UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

In The Matter of	:	
	:	
Georgia Power Company, *et al*.	:	
	:	
(Vogtle Electric Generating Plant, Units 1 and 2)	:	DOCKET NO. 50-424-OLA 50-425-OLA
	:	ASLBP NO. 90-617-03-OLA

AFFIDAVIT OF JOHN DAVE LISENBY
IN SUPPORT OF APPLICANTS' RESPONSE TO
THE BOARD'S MEMORANDUM AND ORDER OF JANUARY 22, 1991

I, John Dave Lisenby, having first been duly sworn, hereby depose and state as follows:

1. I am currently employed by Southern Company Services, Inc. as a Senior Engineer in the Nuclear Plant Support - Vogtle Department. My office is located in Birmingham, Alabama. Southern Company Services is a subsidiary of The Southern Company, and currently provides technical support services to its affiliates, including the Southern Nuclear

Operating Company, Georgia Power Company and Alabama Power Company.

2. I graduated from the University of Alabama in 1980 with a Bachelor of Science degree in Mechanical Engineering. I was employed by Georgia Power Company in 1980. My first position was a Junior Engineer at the Vogtle Electric Generating Plant ("VEGP"). However, I was assigned to the Edwin I. Hatch Nuclear Plant and worked as a system engineer for an interim period until Plant Vogtle was ready for start-up. I held this position at Plant Hatch for one year, after which I transferred to Southern Company Services and performed mechanical design work in support of Plant Hatch. In 1984, I was transferred to Plant Vogtle where I held the position of a start-up test supervisor. In this position, I assisted Georgia Power personnel at the VEGP in the pre-operational testing and start-up of the diesel generators. In 1986 I was transferred into the Southern Company Services/Bechtel Project field design support group, where I worked until August, 1986. In August, 1986, I left Southern Company Services and went to work with Franklin Engineering in Panama City, Florida. At Franklin Engineering I was responsible for performing mechanical failure analysis. This involved investigating failures of mechanical components and systems to determine the cause of the failure as well as to

determine if proper codes and standards were applied to the original design. On occasion I would also provide recommended design changes to repair the failure. In August, 1989, I came back to work at Southern Company Services in the Nuclear Plant Support - Vogtle Department, where I hold the position of Senior Engineer. My mechanical design experience includes application of Nuclear Regulatory Commission requirements and recommendations to proposed modifications of the mechanical systems of the VEGP. I hold Professional Engineer's licenses from the States of Alabama, Georgia and Florida.

3. In my present position I provide design analysis and evaluations for proposed changes or modifications to VEGP systems. Depending upon the nature of the proposed change, the mechanical discipline may have the lead in reviewing the proposed change relative to NRC requirements, industry standards and prudent engineering judgment. This review is reflected in "Design Change Packages," commonly referred to as "DCPs." The DCP process provides for a structured, comprehensive, inter-disciplinary review of proposed changes. Extensive discussion between the disciplines and with plant site representatives associated with this review are undertaken to identify and address the safety-related impact, if any, associated with a particular design change.

4. Shortly after the March 20, 1990 event at Unit 1 of the VEGP, I was assigned to review the trip logic for the High Jacket Water Temperature ("HJWT") trip on the emergency diesel generators in the nuclear industry, including those manufactured by the vendor of the VEGP diesel generators. I also personally reviewed the procurement specification for the diesel generators at the VEGP. Thereafter, Bechtel Power Corporation was retained to examine more formally the trip functions for the VEGP relative to those functions at other plants. The Bechtel review concludes that the VEGP diesel generators were unique in their trip logic for loss of station power ("LOSP") (i.e., protective trips for high lube oil temperature, low jacket water pressure, high bearing temperature and several non-essential trip functions were active for LOSP). As one of many approaches to enhance the operation of the VEGP diesel generators, the VEGP trip logic was modified so that, today, during an emergency LOSP start signal the diesel generators do not trip for the non-essential trip functions.

5. In addition to modification of the LOSP trip logic, I was responsible for contacting licensed facilities to determine whether the HJWT trip on diesel generators manufactured by the same manufacturer as the VEGP diesel generators was "active" or operational during emergency

starts. The results of my efforts are summarized in an October 11, 1990 letter from W.C. Ramsey to Mr. C.C. Miller, which is included in Exhibit 9 of the Applicants' Supplemental Statement dated November 14, 1990. These types of data, together with experience with "Calcon" temperature sensors, lead to the licensee's decision to examine whether a bypass of the HJWT trip logic during emergency starts complied with regulatory/licensing requirements. I was the Lead Discipline Responsible Engineer for the DCPs which address the removal of the HJWT trip from the diesel generator trip logic during emergencies. The DCPs are included as Exhibit 1 to the Applicants' Supplemental Statement. The Safety Evaluation in these DCPs conclude, among other things, that the proposed change does not increase the probability of or consequences of the "design basis" accidents described in the VEGP's Final Safety Evaluation Report ("FSAR") and does not decrease the margin of safety defined in the "design basis" indicated in the VEGP's Technical Specifications.

6. This Board, in its January 22, 1991 Memorandum and Order, poses the question whether the applicants intended to use "a mandatory term such as 'will' or 'must,' at DCP-90-V1N0138-0-1, page 1 of 2, and DCP-90-V2N0166-0-1, page 1 of 2". The answer is "no"; the word "should" as used in the DCP

cited Narrative Design Summaries is used correctly. The DCP's analysis and conclusions are not dependent upon the dispatch, or presence, of a local operator at the emergency diesel generator control panel to meet regulatory requirements. More specifically, under all design basis analysis the control room operator has sufficient time to take appropriate action without reliance on the dispatch of a local plant equipment or licensed operator to the diesel generator. If the DCP analysis had indicated that a local operator was required to meet design basis requirements, the word "will" would have been used and a regulatory obligation made to dispatch the operator.

7. The reason the discussion of a dispatch of a plant equipment or licensed operator is included in the DCP is a recognition of the real-world practice, and the associated additional flexibility, of response actually available to the control room licensed operators. In other words, the DCP's references to the dispatch of a local operator places in context the elements of the design basis analysis. The relevant Narrative Design Summary wording, stripped of this context language and edited for clarity, would read as follows:

> This change will prevent the diesel generator from tripping on High Jacket Water Temperature (200°F) during emergency starts. However, the High Jacket Water Temperature alarm (190°F, window C04 on Annunciator Light

Board 35) will remain operable and still annunciate. If a high temperature alarm is received, the licensed operator in the control room will be required to evaluate the cause of the actuation of the High Jacket Water Temperature (190°F) alarm's annunciation and take appropriate action or trip the diesel from the control room. Except for a design basis fire scenario, the design basis of the plant assumes LOSP and the ability to lose one diesel generator, and the other diesel generator would still be available. The length of time, therefore, for heat-up from 190°F to damage of the diesel generator is not a factor under design basis analysis of the Plant except a control room fire scenario.

For the most limiting design basis scenario (i.e., control room fire where only one diesel generator is assumed available), all annunciation in the control room will be lost, and there is no annunciation at the remote plant shutdown panel to which the licensed operators would move. The NSCW flow to the jacket water heat exchanger could also be reduced in this scenario. Therefore, operator action may be required to establish adequate NSCW flow to the jacket water heat exchanger within thirty (30) minutes of the control room fire.

8. Calculations in support of the DCP were developed and approved which established that the diesel generators can operate for thirty (30) minutes with the potential reduced NSCW flow of 500 gpm at a temperature up to 100°F for the NSCW water without damage to the diesel generators. Mr. Patrick M. Madden, in his affidavit filed with this Board in the NRC Staff's Comments of January 11, 1991, discusses his review of this calculation (page 4, Item 4).

9. Subsequent to the development of the DCP, the NRC Staff in December, 1990 requested a determination of the time available for the control room operator to take action following receipt of the high jacket water alarm at 190°F and

prior to the time the jacket water temperature reaches 200°F, assuming loss of cooling. This request is referenced in Mr. Ralph E. Architzel's affidavit (pages 6 and 7) submitted with the NRC Staff's Comments of January 11, 1991. The Board should note that engine damage is not likely to occur without extended operation above 200°F, and such factors as load, duration of operation prior to alarm and initial water temperature will affect temperature rise above 200°F.

In responding to the Staff's request to determine the rate of temperature rise and operator time available, I obtained a 1980 vendor calculation applicable to a foreign plant with the same model diesel generators and, using data for the VECP diesel engines (e.g., generator output of 5517 Kilowatts and with no NSCW flow), calculated a temperature rise of approximately 10°F/minute under maximum LOSP loads. Attachment A, attachment 3, to this Affidavit sets forth that calculation (the 1980 calculation determined the jacket water temperature after running three (3) minutes with no raw water circulation at 110% load. That calculated temperature was 204°F. Applying the historic calculation for a 10°F rise yielded 1.03 minutes). The 10°F/minute rise also would apply to temperatures below 190°F (e.g., 160°F to 170°F, 170°F to 180°F, etc.)

10. In reality, additional assurance exists that those scenarios examined by the DCP will be handled in a manner which assures alternate supply of electric power for the plant's safety systems. My understanding is that plant practice *is* for a plant equipment or licensed operator to be dispatched to the diesel generators upon an automatic (emergency) diesel start to monitor the diesel generator locally, including HJWT. If a high temperature alarm is received, the dispatched operator will be monitoring the temperature at the local engine control panel and, if the temperature in the jacket water system exceeds 190°F, the dispatched operator (who is dispatched upon emergency start, when the jacket water temperature is in the range of 145°F to 165°F) or control room operator will have adequate time to trip the diesel. Moreover, as recognized by the DCP (page 5 of the Safety Evaluation) and the NRC's Ralph E. Architzel (pages 7-8 of his January 11, 1991 Affidavit), if an HJWT event were to occur and the diesel was damaged, the other train would be available under single failure scenarios to safely shut down the plant.

11. In its January 22, 1991 Order the Board also requested information on "the observed failure rate in the industry of the three way valve that bypasses the NSCW/jacket water heat exchanger." The Applicants are aware of only one

failure of this thermostatic control valve to open in application at a nuclear facility, which occurred in May, 1986, at a domestic facility. The failure occurred while the diesel generator was undergoing surveillance testing and, after running four (4) minutes unloaded and loaded to 5800 Kw for eleven (11) minutes, the operator in the Control Room manually shut down the engine after receiving high vibration, high jacket water temperature trip, high engine bearing and high jacket water inlet temperature alarms. The failed thermostatic control valve was caused by a failed "power assembly." [The "power assembly" is a container filled with wax pellets which melt and expand to open the valve at a prescribed temperature. The event was formally reported to the NRC by a Special Report dated June 18, 1986]. The domestic licensee at that time conducted discussions with the valve manufacturer which indicated no previous power assembly failure in the industry. The engine was not damaged by this event (e.g., no bearing damage).

In February, 1991 we contacted Cooper Industries (the diesel engine manufacturer) and, in the time available, made contact with knowledgeable representatives at six of the domestic nuclear plants with diesel engines manufactured by Transamerica-Delaval Industries/Enterprise Engine Division (the corporate predecessor of Cooper Industries). A search

of NPRDS data was also conducted for reports of Amot (the valve manufacturer) three-way valve problems, regardless of diesel generator manufacturer. Our investigation found that the May, 1986 three-way valve failure was the only failure where the valve did not open (in addition, four plants had experienced nine separate occasions in which the valve, while permitting adequate flow, failed to limit flow. As a result, additional cooling occurred).

Based on the fact that only one failure of the three-way valve is known to have occurred where the valve failed closed, the duration required for heat-up to alarm on that occasion (over eleven minutes under load), and the high frequency of surveillance testing of the diesel engines in the industry (at least once per 31 days per diesel), the reliability of the valve has been demonstrated to be very high and the likelihood of a three-way valve failure causing a complete loss of coolant flow to the jacket water heat exchanger and resultant diesel engine damage is remote.

12. I have reviewed a calculation submitted by GANE's letter of January 22, 1991 to this Board which purports to calculate the temperature rise of the diesel engine's jacket water upon total loss of NSCW cooling. GANE's calculation is premised on a "heat load" which is wrong for several reasons. Foremost, the heat load of approximately 24.6 million BTU/hr.

assumed by GANE is really the cooling capability of the NSCW flow through the heat exchanger, assuming a 100°F inlet temperature and a 133°F outlet temperature. GANE incorrectly assumed that this value was the heat generated by the diesel engine (i.e., no margin). The heat being rejected to the jacket water by the engine under maximum LOSP load of 5517 Kilowatts, however, is actually around 10.9 million BTU/hr. See, April 12, 1990 letter from Cooper Industries (Attachment 1 to Attachment A, p. 1 of 3). Thus, the NCSW flow as calculated by GANE is capable of cooling over two times the heat rejected by the diesel to the NSCW flow. The temperature rise per minute estimated by GANE, therefore, is in gross error -- comparable to calculating the temperature rise of a reactor of a plant by determining the cooling capability of the plant's cooling water capacity.

13. Actual data from VEGP diesel generator runs taken from diesel generator operating logs (VEGP Procedure 11885-C), including NSCW inlet and outlet temperature and NSCW flow, were analyzed independent of my calculations to determine the observed "heat load" rejected by the diesel engines to the NSCW. The analysis estimated 13.48 million BTU/hr. actually rejected under generator loads of, approximately, 7,000 Kilowatts. Extrapolating from this observed heat load to the heat load from the engine for

maximum LOSP generator load of 5517 Kilowatts yields approximately 10.7 million BTU/hr (= 13.48 x 106 BTU/hr. x 5517 Kilowatts/7000 Kilowatts), and verifies the Cooper Industries value of 10.9 million BTU/hr. (Attachment 1 to Attachment A, p. 1 of 3).

The foregoing is true and correct to the best of my knowledge and belief.

John Dave Lisenby

John Dave Lisenby

Sworn to and subscribed before me this 18 day of March, 1991.

Ginger Cartee

Notary Public

MY COMMISSION EXPIRES JANUARY 12, 1993

ATTACHMENT A

Calculation Cover Sheet

Southern Company Services

Calculation Number	X4C2403V06
Discipline	MECH.
Number	V4-0047

Project: PLANT VOGTLE Units 1 & 2

Objective: Determine time for JW Temp to increase with NO NSCW

Subject/Title: Diesel Generator Jacket water Temperature Rise At No NSCW Flow

Originator's Signature	Date	Last Page Number
[signature]	2/14/91	10

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Topic	Page	Attachments (Computer Printouts, Technical Papers, Sketches, Correspondence, etc.)	Number of Pages
Purpose of Calculation/ Summary of Conclusions	1 & 3	April 12, 1990 Letter (Carmichael-[illegible])	3
Criteria	1	Feb. 20, [illegible] FAX From C. Carmichael & [illegible]	1
Major Equation Sources/ Derivation Methods	4-10	12/22/80 Manishan Calculation	2
Assumptions	3		
Listed References	1 & 2		
Body of Calculations	4-10		

Safety Related	☒ Yes ☐ No	Nonsafety-Related That Could Impact Safety-Related	☐ Yes ☒ No

Record of Revisions

Rev. No.	Description	Originator	Date	Reviewer	Date	Approval	Date
0	APPROVED	[signature]	2/11/91	SWA	3/14/91	[signature]	3-18-91

NOTES:

Form No. 9-3630

See Back for Instructions

Design Calculations

Southern Company Services

Project Plant Vogtle Units 1 and 2	Prepared By [signature]	Date 3/11/91
Subject/Title DIESEL GENERATOR JACKET WATER	Reviewed By S. W. Ashurst	Date 3/18/91
TEMPERATURE RISE AT NO NSCW FLOW	Calculation Number X4C2403V06	Sheet 1 of 10

PURPOSE:

The purpose of this calculation is to show that the operator has sufficient time (a minimum of 1 minute) to trip the diesel generator from the control room between the time a high jacket water temperature alarm (190° F at TC-22) is received and when the jacket water temperature reaches 200° F at TC-22.

BACKGROUND:

During an NRC audit in December, 1990, we were requested to determine the time available for the control room operator to take action following receipt of the high jacket water alarm at 190° F and prior to the time the jacket water temperature reaches 200° F, assuming a loss of NSCW cooling to the emergency diesel jacket water. In response to the request we obtained a calculation from Cooper Industries which they had performed on Maanshan on December 22, 1980, which were the same size and model engines, and the generators were also the same capacity as the emergency diesel generators used at the VEGP. Per Cooper Industries, the differences in the two emergency diesel generators would be the routing of the auxiliary piping which could have an effect on the total volume of jacket water. Other than this the emergency diesel generators are basically the same. Using a Maanshan calculation as the bases, we extrapolated a time of approximately 1.03 minutes or 61.8 seconds (see attachment 3). Following the December, 1990, audit, this calculation was generated specifically for the VEGP using the actual data from the VEGP emergency diesel generators.

REFERENCES:

1. April 12, 1990, letter from C. R. Carmichael (Cooper Industries) to David Lisenby (SCS) (attachment 1)
2. Vendor Manual AX4AK01-510 Rev. 5
3. Heat Transfer, McGraw-Hill, J. P. Holman, 1976
4. Vendor Drawing 1X4AK01-344 Rev. 3
5. Vendor Drawing 2X4AK01-345 Rev. 2
6. Vendor Drawing 1X4AK01-346 Rev. 2
7. Vendor Drawing 2X4AK01-347 Rev. 1

REFERENCES (CONTINUED):

8. Fax from C. R. Carmichael to David Lisenby, dated February 20, 1991 (attachment 2)

9. Instrument Setpoint Index CX5DT101-40 Rev. 8

10. Vendor Manual AX4AK01-564 Rev. 16

11. Crane Technical Paper 410, 1981

12. Maanshan calculation (attachment 3)

ASSUMPTIONS:

1. Jacket Water Temperature in the engine jacket water return header at thermocouple TC-22 is 190° F at the beginning of the time interval (note: the temperature in the auxiliary piping will be at a lower temperature than 190° F when a loss of NSCW flow occurs and the temperature will increase to 190° F at TC-22 as it exits the engine jacket. TC-22 is located in the return piping which connects the engine jacket to the jacket water standpipe.). It is assumed that the jacket water temperature increases at a uniform rate (i.e. sufficient time has elapsed since initial start of loss of NSCW flow that the temperature profile around the cooling water loop has become fully developed and is increasing at a uniform rate).

2. The generator output is assumed to be 5517KW which is loss of offsite power load. This is the maximum generator loading required per FSAR Section 8.3 Table 8.3.1-2. Per the manufacturer (Reference 1), the equivalent engine brake horsepower for this generator loading, assuming the generator efficiencies is 7785 BHP.

3. Per the diesel engine manufacturer, the fuel consumption of the engine at 7785 BHP is 0.35 lb/BHP-HR of 18,190 BTU/lb standard fuel providing a total quantity of 49,563,202 BTU/HR (Reference 1).

4. Per the diesel engine manufacturer, the heat rejection to jacket water, including jackets, lube oil and air coolers equal 12% + 4% + 6% (Reference 1), respectively, which is (note: the heat input from the engine driven jacket water pump is assumed to be negligeable):

$$(49{,}563{,}202 \text{BTU/HR}) * (0.22) = 10{,}903{,}484 \text{ BTU/HR} = Q$$

5. No NSCW flow exists to the diesel jacket water heat exchanger.

ASSUMPTIONS (CONTINUED):

6. We calculate the heat transfer between the jacket water and the auxiliary piping metal, however, we assumed no heat transfer between the jacket water and the engine block (i.e. as the temperature of the water increases, the metal in the engine block will also increase. The increase in the metal temperature will be the result of the water giving up heat to the metal. This process will remove BTU's from the jacket water that were input from the engine. However, by assuming no heat transfer from the jacket water to the metal is conservative for this calculation.)

7. No heat loss to the environment is assumed (i.e. the piping is not insulated and therefore, some heat will be lost to the environment as the jacket water passes through the piping and the piping is heated by the jacket water. Heat will also be lost from the engine block to the environment. However, by assuming no heat loss to the environment the calculation is conservative.)

8. Assumed no heat transfer to the NSCW in the tubes of the heat exchanger (i.e. the NSCW will be at a lower temperature than the jacket water. Therefore, heat will be transferred from the jacket water to the NSCW. However, by assuming no heat transfer the calculation is conservative.)

9. 1 minute is an acceptable time for operator actions (based on discussions between site personnel (operations) and the NRC).

SUMMARY OF CONCLUSIONS:

With no NSCW flow to the emergency diesel generator jacket water heat exchanger, an operator will have adequate time, based on the criteria used in this calculation, to respond to a high jacket water temperature alarm and verify the other diesel is running or, if not running, start the other diesel generator, and secure the failed diesel generator before more serious damage occurs to the diesel engine as a result of the high jacket water temperature.

CALCULATION:

TOTAL COOLING WATER VOLUME

Per Reference 8, the volume of water in the engine jacket (V_{engine}) is approximately 920 gallons (123 Ft^3).

Per References 4, 5, 6, and 7, the volume of water in the shell side of the jacket water heat exchanger and the tube side of the lube oil heat exchanger is 29 Ft^3 (216 gallons) and 28 Ft^3 (209 gallons). These volumes were calculated as shown below:

For the jacket water heat exchangers, Per References 4 and 5 there are 466 3/4" O.D. tubes inside the shell of the jacket water heat exchanger. Each tube is 22' long. There are 90 1/2" O.D. spacers which are 22' long. There are 18 baffles 1/4" thick and 23.25" in diameter (note that the baffles are not solid but have holes in them. However, for conservatism, we will assume the baffles are solid.). The shell of the heat exchanger is 23.25" in diameter and 22' long in the shell area. The volume of water in the shell side of the heat exchanger will be:

$\pi \times (23.25 / 24)^2 \times (22) = 64.86\ Ft^3$ (shell)

$\pi \times (0.75 / 24)^2 \times (22) \times (466) = 31.45\ Ft^3$ (tubes)

$\pi \times (0.5 / 24)^2 \times (22) \times (90) = 2.7\ Ft^3$ (spacers)

$\pi \times (23.25 / 24)^2 \times (0.25 / 12) \times (18) = 1.11\ Ft^3$ (baffle)

Total volume = 64.86 - (31.45 + 2.7 + 1.11)

Total volume = 29.6 Ft^3

Therefore 29 Ft^3 is conservative

For the lube oil heat exchangers, Per References 6 and 7 there are 400 3/4" O.D. tubes (I.D. for the tubes is 0.652"). Each tube is 22' long. There are 2 ends on the heat exchanger which contain jacket water. Each end is 22" O.D. (assume 20" I.D. for conservatism) and approximately 22" long. The volume of water in the tube side of the heat exchanger will be:

CALCULATION (CONTINUED):

$\pi \times (0.652 / 24)^2 \times (400) \times (22) = 20.4 \text{ Ft}^3$ (tubes)

$\pi \times (20 / 24)^2 \times (20 / 12) \times (2) = 7.2 \text{ Ft}^3$ (ends)

Total volume = 20.4 + 7.2

Total volume = 27.6 Ft^3

The following is a breakdown of the volume of water in the auxiliary piping as given in Reference 2:

Vendor Drawing Number 102138

47.0' of 8" pipe

18.0' of 6" pipe

Vendor Drawing Number 102140

6.0' of 10" pipe

Vendor Drawing Number 102141

31.0' of 6" pipe

Vendor Drawing Number 102144

4.0' of 8" pipe

Total volume of water in the auxiliary piping is:

For 6" pipe:

$\pi \times (6.065/24)^2 \times 49 = 9.83 \text{ Ft}^3$

For 8" pipe:

$\pi \times (7.98/24)^2 \times 51 = 17.71 \text{ Ft}^3$

For 10" pipe:

$\pi \times (10.02/24)^2 \times 6 = 3.29 \text{ Ft}^3$

$V_{pipe} = 9.83 + 17.71 + 3.29$

$= 30.83 \text{ Ft}^3$

CALCULATION (CONTINUED):

Per Reference 2 the jacket water standpipe is 30" inside diameter and the water height in the standpipe is 180" (Reference 9). Therefore, the volume of water in the standpipe is:

$$V_{stpipe} = \pi X (30/24)^2 X 15 = 73.63 Ft^3$$

There are two air intercoolers for each engine and, per Reference 10, each intercooler has 512 3/8" tubes (0.025" wall thickness) and are 42" long. The total volume of water in the intercoolers is:

$$V_{inter} = \pi X (0.325 / 24)^2 X (42 / 12) X 512 X 2$$

$$V_{inter} = 2.06 Ft^3$$

Total volume of jacket water in the emergency diesel generator engine jacket water system is:

$$V_{total} = V_{engine} + V_{jwhx} + V_{lohx} + V_{pipe} + V_{stpipe} + V_{inter}$$

$$V_{total} = 123 + 29 + 27.6 + 30.83 + 73.63 + 2.06 = 286.12 Ft^3$$

Converting the volume of water to mass of water gives:

$M = 286.12 Ft^3 X 60.23 Lb/Ft^3$ (assume water density at 195° F)

M = 17,233 Lbs

Calculating the time for the jacket water to increase 10° F (from 190° F to 200° F) gives:

$$Q = (M/t) X C X T$$

Where: Q = Heat Transfer = 10,903,484 BTU/HR X (1 HR/60 Min) = 181,724.73 BTU/Min

M = Mass of water = 17,233 Lbs

t = Time

C = Specific Heat = 1 BTU/Lb-$^\circ$F

T = Temperature increase = 10° F

CALCULATION (CONTINUED):

Therefore:

t = (M X C X T) / Q

t = (17,233 X 1 X 10) / 181,724.73

t = 0.948 Minutes = 56.9 Seconds

Due to the fact that all of the jacket water piping (part of the piping to the intercoolers, piping to the turbochargers, and water in the turbochargers) was not included in the above calculation, the 56.9 seconds is conservative and will be taken to be 57 seconds.

Some of the heat will be used in raising the temperature of the metal in the piping and engine block. The heat required to raise the temperature of the metal 10° F in the auxiliary piping is:

For the 10" schedule 40 piping, there is 6 feet of piping. Therefore:

Volume of 10" piping = ((10.02 + 0.365) / 12) X π) X (0.365 / 12) X 6

= 0.49 Ft^3

For the 8" schedule 40 piping, there is 51 feet of piping. Therefore:

Volume of 8" piping = ((7.981 + 0.322) / 12) X π) X (0.322 / 12) X 51

= 2.97 Ft^3

For the 6" schedule 40 piping, there is 49 feet of piping. Therefore:

Volume of 6" piping = ((6.065 + 0.280) / 12) X π) X (0.280 / 12) X 49

= 1.9 Ft^3

For the standpipe, per Reference 2, we will use a height of 15' and an inside diameter of 30" and a wall thickness of 0.375"

CALCULATION (CONTINUED):

Volume of standpipe piping = (30 / 12) X π X (0.375 / 12)

X 15

= 3.68 Ft^3

For the jacket water heat exchanger, per References 4 and 5, we will use a length of 22' and an inside diameter of 23.25" and a wall thickness of 0.375"

Volume of Htexch piping = (23.25 / 12) X π X (0.375 / 12)

X 22

= 4.18 Ft^3

The total volume of pipe will be:

Total Volume = 0.49 + 2.97 + 1.9 + 3.68 + 4.18

= 13.22 Ft^3

The density of the piping will be (based on 10" schedule 40 pipe. Reference 11):

Density of 10" piping = 40.48 Lbs/Ft / (((10.02 + 0.365) / 12) X π X (0.365 / 12))

= 489.5 Lbs/Ft^3

The mass of the piping is:

Mass = 489.5 Lbs/Ft^3 X 13.22 Ft^3

= 6,471 Lbs.

CALCULATION (CONTINUED):

Calculating the heat transfer rate to the piping for a piping temperature increase of 10° F:

q = M X C X T

Where: q = Heat Transfer = BTU

M = Mass of steel = 6,471 Lbs

t = Time

C = Specific Heat = 0.113 BTU/Lb-$^\circ$F (this is at 68° F. As temperature increases this value increases therefore, this value is conservative. Reference 3)

T = Temperature increase = 10° F

Therefore:

q = 6471 Lbs. X 0.113 BTU/Lb-$^\circ$F X 10° F

q = 7312 BTU

The time to heat the metal will take:

t = 7312 BTU / 181,724.73 BTU/Min

t = 0.04 Min. = 2.4 seconds

Therefore, the temperature of the jacket water at TC-22 will increase from 190° F to 200° F in approximately 59 seconds by assuming the heat generated by the engine is transferred to the jacket water and the metal in the auxiliary piping system. This

CALCULATION (CONTINUED):

does not consider any heat lost to the engine piping (jacket water return piping which is considered part of the engine piping, intercooler piping, turbocharger piping, etc.) or to the engine block material. This calculation also does not take credit for any heat transferred to the NSCW in the tube side of the jacket water heat exchanger. Considering the fact that these heat dumps were not considered in the calculation, it can be concluded that the time for the temperature in the jacket water system to increase from 190° F to 200° F will be at least 1 minute. Therefore, based on the criteria of 1 minute being adequate time for operator action as stated in the assumption section of this calculation, an operator will have sufficient time to trip the diesel generator from the control room from the time a high jacket water temperature alarm (190° F at TC-22) is received and when the jacket water temperature reaches 200° F at TC-22 (this is a 10° F per minute temperature rise of the emergency diesel generator jacket water at LOSP load).

CONCLUSION

Based on the above calculation and discussion, an operator will have sufficient time to trip the diesel generator from the control room between the time a high jacket water temperature alarm (190° F at TC-22) is received and when the jacket water temperature reaches 200° F at TC-22.

ATTACHMENT 1
Calc # X4C2403V06
Page 1 of 3

ENERGY SERVICES GROUP

April 12, 1990

Southern Co. Services
P.O. Box 2625
Birmingham, AL 35202

Attention: Mr. David Lisenby

Subject: Georgia Power, Plant Vogtle NGS
Enterprise Engines 76021/24
Operation on Limited Service Water
Enterprise Job. No. S88841

References: Telecons of April 7, 8 and 9, 1990, with D. Lisenby, R. Patrick, and C.R. Carmichael

Gentlemen:

This is to confirm and summarize information given to Mr. David Lisenby on April 9, 1990, concerning diesel generator operation at the Vogtle plant with limited cooling water availability.

Based on information given to *Enterprise*, an analysis was made of engine conditions to determine if the unit could operate with interrupted, then reduced, service water flow to the jacket water cooler.

1.0 ANALYSIS SHALL DETERMINE:

A. Time that engine could operate with service water completely shut off to the jacket water cooler.

B. If engine can operate for 30 minutes with service water flow to the cooler reduced to 500 GPM and at a temperature of 95° F.

2.0 OPERATING CONDITIONS

2.1 J.W. temperature at load initiation is 145° F.

2.2 Engine load will increase to 5517 KW, equal to 7785 BHP.

2.3 Fuel consumption is 0.35 lb/BHP-HR of 18,190 BTU/lb standard fuel providing a total quantity of 49,563,202 BTU/HR.

2.4 Heat rejection to J.W., including jackets, lube oil and air cooling, equals 12% + 4% + 6%, or 10,903,484 BTU/HR.

ENTERPRISE ENGINE SERVICES

14490 Catalina Street
P.O. Box 1837
San Leandro, CA 94577
(415) 614-7400 Fax (415) 614-7409

ATTACHMENT 1
Calc. # X4C2403V06
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2.5 500 GPM of service water enters J.W. cooler at 95° F after approximately two minutes from start.

2.6 Based on a given mixed water temperature of 150° F to lube oil cooler, calculation provides overall heat transfer coefficient U, of 178.94 for J.W. cooler under the given conditions.

2.7 Lube oil cooler U remains at 58.4 since only temperature change slightly, not flows. L.O. enters cooler at 180° F, exits at 165° F; J.W. enters at 150° F, exits at 159° F.

3.0 J.W. COOLER ANALYSIS (B)

Calculating new temperatures, 740 GPM maximum of 165° F J.W. is reduced to 135° F, to mix with approximately 760 GPM of 165° F water to provide a mixed temperature of 150° F. This provides a new LMTD of 30.27 per the TEMA chart.

Capacity Q_{JW} = = 178.94 x 2013 x 30.27 = 10,903,484 BTU/HR

Required capacity = 10,903,484 BTU/HR so cooler is adequate on this basis as expected. The new coefficient is very conservative since the tube velocity is still nearly 2 ft/second and the new inlet temperature is 95° F.

4.0 L.O. COOLER ANALYSIS (C)

The lube oil cooling load is 4% of 49,563,202 or 1,982,528 BTU/HR. Finned tube area = 4365 sq.ft., new LMTD for L.O. cooler is 15.6 by TEMA chart.

Capacity Q_{LO} = = 58.4 x 4365 x 15.6 = 3,976,690 BTU/HR

Required capacity = 1,982,582 BTU/HR - cooler is adequate.

5.0 HEAT TRANSFER COEFFICIENT, . VERIFICATION

After our telecon of Monday, April 9, it was felt that we should have manufacturers verification of the capability of the jacket water cooler under the new conditions. Consequently, our marketing department applied for and received permission to have a computer calculation made for the cooler.

The attached data sheet shows that under the new conditions, the cooler would have a U coefficient of 225.57, a new LMTD of 24.27, and a new capacity of U x A x LMTD = 11,222,052 BTU/HR, which is greater than required so the conclusion in *3.0* is correct.

ATTACHMENT 1
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5.0 **(Continued)**

The difference between the LMTD of 30.27 given in *Section 3.0*, and the attached data sheet is assumed to be due to the jacket water cooler being a two-pass unit rather than single pass. This reduces the efficiency by approximately 10%.

Trusting that this is the information you require, we are,

Very truly yours,

C.R. Carmichael

C.R. Carmichael
Senior Engineer

CRC:djl

Enclosure (Ref. No. EA-197)

cc: Greg Desin
Allen Gillette

ATTACHMENT 2
Calc.# X4C2403V06

ENERGY SERVICES GROUP

ENTERPRISE

TELECOPIER COVER SHEET

To:
Name: MR. DAVID LISENBY
Firm: SOUTHERN COMPANY SERVICES
City: BIRMINGHAM, ALABAMA
Fax Phone: 205 877-7149
Date: FEB 20, 1991

From:
Name: C CARMICHAEL
Energy Services Group
Enterprise Engine Services
14490 Catalina Street
San Leandro, CA 94577
Fax: (415) 614-7409
Verify Fax: (415) 614-7425

TOTAL NUMBER OF PAGES 1 INCLUDING COVER SHEET

IF YOU DO NOT RECEIVE ALL THE PAGES, PLEASE CALL (415) 614-7425.

DAVID:

REFERENCE: YOUR FAX MESSAGE FEB 14, 1991 WITH CALCULATION NO. X4C2403V ATTACHED.

PER MY TELEPHONE MESSAGE THIS DATE, COOPER ESG. HAS REVIEWED THE REFERENCED CALCULATION AND ADVISES GENERAL AGREEMENT.

THE ACTUAL STATED JACKET WATER VOLUME FOR THE BARE ENGINE IS 420 GALLONS. ALSO ENTERPRISE SUGGESTS THAT THE VOLUME OF NCSW IN THE TUBE SIDE OF THE J.W. COOLER WOULD BE AT A MUCH LOWER TEMPERATURE THAN THE 156°F USED FOR THE CALCULATION. THESE TWO CONDITIONS WOULD ADD A MEASURE OF CONSERVANCY TO THE CALCULATION, INCREASING THE TIME REQUIRED TO REACH 200°F.

REGARDS,

C.R. Carmichael

CC: G. DESIN
A. GILLETTE

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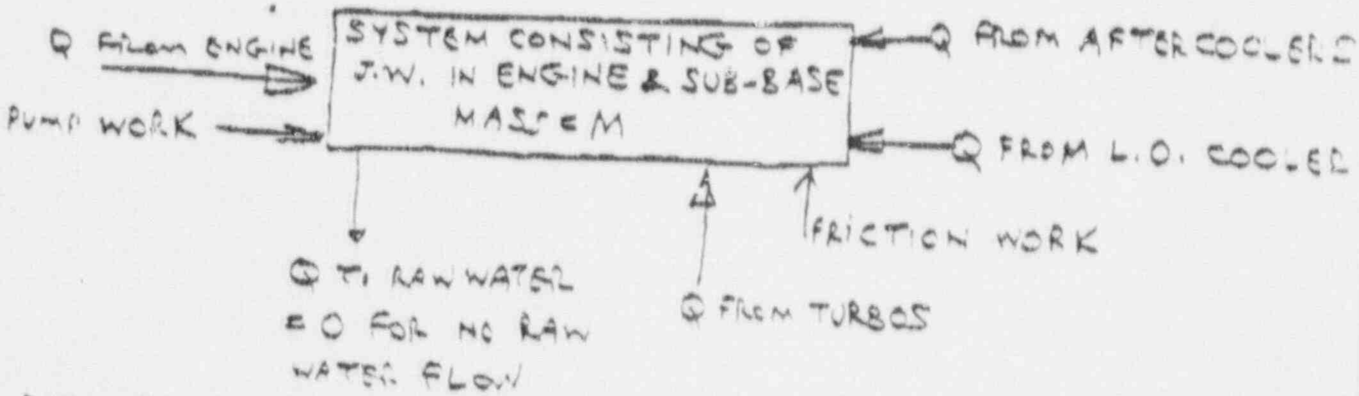
ATTACHMENT 3
Calc. For Marnshall (?)   Calc. # X4C2403V06   Page 1 of 2

ENGINE CALCULATIONS **DE LAVAL TURBINE INC.** ENTERPRISE DIVISION	RV-16 (ENGINE) 78006/09 (ASS'Y. NO.)
SUBJECT ENG. J.W. TEMP., AFTER RUNNING (3) MIN. AT 110% LOAD AND STARTING AT 150°F, WITHOUT RAW WATER CIRCULATION	SHEET 1 OF 2 DATE 12/22/80
PART NO.	BY P. LEACH



WRITING THE GENERAL ENERGY EQUATION FOR THE ABOVE SYSTEM -

$$Q + M\left(U_1 + \frac{V_1^2}{2g_c} + Z_1 \frac{g}{g_c}\right) = W + M\left(U_2 + \frac{V_2^2}{2g_c} + Z_2 \frac{g}{g_c}\right)$$

$V_1 = V_2$, $Z_1 = Z_2$

PUMP WORK = FRICTION WORK SO $W = 0$

$Q = M(U_2 - U_1)$

FROM C. CARMICHAEL

(A) $\left(\frac{Q}{t}\right) = \frac{M}{t}(U_2 - U_1) = \frac{M}{t}(C_v)(\Delta T) = 19 \times 10^6 \frac{BTU}{HR.}$

ITEM	VOLUME (FT³)	SOURCE
ENGINE	930 GAL = 124	← FROM P. MASLEN
8" PIPE (52 FT.)	18	CALCULATED FOR GIVEN JOB
6" PIPE (85 FT.)	17	
10" PIPE (7 FT.)	4	
J.W. COOLER	22	
L.O. COOLER	23	
STANDPIPE 212°F, 17.5 FT. WATER LEVEL	82	
TOTAL	290 FT³	

FOR VOGTLE ASSUME 300 ft³
(intercoolers, turbo piping, etc.)

ENGINE CALCULATIONS DE LAVAL TURBINE INC. ENTERPRISE DIVISION	RV-16 (ENGINE) 78006/09 (ASS'Y. NO.)
SUBJECT ENG. J.W. TEMP., AFTER RUNNING (3) MIN. AT 110% LOAD AND STARTING AT 150°F, WITHOUT RAW WATER CIRCULATION	SHEET 2 OF 2
	DATE 12/22/80
PART NO.	BY P. LEACH

AVE. TEMP. BETWEEN 150°F STANDBY & 212°F BOILING =

$\frac{212-150}{2} + 150 = 181°F$

FOR VOGTLE USE 62.4 $\frac{lbm}{ft^3}$

$v_F @ 181°F = .0165\ FT^3/LBm$

$M = \frac{V}{v_F} = 290\ \cancel{FT^3} \times \frac{LBm}{.0165\ \cancel{FT^3}} = 17578\ LBm$

SUBSTITUTING IN EQ. A,

✓ VOGTLE

10,903,484

$17578\ \cancel{LBm} \times \frac{1}{3.3\ \cancel{MIN}} \times \frac{1\ \cancel{BTU}}{\cancel{LBm}\ °F} \times (\cancel{T-150})\ 10°F = \cancel{19 \times 10^6}\ \frac{\cancel{BTU}}{\cancel{HR}} \cdot \frac{\cancel{HR}}{60\ \cancel{MIN}}$

~~T = 204°F~~

t = 1.03 min.