ARKANSAS POWER & LIGHT COMPANY

SERVICE WATER SYSTEM
INSPECTION AND MODIFICATION
ACTION PLAN
FOR
ANO-2 REFUELING OUTAGE #1

MARCH, 1981

2R1 - UNIT 2 SERVICE WATER ACTION PLAN

1) Change out all 2-inch and under carbon steel piping to stainless steel as shown on Figure 1.

2) Add vents, drains for HPSI pump, LPSI pump and CSS pump coolers as described on Figure 2 (unless these coolers are eliminated or replaced by air cooled heat exchangers).

3) Add flow rate indication as follows:

   Service water flow rate through the following coolers will be added or provisions (isolation valves) added to allow such devices to be installed later during operation:

   2VUC-1A, 1B, 1C, 1D, 1E, 1F
   2VUC-11A, 11B
   2VUC-2A, 2B, 2C, 2D
   2VUC-7A, 7B, 7C
   2VUC-6A, 6B
   2VUC-19A, 19B
   2VUC-20A, 20B

   *Also:

   2E-52A, 52B
   2E-53A, 53B, 53C
   2E-47A, 47B

4) Clean service water bays and pump discharge strainers.

5) Inspect portions of service water piping.

6) Inspect service water cooled heat exchangers as indicated on Figure 3.

7) Replace two failed cooling coils in 2VCC-2B (containment cooling unit). Perform destructive examination of these coils after the outage.

8) Replace 2E-35B tube bundle.

*Provided they are not eliminated by replacement with air cooled units or by analysis.

FIGURE 1

The following equipment will have a portion or all of its associated service water supply and/or return carbon steel piping replaced with 316 L stainless steel piping.

1)	Containment Spray Pump Coolers	2E-47A&B
2)	L.P. Safety Injection Pump Coolers	2E-52A&B
3)	H.P. Safety Injection Pump Coolers	2E-53A,B&C
4)	H.P.S.I. Pump Room Coolers	2VUC-11A&B
5)	Charging Pump Room Coolers	2VUC-7A,B&C
6)	E.F.W. Pump Room Coolers	2VUC-6A&B
7)	Electrical Equipment Room #2091 Coolers	2VUC-19A&B
8)	Electrical Equipment Room #2096 Coolers	2VUC-20A&B
9)	Emergency Switchgear Room Coolers	2VUC-2A-2D
10)	Post Accident Hydrogen Analysis Panels	2C-128A&B
11)	Fuel Pool Ht. Exchanger Rad. Detector	2RE-1525
12)	Containment Cooler Rad. Detectors	2RE-1513 2RE-1519
13)	Shutdown Cooling Ht. Exchanger Rad. Detectors	2RE-1453 2RE-1456

FIGURE 2

I. <u>2E47A & 2E47B and 2E52A & 2E52B</u>

1) Vents will be installed between the cooler inlet isolation MOVS and the coolers themselves and between the cooler outlet and the cooler outlet isolation valves to allow flushing and flow path checking during operation with the service water header pressurized.

2) Pressure points for ΔP instruments will be moved to the small pipe downstream of the inlet reducer as close as possible to the cooler and on the outlet side as close as possible to the cooler and before the pipe increaser.

II. <u>2E53A, B & C</u>

Pressure points will be moved as described in I.2 above from the 3-inch supply and return headers to the new stainless piping and as close as possible to the coolers themselves to make ΔP indications more meaningful.

FIGURE 3

INSPECTION PLAN FOR UNIT 2 SW COOLED HEAT EXCHANGERS

1. Open, inspect, and clean or flush the following coolers during 2R1 outage. These coolers indicated some reduced flow rate capacity during a January, 1981 test.

   A. 2VUC-1A A S/D heat exchanger room cooler
   B. 2VUC-7A A charging pump room cooler
   C. 2VUC-11B C HPSI pump room cooler
   D. 2VUC-19B Auxiliary Building electrical equipment room cooler

2. To be opened, eddy current examined prior to tube bundle replacement and after new bundle is placed in 2E-35B.

   A. 2E-35A A S/D cooling heat exchanger
   B. 2E-35B B S/D cooling heat exchanger

3. To be inspected during coil replacement:

   2VCC-2B Loop I containment cooling unit

4. To be flow checked after piping changeout. The elimination of these coolers by analysis and/or substitution of air cooled heat exchangers is being evaluated and may eliminate the need for this check.

   A. 2E-47A&B
   B. 2E-52A&B
   C. 2E-53A,B&C

5. To be inspected for accessibility of cleaning, inspection and maintenance/replacement. The result will be sketches, photos and proposed design changes to improve accessibility.

A.	2VUC-1A, 1B, 1C, 1D, 1E, 1F	S/D cooler area room coolers
B.	2VUC-11A, 11B	C HPSI pp room coolers
C.	2VUC-7A, 7B, 7C	Charging pump room coolers
D.	2VUC-6A, 6B	EFW pump room coolers
E	2VUC-19A, 19B	Aux. Bldg. Elec. Equip. Room Coolers
F	2VUC-20A, 20B	Aux. Bldg. Elec Equip. Room Coolers
	UC-2A, 2B, 2C, 2D	Switchgear Room Coolers

6. Remove and recalibrate or replace the following instruments:*

A.	2PDIS 1464-1	A HPSI pump cooler ΔP	(2E-53A)
B.	2PDIS 1462-1&2	C HPSI pump cooler ΔP	(2E-53C)
C.	2PDIS 1470-2	B HPSI pump cooler ΔP	(2E-53B)
D.	2PDIS 1465-1	A LPSI pump cooler ΔP	(2E-52A)
E.	2PDIS 1467-2	B LPSI pump cooler ΔP	(2E-52B)
F.	2PDIS 1457-1	A Containment spray pump cooler ΔP	(2E-47A)
G.	2PDIS 1459-2	B Containment spray pump cooler ΔP	(2E-47B)

*This may be unnecessary if the need for these coolers is eliminated or the coolers are replaced by air cooled units.

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December 15, 1980

ARKANSAS POWER & LIGHT COMPANY
P. O. Box 551
Little Rock, Arkansas 72203

Attention: Mr. Dan H. Williams,
Generic Projects Coordinator

SUBJECT: ARKANSAS NUCLEAR ONE - UNITS 1 & 2
SERVICE WATER SYSTEMS
PRELIMINARY FINDINGS AND RECOMMENDATIONS
AP&L CONTRACT NO. L-020G, TASK NO. 001P, PLANT ANO
T.M.L. PROJECT NO. 032-01-001

Dear Mr. Williams,

As we discussed in Little Rock, this report is being generated to summarize our preliminary findings and recommendations. We are sending this report in an effort to provide you with as much information as is possible in the shortest period of time. We realize that you are operating on a very tight and critical schedule.

We are enclosing fifteen (15) copies of this report with the original. We have not distributed any copies of this information other than to our files. Therefore, please distribute this letter report to the proper individuals.

In the interest of time we will not be submitting a formal bibliography referencing the source of statements made within this document. Please be assured that we will make every possible effort to document the efficacy of any statements contained within this report and/or the source of any information used in the preparation of this document. This will be formally done strictly upon your request.

We have written this report with the intent that this will be used strictly as an information source to ARKANSAS POWER & LIGHT COMPANY. In other words, we are being extremely direct. Obviously, we are outsiders to the problem at hand. As such, some of our interpretations might err due to insufficient information. We strongly recommend that ARKANSAS POWER & LIGHT COMPANY make certain that they agree with any of our statements before the information is disseminated to outsiders. We additionally ask that after you have reviewed this document you notify us promptly of any errors which we have made. This information will be corrected in the final report.

BACKGROUND

Essentially the background information is well known to all. The Service Water Systems of both ANO-1 and ANO-2 have, upon inspection, been found to be experiencing apparently excessive corrosion, biological slimes, silt, mud and Asiatic clams (presumably Corbicula fluminea). These generalized waterside phenomenon could be critical to operations and/or critical to safety. In all cases the solution to these problems appears to have a rather significant economic impact.

It is a reasonable assumption that the fire protection systems associated with ANO-1 and ANO-2 could suffer from problems similar to those of the respective Service Water Systems. Therefore, this subject must be investigated in some detail. However, this will not be done directly in this work as it is outside of the presently authorized scope under subject.

It is reported that the condition of this Service Water System at ANO-2 is believed considerably worse than is that at ANO-1. During recent inspections an accumulation of silt, mud and adult clams in the Service Water System at ANO-2 was found. Fewer clams, little silt and some biological slimes were found in the ANO-1 Service Water System.

One of the questions which was raised in our initial meetings was why does this difference exist.

Along these same lines, the component cooling water heat exchangers, 2E28A, B & C, appear to be in considerably worse condition with respect to corrosion and structural integrity than do their parallel functioning exchangers of ANO-1. These latter exchangers are designated as the intermediate cooling water exchangers, E28A, B & C.

The high pressure safety injection heat exchangers of ANO-2 appeared to be in the worst condition upon inspection. The next worse exchangers were reportedly 2VUC24 A & B and subsequently 2VUC20 A & B. The importance of this observation is the simple fact that all of these exchangers are judged to be in the category of "critical to safety".

The highest density of Corbicula was found in the containment service water cooling coils. Exchangers 2VCC2 A, C & D reportedly have the worst biological population. Clams and/or evidence of clams were found in VCC2 A, B, C & D. Clam shells were found in both systems. The location of the clam shells tended to be at the lower elevations.

Finally, metallurgical failures of the shut down cooling heat exchangers, 2E35 A & B have been reported. The design of these exchangers is such that only 2% of the approximately 750 tubes per exchanger can be plugged without affecting power plant heat transfer requirements. At the present time twelve (12) tubes in 2E35 A are plugged and fourteen (14) tubes in 2E35 B are plugged. We understand that both of these exchangers employ 304 stainless steel tubes in a carbon steel shell. The cooling water is reportedly on the shell side.

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MAKE UP WATER - SOURCES AND COMPOSITION

It is our judgment that any resolution of the existing problems at ANO-1 and/or ANO-2 should be based upon the assumption that a single, marginal quality makeup water source exists for these units. We make this statement simply because the quality of the water in the emergency cooling pond is judged to be marginal, the City of Russellville, Arkansas has water which is judged to be marginal, the quality of well water in the immediate area is judged to be marginal to poor and the quality of Lake Dardanelle is also marginal.

Given this information the first item of importance which one must have is an idea of the water quality which is capable of entering the intake structure of both units through the inlet canal. It is our opinion that the water chemistry data which exists was not collected with the idea that the water could potentially have negative impact on the Service Water System. As such, several parameters were not, apparently, examined in detail. These parameters such as total solids and suspended solids do not appear to have been given the necessary position of importance. Please understand that this is not a criticizm, but rather an observation. In fact, this statement will be used as the basis for several recommendations in our work.

Because of these conditions, one (1) of the first problems which has to be resolved relates to the range of water quality expected at the service water intake.

Along these lines, we have prepared Attachment I and Attachment II of this report. Attachment I shows a synthesized range of anticipated water quality. While this may apparently be conservative, we do not think so. Rather, we think this to be highly realistic. Had we wanted to be overly conservative, we could have greatly extended the ranges shown.

Attachment II is the result of calculations which we made with the values of the parameters presented in Attachment I. We did not construct the ranges so that the calculations came out to any certain values.

Please note that the maximum temperature which we have used in this work is 130° Fahrenheit. We are aware that the water in the Service Water System could potentially reach a temperature of 150°F. However, we believe that it is more realistic to look at an upper temperature limit of 130°F for these purposes.

The results of our work show that the service water quality can range from relatively scaling with respect to calcium carbonate to extremely corrosive. In fact, we would predict that under the majority of conditions the service water would tend to be corrosive.

An examination of the majority of available data suggests to us a need for upgrading the existing chemical monitoring program. We would recommend that total solids and suspended solids be monitored at the service water intakes of both units at least once per week. We additionally believe that rather extensive corrosion testing should become a part of a permanent program at ANO. This program should utilize corrosion coupons placed in properly operated cooling water loops at various points in the system. The data from the corrosion coupons could be supplemented with data gathered through the use of corrosion rate meters. Additionally, we would recommend the installation of several spool pieces of pipe at critical locations. These could be put in a bypass such that they could be readily removed for purposes of inspection and analysis. As a portion of our work scope, we will present more specific details on our recommended monitoring program.

Obviously, the collection of data costs money. As such, there should be a specific reason for this collection. The first reason which we offer is the support of our earlier statement that insufficient data exists to characterize the response expected from cooling water heat transfer equipment. Hopefully, the accumulation of data will lead plant operations to the establishment of guidelines designed to avoid costly shutdowns, perform preventative maintenance and to assess overall system performance.

The program is best designed to answer some of the questions relative to the variability of the service water influent with respect to suspended solids, etc. It was reported to us that the lower temperature of the water tends to occur between the months of January and February. The highest temperature of the water tends to occur in the months of July and August. The greatest turbidity of the water tends to occur between March and May. While this may be the case, it is not apparent from the existing body of data. Additionally, the concern should be placed upon the actual measurement of suspended solids and not upon the measurement of just turbidity.

The chemistry staff of ANO does perform the analysis for certain water quality parameters on both the inlet water, discharge water and recirculating cooling water. As a portion of our work, we examined twelve (12) (approximately one per month) of the Cooling Tower/Circulating Water Analysis Report.

Perhaps the results which were delivered to us were not representative. However, if these results were representative of the analytical work being done on the service water influent, we must conclude that it is not sufficiently complete. To explain this statement we reviewed thirteen (13) individual parameters. Of these thirteen (13) individual parameters, values appeared on each sheet for only three (3). Of the remaining ten (10) parameters the quantity of reported information existed at 50% or less for nine (9) of the parameters. Simply stated, there were too many blanks on the report to our way of thinking.

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The obvious implication of this is simply that insufficient work is being done. We wish to make it clear that our investigation shows this not to be the case. In fact, we judge the most significant problem as being the existence of a smaller than desirable chemistry staff at both units. In support of this statement we allocated the time spent by the six (6) plant chemists who comprise the total staff of ANO-1 and ANO-2. We assume that the Chemistry Supervisor is expected to devote his full time to supervision. We then calculated what we consider to be the demands placed upon the plant staff simply by environmental requirements. This totals 7.4 man weeks per month of direct environmental labor or 28% of the total, twenty-six (26) man weeks, of the available total labor force. In other words, only 52.8% of the total available labor or 13.7 man weeks per month are available to perform routine operating chemistry, etc.

We believe that this staff could be effectively augmented with people. We believe this recommendation to have major benefits to ARKANSAS POWER & LIGHT COMPANY. At least, there would appear to be a need for a "special projects team". Perhaps some of the routine chemical analytical work could be done by skilled technicians with some of the plant chemists spearheading special projects. Our experience with nuclear power plants suggests that "special projects" are the rule and not the exception.

We recently had the opportunity to establish the operating bas[illegible] for the staff of the chemistry department of a nuclear unit. It was our feeling that the minimum staff should consist of at least one (1) supervising chemist, one (1) plant chemist and seven (7) to eight (8) chemistry technicians. Unless we are missing some very important information, it would seem that this work which we recently completed has a direct parallel to the needs of ANO-1 and ANO-2.

If you are to continue operating ANO with the existing staff, we would recommend that you give consideration to adding between three (3) and four (4) members to your existing staff for the purpose of performing specialty analyses, specialty inspections, long term projects in support of operation and short term projects in support of operation.

SERVICE WATER SYSTEM DIFFERENCES

After carefully reviewing the available information, we find several plausible explanations for why Unit 2 Service Water System appears to be experiencing more problems than does that associated with Unit 1. Overall, we believe that the design basis for the Unit 1 system is considerably better than is that of Unit 2.

Shellside, U-tube and/or straight tube heat exchangers tend to be subject to many more corrosion and fouling problems than do their tubeside analogs. From reviewing the drawings of your system, we believe that you have several shellside coolers on ANO-2 Service Water System. We could not locate any shellside exchangers on ANO-1.

We believe that the following coolers on ANO-2 are shellside exchangers. We additionally believe that each of these are U-bundle type exchangers, including:

2E35A, B
2E47A, B
2E52A, B
2E53A, B, C

It is conceivable that we have not identified all of the shellside exchangers on ANO-2. Considering the service to which these exchangers are being subjected, we would have preferred that no shellside exchangers be employed. Most industries which use shellside exchangers experience consistently more problems with these exchangers than they do with tubeside exchangers.

The design of the intake structures for Unit 1 and Unit 2 are considerably different. The flow to the intake bays appears to have widely different velocities at Unit 1 and at Unit 2. Essentially, heavy siliceous material appears to settle in front of the intake structures associated with Unit 1 while it carries through into the same associated with Unit 2. This information has been satisfactorily documented through the several inspection reports written by ARKANSAS POWER & LIGHT COMPANY personnel.

We suspect that the average velocity of cooling water in the Unit 2 system is, overall, considerably lower than is that in the Unit 1 system. The former system is obviously larger and contains a greater number of heat exchange components. Along these lines it would appear that Unit 2 Service Water System operates with a significantly higher differential pressure than does that associated with Unit 1.

The metallurgies of both service water systems have been reported to us as being extremely mixed. As a minimum, we are told that Unit 1 Service Water System contains carbon steel, aluminum, copper, galvanized steel, Admiralty and 304 stainless steel. That of Unit 2 contains, by report, carbon steel, 304 stainless steel, copper, 90/10 copper-nickel and Admiralty. It would seem that both systems could benefit from a reduction in the number types of material employed.

The intermediate cooling water exchangers associated with Unit 1 appear to be physically located near the service water intake. The component cooling water exchangers associated with Unit 2 appear to be located near the discharge of the Service Water System. Therefore, the latter tend to be the "garbage can" for everything in front of them in the system, i.e., corrosion products, silt, slimes, etc.

There are some rather obvious differences in the elevations of the various exchangers of each of these systems. We would suspect that a thorough problem analysis might show some correlation between the problems and the elevations of various system components.

We believe that some of the heat exchangers associated with Unit 1 tend to run at somewhat higher temperatures than do those associated with Unit 2. We are strictly concerned with the differences between the intermediate cooling water exchangers and the component cooling water exchangers. The FSAR for Unit 2 shows that the total heat load on the CCW exchangers is 52,000,000 Btu per hour. Under normal operation two (2) of the three (3) component coolers would be in service. The rated flow for this service is reportedly 4,860 gallons per minute. The operating temperature differential across this system is designed to be 11.3^{o}F. From other information supplied to us by ARKANSAS POWER & LIGHT COMPANY the actual flow to these exchangers is 4,600 gallons per minute. Using these numbers one can calculate a simple error. Either the total heat load on this system is in error by approximately a factor of two (2) or the cooling water is low by a factor of approximately two (2). In other words, if one calculates the heat sink of the cooling water using these numbers, it is found that approximately 2.0 Btu per hour per ^{o}F are rejected. Obviously, this is an error by approximately a factor of two (2).

If one examines similar data supplied for ANO-1, the numbers show that the operating temperatures of the intermediate coolers differ by 21^{o}F on the waterside. The total heat load is 30,000,000 Btu per hour. The associated water flow is 2,800 gpm. Making a similar calculation from this information yields a heat sink to the cooling water of 1.0 Btu per pound per ^{o}F. Obviously, this is reasonable. What is significant is the difference between the heat removal across these units and their operating temperature ranges. The process side of the component cooling water heat exchangers has a design maximum temperature of 114.3^{o}F.

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That associated with the intermediate cooling water heat exchangers is 125°F. This is one of the major differences between the Service Water Systems of ANO-1 and ANO-2.

In summary of this information, we would prefer to have the Service Water System associated with ANO-1 in our plant as opposed to that associated with ANO-2. We would predict the occurrence of more problems on that associated with ANO-2. We would predict the difficulty of controlling problems to be considerably greater on ANO-2 than it would be on ANO-1. This latter comment is a direct offshoot of the inclusion of shellside exchangers on ANO-2.

SERVICE WATER SYSTEM METALLURGY

At the outset, the ideal system would employ compatible metallurgy such that only slightly differing galvanic couples exist between the various components associated with the Service Water System as well as those associated with the balance of plant. In both ANO-1 and ANO-2 we would prefer to see no copper, no zinc, no copper alloys and no galvanized materials. Obviously, it would be advantageous to also not have to use carbon steel. However, given proper water treatment, carbon steel could be reasonably predicted to perform adequately.

Component failures have been experienced with alloys containing both copper and stainless steel. The failures associated with the former material have been related to the presence of sulfur and/or its compounds. The failures of the 304 stainless steel have been attributed to phenomena associated with the presence of chloride in the water.

At the present time we understand that ARKANSAS POWER & LIGHT COMPANY is considering changing the tubing associated with the shutdown cooling heat exchanger of ANO-2 to an alloy designated as E-Brite 26-1.

We believe that we understand the reasons for this selection of material. However, we also feel that the problems which have brought about the need for change cannot reasonably be expected to be solved by simply changing out the metallurgy of single components. We realize that this type of retrofit maintenance offers your system a condition of improved quality material.

However, we also believe that you are expecting the metallurgy of your system to perform some services which it may not do very well. Very few alloys of steel would be reliably predicted to withstand the underdeposit corrosion phenomena associated with the presence of large accumulations of silt, crud, deposits and/or slimes. Obviously, some materials are better than are others. However, as a general rule, stainless steel should be operated such that its surfaces are kept essentially clean. In all cases, we would recommend laying up this type of system in a clean mode.

Before proceeding further, we have considered a wide variety of metallurgy which could be applicable to your needs. In each of these cases we have attempted to rate the performance of the metal as it would be expected to hold up in service. We have specifically rejected from further consideration the use of copper-containing alloys.

The reason for this latter decision is simply that many of your heat exchangers associated with the Service Water System of ANO-2 appear to be subject to anaerobic conditions, adverse bacteriological growth, etc. When this type of condition exists, sulfur and its compounds typically attack the surfaces of copper-containing alloys. In our judgement, this is sufficient reason for rejection of these materials at this point. We believe that your experience will support this judgement.

The next alloy which we advise ARKANSAS POWER & LIGHT COMPANY to reject from further consideration is titanium. While titanium is a "super" material, it is costly and difficult to fabricate. Additionally, titanium tubing is typically installed in heat exchangers employing thinner walled tubes than those associated with other materials. Because of this fact, the need for extremely careful design and operation of heat exchangers containing titanium tubes is great. We do not feel that this lends itself to the retrofit conditions at your nuclear power generating station. We also do not feel that you would be sacrificing any quality by not using titanium.

The following is a list of alloys which should be considered in this discussion:

Alloy Name	Alloy Predominate Structure
Inconel 625	Austenitic
Incoloy 825	Austenitic
AL 29-4C	Ferritic
AL 6X	Austenitic
E-Brite 26-1	Ferritic
316	Austenitic
304	Austenitic

In your service, we feel that both 304 stainless steel and 316 stainless steel are not good choices of materials. We would make the same statement about respective "L" grades. Certainly, the 304 is not acceptable. The 316 would be predicted to perform considerably better than would the 304. This is particularly true with respect to pitting corrosion. However the 316 alloy is not particularly good where crevices exist.

To facilitate consideration of one (1) item, you will find that we have listed the alloys above in order of decreasing cost. When one is looking at "exotic" materials, cost is a major factor. For example, Inconel 625 would probably be about four (4) times the cost, at least, of E-Brite 26-1. Incoloy 825 would be approximately twice the cost of E-Brite 26-1.

In our opinion AL 29-4C and E-Brite 26-1 offer the best resistence to stress corrosion cracking of the reasonably priced alloys. In other words, we are eliminating Inconel 625 and Incoloy 825 from further consideration because of cost.

We judge AL 29-4C to be superior to both AL 6X and subsequently to E-Brite 26-1 with respect to its resistence to both pitting and crevice corrosion. In a truly fresh water environment we would be tempted to not draw distinction between the pitting and crevice corrosion responses of E-Brite 26-1, AL 29-4C and Al 6X. In a seawater environment, we judge AL 29-4C and AL 6X to be better than E-Brite 26-1 with respect to its resistence to pitting and crevice phenomena. Therefore, the question is how does one go about judging the quality of water at ANO-1 and ANO-2. We are adopting the philosophy that "an ounce of prevention is worth a pound of cure".

To the best of our knowledge AL 29-4C and AL 6X are not properly certified to meet your code requirements. However, we believe that both alloys could be certified on an expedited basis. We are aware that you have discussed this with respect to AL 6X. However, we have not seen any mention of AL 29-4C. We would think it in your best interest to further pursue this matter.

There is one very significant recommendation which we would offer to ARKANSAS POWER & LIGHT COMPANY as a consideration when upgrading your existing heat exchangers. Obviously, the metallurgies associated with tubes, tube sheets, shells, valves, piping, etc. must be sufficiently compatible from the galvanic corrosion point of view. The materials which we have just discussed as being wise recommendations for you to consider as candidate tube materials are considerably more noble than is carbon steel. As a result, we would not recommend your retubing heat exchangers in such a way that the galvanic corrosion potential increases. This situation must be looked at very carefully on an individual system element by element basis. Along these lines, we would suggest that one of the most suitable materials for tube sheet construction in an upgraded exchanger consisting of the metallurgies we have recommended might be AL 4X. This material contains about 4-1/2% molybdenum, should be readily available and should lower the galvanic couple between system elements of construction. We are not certain whether AL 4X meets your code requirements. However, this is simply a matter of a telephone call. If you seriously consider the use of this alloy, we would be happy to get the information for you.

While this is not directly a technical consideration, we think it wise to determine which "fixes" could be capitalized and which "fixes" are simply subject to expensing. We anticipate some highly attractive investment tax credits to be available in 1981. We suspect that new bundles may be subject to such tax credits while retubing may not.

SYSTEM DESIGN CHANGES

During your upcoming refueling outages we would recommend the modification of both service water systems wherever possible.

The most important recommendation would be for ARKANSAS POWER & LIGHT COMPANY to clean each element of the existing system as thoroughly as is possible. This recommendation is not as straightforward as it may sound. The execution of the required cleaning operations may prove to be extremely difficult.

To facilitate the cleaning operations, we would suggest that each individual heat exchanger be valved at their respective feed and discharge headers. Where possible, flushing connections should be installed. Pressure indicating equipment and/or flow indicators should be installed wherever possible. These should best be set up so that functional monitoring can be conducted during operation subsequent to the refueling outages.

We are aware of your plans to additionally replace small bore pipe, ≤ 2-1/2 inch pipe, with 316 L alloy material. This procedure will obviously upgrade your system considerably. However, we still believe that it is necessary to make every possible attempt to operate your system in a clean fashion. Components which are not on the line continually must be flushed prior to layup. Components which are on line continually should have sufficient velocity during operation to enable the transport of siliceous materials from the inlet through the outlet on a quantitative basis. These conditions alone are predicted to go a long way towards eliminating the build up of corrosion products, silt, biological slimes and Asiatic clams in your Service Water Systems.

We would also suggest that you give serious consideration to lining the water boxes of your condensers. We understand that ANO-1 does not employ a cathodic protection system. We also understand that the cathodic protection system on ANO-2 does not work properly. For these reasons, any steps which can be taken to line these water boxes would seem to be much to your advantage.

As we have indicated throughout our work, we judge your corrosion monitoring program to be less than adequate. During July and August of 1980 your water treatment chemical vendor installed a single set of corrosion coupons of three (3) different materials in your recirculating cooling water system associated with ANO-2. The results obtained from this work are judged to be highly unsatisfactory. These corrosion rates were reported to you as ranging from 4.3 milligrams per square decimeter per day with a copper-nickel alloy of unspecified concentration to 764.3 milligrams per square decimeter per day on carbon steel. While this is only one (1) set of results, these are not very encouraging.

Along these same lines, we strongly suspect that you ought to be able to operate your recirculating cooling water system without specialty chemical treatment. We believe that you could properly feed a combination of sulfuric acid and gaseous chlorine to this system at reasonably low corrosion rates.

With respect to keeping the service water system clean, the recirculating water system clean and the once through cooling water system clean, we would hold very little hope for proprietary dispersants. Most of these dispersants tend to be water suspensions of polyacrylates and/or polymethacrylates. Essentially these materials operate to lower the bulk density of the siliceous materials present in the raw water. With a lower bulk density, these materials tend to carry through the system to the point of discharge rather than settle out in the system. Our estimation of the cost for treating these units chemically seems to be considerably higher than does yours. We would predict that this would prove to be somewhere between $150,000 per year and $300,000 per year minimum for chemicals alone. In addition, highly adverse affects could be experienced in components of your system which continue to have dead areas and/or which are laid up in the presence of water-containing solids plus chemicals. Many salts of both polyacrylates and polymethacrylates are insoluble. Excessive concentrations of these materials tend to be very viscous. Additionally, these materials tend to be biodegradables, i.e., food for biological organisms. We would recommend that every possible effort be made to not rely on the feed of such specialty chemicals as a solution to existing problems. We regard this as a last ditch, trial and error measure.

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When performing any mechanical modifications on your system, we would strongly suggest that all modifications provide for the maximum
12 possible degree of ease with respect to accessibility to system components. Where piping and/or heat exchangers can be open, ARKANSAS POWER & LIGHT COMPANY will have an advantage. This includes such items as the relocation of branch connections off headers from the bottom of pipes to the top of pipes. Incidentally, this was not our idea. All credit for this recommendation should be given to ARKANSAS POWER & LIGHT COMPANY personnel.

13 The installation of flushing connections on the shells of any shellside heat exchangers is recommended. We also recommend the installation of
14 inspection ports.

Any modifications which result in a demand for electricity during operation and/or critical safety modes should first consider diesel generator capacity at ANO. Care should be taken when installing motor operated isolation valves, etc. to make certain that the diesel generator capabilities at ANO can adequately support this increase in electrical demand.

Wherever possible, pipe connections should avoid the creation of
15 stressed areas and/or reduced diameters. In other words, crevices as well as constrictions should be avoided at practically all costs. Stress relieving of welds is considered a "must" to preclude future problems at weld heat affected zones.

In conjunction with all of this work, we advise that you re-evaluate the quality assurance and quality control programs applicable to both Service
16 Water Systems as well as those applicable to other plant water systems. We suggest that any systems requiring chemical monitoring should require the analytical procedures to be fully standardized at least once per week. Incidentally, this is a minimum to our way of thinking. We suggest that

inspection procedures be set in such a way that significant areas of the same piece of equipment be inspected each time equipment is opened. A detailed record of this inspection report should be kept. To facilitate such record keeping, we would suggest that a Critical Inspection Report form be established which forces the inspector to fill out information about the specific areas of the equipment in question. From these, accurate system histories can be constructed.

THE ULTIMATE SOLUTION

The ultimate solution to the problems at ANO-1 and ANO-2 under discussion rests with prolonging the safe and reliable service life of all systems and their components. As a corollary to this recommendation we offer the statement that this should be done at optimum cost. It is very important that one look at optimum cost rather than at low cost. The reason for this statement is simply that in going from one material of construction to a more exotic material of construction in a given system one may simply be prolonging the time to failure and not eliminating the potential for failure.

We have reviewed the several discussions and the written report concerning the installation of backflushable strainers at the inlet of the Service Water Systems on both ANO-1 and ANO-2. We are also extremely familiar with the strainers being considered. We believe these strainers to be of top quality. We further believe that their producer is a relatively easy company with which to conduct business. What we don't know is whether these strainers will work.

The biggest problems which we see with the ANO systems are those which primarily result from the inclusion of silt and corrosion products within the piping associated with the Service Water Systems. We view the other biological problems, chloride stress corrosion problems, sulfide induced attack and/or specifically the Asiatic clam problem to be ancillary and/or secondary. The elimination of silt from your systems promises to be perhaps the single most important consideration. Obviously, the elimination of corrosion product accumulation is being termed as equivalent to the elimination of silt. In other words, the corrosion products are being considered, in the light of this discussion, as a silt. After all, this material or debris simply is transported from one point in your system to another point in the system where it further promotes corrosion and other undesirable effects.

Before leaving this point, we do not agree in any way with several of the statements which have been presented to you relative to the level of chlorides which are tolerable in your water. It is our experience that the tolerable level of chlorides in a given system containing stainless steel components is strictly system specific and very difficult to predict. Minute quantities of chloride in the bulk water phase can concentrate at surfaces to hundreds to thousandths of parts per million. This can then result in underdeposit corrosion, pitting, etc. In fact, this phenomenon is well known to NSSS vendors. To the best of our knowledge the most rigid specifications existing among vendors require that bulk chlorides in water contacting stainless steel be limited to 0.15 mg/L. This same specification requires the surface of piping to not be contaminated with more than 0.0015 milligram per square decimeter of chlorides. Obviously, this quantity of chloride in the bulk phase of water is considerably less than the 3 mg/L value which has come up in discussion. In other words, the system must be kept clean and the chlorides should be kept as low as is possible.

We view the reliance of eliminating Corbicula and/or other future molluscs from habitating in your water systems to be somewhat of a gamble if only strainers are used. Additionally the supplemental use of chlorination is not the most desirable procedure.

To our way of thinking, the most desirable procedure would be to install closed loop cooling water systems in place of the existing once through service water systems.

A reasonable alternative might be the installation of clarification equipment and/or filtration equipment. Considering the capacity of this equipment to be able to handle approximately 40,000 gallons per minute of water over a wide range in temperatures, one can see readily what the cost of this equipment might be. The cost for what we consider to be the best clarification equipment on the market would be somewhat under $2,000,000 at the present time. The cost for the proprietary elements of a suitable filtration system capable of polishing the clarified water would be expected to range just under $1,000,000. The cost of single stage, front end filtration equipment is estimated to cost $2,500,000 to $3,000,000. More detail on these alternatives will follow in our final report.

We strongly believe that clarifier sludge can be recategorized for ease of disposable. However, we also acknowledge this to be a very realistic problem which must be addressed squarely. One alternative which might suit ARKANSAS POWER & LIGHT COMPANY's needs would be to consider building a water treatment plant which could service the needs of the City of Russellville, Arkansas, etc. We believe the City of Russellville is in rather severe need of an upgraded water treatment system. In addition to potentially providing an economic advantage to ARKANSAS POWER & LIGHT COMPANY such a system could upgrade living conditions in the area adjacent to ARKANSAS POWER & LIGHT COMPANY's operations. In other words, the needs of both the community and of the nuclear plant could be satisfied in a single venture.

We would recommend that every possible effort be made to construct the cooling water system modifications in such a way that they do not require special qualifications. In other words, we would recommend that the existing open recirculating system be left intact as a bypass to any system modification. Obviously, this recommendation would require that certain motor-operated isolation valves be installed at important points in the system such that when safety considerations require, the appropriate valve line up will result.

CONCLUSION

Mr. Williams, we believe that this report contains both a sizable number of recommendations and some highly important recommendations. We also view this report, as previously stated, as being preliminary. Because of this fact and in the best interest of time, we would ask that you contact us with your comments and those of your associates as rapidly as is possible. We, in turn, will make every effort to factor these comments directly into our final report preparation.

Thank you once again for the opportunity to be of service to you and your associates.

Very truly yours,

Thomas M. Laronge

Thomas M. Laronge,
President

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ATTACHMENT I

RANGE OF ANTICIPATED SERVICE WATER QUALITY[1]

Parameter	Low	High	Average[2]
pH, pH Units	6.5	9.5	8.2
Total Hardness, mg/L as $CaCO_3$	50	225	
Calcium, mg/L as Ca	10	90	44
Magnesium, mg/L as Mg	1	25	
Sodium, mg/L as Na	30	165	
Potassium, mg/L as K	0	10	
Total Iron, mg/L as Fe	0.1	1	
Total Manganese, mg/L as Mn	0	1	
M Alkalinity, mg/L as $CaCO_3$	40	120	80
P Alkalinity, mg/L as $CaCO_3$	0	0	0
Chloride, mg/L as Cl	40	200	
Sulfate, mg/L as SO_4	20	100	
Nitrate, mg/L as NO_3	0	10	
Fluoride, mg/L as F	0	1.5	
Silica, mg/L as SiO_2	0.2	10	
Total Dissolved Solids, mg/L	150	800	350
Suspended Solids, mg/L	10	100	50
Total Solids, mg/L	160	900	400
Equivalent Specific Conductance, umhos/cm	250	1,200	
Turbidity, NTU	10	80	
Temperature, °F	33	130	100[3]

Notes for Table I:

1. The values which appear in this table have been strictly synthesized for the purpose of generating a reasonable working base.

2. The term average actually has little to no meaning. This is presented here for purposes of calculating a Langelier Saturation Index and a Ryznar Stability INdex.

3. This average temperature value assumes that the water is sampled at the discharge of the service water system.

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ATTACHMENT II

RANGE OF ANTICIPATED SERVICE WATER TENDENCIES TO SCALE WITH CALCIUM CARBONATE OR TO BE CORROSIVE TO MILD STEEL[1,2]

	Langelier Saturation Index	Ryznar Stability Index
Highest apparent scaling tendency water composition[3,5]	2.6	4.3
Lowest apparent scaling tendency water composition[4,5]	-3.0	12.5
Average water composition	0.5	7.3

Notes for Table II:

1. All calculations are based upon data taken from Table I.
2. All calculations are approximate.
3. Calculations based upon the assumption that the worst scaling water occurs when pH, alkalinity, temperature and calcium are at the maximums while total solids are at the minimum.
4. Calculations based upon the assumption that the most corrosive water occurs when pH, alkalinity, temperature and calcium are at the minimums while total solids are at the maximum.
5. The assumptions in notes 3. and 4. above are strictly those implicit in the calculation of the Langlier Saturation Index as a result of the inverse solubility of calcium carbonate with temperature. We are specifically not stating that corrosion rates are inversely related to temperature.

Thomas M. Laronge, Inc.

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January 19, 1981

ARKANSAS POWER & LIGHT COMPANY
P. O. Box 551
Little Rock, Arkansas 72203

Attention: Mr. Dan H. Williams,
Generic Projects Coordinator

SUBJECT: RECOMMENDATIONS FOR THE SERVICE WATER SYSTEMS
- ARKANSAS NUCLEAR ONE - UNITS 1 & 2 -
AP&L CONTRACT NO. L-020G, TASK NO. 001P, PLANT ANO
T.M.L. PROJECT NO. 032-01-001

Dear Mr. Williams,

Attached to this letter please find fifteen (15) copies of our report titled in subject. If you need other copies, kindly let us know. You will note that we retained the original of this report so that we can reproduce this rapidly.

In the preparation of this report, we have furthered our work reported to you on December 15, 1980 and attempted to incorporate the comments of yourself and your co-workers.

We feel safe in stating that the general consensus of opinions which we received on our report of December 15 was the desire that the attached report contain as many "specifics" as is possible. In addition to attempting to be specific in this report, we trust that the organization of the material presented is readily usable.

Please let us know if you have any questions and/or if we can be of any further assistance.

Very truly yours,

Thomas M. Laronge

Thomas M. Laronge,
President

TML:mt

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