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MAY 1 0 2013

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

SUSQUEHANNA STEAM ELECTRIC STATION
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING CHANGES TO TECHNICAL SPECIFICATION (TS) SURVEILLANCE REQUIREMENT (SR) 3.8.1.19 TO INCREASE DIESEL GENERATOR E MINIMUM STEADY STATE FREQUENCY
PLA-6998

Docket Nos. 50-387 and 50-388

References:
1) *Letter from PPL (PLA-6809) to USNRC (Document Control Desk), "Susquehanna Steam Electric Station Proposed Amendment No. 309 to License NPF-14 and Proposed Amendment No. 280 to License NPF-22: Change to Technical Specification Surveillance Requirement (SR) 3.8.1.19 to Increase Diesel Generator E Minimum Steady State Frequency," dated September 18, 2012.*

2) *Letter from NRC to PPL, "Susquehanna Steam Electric Station, Units 1 and 2 - Request for Additional Information Regarding Request for Changes to Technical Specification Surveillance Requirement 3.8.1.19 to Increase Diesel Generator E Minimum Steady State Frequency (TAC Nos. ME9609 and ME9610)," dated February 22, 2013.*

PPL Susquehanna, LLC (PPL) submitted a proposed amendment to the Susquehanna Steam Electric Station (SSES) Unit 1 and Unit 2 Technical Specification (TS) Surveillance Requirement (SR) 3.8.1.19 in Reference 1. On February 22, 2013, the NRC requested additional information (RAI) via Reference 2. Enclosure 1 to this letter contains PPL's response to the RAI. Enclosure 2 contains PPL calculation EC-024-1014, "Justification for ITS Diesel Generator Frequency Acceptance Limits of 60 +/- 1.2 Hz," which is referenced in the RAI responses.

There are no new commitments contained in this letter.

Please direct any questions or requests for additional information to Mr. Duane L. Filchner at (610)774-7819.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on: 5-10-2013

Jeffrey M Helsel for J. A. Franke

J. A. Franke

Enclosure 1 - Response to NRC Request for Additional Information
Enclosure 2 – Calculation EC-024-1014, "Justification for ITS Diesel Generator Frequency Acceptance Limits of 60 +/- 1.2 Hz"

Copy:
Mr. W. M. Dean, NRC Region I Administrator
Mr. P. W. Finney, NRC Sr. Resident Inspector
Mr. J. A. Whited, NRC Project Manager
Mr. L. J. Winker, PA DEP/BRP

Enclosure 1 to PLA-6998

Response to NRC Request for Additional Information

Response to NRC Request for Additional Information

NRC QUESTION 1:

Explain why the steady state frequency requirements in SR 3.8.1.7, SR 3.8.1.11, SR 3.8.1.12, SR 3.8.1.15, and SR 3.8.1.20 are not considered applicable for demonstrating that the DG will perform its intended safety functions. The staff recognizes that some surveillances with DG in droop mode require manual actions to achieve the required parameters.

PPL RESPONSE:

Reference 1 submitted the proposed License Amendment Request (LAR) to SR 3.8.1.19. This LAR is based on an issue that resulted in NRC findings at other nuclear power plants. The findings identified a potential violation in which the DG frequency could dip below 57 Hz if the DG is operating at the lower end of allowable frequency range. The LAR proposes to increase the minimum steady state frequency for SR 3.8.1.19 as it pertains to Diesel Generator "E" (DG-E) only.

The steady state frequency requirements in SRs 3.8.1.7, 3.8.1.11, 3.8.1.12, 3.8.1.15 and 3.8.1.20 are not applicable to demonstrate that the DG's will perform their safety function described in SR 3.8.1.19. Each of the SR's listed above tests a portion of the DG safety function and therefore each of these SR's is less challenging than SR 3.8.1.19, which demonstrates the DG capability to start and run to provide power to connected loads under simulated design basis accident conditions of Loss of Coolant Accident (LOCA) and Loss of Offsite Power (LOOP).

Specifically:

- SR 3.8.1.7 is a monthly operability surveillance performed with the DG in test mode to ensure its capability of starting from standby conditions and achieves proper voltage and frequency within the allowable timeframe. As the diesel is operated in droop mode, the frequency of the engine is fixed to the frequency of its connected offsite source. The grid frequency is typically steady at 60 Hz and an offsite source steady state frequency at 58.8 Hz would be an indication of grid power quality issues, which would prevent performance of the DG surveillance test.

- SR 3.8.1.11 is a bi-annual surveillance, which demonstrates the as designed operation of the standby power sources during loss of the offsite source (LOOP). This test verifies all actions encountered from the loss of offsite power, including the shedding of nonessential loads and energization of the ESS buses and respective 4.16 kV loads from the DG. The DG autostarts in the emergency (isochronous) mode with its output frequency fixed by the electronic governor to a preset value of 60 Hz. The largest load connected by the DG under this surveillance would be its aligned ESW pump motor, which starts after the DG has reached steady state operation.

- SR 3.8.1.12 is the LOCA scenario where the DG is started in the isochronous mode to demonstrate that the DG automatically starts and achieves the required voltage and frequency within the specified time (10 seconds) from the design basis LOCA actuation signal and operates for >= 5 minutes. It also ensures that permanently connected loads and the emergency loads are energized from the offsite electrical power system on a LOCA signal, without a LOOP. There are no additional loads required to be added to DG-E. The DG frequency regulation will be performed by the electronic governor. Since Offsite power is available, the diesel will remain running unloaded until it is secured.

- SR 3.8.1.15 is a bi-annual surveillance performed with the DG operating in test (droop) mode. This test demonstrates that the diesel engine can restart from a hot condition, such as subsequent to shutdown from full load temperatures, and achieve the required voltage and frequency within 10 seconds.

- SR 3.8.1.20 is decennial surveillance in which all four DGs are started in test (droop) mode. It demonstrates that the DG starting independence has not been compromised and that each engine can achieve proper speed within the specified time when the DGs are started simultaneously.

NRC QUESTION 2:

Provide excerpts from the calculation [verifying that] with the DGs operating at the lower end of the allowable frequency and voltage ranges, the flow requirements of emergency safety feature (ESF) pumps are not adversely impacted and the shift in operating point of induction motors does not impact DG loading.

PPL RESPONSE:

The enclosure contains calculation EC-024-1014, Rev. 3, "Justification for ITS Diesel Generator Acceptance Limits of 60 +/- 1.2 Hz." Following is an excerpt from Section 6.4 – Induction Motors, which addresses the flow requirements of ESF pumps.

The effects of a 2% speed reduction on the driven load depends on the type of mechanical load being driven. Some examples are discussed below.

Pumps – pump discharge pressures are reduced by approximately 4% and pump flows are reduced by approximately 2%. For Emergency Core Cooling System (ECCS) pumps (Low Pressure Coolant Injection (LPCI) and Core Spray), small reductions in performance are potentially significant to the LOCA analyses because these analyses use 60 Hz nominal pump flows and pressure near the design values of the pumps.

Attachment 1 of calculation EC-024-1014, Rev. 3 provides a detailed analysis of LPCI and Core Spray performance in terms of the LOCA analyses considering a 2% variation in the power supply frequency.

Attachment 1 also shows that a 2% variation in power supply frequency combined with errors in pressure and flow instrumentation result in total ECCS pump flow uncertainties between 5.2% and 7.4% for the various LOCA scenarios; however, this is acceptable due to the inherent conservatism of the Appendix K LOCA analysis in terms of calculating peak cladding temperatures.

Attachment 2 of calculation EC-024-1014, Rev. 3, provides an excerpt of the calculation, titled "Effects of 2% Frequency Variation on Plant Systems and Components." Specifically, Section III, C, 3 – RHR and Core Spray Pumps states the following:

"The need to account for the impacts of uncertainties in ECCS flow-rates, which are induced by a 2% reduction in diesel speed, in the SSES LOCA analysis is addressed in an engineering position paper which has been prepared by the Nuclear Fuels Group. It has been concluded that NRC regulations do not explicitly require an analytical allowance for diesel generator frequency uncertainties in Appendix "K" methods. In addition, these methodologies, which are used for the SSES LOCA analysis, are conservative and consistent with the NRC's current expectations. Hence, the inclusion of such allowance is not needed to assure the health and safety of the public."

The shift in operating point of induction motors does not impact DG loading because:

"The minimum operating frequency for induction motors is also related to the maximum allowable volts per hertz ratio which affects the magnetizing currents and losses. Decreasing the frequency by 2% has the same effect as increasing the voltage by 2% in terms of magnetizing current and losses. NEMA Standard MG-2 (EC-024-1014, Rev. 3, Attachment 3) allows a frequency variation of up to 5% provided the arithmetic sum of the frequency variation and the voltage variation does not exceed 10%. This is very conservative. A 2% frequency reduction reduces the synchronous speed by 2% and causes induction motors to run 2% slower, reducing the mechanical load and the load current of the motor; therefore, the increase in magnetizing losses at the lower frequency is offset by a reduction in the load current losses at the slower speed."

NRC QUESTION 3:

Provide excerpts from the calculation [verifying that] motor-operated valve performance (in accident analyses) is not adversely impacted at the lower end of the steady state TS allowable frequency range coupled with the frequency and voltage variations experienced during load sequencing.

PPL RESPONSE:

Enclosure 2 contains calculation EC-024-1014, Rev. 3, "Justification for ITS Diesel Generator Acceptance Limits of 60 +/- 1.2 Hz." Following is an excerpt from Section 6.4 – Induction Motors, which addresses the speed – torque characteristics of motor operated valves.

The effects of a 2% speed reduction on the driven load depend on the type of mechanical load being driven. Some examples are discussed below.

Motor Operated Valves – Since the speed-torque characteristic of a typical MOV induction motor at the operating point is relatively flat compared to pump or fan motors, both voltage and frequency affect motor speed for a given load torque. Reducing the frequency decreases the synchronous speed, however, this is offset by a slight increase in torque due to higher magnetizing current and magnetic flux at the higher volts per hertz ratio. Therefore, MOV stroke times are increased by somewhat less than 2%. Maintenance Technology – Valve Team prepared the following assessment of increasing MOV stroke times by 2%:

"Increasing valve stroke times by 2% would have no adverse impact on the valve's ability to change position within its accident analysis limits (Tech Spec or FSAR). Of the 52 MOVs affected, 31 have IST limits, which are at least 2% below the FSAR/Tech Spec limit thereby insuring that the accident analysis limit is not exceeded. For the remaining 21 MOVs the IST limit is the same as the FSAR/Tech Spec limit. A review of the most recent stroke times for the MOVs revealed a greater than 2% margin between the actual stroke time and the accident analysis limit hence no concern exists."

NRC QUESTION 4:

Provide excerpts from the calculation [verifying that] with the DGs operating at the upper end of the allowable frequency range the speed change in ESF motors does not increase the DG loading such that the postulated accident loading exceeds the TS SRs.

PPL RESPONSE:

Enclosure 2 contains calculation EC-024-1014, Rev. 3, "Justification for ITS Diesel Generator Acceptance Limits of 60 +/- 1.2 Hz." Section 2 of the calculation concludes that the electrical and mechanical equipment driven by the DG are capable of performing their required functions at a power supply frequency between 58.8 Hz and 61.2 Hz. This provides the justification for the acceptance criteria incorporated into the TS SRs.

Following is an excerpt from Section 6.4 – Induction Motors, which addresses DG operation at the upper end of the frequency range.

A 2% increase in the power supply frequency increases the speeds of driven loads by approximately 2%. This does not decrease the ability of these loads to perform their required functions. In general, horsepower is proportional to the cube of the speed of the driven load; therefore, a 2% increase in frequency results in approximately a 6% increase in the horsepower load on the motors. Induction motors are generally sized to equal or exceed the nominal horsepower of the driven loads."

With the exception of RHR and Core Spray pumps, induction motors at SSES were specified to have a service factor of 1.15; therefore, these motors are not overloaded for a 2% increase in frequency. See Attachment 3 of EC-024-1014, Rev. 3 for discussion pertaining to RHR and Core Spray pump motors.

Enclosure 2 to PLA-6998

Calculation EC-024-1014 Justification for ITS Diesel Generator Frequency Acceptance Limits of 60 +/- 1.2 Hz

NUCLEAR ENGINEERING CALCULATION COVER SHEET NEPM-QA-0221-1	1. Page 1 of 46 Total Pages 49

➢2. TYPE: CALC ➢3. NUMBER: EC-024-1014 ➢4. REVISION: 3

*➢5. UNIT: 0 *➢6. QUALITY CLASS: Q

➢7. DESCRIPTION: Justification for ITS Diesel Generator Frequency Acceptance Limits of 60 +/-1.2 Hz

8. SUPERSEDED BY: N/A

9. Alternate Number: N/A 10. Cycle: N/A

11. Computer Code/Model used: N/A 12. Discipline: E

➢ 13. Are any results of this calculation described in the Licensing Documents?
☐ Yes, *Refer to NDAP-QA-0730 and NDAP-QA-0731* ☒ No

➢ 14. Is this calculation changing any method of evaluation described in the FSAR and using the results to support or change the FSAR? (Refer to PPL Resource Manual for definition of FSAR)

☐ Yes, *50.59 screen or evaluation required.* ☒ No

➢ 15. Is this calculation Prepared by an External Organization?
☐ Yes ☒ No
EG771 Qualifications may not be required for individuals from external organizations (see Section 7.4.3).

	Print Name	Signature	Date
➢16. Prepared by[1]:	Amanda May Allen *Print Name(EG771 Qualification Required)*	Amanda Allen	9/17/12
➢17. Reviewed by[1]:	JARON J. BERNATH *Print Name(EG771 Qualification Required)*	[signature]	09/25/2012
➢18. Verified by:	JARON J. BERNATH *Print Name (EG771 & QADR Qualification Required)*	[signature]	09/25/2012
➢19. Approved by:	G.S. LUBINSKY *Print Name (Qualified per NEPM-QA-0241 and comply with Section 7.8 of NEPM-QA-0221)*	[signature]	9-26-12
➢20. Accepted by:	N/A *Print Name(EG771 Qualification Required and comply with Section 7.9 of NEPM-QA-0221)*		

[1]For Fire Protection related calculations see Section 7.4.3.n for additional qualification requirements.

ADD A NEW COVER PAGE FOR EACH REVISION

* Verified Fields
➢ REQUIRED FIELDS

CALCULATION REVISION DESCRIPTION SHEET
NEPM-QA-0221-2

REVISION NO: 3	CALCULATION NUMBER: EC-024-1014

- ☐ FULL REVISION
- ☐ SUPERSEDED
- ☒ PAGE FOR PAGE
- ☐ VOIDED

Revised Pages	Add	Rpl	Rmv	Description of Revision on the Listed Pages
1	☐	☒	☐	Replace - Place previous revision coversheet in Backup
1a	☐	☒	☐	Replace - Place previous revision page 1a in Backup
1b	☐	☒	☐	Replace - Place previous revision page 1b in Backup
2	☐	☒	☐	
	☐	☐	☐	
	☐	☐	☐	
	☐	☐	☐	
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TECHNICAL CHANGE SUMMARY PAGE
NEPM-QA-0221-5

Calculation: Number: EC-024-1014 **Revision No.** 3

This form shall be used to (1) record the Technical Scope of the revision and (2) record the scope of verification if the calculation was verified. It should not be more than one page. Its purpose is to provide summary information to the reviewer, verifier, approver, and acceptor about the technical purpose of the change. For non-technical revisions, state the purpose or reason for the revision.

Scope of Revision:

Revision 3 of EC-024-1014 includes reference to Technical Specification LDCN's 4972, 4973, 4974 and 4975, which propose an increase in the minimum steady state frequency for Diesel Generator E for the LOCA/LOOP surveillance (SR 3.8.1.19) only. The change was requested in order to prevent a possible FSAR violation of the 57 Hz minimum transient frequency during the starting of an RHR pump motor. Reference EWR 1486107, CRA 1391273 and CR 1289723. This addition to the calculation was made for information only, and does not affect the outcome of the calculation.

Also, Technical Specification Surveillance Requirement SR 3.8.1.2 was deleted from the References Section on page 2. This SR is labeled as "Not Used" in Unit 1 and Unit 2 Technical Specifications.

Scope of Verification (If verification applies): The verifier shall perform a detailed line-by-line check of the revised sections of the calculation. The verifier shall ensure that the content of the calculation satisfies the purpose, that all required inputs have been identified and approved, that the design approach used and the documents produced appear in an overview sense to be technically acceptable and complete.

BJF 9/28/12

Section 1.0 - Purpose and Scope

Improved Technical Specifications (Reference 3.1) incorporates 60 Hz ±2% as the acceptance criterion for the steady-state diesel generator frequency for the diesel generator surveillance requirements. The basis for the acceptance criterion is Regulatory Guide 1.9 Rev 3 Position C.1.4, requiring diesel generator frequency to be restored within 2% of nominal in less than 60 percent of each load-sequence interval for stepload increases and in less than 80 percent of each load-sequence interval for disconnection of the single largest load. The purpose of this Study is to justify the Improved Technical Specification acceptance criterion for steady-state frequency based on the ability of the diesel generators to accept load.

Reference 3.9 proposes an increase to the minimum steady state frequency for Diesel Generator E for the LOCA/LOOP surveillance (SR 3.8.1.19) from a minimum steady state frequency of 58.8 Hz to 59.3 Hz. This is to prevent a possible FSAR violation of the minimum transient frequency of 57 Hz. This calculation is not affected by this change, because it analyzes the worst-case steady state frequency for Diesel Generators A-D (all surveillances) and Diesel Generator E (for all surveillances except the LOCA/LOOP). 3

Section 2.0 - Conclusions and Recommendations

The results in Section 6.1 through 6.7 demonstrate that electrical and mechanical equipment driven by emergency diesel generators are capable of performing their required functions at a power supply frequency between 58.8 Hz and 61.2 Hz. This provides sufficient justification for the acceptance criterion incorporated into the Improved Technical Specifications for the diesel generator surveillance requirements. *

Section 3.0 - References

3.1 Unit 1 and Unit 2 Improved Technical Specifications ~~SR 3.8.1.2,~~ SR 3.8.1.9, SR 3.8.1.11, SR 3.8.1.12, SR 3.8.1.15, SR 3.8.1.19, and SR 3.8.1.20. 3

3.2 Regulatory Guide 1.9 Rev 3, "Selection, Design, Qualification, and Testing of Emergency Diesel Generator Units Used as Class 1E Onsite Electrical Power Systems at Nuclear Power Plants"

3.3 E54, E57, and E119A - Purchase Specifications for Vital AC, Computer UPS and Battery Chargers

3.4 E112 - Purchase Specification for Induction Motors

3.5 E117 - Purchase Specification for Load Centers

3.6 NEMA Standard MG-2-1977, "Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators"

3.7 IEEE/ANSI Standard C57.12.01-1987, "Standard General Requirements for Dry Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin Encapsulated Windings"

3.8 PL-NF-98-007(P), "Susquehanna SES Measurement Uncertainties in Appendix K LOCA Analyses"

3.9 LDCN's 4972, 4973, 4974, 4975 - Proposed Technical Specification Change to Increase Minimum Steady State Frequency for Diesel Generator E for LOCA/LOOP Surveillance SR 3.8.1.19 3

* Attachment 3 addresses issues raised in MAA 1236659.

Section 4.0 - Inputs and Assumptions

Momentary frequency transients during changes in diesel loading are not considered in this Study.

Standards and specifications for some equipment types do not have explicit information pertaining to continuous operation at power frequencies other than 60 Hz. For those cases, this Study uses engineering judgment and qualitative reasoning to evaluate equipment performance with a ±2% frequency variation.

Section 5.0 - Method

5.1 - Identify the basic types of plant electrical equipment that are powered by the emergency diesel generators.

5.2 - Identify the types of mechanical equipment that are electrically driven by the emergency diesel generators.

5.3 - Describe qualitatively how the power frequency affects the performance of each type of equipment identified above.

5.4 - Qualitatively evaluate whether a ±2% change in diesel generator frequency is acceptable for the operation of each equipment type identified above.

Section 6.0 - Results

6.1 - Heaters

The output from an electric heater depends on the root mean square (RMS) value of the supply voltage and is not affected by the supply frequency.

6.2 - Power Transformers

The minimum operating frequency for transformers is limited by magnetizing currents and core losses which depend on the volts per hertz ratio. The ANSI/IEEE standards (Reference 3.7) do not specify transformer operation at frequencies other than 60 Hz; however, decreasing frequency by 2% has the same effect on the volts per hertz ratio and core losses as increasing the supply voltage by 2%. Since transformers have a nominal voltage operating range of ±10% at 60 Hz and are loaded by design to 80% or less of their nominal KVA ratings at SSES, it is reasonable to expect these transformers are able to operate within a frequency range of 60 Hz ±2% without overheating from excessive losses within the nominal voltage operating range.

6.3 - Instrument Transformers

The above discussion for power transformers also generally applies to potential transformers (PTs), assuming that the electrical burdens are maintained below the volt-amp ratings of the PTs. For current transformers (CTs), operation at a lower frequency reduces the magnitude of the current where core saturation begins; however, since

CTs typically operate well below saturation current levels, a 2% frequency reduction has a negligible effect on the operation of these devices.

6.4 - Induction Motors *

The minimum operating frequency for induction motors is also related to the maximum allowable volts per hertz ratio which affects the magnetizing currents and losses. Decreasing the frequency by 2% has the same effect as increasing the voltage by 2% in terms of magnetizing current and losses. NEMA Standard MG-2 (Reference 3.6) allows a frequency variation of up to 5% provided that the arithmetic sum of the frequency variation and the voltage variation does not exceed 10%. This is very conservative. A 2% frequency reduction reduces the synchronous speed by 2% and causes induction motors to run 2% slower, reducing the mechanical load and the load current of the motor; therefore, the increase in magnetizing losses at the lower frequency is offset by a reduction in the load current losses at the slower speed.

The effects of a 2% speed reduction on the driven load depend on the type of mechanical load being driven. Some examples are discussed below.

- Pumps - Pump discharge pressures are reduced by approximately 4% and pump flows are reduced by approximately 2%. For ECCS pumps (LPCI and Core Spray), small reductions in performance are potentially significant to the LOCA analyses because these analyses use 60 Hz nominal pump flows and pressures near the design values of the pumps; therefore, Attachment 1 provides a detailed analysis of LPCI and Core Spray performance in terms of the LOCA analyses considering a 2% variation in the power supply frequency.

  Attachment 1 shows that a 2% variation in power supply frequency combined with errors in pressure and flow instrumentation result in total ECCS pump flow uncertainties between 5.2% and 7.4% for the various LOCA scenarios; however, this is acceptable due to the inherent conservatism of the Appendix K LOCA analysis in terms of calculating peak cladding temperatures.

- Chillers - The chiller capacity in BTU per hour is reduced by approximately 2%. This estimate is based on a standard refrigeration cycle where saturated refrigerant vapor is compressed by a positive-displacement pump to a superheated state and is then cooled through a condenser which discharges heat to the environment. Saturated liquid from the condenser is bled through a valve at a constant enthalpy to a lower pressure and temperature, and the refrigerant is then heated through an evaporator which absorbs heat from the process. If the speed of the positive-displacement pump is reduced by 2% the change in enthalpy per pound of refrigerant passing through the evaporator is essentially the same as at nominal speed; however the refrigerant flow in pounds per second is reduced by approximately 2%. Therefore, the rate of heat absorbed by the evaporator is reduced by approximately 2%.

* See Att. 3 for discussion of torque at higher frequency.

- Fans - Air flow is reduced by approximately 2%. If the fan discharges air through an electric heater, the heated air temperature is increased and the heating effect of the air remains essentially unchanged. If the fan is part of a refrigeration system, the reduction in air flow is approximately the same as the BTU/hr capacity of the chiller; hence, the chilled air temperature is essentially unchanged but the cooling effect of the air is reduced by approximately 2%.

- Motor Operated Valves - Since the speed-torque characteristic of a typical MOV induction motor at the operating point is relatively flat compared to pump or fan motors, both voltage and frequency affect motor speed for a given load torque. Reducing the frequency decreases the synchronous speed; however, this is offset by a slight increase in torque due to higher magnetizing current and magnetic flux at the higher volts per hertz ratio. Therefore, MOV stroke times are increased by somewhat less than 2%. Maintenance Technology - Valve Team prepared the following assessment of increasing MOV stroke times by 2%:

  "Increasing valve stroke times by 2% would have no adverse impact on the valve's ability to change position within its accident analysis limits (Tech Spec or FSAR). Of the 52 MOVs affected, 31 have IST limits which are at least 2% below the FSAR/Tech Spec limit thereby insuring that the accident analysis limit is not exceeded. For the remaining 21 MOVs the IST limit is the same as the FSAR/Tech Spec limit. A review of the most recent stroke times for these MOVs revealed a greater than 2% margin between the actual stroke time and the accident analysis limit hence no concern exists."

With the exception of ECCS pumps and MOVs, the effect of a 2% speed reduction on system performance is inconsequential because these systems are not typically required to operate continuously at their maximum capabilities. For example, chillers and closed cooling water systems are typically cycled or throttled. A small reduction in performance merely results in changes in the throttle settings or the on/off cycle times.

A 2% increase in the power supply frequency increases the speeds of driven loads by approximately 2%. This does not decrease the ability of these loads to perform their required functions. In general, horsepower is proportional to the cube of the speed of the driven load; therefore, a 2% increase in frequency results in approximately a 6% increase in the horsepower load on the motors. Induction motors are generally sized to equal or exceed the nominal horsepower of the driven loads. Per Reference 3.4, * induction motors at SSES were specified to have a service factor of 1.15; therefore, these motors are not overloaded for a 2% increase in frequency. △1

Detailed evaluations of specific safety-related plant systems and components are presented in Attachment 2 of this study.

* For RHR & Core Spray which have a S.F. of 1.0, see Attachment 3. △1

6.5 - Relays and Solenoid Devices

For electromechanical relays, a 2% decrease in frequency has roughly the same effect as a 2% increase in voltage, since the magnetizing current and the magnetic flux are approximately proportional to the volts per hertz ratio. For over- and under-voltage relays, reducing the frequency by 2% is therefore roughly equivalent to decreasing the voltage setpoint by 2%. Increasing the frequency by 2% is roughly equivalent to increasing the voltage setpoint by 2%. Electromechanical relays are not typically used where high precision is required.

For A.C. solenoids, a 2% reduction in frequency increases the volts per hertz ratio thereby decreasing the minimum pickup voltage. This improves the low-voltage performance of solenoids, although heating losses will increase at full voltage at the lower frequency. Conversely, a 2% increase in frequency increases the minimum pickup voltage; however, since an A.C. solenoid device is typically designed to be fail-safe, the safety function is performed by de-energizing the solenoid. Therefore, a 2% frequency variation in either direction should have no adverse consequences on the safety functions of these devices.

6.6 - Electronic Devices

Electronic voltage relays operate by measuring peak voltage values; therefore, these relays are relatively insensitive to the fundamental frequency. For relays equipped with harmonic filters, the peak voltage measurements should not be affected by a 2% change in frequency because these filters only attenuate frequencies approaching 120 Hz.

In cases where power quality (i.e., frequency, voltage, harmonics), could affect the performance of electronic devices such as instruments and computers, these devices are supplied either by D.C. power supplies or uninterruptible A.C. power supplies (UPS). A UPS rectifies the A.C. supply voltage to D.C. voltage and the D.C. voltage is then electronically inverted into a high-quality, regulated 60 Hz output. The SSES purchase specifications for Vital AC, Computer UPS and Battery Chargers (Reference 3.3) all specify an input power frequency range of 60 Hz ± 5%; therefore a 2% variation in frequency does not affect performance characteristics of these devices.

6.7 - Circuit Breakers

Thermally-operated circuit breakers are unaffected by the power frequency, since these breakers are actuated by the heating effect of the overload current on the eutectic or bimetal device that operates the breaker. The heating effect depends on the root mean square (RMS) value of the current and is not affected by the frequency.

Magnetic circuit breakers are unaffected by the power frequency, since magnetic breakers are actuated by magnetic forces produced by the overload current. These forces depend only on the magnitude of the overload current and not on the frequency.

Therefore, the tripping characteristics of circuit breakers are not affected by a ±2% frequency variation.

The uncertainties induced by instrumentation inaccuracies during surveillance testing, as well as the uncertainty which results from the potential for a reduced emergency diesel generator speed will be estimated. Since there is an equal probability that these uncertainties could result in a conservatively high flow, it is acceptable to combine them via the Square Root of the Sum of the Squares (SRSS) method provided they are statistically independent. To allow for a comparison of the magnitude of these uncertainties, they will be described in terms of flow (GPM). In addition, where statistically allowable, the terms will be combined via the SRSS method, and then described in terms of a percentage of the total flow.

The Core Spray flow uncertainties for one loop and two loop accident scenarios will be determined. For LPCI, the flow uncertainties for the following accident cases will be determined: 1) a single pump in one loop; 2) a single pump in each loop; 3) two pumps in one loop; and 4) two pumps in two loops. Finally, the uncertainties will be determined for the most limiting Design Basis LOCA scenarios identified in Table 6.3-5 of the FSAR.

I) CORE SPRAY

a) <u>Assumptions / Inputs</u>

With respect to pump quarterly flow surveillance testing: [1a]

1) The Technical Specification surveillance requirement for a loop of Core Spray is 6350 GPM at a pump discharge pressure of 269/282 PSI for Unit 1/2.[2]

2) The overall accuracy of the flow and pressure readings obtained during quarterly pump surveillance testing is 2%.[3-5]

3) During Core Spray loop surveillance testing, the discharge pressure is read from PI-E21-1(2)R600A/B[1] or computer point NSP001/2Z, which have a full scale range of 0 - 500 PSI[6].

4) During surveillance testing, the loop flow is read from FI-E21-1(2)R601A/B[1] or NSF001/2Z which have a full scale range of 0 - 10,000 GPM[6].

5) The pump test conditions are assumed to be 75°F, which corresponds to .4324 PSI per FT of pump head[7], or 2.313 FT per PSI.

6) The points on the Core Spray Unit 2 system flow vs. pump head curves which will be used in this evaluation are obtained from Reference 8 and are: <u>6000 GPM @ 665 FT-TDH</u>, and the test point of <u>6350 GPM @ 644 FT-TDH</u>.

With respect to emergency diesel generator diesel testing: [9-10]

7) The assumed Technical Specification surveillance requirement for steady state diesel generator speed is 60 Hz +/- 2 %, or 58.8 Hz.[11]

8) The overall accuracy of the frequency measurement during diesel generator testing is 0.5%.[8]

b) Flow Uncertainty During Pump (i.e., Loop) Testing

During testing, the actual loop flow could be less than the indication on FI-E21-1(2)R601A/B, which has a full scale range of 0 - 10,000 GPM. Per Input #2 the accuracy of the instrument is 2% of full scale. Therefore, the uncertainty induced due to flow instrumentation accuracy is:

$$\sigma_{CS,Flow} = .02 \times 10{,}000 = \underline{200\ GPM}$$

c) Discharge Pressure Uncertainty During Pump (i.e., Loop) Testing

During testing, the actual loop flow could be less than the indication on PI-E21-1(2)R600A/B, which has a full scale range of 0 - 500 PSI. Per Input #2 the accuracy of the instrument is 2% of full scale. Therefore, the actual pressure could be 10 PSI (.02 x 500) less than indicated. Per Input #5 above, this corresponds to approximately: 10 ~~PSI~~ * 2.313 FT/~~PSI~~ = 23 FT of pump head.

From Reference 8 and per Input #6 above, the slope of the Core Spray system flow vs. pump head at the test flow of 6350 GPM (3175 GPM per pump) is (6000 - 6350) / (665 - 644) = -16.7 GPM/FT. Therefore, the equivalent reduction in flow corresponding to a 23 FT reduction in head is:

$$\sigma_{CS,Press} = 16.7\ GPM/\cancel{FT} \times 23\ \cancel{FT} = \underline{384\ GPM}$$

d) Uncertainty Due To The Potential For Lower Diesel Speed

Per Input #7 above, the minimum allowable steady state diesel speed assumed for this evaluation is 60 Hz +/- 2%. In addition, as the result of instrumentation accuracies, the actual speed could be 0.5% less than the indicated reading. Since the minimum allowable speed and the measurement uncertainty are independent, as well as the fact that there is an equal probability that these factors could result in a conservatively high speed, they can be combined via the SRSS method. Therefore, the minimum expected diesel speed is:

$$SPEED_{Low} = [\ (\%_{Tolerance})^2 + (\%_{Accuracy})^2\ ]^{0.5}$$

$$= [\ (2.0)^2 + (0.5)^2\ ]^{0.5} = 2.06\ \%$$

Since 100% diesel speed corresponds to 60 Hz, the minimum diesel speed expressed in terms of Hertz is:

$$MIN\ SPEED_{Hertz} = 60 - (.0206 * 60) = 58.76\ Hz$$

Per Reference 8, and Input #6 above, the point on the Core Spray head vs. system flow curve which is verified via the Unit 2 surveillance testing is: 6350 GPM (3175 GPM per pump) @ a pump total developed head of about 644 FT. In addition, another point on the curve which will be used for this evaluation is: 6000 GPM (3000 GPM per pump) @ 665 FT-TDH. Applying the pump affinity laws (Ref. 13) to these points yields new operating points on an "adjusted curve" as follows:

For the operating point of 6000 GPM @ 665 FT-TDH:

$$Q_{58.76Hz} = Q_{60Hz} * [\,58.76 / 60\,] = 6000 * [\,58.76 / 60\,] = 5876 \text{ GPM}$$

$$H_{58.76Hz} = H_{60Hz} * [\,58.76 / 60\,]^2 = 665 * [\,58.76 / 60\,]^2 = 638 \text{ FT}$$

And for the test point of 6350 GPM @ 644 FT-TDH:

$$Q_{58.76Hz} = Q_{60Hz} * [\,58.76 / 60\,] = 6350 * [\,58.76 / 60\,] = 6219 \text{ GPM}$$

$$H_{58.76Hz} = H_{60Hz} * [\,58.76 / 60\,]^2 = 644 * [\,58.76 / 60\,]^2 = 617 \text{ FT}$$

Since the potential reduction in pump speed would result in a reduction of both pump head, and pump flow, both of these factors must be accounted for in estimating the overall effect on flow. This overall reduction in flow will be estimated as the point where the "adjusted curve" (i.e., adjusted for a supply frequency of 58.76 Hz) crosses the original test head of 644 FT.

The "adjusted" points calculated above will be applied to the Point-Slope Form of the Straight-Line Equation to determine the slope of the "adjusted" head vs. system flow curve:

$$m = (Y_2 - Y_1) / (X_2 - X_1) = (638 - 617 / 5876 - 6219)$$
$$= -0.0612 \text{ FT/GPM}$$

The point where the adjusted curve passes through the head verified by the surveillance testing (i.e., 644 FT) is estimated by applying the straight line equation, and using the: 1) the slope of the adjusted curve (m); 2) the original test point, as adjusted for the reduction in speed (6219 GPM @ 617 FT); and, 3) the original test head of 644 FT:

$$Y_2 - Y_1 = m * (X_2 - X_1)$$

Where

m = -0.0612 FT/GPM

(X_1, Y_1) = (6219, 617) (The original test point of test point of 6350 GPM @ 644 FT as adjusted for a reduced pump speed)

$(X_2, Y_2) = (X_2, 644)$ (X_2 approximates the point where the "adjusted" curve passes through 644 FT)

Therefore:

$$644 - 617 = -0.0612 * (X_2 - 6219)$$

$$X_2 = (644 - 617) / -0.0612 + 6219 = 5778$$

The overall reduction in loop flow corresponding to the potential for a lower speed is therefore:

$$CS_{REDUCT\text{-}LOOP} = 6350 - 5778 = 572 \text{ GPM per loop}$$

And:

$$\sigma_{CSPump,Speed} = 572 / 2 = \underline{286 \text{ GPM}} \text{ per pump}$$

Note that the reduction in loop flow (572 GPM) would represent the uncertainty for a loop of Core Spray if both pumps were powered from the same diesel. However, since the pumps are powered from separate, independent diesels, the SRSS method can be applied to the uncertainty for a single pump (286 GPM) to determine the true uncertainty for a loop of Core Spray due to the potential for a lower diesel speed. Therefore:

$$\sigma_{CSLoop,Speed} = [(\sigma_{CSPump,Speed})^2 + (\sigma_{CSPump,Speed})^2]^{1/2}$$

$$= [(286)^2 + (286)^2]^{1/2}$$

$$\sigma_{CSLoop,Speed} = \underline{404 \text{ GPM}}$$

e) Combined Core Spray Uncertainties

Core Spray Single Loop Uncertainty (A or B Loop)

As previously identified, since the uncertainties due to pressure, flow and speed are independent, they can be combined via the SRSS method. Therefore:

$$UNCERT_{CS\text{-}1Loop} = [(\sigma_{CS,Flow})^2 + (\sigma_{CS,Press})^2 + (\sigma_{CSLoop,Speed})^2]^{1/2}$$

$$UNCERT_{CS\text{-}1Loop} = [(200)^2 + (384)^2 + (404)^2]^{1/2} = \underline{592 \text{ GPM}}$$

Since a loop of Core Spray is rated for, and tested to a flow of 6350 GPM, this uncertainty can be described in terms of a percentage:

$$UNCERT\%_{CS\text{-}1Loop} = 592 / 6350 \sim \underline{9.3\ \%}$$

Core Spray Two Loop Uncertainty (A and B Loops)

For the two loop case, it is reiterated that each pump is powered from a separate diesel. In addition, since each loop is completely separate, with independent flow and pressure test instrumentation, the "A" loop and "B" the loop uncertainties are likewise independent, and can therefore be combined via the SRSS method:

$$UNCERT_{CS\text{-}2Loops} = [(UNCERT_{CS\text{-}1Loop})^2 + (UNCERT_{CS\text{-}1Loop})^2]^{1/2}$$

$$UNCERT_{CS\text{-}2Loops} = [(592)^2 + (592)^2]^{1/2} = \underline{837\ \ GPM}$$

The combined flow of both loops of Core Spray is 12,700 GPM (6350 x 2). Therefore, the two loop uncertainty, in terms of a percentage, is:

$$UNCERT\%_{CS\text{-}2Loops} = 837 / 12{,}700 \sim \underline{6.6\ \%}$$

II) RHR

a) Assumptions / Inputs

With respect to pump quarterly flow surveillance testing: [1b]

1) The Technical Specification surveillance requirement for an RHR pump is 12,200 GPM at a pump discharge pressure of 204/222 PSI for Unit 1/2.[2]

2) The overall accuracy of the flow and pressure readings obtained during quarterly pump surveillance testing is 2%.[3-5]

3) During RHR pump surveillance testing, the discharge pressure is read from PI-E11-1(2)R600A/B/C/D[1b], which has a full scale range of 0 - 600 PSI[6].

4) During surveillance testing, the pump flow is read from FR-E11-1(2)R608[1] or FI-E11-1(2)R603A/B, which have a full scale range of 0 - 30,000 GPM[6].

5) The pump test conditions are assumed to be 75°F, which corresponds to .4324 PSI per FT of pump head[7], or 2.313 FT per PSI.

6) The points on the pump curve which is verified via Unit 2 testing which will be used in this evaluation are obtained from Reference 12 and are: 12,000 GPM @ 502 FT-TDH, and the test point of 12,200 GPM @ 492 FT-TDH.

With respect to emergency diesel generator diesel testing: [9-10]

7) The assumed Technical Specification surveillance requirement for steady state diesel generator speed is 60 Hz +/- 2 %, or 58.8 Hz.[11]

8) The overall accuracy of the frequency measurement during diesel generator testing is 0.5%.[8]

b) Flow Uncertainty During Pump Testing

During testing, the actual loop flow could be less than the indication on FR-E11-1(2)R608 or FI-E11-1(2)R603A/B, which have a full scale range of 0 - 30,000 GPM. Per Input #2 the accuracy of these instruments is 2% of full scale. Therefore, the uncertainty induced due to flow instrumentation accuracy is:

$\sigma_{RHR,Flow}$ = .02 x 30,000 = 600 GPM

c) Discharge Pressure Uncertainty During Pump Testing

During testing, the actual loop flow could be less than the indication on PI-E11-1(2)R600A/B/C/D, which has a full scale range of 0 - 600 PSI. Per Input #2 the accuracy of the instrument is 2% of full scale. Therefore, the actual pressure could be 12 PSI (.02 x 600) less than indicated. Per Input #5 above, this corresponds to approximately: 12 ~~PSI~~ * 2.313 FT/~~PSI~~ = 28 FT of pump head.

From Reference 12 and per Input #6 above, the slope of the RHR pump curve at the test flow of 12,200 GPM (12,000 - 12,200) / (502 - 492) = -20 GPM/FT. Therefore, the equivalent reduction in flow corresponding to a 23 FT reduction in head is:

$\sigma_{RHR,Press}$ = 20 GPM/~~FT~~ x 28 ~~FT~~ = 560 GPM

d) Uncertainty Due To The Potential For Lower Diesel Speed

Per Section 1d above, the minimum expected diesel speed is 58.76 Hz.

Per Reference 12 and Input #6 above, the point on the RHR pump curve which is verified via the Unit 2 surveillance testing is: 12,200 GPM @ a pump total developed head of about 492 FT. In addition, another point on the curve which will be used for this evaluation is: 12,000 GPM @ 502 FT-TDH. Applying the pump affinity laws (Ref. 13) to these points yields new operating points on an "adjusted curve" as follows:

For the operating point of 12,000 GPM @ 502 FT-TDH:

$Q_{58.76Hz}$ = Q_{60Hz} * [58.76 / 60] = 12,000 * [58.76 / 60] = 11,752 GPM

$H_{58.76Hz}$ = H_{60Hz} * $[58.76 / 60]^2$ = 502 * $[58.76 / 60]^2$ = 481 FT

And for the test point of 12,200 GPM @ 492 FT-TDH:

$$Q_{58.76Hz} = Q_{60Hz} * [58.76/60] = 12{,}200 * [58.76/60] = 11{,}948 \text{ GPM}$$

$$H_{58.76Hz} = H_{60Hz} * [58.76/60]^2 = 492 * [58.76/60]^2 = 472 \text{ FT}$$

Since the potential reduction in pump speed would result in a reduction of both pump head, and pump flow, both of these factors must be accounted for in estimating the overall effect on flow. This overall reduction in flow will be estimated as the point where the "adjusted curve" (i.e., adjusted for a supply frequency of 58.76 Hz) crosses the original test head of 492 FT.

The "adjusted" points calculated above will be applied to the Point-Slope Form of the Straight-Line Equation to determine the slope of the "adjusted" head vs. system flow curve:

$$m = (Y_2 - Y_1) / (X_2 - X_1) = (481 - 472 / 11{,}752 - 11{,}948)$$

$$= -0.0459 \text{ FT/GPM}$$

The point where the adjusted curve passes through the head verified by the surveillance testing (i.e., 492 FT) is estimated by applying the straight line equation, and using the: 1) the slope of the adjusted curve (m); 2) the original test point, as adjusted for the reduction in speed (11,948 GPM @ 472 FT); and, 3) the original test head of 492 FT:

$$Y_2 - Y_1 = m * (X_2 - X_1)$$

Where

m = -0.0459 FT/GPM

(X_1, Y_1) = (11948, 472) (The original test point of test point of 12,200 GPM @ 492 FT as adjusted for a reduced pump speed)

(X_2, Y_2) = $(X_2, 492)$ (X_2 approximates the point where the "adjusted" curve passes through 492 FT)

Therefore:

$$492 - 472 = -0.0459 * (X_2 - 11948)$$

$$X_2 = (492 - 472) / -0.0459 + 11948 = 11512$$

The overall reduction in a single pump flow corresponding to the lower pump speed is therefore:

$$\sigma_{RHR,Speed} = 12{,}200 - 11{,}512 = \underline{688 \text{ GPM}}$$

e) **Combined LPCI Uncertainties**

LPCI One Pump Uncertainty (1 Pump in 1 Loop)

As previously identified, since the single pump uncertainties due to pressure, flow and speed are independent, they can be combined via the SRSS method. Therefore, the single pump uncertainty is:

$$UNCERT_{RHR\text{-}1Pump} = [(\sigma_{RHR,Flow})^2 + (\sigma_{RHR,Press})^2 + (\sigma_{RHR,Speed})^2]^{1/2}$$

$$UNCERT_{RHR\text{-}1Pump} = [(600)^2 + (560)^2 + (688)^2]^{1/2} = \underline{1071}$$
GPM

Since a single RHR pump is rated for, and tested to a LPCI flow of 12,200 GPM, this uncertainty can be described in terms of a percentage:

$$UNCERT\%_{RHR\text{-}1Pump} = 1071 / 12{,}200 = 0.0878 \sim \underline{8.8\ \%}$$

LPCI Two Pump Uncertainty (1 Pump in Each of 2 Loops)

For the two pump case, one pump from each loop is available. Each pump is powered from an independent diesel, and is completely separated, with independent flow and pressure test instrumentation. The pump uncertainty for the two pump case (1 pump in each loop) can therefore be calculated by applying the SRSS method to the one pump uncertainty:

$$UNCERT_{RHR\text{-}2Pumps} = [(UNCERT_{RHR\text{-}1Pump})^2 + (UNCERT_{RHR\text{-}1Pump})^2]^{1/2}$$

$$UNCERT_{RHR\text{-}2Pumps} = [(1071)^2 + (1071)^2]^{1/2} = \underline{1515}$$
GPM

The combined flow of two pumps, with one in each loop, is 24,400 GPM (12,200 x 2). Therefore, the two pump uncertainty, in terms of a percentage, is:

$$UNCERT\%_{RHR\text{-}2Pumps} = 1515 / 24{,}400 \sim \underline{6.2\ \%}$$

LPCI One Loop Uncertainty (2 Pumps in the Same Loop)

For the one loop case, it is postulated that a single complete loop (i.e., with two pumps) is available. In this case, both pumps are powered from separate diesels, and tested with separate pressure instrumentation. However, since the same flow instrument is used to test the performance of each pump, this is not an independent variable. Therefore, the uncertainty due to flow instrumentation must be accounted for separately.

Since both diesel speed and the pressure terms are independent for each pump, these terms may be combined for each pump as follows:

$$UNCERT_{Pump} = [(\sigma_{RHR,Press})^2 + (\sigma_{RHR,Speed})^2]^{1/2} = [(560)^2 + (688)^2]^{1/2}$$

$$= 887 \text{ GPM}$$

This term is included for each pump, along with the flow uncertainty to determine the total uncertainty for the one loop case as follows:

$$UNCERT_{RHR\text{-}1Loop} = [(2 \times (887)^2) + (2 \times \sigma_{RHR,Flow})^2]^{1/2}$$

$$UNCERT_{RHR\text{-}1Loop} = [(887)^2 + (887)^2 + (2 \times 600)^2]^{1/2} = \underline{1736 \text{ GPM}}$$

Since a single loop of LPCI is rated for a flow of 21,300 GPM, this uncertainty can be described in terms of a percentage:

$$UNCERT\%_{RHR\text{-}1Loop} = 1736 / 21{,}300 \sim \underline{8.2 \%}$$

<u>LPCI Two Loop Uncertainty (4 Pumps: 2 Pumps Available in Both Loops)</u>

For the two loop case, each pump is powered from a separate diesel, and each loop is completely separated, with independent flow and pressure test instrumentation. Hence, the "A" loop and "B" loop uncertainties are likewise independent, and can therefore be combined via the SRSS method:

$$UNCERT_{RHR\text{-}2Loops} = [(UNCERT_{RHR\text{-}1Loop})^2 + (UNCERT_{RHR\text{-}1Loop})^2]^{1/2}$$

$$= [(1736)^2 + (1736)^2]^{1/2} = \underline{2455 \text{ GPM}}$$

The combined flow of both loops of LPCI is 42,600 GPM (21,300 x 2). Therefore, the two pump uncertainty, in terms of a percentage, is:

$$UNCERT\%_{RHR\text{-}2Loops} = 2455 / 42{,}600 \sim \underline{5.8 \%}$$

III) DESIGN BASIS LOCA CASES

a) <u>Discussion</u>

From Sections I.e. and II.e above, it is seen that the uncertainties for individual Core Spray and RHR subsystems range from 5.8% to 9.3%. It is also seen that when more pumps are considered in combination, the overall uncertainty decreases. The reason for this is that when more than one pump is considered, the mean flows are added and the flow variances are added. However, the total uncertainty in terms of percentage (UNCERT%), equals the total standard deviation (UNCERT) divided by the total flow. Since the standard deviation is the square root of the variance, the root of the variance is divided by the increase flow. This process results in a lower uncertainty when expressed in terms of percentage.

To illustrate, if four identical pumps are considered, the total flow rate is 4 times the flow rate of one pump and the total variance is 4 times the variance of one pump. However, the total uncertainty percentage (UNCERT%) is total standard deviation (i.e., the square root of variance) the divided by the total flow. Since the standard deviation is the square root of the variance, this amounts to only 1/2 of the percent uncertainty of each pump.

Conversely, with fewer pumps, the total percent uncertainty will be higher. It follows that higher uncertainties will exist for design basis accident scenarios with fewer pumps available. Table 6.3-5 of the FSAR identifies the most limiting Design Basis LOCA break locations along with the most limiting single failures. That table also identifies the ECC sub-systems which remain available for these most limiting scenarios. The six cases identified below identify the uncertainties for all of the scenarios identified in that table.

Finally, note that for these cases, the diesel combination which posses the largest affect on uncertainty will be utilized. In practice, if each pump is assumed to be powered by a separate, independent diesel, a lower uncertainty will result. However, for this assessment, a diesel/pump lineup which results in the largest uncertainty will be assumed.

b) CASE 1 - <u>One Loop Core Spray Loop AND One LPCI Pump</u>

Number of Pumps Available: 3
Total Design Rated Flow: 18,550 GPM = (1 x 6350) + (1 x 12,200)
Applicable Break / Single Failure Scenarios:

- Recirc Discharge / False LOCA
- Recirc Discharge / Battery (*)
- Recirc Discharge / Diesel Generator (*)

To conservatively estimate the effects of diesel speed, it will be assumed that the diesel which is supplying one of the Core Spray pumps is also supplying the available RHR pump. Therefore:

$$UNCERT_{CASE1} = [(\sigma_{CS,Flow})^2 + (\sigma_{CS,Press})^2 + (\sigma_{RHR,Flow})^2 + (\sigma_{RHR,Press})^2 + (\sigma_{CSPump,Speed})^2 + (\sigma_{CSPump,Speed} + \sigma_{RHR,Speed})^2]^{1/2}$$

$$= [(200)^2 + (384)^2 + (600)^2 + (560)^2 + (286)^2 + (286 + 688)^2]^{1/2}$$

$$UNCERT_{CASE1} = 1375 \text{ GPM}$$

$$UNCERT\%_{CASE1} = 1375 / 18{,}550 \sim \underline{7.4\ \%}$$

(*) Note that for the battery and diesel generator failure scenarios, no credit is taken for a third Core Spray pump which could be available per FSAR Table 6.3-5. The rated flow of the "uncredited" third Core Spray pump (3175 GPM) exceeds the calculated uncertainty of 1375 GPM.

c) CASE 2 - One Loop Core Spray Loop AND Two LPCI Pumps (One Per Loop)

Number of Pumps Available: 4
Total Design Rated Flow: 30,750 GPM = (1 x 6350) + (2 x 12,200)
Applicable Break / Single Failure Scenarios:

- Recirc Suction / False LOCA

This case is similar to Case 1 in that a diesel which is supplying one of the Core Spray pumps is also supplying one of the available RHR pumps. However, in addition, since two RHR pumps in separate and independent divisions are available, it follows that a third diesel must be supplying the second RHR pump. The uncertainty from Case 1 can therefore be combined via the SRSS method with the uncertainty of a single RHR pump ($UNCERT_{RHR\text{-}1Pump}$ = 1071 GPM), as calculated in Section II.e above..

$$UNCERT_{CASE2} = [(UNCERT_{CASE1})^2 + (UNCERT_{RHR\text{-}1Pump})^2]^{1/2}$$

$$= [(1375)^2 + (1071)^2]^{1/2}$$

$$UNCERT_{CASE2} = 1743 \text{ GPM}$$

$$UNCERT\%_{CASE2} = 1743 / 30{,}750 \sim \underline{5.7\ \%}$$

d) CASE 3 - One Loop Core Spray Loop AND Three LPCI Pumps (One Complete LPCI Loop plus One Pump in Other Loop)

Number of Pumps Available: 5
Total Design Rated Flow: 39,850 GPM = (1 x 6350) + (1 x 21,300) + (1 x 12,200)
Applicable Break / Single Failure Scenarios:

- Recirc Suction / Battery (*)
- Recirc Suction / Diesel Generator (*)

For this case, three diesels are available. The most conservative line-up assumes that the division which powers Core Spray also supplies a complete loop of RHR. In addition, the remaining RHR pump is powered from a diesel in the opposite division. For this configuration, the uncertainty for the single RHR pump is equal to one pump uncertainty ($UNCERT_{RHR\text{-}1Pump}$ = 1071 GPM), as calculated in Section II.e above.

The uncertainty due to the complete division of two Core Spray and two LPCI pumps must account for the fact that they are powered from the same pair of diesels. Also, the fact that the RHR pump flow instrumentation uncertainties are not independent must be accounted for as previously outlined in the LPCI one loop uncertainty case in Section II.e above. The uncertainty due to a complete division of Core Spray and LPCI is:

$$UNCERT_{CS\&RHR} = [(\sigma_{CS,Flow})^2 + (\sigma_{CS,Press})^2 + (2 \times \sigma_{RHR,Flow})^2 + (2x(\sigma_{RHR,Press})^2) + (2x(\sigma_{CSPump,Speed} + \sigma_{RHR,Speed})^2]^{1/2}$$

$$= [(200)^2 + (384)^2 + (2 \times 600)^2 + (2 \times 560)^2 + (2 \times (286 + 688)^2)]^{1/2}$$

$$= 2038 \text{ GPM}$$

(Note: 2038 / (6350+21300) ~ 7.4% for a complete ECCS Division)

Applying the SRSS method to this uncertainty and the LPCI one pump uncertainty yields:

$$UNCERT_{CASE3} = [(UNCERT_{CS\&RHR})^2 + (UNCERT_{RHR\text{-}1Pump})^2]^{1/2}$$

$$= [(2038)^2 + (1071)^2]^{1/2}$$

$UNCERT_{CASE3}$ = 2302 GPM

$UNCERT\%_{CASE3}$ = 2302 / 39,850 ~ 5.8 %

(*) Note that for these scenarios, no credit is taken for a third Core Spray pump which could be available per FSAR Table 6.3-5. The rated flow of the "uncredited" third Core Spray pump (3175 GPM) exceeds the calculated uncertainty of 2302 GPM.

e) CASE 4 - Two Core Spray Loops

Number of Pumps Available: 4
Total Design Rated Flow: 12,700 GPM = (2 x 6350)
Applicable Break / Single Failure Scenarios:

- Recirc Discharge / LPCI Injection Valve

The uncertainty for this case is determined in the Core Spray two loop uncertainty case in Section I.e above.

$UNCERT_{CASE4}$ = $UNCERT_{CS\text{-}2Loops}$ = 837 GPM

$UNCERT\%_{CASE4}$ = $UNCERT\%_{CS\text{-}2Loops}$ = 837 / 12,700 ~ 6.6 %

f) CASE 5 - Two Core Spray Loops AND One LPCI Loop

Number of Pumps Available: **6**
Total Design Rated Flow: **34,000 GPM** = (2 x 6350) + (1 x 21,300)
Applicable Break / Single Failure Scenarios:

- Recirc Suction / LPCI Injection Valve
- Recirc Discharge / HPCI

Since all four Core Spray pumps are available, all diesels must be in operation. In this configuration, a complete divisional complement of RHR and Core Spray pumps are available, and the opposite loop of Core Spray is likewise available.

The uncertainty due to a complete division of two Core Spray and two LPCI pumps was calculated above in Case 3 and was determined to be:

$UNCERT_{CS\&RHR}$ = 2038 GPM

The uncertainty for the opposite loop of Core Spray is identified as the Core Spray single loop uncertainty as determined in Section I,e above:

$UNCERT_{CS\text{-}1Loop}$ = 592 GPM

Applying the SRSS method to these uncertainties yields:

$$UNCERT_{CASE5} = [(UNCERT_{CS\&RHR})^2 + (UNCERT_{CS\text{-}2Loops})^2]^{1/2}$$

$$= [(2038)^2 + (592)^2]^{1/2}$$

$UNCERT_{CASE5}$ = **2123 GPM**

$UNCERT\%_{CASE5}$ = **2123 / 34,000 ~ <u>6.2 %</u>**

g) CASE 6 - Two Core Spray Loops AND Two LPCI Loops

Number of Pumps Available: 8
Total Design Rated Flow: 55,300 GPM = (2 x 6350) + (2 x 21,300)
Applicable Break / Single Failure Scenarios:

- Recirc Suction / HPCI

In this case, all low pressure ECC subsystems in both divisions are available. The uncertainty due to a complete division of two Core Spray and two LPCI pumps was calculated above in Case 3 and was determined to be:

$UNCERT_{CS\&RHR}$ = 2038 GPM

Applying the SRSS method to account for both separate, independent divisions yields:

$$UNCERT_{CASE6} = [(UNCERT_{CS\&RHR})^2 + (UNCERT_{CS\&RHR})^2]^{1/2}$$

$$= [(2038)^2 + (2038)^2]^{1/2}$$

$UNCERT_{CASE6}$ = 2882 GPM

$UNCERT\%_{CASE6}$ = 2882 / 55,300 ~ 5.2 %

IV) CONCLUSIONS

The following table summarizes the rated flows for the available RHR and Core Spray systems, along with the associated uncertainties for the most limiting SSES Design Basis Accident scenarios:

↓Single Failure / Break→	Recirc Suction	Recirc Discharge
False LOCA	30,750 GPM / 5.7 %	18,550 GPM / 7.4 %
Battery	39,850 GPM / 5.8 % (*)	18,550 GPM / 7.4 % (*)
LPCI Injection Valve	34,000 GPM / 6.2 %	12,700 GPM / 6.6 %
Diesel Generator	39,850 GPM / 5.8 % (*)	18,550 GPM / 7.4 % (*)
HPCI	55,300 GPM / 5.2 %	34,000 GPM / 6.2 %

(*) Note that for the battery and diesel generator failure scenarios, no credit is taken for a third Core Spray pump which could be available per FSAR Table 6.3-5. For these cases, the rated flow of the "uncredited" third Core Spray pump (3175 GPM) exceeds the calculated uncertainties.

V) REFERENCES

1a) SO-151-A02, Rev. 2, SO-151-B02, Rev. 2, SO-251-A02, Rev. 2, SO-251-B02, Rev. 2, "Quarterly Core Spray Flow Verification - Division I (II)"

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Attachment 2

Effects of 2% Frequency Variation on Plant Systems and Components

I) DISCUSSION

With the implementation of Improved Technical Specifications (ITS), the allowable steady state operating frequency band for the emergency diesel generators is 58.8 Hz (60 +/- 1.2 Hz)[1]. The purpose of this licensing requirement (i.e., a 2% allowance band on diesel generator speed) is to assure that on-site emergency power is of an adequate quality, such that proper operation of electrical devices, such as relays, transformers, solenoids, etc., is assured. However, it is PP&L's position that this 2% speed tolerance need not be considered as a penalty in evaluating the performance of mechanical equipment/systems such as pumps, fans, compressors, etc.

As the result of conservative "over-design" margins which are inherent in nuclear power plant components and systems, a 2% increase in speed would not impose excessive stresses, nor cause unusual "wear and tear" on equipment during accident periods. Further, the relatively modest shortcomings in equipment performance which would result from a 2% decrease in power supply frequency are offset by the inherent conservatism of SSES licensing and design basis evaluations. In addition, The uncertainties in equipment performance, which are induced by the potential for a 2% reduction in the power supply frequency, are accounted for by conservative assumptions and methodologies which are mandated by regulatory analytical practices.

II) PURPOSE

The purpose of this evaluation is to provide a qualitative assessment addressing the impact on (the performance of) large mechanical components/systems which results from a potential 2% reduction in diesel speed (and hence a lower power supply frequency). It will be demonstrated that this potential either: 1) does not in any way impact system operation; or, 2) does not adversely affect the system/component capability to satisfactorily perform its design intended function. Hence, the potential for a 2% lower diesel power supply frequency imposes no implications to plant safety.

III) EVALUATION

In the vast majority of cases, the actual uncertainty of equipment performance which is induced by the subject allowance band in diesel generator frequency is actually less than 2%. This is due to the fact that for any given diesel, there is an equal probability that diesel speed (and hence the speed of rotating equipment) could be conservatively high. Since most safety-related systems contain redundant, 100% capacity components which serve the same function, the overall uncertainty induced by the potential for lower speed decreases so long as each component is supplied by a separate diesel.

For example, if two identical pumps are considered, the total flow rate is 2 times the mean flow rate and the total variance is 2 times the variance of one pump. However, the total uncertainty, in terms of percentage, is the total standard deviation (i.e., the square root of variance) divided by the total flow. Since the standard deviation is the square root of the variance, the uncertainty associated with the 2% allowance band is [2% x (SQRT(2))/2] = [2% x (1.41/2)] = [2% x (0.71)] = 1.42 %.

Therefore, the actual expected reduction in flow would be less than 2%. Similarly, the associated uncertainty is [2% x (SQRT(3))/3] =1.16 % if three pumps are considered and the associated uncertainty is [2% x (SQRT(4))/4] = 1.0% if four pumps are considered.

The uncertainty in performance for most safety related, redundant systems will therefore be less than 2%. Nonetheless, the evaluation below will assess the effects of a full 2% reduction in diesel speed on large mechanical components and systems.

A) Reactivity Control

1) Control Rod Drives

The CRD system pumps are not required for the emergency SCRAM function. The motive force for the rapid insertion of the control rod drives is provided via stored hydraulic/pneumatic energy (i.e., CRD accumulators) and the reactor vessel pressure itself. Hence, the ability for the CRD system to execute a SCRAM is unaffected by a 2% reduction in diesel speed.

2) SBLC Pumps

During an ATWS, two SBLC pumps would be initiated to inject sodium-pentaborate into the vessel. Since two independent pumps would be in operation and powered by separate diesels, , the uncertainty in equipment performance associated with the 2% allowance band is actually 1.42 %.

The SBLC pumps are positive displacement pumps and their discharge head characteristics would not be affected by a reduction in pump speed, but a proportional reduction in flow would occur. However, the potential for a slight reduction in diesel supply frequency is not seen to impact the conclusions of the SSES ATWS analysis[3] for several reasons. First, the SSES administrative concentration of sodium pentaborate is maintained higher than that required by Technical Specifications. While the Tech Spec allowable concentration ranges from 13.4% to 12.6% (by weight),[9d] the minimum administrative concentration is 13.6%.[25,26] Hence, the actual concentration of the solution injected is at least 1.5% higher than that required in Tech Specs. Although the SBLC pumps may run slightly slower when powered by the diesels, this higher concentration would act to offset the effects of a lower pump speed and thus assure that the required quantity of sodium pentaborate is injected to the vessel in a timely manner. Secondly, the ATWS case which involves a Loss of Off-site Power, which is when the diesels would be supplying the SBLC pumps, is not the most liming event with respect to peak vessel pressure, suppression pool temperature, nor fuel cladding temperature.

Finally, as a result of the low event probabilities, the regulatory assumptions which govern plant specific ATWS evaluations allow for the use of nominal values. Since there is an equal probability that the diesel supply frequency could be 2% above the 60 Hz setpoint, it is acceptable to assume a nominal supply frequency of 60 Hz. Since the

ATWS rules allow for the use of nominal values, it is not a licensing requirement to assume a penalty for a potential 2% reduction in emergency diesel generator speed.

B) RPV Pressure Boundary

1) Main Steam Safety Relief Valves

The primary means for overpressure protection of the reactor vessel are the Main Steam Safety Relief Valves (MSRVs). These valves have several modes of operation, none of which are affected by a reduction in diesel speed. In the "safety mode", which is the only mode governed by Technical Specifications, the valves are directly actuated by vessel pressure. In the non-safety-related "relief mode", the valves are opened, and maintained in the open position, via stored pneumatic energy (i.e., accumulators). None of the components which are required for valve operation rely on AC power sources and hence valve operation is not impacted by lower diesel speeds.

C) ECCS

1) HPCI / RCIC Systems/Pumps

The HPCI and RCIC system major support components are powered by DC electrical sources and do not require AC power for operation. The motive power for the pumps is supplied by steam driven turbines. As such, they are not impacted by a 2% reduction in diesel speed.

2) ADS

As with the other modes of MSRV operation, the motive force to actuate the ADS function of the valves is provided via stored pneumatic energy (i.e., accumulators and stored N_2 bottles). The function of the ADS system is therefore unaffected by a 2% reduction in diesel speed.

3) RHR & Core Spray Pumps

The need to account for the impacts of uncertainties in ECCS flow-rates, which are induced by a 2% reduction in diesel speed, in the SSES LOCA analyses is addressed in an engineering position paper which has been prepared by the Nuclear Fuels Group.[24] It has been concluded that NRC regulations do not explicitly require an analytical allowance for diesel generator frequency uncertainties in Appendix "K" methods. In addition, these methodologies, which are used for the SSES LOCA analyses, are conservative and consistent with the NRC's current expectations. Hence, the inclusion of such allowances is not needed to assure the health and safety of the public.

D) Containment Heat Removal

The design of the SSES units provides for two independent loops of decay/accident heat removal, and only one is needed for design basis accident mitigation. Each independent loop consists of an RHR heat exchanger which can be supplied by either of two 100% capacity RHR pumps. In addition, as a result of the "cross-unit" RHR Service Water (RHR SW) arrangement, each heat exchanger can be cooled by either of two 100% capacity RHR SW pumps. The redundancy of this configuration provides for a high level of system reliability and assures the adequate capability for decay/accident heat removal. Since multiple pumps are supplied by different diesels, the uncertainty in equipment performance associated with the 2% allowance band is at most 1.42 %. This notwithstanding, the following discussion is provided to demonstrate that any RHR / RHR SW pump combination would provide adequate post accident flows, even if both pumps operated under a 2% speed reduction.

1) RHR

A 2% reduction in speed will not impact the RHR pumps' ability to provide the design rated shell side heat exchanger flow of 10,000 GPM for post accident decay heat removal. Although a lower pump speed affects both flow and total developed head (TDH), the suppression pool return valves are throttled to only about 10-15% open when RHR is in the suppression pool cooling mode.[4] This is due to the fact that the suppression pool cooling line losses are relatively small when compared to the total developed head of the pump. The difference is taken up by throttling the return valve, which results in a large valve delta-P. If pump performance (i.e., flow and TDH) were to decrease because of a lower speed, a system flow of 10,000 GPM could still be easily established by further opening the return valve. Therefore, a 2% reduction in pump speed will not affect post accident RHR cooling flow.

2) RHR SW

In Figure 1, the pump curve for a typical SSES RHR SW pump is plotted.[5] The pump affinity laws were used to calculate a "degraded" curve corresponding to a pump speed of 58.8 Hz which is also plotted. Finally, a system resistance curve, which corresponds to a flow of 9000 GPM at 100% pump speed, is identified. Note that this system resistance curve would be established by operators via the throttling of the RHRSW heat exchanger inlet valve in accordance with operating procedures.[6] If pump performance were to decrease because of a lower speed, the RHR SW flow through the heat exchanger would decrease to the point where the system resistance curve intersects the degraded curve. By inspection, it is seen that this flow is approximately 8750 GPM. This flow is well in excess of the minimum required RHR SW flow of 8000 GPM, as identified in Reference 7. Therefore, a 2% reduction in pump speed will not adversely affect post accident RHR SW cooling flow.

E) ESW / DIESEL COOLING

1) ESW System

ESW system supplies cooling water to the emergency diesel generators, the ECCS pump room coolers (RHR, CS, HPCI/RCIC), the RHR pump motor oil coolers, the control structure chillers, and the Unit 2 direct expansion units. These loads are also addressed in other sections, but the following discussion is provided to demonstrate that the potential for a 2% reduction in diesel speed will not threaten adequate cooling for emergency loads.

Performance Uncertainty

During a Design Basis Accident, at least one loop of ESW (i.e., two pumps) would be in operation. Since all ESW pumps are supplied by separate diesels, the associated uncertainty in equipment performance for a two pump configuration is actually 1.42 %. Likewise, the uncertainties associated with three and four pump operating configurations is 1.16% and 1.0% respectively.

Spray Pond / ESW Short Term Temperatures

The design basis flows for all ESW users is based on the maximum spray pond design temperature of 97°F.[8] The maximum administrative operating limit of 85°F[9a] assures that the 97°F threshold will not be exceeded, even with the worst case single failure for spray pond temperature; a failure of an ESW return bypass valve to close. (This failure can prevent the effective use of the spray arrays and hence results in higher spray pond temperatures.)

The spray pond temperature profile following a Design Basis Accident increases by about two degrees-F in the first three hours of an accident; from 85.5°F to 87.6°F.[10] Subsequently, after six hours, temperature increases to 90.6°F and then to 93.4°F at twelve hours. With the inability to close a loop's bypass valve, appropriate operator actions are taken but spray pond temperature continues to increase to 95.9°F at 24 hours and peaks at 97.42°F at t=44 hours. Soon thereafter, a downward trend in temperature occurs. Based on this profile, ESW users would be supplied with relatively low temperature cooling water during the initial stages of an accident. As a result of lower initial supply temperatures, as well as the fact that margin exists between the actual and minimum required ESW cooler flows,[11] it is reasonable to expect that all ESW users would be adequately cooled, even if diesel speeds (and hence pump speeds) were to be slightly lower.

ESW System Performance

Two ESW pumps are capable of supplying all required emergency loads during a DBA (i.e., four diesels and a complete division of safety-related equipment).[11] In addition, for most DBA scenarios, it is expected that a minimum of three pumps would be available; the only single failures which would prevent the auto-initiation of at least three pumps is the loss of 125 VDC batteries 1D614 or 1D624. However, for these specific single failures, it is expected that two pumps would nonetheless provide for adequate cooling in the short term, even with a 2% reduction in speed. This is due to the fact that spray pond temperatures will be less than the design basis temperature limit of 97°F as described above. In the short term, the cooler supply temperatures would act to offset the effects of a slightly lower flow which might occur if only two pumps were available and operating at a lower speed.

In the event of a failure of 1D614 or 1D624, additional pumps could be placed in service by transferring their control power from the failed battery to the corresponding Unit 2 battery (2D614 or 2D624). At this point, at least three pumps would be available and capable of supplying all required loads as described below:

In Figure 2, the pump curve for a typical SSES ESW pump is plotted.[12] Also plotted is the equivalent curve for two pump operation in parallel, as well as a conservative system resistance curve which intersects the two pump curve at a flow of 7000 GPM. This flow was selected because it bounds the flow requirements of a single loop of ESW.[8] Finally, a "degraded" curve is plotted which corresponds to three pumps operating with a 2% reduction in speed (58.8 Hz). By inspection, it is seen that 7000 GPM, the "degraded" three-pump curve is above the "normal" two pump curve, which is known to provide adequate flow to the associated users.[11] Therefore, as long as three ESW pumps are available, they would be able to provide adequate flow and head even when operated with a 2% reduction in speed.

Spray Cooling

As a final note, it should be identified that the potential for a 2% reduction in ESW pump speed will not result in inadequate spray cooling. This is due to the fact that guidelines have been developed and incorporated into the appropriate operating procedures[6] which provide direction for the optimum use of the spray networks, based on system flow. Therefore, operators have the required information and operating guidelines to effectively use the spray networks and optimize spray cooling regardless of actual system/loop flow.

2) Emergency Diesel Generator Cooling

Based on the discussion above, it is reasonable to expect that the emergency diesel generators would be provided enough cooling to provide for the disbursement of their design heat load. Hence, a 2% reduction in ESW pump speed would not affect either the short or long term phases of diesel operation during accident scenarios.

In the short term phase, just after diesel start, the engine is cold and operation can continue for several minutes without cooling.[13] In addition, during this point of the accident, cooler inlet temperatures would be at least 12°F cooler than assumed in the diesel heat exchanger design calculations. (The heat exchanger design calculations assume an inlet temperature equal to the ESW spray pond design limit of 97°F, whereas the pond temperature at the start of the event would be at most 85°F - the Tech Spec administrative limit.)

In the longer term, it is expected that at least three ESW pumps would be available as described above, and hence the diesels would be supplied with their design flow rates. In addition, it should be noted that if a diesel were running with a 2% slower steady state speed, the mechanical components it powers would also be running 2% slower. Under these conditions, the work done by these mechanical components would be less, and hence their associated load on the diesel would be less. With a lower diesel load, the cooling requirements would likewise be less. Hence, it is concluded that unacceptable diesel operating conditions would not result from any potential shortcomings in ESW flow due to a 2% reduction in diesel speed.

F) HVAC

1) Control Structure Chilled Water

The Control Structure Chilled Water (CSCW) system consists of two independent chiller trains, each of which has a 100% capacity of 202 tons with the maximum ESW supply temperature of 97°F, and a loop supply temperature of 44°F.[14] In general, the entire temperature profile in the control structure during Design Basis Accidents qualifies as a "mild" environment. This is evidenced by the fact that equipment qualification is not required for components in the building. Unlike the reactor building, which is completely isolated under accident conditions, outside air is drawn into the control structure through the CREOASS trains. The overall heat load is therefore dependent not only on the building's internal heat load, but also on the on outside air temperature which varies throughout the day.

There are several ways in which a 2% lower diesel speed would affect the CSCW system. There are a number of components which would operate at a lower speed, and hence provide lower flows. These components include the system's outside supply and area cooling fans, the condenser circ and loop circ pumps, as well as the chiller's centrifugal compressor. In general, with a lower compressor speed, the available capacity of the chiller will decrease since the overall flow rate of the refrigerant will decrease.

With the fans and loop circ pumps providing lower flows, the actual heat load induced on the chiller will be lower, since lower flows would remove less heat from the cooled areas. The net effects of a 2% reduction in diesel speed would result in a steady state equilibrium operating point for the system with slightly higher room/area temperatures. This steady state operating point will not only be a function of these areas temperatures, but also of the chilled loop supply/return temperatures, outside air (i.e., supply) temperatures, and the ESW supply temperature and flow.

A review of the building temperature response during accidents was performed.[15] That analysis considers the effect of variable chiller loads and loop supply temperatures, as well as outside air temperature. When loop supply temperature is increased by 6°F (from 44°F to 50°F), chiller load is reduced by up to 20 tons (about 10%), and peak room/area temperatures increase by an average of about 4°F - 5°F. In addition, all peak temperatures do not occur until 720 hours (30 days) after the start of the accident. With a 2% reduction in diesel speed, it is expected that peak room/area temperatures would be slightly higher than those calculated for 100% equipment speed. However, temperatures for those areas which are cooled by the CSCW system would nonetheless still fall within the envelope which defines a "mild" environment.

In addition, as the result of the thermal inertia of the entire building and system, the effect of a slower diesel speed would be slow to develop. This slow response, coupled with the 30 day time required to reach peak room/area temperatures, would provide for an adequate "buffer" to allow for operators to diagnose unusual control structure environmental conditions. Since operators have complete access to the CSCW system during accidents, appropriate corrective actions could be taken to preclude the onset of unacceptable control structure temperatures. Therefore, a 2% reduction in diesel speed will not affect the CSCW system's capability of maintaining a "mild" environment in the control structure.

2) Unit 2 DX Units

Area cooling for the Unit 2 emergency switch-gear rooms and load center areas is provided by the skid mounted direct expansion units (DX units) which reject heat to the ESW system. There are two independent units which are powered from independent diesels and supplied by separate loops of ESW. With two independent units, the uncertainty induced by the potential for a 2% reduction in diesel speed is actually 1.42%, as discussed above.

Unlike other chilled water systems at SSES, these units do not operate in a "load-following" mode. At steady state operating conditions, they are capable of removing a heat load of approximately 40 tons with an ESW supply temperature of 97°F.[18,19] However, the heat load in the areas these units serve is on the order of approximately 32 tons.[19] Although a 2% reduction in diesel speed could potentially affect the capacity of the DX units, there is sufficient margin between the rated capacities of these units and their worst case accident heat load. Therefore, the potential for a 2% reduction in diesel speed will not affect adequate cooling of the Unit 2 emergency switch gear rooms.

3) Reactor Building HVAC (ECCS Room Coolers)

The performance of the reactor building room coolers could potentially be affected by a 2% reduction in diesel speed since they would be supplied with a lower ESW flow, and fan speed would be reduced by 2%. However, adequate cooling for the affected areas is nonetheless assured as discussed below:

RHR & Core Spray

Each division of RHR and Core Spray has two 50% capacity fan/cooling units. Since each fan unit is supplied by separate diesels, the uncertainty associated with the 2% diesel allowance band is actually 1.42%.

The design basis ESW flow to the RHR and Core Spray fan units is 120 GPM and 36 GPM respectively.[8] However, calculations performed in support of the Appendix "R" Program have indicated that acceptable room temperatures (i.e., design basis temperatures) are maintained with flows as low as 50 GPM for RHR and 14 GPM for Core Spray.[20] It is therefore evident that a significant amount of cooling margin exists for these coolers. In addition, it is noteworthy to add that the maximum area temperatures for these rooms does not occur until 30 days after the start of an accident.[19] Therefore, if diesel speed were to be reduced by 2%, any unusual conditions would be slow to evolve and there would be ample time to allow for proper operator response. It is therefore concluded that the potential for a reduction in both ESW and fan flow which results from a 2% lower speed would not result in unacceptable temperatures for the affected areas.

HPCI & RCIC

The HPCI and RCIC rooms are provided with two 100% capacity fan/cooling units, each of which is powered from a separate diesel and supplied by a separate loop of ESW. As with the RHR & Core Spray Coolers, their performance could be affected, since they could potentially be supplied with a lower ESW flow, and the fans speed could be reduced by 2%.

Calculations have demonstrated that under large break DBA scenarios, these coolers are not required to maintain acceptable area temperatures, since the HPCI & RCIC systems isolate under these conditions.[19] For small break scenarios, these coolers are only required if the barometric condenser piping is assumed to fail.[19,21] For scenarios during which the systems are assumed to operate, the primary heat load in these rooms therefore results from a pipe break outside containment with a small break LOCA inside containment. During these scenarios, peak area temperatures do not occur until several hours after the start of the event. At this point, it is likely that the vessel would be depressurized and high pressure make-up systems would no longer be required. Even under the worst case postulated scenarios, peak temperatures do not occur until a point when the systems would no longer be required. Therefore, even if area cooling was affected by the slower diesel speed, this would not impact the ability of the HPCI and RCIC system to perform their design intended function during the postulated scenarios.

4) The Stand-By Gas Treatment System

The Stand-By Gas Treatment System (SBGT) consists of two 100% capacity independent filter trains and fans which are supplied from separate diesels. Under accident conditions, the system auto-initiates and takes suction from the unit-common reactor building recirculation plenum. Since each fan unit is independent, the uncertainty in system performance associated with the 2% allowance band is 1.42%.

The primary functions of the SBGT system are to: 1) establish a negative pressure of 0.25" H_2O in the secondary containment upon system initiation (i.e., draw-down phase); and 2) maintain this pressure to prevent un-monitored effluvium from reactor building leakage pathways. In performing its design function, the SBGT system assures that gaseous effluents are filtered and monitored, and maintains off-site doses below 10CFR100 limits. While a 2% reduction in diesel speed would result in lower fan flows, this reduction in system performance is not expected to impact off-site doses.

Upon initiation, SBGT is required to "draw-down" secondary containment to -0.25" H_2O in 3 minutes. Calculations have indicated that with the maximum allowable reactor building in-leakage of 4000 SCFM,[9b] a single SBGT fan can draw-down Zones I, II, & III in 142 seconds. Thus a 38 second, or 21% margin exists.[22] In addition, another calculation has shown that even with a 13 minute draw-down time, there is virtually no change in calculated off-site doses.[23] Thus, even if the system required an additional 10 minutes to draw-down the reactor building, there are no consequences with respect to off-site doses. In any case, it is reasonable to conclude that a 2% reduction in fan speed would not prevent the SBGT system from establishing -0.25" H_2O reactor building pressure prior to the propagation of fission products into the secondary containment

In the longer term phase of system operation, SBGT must maintain a -0.25" H_2O pressure in secondary containment. This is achieved by maintaining a constant SBGT system flow of 10,100 SCFM, which is drawn from two sources: an outside air supply, and the reactor building recirculation plenum. Modulating dampers control the flows from both the recirculation plenum and the outside air source, such that the reactor building is maintained at -0.25" H_2O. Since the maximum allowable reactor building in-leakage is only 4,000 SCFM, it follows that at least 6,100 SCFM must be drawn from the outside source.

The first effect of a lower fan speed would be that the fan inlet dampers, which control to maintain a constant flow of 10,100 SCFM would open further. If the fans were unable to maintain a flow of 10,100 SCFM, the other system dampers would modulate to maintain reactor building pressure by drawing less flow from the outside supply source. As a result of the large margin between the maximum reactor building in-leakage (4,000 SCFM), and the rated fan flow (10,100 SCFM), it is concluded that a 2% reduction in fan speed would not prevent the SBGT system from achieving its long term design basis objective.

IV) CONCLUSION

As a result of existing calibration procedures and practices, as well as the accuracy of the diesel generator electronic governor, it is unlikely that the diesel speed would deviate from 60 Hz. However, the above evaluation qualitatively considers the effects of a 2% diesel speed reduction on large mechanical components and systems. The following summarizes these effects:

- As a result of equipment/system redundancy, the actual uncertainty in equipment speed which results from the potential for a 2% lower diesel speed is, in actuality, less than 1%.

- With respect to the short term plant response during accidents and transients: It was demonstrated that an **actual 2% reduction in diesel speed does not adversely affect: 1) the ability to establish sub-critical core conditions; 2) the ability to maintain and protect the reactor vessel pressure boundary; and, 3) provide adequate make-up capability during design basis accidents and/or transients.**

- With respect to the long term plant response during accidents and transients: It was demonstrated that as the result of the redundancy and independence of plant components, as well as conservative design practices, an **actual 2% reduction in equipment speed would not adversely affect the ability to mitigate these events, and will not result in off-site doses in excess of 10CFR100 limits.**

In summary, past and present engineering practices which govern the design and licensing bases of SSES provide for an extremely conservative and safe plant design. These practices mandate many engineering conservatisms (i.e., assumptions, inputs, methodologies, etc.) which are applied in the design of systems and also in the evaluation of specific licensing basis events. As a result of these conservatisms, many of which are mandated by regulatory requirements/commitments, a high level of system and component "over-design" establishes an ample margin of plant safety. As a result of this margin, it is not an appropriate licensing basis requirement that an additional 2% penalty be incurred due to the allowance in emergency diesel generator speed.

See page 34a for EPU and additional discussion rev. 2

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22) EC-070-0526, Rev. 0, "SGTS Draw-down Analysis"
23) EC-RADN-1032, Rev. 0, "Evaluation Of Offsite & Control Room Dose Consequences For Standby Gas Treatment System Single Failure Events"
24) PL-NF-98-007(P), Rev. 0 ~~(DRAFT),~~ "Susquehanna SES - Measurement Uncertainties In Appendix "K" LOCA Analyses", 5/98 rev. 2
25) PLA-3171, "Susquehanna Steam Electric Station - Anticipated Transient Without SCRAM"
26) SC-153-101, Rev. 6 & SC-253-101, Rev. 10, "Chemistry Surveillance Of Unit 1(2) Standby Liquid Control System"

Discussion of OE 31798 (AR 1296983)

Discussion: AR/CR 1302108 was generated to document the applicability of the OE to SSES and CRA 1307834 was generated to update this calculation. Clinton Power Station generated OE31798 (AR 1296983) which documented that power uprate significantly reduced the available ECCS margin for the containment analysis. This margin had previously been used to address lower diesel frequencies as allowed by the Technical Specifications. The main concern is that the Clinton uncertainty analysis did not specifically address the containment cooling functions of the RHR pumps. The PPL analysis in EC-024-1014 Attachment 2 section D specifically addresses the containment analysis. This section was not specifically updated for EPU.

A review of EC-PUPC-20601 determined that the power requirements for safety related systems post-EPU have remained the same. Additionally, a review of each specific section of the Attachment 2 analysis determined that although some of the details have changed slightly the conclusions of each section remain the same for EPU. Since the containment analysis is specifically mentioned in the OE that issue is discussed. As stated in the Attachment 2 section D, the RHR pumps are assumed to have a flow rate of 10,000 gpm through the heat exchanger. This is significantly below the RHR pump capacity and with a 2% reduction in frequency this flow rate will still be met. EC-PUPC-20400 evaluates containment pressure and temperature response for EPU. The analysis calculated an acceptable response even without containment sprays. Additionally, a review of EC-PUPC-20400 determined that running all 4 RHR and all 4 Core Spray pumps is conservative from a containment heat-up perspective since all these pumps add heat to the containment. If the pump speed is reduced by 2% this will reduce the pump heat load within containment which would lower suppression pool temperatures. This is conservative. So based on the specific analysis for SSES, EPU did not impact the margin for these systems as it related to the diesel frequency issue. The other concern would be equipment cooling (RHR room coolers, diesel cooling DX unit, etc.). The peak spray pond temperature did not change as a result of EPU (still 97°F) and the discussion for each of these cooling systems is still applicable. Based on this evaluation, the concerns of OE 31798 have been effectively evaluated for SSES and the conclusions remain acceptable.

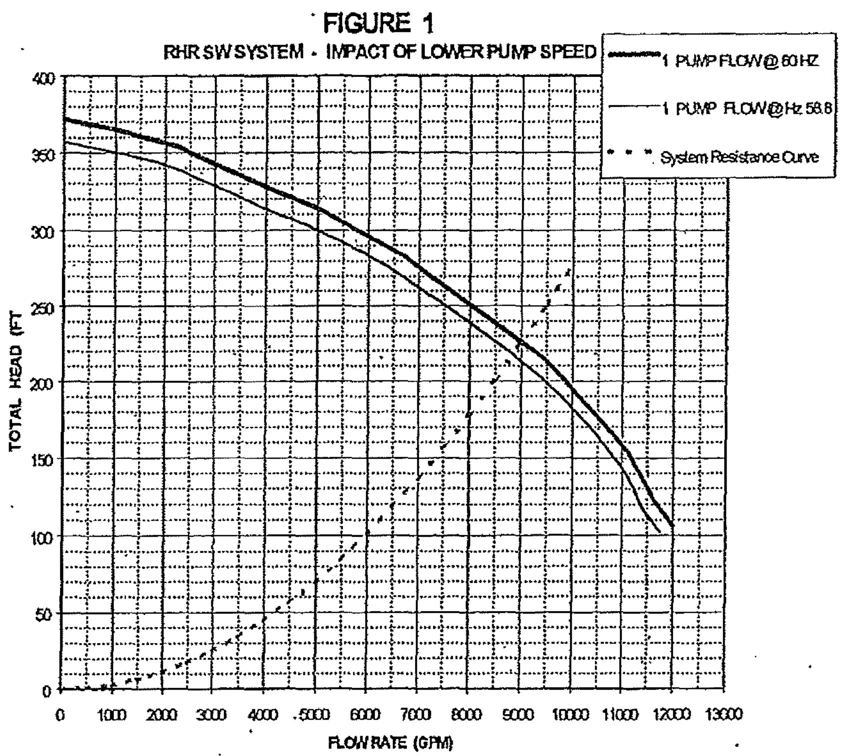
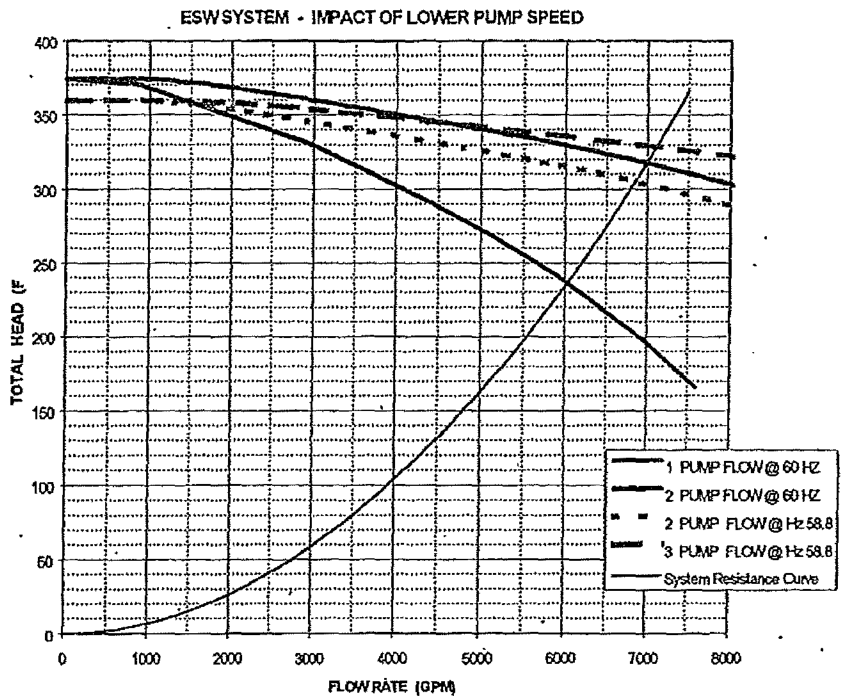


FIGURE 1
RHR SW SYSTEM - IMPACT OF LOWER PUMP SPEED
1 PUMP FLOW @ 60 HZ
1 PUMP FLOW @ Hz 58.8
System Resistance Curve
TOTAL HEAD (FT
FLOW RATE (GPM)
0
50
100
150
200
250
300
350
400
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000

FIGURE 2


ESW SYSTEM - IMPACT OF LOWER PUMP SPEED
TOTAL HEAD (F
FLOW RATE (GPM)
0
50
100
150
200
250
300
350
400
1000
2000
3000
4000
5000
6000
7000
8000
1 PUMP FLOW @ 60 HZ
2 PUMP FLOW @ 60 HZ
2 PUMP FLOW @ Hz 58.8
3 PUMP FLOW @ Hz 58.8
System Resistance Curve

Issue:

Calculation EC-024-1014 considers the impact of the tech spec allowable +/- 1.2 Hz frequency variation on the connected loads. However, a review of the calculation did not show that the impact of higher frequency on starting torque was addressed. Flux is inversely related to speed. So an increase in speed decreases motor field flux. This in turn impacts the motor's starting torque. It appears that this impact needs to be addressed in a calculation.

Response:

A detailed review of the calculation shows discussion of MG 2 requirements which state that motors will operate successfully under running conditions at rated load with frequency variations of up to +/-5 percent, voltage variations up to +/-10 percent, and voltage and frequency variations summed by absolute value of +/-10 percent. However, a review of MG 2 shows that the referenced section in MG 2 refers to **running** loads. In MG 2, the 10/1981 version, the discussion of **starting torque** is generic but notes that the torque developed by the motor at any speed is proportional to voltage squared and inversely proportional to frequency.

For the 4 KV safety related motors, GE specifications apply for the RHR and CS motors, and E112 applies to the Bechtel scope of supply. **The specifications do not reference MG 2, but instead reference MG 1.**

The motor specs for RHR (GE 21A9369AZ), Core Spray (GE 21A9369AY) and E112 for the Bechtel scope of supply all reference MG 1 requirements for torque. Specification E112 specifically references MG 1-20.45. The number 20.45 is a section/paragraph within MG 1.

The requirements relevant to the problem statement are in MG 1-20.45 which states that the motor shall be capable of starting and accelerating a load with a torque characteristic and inertia value not exceeding that listed in MG 1-20.42 with voltage and frequency variations specified in Par. A of MG 1-20.45. Par. A allows frequency variations of up to +/-5 percent, voltage variations up to +/-10 percent, and voltage and frequency variations summed by absolute value of +/-10 percent.

The inertia values for the RHR and Core Spray motor (respectively 3960, 420 wk^2). determined by MPR in developing dynamic motor models are below the inertia values provided in MG 1-20.42 (16780, 2514 wk^2).

It can be concluded that adequate starting and accelerating torque would be available at a frequency of 60 +1.2 = 61.2 hertz.

Relevant pages of MG 1 and MG 2 follow:

Att. 3

MG 1-20.42 Load Wk^2 for Polyphase Squirrel-cage Induction Motors

The following table lists load Wk^2 which polyphase, squirrel-cage motors having performance characteristics in accordance with Part 20 can accelerate without injurious temperature rise under the following conditions:

1. Applied voltage and frequency within the limits set in MG 1-20.45.
2. During the accelerating period, the connected load torque shall be equal to, or less than, a torque which varies as the square of the speed and is equal to 100 percent of full-load torque at rated speed.
3. Two starts in succession (coasting to rest between starts) with the motor initially at ambient temperature or one start with the motor initially at a temperature not exceeding its rated load operating temperature.

	Speed, Rpm											
	3600	1800	1200	900	720	600	514	450	400	360	327	300
Hp	Load Wk^2 (Exclusive of Motor Wk^2), Lb-ft²											
100	...	...	...	...	...	...	...	12670	16830	21700	27310	33690
125	...	...	...	...	...	...	...	15610	20750	26760	33680	41550
150	...	...	...	...	...	...	13410	18520	24610	31750	39960	49300
200	...	...	...	...	...	12060	17530	24220	32200	41540	52300	64500
250	...	...	...	...	9530	14880	21560	29800	39640	51200	64400	79500
300	...	...	...	6540	11270	17550	25530	35300	46960	60600	76400	94300
350	...	...	...	7530	12980	20230	29430	40710	54200	69900	88100	108800
400	...	...	4199	8500	14670	22870	33280	46050	61300	79200	99800	123200
450	...	...	4666	9460	16320	25470	37090	51300	68300	88300	111300	137400
500	...	...	5130	10400	17970	28050	40850	56600	75300	97300	122600	151500
600	443	2202	6030	12250	21190	33110	48260	66800	89100	115100	145100	179300
700	503	2514	6900	14060	24340	38080	55500	76900	102600	132600	167200	206700
800	560	2815	7760	15830	27440	42950	62700	86900	115900	149800	189000	233700
900	615	3108	8590	17560	30480	47740	69700	96700	129000	166900	210600	260300
1000	668	3393	9410	19260	33470	52500	76600	106400	141900	183700	231800	286700
1250	790	4073	11380	23390	40740	64000	93600	130000	173600	224800	283900	351300
1500	902	4712	13260	27350	47750	75100	110000	153000	204500	265000	334800	414400
1750	1004	5310	15060	31170	54500	85900	126000	175400	234600	304200	384600	476200
2000	1096	5880	16780	34860	61100	96500	141600	197300	264100	342600	433300	537000
2250	1180	6420	18440	38430	67600	106800	156900	218700	293000	380300	481200	596000
2500	1256	6930	20030	41900	73800	116800	171800	239700	321300	417300	528000	655000
3000	1387	7860	23040	48520	85800	136200	200700	280500	376500	489400	620000	769000
3500	1491	8700	25850	54800	97300	154800	228600	319900	429800	559000	709000	881000
4000	1570	9460	28460	60700	108200	172600	255400	358000	481600	627000	796000	989000
4500	1627	10120	30890	66300	118700	189800	281400	395000	532000	693000	881000	1095000
5000	1662	10720	33160	71700	128700	206400	306500	430800	581000	758000	963000	1198000
5500	1677	11240	35280	76700	138300	222300	330800	465600	628000	821000	1044000	1299000
6000	...	11690	37250	81500	147500	237800	354400	499500	675000	882000	1123000	1398000
7000	...	12400	40770	90500	164900	267100	399500	565000	764000	1001000	1275000	1590000
8000	...	12870	43790	98500	181000	294500	442100	626000	850000	1114000	1422000	1775000
9000	...	13120	46330	105700	195800	320200	482300	685000	931000	1223000	1563000	1953000
10000	...	13170	48430	112300	209400	344200	520000	741000	1009000	1327000	1699000	2125000
11000	...	...	50100	117900	220000	366700	556200	794000	1084000	1428000	1830000	2291000
12000	...	...	51400	123000	233500	387700	590200	844800	1155000	1524000	1956000	2452000
13000	...	...	52300	127500	244000	407400	622400	893100	1224000	1617000	2078000	2608000
14000	...	...	52900	131300	253600	425800	652800	934200	1289000	1707000	2195000	2758000
15000	...	...	53100	134500	262400	442900	681500	983100	1352000	1793000	2309000	2904000

The values of Wk^2 of connected load given in the foregoing table were calculated from the following formula:

$$\text{Load } Wk^2 = A\left[\frac{Hp^{.95}}{\left(\frac{Rpm}{1000}\right)^{2.4}}\right] - 0.0685\left[\frac{Hp^{1.5}}{\left(\frac{Rpm}{1000}\right)^{1.8}}\right]^{*}$$

Where A—24 for 300 to 1800 rpm, inclusive, motors
A—27 for 3600 rpm motors

* This formula may not be applicable to ratings not included in the above table. Consult the manufacturer for the ratings which are not shown.

Authorized Engineering Information 11-12-1953, revised 6-1-1959; 7-13-1967; 5-17-1971; 11-8-1973.

EC-024-1014
Page 38

Att. 3

EC-024-1914
Page 39

MG 1-20.43 Number of Starts

A. Squirrel-cage induction motors shall be capable of making the following starts, providing the Wk^2 of the load, the load torque during acceleration, the applied voltage, and the method of starting are those for which the motor was designed:

1. Two starts in succession, coasting to rest between starts, with the motor initially at ambient temperature, or
2. One start with the motor initially at a temperature not exceeding its rated load operating temperature.

NEMA Standard 6-1-1959.

B. If additional starts are required, it is recommended that none be made until all conditions affecting operation have been thoroughly investigated and the apparatus examined for evidence of excessive heating. It should be recognized that the number of starts should be kept to a minimum since the life of the motor is affected by the number of starts.

C. When requested by the purchaser, a separate starting information plate will be supplied on the motor.

Authorized Engineering Information 6-1-1959, revised 11-12-1970.

MG 1-20.44 Overspeeds

Squirrel-cage and wound-rotor induction motors shall be so constructed that, in an emergency, they will withstand without mechanical injury overspeeds above synchronous speed in accordance with the following:

Synchronous Speed, Rpm	Overspeed, Percent of Synchronous Speed
1801 and over	20
1800 and below	25

NEMA Standard 5-17-1955.

MG 1-20.45 Variations from Rated Voltage and Rated Frequency

A. RUNNING

Motors shall operate successfully under running conditions at rated load with a variation in the voltage or the frequency up to the following:

1. Plus or minus 10 percent of rated voltage, with rated frequency.
2. Plus or minus 5 percent of rated frequency, with rated voltage.
3. A combined variation in voltage and frequency of plus or minus 10 percent (sum of absolute values) of the rated values, provided the frequency variation does not exceed plus or minus 5 percent of rated frequency.

Performance within these voltage and frequency variations will not necessarily be in accordance with the standards established for operation at rated voltage and frequency.

B. STARTING

Motors shall start and accelerate to running speed a load which has a torque characteristic and an inertia value not exceeding that listed in MG 1-20.42 with the voltage and frequency variations specified in par. A. For loads with other characteristics, the starting voltage and frequency limits may be different.*

NEMA Standard 11-15-1958, revised 3-14-1963; 11-12-1970.

* The limiting values of voltage and frequency under which a motor will successfully start and accelerate to running speed depend on the margin between the speed-torque curve of the motor at rated voltage and frequency and the speed-torque curve of the load under starting conditions. Since the torque developed by the motor at any speed is approximately proportional to the square of the voltage and inversely proportional to the square of the frequency, it is generally desirable to determine what voltage and frequency variations will actually occur at each installation, taking into account any voltage drop resulting from the starting current drawn by the motor. This information and the torque requirements of the driven machine define the motor-speed-torque curve, at rated voltage and frequency, which is adequate for the application.

NOTE—Induction motors to be operated from solid-state or other types of variable-frequency and/or variable-voltage power supplies for adjustable-speed-drive applications may require individual consideration to provide satisfactory performance. Especially for operation below rated speed, it may be necessary to reduce the motor torque load below the rated full-load torque to avoid overheating the motor. The motor manufacturer should be consulted before selecting a motor for such applications.

Authorized Engineering Information 3-14-1963; revised 7-16-1969; 11-12-1970.

MG 1-20.46 Routine Tests

1. Measurement of winding resistance
2. No-load readings of current and speed at normal voltage and frequency. On 50-hertz motors, these readings may be taken at 60 hertz if 50 hertz is not available. On motors furnished without complete shaft and bearings, this test will not be taken.
3. Measurement of open-circuit voltage ratio on wound-rotor motors.
4. High-potential test in accordance with MG 1-20.47.

NEMA Standard 11-14-1957.

MG 1-20.47 High-potential Tests

A. SAFETY PRECAUTIONS AND TEST PROCEDURE

See MG 1-3.01.

B. TEST VOLTAGE—PRIMARY WINDINGS

The test voltage shall be an alternating voltage whose effective value is 1000 volts plus twice the rated voltage of the machine.*

C. TEST VOLTAGE—SECONDARY WINDINGS OF WOUND ROTORS

The test voltage shall be an alternating voltage whose effective value is 1000 volts plus twice the maximum voltage which will appear between slip rings on open-circuit with rated voltage on the primary and with the rotor either at standstill or at any speed and direction of rotation (with respect

Insulation Class	Typical Total Winding Temperature 1.15 Service Factor	1.0 Service Factor
Class H	—	180 C
Class F	165 C	155 C
Class B	140 C	130 C
Class A	115 C	105 C

The rotor surface temperature of squirrel-cage induction motors cannot be accurately measured on production units. The rotor surface temperature varies greatly with enclosure type, cooling method, insulation class, and slip, but may be in the range of 150-225 C for Class B or Class F insulated normal slip motors when operating at rated load and in a 40 C ambient temperature.

The above insulated winding temperature and rotor surface temperature values are typical values based on continuous operation at rated voltage and rated frequency under usual service conditions. Margin for voltage and frequency variations, manufacturing variation, overload, or hot start and acceleration is not included. The motor manufacturer should be consulted for further information.

When motor-mounted space heaters are to be furnished, it is recommended that the exposed surface temperature be limited to 80 percent of the ignition temperature of the gas or vapor involved with rated space heater voltage applied and the motor deenergized.

The range of ignition temperatures is so great and variable that it is not practical for the motor manufacturer to determine if a given motor is suitable for a Division 2 area. The user's knowledge of the area classification, the application requirements, the insulation system class, and past experience are all factors which should be considered by the user, his consultant, or others most familiar with the details of the application involved when making the final decision.

Authorized Engineering Information 9-7-1977.

MG 2-3.06 PROPER SELECTION OF APPARATUS

Motors and generators should be properly selected with respect to their usual or unusual service conditions, both of which involve the environmental conditions to which the machine is subjected and the operating conditions. Machines conforming to Parts 1 and 2 of this publication are designed for operation in accordance with their ratings under usual service conditions. Some machines may also be capable of operating in accordance with their ratings under one or more unusual service conditions. Definite-purpose or special-purpose machines may be required for some unusual conditions.

Service conditions, other than those specified as usual, may involve some degree of hazard. The additional hazard depends upon the degree of departure from usual operating conditions and the severity of the environment to which the machine is exposed. The additional hazard results from such things as overheating, mechanical failure, abnormal deterioration of the insulation system, corrosion, fire and explosion.

Although past experience of the user may often be the best guide, the manufacturer of the driven or driving equipment and/or the motor and generator manufacturers should be consulted for further information regarding any unusual service conditions which increase the mechanical or thermal duty of the machine and, as a result, increase the chances for failure and consequent hazard. This further information should be considered by the user, his consultants, or others most familiar with the details of the application involved when making the final decision.

Authorized Engineering Information 11-16-1972.

MG 2-3.07 VARIATION FROM RATED VOLTAGE AND RATED FREQUENCY

A. Induction Motors

1. *Running*—Motors will operate successfully under running conditions at rated load with a variation in the voltage or the frequency up to the following:

a. Plus or minus 10 percent of rated voltage with rated frequency.
b. Plus or minus 5 percent of rated frequency with rated voltage.
c. A combined variation in voltage and frequency of plus or minus 10 percent (sum of absolute values) of the rated values, provided the frequency variation does not exceed plus or minus 5 percent of rated frequency.

Performance within these voltage and frequency variations will not necessarily be in accordance with the standards established for operation at rated voltage and frequency.

2. *Starting*—The limiting values of voltage and frequency under which a motor will succesfully start and accelerate to running speed depend on the margin between the speed-torque curve of the motor at rated voltage and frequency and the speed-torque curve of the load under starting conditions. Since the torque developed by the motor at any speed is approximately proportional to the square of the voltage and inversely proportional to the square of the frequency, it is generally desirable to determine what voltage and frequency variations will actually occur at each installation, taking into account any voltage drop resulting from the starting current drawn by the motor. This information and the torque requirements of the driven machine define the motor-speed-torque curve, at rated voltage and frequency, which is adequate for the application.

NOTE—If induction motors are to be operated from solid-state or other type of variable-frequency and/or variable-voltage power supplies for adjustable-speed-drive applications, each application should be individually considered to provide satisfactory performance. Especially for operation below rated speed, it may be necessary to reduce the motor torque load below the rated full-load torque to avoid overheating the motor. The motor manufacturer should be consulted before selecting a motor for such applications.

B. Synchronous Motors

1. *Running*—Motors will operate successfully in synchronism, rated exciting current being maintained, under running conditions at rated load with a variation in the voltage or the frequency up to the following:

a. Plus or minus 10 percent of rated voltage with rated frequency.

b. Plus or minus 5 percent of rated frequency with rated voltage.

c. A combined variation in voltage and frequency of plus or minus 10 percent (sum of absolute values) of the rated values, provided the frequency variation does not exceed plus or minus 5 percent of rated frequency.

Performance within these voltage and frequency variations will not necessarily be in accordance with the standards established for operation at rated voltage and frequency.

2. *Starting*—The limiting values of voltage and frequency under which a motor will successfully start and synchronize depend upon the margin between the locked-rotor and pull-in torques of the motor at rated voltage and frequency and the corresponding requirements of the load under starting conditions. Since the locked-rotor and pull-in torques of a motor are approximately proportional to the square of the voltage and inversely proportional to the square of the frequency, it is generally desirable to determine what voltage and frequency variation will actually occur at each installation, taking into account any voltage drop resulting from the starting current drawn by the motor. This information and the torque requirements of the driven machine determine the values of locked-rotor and pull-in torque at rated voltage and frequency that are adequate for the application.

NOTE—If synchronous motors are to be operated from solid-state or other types of variable-frequency power supplies for adjustable-speed-drive applications, each application should be individually considered to provide satisfactory performance. Especially for operation below rated speed, it may be necessary to reduce the motor torque load below the rated full-load torque to avoid overheating the motor. The motor manufacturer should be consulted before selecting a motor for such application.

C. Synchronous Generators

Synchronous generators will operate successfully at rated kVA, frequency, and power factor with a variation in the output voltage up to plus or minus 5 percent of rated voltage.

Performance within these voltage variations will not necessarily be in accordance with the standards established for operation at rated voltage.

D. Direct-current Motors

Direct-current motors will operate successfully using the power supply selected for the basis of rating up to and including 110 percent of rated direct-current armature voltage provided the highest rated speed is not exceeded. Direct-current motors rated for operation from a rectifier power supply will operate succesfully with a variation of plus or minus 10 percent of rated alternating-current line voltage.

Performance within this voltage variation will not necessarily be in accordance with the standards established for operation at rated voltage. For operation below base speed, see MG 2-3.10.

Authorized Engineering Information 11-16-1972.

Att. 3

Issue:

EC-024-1014 states that induction motors at SSES were specified to have a service factor of 1.15. This is true of the motors purchased to E112, but not true for the RHR and Core Spray motors which have a service factor of 1.0. The comment is made with regards to the horsepower (HP) demanded from the motor by the pump at a higher generator frequency which results in higher pump speed. Per the pump affinity laws, HP is proportional to the cube of the speed. The calculation assumes some increase in motor slip and uses an increase of 6 percent power demand in response to a 2% DG steady state frequency increase.

RHR Response:

For the RHR pump, the GE purchase spec 21A9369AZ specifies a maximum brake HP for the load of 1800. The RHR is a 2000 HP motor. Since the motor rating is based on output power, this is more than sufficient margin to allow an 8% load increase which is the maximum postulated increase if no increase in slip is assumed (1800*1.08 = 1944 HP)

The RHR relay setting calc EC-SOPC-0503 uses the motor Full Load Amperes (FLA) as the basis of the time overcurrent trip, time overcurrent alarm, and instantaneous overcurrent trip. Since FLA is based on the rated 2000 HP. Therefore the relay setting values are not impacted by the issue.

Since the motor is being operated within its specified values, this issue is resolved for RHR.

Core Spray Response:

For the core spray pump, the GE purchase spec 21A9369AY specifies a maximum brake HP of 690. The Core Spray is a 700 HP motor. This is less than a 6% difference.

The core spray motor data sheet shows that Full Load Amps (FLA) for the core spray motor is 90 amperes.

Operating procedures OP-151-001 and OP-251-001 specify that the core spray injection shutoff valve be throttled to limit motor amps to not exceed 90 amperes.
Since 90 amperes is the specified full load amperes, the motor is being operated within its specified values. This issue is resolved for CS.

Relevant core spray motor data sheet and procedure sections follow:

GENERAL ELECTRIC 992C302FE

OUTLINE (INDUCTION MOTOR)

INGERSOLL RAND CO.
FIRST MADE FOR Y.633BPZ5C

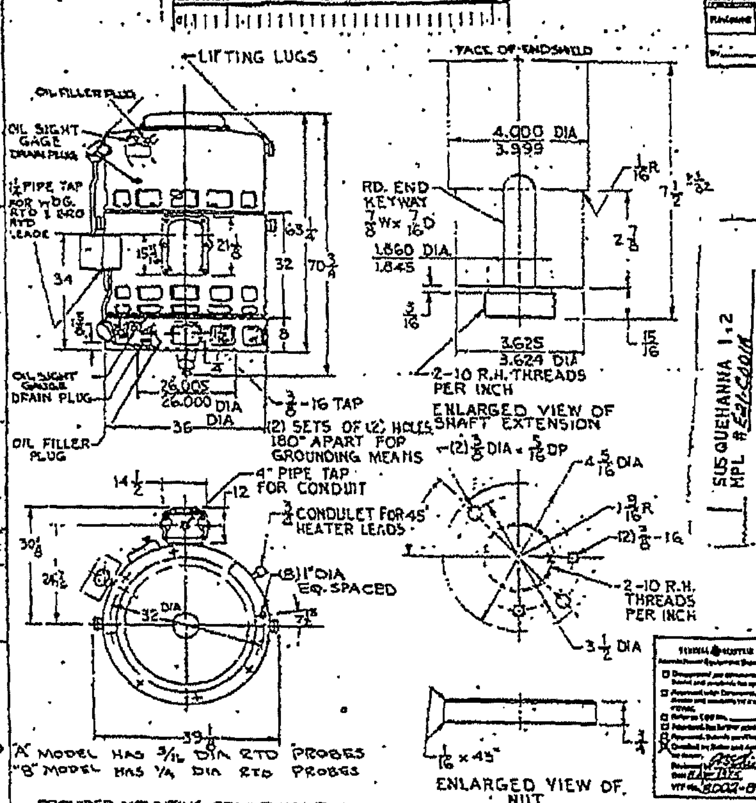
NUCLEAR

E21C001A

MAY 14 1976

VENDOR'S DRAWING REVIEW

JOB No. 8856



"A" MODEL HAS 3/16 DIA RTD PROBES
"B" MODEL HAS ¼ DIA RTD PROBES

PROVIDED MOUNTING CONDITIONS PERMIT, CONDUIT BOX MAY BE TURNED SO THAT ENTRANCE CAN BE MADE UPWARD DOWNWARD OR FROM EITHER SIDE

MOTOR WILL START AND ACCELERATE UNDER TYPICAL PUMP LOAD WITH 80% OF RATED VOLTAGE APPLIED.

MOTOR IS DESIGNED TO CONTINUE OPERATING WHEN SUBJECTED TO A STATIC SEISMIC FORCE OF 1.5G HORIZONTALLY AND 0.5 VERTICALLY. CAPSCREWS FOR BOLTING MOTOR TO PUMP HEAD MUST BE S.A.E. 5 OR BETTER.

FOR INFREQUENT OR EMERGENCY USE AND FOR LOAD WK² NOT EXCEEDING 50% OF NEMA VALUE AND A LOAD CURVE SIMILAR TO "NA" OF A PUMP OR FAN, 2 SUCCESSIVE STARTS FROM AMBIENT TEMPERATURE, OR ONE START FROM RATED TEMPERATURE ARE ALLOWED FOR SUBSEQUENT STARTS, ALLOW 30 MINUTES RUNNING TIME AT FULL SPEED OR 60 MINUTES IDLE TIME.

G.E. REQ NO: 205-A0567
ITEM NO: 1
CUSTOMER: A.P.E.D. / PENN. P.&L.
ORDER NO.:
INSTALLATION SITE: SUSQUEHANNA I AND II
APPLICATION: CORE SPRAY PUMP
CUST. SPEC. NO.: Z1A9369 AND Z1A9369AY

MOTOR RATING & DESCRIPTION

TYPE: K- SQUIRREL CAGE INDUCTION
FRAME: 633BPZ 5G
HORSEPOWER: 700
TIME RATING: CONTINUOUS
TEMP. RISE: 66 DEG. C
WINDING TYPE: FORM COIL

F.L. SPEED: 1780 RPM
RATED VOLTAGE: 4000 VOLTS
F.L. CURRENT: 90 AMPS
SERVICE FACTOR: 1.0
RATED FREQ.: 60 CPS
INSTRUCTION BOOK:

NO. OF PHASES: 3
CODE LETTER: G
DESIGN LETTER: —
ROTOR INERTIA: 420 LB. FT.²
APPROX. ROTOR WEIGHT 1379 LBS.
APPROX. STATOR WEIGHT 2700LBS

INSULATION CLASS & SERVICE CONDITIONS: CLASS B VPI EPOXY-CUSTOM POLYSEAL 65° C AMBIENT
ENCLOSURE & VENTILATION: OPEN DRIPPROOF ALL OPENINGS ARE SCREENED
MOTOR LEAD TERMINAL LUGS (INTERNAL) (3) AMP #35154 FOR #2 AWG LEADS AND WITH HOLE FOR ⅜ BOLT
ROTATION DIRECTION: CCW LOOKING DOWN

MOTOR PERFORMANCE CHARACTERISTICS AT RATED VOLTAGE & FREQUENCY

	FULL LOAD	3/4 LOAD	1/2 LOAD
*EFFICIENCY	93.4	93.0	91
POWER FACTOR	90	89	84

*EXCLUSIVE OF .95 KW BRG. LOSS DUE TO EXTERNAL THRUST

LOCKED ROTOR CURRENT: 585 AMPS
LOCKED ROTOR P.F. (APPROX.): 22 %
LOCKED ROTOR TORQUE: 90 % F.L. TORQUE
MAXIMUM TORQUE: 200 % F.L. TORQUE
FULL LOAD TORQUE 2060 LB. FT.

MAXIMUM ALLOWABLE STALL TIME: 14 SEC FROM 90°C OR 18 SEC FROM 30°C INITIAL TEMPERATURE
STATOR WINDING RESISTANCE - LINE TO LINE: .60 OHMS AT 25°C (APPROX.)
SOUND PRESSURE LEVEL 95 dBA AT 5 FT.
SOUND POWER LEVEL 111

SPEED-TORQUE-CURRENT CURVE 388HA629

MOTOR BEARING & LUBRICATION DATA

	UPPER BEARING	LOWER BEARING
BEARING TYPE:	INSULATED ANGULAR CONTACT BALL	RADIAL BALL BEARING
BEARING CATALOGUE NO.:	629A230G2 (Z) 7230DT	289Z334P26 (NO322B)
LUBRICANT TYPE:	OIL	OIL
QUANTITY OF LUBRICANT:	40 QUARTS	5 QUARTS
WITH VISCOSITY AT 100°F	150 SUS	150 SUS
VISCOSITY AT 210°F	45 SUS	45 SUS.

RECOMMENDED LUBRICANT: OXIDATION & CORROSION INHIBITED TURBINE OIL

THRUST BEARING RATED CAPACITY & RATED LIFE:
CONTINUOUS DOWN-THRUST: 9735 LBS. OVER 5 YEARS AVERAGE LIFE
CONTINUOUS UP-THRUST: — LBS. — HRS / PLATE BRG.- NO FATIGUE LIFE LIMIT
MAX. MOMENTARY DOWN-THRUST: 12152 LBS.
MAX. MOMENTARY UP-THRUST: 2575 LBS.
MINIMUM ALLOWABLE CONTINUOUS DOWNTHRUST TO PREVENT DAMAGE TO GUIDE BRG. 0
MOMENTARY PERIODS OF UPTHRUST OR LIGHTER DOWNTHRUST ARE PERMISSIBLE.

THRUST BEARING COOLING WATER: — GPM — PSI MAX. (INLET) — °F MAX. (INLET)
TOTAL AXIAL ENDPLAY: .005 INCHES

MOTOR ACCESSORY EQUIPMENT DATA

SPACE HEATERS: 120 VOLT 5.45 AMPS 655 WATTS (SINGLE-PHASE)
WINDING TEMP. DEVICES: TYPE - (6) RTD'S 100Ω @ 0°C PLATINUM
VOLTS — AMPS — NORMALLY: OPEN CLOSED
BEARING TEMP. DEVICES: TYPE - (1) DUAL ELEMENT PLATINUM (100Ω @ 0°) RTD PER BRG
VOLTS — AMPS — NORMALLY: OPEN CLOSED

FF 12650
FF 12650

SYSTEM CRITICAL REED FREQUENCY CALCULATION DATA

IN ORDER TO AVOID EXCESSIVE VIBRATION IT IS NECESSARY THAT THE REED CRITICAL FREQUENCY (CPM) OF THE MOTOR-PUMP SYSTEM BE NUMERICALLY AT LEAST 25% ABOVE OR BELOW MOTOR OPERATING SPEED (RPM). DESIGN OF COMPLETE SYSTEM (MOTOR, PUMP, FOUNDATIONS & PIPING) MUST PROVIDE FOR THIS. MOTOR DATA FOR SYSTEM CRITICAL CALCULATIONS ARE BELOW. REED CRITICAL FREQUENCY AND DEFLECTION OF MOTOR AT CENTER OF GRAVITY (C.G.) ARE SHOWN FOR MOTOR BOLTED TO A RIGID MASS AND CONSIDERED AS A HORIZONTAL CANTILEVER BEAM. DEFLECTION OF MOTOR AT C.G. IS THAT CAUSED BY WEIGHT OF MOTOR ONLY, AT STANDSTILL.

8856-M1-B21-8-6

MOTOR WEIGHT 6300 LBS
DIST. FROM MOTOR BASE TO CG. 29 INCHES
MOTOR REED CRITICAL FREQ. 2530 CPM
DEFLECTION OF MOTOR AT CG. .0035 INCHES
SUGGESTED SYSTEM REED CRITICAL FREQ. 1350 CPM MAX.

PROPOSED DEPARTURES FROM SPECIFICATIONS

REVISIONS — PRINTS TO: 15, 8, 3, 28, 2, 16

VMES SAN JOSE 992C302FE

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992C302FE

EC-034-1014 Page 93

ATT. 3

☐ g. Core Spray Room Unit Coolers 1V211A and C(B and D) **AUTO START** Indicated on Heating and Ventilation Panel 1C681.

☐ h. CORE SPRAY Loop A(B) flow increases as Reactor Pressure decreases.

NOTE (1):	Placing control switch to **CLOSED** with initiation signal present and reactor pressure < 420 psig will cause White indicating light over control switch to **ILLUMINATE**. This indicates initiation signal present with operator action overriding initiation signal. This light will remain **ILLUMINATED** until Initiation signal is reset even if valve returned to **FULLY OPEN** position.
NOTE (2):	In support of Emergency Operating Procedures the Core Spray System can be operated at a maximum current limit of 90 amps on the pump motor. This corresponds to a run out flow of 7900 gpm for 2 loop pumps or 3950 for 1 pump at 0 psig RPV pressure. As Suppression Pool temperature increases and level decreases, pump performance must be monitored for loss of adequate NPSH.

2.2.6 **Throttle** CORE SPRAY LOOP A(B) IB INJ SHUTOFF HV-152F005A(B) as required to support RPV level control:

☐ a. <90 amps and <7900 gpm for two pump operation (emergency operation)

☐ b. <90 amps and <3950 gpm for one pump operations (emergency operation)

<u>OR</u>

☐ c. <6350 gpm for two pump operation (non-emergency operation).

☐ d. <3175 gpm for single pump operation (non-emergency operation).

☐ g. Core Spray Room Unit Coolers 2V211A and C (B and D) **AUTO START** indicated on Heating and Ventilation Panel 2C681.

☐ h. CORE SPRAY LOOP A(B) flow increases as Reactor Pressure decreases.

NOTE (1):	**Placing** control switch to **CLOSED** with initiation signal present and reactor pressure < 420 psig will cause White indicating light over control switch to **ILLUMINATE**. This indicates initiation signal present with operator action overriding initiation signal. This light will remain **ILLUMINATED** until initiation signal is reset even if valve returned to **FULLY OPEN** position.
NOTE (2):	In support of Emergency Operating Procedures the Core Spray System can be operated at a maximum current limit of 90 amps on the pump motor. This corresponds to a run out flow of 7900 gpm for 2 loop pumps or 3950 for 1 pump at 0 psig RPV pressure. As Suppression Pool temperature increases and level decreases, pump performance must be monitored for loss of adequate NPSH.

2.2.6 **Throttle** CORE SPRAY LOOP A(B) IB INJ SHUTOFF HV-252F005A(B) as required to support RPV level control:

☐ a. < 90 amps and < 7900 gpm for two pump operation (emergency operation)

☐ b. < 90 amps and < 3950 gpm for one pump operation (emergency operation)

<u>**OR**</u>

☐ c. < 6350 gpm for two pump operation (non-emergency operation).

☐ d. < 3175 gpm for single pump operation (non-emergency operation).

Att 3 EC-024-1014

For Information Only

IOM 156 Page 46

Core Spray Pumps

PUMP DATA SHEET

PURCHASER	General Electric Company
USER	Pennsylvania Power And Light Company
LOCATION	Susquehanna Nos. 1 & 2 Berwick, Pennsylvania
INGERSOLL-RAND ORDER NO.	006-36051
PUMP SERIAL NUMBERS	1073-79 thru 86
PUMP APPLICATION	Core Spray Pump(s)
PUMP SIZE	25 APKD
NUMBER OF PUMP STAGES	6 (Double Suction First Stage)
PUMP RATING	3175 GPM at 1780 RPM
NET POSITIVE SUCTION HEAD REQUIRED @ 3175 GPM	4.5' (Ref. C.L.Suction)
TOTAL HEAD FEET @ 3175 GPM	668'
SUCTION PRESSURE	125 PSI (Max.)
DISCHARGE PRESSURE	500 PSI (Max.)
PUMP EFFICIENCY @ 3175 GPM	83.5%
SHAFT PACKING	Mechanical Seal
PUMP DRIVER	700 H.P. Motor with 1.0 S.F.
DRIVER MANUFACTURER	General Electric

APPROXIMATE WEIGHTS

WEIGHT OF PUMP ELEMENT AND DISCHARGE HEAD	5,560 Lbs.
WEIGHT OF THE SHELL	1,555 Lbs.
TOTAL WEIGHT OF PUMP DRY	7,115 Lbs.
WEIGHT OF WATER IN PUMP	2,500 Lbs.
WEIGHT OF MOTOR	6,300 Lbs.
WEIGHT OF TOTAL FLOOR LOAD	15,915 Lbs.
WK^2	47 Lb-ft^2