissolved oxygen level

5-10 ppm level should be maintained.

(5) Any anaerobic conditions experienced/special provisions to monitor dissolved oxygen?

Once in 15 years, UCC experienced a fish kill condition. They found that the dissolved oxygen level was low.

The accident was investigated and the cause was traced to the leakage of heat exchangers. This condition promoted the rapid growth of microorganisms and created an anaerobic condition. Since then, Total Organic Carbon (TOC) and dissolved oxygen level are closely monitored.

D. Heat exchanger conditions

(1) Scale buildup in tubes

Due to the scaling tendency of the pond water, UCC is experiencing scale buildup in tubes. It is hard to prevent scaling without treatment of the water. Especially, the scale buildup accelerates above 45°C (113°F). UCC stated that only acid cleaning of heat exchangers has been applied to control the scale buildup.

UCC stated that the expense for acid cleaning of heat exchangers is about $100,000 annually. They assign one man to cle. . all heat exchangers in the plant.

(2) Abnormal problems/maintenance

UCC did not experience any abnormal problems. Small fish and clams occasionally pass through traveling screens and are carried into the cooling water network. These plug heat exchangers in process units located near the end of the headers, require extensive back flushing.

(3) Any design changes in exchangers used with pond vs. cooling towers?

UCC did not suggest any special design changes other than providing provisions for monitoring cooling water return headers for detecting leakage and for back flushing of heat exchangers to remove scale, fish, and clams.

V. Environmental Concerns

A. Pond generated fog/distance/density/etc.

UCC does not have a fog problem. Usually, the surrounding area of the plant is fogy at all times. They do not think that the fog is a problem for them. Also, UCC feels that the heat generated from the plant will increase the wet bulb temperature of the surrounding area to reduce fog formation over the ponds. However, UCC feels that if ponds are located near the highway, the fog may create problems for traffic.

B. Any environmental monitoring?

(1) UCC is monitoring dissolved oxygen level and TOC to control slime and bacteria.

(2) The blowdown from ponds should be monitored for TOC, pH, and temperature to meet EPA requirements.

(3) UCC installed monitors at critical locations in the cooling water lines to detect heat exchanger leaks.

C. Any environmental problems?

No, UCC did not experience any problems except killing fish once in 15 years.

D. Any groundwater monitoring/level, quality?

There is no such monitoring required.

E. Aquatic life in ponds? species? density?

There are many varieties of fish which can live in this type of water, including alligators.

F. Any special permits required because of the ponds?

No, normal permits are required.

VI. UCC Recommendation

A. Would UCC build ponds again if starting new

Yes. UCC feels that the cooling ponds are more cost-effective than cooling towers for the standpoint of the capital investment and operating costs.

UCC stated that water treatment costs and power consumption are lower for the pond. Since the cooling water pressure is lower (32.5 psig for UCC plant) and there are no fans, power saving is substantial.

B. Suggestions for TSSC cooling ponds

(1) UCC suggested concrete liner for all banks.

(2) UCC suggested that many monitoring points should be provided to check circulating water for TOC (leakage) and scaling. There should be provisions for back flushing of heat exchangers.

C. Problems overcome by UCC

At early days of plant operation, UCC had problems of plugging lines and heat exchangers with algae which was a kind of hairy mess.

After the proper application of biocide, the problem dissappeared.

Summary

The result of the visit to the UCC plant was informative and successful. We learned that UCC has operated ponds successfully for many years and has proven that ponds are a viable alternative to cooling towers. Seadrift is an ideal location for building ponds. The land surrounding the plant is flat and the soil condition is perfect. Also, they found that ponds are more cost-effective, and have lower capital investment, and operating costs.

The proper sizing of ponds is the key to provide enough heat transfer surface to cool the water. UCC had used the following criteria for their pond sizing:

(1) Total heat transfer rate of 80 Btu/hr/ft^2.

(2) Equilibrium temperature for nonheat load pond is 1.5°C (2.7°F) above the river water temperature.

(3) Design temperature of cooling water supply is 9°F above wet bulb temperature or 3.6°F above the equilibrium temperature.

Although ponds at Seadrift plant are performing adequately, the addition of more baffles in the ponds will increase efficiency.

Texas Instrument Company made an aerial survey of the ponds and took infrared pictures. These pictures showed that there are many stagnant areas in the ponds, especially basins No. 3, 4, and 5.

UCC hired Dr. Donald R. F. Harleman of MIT and asked him to investigate the problem and to make a recommendation. The attached (article no. 3) is Dr. Harleman's report.