Entergy

Entergy Nuclear Northeast
Entergy Nuclear Operations, Inc.
Vermont Yankee
185 Old Ferry Rd.
P.O. Box 500
Brattleboro, VT 05302
Tel 802-257-5271

May 19, 2004
BVY 04-050

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Subject: **Vermont Yankee Nuclear Power Station**
License No. DPR-28 (Docket No. 50-271)
Technical Specification Proposed Change No. 263 - Supplement No. 7
Extended Power Uprate – Confirmatory Results

By letter dated January 31, 2004[1], Vermont Yankee[2] (VY) supplemented its September 10, 2003, license amendment request[3] (LAR) to increase the maximum authorized power level for the Vermont Yankee Nuclear Power Station (VYNPS) from 1593 megawatts thermal (MWt) to 1912 MWt. The information provided on January 31, 2004, consisted of VY's response to a draft NRC request for additional information[4] (RAI). At the time, VY's analyses were not complete with regard to the two RAIs discussed below.

NRC Electrical Engineering Section (EEIB-B) RAI No. 1 requested the results of the additional analysis referenced in section 10.3.1 of the Power Uprate Safety Analysis Report[5] (PUSAR) regarding the effect of the extended power uprate (EPU) on the environmental qualification of electrical equipment in harsh environments located inside and outside the containment. Attachment 1 to this letter provides the information requested. The results of the analysis show that safety-related electrical components are qualified for operation under EPU conditions.

NRC EEIB-B RAI No. 3 requested the evaluation referenced in section 6.1.2 of the PUSAR regarding operation of the condensate and feedwater pump motors at higher summer temperatures at EPU conditions. Attachment 2 to this letter provides the information requested. The non-safety-related condensate pump motors and feedwater pump motors have been evaluated for operation under EPU conditions and were determined to be acceptable for such application. In addition, associated support components (e.g., cable, instrumentation and controls) were also confirmed to be adequate for EPU

[1] Vermont Yankee letter to U.S. Nuclear Regulatory Commission, "Technical Specification Proposed Change No. 263, Supplement No. 5, Extended Power Uprate – Response to Request for Additional Information," BVY 04-008, January 31, 2004.

[2] Entergy Nuclear Vermont Yankee, LLC and Entergy Nuclear Operations, Inc. are the licensees of the Vermont Yankee Nuclear Power Station.

[3] Vermont Yankee letter to U.S. Nuclear Regulatory Commission, "Technical Specification Proposed Change No. 263, Extended Power Uprate," BVY 03-80, September 10, 2003.

[4] A draft NRC request for information (RAI) was transmitted on December 18, 2003, to VY as documented in NRC memorandum from Richard B. Ennis to Darrell J. Roberts under TAC No. MC0761.

[5] The Power Uprate Safety Analysis Report was provided as Attachment 4 (proprietary version) and Attachment 6 (non-proprietary version) to VY's September 10, 2003 LAR.

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conditions. Vendor recommendations contained in the evaluation will be addressed in accordance with the VYNPS design change process.

This LAR supplement provides additional information that does not expand the scope of the original application, nor does it change VY's determination of no significant hazards consideration. The information provided herewith is not considered to be proprietary information in accordance with 10CFR2.390 and there are no new regulatory commitments associated with this LAR supplement.

If you have any questions, please contact Mr. James DeVincentis at (802) 258-4236.

Sincerely,

Jay K. Thayer
Site Vice President

STATE OF VERMONT)
)ss
WINDHAM COUNTY)

Then personally appeared before me, Jay K. Thayer, who, being duly sworn, did state that he is Site Vice President of the Vermont Yankee Nuclear Power Station, that he is duly authorized to execute and file the foregoing document, and that the statements therein are true to the best of his knowledge and belief.

Mary J. Dower, Notary Public
My Commission Expires February 10, 2007

MARY J. DOWER NOTARY PUBLIC WINDHAM COUNTY, VT

Attachments (2)

cc: USNRC Region 1 Administrator (w/o attachments)
USNRC Resident Inspector – VYNPS (w/o attachments)
USNRC Project Manager – VYNPS
Vermont Department of Public Service

Docket No. 50-271
BVY 04-050

Attachment No. 1

Vermont Yankee Nuclear Power Station

Technical Specification Proposed Change No. 263

Supplement No. 7

Extended Power Uprate – Confirmatory Results

Equipment Qualification

Response to NRC EEIB-B RAI No. 1

NRC EEIB-B RAI No. 1 requested the following: Provide the results of the additional analysis referenced in Section 10.3.1 of Attachment 6 [Power Uprate Safety Analysis Report (PUSAR)] of your submittal dated September 10, 2003, for the effect of the EPU on the environmental qualification (EQ) of electrical equipment in harsh environments located inside and outside the containment.

Section 10.3.1 of Attachment 6 evaluated the change in plant environments as they relate to the Vermont Yankee Nuclear Power Station (VYNPS). The submittal states in Part:

"Inside Containment"

"...the total integrated doses (normal plus accident) for [constant pressure power uprate] CPPU conditions were determined to challenge the qualification of some equipment located inside containment. Equipment that required further evaluation included certain cable types, splices, and electrical penetrations. A qualitative evaluation, using equipment-specific radiation dose assessment, indicates that with additional analysis, the equipment should be acceptable for the CPPU conditions."

"Outside Containment"

"...the total integrated doses (normal plus accident) for CPPU conditions were evaluated. There were several types of equipment located outside of containment that were adversely affected by the radiation dose increase. A qualitative evaluation, using equipment specific radiation dose assessment indicates that with additional analysis, the equipment should be acceptable for the CPPU conditions"

The VYNPS TID-14844 source term based radiation analysis is contained in a plant calculation. The calculation divided the plant into volumes or zones and determined a generic integrated dose for the volume. Additional equipment specific analyses have been added to the calculation over the years as needed. For CPPU the total integrated dose for each volume, or specific analysis, was adjusted using a scaling methodology. This evaluation was captured in a Technical Evaluation (TE). The statements in the PUSAR were developed based on the TE results. The TE identified a number of volumes or specific analyses where the CPPU integrated dose exceeded the qualified dose of the equipment located in that volume. Subsequently, a new calculation was prepared that performed localized specific analyses for those components identified for CPPU conditions.

While preparing the new calculation it was discovered that the original radiation dose calculation failed to consider the internal post-LOCA drywell air radiation dose to some equipment. The re-evaluation to correct this error was included in the new calculation.

The following is a summary of the major adjustments to the current licensing basis (CLB) EQ dose specifications that were incorporated in the present calculation:

Response to NRC EEIB-B RAI No. 1

A. LOCA Source Term

(1) The source term for airborne releases was updated (using ORIGEN-2.1 and data libraries for extended burnup) to reflect 1950 MWt, 4.65 wt % U-235, 3-cycle and 3-region core configuration, 52.4 GWD/MTU, and three potential accident times during the 3rd cycle (for sensitivity evaluations).

The CLB model had a single cycle, end-of-cycle inventories, and a power level of 1665 MWt (based on ORIGEN-1).

(2) For the waterborne source term, the ORIGEN-2.1 computer runs were also used to produce the time-dependent photon spectra emanating from contaminated liquids. The radionuclide core-inventory fractions which were assumed to be released to the liquids were 0% noble gases, 50% halogens, and 1% of the others (also identified as a 0/50/1 mixture of "noble-gases/halogens/others")[1]. The noble gases produced by the decay of waterborne halogens were assumed to remain within the coolant and contribute to the dose.

The CLB model was overly conservative and assumed a mix of 100/50/1, implying that all core-inventory noble gases will remain in the liquid phase.

B. Submersion Doses in Drywell

(1) Consideration was given to the noble gas decay products (Rb and Cs) in the dose calculations. The software employed in the CLB analysis did not have that capability.

(2) The airborne fraction of halogens was conservatively assumed to be 25%, and to be unaffected by plateout and spray effects. The other half of the released iodines (25% of the core inventory) is expected to be retained by the primary coolant. This assumption differs from the original VYNPS EQ analysis which was based on 50% of the halogens remaining airborne for the duration of the accident.

(3) The gamma doses were computed with an improved point-kernel shielding computer code for obtaining the time-dependent dose rates and cumulative doses.

C. Submersion Doses in Reactor Building

(1) Consideration was given to the noble gas decay products (Rb and Cs) in the dose calculations. The software employed in the CLB analysis did not have that capability.

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1 Photon spectra were also calculated for a 0/25/1 mix, for the dose to equipment components that are exposed to both airborne and waterborne sources. Use of these spectra could have reduced the doses by about 17%; however, it was determined that this dose reduction credit was not necessary, and was not implemented.

(2) Credit for mixing in the Reactor Building (RB) was increased from 50% to 100% of the building volume, and the RB exhaust rate was increased from 1 air change per day to 1.140 (the latter corresponding to the SGTS design flow rate of 1500 cfm with single-fan operation, less 100 cfm). Use of full mixing in the RB is justifiable since the SGTS flow distribution, drawing air from all elevations of the reactor building via the same ductwork as the normal ventilation exhaust, along with diffusion through the open equipment hatch, will lead to practically uniform concentration within the entire RB in a short time (in comparison to the exposure interval of one year).

(3) The immersion gamma doses in the RB were reduced by taking credit for the actual volume contributing to dose in each floor, in lieu of the entire RB volume.

D. Adjustments to Drywell and RB Beta Doses for Shielding and Small Submersion Volumes.

(1) The beta shielding provided by component sheathing and coatings was based on a tabulation of adjustment factors prepared through the use of Monte Carlo calculations. In the CLB, the shielding adjustment factors were based on different approaches, depending on radionuclide.

(2) Changes in beta-shielding thicknesses between the CLB and those used in the present calculation. It is noted that the CLB thicknesses were conservatively selected, and do not reflect the actual conditions.

The results of this new calculation are summarized in the following table. The major differences discussed above apply to all the components in the table. In addition, the table has comments for specific dose adjustments.

Response to NRC EEIB-B RAI No. 1

Qualification Documentation Review Pckag(QDR) #and Component[1]	Qual.[2] (rad)	CLB[3] (rad)	CPPU[4] (rad)	Comments[5]
QDR 3.1 - Limitorque Valve Operators - RB above El. 223'-9" outboard of torus	2.00E+07	1.80E+07	1.96E+07	C1, C4, C7
QDR 35.2A - Target Rock Model 75E Solenoid Valves NG-13A and NG-13B - RB El. 213'-9" & 232'-6"	1.00E+08	7.47E+06	8.69E+06	C1, C7, C9
QDR 8.7 - Teledyne H2/O2 Analyzers - Parts not in contact with drywell nor RB air - RB El. 280'-0" Vol 29	1.60E+06	1.59E+06	4.29E+05	C1
QDR 36.3 - Filnor Knife Switch - RB El. 280'-0" Vol 21 - Fuel Pool Line Area	1.34E+06	1.31E+06	1.23E+06	C1
QDR 35.2A - Target Rock Model 75E Solenoid Valve VG-9A - RB El. 303'-0" [Dose during post-LOCA drywell purge]	1.00E+08	8.51E+04	7.18E+07	C1, C3, C8
QDR 5.1 - Rosemount Model 710 DU Trip/Cal Systems, ECCS Cabinet 25-5B Circuit Boards - RB El. 280'-0" Vol. 20	2.00E+05	1.95E+05	1.93E+05	C1, C3
QDR 5.2 - Rosemount Model 510 DU Trip/Cal Systems - ECCS Cabinet 25-6B Circuit Boards - RB El. 280'-0" Vol. 22	1.90E+05	1.75E+05	1.48E+05	C1, C3
QDR 6.4-2 - Rockbestos (CERRO) XLPE/Firewall III Cable - RB El. 280'-0" and Vol 41	1.84E+08	4.79E+07	1.11E+08	C1, C13
QDRs 10.1 and 10.1A - Chromalox 9 KW Duct Heater and High Temperature Cut-Out Switch - RB El. 280'-0" Vol. 29	4.80E+07	4.35E+07	1.28E+07	C1
QDR 35.2A - Target Rock Model 75E Solenoid Valve - RB El. 280'-0" Vol 29	1.00E+08	1.50E+06	9.64E+05	C1, C7
QDRs 6.14, 14.3, 16.2, 35.3 - RB El. 280'-0" Vol 29	2.00E+08	8.53E+07	3.13E+07	C1
QDR 9.3 - Microswitch Limit Switches - RB El. 280'-0" Vol 29	7.80E+07	7.75E+07	2.85E+07	C1
QDR 8.7 - Teledyne H2/O2 Analyzer A - O2 Membrane - RB El. 280'-0" Vol 29 [30-day LOCA Dose]	1.00E+08	9.42E+06	5.73E+07	C1, C3, C12
QDR 8.7 - Teledyne H2/O2 Analyzer A - Pump/Regulator Diaphragms - RB El. 280'-0" Vol 29 [30-day LOCA Dose]	2.00E+08	1.60E+07	1.11E+08	C1, C3, C12
QDRs 8.7, 35.3 - Teledyne H2/O2 Analyzers / Solenoid Valves - RB El. 280'-0" Vol 29 [30-day LOCA Dose]	6.00E+07	8.87E+06	5.53E+07	C1, C3, C12
QDR 8.7 - Teledyne H2/O2 Analyzers - Flow Alarms - RB El. 280'-0" Vol 29 [30-day LOCA Dose]	2.00E+08	6.78E+06	4.06E+07	C1, C3, C12
QDR 34.4 EGS/PATEL P1 Thread Sealant - Drywell outside sacrificial shield	1.70E+08	1.56E+08	7.97E+07	C1, C3
QDR 6.23 - Rockbestos RSS-6-104 Coaxial Cable - Drywell Below El. 290', > 5' from Recirc Pipe & at least 3' from sacrificial shield openings	1.71E+08	1.71E+08	8.59E+07	C1, C3
QDR 15.3 GE Penetration Assembly Cable - Drywell Below El. 290, within 5' of Recirc Pipe & at least 3' from sacrificial shield	1.80E+08	1.60E+08	1.62E+08	C1, C3
QDRs 6.4-2, 6.29, 6.31,16.2 Cable - Drywell Below 270, > 5' from Recirc Pipe & at least 3' from sacrificial shield openings	1.84E+08	1.83E+08	1.29E+08	C1, C3
QDR 2.1 Westinghouse MCC-8B - RB El. 280'-0" Vol 29	8.70E+05	8.63E+05	8.26E+05	C1, C3
QDR 2.1 Westinghouse MCC-DC-2A - RB El. 280'-0" Vol 21	8.70E+05	8.15E+05	8.08E+05	C1
QDR 2.1 Westinghouse MCC-9B - RB El. 280'-0" Vol 22	8.70E+05	7.29E+05	7.61E+05	C1
QDR 8.3 ITT-Barton Differential Pressure Switch - RB El. 213'-9" Vol 53	1.00E+06	9.79E+05	8.46E+05	C1
QDR 8.3 - Barton 288/289 Pressure Switch - RB El. 213'-9" Vol 32	1.00E+06	9.79E+05	8.46E+05	C1
QDR 8.3 - Barton 288/289 Pressure Switch - RB El. 213'-9" Vol 53	1.00E+06	9.79E+05	8.46E+05	C1

Footnotes

[1] These are the components that were identified in a conservative screening process to potentially exceed their qualification dose limits.
[2] Equipment qualification radiation level in rads. Equipment is qualified to the given value.
[3] The current dose specification is based on a power level of 1665 MWt. The current licensed power level is 1593 MWt.
[4] Constant Pressure Power Uprate (CPPU) is 120% of the current licensed power level, or 1912 MWt. The dose specification for CPPU is based on 1950 MWt.
[5] References are to comments appended to the end of the table.

COMMENTS	DESCRIPTION	Value or Adjustment	
C1	The 40-year normal background doses were adjusted by the factor [32*1593 + 8*(1950/1.02)] / (40*1593) = 1.040, reflecting a 20% increase in the background radiation levels as a result of power uprate, and an estimated 8-year operation at the EPU level. (See Comment C6 for exception.)	Background	1.040
C2	Power level adjustment factor for LOCA beta and gamma doses (1950 MWt/1665 MWt)	LOCA, beta/gamma	1.171
C3	Dose adjustments applying finite cloud and/or shielding.		
C4	The dose listed for the Limitorque Valve Operators from post-LOCA torus sources in the current licensing basis (i.e., pre-EPU, namely, 1.46E+07 rad) was incorrect. The actual dose is 1.36E+07 rad. This dose is due to both airborne and waterborne sources within the torus. Adjusting for the power level (see C2), the corrected dose is 1.36E+07 * 1.171 = 1.59E+07 rad.	Typo plus power adjustment	1.59E+07
C5	The doses listed for the 24 vdc power supplies are for a HPCI Line Break, based on the technical specification limit of 1.1 µCi/gm DE-I131 [TS 3.6 (B)], and the activity release rate to the atmosphere of 0.16 Ci/sec (after 30 min decay) [TS Sec. 3.8(K)]. The current licensing basis (i.e., pre-EPU) analysis used 1.1 µCi/gm DE-I131 in the coolant, and 0.3 Ci/sec for the atmospheric release, and is therefore bounding.		
	There is no beta dose since the Technipower power supplies are sealed in metal containers; there is no access to any components within the supplies.	Shielding adjustment	0.0
	The gamma dose listed for the 24 vdc power supplies in the current licensing basis (i.e., pre-EPU, namely 14 rad) is not correct. The actual dose is 1.4 rad. Adjusting for the power level (see C2), the corrected dose is 1.4 * 1.171 = 1.64 rad.	Typo plus power adjustment	1.6
C6	The component life time in the current licensing basis (i.e., pre-EPU) is currently limited to 10 years. Following power uprate, the normal background radiation is expected to be 12 mrad/hr (a 20% increase on the pre-uprate value). In order to maintain the qualification limit under both pre- and post-uprate levels, these components must now be replaced every 8 years (corresponding to a background dose of 0.012 * 8760 * 8 = 841 rad).	gamma	841
C7	Internal dose is not a concern and was considered to be zero. [Note: Internal doses to QDR 35.2A valves has been considered (containment purge valves).]		

COMMENTS	DESCRIPTION	Value or Adjustment	
C8	Drywell purge under the CLB is based on purge initiation at 192 hours and continued through 1 year. The corresponding basis for the EPU calls for intermittent purging starting at 35 days post LOCA to maintain drywell pressure below 28 psig. The valve internal exposure in the present application was conservatively assumed to cover the interval from 192 hrs to one year, for both the CLB and the EPU; the external gamma exposure is for one year.		
C9	The dose listed is from post-LOCA torus sources. It was calculated using the power adjustment factor under C2.		
C10	The dose to internal components due to drywell air is included.		
C11	Limitorque MOVs dose contribution from the SGTS filters.		
C12	Dose is for the 30-day mission time and the doses from "Gamma LOCA Other" (i.e., from the SGTS filters in these cases) are for one-year exposure.		
C13	ELEC31 cable requirement that the cable be in excess of 2 ft away from the SGTS carbon beds.		

Docket No. 50-271
BVY 04-050

Attachment No. 2

Vermont Yankee Nuclear Power Station

Technical Specification Proposed Change No. 263

Supplement No. 7

Extended Power Uprate – Confirmatory Results

Condensate and Feedwater Pump/Room Evaluation

Project Technical Report

Condensate and Feedwater Pump/Room Evaluation

Prepared for

Entergy Vermont Yankee Nuclear Plant

May 18, 2004

Preparer

Preparer

Reviewer

Interdisciplinary Review

Project Manager

D. YASI for Telican
May 18, 2004

Shaw/Stone & Webster, Inc.
Stoughton, MA 02072

Abstract/Summary

The EPU BOP evaluations associated with the Condensate and Feedwater Pump systems recommended that a follow on confirmatory evaluation be performed to provide a well-documented basis for the acceptability of summer EPU room temperatures coincident with EPU loads on the pump motors.

This technical evaluation documents the acceptability of summer EPU room temperatures coincident with EPU loads on the Condensate and Feedwater Pump motors. Operation as follows is confirmed:

- Condensate Pump motors at approximately 2% above nameplate in a 50° C ambient.
- Feedwater Pump motors in a 45° C ambient.

The acceptability of summer EPU room temperatures on other potentially temperature sensitive components, i.e. cable, instruments, fan motors, etc., is also addressed.

1 Introduction

1.1 Condensate Pump and Pump Room (Ref 13)

The brake horsepower is calculated to increase by approximately 100HP (Ref 8) due to uprate. With this demand, the condensate pumps will exceed nameplate, but remain within the 15% service factor of the motors.

The total pump heat input to the room will increase due to higher total pumping power. Room heatup projections with the higher pump motor load after EPU and the design summer river temperature of 85° F indicate that room temperatures up to 122° F are possible. Presently, the peak summer temperatures rarely exceed 119° F.

1.2 Reactor Feedwater Pump and Pump Room (Ref 13)

The brake horsepower demands on the reactor feedwater pumps will decrease for EPU due to operation of 3 pumps in parallel versus the current 2 pump combination.

The total pump heat input to the room will increase due to higher total pumping power with 3 pump operation. Room heatup projections with the higher 3 pump motor load and the design summer river temperature of 85° F indicate that room temperatures slightly higher than 105° F design temperature are possible after EPU. Presently, the peak summer temperatures rarely exceed 100° F.

1.3 Objectives

The objectives of the technical evaluation are:

1. Justify that condensate pump motors operating above nameplate during EPU conditions are acceptable.
2. Justify that the feedwater pump motors operating at nameplate during EPU conditions are acceptable.
3. Demonstrate/justify impact of elevated EPU condensate/feedwater pump room temperatures on other potentially temperature sensitive components, i.e. cable, instruments, fan motors, etc., within each room.

2 Conclusions/Recommendations

2.1 Condensate Pump and Pump Room

The Westinghouse Condensate Pump Motors and the GE Condensate Pump Motor are adequate for operation at EPU conditions in the Condensate Pump Room. Westinghouse will provide new nameplates confirming 1600HP and 50° C ambient operation. GE has confirmed that operation up to a 5% load increase (1575HP) in a 50° C summer and 40° C remainder of year ambient environment is within its motor's capability.

Both the Westinghouse and the GE analyses bound the predicted pump flow run out condition of 1519HP (Ref 8).

The predicted EPU Thrust Bearing temperature exceeds the expected running temperatures recommended by Westinghouse (Ref 11) for mineral-oil-lubricated bearings. The lubricant used at VY is Mobil DTE heavy mineral oil with a continuous operating temperature limit of 210° F (98.9° C). The existing 175° F (79.4° C) Thrust Bearing temperature alarms should be changed to be consistent with expected operating conditions and maintain margin to lubricant temperature limit.

The predicted EPU Guide Bearing temperature exceeds the design temperature recommended by GE (Ref 12). GE has indicated that operation up to 205° F (96.1° C) for a short period of time (one month) is acceptable, after which the lubricating oil would have to be replaced.

Medium voltage Condensate Pump Motor feeder cables are adequate for operation at EPU conditions in the Condensate Pump Room based on application of appropriate de-rating factors.

Low voltage power cables existing within the room are assumed to be operating at or below their thermal limit. They are adequate for EPU conditions in the Condensate Pump Room.

Control and instrument cables existing within the room are considered adequate for EPU conditions in the Condensate Pump Room based on continued operation within thermal capability.

Instruments, motors, and miscellaneous equipment are considered adequate for operation at EPU conditions in the Condensate Pump Room based on vendor manuals, drawings, etc. or expected life with respect to ambient conditions.

The protection curve for the Condensate Pump Motor (Ref 21) bounds the new EPU operating condition ampacity for both the Westinghouse and GE motors. A CCN or revision to Reference 21 should be issued to revise page B-6 to document the new operating conditions:

1. Both the Westinghouse and the GE analyses indicate new full load current for the Condensate Pump motors
2. Westinghouse will provide a new 1600HP nameplate for its Condensate Pump motors

2.2 Reactor Feedwater Pump and Pump Room

The Westinghouse Reactor Feedwater Pump Motor is adequate for operation at EPU conditions in the Feedwater Pump Room. The predicted winding temperature of 103.4° C is within the allowable 130° C temperature for a Class B insulation system.

Note: The allowable insulation temperature is applicable to the sum of any combination of temperature rise and ambient temperature bounded by the allowable insulation temperature.

The Feedwater Pump Motors remain adequate for all pump operating conditions including flow run out (Ref 8).

The predicted EPU pump Inboard and Outboard and motor Outboard Bearing temperatures exceed the expected running and alarm temperatures recommended by Westinghouse (Ref 11) for mineral-oil-lubricated bearings. The lubricant used at VY is Mobil DTE heavy mineral oil with a continuous operating temperature limit of 210° F (98.9° C). The existing 180° F (82.2° C) pump Inboard and Outboard and motor Outboard Bearing temperature alarms should be changed to be consistent with expected operating conditions and maintain margin to lubricant temperature limit.

Medium voltage Reactor Feedwater Pump Motor feeder cables are adequate for operation at EPU conditions in the Feedwater Pump Room based on application of appropriate de-rating factors.

Low voltage power cables existing within the room are assumed to be operating at or below their thermal limit. They are adequate for EPU conditions in the Feedwater Pump Room.

Control and instrument cables existing within the room are considered adequate for EPU conditions in the Feedwater Pump Room based on continued operation within thermal capability.

Instruments, motors, valves and miscellaneous equipment are considered adequate for operation at EPU conditions in the Feedwater Pump Room based on vendor manuals, drawings, etc. or expected life with respect to ambient conditions.

3 Technical Analysis

3.1 Condensate Pump and Pump Room

3.1.1 Room Ambient

Calculation VYC-2279 (Ref 10) establishes the Current Licensing Thermal Power (CLTP) and EPU Condensate Pump Room ambient temperature:

	Area Temperature °F	Area Temperature °C	
CLTP	109.7	43.2	Based on design
CLTP	119	48.4	Based on empirical data
EPU	113.2	45.1	Based on design
EPU	122.5	50.3	Based on empirical data (data used in evaluation)

Note: The BHP used in calculation VYC-2279 (Ref 10) to predict the room temperature is slightly less than the required BHP indicated in the ERC Section 3.4.3 (Ref 8), i.e. 1493 vs. 1508HP. The factors used in determining the room temperature are conservative considering the worst-case heat balance and service water temperatures. Increasing the BHP of the condensate pumps to match the value in the engineering report introduces a room temperature increase of 0.2 deg C which is insignificant when considered with the conservative factors used in predicting the room temperature.

These temperatures are conservatively calculated bounding maximum temperatures. Actual EPU maximum temperatures are anticipated to be lower than these bounding values.

3.1.2 Condensate Pump Motor

There are three Westinghouse and one GE Condensate Pump Motors and three Condensate Pumps. Three motors power the Condensate Pumps and one motor is spare. Every refueling outage one motor is swapped out with the spare.

The Westinghouse Condensate Pump Motors have the following characteristics: 1500 HP, 1.15 SF, 4000V, 60° C rise, Class B insulation, Open Drip-Proof, 40° C Ambient (Ref 3 & 5).

The General Electric Condensate Pump Motor has the following characteristics: 1500 HP, 1.15 SF, 4000V, (90° C rise), (Class F insulation), Weather Protected I, (40° C Ambient) (Ref 4&(Ref 12)).

Attachment B summarizes VY plant operating temperature data (Ref 6) for the Condensate Pump Motor/Room. Data presented is highest temperature recorded per location during the several days of data collection. The highest and average temperature is calculated. In addition, Condensate Pump Motor winding temperature for early and late July 2003, including corrections for GE motor, have been included per TE 2004-025 (Ref 7).

Smeaton (Ref 1, Section 14) indicates that bearing temperature rise for an open Class B motor is expected to be one quarter to one half of the 90° C (162° F) maximum rise for the winding, i.e. 22 to 45° C (40 to 81° F) above the ambient-air temperature.

The results of data review are summarized below:

Location	Highest Att B °C	EPU °C	Remarks
Ambient (Room Avg.)	44.9	50.3	
Westinghouse Motor			
Winding	120.0 (Note 1a)	125.0 (Note 1a & 1b)	Class B insulation system rated up to 130° C (Note 4)
Thrust Bearing	78.7	83.7 (Note 2)	95° C (Note 3)
Guide Bearing	72.6	77.6 (Note 2)	95° C (Note 3)
GE Motor			
Winding	100.0 (Note 1a)	105.0 (Note 1a & 1b)	Class B insulation system rated up to 130° C (Note 5)
Thrust Bearing	71.6	76.6 (Note 2)	95° C (Note 3)
Guide Bearing	88.9	93.9 (Note 2)	95° C (Note 3)

Note 1a Winding temperature adjusted for 10° C hot spot allowance
Note 1b Winding temperature adjusted for approximate 5° C ambient increase at EPU
Note 2 Bearing temperature adjusted for approximate 5° C ambient increase at EPU
Note 3 Expected bearing temperature (ambient 50° C plus 45° C) per Reference 1, Section 14
Note 4 Refer to the discussion below on Westinghouse analysis conclusions.
Note 5 The GE motor has Class F insulation system rated up to 165° C

General Electric Nuclear Energy was requested to evaluate operation of its motor at 1600HP in a 50° C summer and 40° C remainder of year ambient in accordance with Vermont Yankee's Technical Evaluation No. 2004-025 (Ref 7).

General Electric Nuclear Energy concluded in its evaluation (Ref 12) that the motor has "approximately 30 years of remaining life with normal reliability, at loads of up to 1575HP, with maximum cooling air temperature of 50° C during the three summer months and 40° C for the remainder of the year, with conditions" outlined in Section 5.0

of its report. General Electric's evaluation includes analysis of the insulation system, thermal aging, and effects on rotor assembly, mechanical components including bearing design temperature of 200° F (93.3° C), and other electrical components under increased load.

General Electric Nuclear Energy concludes that no additional maintenance is necessary resulting from the increased load rating.

The predicted at EPU Guide Bearing temperature exceeds the design temperature recommended by GE (Ref 12). GE has indicated that operation up to 205° F (96.1° C) for a short period of time (one month) is acceptable, after which the lubricating oil would have to be replaced.

Westinghouse was requested to evaluate operation of its motors at 1600HP in a 50° C summer and 40° C remainder of year ambient (Ref 19).

Westinghouse concluded in its evaluation (Ref 11) that there is sufficient electrical and mechanical design margin to allow operation of the existing motors at 1600 HP in a 50° C ambient. Westinghouse's evaluation includes analysis of insulation class, temperature rise, starting characteristics, bearing loading, motor lead cable, speed vs. torque, thermal limits and starting duty limits.

Note: Westinghouse will provide a new nameplate: 1600HP, 1.0 SF, 50° C Ambient.

Westinghouse concludes that operating the motor at the higher load will not necessitate a change in frequency or maintenance procedures that have already been established.

The predicted EPU Thrust Bearing temperature exceeds the expected running temperatures recommended by Westinghouse (Ref 11) for mineral-oil-lubricated bearings. The lubricant used at VY is Mobil DTE heavy mineral oil with a continuous operating temperature limit of 210° F (98.9° C). The existing 175° F (79.4° C) Thrust Bearing temperature alarms should be changed to be consistent with expected operating conditions and maintain margin to lubricant temperature limit.

3.1.3 Cables, Instruments, Fan Motors, Miscellaneous

A walk down of the Condensate Pump room was conducted to identify potentially temperature sensitive components, i.e. cable, instruments, fan motors, etc. Attachment D documents the results this walk down.

Cables

The Condensate Pump feeder cables, 3 1/C 4/0 AWG, 85° C conductor temperature (Ref 22) identified on Attachment D have adequate margin at uprate. The cables are installed in conduit, three conductors in conduit.

Per Reference 14, the ampacity of the three single conductor 4/0 cable in conduit is 274 A. This ampacity figure in turn, per Reference 14, must be corrected for conduit configuration and EPU ambient. This is accomplished by multiplication by a group correction factor and the EPU ambient (50° C) correction factor. For conservatism, the conduit grouping is assumed to be arranged six horizontal conduits with one quarter conduit diameter spacing.

4/0 Ampacity = 274 A x 0.89 (50° C Ambient Temp Correction Factor) x 0.86 (Group Correction Factor) = 209 A

Per Reference 3, the Westinghouse Condensate Pump motor nameplate ampacity is 185 A. Per Reference 11, the ampacity increases to 197 A at 1600HP. This is within the available cable ampacity. Note: Per Reference 8, at EPU requirement is 1508 HP (100.5%; normal operation) and 1526 HP (101.7%; off normal loss of one pump).

Per Reference 4, the GE Condensate Pump motor nameplate ampacity is 195 A. Per Reference 12, the ampacity increases to 205 A at 1575HP (5% increase in torque). This is within the available cable ampacity. Note: Per Reference 8, at EPU requirement is 1508 HP (100.5%; normal operation) and 1526 HP (101.7%; off normal loss of one pump).

The low voltage power cables (Ref Attachment D) existing within the Condensate Pump Room are assumed operating below their thermal limit. Typically voltage drop is the limiting factor when sizing power cable due to long runs back to the distribution equipment and cable ampacity is a secondary consideration. VY low voltage power cables similarly sized have been demonstrated to be adequate (Ref 23).

Periods of operation in a 50° C ambient could decrease the expected life; however, the decrease in expected life due to summer time room ambient temperature excursions up to 50° C can be offset by operation in a 40° C or below ambient temperatures for the remainder of the year.

Life reduction due to uprate ambient increase of control and instrumentation cables (Ref Attachment D) existing within the Condensate Pump Room is considered to be small. These cables are typically operated in electrical circuits with low current well below the insulation thermal limit. VY control cables similarly sized have been demonstrated to be adequate (Ref 24).

Periods of operation in a 50° C ambient could decrease the expected life; however, the decrease in expected life due to summer time room ambient temperature excursions up to 50° C can be offset by operation in a 40° C or below ambient temperatures for the remainder of the year.

Instruments

Per Reference 17, the various Allen Bradley (Ref Attachment D) pressure switches were determined to have an ambient rating of 55° C.

In the absence of vendor data, the Condensate Hotwell Sampling Points (Ref Attachment D) have been assumed to have an ambient temperature capability of 40° C. Operation of the hotwell sampling in an ambient below 40° C will increase the expected life. Periods of operation in a 50° C ambient could decrease the expected life: however, the decrease in expected life due to summer time room ambient temperature excursions up to 50° C are offset by the increase in expected life due to 40° C or below ambient temperatures for the remainder of the year.

Motors

Per Reference 16, the 10 HP Dayton Turbine Recirculation Unit (TRU5) (Ref Attachment D) was determined to have an ambient rating of 40°.

Operation of recirculation unit in an ambient below 40° C will increase the expected life. Periods of operation in a 50° C ambient could decrease the expected life: however, the decrease in expected life due to summer time room ambient temperature excursions up to 50° C are offset by the increase in expected life due to 40° C or below ambient temperatures for the remainder of the year.

Miscellaneous

Per Reference 20, the various NAMCO limit switches (Ref Attachment D) were determined to have an ambient rating of 90° C.

In the absence of vendor data, switches and lighting fixtures (Ref Attachment D) have been assumed to have an ambient temperature capability of 40° C.

Operation of switches and lighting fixtures in an ambient below 40° C will increase the expected life. Periods of operation in a 50° C ambient could decrease the expected life: however, the decrease in expected life due to summer time room ambient temperature excursions up to 50° C are offset by the increase in expected life due to 40° C or below ambient temperatures for the remainder of the year.

3.1.4 Motor Protection

The protection curve for the Condensate Pump Motor (Ref 21) bounds the new EPU operating condition ampacity for both the Westinghouse and GE motors. A CCN or revision to Reference 21 should be issued to revise page B-6 to document the new operating conditions:

1. Both the Westinghouse and the GE analyses indicate new full load current for the Condensate Pump motors
2. Westinghouse will provide a new 1600HP nameplate for its Condensate Pump motors

3.2 Feedwater Pump and Pump Room

3.2.1 Room Ambient

Calculation VYC-2279 (Ref 10) establishes the Current Licensing Thermal Power (CLTP) and EPU Feedwater Pump Room ambient temperature:

	Area Temperature		
	° F	**° C**	
CLTP	105	40.6	
EPU	112.6	44.8	Based on design
EPU	112.6	44.8	Based on empirical data

These temperatures are conservatively calculated bounding maximum temperatures. Actual EPU maximum temperatures are anticipated to be lower than these calculated bounding values.

3.2.2 Feedwater Pump Motor

The Reactor Feedwater Pump Motor has the following characteristics: 5500HP, 1.15 SF, 4000V, 60° C rise, Class B insulation, Open Drip-Proof, 40° C Ambient (Ref 2 & 5).

Attachment A summarizes VY plant operating temperature data (Ref 6) for the Feedwater Pump Motor/Room. Data presented is highest temperature recorded per location during the several days of data collection. The highest and average temperature is calculated.

Smeaton (Ref 1, Section 14) indicates that bearing temperature rise for an open Class B motor is expected to be one quarter to one half of the 90° C (162° F) maximum rise for the winding, i.e. 22 to 45° C (40 to 81° F) above the ambient-air temperature.

The results of data review are summarized below:

Location	**Highest Att A °C**	**At EPU °C**	**Remarks**
Ambient (Room Avg.)	35.0	44.8	
Winding	93.4 (Note 1a)	103.4 (Note 1a & 1b)	Class B insulation system rated up to 130° C
Inboard Bearing	76.0	86.0 (Note 2)	90° C (Note 3)
Outboard Bearing	80.2	90.2 (Note 2)	90° C (Note 3)
Thrust Bearing	61.3	71.3 (Note 2)	90° C (Note 3)
Motor Inboard Bearing	70.9	80.9 (Note 2)	90° C (Note 3)
Motor Outboard Bearing	82.9	92.9 (Note 2)	90° C (Note 3)

Note 1a Winding temperature adjusted for 10° C hot spot allowance
Note 1b Winding temperature adjusted for approximate 5° C ambient increase at EPU
Note 2 Bearing temperature adjusted for approximate 10° C ambient increase at EPU
Note 3 Expected bearing temperature (ambient 45° C plus 45° C) per Reference 1, Section 14

The predicted EPU winding temperature, including 10° C increase in ambient and a 10° C hot spot allowance, is 103.4° C. This temperature is well within the allowable 130° C temperature for a Class B insulation system.

The predicted EPU bearing temperatures approximate the Smeaton expectations.

The predicted EPU pump Inboard and Outboard and motor Outboard Bearing temperatures exceed the expected running and alarm temperatures recommended by Westinghouse (Ref 11) for mineral-oil-lubricated bearings. The lubricant used at VY is Mobil DTE heavy mineral oil with a continuous operating temperature limit of 210° F (98.9° C). The existing 180° F (82.2° C) pump Inboard and Outboard and motor Outboard Bearing temperature alarms should be changed to be consistent with expected operating conditions and maintain margin to lubricant temperature limit.

3.2.3 Cables, Instruments, Fan Motors, Miscellaneous

A walk down of the Feedwater Pump room was conducted to identify potentially temperature sensitive components, i.e. cable, instruments, fan motors, etc. Attachment C documents the results this walk down.

Cables

The Feedwater Pump feeder cables, 3 1/C 750 MCM, 85° C conductor temperature (Ref 22) identified on Attachment C have adequate margin at uprate. The cables are installed in conduit, three conductors in each conduit.

Per Reference 14, the ampacity of the three single conductor 750 MCM cable in conduit is 551 A This ampacity figure in turn, per Reference 14, must be corrected for conduit configuration and EPU ambient. This is accomplished by multiplication by a group correction factor and the EPU ambient (50° C) correction factor. For conservatism, the conduit grouping is assumed to be arranged six horizontal conduits with one quarter conduit spacing.

750 MCM Ampacity = 551 A x 0.89 (50 C Ambient Temp Correction) x 0.86 (Group Correction Factor) = 421 A. Since 2 conductor per phase are used, the total ampacity available to each motor is 421 x 2 = 842 A.

Per Reference 2, the Westinghouse Feedwater Pump motor nameplate ampacity is 666 A. This is well within the available cable ampacity.

The low voltage power cables (Ref Attachment C) existing within the Feedwater Pump Room are assumed operating below their thermal limit. Typically, voltage drop is the limiting factor when sizing power cable due to long runs back to the distribution equipment and cable ampacity is a secondary consideration. VY low voltage power cables similarly sized have been demonstrated to be adequate (Ref 23).

Periods of operation in a 45° C ambient could decrease the expected life; however, the decrease in expected life due to summer time room ambient temperature excursions up to 45° C can be offset by operation in a 40° C or below ambient temperatures for the remainder of the year.

Life reduction due to uprate ambient increase of control and instrumentation cables (Ref Attachment C) existing within the Feedwater Pump Room is considered to be small. These cables are typically operated in electrical circuits with low current well below the insulation thermal limit. VY control cables similarly sized have been demonstrated to be adequate (Ref 24).

Periods of operation in a 45° C ambient could decrease the expected life; however, the decrease in expected life due to summer time room ambient temperature excursions up to

45° C can be offset by operation in a 40° C or below ambient temperatures for the remainder of the year.

Instruments

Per Reference 18, the various GE pressure transmitters (RFP Suction Flow, FT-102-2A, -2B, -2C) and heater transmitters (ESS to 3rd and 4th Pt Htrs A&B, PT-101-17A, -19A, -19B; RFP Suction Header Press, PT-102-24; RFP Discharge Header Press, PT-102-26; and Feedwater Header Press, PT-102-27) (Ref Attachment C) used in the Feedwater Pump room were determined to have an ambient rating of 162° C or 185° C.

Per Reference 18, the Foxboro heater transmitter (ESS to 3rd Pt Htr B, PT-101-17B) (Ref Attachment C) was determined to have an ambient rating of 185° C.

Per Reference 17, the various Allen Bradley pressure switches (Ref Attachment C) were determined to have an ambient rating of 55° C.

Motors

Per Reference 16, the 10 HP Dayton Turbine Recirculation Units (TRU1, TRU2, TRU3, TRU4) (Ref Attachment C) were determined to have an ambient rating of 40° C.

Operation of recirculation unit in an ambient below 40° C will increase the expected life. Periods of operation in a 45° C ambient could decrease the expected life: however, the decrease in expected life due to summer time room ambient temperature excursions up to 45° C are offset by the increase in expected life due to 40° C or below ambient temperatures for the remainder of the year.

Spring Operated Valves

Per Reference 18, the Babcock & Wilcox spring operated valves (Feedwater Pump Recirc Valves, FCV-102-2A, -2B, -2C; Main Feed Reg Valves, FCV-6-12A, -12B; Start Up Feed Reg Valve, FCV-6-13) (Ref Attachment C) used in the Feedwater Pump room were determined to have an ambient rating of 204° C. The Digital Valve Actuators associated with FCV-6-12A & -12B were determined to have an ambient rating of 80° C (Refer to Attachment C).

Motor Operated Valves

Per Reference 15, the Limitorque MOV's (RFP Discharge Valves, V63-4A, -4B, -4C; Feedwater Aux Regulator Inlet Valves, V63-10 & -11A) (Ref Attachment C) used in the Feedwater Pump room were determined to have an ambient rating of 60° C.

Miscellaneous

In the absence of vendor data, the FWP/CP Flow Instrument Rack and lighting fixtures have been assumed to have an ambient temperature capability of 40 C.

Operation of the instrument rack and lighting fixtures in an ambient below 40° C will increase the expected life. Periods of operation in a 45° C ambient could decrease the expected life: however, the decrease in expected life due to summer time room ambient temperature excursions up to 45° C are offset by the increase in expected life due to 40° C or below ambient temperatures for the remainder of the year.

4 References

1. "Motor Application and Maintenance Handbook", Robert W Smeaton, Editor, Copyright 1969 by McGraw-Hill, Inc.

2. 5920-1602, R3, 7/25/69, "Reactor Feed Pump Motor Outline" (Westinghouse)

3. 5920-836, R0, 11/25/68, "Condensate Pump Motor Outline" (Westinghouse)

4. 5920-11947, R0, 7/28/97, "Repl. Condensate Pump Motor" (Outline) (GE Motors)"

5. VYNP-IV-M-2, R3, October 14, 1969, "Specification EBASCO 8-53 Motors for Station Auxiliary Service"

6. VY Engineering Correspondence, ERC No. 2003-053, 8/20/03, "Plant Operating Data Supporting VYC-2279"

7. Technical Evaluation No. 2004-025, "Input to WIN-012 DIR, Rev. 0, Condensate Pump Motor Evaluation"

8. BOP Engineering Report, ERC Section 3.4.3, R0, 5/18/04 "Condensate and Feedwater"

9. Vermont Yankee EPU Engineering Report, April 2, 2004, "Power Dependent Heating, Ventilation, and Air Conditioning (HVAC)"

10. Calculation VYC-2279, R 0, 8/26/03, "Evaluation of EPU Impact on Ambient Space Temperatures During Normal Operation"

11. Westinghouse Engineering Study Number ES00166 "Determine If Motor Shop Order 76P0948 Can be Re-rated From 1500 HP to 1600 HP With No Physical

Changes": Report dated 4/19/04, revised 5/4/04, and Data Pack dated 4/19/04. Westinghouse Oil Lubrication Guideline, undated. All included as Attachment F.

12. General Electric letter DRF 0000-0027-1611, May 13, 2004, Condensate Pump Motor Increased Load Evaluation-GE Motor Model 5KV84483656501. Included as Attachment E.

13. Scope Change Notice-040, Rev. 1, 3/1/04, "Condensate and Feedwater Pump/Room Evaluation for EPU"

14. AIEE-IPCEA Power Cable Ampacities Copper Conductors, 1962.

15. Calculation VYC-2166, "Evaluation of Motor Performance Parameters for MOV-63-11A Motor 1YF50007A3QY", Att. B Page 16 of 47

16. EE-1600, AC Motor for Turbine Building Air Handling / Air Recirculation Unit, Rev. 1, 4/28/03.

17. Allen Bradley Bulletin 800T, Rev. 1

18. EMPAC (Enterprise Maintenance Planning and Control) Asset

19. Stone & Webster, Inc Scope of Work letter VY 2004-0145 dared 2/2/2004 part of Subcontract No. 59029-A003.

20. 5920-11981 Rev 0, 7/10/98, NAMCO Controls limit switch drawing.

21. Calculation VYC-1087, Rev 1, "4160VAC and 480VAC Relay and Breaker Coordination.

22. VYNP-IV-C-2A, R2, October 11, 1969, "EBASCO Services Incorporated Specification EBASCO CX-68 Electric Cables 5KV Power Cable Normal Service"

23. Calculation VYC-1854, "Determination of Ampacity for Safety Related Power Cables for the Auxiliary Power Distribution System".

24. Calculation VYC-1314 Rev 3, "Determination of Minimum Pickup Voltage for SCE 480V MCC Control Circuit Devices During Normal Operational Transient Conditions"

5 Attachments

Attachment A	Feedwater Pump Room Temperature Analysis
Attachment B	Condensate Pump Room Temperature Analysis

Attachment C	Feedwater Pump Cable/Instrument/Misc. Analysis
Attachment D	Condensate Pump Cable/Instrument/Misc. Analysis
Attachment E	GE Nuclear Energy Motor Evaluation
Attachment F	Westinghouse Motor Company Engineering Study

Attachment A
FeedWater PP Room

	6/26/03	6/30/03	7/1/03	7/2/03	7/3/03	7/9/03	7/14/03	7/15/03	7/16/03	7/18/03	7/24/03	7/28/03	Highest Temp		Avg Temp	
	F	F	F	F	F	F	F	F	F	F	F	F	F	C	F	C
OUTSIDE AIR TEMP	95.5	82.3	84.9	87.3	85.8	69.2	80.5	86.9	80.5	75.2	83.4	81.9				
RX FEED PUMP A MOTOR WINDING									**77.9**	**77.7**	**78.1**	**78.5**	**78.5**	78.5	**78.1**	78.1
RX FEED PUMP B MOTOR WINDING									**34.2**	**33.9**	**33.8**	**33.9**	**34.2**	34.2	**34.0**	34.0
RX FEED PUMP C MOTOR WINDING									**82.8**	**82.4**	**83.2**	**83.4**	**83.4**	83.4	**83.0**	83.0
RX FEED PUMP A INBOARD BEARING									168.6	168.6	168.8	168.7	168.8	76.0	168.7	75.9
RX FEED PUMP A OUTBOARD BEARING									169.5	169.8	169.9	170.2	170.2	76.8	169.8	76.6
RX FEED PUMP A THRST BRG E PLATE									135.8	135.5	135.7	135.9	135.9	57.7	135.7	57.6
RX FEED PUMP A MOTOR INBOARD BRG									146.9	146.7	146.8	147.3	147.3	64.1	146.9	63.8
RX FEED PUMP A MOTOR OUTBD BRG									180.6	180.6	181.2	181	181.2	82.9	180.9	82.7
RX FEED PUMP B INBOARD BEARING									114.9	115.5	115.8	115.9	115.9	46.6	115.5	46.4
RX FEED PUMP B OUTBOARD BEARING									122.9	122.7	122.9	122.9	122.9	50.5	122.9	50.5
RX FEED PUMP B THRST BRG E PLATE									87.7	87.5	87.8	87.5	87.8	31.0	87.6	30.9
RX FEED PUMP B MOTOR INBOARD BRG									89.2	89	89.6	89.5	89.6	32.0	89.3	31.8
RX FEED PUMP B MOTOR OUTBD BRG									90	89.5	90	89.9	90	32.2	89.9	32.1
RX FEED PUMP C INBOARD BEARING									164.4	164	164.1	164	164.4	73.6	164.1	73.4
RX FEED PUMP C OUTBOARD BEARING									176	175.9	176.4	176.4	176.4	80.2	176.2	80.1
RX FEED PUMP C THRST BRG E PLATE									142.2	142.1	142.2	142.3	142.3	61.3	142.2	61.2
RX FEED PUMP C MOTOR INBOARD BRG									159.5	159.3	159.5	159.6	159.6	70.9	159.5	70.8
RX FEED PUMP C MOTOR OUTBD BRG									156.2	156	156.4	156.6	156.6	69.2	156.3	69.1
Room Bulk Air Temp 1	93.5	95.7	96.7	96.6	98.4	99	98.2	98.4	95.8	94.7	95.4	96.3	99	37.2	96.6	35.9
Room Bulk Air Temp 2	91	94.5	95.8	95.8	96	97.1	94.6	95.5	93.4	92.9	94.3	93.8	97.1	36.2	94.6	34.8
Room Bulk Air Temp 3	90.1	93.6	92.4	93.1	93.9	95.7	92.1	93.8	91.5	90.8	92.1	92.3	95.7	35.4	92.6	33.7
Room Bulk Air Temp 4	92.2	93.5	95.1	95.4	95.5	96.2	93.6	96.2	92.3	92.2	93.7	93.8	96.2	35.7	94.1	34.5
Room Bulk Air Temp 5									99.5	101.2	100.7	98.6	101.2	38.4	100.0	37.8
Room Bulk Air Temp 6									96.3	96	95.4	96.6	96.6	35.9	96.1	35.6
Room Bulk Air Temp 7									94.6	94.4	93.7	95.2	95.2	35.1	94.5	34.7
Room Bulk Air Temp 8									92.5	91	92.2	92.2	92.5	33.6	92.0	33.3
Room Bulk Air Temp 9									92.7	92.6	93.1	92.7	93.1	33.9	92.8	33.8
Room Bulk Air Temp 10									91.3	94	93.6	92.4	94	34.4	92.8	33.8
Room Bulk Air Temp 11									94.6	93.8	95.6	95.2	95.6	35.3	94.8	34.9
Room Bulk Air Temp 12									92.8	96	98	97.3	98	36.7	96.0	35.6
Room Bulk Air Temp 13									98.5	98	97.8	99	99	37.2	98.3	36.8
													101.2	38.4	95.0	35.0
Room Bulk Air Avg Temp	91.7	94.3	95.0	95.2	96.0	97.0	94.6	96.0	94.3	94.4	95.0	95.0	97	36.1	94.9	34.9

Bold Degs C

Attachment B
Condensate PP Room

	6/26/03	6/30/03	7/1/03	7/2/03	7/3/03	7/9/03	7/14/03	7/15/03	7/16/03	7/18/03	7/24/03	7/28/03	Highest Temp		Avg Temp	
	F	F	F	F	F	F	F	F	F	F	F	F	F	C	F	C
OUTSIDE AIR TEMP	95.5	82.3	84.9	87.3	85.8	69.2	80.5	86.9	80.5	75.2	83.4	81.9				
CONDENSATE PUMP A MOTOR WINDING									106	105.6	106	105.7	106.0	106.0	105.8	105.8
From TE 2004-025				110	110				106	106	106	106	110.0	110.0	107.3	107.3
CONDENSATE PUMP B MOTOR WINDING									53.4	53.1	53.4	52.6	53.4	53.4	53.1	53.1
From TE 2004-025				90	90				87.5	87.5	87.5	87.5	90.0	90.0	88.3	88.3
CONDENSATE PUMP C MOTOR WINDING									100.7	100.9	100.2	100	100.9	100.9	100.5	100.5
From TE 2004-025				105	105				101	101	101	101	105.0	105.0	102.3	102.3
CONDENSATE PUMP A MTR THRUST BRG									173.6	173.2	173.3	173.3	173.6	78.7	173.4	78.5
CONDENSATE PUMP A MTR GUIDE BRG									162.2	161.7	162.5	162.6	162.6	72.6	162.3	72.4
CONDENSATE PUMP B MTR THRUST BRG									160.8	160.7	160.9	160.7	160.9	71.6	160.8	71.5
CONDENSATE PUMP B MTR GUIDE BRG									192.1	191.9	192	191.7	192.1	88 9	191.9	88.8
CONDENSATE PUMP C MTR THRUST BRG									169.4	169	169.3	169.3	169.4	76.3	169.3	76.3
CONDENSATE PUMP C MTR GUIDE BRG									147.4	147	147.3	147.3	147.4	64.1	147.3	64.0
Room Bulk Air Temp 1	105.3	106.9	110.3	108.3	108.8	105.8	104.2	106.9	103	105.5	103.6	105.1	110.3	43.5	106.1	41.2
Room Bulk Air Temp 2	111.5	110.3	112.5	114.5	116.5	116.4	107.1	109	112.5	115.8	110	111.4	116.5	46.9	112.3	44.6
Room Bulk Air Temp 3	105.8	111.3	111.2	108.8	111	110.9	107.8	108 8	106.8	109.3	106	106.7	111.3	44.1	108.7	42.6
Room Bulk Air Temp 4	108.3	109.9	114.4	116.3	115	113.5	114.8	113	114.3	115.1	111.4	115.1	116.3	46.8	113.4	45.2
Room Bulk Air Temp 5									112.3	114.6	115.8	114.3	115.8	46.6	114.3	45.7
Room Bulk Air Temp 6									116.5	113.3	117.6	118 2	118.2	47.9	116.4	46.9
Room Bulk Air Temp 7									115.7	113.8	117.1	115.2	117.1	47.3	115.5	46.4
Room Bulk Air Temp 8									118.3	121.3	126	121.8	126.0	52.2	121.9	49.9
Room Bulk Air Temp 9										113	108.5	115.5	115.5	46.4	112.3	44.6
Room Bulk Air Temp 10									118.7	117.1	114.3	119	119.0	48.3	117.3	47.4
Room Bulk Air Temp 11									102.4	106	103.1	103.2	106.0	41.1	103.7	39.8
Room Bulk Air Temp 12																
Room Bulk Air Temp 13																
													126 0	52.2	112.9	44.9
Room Bulk Air Avg Temp	107.7	109.6	112.1	112.0	112.8	111.7	108.5	109.4	112.1	113.2	112.1	113.2	113.2	45.1	111.2	44.0

Bold Degs C

Attachment C					
FWP Area					
Equipment N	Description	Source Document	Ambient Temp	Acceptable Yes/No	Notes
TRU1	Dayton Turbine Recirc Unit	G-191303 Sheet 1 & G-191304 Sheet 1, EE-1600	40 C	Yes	Reference 16, Note 2
TRU2	Dayton Turbine Recirc Unit	G-191303 Sheet 1 & G-191304 Sheet 1, EE-1600	40 C	Yes	Reference 16, Note 2
TRU3	Dayton Turbine Recirc Unit	G-191303 Sheet 1 & G-191304 Sheet 1, EE-1600	40 C	Yes	Reference 16, Note 2
TRU4	Dayton Turbine Recirc Unit	G-191303 Sheet 1 & G-191304 Sheet 1, EE-1600	40 C	Yes	Reference 16, Note 2
V63-4A	RFP Discharge Valves	G-191303 Sheet 1, & G-191304 Sheet 1, VYC-2166 Att. B Page 16 of 47	60 C	Yes	Reference 15
V63-4B	RFP Discharge Valves	G-191303 Sheet 1, & G-191304 Sheet 1, VYC-2166 Att. B Page 16 of 47	60 C	Yes	Reference 15
V63-4C	RFP Discharge Valves	G-191303 Sheet 1, & G-191304 Sheet 1, VYC-2166 Att. B Page 16 of 47	60 C	Yes	Reference 15
V63-10	Feedwater Aux. Regulator Inlet Valve	G-191303 Sheet 1, & G-191304 Sheet 1, VYC-2166 Att. B Page 16 of 47	60 C	Yes	Reference 15
V63-11A	Feedwater Aux. Regulator Inlet Valve	G-191303 Sheet 1, & G-191304 Sheet 1, VYC-2166 Att. B Page 16 of 47	60 C	Yes	Reference 15
FT-102-2A	Reactor FDW Pump Suction Flow	GE Diff. Pressure Transmitter Model GE-50-555	162 C	Yes	Reference 18
FT-102-2B	Reactor FDW Pump Suction Flow	GE Diff. Pressure Transmitter Model GE-50-555	162 C	Yes	Reference 18
FT-102-2C	Reactor FDW Pump Suction Flow	GE Diff. Pressure Transmitter Model GE-50-555	162 C	Yes	Reference 18
PT-101-17A	GE Heater Transmitter (ESS to 3rd Pt Htr A)	Model GE-50-551032	185 C	Yes	Reference 18
PT-101-17B	Foxboro Heater Transmitter (ESS to 3rd Pt Htr B)	Model N-821-GM-H51SM2	185 C	Yes	Reference 18

Attachment C					
FWP Area					
Equipment N	Description	Source Document	Ambient Temp	Acceptable Yes/No	Notes
PT-101-19A	Heater Transmitters (ESS to 4th Pt Htr A)	Model GE-50-552032	185 C	Yes	Reference 18
PT-101-19B	Heater Transmitters (ESS to 4th Pt Htr B)	Model GE-50-552032	185 C	Yes	Reference 18
PT-102-24	Heater Transmitter (RFP Suction Header Press)	Model GE-50-551032	162 C	Yes	Reference 18
PT-102-26	Heater Transmitters (RFP Discharge Header Press)	Model GE-50-551032	162 C	Yes	Reference 18
PT-102-27	Heater Transmitters (Feedwater Header Press)	Model GE-50-551032	162 C	Yes	Reference 18
FCV-102-2A	Spring Operated Valves w/Valve Actuators (Feedwater Pump A Recirc Valve)	Babcock & Wilcox Model 730114044	204 C	Yes	Reference 18
FCV-102-2B	Spring Operated Valves w/Valve Actuators (Feedwater Pump B Recirc Valve)	Babcock & Wilcox Model 730114044	204 C	Yes	Reference 18
FCV-102-2C	Spring Operated Valves w/Valve Actuators (Feedwater Pump C Recirc Valve)	Babcock & Wilcox Model 730114044	204 C	Yes	Reference 18
FCV-6-12A	Spring Operated Valves w/Digital Valve Actuators (Main Feed Reg Valve)	Babcock & Wilcox Model 730114044/Siemens Model SIPART PS2	204 C / 80 C	Yes	Reference 18 / Note 3
FCV-6-12B	Spring Operated Valves w/Digital Valve Actuators (Main Feed Reg Valve)	Babcock & Wilcox Model 730114044/Siemens Model SIPART PS2	204 C / 80 C	Yes	Reference 18 / Note 3
FCV-6-13	Spring Operated Valves w/Valve Actuators (Start Up Feed Reg Valve)	Babcock & Wilcox Model 730114044	204 C	Yes	Reference 18
	9x Pressure Switches	Allen Bradley Model 836T, Allen Bradley 800 T Bulletin	55 C	Yes	Reference 17
n/a	Feedwater & Condensate Instrument Rack	Instrument Rack		Yes	Note 1, Note 2
n/a	12x Lighting Fixtures			Yes	Note 1, Note 2

Attachment C					
FWP Area					
Equipment N	Description	Source Document	Ambient Temp	Acceptable Yes/No	Notes
R201	low voltage power cable in tray			Yes	Note 2
R202	low voltage power cable in tray			Yes	Note 2
R203-BB	low voltage power cable in tray			Yes	Note 2
R301	low voltage control cable in tray			Yes	Note 2
R301-BB	low voltage control cable in tray			Yes	Note 2
R302	low voltage control cable in tray			Yes	Note 2
R402	low voltage instr. cable in tray			Yes	Note 2
R403	low voltage instr. cable in tray			Yes	Note 2
1502H	1-3/C #16	C&CL B191301 Sh. 502		Yes	Note 2
1502F	1-5/C #16	C&CL B191301 Sh. 502		Yes	Note 2
1502G	1-2/C #16	C&CL B191301 Sh. 502		Yes	Note 2
1502L	1-2PR TW/SH #16 XLPE	C&CL B191301 Sh. 502		Yes	Note 2
1502M	1-2PR TW/SH #16 XLPE	C&CL B191301 Sh. 502		Yes	Note 2
1502D	1-5/C #16	C&CL B191301 Sh. 502		Yes	Note 2
1502E	1-2/C #16	C&CL B191301 Sh. 502		Yes	Note 2
1502J	1-3/C #16	C&CL B191301 Sh. 502		Yes	Note 2
1550A	3-1/C 750 MCM	C&CL B191301 Sh. 550	40 C	Yes	P-1-1A Feeder; Note 2
1550B	3-1/C 750 MCM	C&CL B191301 Sh. 550	40 C	Yes	P-1-1A Feeder; Note 2
1551A	3-1/C 750 MCM	C&CL B191301 Sh. 551	40 C	Yes	P-1-1B Feeder; Note 2
1551B	3-1/C 750 MCM	C&CL B191301 Sh. 551	40 C	Yes	P-1-1B Feeder; Note 2
1552A	3-1/C 750 MCM	C&CL B191301 Sh. 552	40 C	Yes	P-1-1C Feeder; Note 2
1552B	3-1/C 750 MCM	C&CL B191301 Sh. 552	40 C	Yes	P-1-1C Feeder; Note 2

Note 1: In the absence of vendor data, these components have been assumed to have an ambient temperature of 40 C.

Note 2: Refer to analysis provided within technical report.

Note 3: Seimens Catalog F1 01 November 2003, Electopnuematic Positioner / SIPART PS 2

Attachment D					
Condensate Pump Area					
Equipment N	**Description**	**Source Document**	**Ambient T**	**Acceptable Yes/No**	**Notes**
TRU5	Dayton Turbine Recirc Unit	G-191303 Sheet 1 & G-191304 Sheet 1, EE-1600	40 C	Yes	Reference 16, Note 2
21-22	Condensate Hotwell Sampling Point	Instrumentation	40 C	Yes	Note 1, Note 2
23-24	Condensate Hotwell Sampling Point	Instrumentation	40 C	Yes	Note 1, Note 2
n/a	7x Lighting Fixtures		40 C	Yes	Note 1, Note 2
n/a	3x Pressure Switches	Allen Bradley Model 836T, Allen Bradley 800 T Bulletin	55 C	Yes	Reference 17
n/a	3x Condensate Pump Switches		40 C	Yes	Note 1, Note 2
n/a	3x Valve Postion Limit Switches	5920-11981	90 C	Yes	Reference 20
R201	low voltage power cable in tray			Yes	Note 2
R203-BB	low voltage power cable in tray			Yes	Note 2
R301	low voltage control cable in tray			Yes	Note 2
R301-BB	low voltage control cable in tray			Yes	Note 2
R302	low voltage control cable in tray			Yes	Note 2
R402	low voltage instr. cable in tray			Yes	Note 2
R403-BB	low voltage instr. cable in tray			Yes	Note 2
R403-CC	low voltage instr. cable in tray			Yes	Note 2
1530A	3-1/C 4/0	C&CL B-191301 Sh. 530	40 C	Yes	P2-1A Feeder, Note 2
1531A	3-1/C 4/0	C&CL B-191301 Sh. 531	40 C	Yes	P2-1B Feeder, Note 2
1532A	3-1/C 4/0	C&CL B-191301 Sh. 532	40 C	Yes	P2-1C Feeder, Note 2

Note 1: In the absence of vendor data, these components have been assumed to have an ambient temperature of 40 C.

Note 2: Refer to analysis provided within technical report.

ATTACHMENT E

GE Nuclear Energy

General Electric Company
175 Curtner Avenue, M/C 733, San Jose, CA 95125

DRF 0000-0027-1611
May 13, 2004

Craig Nicholes
Vermont Yankee
Energy Nuclear Northeast

SUBJECT: Condensate Pump Motor Increased Load Evaluation
GE Motor Model 5KV84483656501

REFERENCE:
1. Entergy Nuclear Work Impact Notice (WIN) 012, dated 3/17/04
2. VY supplied data, DIR WIN 012, Rev. 0, Rev 1 and Rev 2, Evaluation No. 2004-025 and 2004-029

This letter report provides the results of an evaluation to determine the effect on the life and reliability of increasing the load on the GE Condensate Pump Motor (CPM) at Vermont Yankee (VY). The increased load is the result of changes to the system hydraulic resistance that results in the pump operating at a higher flow to meet plant power uprate conditions. The uprated operating load is estimated to be less than 5% greater than the existing nameplate rated value of 1500 HP (195 amps). The Evaluation was performed for an uprated load of 1575 HP in accordance with the Reference 1 purchase order using plant data from the Reference 2 DIR.

1.0 SUMMARY

- The evaluation concluded that the Condensate Pump Motor has approximately 30 years of remaining life with normal reliability, at loads of up to 1575 HP with maximum cooling air temperature of 50°C during the three summer months and 40°C for the remainder of the year, within the constraints listed in the conclusions section of this letter report. After that time, a review of the latest operating data and an assessment of the motor condition should be performed to determine future remaining life and appropriate maintenance actions.

- Based on the existing design margin in the motor and operating history, there is no need to rewind or modify the motor at this time to achieve 30 years or more of life at the maximum increased load and ambient temperature.

- When the motor is initially operated at the increased load, it should be monitored and values compared to acceptance criteria. Monitored parameters should include winding and bearing temperature using installed sensors or thermography, discharge air temperature, vibration, stator current, noise, and visual inspection. Acceptance criteria provided in revised Data Sheet.

2.0 BACKGROUND

The Condensate Pump Motor brake horsepower is calculated to be approximately 1510 BHP at the power uprate condition. The motor presently operates near the current nameplate full load of 195 amps. The motor is located in a room that experiences ambient temperatures between 40°C and 50°C during hot summer days, and the room temperature drops to below 40°C in the non-summer days. At uprate, the current draw is expected to be higher, since the horsepower demand is calculated to increase by approximately 100 HP.

The objective of the evaluation was to evaluate acceptability of uprating the motor to a 5% increase in load above rated, 1575 HP, and operation during the three summer months at 50°C and at 40°C for the remainder of the year. The objective of the evaluation was to address the primary effect of the increased load on the motor and not the secondary effects, such as, electrical system protection equipment setpoints, additional heat load to plant HVAC or cooling water systems, power cable voltage drop increase due to higher current, shaft rotordynamics if speed is increased, or effect on equipment other than the motor.

3.0 MOTOR DESCRIPTION

3.1 Design Characteristics (Original Design)

GE Motor Model:	5KV84483656501, serial number 840703
Safety Class:	Non-safety related
Application:	Condensate Pump Motor
Horsepower:	1500 HP
Voltage:	4000 VAC, 3 phase, 60 Hz (to be confirmed by Entergy)
Full Load Current:	195 amps (nameplate rated)
Full Load Speed:	1185 RPM
Insulation Class:	NEMA Class F
Ambient:	40°C (nameplate rated)
Thrust Load at Coupling:	21,400 lbs (downthrust)

3.2 Operating Characteristics

Plant operating data was provided in the referenced DIR that were used as the baseline from which to extrapolate operating current and winding temperature to the increased loads.

The motor was manufactured in 1994, and is conservatively assumed to have been operating since then for approximately 10 years at approximately the same load and cooling air temperature as presently exists. Plant data shows that the motor maximum temperature is 90°C, when the ambient temperature is approximately 45°C. Winding temperatures were measured by sensors embedded in the winding, which approximate the insulation temperature. Industry practice is to assume the temperature in some other part of the winding insulation to be 10°C greater (hotspot) than the measured temperature. Therefore, the maximum expected insulation temperature is 100°C with the corresponding ambient temperature of 45°C under current conditions. Based on this operating data, the temperature rise is 55°C. The DIR transmittal identified a typical load of 185 amps corresponding to this temperature rise.

4.0 EVALUATION SUMMARY

4.1 Evaluation Method

The evaluation summarized in this letter report included the following steps:

- Obtained motor design data from GE archives. Obtained site operating data, such as, motor current, winding temperatures, ambient temperature, bearing temperature and vibration data.
- Determined the expected motor performance characteristics, including current, efficiency, power factor, speed, torque, heat rise and operating temperature at the original rated 1500 HP and increased loads.
- Determined the effect of the increased load and operating temperature on the stator assembly, focusing on the long-term thermal aging characteristics and life of the stator winding insulation system.
- Determined the effect of the increased load and operating temperature on the rotor assembly, focusing on the reliability of the rotor bars, endrings, retaining rings, and core.
- Determined the effect of the increased load torque and stress on the critical mechanical components of the rotor, bearings, lubrication system, and stator core support structure.
- Determined the effect of the increased load on the motor electrical components considering ampacity and magnetic forces on the current carrying components.
- Determined the effect of the increased heat load on the heat transfer capability of the ventilation system and discharge to the room.
- Revised documentation will be provided to supplement the original motor rating data in the instruction manuals and any changes in maintenance or lubrication recommendations provided.
- Performed independent verification of above evaluation, documented in accordance with GE Quality Assurance practices.
- Issued draft and final letter reports with the evaluation results, conclusions, and recommendations, for VY review and comment.

The motor performance characteristics of current, efficiency, power factor, slip and losses for a range of loads were included in the original electrical design. The calculated values at 1500 HP differed slightly from nameplate rating values, because the nameplate rating values are guaranteed minimum or maximum values with margin added relative to the calculated design values for commercial reasons. For example, conservatism was added to the design values to compensate for uncertainty, such as, the efficiency and power factor values were rounded down and current was rounded up. The electrical design values were considered to be the best estimates of the motor performance characteristics. The nameplate values were extrapolated for the uprated load and are an "upper-bound" value. They are tabulated in the report.

The winding losses used in the evaluation were obtained from the original electrical design and the heat transfer effectiveness of the ventilation system was based on the more conservative value obtained from the original motor design data or plant operating data. The operating data shows that the motor is performing better than designed.

The aging mechanism related to the electromechanical forces on the windings, as described in IEEE 434, was evaluated using GE test data of large motors subjected to repetitive starting transients. This testing evaluated the adequacy of the winding mechanical strength relative to electromagnetic loads, and is typically referred to as "plug-reversal" tests. A load versus life relationship was used to estimate the remaining life and was found to be non-limiting for the 5% overload of the CPM motor.

4.2 Effect Of Increased Load On Insulation System Thermal Life

The winding temperature and corresponding remaining years of winding life in terms of horsepower and current was calculated for rated and uprated loads at the maximum cooling air temperature of 50°C.

It was found that the original motor design included significant margin such that the aging to-date has consumed less than 10% of the total thermal life. Therefore, increases in loads and winding temperatures are acceptable without reaching end of winding thermal life within the expected future motor operating life of 30 years.

The assessment of the motor focused on the electrical system. Typically, the operating risk associated with the electrical system (stator and rotor) is greater than the mechanical system, because the consequence of failure would require removal and rewinding the stator or rebarring the rotor at a significant cost and schedule impact. Also, the assessment found adequate margin in the mechanical system for increased loads.

The thermal aging portion of the evaluation was based on methods used to determine qualified life of safety-related motors. Aging is caused by the gradual breakdown of chemical bonds in the polymers making up the insulation system. As the material ages it loses its electrical and mechanical capability or "life". Aging is related to the rate of chemical reactions and is approximated by the 10°C rule, which says for each 10°C of increased temperature, the insulation life is reduced by a factor of 2.

Increases in the motor load affect the motor heat rise by increasing the current and the corresponding I^2R losses of the winding. Decreases in voltage also affect the heat rise of the motor by increasing the current but decreasing the losses in the stator and rotor core iron. The original electrical design program calculated the losses due to stator and rotor core iron losses,

I^2R losses in the stator winding, I^2R losses in the rotor winding, windage and friction losses, and stray load losses. These losses were the basis of motor efficiency and temperature rise estimates.

Life test data was obtained from motor material samples, assembled in "motorettes", which were tested to failure under accelerated aging conditions of temperature, humidity, and mechanical loads. The times and temperatures to failure of approximately 10 samples at three different temperatures (30 samples) were used to plot a regression line following the methods of IEEE Std 101-1972, The Guide for Statistical Analysis of Thermal Life Test Data. The data was used to calculate the activation energy for use in the end-of-life estimation.

The Arrhenius Equation describes the temperature dependence on the rate of chemical reactions, and can be adapted to approximate the relationship between insulation life and temperature. For a chemical reaction rate, the Arrhenius equation is given by:

$$K = A * \exp(-\phi/RT)$$

where

K = specific reaction rate

ϕ = activation energy of the reaction (assumed to be constant for the temperature range considered)

R = constant

T = absolute temperature, °K

A = frequency factor (assumed constant)

This equation is adapted to represent insulation life, y, by assuming that the reaction rate is inversely proportional to the life. This leads to:

$$\ln(\text{life}) = \ln(y) = \text{constant} + (1/2.303) * (E/RT)$$

This is a linear algebraic equation representing the logarithm of the life of the motor as a function of the inverse of the motor temperature. Test data from the motorettes aged at an elevated temperature is used to determine the solution of this equation. The solution is then extrapolated to the operating temperatures of the motor to determine its corresponding operational life.

Activation Energy

Arrhenius methodology states that if a material is thermally aged at a temperature of T_1 for a duration t_1, the equivalent aging duration t_2 at a temperature of T_2 is given by the relationship:

$$t_2 = t_1 e^{\left[\frac{\phi}{K}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)\right]}$$

where: ϕ is the activation energy of the material

K is the Boltzmann's constant = 8.617×10^{-5} eV/°K

The following two points of thermal aging were chosen from test data per IEEE 275, Test Procedure for Evaluation of Systems of Insulating Materials for A/C Electric Machinery Employing Form-Wound Preinsulated Stator Coils, for use with IEEE Std 101, Guide for Statistical Analysis of Thermal Life Test Data, to calculate the activation energy (ϕ). The values were obtained from test data of Class B insulation systems applicable to the CPM motor.

T_1 = 130°C (403°K) t_1 = 140,000 hrs

T_2 = 200°C (473°K) t_2 = 1,200 hrs

Substituting the above values in Arrhenius equation:

$$1{,}200 = 140{,}000\ e^{[\phi/8.617\times10^{-5}\ (1/473\ -\ 1/403)]}$$

ϕ = 1.117 eV

This value of ϕ was used in the following analysis summary to estimate motor life based on expected operating times and temperatures.

Thermal Aging With Increasing Load

The determination of consumed life was based on assuming 84,000 hours of motor operation since installation (10 years less 15 days per year of equivalent outage time), with normal cooling air temperature at a rated 1500 HP load and at a nominal 4000 VAC terminal voltage. The remaining life calculation was found to be insensitive to the assumed operating hours.

During standby duty during the outages the thermal aging effect of the space heaters operating is insignificant.

The calculation was performed for the Class B materials having a life of 140,000 hours at 130°C as noted above.

T_1 = 130°C = 403°K (reference temperature from thermal aging test)

T_2 = 50°C ambient + 55°C rise + 10°C margin = 115°C + 273 (Kelvin) = 388°K

t_1 =140,000 hours life capability from thermal aging test

$$t_2 = 140{,}000\, e^{[1.117 / 8.617\times10^{-5} (1/388 - 1/403)]}$$

$t_2 = 4.85 \times 10^{5}$ hours of aging capability at 50°C ambient

Therefore, if the motor has been in service for 10 years and operated at the uprated load, there would be approximately 45 years of remaining life at uprated load and 50°C. This shows that there is significant margin in the insulation thermal life.

4.3 Effect On Rotor Assembly

The rotor in the CPM motor consists of the shaft, magnetic core, current carrying conductors consisting of rotor bars and endrings. The increased load increases the current, I^2R losses, and temperature of the rotor bars and endring. As the temperature increases, the yield strength of the rotor bars and endring decreases. The reliability of the rotor is acceptable at temperatures less than those allowed at the starting limitation, of 200°C for copper and 400°C for aluminum. The maximum rotor temperature during operation is comparable to the stator winding temperature for values of slip (or load) near rated. Therefore, since the stator temperatures shown in Reference 2 are less than 130°C; there is sufficient margin and the rotor assembly is judged to be acceptable up to the increased load values.

4.4 Effect On Mechanical Components

The increased horsepower load on the motor results in a proportional increase in torque on the shaft and rotor assembly, and an increase in the reaction torque on the mounting bolts and stator frame assembly. The rotor assembly and stator assembly have the strength for meeting the speed and torque values of the maximum torque point on the motor speed-torque curve, which is greater than 200% of the rated load torque. Based on the original design analysis for 1500 HP and the full load speed of 1185 RPM, the full load torque is approximately 6646 ft. lbs. Therefore, the maximum short-term strength capability is greater than 13,000 ft. lbs. This is greater than the expected torque at 1575 HP of 7000 ft. lbs. Therefore, at the increased load torque, the mechanical components will not be overstressed.

The primary load carrying mechanical components of the rotor include the shaft key/keyway, shaft, rotor core keys, and rotor laminated core assembly. The primary load components of the stator and frame assembly are at a significantly greater radius than the rotor mounted components with correspondingly lower stress for the same torque. Therefore, the rotor components are more limiting from a mechanical standpoint.

The nominal shear stress in the shaft is less than 6000 psi at the design loads. The 5% increase in torque from 1500 HP to 1575 HP will not increase shaft stress above the fatigue endurance limit value of 10,000 psi, and therefore the increased load will not reduce the long term fatigue life of the shaft and major rotor components.

The motor bearings are designed for the weight of the motor rotor, radial and axial loads transmitted through the coupling from the pump, and magnetic and centrifugal forces from the rotor core. The increase in horsepower load will not increase the weight, magnetic or centrifugal forces, however, the axial thrust load from the pump was determined to be higher as a result of the uprated flow conditions as reported by Entergy in Reference 2.

The motor thrust load design is rated for 21,400 lbs continuous and 26,800 lbs momentary downthrust. The peak pump efficiency uprate load of 21,458 lbs slightly exceeds the continuous rating by 0.2%. The closed valve load of 23,348 lbs is within the momentary load rating. An evaluation of bearing thrust capacity was completed and determined that the thrust rating can be increased to 21,500 lbs to cover the slight increase in load at the peak efficiency operating point. The uprated capacity is shown in the supplemented Data Sheet.

The bearing losses are primarily due to rotational speed. Since the speed does not increase at the increased loads, the heat generation rate will not increase; therefore, the lubrication cooling system design is adequate. The increased load will increase the overall temperature of the winding and increase the heat transferred to the bearing assembly. However, Entergy operating data showed the maximum bearing temperatures to be less than 162°F thrust bearing and 195°F guide bearing, compared to a temperature of 200°F long-term or 205°F short–term (such as one month) for which the bearings are designed to meet minimum allowable film thickness requirements. The increase in load is expected to increase the thrust bearing temperature to a greater extent than the guide bearing temperature. Based on the margin between 162°F and 200°F/205°F, the thrust bearing is judged to be acceptable at the uprated load. The guide bearing loads are not affected by the uprated load and there is margin to the 200°F/205°F allowable temperature.

Therefore the bearings are considered to be acceptable at the increased horsepower loads over the pump operating range.

Since the motor is a rotating machine, increased vibratory forces and differential thermal expansion effects could potentially loosen the assembly at the increased loads. Therefore, prior to increased load operation, and periodically through the remaining plant life, the externally accessible bolting (such as endshield, mounting, conduit box, etc) should be verified to be tight to standard torque values for the size of bolt, and vibration should be monitored and analyzed for indications of loose components as part of normal maintenance.

4.5 Motor Electrical Components

The increase in line current due to higher load results in increased current density of the stator conductors and leads. The stator was designed with margin for load increase up to 1.15 rated. Therefore, a power increase of 5% remains within the current density design capability.

The motor internal connections are made of jumper connections and leads that pass to the conduit box for the external connection. Based on the cross sectional area of the leads, the current density and ampacity values are less than the allowable design and NEC values for the maximum expected current at the overload condition. Other current carrying conductors will not have current in excess of starting inrush current, for which the motor is designed, therefore are not expected to have reduced life from mechanical strain from magnetic loads. Since the increased load does not effect the starting characteristics, the locked rotor inrush current of the motor will not increase.

The magnetic sidepull loads on the rotor are not expected to increase since the airgap flux remains constant because the volts/hertz value remains constant.

Therefore, the increase in load of up to 105% of rated current does not exceed original design criteria or appreciably reduce the operating reliability of the electrical components.

4.6 Effect On Electro/Mechanical Components

The increases in line current due to higher load results in increased current density of the stator conductors, stator endturns, stator leads, rotor bars, and endrings. As noted previously, the current densities are acceptable up to 115% of rated power, such that an increase in current density due to power at 105% of rated is acceptable.

The increased current and temperature reduces the yield strength of the rotor bar and endrings and increases the differential thermal expansion of the bars relative to the rotor slots which support the bars. The temperatures are related to the current density, and maintaining the values less than or equal to the design values meets acceptance criteria used in the original motor design for rotor bar and endring long-term reliability.

The motor internal connections are made of circuit rings and leads that pass to the conduit box for the external connection. Based on the cross sectional area of the circuit rings and leads, the current density and ampacity values are less than the allowable design and NEC values for the maximum expected current. The conductors will not have short-term current in excess of the original starting inrush current, for which the motor was designed; therefore they are not expected to have reduced life from mechanical strain from magnetic loads. Since the increased load does not effect the starting characteristics, the locked rotor inrush current of the CPM motor will not increase.

The magnetic sidepull loads on the rotor are not expected to increase since the airgap flux remains constant because the volts/hertz value is constant as the load increases. Constant volts/hertz also keeps the magnetizing current portion of the total current constant.

Increasing the load will increase the electromechanical effects as discussed in IEEE 434. GE "plug-reversal" tests of similar motors found the motor to be capable of 400,000 starting transients without failure. Based on the duration and magnitude of load, an electromechanical aging relationship was obtained and the remaining life estimated.

Therefore, the increase in load of up to 1575 HP does not exceed original design criteria or appreciably reduce the operating reliability of the electrical components.

4.7 Uprated Operating Parameters

The GE supplied Data Sheet for the original motor applies with the supplemented data as tabulated below in Table 1. Acceptance criteria for operating parameters not shown in Table 1 are unchanged from the original Data Sheet.

TABLE 1 – Motor Data Sheet Supplement

Parameter	Original	New
Power Output (HP)	1500	1575
Speed (RPM)	1185	1184
Current (amps)	195	205
Efficiency	95.2	95.1
Service Factor	1.15	1.10
Ambient Temp. (°C)	40 Max	50 max, 3 Mo/Yr 40 max, 9 Mo/Yr
Downthrust Continuous, lbs	21,400	21,500

5.0 CONCLUSIONS AND RECOMMENDATIONS

The evaluation concluded that the CPM motors have approximately 30 years of remaining life with normal reliability, at the highest expected load of 1575 HP, at 50°C maximum cooling air temperature, within the conditions summarized below. After that time, a review of the latest operating data and an assessment of the motor condition should be performed to determine future maintenance actions. Based on the design margin in the motor, there is no need to rewind or modify the motor at this time to achieve 30 or more years of life at the increased load. No additional maintenance or change in lubrication practice is necessary resulting from the increased load rating.

This evaluation addressed the primary effect of the increased load on motor and did not address the secondary effects, such as, electrical system protection equipment setpoints, additional heat load to plant HVAC or cooling water systems, power cable voltage drop increase due to higher current, shaft rotordynamics if speed is increased, or effect on equipment other than the motor.

The above conclusions were based on the following conditions:

- The motor has been maintained in accordance with good industry practice since they were originally installed.
- Prior to operating at the increased load, the general condition of the motor should be assessed to show that the motor is in a normal condition for their age. The following assessment criteria should be met; vibration less than 0.3 in/sec (or not in excess of normal operation values), insulation resistance at the breaker greater than 500 megohms, polarization index greater than 2.0, windings not abnormally dirty or oil fouled, bearing oil analyses with no abnormal findings, external bolting is verified to be tight, and general visual inspection without anomalies.
- The motor should be visually monitored and vibration measured when the load is increased beyond established levels.
- If the modification of the pump results in increased rotational inertia, the motor acceleration time should be reviewed relative to thermal limits and time-current relay set points.
- When starting the motor, minimize the BHP load on the motor from the pump.
- The long-term (normal operation excluding starting and transient conditions) motor terminal voltage should not be less than 4000 VAC considering increased voltage drop due to higher load current.
- Motor protection relay setpoints should be reviewed to verify acceptability at a higher current of up to 205 amps during increased load operation at 1575 HP.
- Stator winding temperature alarm setpoints should be reviewed for acceptability during increased load operation that is potentially 10°C greater than existing load operation. Shutdown setpoint limit with respect to NEMA should not be changed. If existing Alarm setpoints are in relation to operating temperature, they should be increased 10°C to cover increase in winding temperature.
- Although the evaluation determined that the motor are capable of long-term operation of up to 1575 HP, random failures can occur at any time without warning and contingency plans and spare parts should be available.
- The evaluation summarized in this letter report is an engineering assessment using standard assumptions based on the plant data provided, and is not a guarantee by GE that the CPM motor will operate at the increased load without failure.

The input data, evaluation results, and record of independent design verification are contained in DRF 0000-0027-1611.

If clarification is needed of the evaluation described above, please feel free to call.

J. S. Mokri
Technical Services
(408) 925-4678

Verified By: W. J. Roit
Technical Services
(408) 925-3578

ATTACHMENT F

Westinghouse Motor Company

Engineering Study

Title: **Determine If Motor Shop Order 76P0948 Can Be Re-rated From 1500 HP To 1600 Hp With No Physical Changes.**

Customer: Stone & Webster
A Shaw Group Company
100 Technology Center Drive
Stoughton MA 02072-4705

Shop Order Number For This Report: ES00166

Purchase Order Number For This Report: 59029-A003

Date: 04/19/2004
Revised with minor clarifications on 05/04/2004

Note: the data and conclusions that are presented in this report are derived from the original design folder which may not reflect changes that have been made in the field since that time that have an influence on these conclusions. The assumption is also made that the motor has been well maintained and thus is in an "as shipped" condition, which may not be the case since this motor over 35 years old. Also, all values are calculated, not guaranteed or verifiable by testing.

Summary:

Based on the expected effects on: insulation class, temperature rise, starting characteristics, bearing loading, motor lead cable, speed vs. torque, thermal limits and starting duty limits, the motor on shop order 76P0948 can be rated to 1600 HP, with a 1.00 service factor. The motor is approved for use in an ambient temperature of 50 degrees Celsius at the 1600 HP rating.

Jerry R. Avey
Manager, Service Engineering

UprateES166rev1.doc

Discussion

Technique:

In order to perform this study, the 76P0948 electrical design was retrieved from the Westinghouse Electric® archives. After this information was obtained, the parameters of the design were entered into TWMC's version of the Westinghouse Electric® design program.

This is a complex task because of the changes that have taken place in motor designs since the 1960's. The computer inputs must be manipulated such that an old design, with the old materials and characteristics, will be generated. Simulation runs are then conducted until the motor's calculated performance output matches precisely with the performance output of 76P0948. Once this has been accomplished, the original design was "locked-in" and analysis computations were then made.

To determine what, if any, design margin exist in this motor, temperature rise, safe stall times, acceleration times and torque output was studied. To aid in this analysis, performance curves were also generated and are attached.

The following table compares the operation of the 1500 vs. 1600 rating.

Calculated with WYE connected winding Line Voltage [4.0 KV]:	At 1500 Horsepower	At 1600 Horsepower
Full Load Rpm	1182	1181
Power Factor	92.8	92.7
Full Load Torque	6662 Ft-Lb.	7115 Lb.-Ft
Full Load Amps	184	197
Efficiency	94.4	94.3
Temperature Rise At 1.0 Service Factor	*45°C At 1.00 S.F. (value obtained from 1966 test data)	55°C At 1.00 S.F. Calculated
Ambient Temperature	40°C	50°C

* When investigating the capabilities of the original machine, actual test data, when available, is always preferred over calculated values. Since a load test was performed when the motor was originally tested by Westinghouse Electric, this value is shown in lieu of the calculated value for temperature rise. The engineering test was performed at 1.00 S.F. instead of at the nameplated 1.15 S.F. This was normally done when the rise guarantee made at the time the order was negotiated, was at the 1.00 rating. Obtaining test data at also the 1.15 rating would have required Westinghouse to perform two separate test. According to the files, this extra test was not done because only the 1.00 test data is contained in the archives.

Bearings:

Bearing temperature rise in an electric motor is primarily a function of the weight of the rotor, the R.P.M. of the shaft and the type of lubrication. Since an increase in rating will not warrant a change in the rotor, the bearing temperature should remain approximately the same. However since the internal air in the motor is circulating around the bearings and this air temperature will increase under the higher load, there maybe a noticeable rise in bearing temperatures.

There is insufficient data to accurately calculate what the rise will be at the higher horsepower but a general rule of thumb is that the bearings will be running in the area of 5°C [or less] higher temperature.

It should be noted that the published motor bearing temperature limits are based on the capability of the lubricant since the babbitt material melting point is very high [440° F/240°]. When bearings operate at higher than normal temperatures, service life may suffer due to a deterioration of the lubricant oil film thickness and quality.

If the higher load presents a problem with higher bearing temperatures then the user is recommended to change from a mineral oil base lubricant to a synthetic after which any bearing temperature monitoring settings can be raised to:

- run temperature: 110° C, (230 deg F)
- alarm temperature: 120° C, (248 deg F)
- shutdown temperature: 130° C, (266 deg F)

Noise:

There will be no noticeable change in motor produced noise when operated at the higher rating.

Environmental:

The ambient temperature this motor is allowed to operate in is being increased from 40°C to 50°C. The increase in HP output and ambient temperature will cause the motor surface and exhaust air temperatures to increase. The corresponding exhaust air temperature will be approximately 8 deg. C higher than before. [Note: we are unable to calculate the exact values]. This is a warning that the motor will be hotter to the touch and the higher exhaust temperatures could be disturbing to surrounding personnel and equipment

Starting duty:

Based on the temperature rise of the rotor and stator components during hot and cold starting, the starting duty shall be 2 cold and 1 hot.

Maintenance:

Operating the machine at the higher load will not necessitate a change in the frequency or maintenance procedures that have already been established.

Conclusion with assumptions:

Assumptions:

1. The load torque and load inertia values are equal or less than what the motor was originally designed for.

2. The motor insulation is the original Westinghouse Electric® Thermalastic® and in "like new" condition.

Conclusion: There is sufficient electrical and mechanical design margin to allow the existing motors to operate at 1600 Hp in a 50°C ambient with no physical change to the motor.

Motor nameplate at 1600 hp

Motor type	CS VSS DP induction motor
Style	Vertical
Frame	CS 41
Horsepower	1600
Time rating	Continuous
Temperature rise by detector	75 °C
Service factor	1.0
Full load speed	1181 rpm
Rated voltage	4000 / 2300 VAC
Full load current	197 / 343 amps
Rated frequency	60 Hz
Number of phases	3
Locked kva/hp code	E
NEMA design code	B
Rotor type	Brazed squirrel cage
Insulation class	B
Ambient Temperature	50°C
Enclosure	Open Drip Proof

Starting and thermal limit curves:

See attached 1600 Hp curves at 100% and 80% operating voltages.

TECO-WESTINGHOUSE MOTOR COMPANY
ROUND ROCK, TEXAS U.S.A.

CUSTOMER STONE & WEBSTER DATE - APR 19, 2004
CUSTOMER ORDER NO.
APPLICATION PUMP
S.O. ES0166

DATA FOR WORLD SERIES, HORIZONTAL, BRACKET TYPE INDUCTION MOTOR

1. RATING

HP	1600	HERTZ	60	INSUL CLASS	B
RPM FL	1181	SERVICE FACTOR	1.0	KVA CODE	E
VOLTS	4000	RISE C (1.00 SF)	75	DUTY	CONTINUOUS
AMPS FL	197	METHOD	RTD		
PHASES	3	AMBIENT C	50		

2. MECHANICAL

FRAME	CS VSS DP	BRG TYPE	SLEEVE	END PLAY INCH	0.50
ENCL TYPE	ODP	LUBE TYPE	SELF	MOTOR WK SQ	2469
ROTATION (ODE)	CW	NO. BRGS	2	LOAD WK SQ	5000

3. STARTING PERFORMANCE - NOMINAL, VALUES WITH (*) ARE GUARANTEED

		100% VOLTS	80% VOLTS
AMPS (LR)		1050	811
AMPS (LR)	%	533	412
POWER FACTOR	%	21.3	20.5
START TORQUE	%	84	50
ACCELERATION SEC		4.0	7.1
SAFE LOCK SEC	FROM HOT	12.4	20.8
SAFE LOCK SEC	FROM COLD	14.6	24.3

PULLOUT TORQUE AT 100% VOLTS = 243 %

4. EFFICIENCY - NOMINAL

LOAD	%	115	100	75	50
EFFICIENCY	%	93.85	94.30	94.77	94.59

5. POWER FACTOR - NOMINAL

LOAD	%	115	100	75	50
POWER FACTOR	%	92.2	92.7	92.8	91.1

6. POWER FACTOR CORRECTION

MAX KVAR = 175 MAX FL P.F. = 96.6 %

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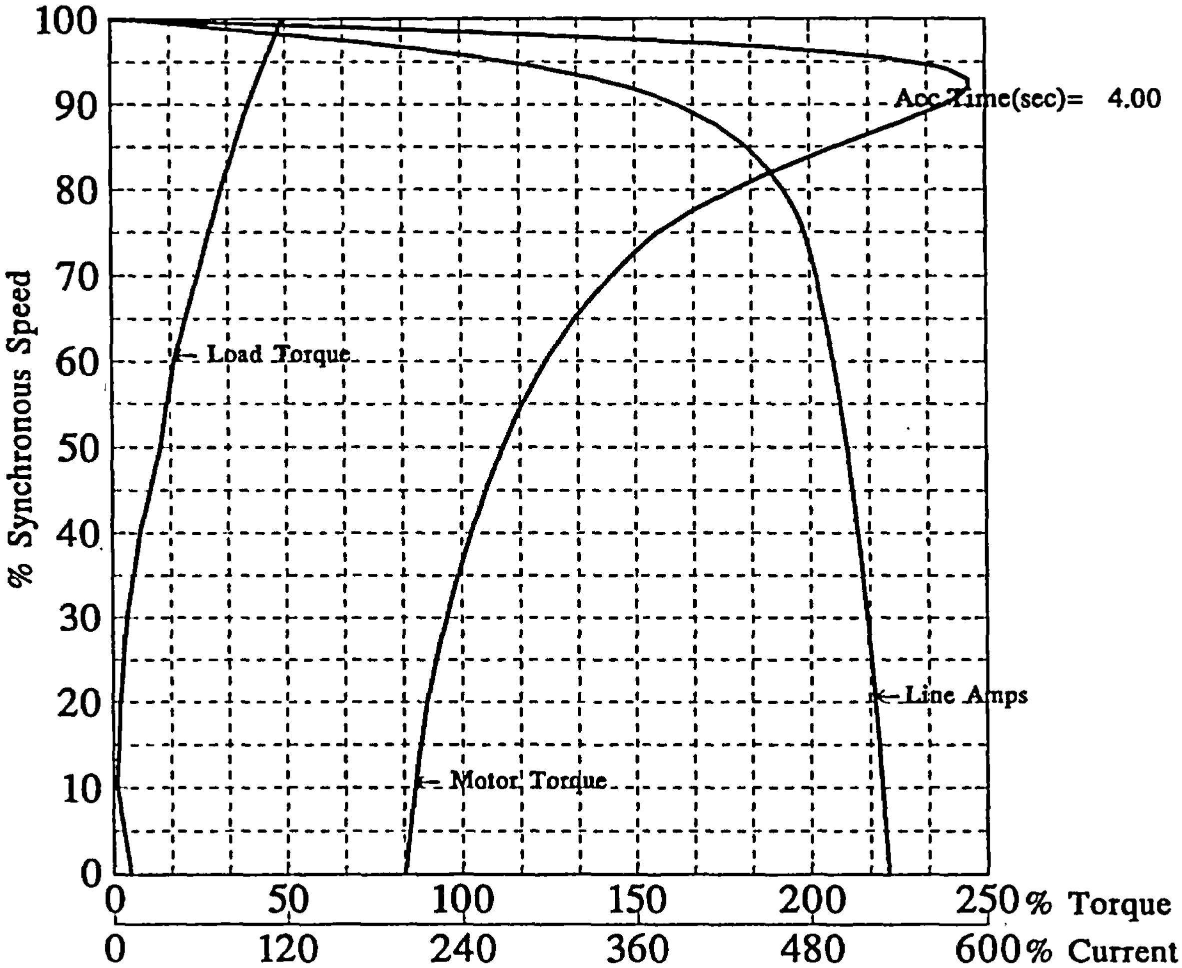
Induction Motor Starting Characteristics
Calculated at 100% Line Voltage

Design.ID	ES0166	Customer	STONE & WEBSTER
Engineer	FANSLOW	Application	PUMP

Poles	6	Volts	4000	Rpm(fl)	1181	Load Curve	ASSUMED
Hp	1600	Fl Amps	197	Rpm(syn)	1200	Lock Amps(%)	533
Pf	0.93	Frame	0	Load Wk^2	5000	Fl Torque(lb-ft)	7115
Phase	3	Hertz	60	Motor Wk^2	2469	Lock Torque(%)	84



TECO-Westinghouse Motor Company Round Rock, Texas

Signature Mark Fanslow Curve No. -1

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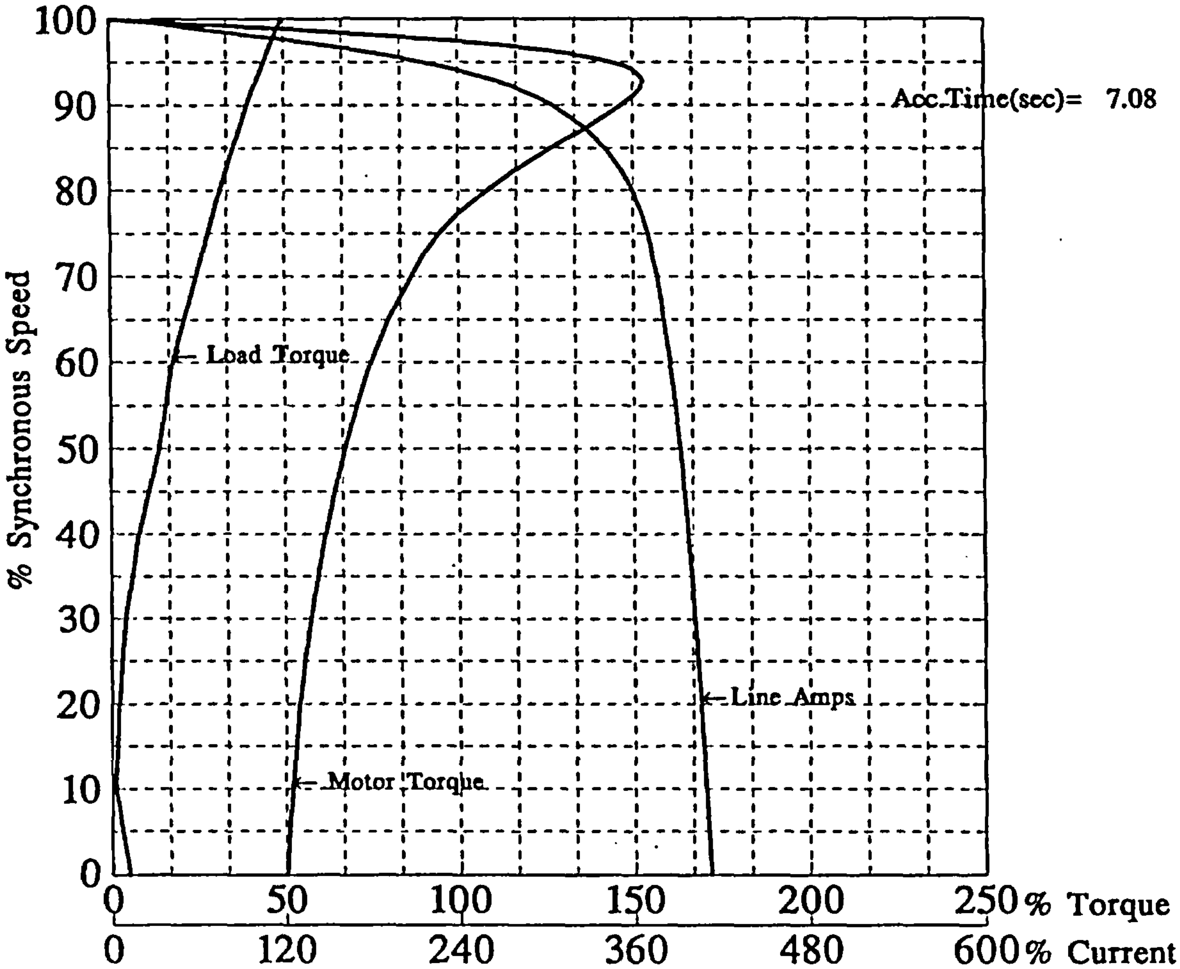
Induction Motor Starting Characteristics

Calculated at 80% Line Voltage

Design.ID ES0166 Customer STONE & WEBSTER
Engineer FANSLOW Application PUMP

Poles 6	Volts 4000	Rpm(fl) 1181	Load Curve ASSUMED
Hp 1600	Fl Amps 197	Rpm(syn) 1200	Lock Amps(%) 412
Pf 0.93	Frame 0	Load Wk^2 5000	Fl Torque(lb-ft) 7115
Phase 3	Hertz 60	Motor Wk^2 2469	Lock Torque(%) 50



TECO-Westinghouse Motor Company Round Rock, Texas

Signature *Mark Fanslow* Curve No. -2

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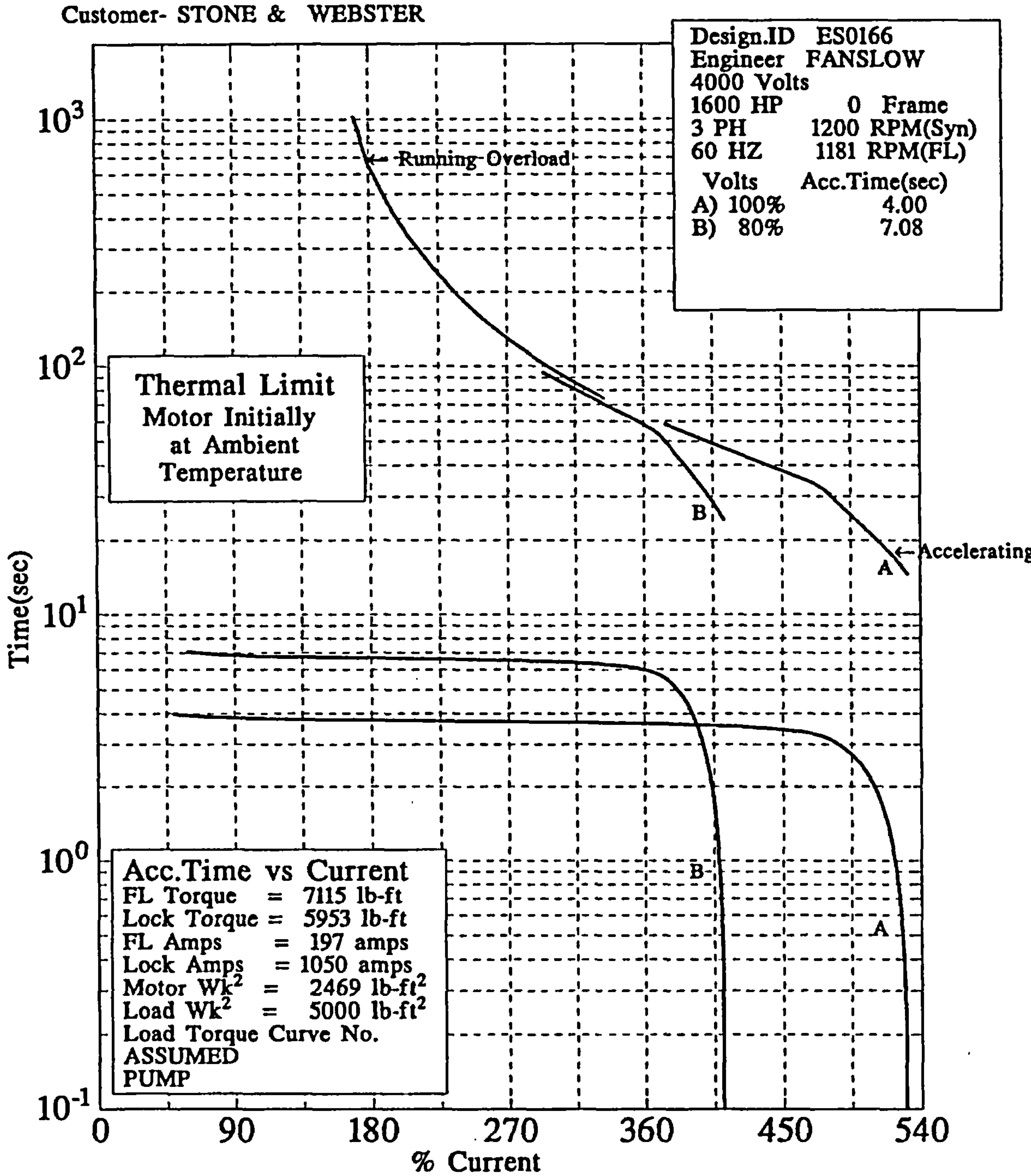
Time vs Current and Thermal Limit Curves

Customer- STONE & WEBSTER



TECO-Westinghouse Motor Company — Round Rock, Texas

Signature *Mark Fanslow* — Curve No. -3

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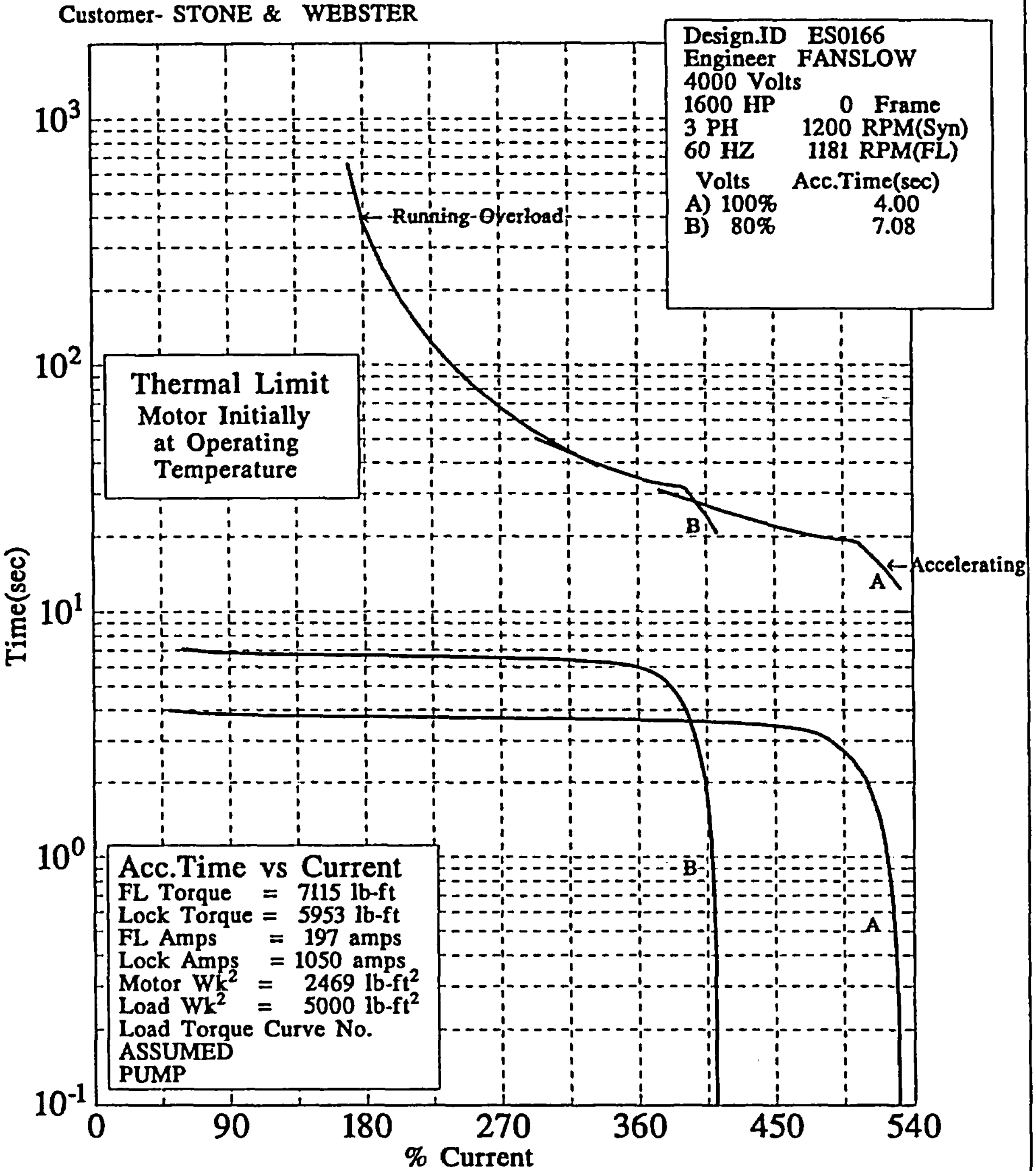
Time vs Current and Thermal Limit Curves

Customer- STONE & WEBSTER



TECO-Westinghouse Motor Company Round Rock, Texas

Signature *Mark Fanslow* Curve No. -4

TECO-Westinghouse

MOTOR COMPANY

Oil Lubrication

WARNING: Motor must be at rest and electrical controls should be locked open to prevent energizing while motor is being serviced.

Use a premium quality turbine oil [see Table 3] which is fully inhibited against oxidation and corrosion.

The for sleeve bearings, the oil should have an ISO cleanliness code [target] of 17/15/12.

Oil is added to a bearing by pouring through the oil fill hole at the top of each bearing housing. Add oil until the oil level reaches the center of the oil sight gauge window. See the motor outline drawing for the approximate quantity of oil required.

Frequent starting and stopping, damp or duty environment, extreme temperature, or any other severe service conditions will warrant more frequent oil changes.

Use Viscosity range noted in Table 1 unless lubrication plate or outline drawing on motor indicates otherwise. See Table 2 for viscosity comparisons.

Table 1: Recommended Oil Type

Ambient Temperature	Speed In RPM	* Oil Viscosity Grade	** Re-lubrication Interval
Below 50°F (10°C)	All Speeds	Considered a severe service condition which may require sump heaters.	
50° to 104°F (10° to 40°C)	3600	ISO 32	5000 Hours or Every 12 months
	1800 or less	ISO 68	Every 12 months
Above 104°F (40°C)	All Speeds	Considered a severe service condition. Consult TECO/ Westinghouse Service	

* Unless noted otherwise on outline drawing or motor lubrication nameplate.

** **WARNING:** Frequent starting and stopping, damp or dirty environment, extreme temperature, or any other severe service conditions, will warrant more frequent oil changes. It is therefore recommended that oil sampling be made every 500 hours.

Table 3: Some Recommended Oils

Oil Manufacturer	ISO VG 32 Viscosity: 130-165 SSU at 100 F		ISO VG 68 Viscosity: 284-347 SSU at 100F	
	MINERAL BASE OIL	SYNTHETIC BASE OIL	MINERAL BASE OIL	SYNTHETIC BASE OIL
Chevron USA. Inc.	GST Turnbine Oil 32	Tegra 32	GST Turbine Oil 68	Tegra 68
Conoco Oil Co.	Hydroclear Turbine Oil 32	Syncon 32	Hydroclear Turbine Oil 68	Syncon 68
Exxon Co., USA	Teresstic 32	Synnestic 32	Teresstic 68	Synnestic 68
Mobil Oil Co.	DTE Oil Light	SHC 624	DTE Oil Heavy Medium	SHC 626
Pennzoil Co., Inc.	Pennzbell TO 32	Pennzbell SHD 32	Pennzbell TO 68	Pennzbell SHD 68
Philips Petroleum Co.	Magnus 32	Syndustrial "E" 32	Magnus 68	Syndustrial "E" 68
Shell Oil Co.	Tellus 32	Tellus HD Oil AW SHF 32	Tellus 68	Tellus HD Oil AW SHF 68
Texaco Lubricants Co.	Regal 32	Cetus PAO 32	Regal 68	Cetus PAO 68

Bearing Temperature: The following is a list of standard temperatures for both mineral-oil-lubricated and synthetic-oil-lubricated bearings.

Mineral-oil-lubricated bearings:

- Expected running temperature: 80° C, 353 Kelvin (176 deg F)
- Alarm temperature: 90° C, 363 Kelvin (194 deg F)
- Shutdown temperature: 100° C, 373 Kelvin (212 deg F)

Synthetic-oil-lubricated bearings:

- Expected Run Temperature: 110° C, 383 Kelvin (230 deg F)
- Alarm Temperature: 120° C, Kelvin (248 deg F)
- Shutdown Temperature: 130° C, Kelvin (266 deg F)

These temperatures apply to grease-lubricated as well as oil-lubricated bearings. In addition, new bearings often require a break-in period of up to 100 hours. During this time, temperatures and noise levels can be slightly elevated. However, these levels should decrease somewhat after this break-in period.

Jerry Avey
Manager Service Engineering

Table 2. Comparative Viscosity Classifications