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Treatment of Diesel Generator (DG) Technical Specification Frequency and Voltage Tolerances

Westinghouse

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Treatment of Diesel Generator (DG) Technical Specification Frequency and Voltage Tolerances

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NOMENCLATURE

LIST OF ACRONYMS AND ABBREVIATIONS

AC	alternating current
AFW	auxiliary feedwater
B&W	Babcock & Wilcox
CDBI	component design basis inspection
CE	Combustion Engineering
CSS	containment spray system
CST	closed torque switch trip
DG	diesel generator
DP	differential pressure
DRU	digital reference unit
ECCS	emergency core cooling system
ESF	engineered safety feature
ESFAS	engineered safety feature actuation system
GL	Generic Letter
HVAC	heating, ventilation and air conditioning
IST	inservice test
JOG	Joint Owners Group
LOOP	loss of offsite power
MCC	motor control center
MOV	motor-operated valve
NEMA	National Electrical Manufacturers Association
NRC	Nuclear Regulatory Commission
NSSS	nuclear steam supply system
PWROG	Pressurized Water Reactor Owners Group
RG	Regulatory Guide
RPS	reactor protection system
SI	safety injection
SP	static pressure
SR	Surveillance Requirements
SRSS	square root sum-of-the-squares
TS	Technical Specification
VFTP	Ventilation Filter Testing Program

LIST OF SYMBOLS

AO	actuator output thrust (lb)
AO_0	actuator output thrust at initial conditions (lb)
AO_1	actuator output thrust at conditions 1 (lb)
CFM_1	fan volumetric flow rate at conditions 1 (ft^3/min)
CFM_2	fan volumetric flow rate at conditions 2 (ft^3/min)
D_1	fan diameter at conditions 1 (inch)

NOMENCLATURE (cont.)

LIST OF SYMBOLS (cont.)

D_2	fan diameter at conditions 2 (inch)
E	energy (ft-lb)
f_{Nom}	nominal supply frequency (60 Hz)
f_1	baseline frequency (60 Hz)
f_2	postulated frequency (Hz)
f	frequency (Hz)
F_e	force component of work done when the valve closes (lb)
g	gravitational constant, ft/sec^2
HP_1	fan power consumed at blade for conditions 1 (hp)
HP_2	fan power consumed at blade for conditions 2 (hp)
M	margin (dimensionless fraction)
M_0	margin at initial conditions (dimensionless fraction)
M_1	margin at condition 1 (dimensionless fraction)
N	rotational speed (rpm)
N_1	fan rotational speed at conditions 1 (ft^3/min)
N_2	fan rotational speed at conditions 2 (ft^3/min)
P	number of poles
P_D	pump discharge pressure, psig
P_S	pump suction pressure, psig
Q	pump flow rate, gpm
RT	required thrust (lb)
RT_0	required thrust at initial conditions (lb)
RT_1	required thrust at conditions 1 (lb)
SP_1	fan static pressure for conditions 1 (inch H_2O)
SP_2	fan static pressure for conditions 2 (inch H_2O)
S_{Nom}	nominal operating speed of motor at nominal frequency and voltage (rpm)
S_{Synch}	synchronous speed of motor (rpm)
S_{Synch1}	synchronous speed at condition 1 (rpm)
S_{Synch2}	synchronous speed at condition 2 (rpm)
S_1	speed at condition 1 (rpm)
S_2	speed at condition 2 (rpm)
T_1	torque at condition 1 (ft-lb)
T_2	torque at condition 2 (ft-lb)
T_{2-1}	torque at condition 2 and speed S_1 (ft-lb)
TDH	total developed head (ft)
U	uncertainty in thrust (dimensionless fraction)
U_f	uncertainty in frequency, Hz
U_{Gov}	uncertainty in governor frequency control, Hz
$U_{Gov\text{-}Setting}$	uncertainty in governor frequency setting, Hz
U_Q	uncertainty in flow measurement (gpm)
U_{Reg}	uncertainty in regulator voltage control (V)
$U_{Reg\text{-}Setting}$	uncertainty in regulator voltage setting (V)

NOMENCLATURE (cont.)

LIST OF SYMBOLS (cont.)

U_S	uncertainty in pump speed associated with uncertainties in frequency and voltage (rpm)
U_V	uncertainty in voltage (V)
$U_{\Delta H}$	uncertainty in pump developed head measurement (ft)
$U_{\Delta H\text{-}Q}$	uncertainty in pump developed head due to flow uncertainty (ft)
$U_{\Delta H\text{-}S}$	uncertainty in pump head due to uncertainty in speed (ft)
$U_{\Delta H,\ Total}$	total uncertainty in pump head (ft)
V_D	pump discharge velocity (ft/sec)
V_{Nom}	nominal supply voltage (V)
V_S	pump suction velocity (ft/sec)
V_1	baseline voltage (V)
V_2	postulated voltage (V)
WK^2	equivalent inertia of the rotating elements (lb-ft^2)
$WK^2\ _{motor}$	equivalent inertia of the motor (lb-ft^2)
$WK^2\ _{reducer}$	equivalent inertia of the reducer (lb-ft^2)
$WK^2\ _{stem\text{-}disc}$	equivalent inertia of the stem-disc (lb-ft^2)
Z_D	pump discharge pressure sensor elevation (ft)
Z_S	pump suction pressure sensor elevation (ft)
$\frac{d(\Delta H)}{dQ}$	rate of change of pump developed head with flow (ft/gpm)
δ	displacement component of the work done (ft)
ΔE	change in energy (ft-lb)
Δf	change in frequency (Hz)
ΔH	change in head (ft)
ΔS	change in speed (rpm)
$\Delta\delta$	change in displacement (ft)
$\Delta\omega$	change in rotational speed (rpm)
ρ	fluid density (lb/ft^3)
ρ_1	fan air density for conditions 1 (lb/ft^3)
ρ_2	fan air density for conditions 2 (lb/ft^3)
ω	rotational speed (rpm)

EXECUTIVE SUMMARY

The objective of this report is to determine the impact of diesel generator steady-state frequency and voltage variation on essential motor loads such as emergency core cooling system (ECCS) pumps, motor-operated valves (MOVs), and fans/blowers. The impact of the diesel generator steady-state frequency and voltage variation on motor-driven parameters such as pump flow rate and MOV actuation speed can be compared to the required performance values that these components are verified to meet on a periodic basis. In the case of ECCS pump performance, the effect of diesel generator steady-state frequency and voltage variation can be combined with other uncertainties to revise the pump inservice test (IST) curves to account for those variables. The impact of diesel generator steady-state frequency and voltage variation on diesel generator loading and fuel oil consumption calculations and the impact on performance of MOVs and fans/blowers have also been determined for plant-specific evaluations. Example NUREG-1431 Technical Specification and Bases markups have been provided as Appendix A to this document.

1 INTRODUCTION

1.1 BACKGROUND

Plant safety analyses make specific assumptions regarding the emergency core cooling system (ECCS) flow to provide the core cooling function following any event that requires safety injection (SI) to mitigate the event. For the events that assume offsite power is lost, the diesel generators (DGs) provide power to the ECCS pumps. Following a loss of offsite power (LOOP), the DG starts and is tied to an engineered safety feature (ESF) electrical bus and essential loads, including the ECCS pumps, which are sequentially connected to the ESF bus by a load sequencer. The calculated ECCS flows typically assume that the steady-state DG frequency is 60 Hz and voltage is 4160V after the DG starting and loading transients. NOTE: Plant-specific motor voltages may differ from 4160V. However, this report will make reference to the 4160V value since the exact value does not impact the calculation methods presented in this report.

After the DG starting and loading sequences, the DG governor maintains the frequency at 60 Hz within a specified tolerance, which is based on the governor manufacturer/model. The DG voltage is controlled by the voltage regulator at 4160V within a specified tolerance, which is based on the voltage regulator manufacturer/model.

The ECCS flow provided by the ECCS pumps is determined by the pump speed, which in turn is a function of the DG frequency and voltage. Historically, the DG frequency and voltage tolerances associated with the governor and voltage regulator are not considered in the development of the ECCS, containment spray system (CSS), and auxiliary feedwater (AFW) flows. The primary effect of reduced frequency and voltage on the ECCS safety functions is to decrease the speed of safety-related motors that are powered by the DG, which affects, for example, pump performance, motor-operated valve (MOV) stroke times, and cooling fan performance.

The Technical Specifications (TS) contain Surveillance Requirements (SR) that place limits on the diesel generator frequency and voltage range. For example, SR 3.8.1.2 in NUREGs-1430, -1431, and -1432 (References 1, 2, and 3) states:

> "Verify each DG starts from standby conditions and achieves steady state voltage ≥ [3740] V and ≤ [4580] V, and frequency ≥ [58.8] Hz and ≤ [61.2] Hz."

The minimum and maximum frequency values of 58.8 Hz and 61.2 Hz and voltage values of 3740V and 4580V typically contained in plant-specific Technical Specification Surveillance Requirements are equal to ±2% of the 60 Hz nominal frequency and ±10% of the 4160 V nominal voltage (i.e., the plant specific transient range specified in the Technical Specifications). However, the ±2% frequency tolerance and ±10% voltage tolerance is only applicable to DG starting and loading transients, and does not apply to steady-state operation as discussed in Regulatory Guide 1.9, Rev. 3 (Reference 4). Steady-state DG operation at the extremes of the frequency and voltage limits would have a broad impact on system design bases, including, for example:

- ECCS performance
- DG loading calculations

- DG fuel oil consumption calculations
- Motor-operated valve performance
- Heating, ventilation and air conditioning (HVAC) fan/blower performance

Since the wording of the Technical Specification Surveillance Requirements would allow steady-state DG operation within those limits, the U.S. Nuclear Regulatory Commission (NRC) has raised the issue during several Component Design Basis Inspections (CDBIs) as to whether the impacts of the allowable tolerances in DG frequency and voltage have been evaluated with respect to ECCS performance. Individual plants have taken different approaches in responding to the NRC. The approaches to address this issue have included the following:

1. Revise the technical specifications to reduce the allowable DG frequency and voltage tolerance;

2. Revise the safety analyses based on ECCS flow rates that include the impact of the Technical Specification DG frequency and voltage tolerances; and

3. Revise the IST pump acceptance criteria to account for allowable Technical Specification DG tolerances in frequency and voltage.

1.2 ISSUE

This issue stems from a discrepancy between the requirements in Regulatory Guide (RG) 1.9 (Reference 4) and the wording of the plant-specific Technical Specification Surveillance Requirements.

Section 1.4 (Design Considerations) of Reference 4 states, in part, the following:

> "Frequency should be restored to within 2 percent of nominal in less than 60 percent of each load-sequence interval for step load increase and in less than 80 percent of each load-sequence interval for disconnection of the single largest load, and voltage should be restored to within 10 percent of nominal within 60 percent of each load-sequence time interval."

Section 2 (Diesel Generator Testing) of Reference 4 describes DG testing. With regard to DG voltage and frequency during testing, the RG states:

> "Verify that the emergency diesel generator reaches required voltage and frequency within acceptable limits and time as defined in the plant technical specifications."

It is important to note that the ±2% criterion on frequency and the ±10% criterion on voltage are starting and accelerating design criteria for the DG and are not specified in Section 2 of Reference 4. The frequency and voltage criteria are specified in the context of the capability of the DG to recover from a transient such as DG load sequencing.

To be consistent with the safety analyses and DG steady-state loading calculations, the ±2% criterion on frequency and the ±10% criterion on voltage should not have been incorporated into the Technical Specifications as steady-state operating criteria. In these analyses and calculations, the motors were assumed to be operating at nominal frequency and voltage; therefore, operating the DG at the extremes of frequency and voltage could have a significant impact on the safety analyses.

An example of a typical diesel generator loading sequence showing initial transient variation during loading followed by steady-state DG operation with minimal variation from nominal frequency is shown in Figure 1-1.

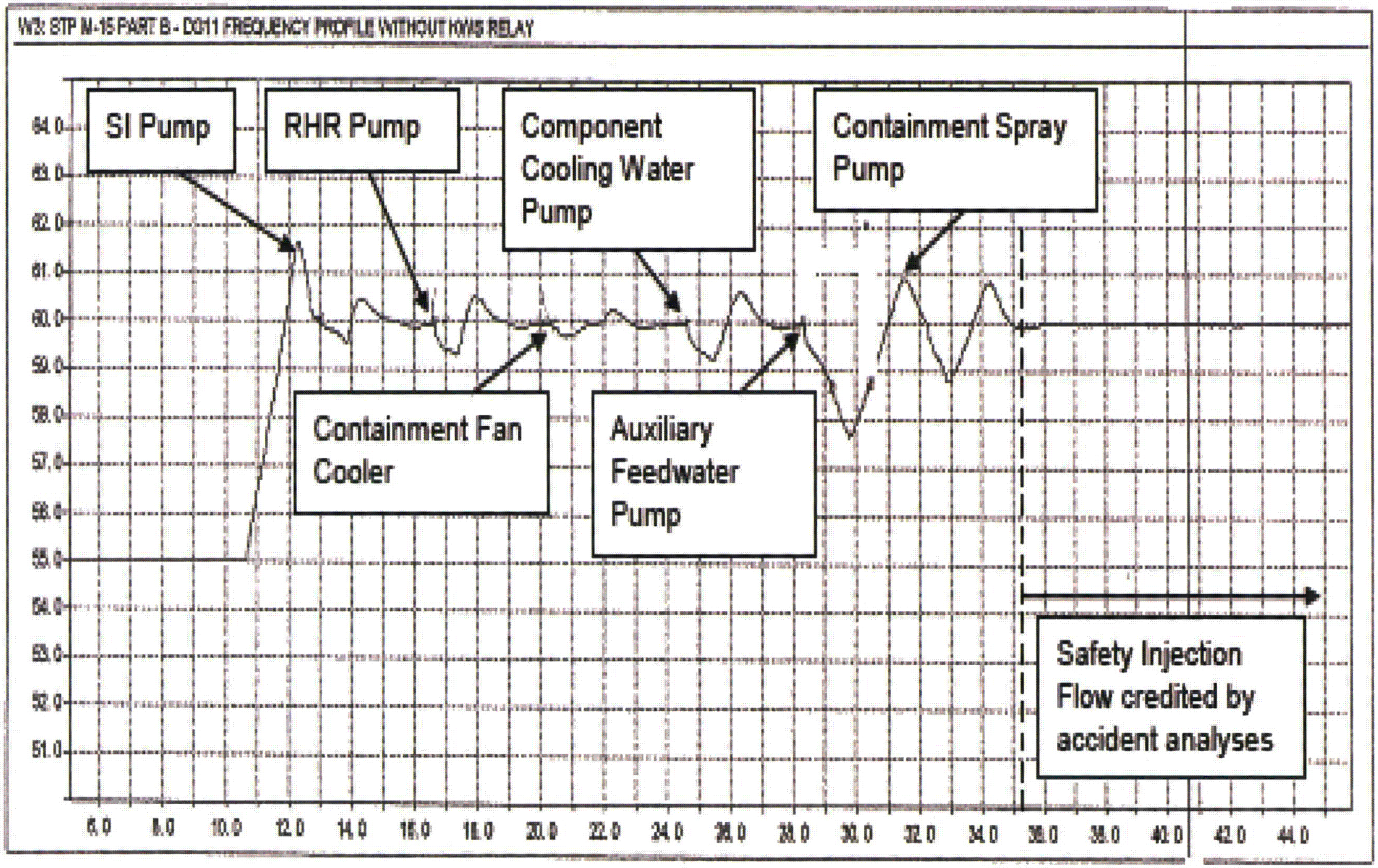


Figure 1-1 Example Diesel Generator Start Test – Frequency Response

1.3 APPROACH

Some licensees have addressed the issue of DG frequency and voltage variation in their safety analyses by assuming that the motors are operating at the extremes of transient frequency and voltage limits, and calculating the impacts on pump flows, developed head, DG steady-state loading, and resulting core response. Unfortunately, this uses significant analytical margin, e.g., peak clad temperatures and DG margins, and the safety analyses may not have sufficient margin to accommodate the adjustment. Therefore, the TS DG steady-state operating limits have to be reduced.

Rather than assuming that the DG is operating at the extremes of the frequency and voltage limits after loading, i.e., treating the transient limits as a bias, the current approach assumes that the DG is set up to control to a nominal 60 Hz and the correct nominal voltage for the design (4160V). By making this assumption, the issue becomes how to account for the ability of the DG control system to control around the design values.

A properly operating governor and voltage regulator will be able to control around a nominal value within the manufacturer's specified tolerances. This capability is validated when a DG is synchronized to the grid, as synchronization requires precise control. If the tolerance on the governor and voltage regulator is treated as an uncertainty, similar to an instrument setpoint, an uncertainty calculation can be performed, which considers the manufacturer's specified tolerance, instrument uncertainties, and setpoint tolerances. The results of this statistical uncertainty calculation for governor and voltage regulator performance can then be translated into an impact on pump flow and developed head. This impact can then be factored into the IST acceptance criteria for the affected pumps.

Since reperforming the plant safety analyses based on the more conservative ECCS flow rates results in reduced analytical margin, there is an impetus to develop a generic approach that can be consistently implemented. In order to develop this approach, a Pressurized Water Reactor Owners Group (PWROG) Systems and Equipment Engineering DG Core Team was established. The DG Core Team met with members of the PWROG Licensing subcommittee on October 13, 2009. The joint team decided that a project authorization should be developed that reflects the following items:

1. The Technical Specifications and Bases need to be revised to clarify that the ±2% frequency and ±10% voltage tolerances are for DG loading transients, in accordance with RG 1.9 (Reference 4) and not steady-state operation.

2. The development of a generic methodology that addresses DG frequency and voltage tolerances, as well as test measurement uncertainties, will be adopted in the pump IST program, so that the ECCS flows and safety analyses will not be impacted. The DG frequency and voltage tolerances will be treated as uncertainties and statistically combined with the test measurement instrument uncertainties and setpoint tolerances. The tolerances will be based on the DG frequency and voltage tolerances specified by the governor and voltage regulator manufacturer and as confirmed by surveillance test results, not the tolerances currently specified in the Technical Specifications. This approach of considering the DG frequency and voltage tolerances as random uncertainties, as opposed to biases, will support the assumption made in the derivation of the ECCS flows for all nuclear steam supply system (NSSS) plants that the pumps are operating at or near nominal frequency and voltage, support the DG fuel oil consumption calculations, and is similar to the

treatment of reactor protection system (RPS) and engineered safety feature actuation system (ESFAS) setpoints.

Some older DG system designs do not have an automatic controller with a preset setting for frequency and/or voltage. These DGs rely on the operator to verify or restore the DG frequency and/or voltage to nominal (i.e., 60 Hz and 4160VAC via motor-operated potentiometers and digital reference units (DRUs)) at the conclusion of DG surveillance. This can be considered a setpoint or "setting" tolerance uncertainty. This "setting" uncertainty would primarily need to account for the DG frequency and/or voltage indication loop uncertainties, since the operator relies on the control board indicators to ensure that the DG governor and voltage regulator settings are at a nominal value in standby conditions. This can be considered $U_{Setting}$ in the methodology defined in Section 2.

2 METHOD FOR DEVELOPING IST CURVES

2.1 INTRODUCTION

This section documents the methodology for developing IST pump curves that account for uncertainties in diesel generator frequency and voltage. The total pump head uncertainty is calculated at discrete flow rates as a function of the combined uncertainties for frequency, voltage, and various other measurements including flow and pressure. Therefore, flow variability due to measurement uncertainties and the effects of frequency and voltage on pump speed are statistically factored into the pump head uncertainty. This method is presented in a step-by-step procedure format and a worked example is also included. The worked example incorporates representative values for uncertainties. It is noted that the worked example only deals with underfrequency and undervoltage. Similar calculations would have to be performed for overfrequency and overvoltage.

2.2 METHODOLOGY

2.2.1 Define Flow Measurement Uncertainty, U_Q

The flow measurement loop will consist of a primary flow element, a sensor(s), and an instrument loop. Each utility has a method for defining the overall uncertainty for the measurement loop used in the test. In general, the flow measurement uncertainty is a function of the flow rate and different uncertainty values will be applied at different points on the pump curve.

2.2.2 Define Pump Developed Head Measurement Uncertainty, $U_{\Delta H}$

The pump developed head is the difference in static pressure head, velocity head, and elevation head across the pump (Equation 1). Therefore, the uncertainty in ΔH will be the combined uncertainty in the measurement of these values. Each utility has a method for defining the overall uncertainty in pump ΔH. In general, this measurement uncertainty is a function of the flow rate and different values will be applied at different points on the pump curve.

$$\Delta H = \frac{144}{\rho}(P_D - P_S) + \frac{V_D^2 - V_S^2}{2g} + (Z_D - Z_S) \qquad \textbf{Equation 1}$$

where,

ρ = fluid density, lb/ft^3
g = gravitational acceleration, ft/sec^2
P_D = pump discharge pressure, psig
P_S = pump suction pressure, psig
V_D = pump discharge velocity, ft/sec
V_S = pump suction velocity, ft/sec
Z_D = pump discharge pressure sensor elevation, ft
Z_S = pump suction pressure sensor elevation, ft

2.2.3 Define Uncertainty in Diesel Generator Frequency, U_f

The DG governor is designed to control output frequency within a specified range about a setpoint. This range is the manufacturer's stated random frequency variation, or tolerance, which is defined herein as the manufacturer's governor uncertainty, U_{Gov}.

In the United States, the setpoint corresponding to standard line frequency is 60 Hz. An additional uncertainty can be defined for the setpoint tolerance, $U_{Gov\text{-}Setting}$. The setpoint should be periodically checked and adjusted as required so that operation at 60 Hz can be expected at the mission time.

The uncertainty in diesel generator frequency is considered a random and independent variability and it may be included as an uncertainty in square-root-sum-of-the-squares (SRSS) combination with the test uncertainties. Therefore, it can be concluded that the uncertainty in performance due to the variable frequency is:

$$U_f = \sqrt{(U_{Gov})^2 + (U_{Gov-Setting})^2} \qquad \textbf{Equation 2}$$

where,

U_f	=	uncertainty in frequency, Hz
U_{Gov}	=	uncertainty in governor frequency control, Hz
$U_{Gov\text{-}Setting}$	=	uncertainty in governor frequency setting, Hz

If the governor manufacturer's specified tolerance is not available, a tolerance that is established by the utility may be used. If a tolerance is determined by the utility, that tolerance should be validated during DG testing and the frequency should periodically be confirmed to be within that tolerance, as described above. Should the DG frequency be found to be out of tolerance, the governor settings must be adjusted to restore the frequency to within the specified tolerance around the nominal frequency value since this tolerance is included in Equation 2.

2.2.4 Define Uncertainty in Diesel Generator Voltage, U_V

The DG voltage regulator is designed to regulate voltage within a specified range about a setpoint. This range is the manufacturer's tolerance, which is defined herein as regulator uncertainty, U_{Reg}. The uncertainty value associated with stability of the regulator setpoint is defined as $U_{Reg\text{-}Setting}$ and must include the random uncertainty associated with the monthly testing and validation of the setpoint.

The uncertainty in diesel generator voltage is considered a random and independent variability and it may be included as an uncertainty in SRSS combination with the test uncertainties. Therefore, it can be concluded that the uncertainty in performance due to the regulator voltage is:

$$U_V = \sqrt{(U_{Reg})^2 + (U_{Reg-Setting})^2} \qquad \textbf{Equation 3}$$

where,

U_V = uncertainty in voltage, V
U_{Reg} = uncertainty in regulator voltage control, V
$U_{Reg\text{-}Setting}$ = uncertainty in regulator voltage setting, V

2.2.5 Calculate Uncertainty in Pump ΔH due to Flow Uncertainty, $U_{\Delta H\text{-}Q}$

The pump developed head varies with pump flow rate. Therefore, there is an uncertainty in pump developed head associated with the uncertainty in measured flow rate. The rate of change of pump ΔH with respect to flow is a function of the flow rate. The uncertainty in pump ΔH due to flow measurement uncertainty is calculated in Equation 4. Note that the absolute value of $\frac{d(\Delta H)}{dQ}$ is used in the equation.

$$U_{\Delta H-Q} = \left|\frac{d(\Delta H)}{dQ}\right| U_Q \qquad \textbf{Equation 4}$$

where,

$U_{\Delta H\text{-}Q}$ = uncertainty in pump developed head due to flow uncertainty, ft
U_Q = uncertainty in flow measurement, gpm
$\frac{d(\Delta H)}{dQ}$ = rate of change of pump developed head with flow, ft/gpm

2.2.6 Calculate Uncertainty in Pump Speed due to Diesel Generator Frequency and Voltage Uncertainties, U_S

Subsection 2.5.3, Equation 12, provides a relation between change in pump speed associated with changes in motor frequency and voltage. Equation 12 is modified to associate changes in motor frequency and voltage with the previously calculated frequency and voltage uncertainties.

$$U_S = \left(\left(\frac{V_{Nom}(f_{Nom} + U_f)}{(V_{Nom} + U_V)f_{Nom}}\right)^2 - 1\right)(S_{Synch} - S_{Nom}) + \left(\frac{f_{Nom} + U_f}{f_{Nom}} - 1\right)S_{Nom} \qquad \textbf{Equation 5}$$

where,

U_S = uncertainty in pump speed associated with uncertainties in frequency and voltage, rpm

f_{Nom} = nominal supply frequency (60 Hz), Hz

S_{Nom} = nominal operating speed of motor at nominal frequency and voltage, rpm. S_{Nom} is determined by the intersection of the nominal motor torque-speed curve with the nominal pump torque-speed curve. It could also be obtained by measurement.

V_{Nom} = nominal supply voltage (4160V), V

S_{Synch} = synchronous speed of motor – speed at zero torque and slip, rpm

Note that, by definition, $U_S \geq 0$ since $U_f \geq 0$ and $U_V \geq 0$.

2.2.7 Determine Uncertainty in Pump Head Associated with Uncertainty in Pump Speed, $U_{\Delta H\text{-}S}$

The uncertainty in pump head due to uncertainty in pump speed is calculated in Equation 6. It is noted that this uncertainty is composed of two terms. The first incorporates the direct effect of a change in speed on the pump head. The second incorporates the indirect effect of change in pump head due to the change in pump flow resulting from the change in speed. Both effects are derived from the pump affinity laws. Note that the absolute value of $\frac{d(\Delta H)}{dQ}$ is used in the equation.

$$U_{\Delta H-S} = \Delta H\left[\left(\frac{S_{Nom}+U_S}{S_{Nom}}\right)^2 - 1\right] + \left|\frac{d(\Delta H)}{dQ}\right|\left(\frac{U_S}{S_{Nom}}\right)Q \qquad \textbf{Equation 6}$$

where,

$U_{\Delta H\text{-}S}$ = uncertainty in pump head due to uncertainty in speed, ft
Q = pump flow rate, gpm

2.2.8 Determine Overall Uncertainty in Pump ΔH

The overall uncertainty in pump ΔH is calculated in Equation 7. It is noted that this uncertainty is a function of flow rate and will therefore vary with each point on the pump curve. The individual points on the IST pump curve are adjusted by these amounts.

$$U_{\Delta H,Total} = \sqrt{U_{\Delta H}^2 + U_{\Delta H-Q}^2 + U_{\Delta H-S}^2} \qquad \textbf{Equation 7}$$

where,

$U_{\Delta H}$ = uncertainty in pump developed head measurement, ft
$U_{\Delta H,\,Total}$ = total uncertainty in pump head, ft

In order to facilitate development of the revised pump curve, it is suggested that a table similar to Table 2-1 be created to adjust the minimum and maximum pump curves.

2.3 APPLICATION OF METHODOLOGY TO ADJUST INSERVICE TEST MINIMUM AND MAXIMUM ALLOWABLE PUMP CURVES

The methodology delineated in Section 2.2 is used to adjust the IST minimum and maximum allowable pump performance curves. There are some important factors associated with the adjustments of minimum and maximum pump curves.

1. The magnitude of the adjustment will vary with pump flow rate since the adjustment is a function of Q, ΔH, and $\frac{d(\Delta H)}{dQ}$, all of which vary at different points of the pump curves.

2. It is noted that, by definition, $U_S \geq 0$ since $U_f \geq 0$ and $U_V \geq 0$. This positive value is used to calculate $U_{\Delta H\text{-}S}$ using Equation 6.

3. The minimum allowable pump curve will be increased at each point by the calculated amount $U_{\Delta H,\,Total}$ for that flow point.

4. The maximum allowable pump curve will be decreased at each point by the calculated amount $U_{\Delta H,\,Total}$ for that point.

5. The magnitude of the adjustment will vary between the minimum and maximum pump curves since the adjustment is a function of ΔH and $\frac{d(\Delta H)}{dQ}$, both of which are a function of the pump curves.

Table 2-1 Method for Adjusting IST Curve

Q (gpm)	ΔH (ft)	d(ΔH)/dQ (ft/gpm)	U_Q (gpm)	$U_{\Delta H}$ (ft)	$U_{\Delta H\text{-}Q}$ (ft) (Equation 4)	$U_{\Delta H\text{-}S}$ (ft) (Equation 6)	$U_{\Delta H,Total}$ (ft) (Equation 7)
Q_1	ΔH_1	$[d(\Delta H)/dQ]_1$	$(U_Q)_1$	$(U_{\Delta H})_1$	$(U_{\Delta H\text{-}Q})_1$	$(U_{\Delta H\text{-}S})_1$	$(U_{\Delta H,\,Total})_1$
Q_2	ΔH_2	$[d(\Delta H)/dQ]_2$	$(U_Q)_2$	$(U_{\Delta H})_2$	$(U_{\Delta H\text{-}Q})_2$	$(U_{\Delta H\text{-}S})_2$	$(U_{\Delta H,\,Total})_2$
Q_3	ΔH_3	$[d(\Delta H)/dQ]_3$	$(U_Q)_3$	$(U_{\Delta H})_3$	$(U_{\Delta H\text{-}Q})_3$	$(U_{\Delta H\text{-}S})_3$	$(U_{\Delta H,\,Total})_3$
Q_n	ΔH_n	$[d(\Delta H)/dQ]_n$	$(U_Q)_n$	$(U_{\Delta H})_n$	$(U_{\Delta H\text{-}Q})_n$	$(U_{\Delta H\text{-}S})_n$	$(U_{\Delta H,\,Total})_n$

2.4 WORKED EXAMPLE PROBLEM

The following is a worked example implementing the methodology contained in this report. It is noted that the worked example only deals with underfrequency and undervoltage. Similar calculations would have to be performed for overfrequency and overvoltage. When this methodology is implemented, the following plant-specific inputs are required.

- U_{Gov} = uncertainty in governor frequency control, Hz
- $U_{Gov\text{-}Setting}$ = uncertainty in governor frequency setting, Hz
- U_{Reg} = uncertainty in regulator voltage control, V
- $U_{Reg\text{-}Setting}$ = uncertainty in regulator voltage setting, V

- U_Q = uncertainty in flow measurement, gpm
- $\frac{d(\Delta H)}{dQ}$ = rate of change of pump developed head with flow, ft/gpm
- $U_{\Delta H}$ = uncertainty in pump developed head measurement, ft

2.4.1 Define Flow Measurement Uncertainty, U_Q

Each utility has a method for defining the overall uncertainty in flow rate. This document is not intended to provide guidance on the determination of flow measurement uncertainty. Table 2-2 is based on the assumption that the flow measurement uncertainty is the larger of either 10 gpm or 2% of the flow rate.

2.4.2 Define Pump Developed Head Measurement Uncertainty, $U_{\Delta H}$

Each utility has a method for defining the overall uncertainty in pump ΔH. This document is not intended to provide guidance on the determination of pump ΔH measurement uncertainty. Table 2-2 assumes the uncertainty in ΔH is 34.65 feet (15 psi for water at 68°F).

2.4.3 Define Uncertainty in Diesel Generator Frequency, U_f

The uncertainty is calculated using Equation 2. The governor uncertainty is assumed to be 0.25 Hz. The setpoint tolerance is also 0.25 Hz. Therefore, it can be concluded that the uncertainty in frequency is:

$$U_f \leq \sqrt{(0.25\text{Hz})^2 + (0.25\text{Hz})^2} = 0.354 \text{ Hz}$$

2.4.4 Define Uncertainty in Diesel Generator Voltage, U_V

The uncertainty is calculated using Equation 3. The regulator uncertainty is assumed to be 100V. The setpoint tolerance is also 100V. Therefore, it can be concluded that the uncertainty in voltage is:

$$U_V \leq \sqrt{(100 \text{ V})^2 + (100 \text{ V})^2} = 141.4 \text{ V}$$

2.4.5 Calculate Uncertainty in Pump ΔH due to Flow Uncertainty, $U_{\Delta H\text{-}Q}$

The minimum IST curve and the vendor curve are shown in Figure 2-1. The minimum IST curve can be fit by the equation:

$$\Delta H_{Min} = 3410\text{ft} - \left(0.0353\frac{\text{ft}}{\text{gpm}}\right)Q - \left(.0039\frac{\text{ft}}{\text{gpm}^2}\right)Q^2$$

Taking the first derivative of this equation with respect to flow results in:

$$\frac{d(\Delta H_{Min})}{dQ} = -\left(0.0353\frac{\text{ft}}{\text{gpm}}\right) - \left(.0078\frac{\text{ft}}{\text{gpm}^2}\right)Q$$

A curve fit for ΔH and $\frac{d(\Delta H)}{dQ}$ was used for this example. The values may also be determined graphically.

The uncertainty in pump ΔH due to flow is calculated in Equation 4:

$$U_{\Delta H-Q} = \left| -\left(0.0353\frac{ft}{gpm}\right) - \left(.0078\frac{ft}{gpm^2}\right)Q \right| U_Q$$

The values in Table 2-2 were calculated using the preceding two equations.

2.4.6 Calculate Uncertainty in Pump Speed due to Diesel Generator Frequency and Voltage Uncertainties, U_S

The nominal pump and motor torque-speed curves are shown in Figure 2-2. The synchronous speed of the motor is 3600 rpm and the nominal operating speed of the pump-motor pair is 3530 rpm. The nominal operating point is the point at which the nominal pump and motor torque-speed curves intersect. The uncertainty in pump speed due to uncertainties in pump frequency and voltage is calculated using Equation 5.

$$U_S = \left(\left(\frac{(4160\text{ V})(60\text{ Hz} + 0.354\text{ Hz})}{(4160\text{ V} + 141.4\text{ V})(60\text{ Hz})}\right)^2 - 1\right)(3600\text{ rpm} - 3530\text{ rpm}) + \left(\frac{60\text{ Hz} + 0.354\text{ Hz}}{60\text{ Hz}} - 1\right)3530\text{ rpm}$$

$$U_S = 24.55\text{ rpm}$$

2.4.7 Determine Uncertainty in Pump Head Associated with Uncertainty in Pump Speed, $U_{\Delta H\text{-}S}$

The uncertainty in pump head due to uncertainty in pump speed is calculated by substituting the appropriate values of S_{Nom}, U_S, and $\frac{d(\Delta H)}{dQ}$ into Equation 6.

$$U_{\Delta H-S} = \Delta H\left[\left(\frac{3530\text{ rpm} + 24.55\text{ rpm}}{3530\text{ rpm}}\right)^2 - 1\right] + \left|\left[-\left(0.0353\frac{\text{ft}}{\text{gpm}}\right) - \left(.0078\frac{\text{ft}}{\text{gpm}^2}\right)Q\right]\right|\left(\frac{24.55\text{ rpm}}{3530\text{ rpm}}\right)Q$$

This equation is a function of the pump flow rate and head at each point on the curve.

2.4.8 Determine Overall Uncertainty in Pump ΔH

The overall uncertainty in pump ΔH is calculated in Equation 7. It is noted that this uncertainty is a function of flow rate and will therefore vary with each point on the pump curve. The individual points on the IST pump curve are adjusted by these amounts.

$$U_{\Delta H,\text{Total}} = \sqrt{U_{\Delta H}^2 + U_{\Delta H-Q}^2 + U_{\Delta H-S}^2}$$

The results of these calculations are summarized in Table 2-2. Figure 2-3 compares the vendor curve, the minimum pump curve, the minimum pump curve adjusted for instrument (measurement) uncertainties, and the minimum pump curve adjusted for total (measurement plus frequency plus voltage) uncertainties. It is seen that combining the uncertainties associated with frequency and voltage variation with measurement uncertainties contributes to a minor shift toward the vendor curve and away from the minimum pump curve. Therefore, it is concluded that, in many cases, it is reasonable to expect that the overall margin will be minimally impacted by implementation of this methodology.

Table 2-2 Worked Example

Q (gpm)	ΔH (ft)	d(ΔH)/dQ (ft/gpm)	U_Q (gpm)	$U_{\Delta H}$ (ft)	$U_{\Delta H\text{-}Q}$ (ft) (Equation 4)	$U_{\Delta H\text{-}S}$ (ft) (Equation 6)	$U_{\Delta H,\ Total}$ (ft) (Equation 7)	$\Delta H_{revised} = \Delta H + U_{\Delta H,Total}$ (ft)
0	3410	-0.035	10	34.65	0.4	47.6	58.9	3469
50	3398	-0.425	10	34.65	4.3	47.6	59.0	3458
100	3367	-0.815	10	34.65	8.2	47.6	59.4	3427
150	3317	-1.205	10	34.65	12.1	47.6	60.1	3377
200	3247	-1.595	10	34.65	16.0	47.5	61.0	3308
250	3157	-1.985	10	34.65	19.9	47.5	62.1	3220
300	3048	-2.375	10	34.65	23.8	47.5	63.4	3112
350	2920	-2.765	10	34.65	27.7	47.5	65.0	2985
400	2772	-3.155	10	34.65	31.6	47.5	66.7	2839
450	2604	-3.545	10	34.65	35.5	47.5	68.6	2673
500	2417	-3.935	10	34.65	39.4	47.4	70.7	2488
550	2211	-4.325	11	34.65	47.6	47.4	75.6	2286
600	1985	-4.715	12	34.65	56.6	47.4	81.5	2066
650	1739	-5.105	13	34.65	66.4	47.4	88.6	1828

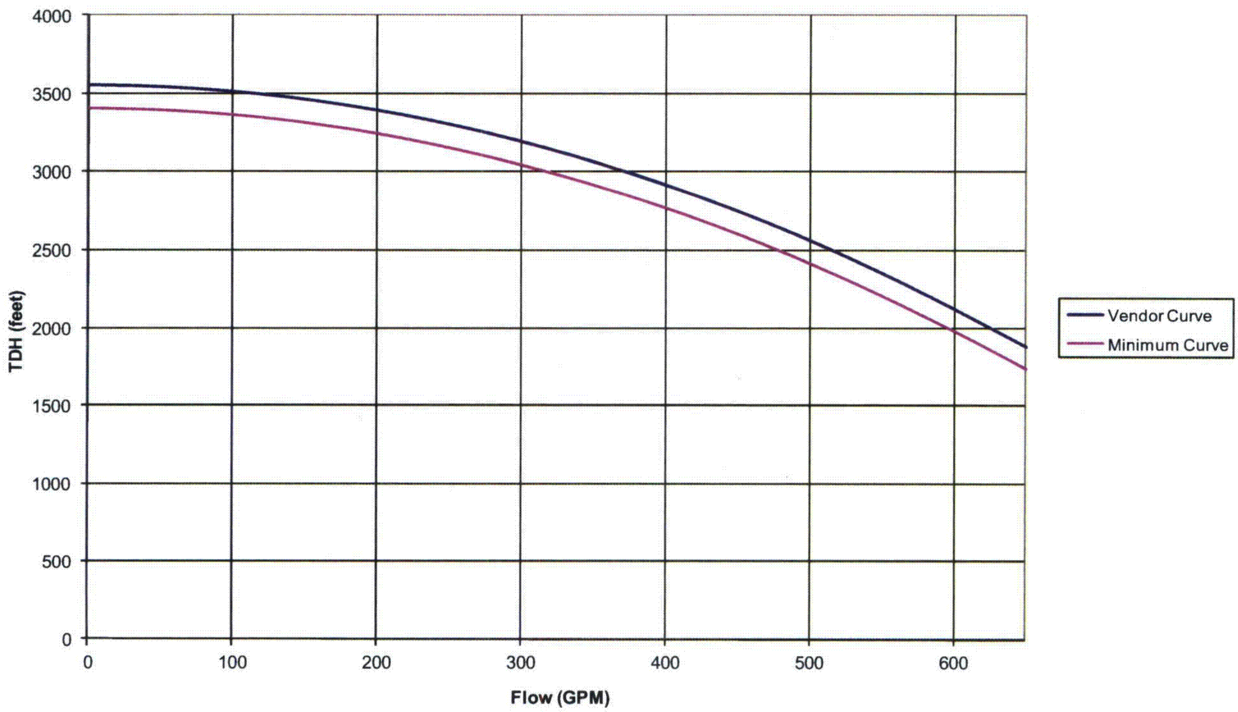


Figure 2-1 Minimum SI Pump Curve

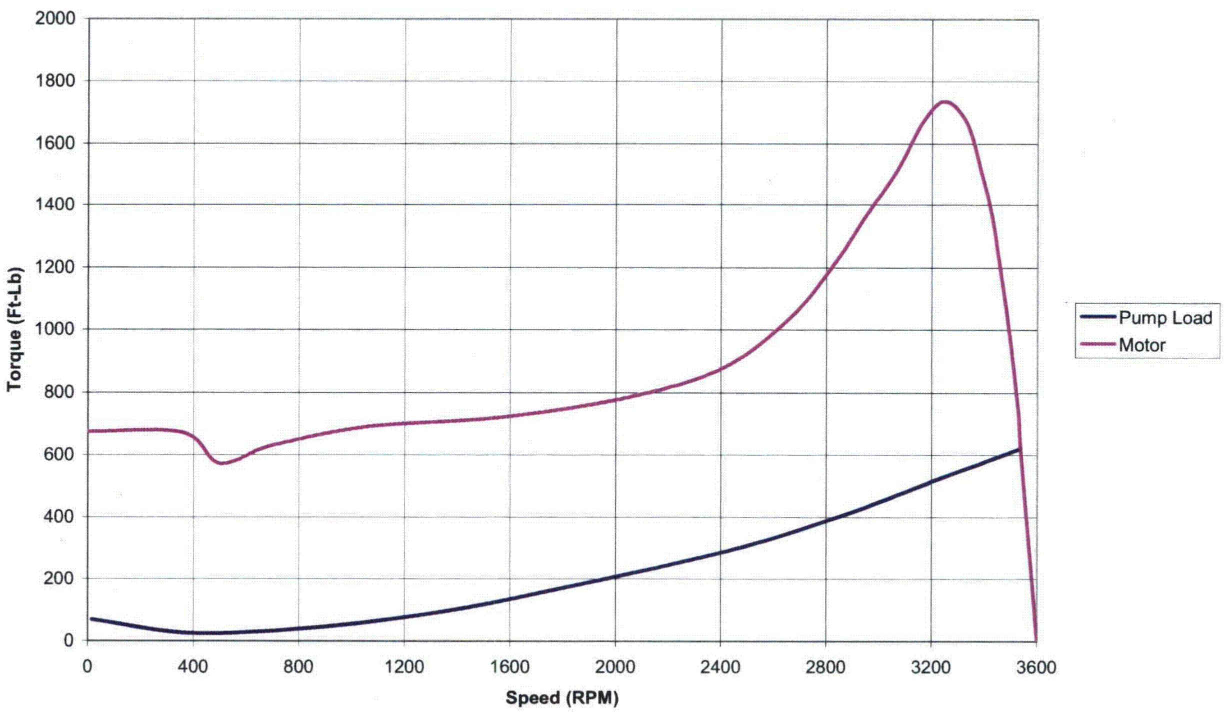


Figure 2-2 Vendor SI Pump and Motor Data

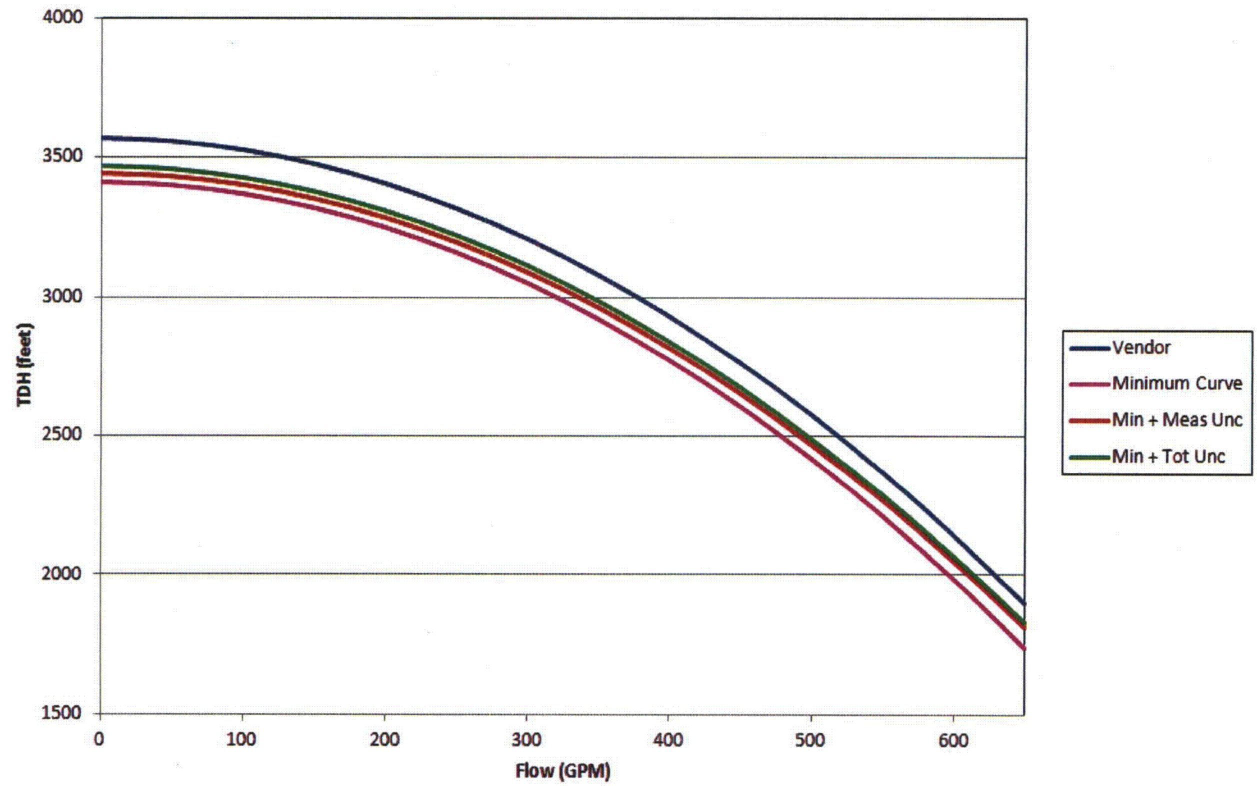


Figure 2-3 Adjusted Minimum SI Pump Curve with Uncertainty

2.5 MOTOR SPEED/TORQUE CURVE NUMERICAL APPROACH

2.5.1 Torque Adjustment due to Voltage

The torque developed by a motor is proportional to the square of the terminal voltage. Thus, motor torque values obtained from the baseline speed/torque curve are adjusted as follows:

$$T_2 = T_1 \cdot \left(\frac{V_2}{V_1}\right)^2 \qquad \textbf{Equation 8}$$

where,

T_1 = torque at voltage V_1 (ft-lb)
T_2 = torque at voltage V_2 (ft-lb)
V_1 = baseline voltage (V)
V_2 = postulated voltage (V)

See Figure 2-4 for an example of the effect of a reduction in voltage.

2.5.2 Torque Adjustment due to Frequency

The torque developed by a motor is inversely proportional to the square of the power supply frequency. Thus, motor torque values obtained from the baseline speed/torque curve are adjusted as follows:

$$T_2 = T_1 \cdot \left(\frac{f_1}{f_2}\right)^2 \quad \textbf{Equation 9}$$

where,

T_1 = torque at frequency f_1 (ft-lb)
T_2 = torque at frequency f_2 (ft-lb)
f_1 = baseline frequency (60 Hz)
f_2 = postulated frequency (Hz)

See Figure 2-5 for an example of the effect of a reduction in frequency.

2.5.3 Motor Speed Adjustment due to Torque, Frequency, and Voltage

The synchronous speed of a motor is proportional to power supply frequency. Steady-state speed is the point at which the speed vs. torque curve of the motor intersects with that of the driven equipment. However, in lieu of plotting speed/torque curves, algorithms can be used to approximate the change in steady-state speed as a result of voltage and frequency variations.

The effect of a motor torque change on steady-state speed can be closely approximated by considering the motor speed vs. torque curve in the area of intersection as a straight line (see Figure 2-4 and Figure 2-5). A change in voltage and frequency alters the slope of the line in this region in accordance with Equation 8 and Equation 9. The relationship between torque and steady-state speed is developed in Figure 2-6.

$$\Delta S = \left(\frac{T_1}{T_{2-1}} - 1\right) \cdot \left(S_{Synch} - S_1\right) \quad \textbf{Equation 10}$$

where,

T_1 = torque at condition 1 (ft-lb)
T_{2-1} = torque at condition 2 and speed S1 (ft-lb)
S_{Synch} = synchronous speed (rpm)
S_1 = speed at condition 1 (rpm)
ΔS = change in speed (rpm)

The effect of a motor synchronous speed change on a steady-state speed can be closely approximated as shown in Figure 2-7.

$$\Delta S = S_1\left(1-\frac{S_{Synch2}}{S_{Synch1}}\right)$$ **Equation 11**

where,

S_1	=	speed at condition 1 (rpm)
S_{Synch1}	=	synchronous speed at condition 1 (rpm)
S_{Synch2}	=	synchronous speed at condition 2 (rpm)
ΔS	=	change in speed (rpm)

The net effect of voltage and frequency variations on steady-state speed can be closely approximated as the sum of the change due to voltage plus the sum of the change due to frequency. Combining Equation 8, Equation 9, Equation 10, and Equation 11, this effect can be expressed as:

$$\Delta S = \left(\left(\frac{V_1 \cdot f_2}{V_2 \cdot f_1}\right)^2 - 1\right)\cdot\left(S_{synch} - S_1\right) + S_1\left(1-\frac{f_2}{f_1}\right)$$ **Equation 12**

where,

f_1	=	rated frequency (60 Hz)
f_2	=	postulated frequency (Hz)
V_1	=	rated voltage (V)
V_2	=	postulated voltage (V)
S_1	=	rated speed (at V1 and f1) (rpm)
ΔS	=	change in speed (rpm)

The resulting speed is $S_1 - \Delta S$.

Starting time is a function of the accelerating torque, which is the difference between motor and driven equipment torque from 0 rpm to the speed at which the motor and driven equipment speed vs. torque curves intersect.

2.6 COMPARISON OF SYNCHRONOUS AND INDUCTION MOTORS

A synchronous machine's speed is proportional to frequency, where its rotational speed is defined by:

$$S_{Synch} = \frac{120f}{P}$$ **Equation 13**

where,

S_{Synch} = synchronous speed, rpm
f = frequency, Hz
P = poles

An induction machine follows a similar rule, except that the rotation lags the synchronous speed by a slip factor. The slip is a value that is usually less than 5% of the synchronous speed.

The "operational region" of the motor speed torque curve can be defined as the approximately linear region from the point of maximum torque to the end of the curve at synchronous speed. The slope of the curve in this region is generally very steep for motors used in pump applications.

If a motor is operated at a different frequency than the nameplate value, this linear section of the curve shifts along the abscissa by a value proportional to the frequency. This is because the end point of the torque curve (at zero torque) ends at the synchronous speed, which is always defined by Equation 13.

As the curve shifts, the new operating speed is determined based on the intersection point with the pump curve.

1. If the torque curve were a straight vertical line in this region, the change is operating speed would be nearly exactly proportional to the change in frequency.

2. The error introduced by this approximation is a function of the slope of the motor torque curve in the operational region. This error approaches zero as the slope of the line approaches $-\infty$.

3. For most pump-motor sets, this curve has a sufficiently steep slope that the error is small.

4. Although the slope also changes slightly as a result of the frequency change, this effect is negligible for small variations (< 5 Hz).

Some motors, such as National Electrical Manufacturers Association (NEMA) Class D type, have torque curve shapes that cause this approximation to be inaccurate. However, most pump applications do not utilize type D motors. Figure 2-8 depicts the different types of motor curves.

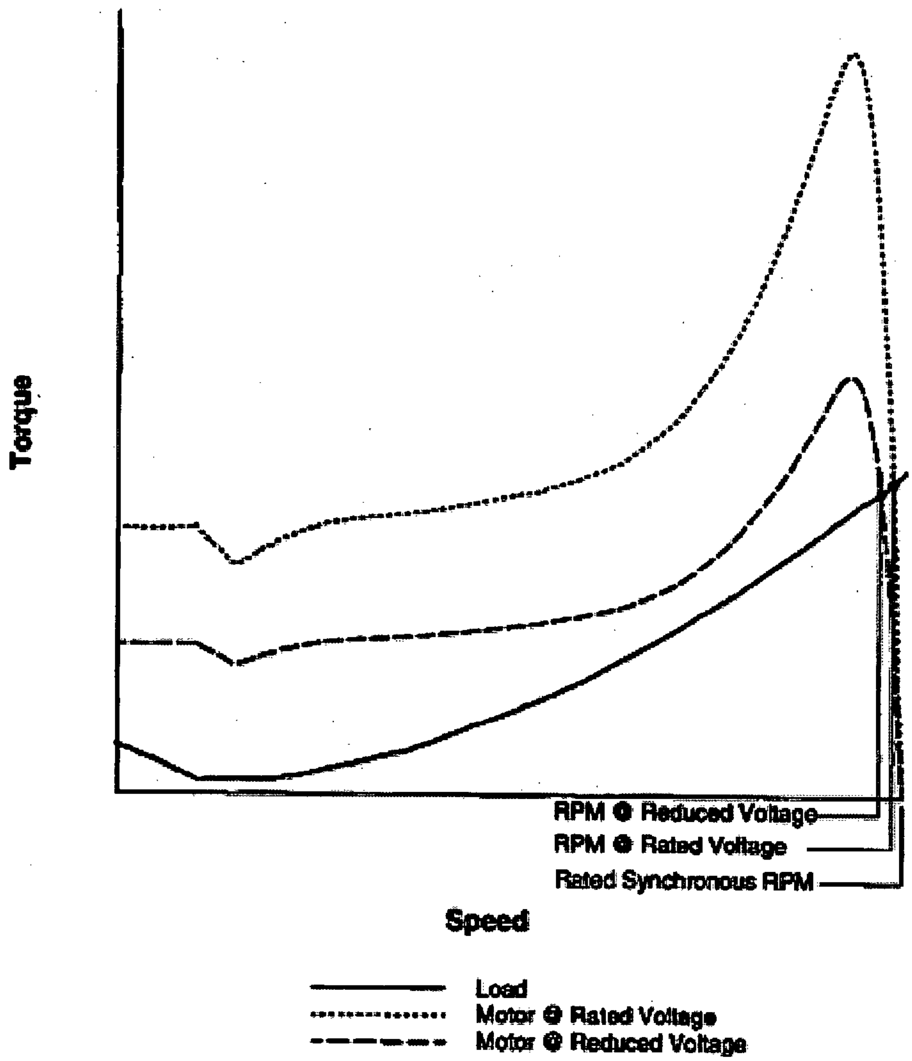


Figure 2-4 Effect of Voltage Variation on Motor Speed

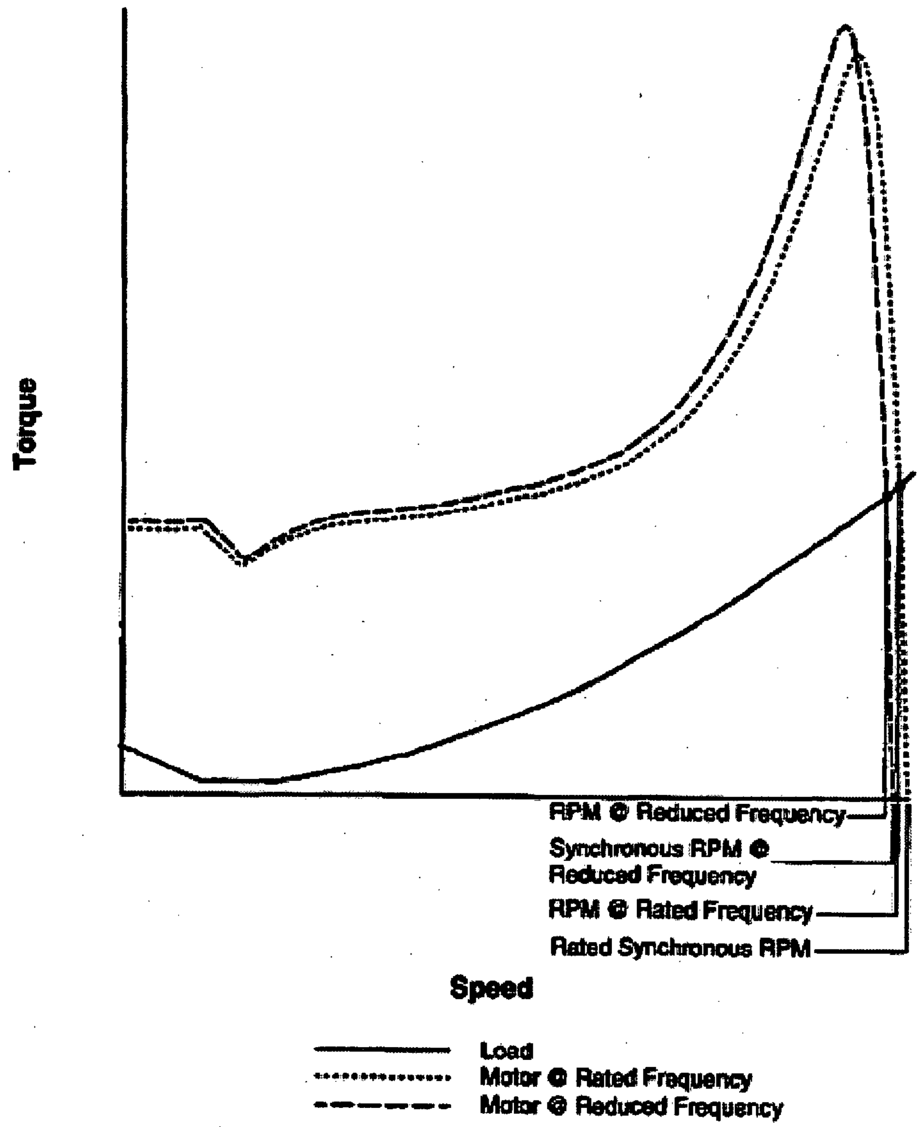
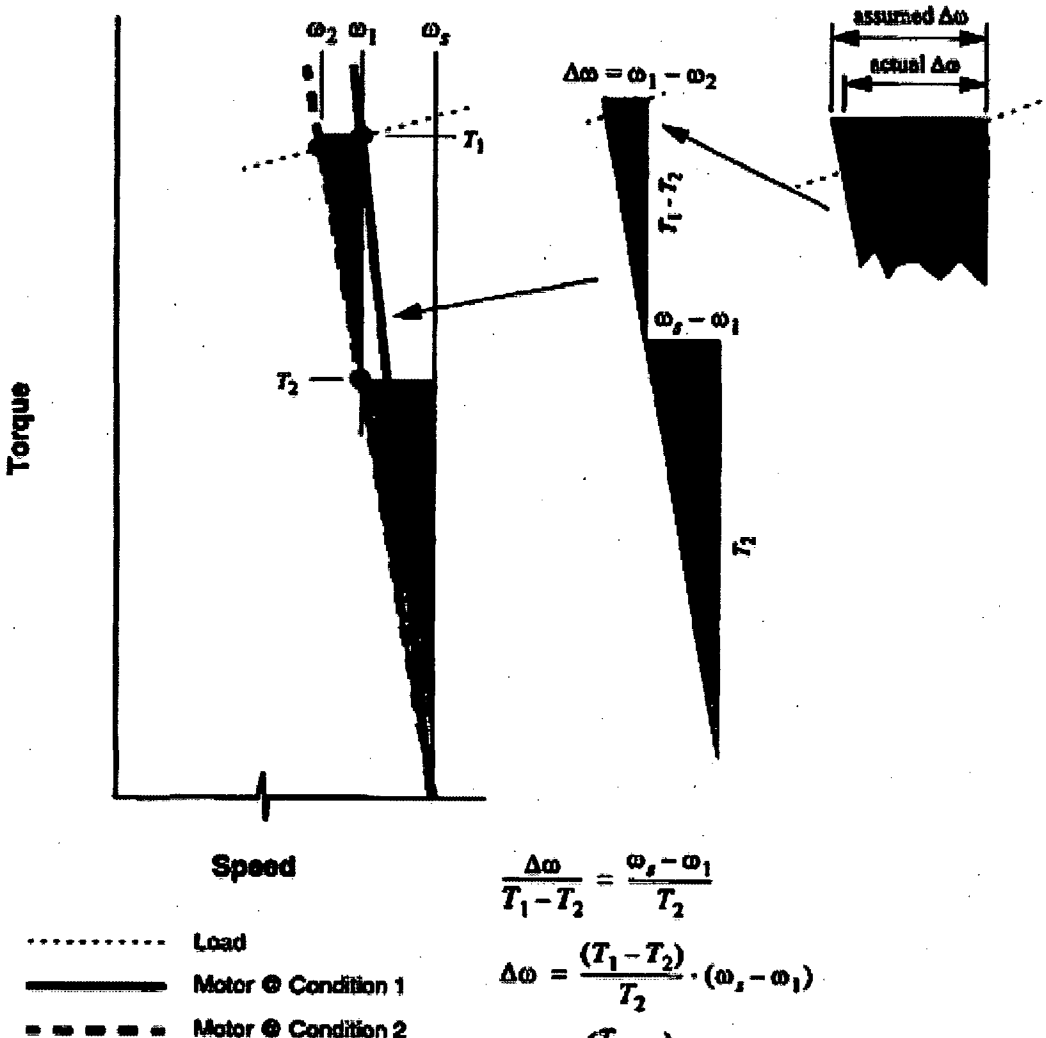


Figure 2-5 Effect of Frequency Variation on Motor Speed



$$\frac{\Delta\omega}{T_1 - T_2} = \frac{\omega_s - \omega_1}{T_2}$$

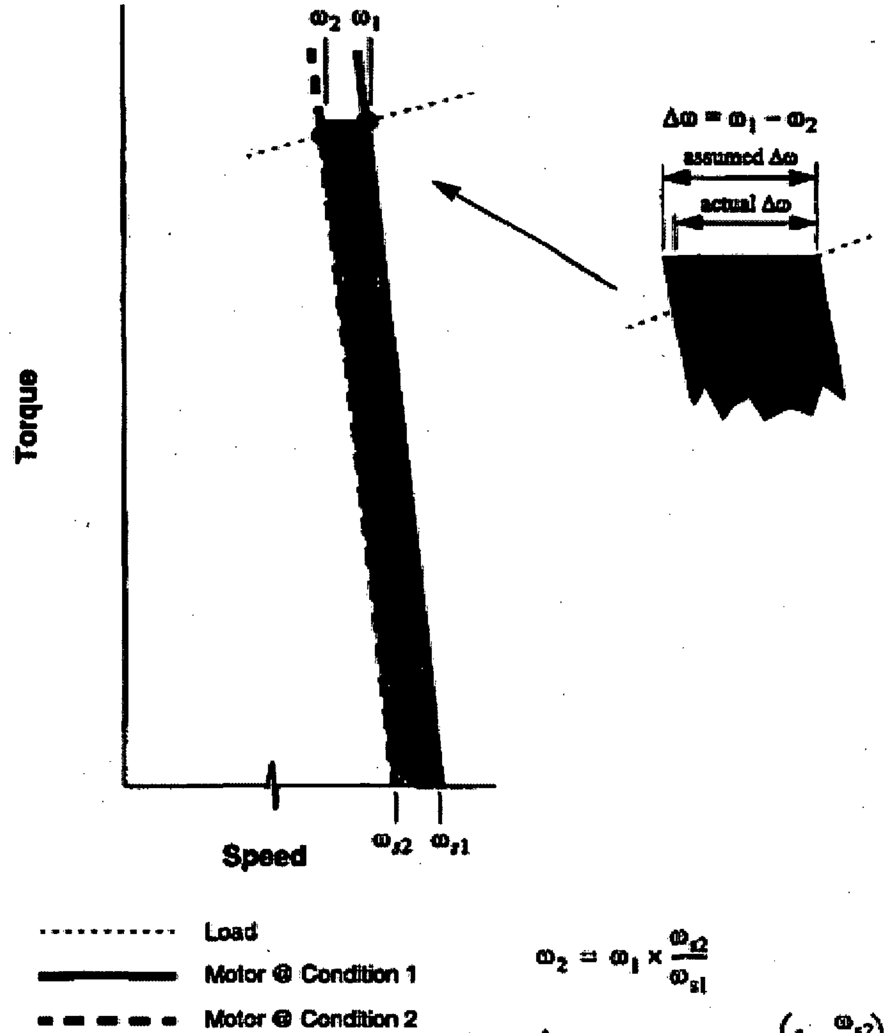
$$\Delta\omega = \frac{(T_1 - T_2)}{T_2} \cdot (\omega_s - \omega_1)$$

$$\Delta\omega = \left(\frac{T_1}{T_2} - 1\right) \cdot (\omega_s - \omega_1) \qquad (4)$$

Where:

T_1 = torque at condition 1 (ft-lb)
T_2 = torque at condition 2 and speed ω_1 (ft-lb)
ω_s = synchronous speed (rpm)
ω_1 = speed at condition 1 (rpm)
$\Delta\omega$ = change in speed (rpm)

Figure 2-6 Effect of Torque Change on Running Speed



$$\omega_2 = \omega_1 \times \frac{\omega_{s2}}{\omega_{s1}}$$

$$\Delta\omega = \omega_1 - \omega_2 = \omega_1\left(1 - \frac{\omega_{s2}}{\omega_{s1}}\right) \qquad (5)$$

Where:

ω_1 = speed at condition 1 (rpm)
ω_2 = speed at condition 2 (rpm)
ω_{s1} = synchronous speed at condition 1 (rpm)
ω_{s2} = synchronous speed at condition 2 (rpm)
$\Delta\omega$ = change in speed (rpm)

Figure 2-7 Effect of Synchronous Speed Change on Running Speed

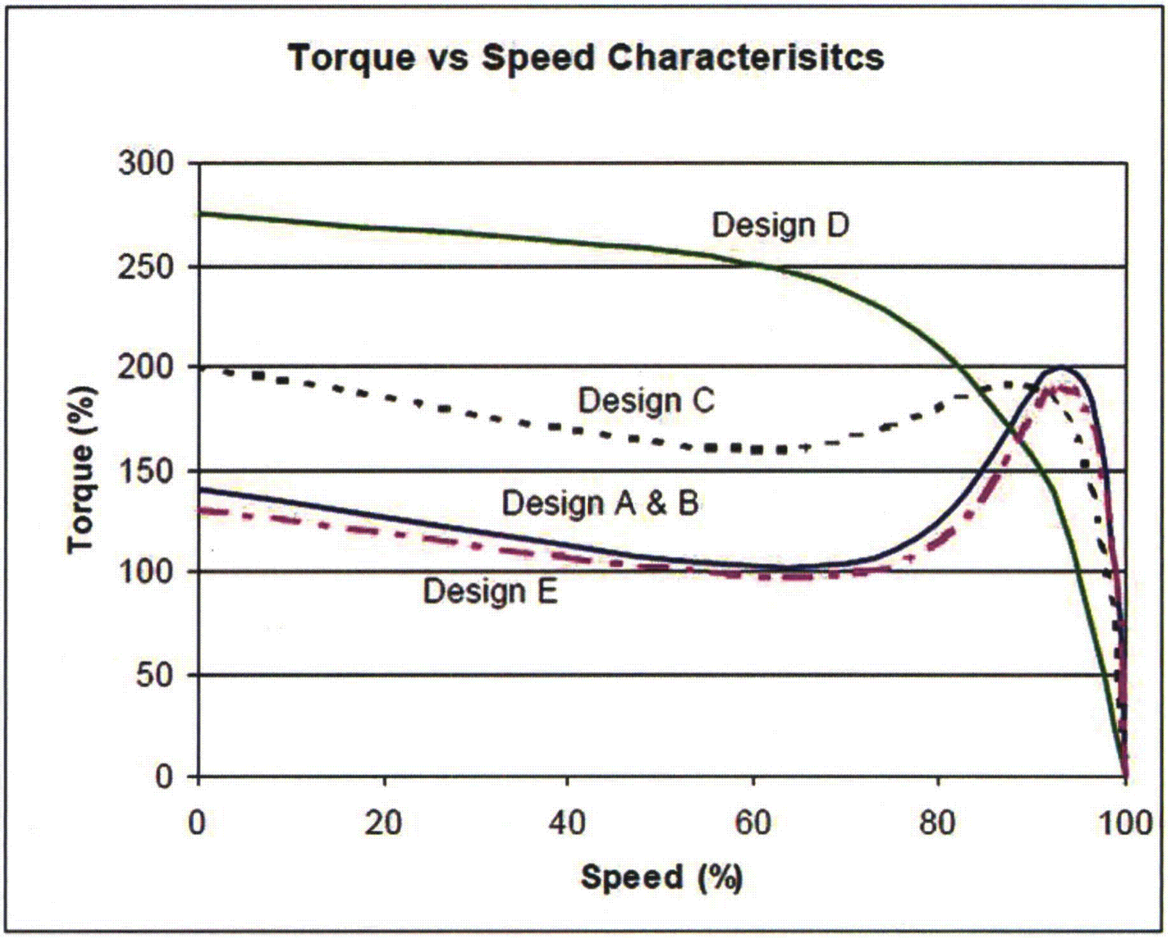


Figure 2-8 Torque-Speed Relations for Various Motors

3 IMPACT ON DIESEL GENERATOR CALCULATIONS

3.1 DIESEL GENERATOR LOADING

The methodology described in previous sections translates the impact of DG frequency and voltage variations to variations in pump developed head and flow. Applying a consistent approach to address the impact of DG frequency and voltage variations on DG loading requires an evaluation of changes in DG loading associated with variations in frequency and voltage allowed by the DG governor and regulator.

3.1.1 Impact of Frequency Variation on Diesel Generator Loading

An underfrequency would not negatively impact diesel generator loading calculations. By applying the upper bound of frequency (> 60 Hz) allowed by the DG governor to the maximum inductive loads calculated for the DG, an additional power load can be calculated for the potential variation in frequency allowed by the DG governor operating range. The example below conservatively assumes the entire DG loading is inductive.

3.1.1.1 Example Calculation of DG Loading Impact

Assumptions:

1. Maximum f = 60.3 Hz
2. DG rating = 2400 kW
3. Maximum DG loading = 2000 kW

The increase in DG inductive power load associated with the increase in frequency is obtained by cubing the ratio of maximum frequency divided by nominal frequency. That is, $(60.3 \text{ Hz}/60 \text{ Hz})^3 = 1.015$. Therefore, the revised loading is 1.015 x 2000 kW = 2030 kW. The change in loading is 2030 kW - 2000 kW = 30 kW.

The additional 30 kW load would be added to the load calculations to account for maximum DG frequency. The extra loading would need to be evaluated for each DG loading calculation to ensure that the calculated loads do not exceed the DG rating.

3.1.2 Impact of Voltage Variation on Diesel Generator Loading

The voltage variation of the DG voltage regulator at steady-state operation should be confirmed to be within the allowable operating voltage range for the motors powered by the DG. The effect of voltage variation from the nominal voltage rating of the DG would cause the current of the motor load circuits to decrease or increase accordingly. There would be no net change in the power required by and delivered to the loads from the DG.

3.2 DIESEL GENERATOR FUEL CONSUMPTION CALCULATIONS

A calculated change in diesel generator loading due to steady-state variation in frequency will also require a commensurate evaluation of the impact on fuel oil consumption as a result of the change in loading.

4 IMPACT ON MOV OPERATION

The impact of frequency and voltage variation on motor-operated valves (MOVs) would be similar to the impact on other inductive motors such as pump motors. A higher than nominal frequency would increase the speed of the motor while a lower frequency would slow the motor speed. All rotating machinery powered by the DG output would be affected by a change in frequency in a similar manner (but specific to each motor).

Since the MOVs are powered by the 480V system, the DG bus frequency translates directly through the step-down transformer; if 59 Hz power is provided in the primary (high voltage) side of the transformer, 59 Hz power at the secondary side (low voltage) transformer terminals will result. It can be noted that a change in frequency affects the reactance of a transformer and, as a result, the output voltage on the secondary side is affected as well. For this study (maximum frequency variations of 2 % or less), it can be assumed that any change in transformer reactance and secondary side voltage is negligible. DG output frequency will carry through the step-down transformer to the motor control centers (MCCs), to the MOVs.

4.1 IMPACT OF MOV MOTOR SPEED CHANGE

The MOV design calculated stroke times are based on typical design speeds of 1725 and 3440 rpm for alternating current (AC) motors. Unless it is determined that the MOV motor speeds resulting from the reduced frequency are lower than these design speeds, the stroke times will not be affected. A slightly faster valve stroke time, caused by an increase in motor speed due to higher than nominal frequency, will not affect the valve performance in an adverse manner.

For example, most safety-related valves are required to open or close within 10 seconds. From Subsection 2.4.3, an uncertainty in diesel generator frequency, U_f, of 0.35 Hz will affect the motor speed as follows:

$$\Delta S_{Motor} = \frac{0.35\ \text{Hz}}{60\ \text{Hz}}(3440\text{rpm}) = 20\ \text{rpm for 3440 rpm motor}$$

$$\Delta S_{Motor} = \frac{0.35\ \text{Hz}}{60\ \text{Hz}}(1725\text{rpm}) = 10\ \text{rpm for 1725 rpm motor}$$

Since there is no change in the reducing gear used in the actuator, the effect of rpm change on the stroke time is 0.058 second (i.e., 20/3440 * 10 sec), which is around 0.6% of total stroke time. This is significantly less than the measurement uncertainty of the instrumentation used to measure stroke. Therefore, the impact of reduced valve stroke time caused by a decrease in motor speed due to lower than nominal frequency, will not affect the valve performance in an adverse manner.

4.2 IMPACT OF FREQUENCY CHANGE ON MOV INERTIA

The inertia of a motor-operated valve is associated with the moving parts of the valve assembly and consists of the sum of the inertias of the motor, the gear train, and the stem-disc assembly. The rotational energy of the moving parts is defined as:

$$E = \frac{WK^2}{2}\omega^2$$ **Equation 14**

where,

WK^2 = equivalent inertia of the rotating elements
ω = rotational speed (rpm)

The rotational energy (E), when dissipated, results in work done during valve closure and is defined as follows:

$$E = Work = F_e\delta$$ **Equation 15**

where,

F_e = force component of work done when the valve closes
δ = displacement component of the work done

The effect of rotational inertia is to do work when the valve closes by creating a force, F_e, and a displacement, δ. The force, F_e, is the inertial effect measured during diagnostic test.

As the moving parts move at different speeds, it is customary to calculate an equivalent inertia, WK^2. The equivalent inertia (WK^2) is the sum of inertias of the moving parts (Reference 6). In MOVs, the inertia effect on load is measured after static tests as the difference in thrust from closed torque switch trip (CST) and hard seat.

The equivalent inertia (WK^2) is defined as:

$$WK^2 = WK^2_{motor} + WK^2_{reducer} + WK^2_{stem-disc}$$ **Equation 16**

The energy contribution of the components is proportional to square of the rotational speed of the component and, for a linear system, it is proportional to the square of the velocity (Reference 6). Note that linear velocity is proportional to rotational speed. Thus, for all the components of the assembly, the energy is a function of the square of the rotational speed. Thus, the expression for the energy of the assembly (E) can be reduced into:

$$E = C * RPM^2 \qquad = C\omega^2$$ **Equation 17**

where C is a constant that represents the sum of the individual inertia constants of the load train.

Since frequency (f) is directly proportional to rotational speed, a change in frequency changes the rotational speed proportionately. Thus, a change in frequency will change the energy content (ΔE) taking into account the square of the rotational speed effect.

$$\Delta E = E_{final} - E_{Initial} = C((\omega + \Delta\omega)^2 - \omega^2)$$ **Equation 18**

Or

$$\Delta E = C(2\omega\Delta\omega + \Delta\omega^2)$$ **Equation 19**

Therefore, the fractional change in energy (ΔE) from the steady-state initial equivalent energy value can be expressed as follows:

$$\frac{\Delta E}{E} = \frac{2f\Delta f}{f^2} + \left(\frac{\Delta f}{f}\right)^2 = \frac{2\Delta f}{f} + \left(\frac{\Delta f}{f}\right)^2$$ **Equation 20**

where,

f = steady-state frequency (60 Hz)
Δf = change in frequency (Hz)

For small changes, such as less than 10% change in frequency, the second term is dropped. The resultant equation of the fractional energy change becomes:

$$\frac{\Delta E}{E} = \frac{2\Delta f}{f}$$ **Equation 21**

The total differential of E in Equation 15 is:

$$\Delta E = \Delta F_e\delta + F_e\Delta\delta$$ **Equation 22**

Dividing Equation 22 by E results in:

$$\frac{\Delta E}{E} = \frac{\Delta F_e}{F_e} + \frac{\Delta\delta}{\delta}$$ **Equation 23**

For practical purposes, $\Delta\delta/\delta$ is negligible; therefore,

$$\frac{\Delta E}{E} = \frac{\Delta F_e}{F_e} = \frac{2\Delta f}{f}$$ **Equation 24**

The change in the inertia effect due to frequency change is:

$$\Delta F_e = \frac{2\Delta f}{f} F_e$$ **Equation 25**

4.2.1 Worked Example

Assuming that the steady-state frequency is 60 Hz and the static test inertia effect measured during the test is 4,000 lb; determine the increase in inertia effect if the frequency increases by 0.5 Hz.

Using Equation 26,

$$\Delta F_e = \left(\frac{2\Delta f}{f}\right) F_e$$

$$\Delta f = 0.5 \text{ Hz}$$

$$f = 60 \text{ Hz}$$

$$F_e = 4{,}000 \text{ lb}$$

$$\Delta F_e = \frac{2 * 0.5 * 4000}{60} = 66.7 \text{ lb}$$

From the worked example, the effect is small for small frequency changes provided that the static test inertia effect is not very high. The user is required to determine the inertia effect of the valve assembly from the static test trace.

4.3 IMPACT OF MOV VOLTAGE

As part of calculations performed to comply with Generic Letter (GL) 96-05 (Reference 5), the MOV calculations are based on worst-case derated voltage conditions. There would be no change in the calculation results unless the low-end voltage range for the DG voltage regulator is less than the derated voltage condition analyzed in the MOV calculations. On very low output voltage, the DG bus breaker should trip as a protective function.

If the voltage regulator allows a 10% drop, then 480V – 48v = 432V is supplied to the MOV MCC.

Additional voltage drop between MCC and MOV should be < 10%.

A typical degraded voltage is approximately 80% of the rated voltage, i.e., ~384V at the MOV.

For typical AC motor and actuator applications, voltage variation from 90% – 100% will not affect the output torque outside its operating range if the nominal ratings are used.

The effect of voltage variation in excess of the nominal voltage rating of the MOV motors would cause the current of the motor load circuits to decrease accordingly. The voltage variation of the DG voltage regulator at steady-state operation should be confirmed to be within the allowable operating voltage range for the MOV motors to ensure that there would be no adverse impact on the MOV motors from the maximum expected steady-state voltage allowed by the voltage regulator.

4.4 IMPACT OF PUMP OUTPUT PRESSURE/DIFFERENTIAL PRESSURE (DP) ON THE MOV

An increase in pump output pressure and, consequently the differential pressure caused by a higher than nominal frequency will create a higher DP at the valve. For those MOV calculations that are based on the vendor pump performance curve at 0 flow rate, i.e., shutoff head, the calculations would be affected if the pump head increased above the nominal shutoff head. This would be a concern for the high end of DG frequency range. For any MOV calculation done at a DP lower than the pump shutoff head, the following conditions shall be satisfied to ensure that the valve remains operable.

An increase in frequency increases the rotational speed, which increases horsepower using affinity laws. Similarly, an increase in rotational speed increases pump developed head using affinity laws. From the example in Section 4.1, the fractional increase in rotational speed is 0.0058, which corresponds to an increase in pump head of 1.2% (i.e., $((1.0058)^2-1)*100$).

An increase in pump head results in a proportional increase in thrust or torque required to operate the valve. The Joint Owners Group (JOG) defines margin for a gate valve as:

$$Margin\ (M) = \frac{Actuator\ Output\ Thrust(AO)}{(Required\ Thrust\ (RT) * (1 + Uncertainities(U))} \qquad \textbf{Equation 26}$$

Or

$$M = \frac{AO}{RT * (1+U)} \qquad \textbf{Equation 27}$$

Let the initial steady-state margin be defined by M_o. Then the above margin equation becomes:

$$M_o = \frac{AO_o}{RT_o * (1+U)} \qquad \textbf{Equation 28}$$

Let the final resultant margin affected by frequency change be defined by M_1. Then the resultant margin affected by the frequency change is:

$$M_1 = \frac{AO_1}{RT_1 * (1+U)} \qquad \textbf{Equation 29}$$

where RT_1 is defined by:

$$RT_1 = RT_0 (1 + 0.012) \qquad \textbf{Equation 30}$$

Dividing Equation 29 by Equation 28, taking into account the definition of RT_1, results in the following:

$$\frac{M_1}{M_o} = 0.988$$ **Equation 31**

This can be written as $M_1 = 0.988\ M_o$. The resultant margin has to be equal or greater than 1 for the valve to be operable. Thus,

$$M_1 = 0.988\ M_o \geq 1.012$$ **Equation 32**

$$M_o \geq 1.012$$ **Equation 33**

Therefore, the effect of the increase in pump output pressure / differential pressure on MOVs due to the frequency change reduces the available margin. Based on Equation 33, the MOV is operable if the initial margin is greater than 1.2%. For cases when the analyzed output pressure / differential pressure exceeds the actual pump output pressure / differential pressure by 1.2%, the valve is operable. This margin relationship applies to rotary valves also.

5 IMPACT ON FAN/BLOWER OPERATION

5.1 FAN/BLOWER AFFINITY LAWS

Calculating the change in fan performance due to small diameter changes, speed variations, and density fluctuations is a matter of multiplying by ratios of the target parameter to the initial parameter (raised to some power). The equations below show the relationships and powers to be used in these calculations. Both direct drive and belt drive fans would be impacted in the same manner by DG frequency and voltage variations.

$$CFM_2 = CFM_1\left(\frac{N_2}{N_1}\right)^1\left(\frac{D_2}{D_1}\right)^3\left(\frac{\rho_2}{\rho_1}\right)^0$$ **Equation 34**

$$SP_2 = SP_1\left(\frac{N_2}{N_1}\right)^2\left(\frac{D_2}{D_1}\right)^2\left(\frac{\rho_2}{\rho_1}\right)^1$$ **Equation 35**

$$HP_2 = HP_1\left(\frac{N_2}{N_1}\right)^3\left(\frac{D_2}{D_1}\right)^5\left(\frac{\rho_2}{\rho_1}\right)^1$$ **Equation 36**

5.2 EFFECTS OF VARIATIONS

For the upper bound of the DG governor control band, the main concern from a higher than nominal frequency value (> 60 Hz) would be the additional power load required from the DG. This additional power requirement would be addressed in the diesel loading calculation as described in Section 3.1 of this report.

The lower range of the DG governor control band, frequency < 60 Hz, would cause a slight reduction in motor speed (rpm) and a decrease in fan performance exhibited by reduced airflow (cfm) and static pressure (SP) as indicated by the formulae shown above.

For air filtration systems, Specification 5.5.11 of NUREG-1430, NUREG-1431, and NUREG-1432, Ventilation Filter Testing Program (VFTP), requires that each ESF ventilation system be tested at ±10% of the specified system flow rate. Therefore, if the fan speed and corresponding airflow do not vary more than ±10% of the specified system flow rate from the effect of DG frequency and voltage variation, the fan for that system can be said to be performing within its expected operating range.

The effect of voltage variation in excess of the nominal voltage rating of the fan/blower motors would cause the current of the motor load circuits to increase or decrease accordingly. The voltage variation of the DG voltage regulator at steady-state operation should be confirmed to be within the allowable operating voltage range for the fan/blower motors to ensure that there would be no adverse impact to the fan/blower motors from the minimum and maximum expected steady-state voltage allowed by the voltage regulator.

6 RESULTS AND CONCLUSIONS

Diesel generator steady-state frequency and voltage variation can be expected and verified to control within a tolerance around the nominal values of 60 Hz and 4160V. The effect of this variation can be evaluated to determine the impact on motor performance for ECCS pumps, MOVs, and other motors required to be powered by the diesel generator. This impact on motor performance can then be compared to existing analyses for ECCS pump performance, MOV operation, fan/blower performance, DG loading, and fuel consumption.

Methods for determining the effect of DG steady-state frequency and voltage variation on motor speed can be used to develop uncertainty factors for the motor performance. For ECCS pump performance, those factors can be summed with other uncertainties to determine an overall pump performance uncertainty. This overall uncertainty can be used to adjust the pump IST curves to account for the DG frequency and voltage variation. Implementation of this methodology should be confirmed on a pump-specific basis to ensure minimal impacts on the existing pump IST curves.

In addition to the impact on ECCS pump performance, the effect of DG steady-state frequency and voltage variation on MOV performance was also determined. In most instances, existing MOV analyses are already bounding for potential DG frequency and voltage impact. For actuators where a user has stretched the actuator rating to a number well above the nominal rating using plant-specific test data, the evaluation of operator capability must take into account changes in pump head and the associated uncertainties considered in MOV analysis to demonstrate that the valve still performs its safety-related function.

Other DG performance considerations such as the effect of frequency variation on loading calculations should be compared to the maximum DG load calculation results to ensure the DG load rating is not exceeded and diesel fuel consumption does not exceed calculated storage requirements. Fans powered by a DG would not be subject to degradation in performance, unless the motor speed was impacted by more than 10 percent of the nominal rating.

7 REFERENCES

1. NUREG-1430, Rev. 4, "Standard Technical Specifications Babcock and Wilcox Plants," U.S. Nuclear Regulatory Commission, April 2012.

2. NUREG-1431, Rev. 4, "Standard Technical Specifications Westinghouse Plants, " U.S. Nuclear Regulatory Commission, April 2012.

3. NUREG-1432, Rev. 4, "Standard Technical Specifications Combustion Engineering Plants," U.S. Nuclear Regulatory Commission, April 2012.

4. Regulatory Guide (RG) 1.9, Rev. 3, "Selection, Design, Qualification, and Testing of Emergency Diesel Generator Units Used as Class 1E Onsite Electric Power Systems at Nuclear Power Plants," U.S. Nuclear Regulatory Commission, July 1993.

5. Generic Letter (GL) 96-05, "Periodic Verification of Design-Basis Capability of Safety-Related Motor-Operated Valves," U.S. Nuclear Regulatory Commission, September 18, 1996.

6. Beer, F. P. and E. R. Johnston, Vector Mechanics for Engineers: Statics & Dynamics, 2nd Edition, McGraw-Hill Book Company.

APPENDIX A
EXAMPLE NUREG-1431 TECHNICAL SPECIFICATION & BASES MARKUPS

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.8.1.1	Verify correct breaker alignment and indicated power availability for each [required] offsite circuit.	[7 days OR In accordance with the Surveillance Frequency Control Program]

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.8.1.2	-----------------------------NOTES---------------------------- 1. All DG starts may be preceded by an engine prelube period and followed by a warmup period prior to loading. [2. A modified DG start involving idling and gradual acceleration to synchronous speed may be used for this SR as recommended by the manufacturer. ~~When modified start procedures are not used, the time, voltage, and frequency tolerances of SR 3.8.1.7 must be met.~~] --	
	Verify each DG starts from standby conditions and achieves steady state voltage and frequency with nominal values of [4160] V and [60] Hz. ~~≥ [3740] V and ≤ [4580] V, and frequency ≥ [58.8] Hz and ≤ [61.2] Hz.~~	[31 days OR In accordance with the Surveillance Frequency Control Program]

SURVEILLANCE REQUIREMENTS (continued)

	SURVEILLANCE	FREQUENCY
SR 3.8.1.3	-----NOTES----- 1. DG loadings may include gradual loading as recommended by the manufacturer. 2. Momentary transients outside the load range do not invalidate this test. 3. This Surveillance shall be conducted on only one DG at a time. 4. This SR shall be preceded by and immediately follow without shutdown a successful performance of SR 3.8.1.2 or SR 3.8.1.7. ---------- Verify each DG is synchronized and loaded and operates for ≥ 60 minutes at a load ≥ [4500] kW and ≤ [5000] kW.	[31 days OR In accordance with the Surveillance Frequency Control Program]
SR 3.8.1.4	Verify each day tank [and engine mounted tank] contains ≥ [220] gal of fuel oil.	[31 days OR In accordance with the Surveillance Frequency Control Program]

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.8.1.5	Check for and remove accumulated water from each day tank [and engine mounted tank].	[[31] days <u>OR</u> In accordance with the Surveillance Frequency Control Program]
SR 3.8.1.6	Verify the fuel oil transfer system operates to [automatically] transfer fuel oil from storage tank[s] to the day tank [and engine mounted tank].	[[92] days <u>OR</u> In accordance with the Surveillance Frequency Control Program]
SR 3.8.1.7	-----------------------------NOTE----------------------------- All DG starts may be preceded by an engine prelube period. --- Verify each DG starts from standby condition and achieves: a. In ≤ [10] seconds, voltage ≥ [3740]V and frequency ≥ 58.8] Hz and b. Steady state voltage ≥ [~~3740~~3950] V and ≤ [~~4580~~4370] V, and frequency ≥ [~~58.8~~59.6] Hz and ≤ [~~61.2~~60.4] Hz.	 [184 days <u>OR</u> In accordance with the Surveillance Frequency Control Program]

SURVEILLANCE REQUIREMENTS (continued)

	SURVEILLANCE	FREQUENCY
SR 3.8.1.8	-----------------------------NOTE----------------------------- [This Surveillance shall not normally be performed in MODE 1 or 2. However, this Surveillance may be performed to reestablish OPERABILITY provided an assessment determines the safety of the plant is maintained or enhanced. Credit may be taken for unplanned events that satisfy this SR. --- Verify [automatic [and] manual] transfer of AC power sources from the normal offsite circuit to each alternate [required] offsite circuit.	[[18] months OR In accordance with the Surveillance Frequency Control Program]]

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.8.1.9	-----------------------------NOTES----------------------------- [1. This Surveillance shall not normally be performed in MODE 1 or 2. However, this Surveillance may be performed to reestablish OPERABILITY provided an assessment determines the safety of the plant is maintained or enhanced. Credit may be taken for unplanned events that satisfy this SR. 2. If performed with the DG synchronized with offsite power, it shall be performed at a power factor ≤ [0.9]. However, if grid conditions do not permit, the power factor limit is not required to be met. Under this condition the power factor shall be maintained as close to the limit as practicable.] --	
	Verify each DG rejects a load greater than or equal to its associated single largest post-accident load, and: a. Following load rejection, the frequency is ≤ [63] Hz, b. Within [3] seconds following load rejection, the voltage is ≥ [3740] V and ≤ [4580] V, and c. Within [3] seconds following load rejection, the frequency is ≥ [58.8] Hz and ≤ [61.2] Hz.	[[18] months OR In accordance with the Surveillance Frequency Control Program]

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.8.1.10	------------------------------NOTES------------------------------ [1. This Surveillance shall not normally be performed in MODE 1 or 2. However, this Surveillance may be performed to reestablish OPERABILITY provided an assessment determines the safety of the plant is maintained or enhanced. Credit may be taken for unplanned events that satisfy this SR. 2. If performed with DG synchronized with offsite power, it shall be performed at a power factor ≤ [0.9]. However, if grid conditions do not permit, the power factor limit is not required to be met. Under this condition the power factor shall be maintained as close to the limit as practicable.] --	
	Verify each DG does not trip and voltage is maintained ≤ [5000] V during and following a load rejection of ≥ [4500] kW and ≤ [5000] kW.	[[18] months <u>OR</u> In accordance with the Surveillance Frequency Control Program]

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.8.1.11	-----------------------------NOTES--------------------------- 1. All DG starts may be preceded by an engine prelube period. 2. This Surveillance shall not normally be performed in MODE 1, 2, 3, or 4. However, portions of the Surveillance may be performed to reestablish OPERABILITY provided an assessment determines the safety of the plant is maintained or enhanced. Credit may be taken for unplanned events that satisfy this SR. --- Verify on an actual or simulated loss of offsite power signal: a. De-energization of emergency buses, b. Load shedding from emergency buses, c. DG auto-starts from standby condition and: 1. Energizes permanently connected loads in ≤ [10] seconds, 2. Energizes auto-connected shutdown loads through [automatic load sequencer], 3. Maintains steady state voltage ≥ [~~3740~~3950] V and ≤ [~~4580~~4370] V, 4. Maintains steady state frequency ≥ [~~58.8~~59.6] Hz and ≤ [~~61.2~~60.4] Hz, and 5. Supplies permanently connected [and auto-connected] shutdown loads for ≥ 5 minutes.	[[18] months OR In accordance with the Surveillance Frequency Control Program]

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.8.1.12	-----------------------------NOTES---------------------------- [1. All DG starts may be preceded by prelube period. 2. This Surveillance shall not normally be performed in MODE 1 or 2. However, portions of the Surveillance may be performed to reestablish OPERABILITY provided an assessment determines the safety of the plant is maintained or enhanced. Credit may be taken for unplanned events that satisfy this SR. ---	
	Verify on an actual or simulated Engineered Safety Feature (ESF) actuation signal each DG auto-starts from standby condition and: a. In ≤ [10] seconds after auto-start and during tests, achieves voltage ≥ [3740] V and frequency ≥ [58.8] Hz, b. Achieves steady state voltage ≥ [~~3740~~3950] V and ≤ [~~4580~~4370] V and frequency ≥ [~~58.8~~59.6] Hz and ≤ [~~61.2~~60.4] Hz, c. Operates for ≥ 5 minutes, d. Permanently connected loads remain energized from the offsite power system, and e. Emergency loads are energized [or auto-connected through the automatic load sequencer] from the offsite power system.	[[18] months <u>OR</u> In accordance with the Surveillance Frequency Control Program]

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.8.1.13	------------------------------NOTE------------------------------ [This Surveillance shall not normally be performed in MODE 1 or 2. However, this Surveillance may be performed to reestablish OPERABILITY provided an assessment determines the safety of the plant is maintained or enhanced. Credit may be taken for unplanned events that satisfy this SR.] --- Verify each DG's noncritical automatic trips are bypassed on [actual or simulated loss of voltage signal on the emergency bus concurrent with an actual or simulated ESF actuation signal].	[[18] months <u>OR</u> In accordance with the Surveillance Frequency Control Program]

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.8.1.14	-----------------------------NOTES----------------------------- 1. Momentary transients outside the load and power factor ranges do not invalidate this test. 2. This Surveillance shall not normally be performed in MODE 1 or 2. However, this Surveillance may be performed to reestablish OPERABILITY provided an assessment determines the safety of the plant is maintained or enhanced. Credit may be taken for unplanned events that satisfy this SR. 3. If performed with DG synchronized with offsite power, it shall be performed at a power factor ≤ [0.9]. However, if grid conditions do not permit, the power factor limit is not required to be met. Under this condition the power factor shall be maintained as close to the limit as practicable. --	
	Verify each DG operates for ≥ 24 hours: a. For ≥ [2] hours loaded ≥ [5250] kW and ≤ [5500] kW and b. For the remaining hours of the test loaded ≥ [4500] kW and ≤ [5000] kW.	[[18] months <u>OR</u> In accordance with the Surveillance Frequency Control Program]

SURVEILLANCE REQUIREMENTS (continued)

	SURVEILLANCE	FREQUENCY
SR 3.8.1.15	-----------------------------NOTES--------------------------- 1. This Surveillance shall be performed within 5 minutes of shutting down the DG after the DG has operated ≥ [2] hours loaded ≥ [4500] kW and ≤ [5000] kW. Momentary transients outside of load range do not invalidate this test. 2. All DG starts may be preceded by an engine prelube period. --- Verify each DG starts and achieves: a. In ≤ [10] seconds, voltage ≥ [3740] V and frequency ≥ [58.8] Hz and b. Steady state voltage ≥ [~~3740~~3950] V, and ≤ [~~4580~~4370] V and frequency ≥ [~~58.8~~59.6] Hz and ≤ [~~61.2~~60.4] Hz.	[[18] months <u>OR</u> In accordance with the Surveillance Frequency Control Program]
SR 3.8.1.16	----------------------------NOTE----------------------------- This Surveillance shall not normally be performed in MODE 1, 2, 3, or 4. However, this Surveillance may be performed to reestablish OPERABILITY provided an assessment determines the safety of the plant is maintained or enhanced. Credit may be taken for unplanned events that satisfy this SR. --- Verify each DG: a. Synchronizes with offsite power source while loaded with emergency loads upon a simulated restoration of offsite power, b. Transfers loads to offsite power source, and c. Returns to ready-to-load operation.	[[18] months <u>OR</u> In accordance with the Surveillance Frequency Control Program]

SURVEILLANCE REQUIREMENTS (continued)

	SURVEILLANCE	FREQUENCY
SR 3.8.1.17	-----------------------------NOTE----------------------------- [This Surveillance shall not normally be performed in MODE 1, 2, 3, or 4. However, portions of the Surveillance may be performed to reestablish OPERABILITY provided an assessment determines the safety of the plant is maintained or enhanced. Credit may be taken for unplanned events that satisfy this SR. -- Verify, with a DG operating in test mode and connected to its bus, an actual or simulated ESF actuation signal overrides the test mode by: a. Returning DG to ready-to-load operation and b. [Automatically energizing the emergency load from offsite power].	[[18] months <u>OR</u> In accordance with the Surveillance Frequency Control Program]
SR 3.8.1.18	-----------------------------NOTE----------------------------- [This Surveillance shall not normally be performed in MODE 1, 2, 3, or 4. However, this Surveillance may be performed to reestablish OPERABILITY provided an assessment determines the safety of the plant is maintained or enhanced. Credit may be taken for unplanned events that satisfy this SR.] -- Verify interval between each sequenced load block is within ± [10% of design interval] for each emergency [and shutdown] load sequencer.	[[18] months <u>OR</u> In accordance with the Surveillance Frequency Control Program]

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.8.1.19	------------------------------NOTES---------------------------- 1. All DG starts may be preceded by an engine prelube period. 2. This Surveillance shall not normally be performed in MODE 1, 2, 3, or 4. However, portions of the Surveillance may be performed to reestablish OPERABILITY provided an assessment determines the safety of the plant is maintained or enhanced. Credit may be taken for unplanned events that satisfy this SR. ---	
	Verify on an actual or simulated loss of offsite power signal in conjunction with an actual or simulated ESF actuation signal: a. De-energization of emergency buses, b. Load shedding from emergency buses, and c. DG auto-starts from standby condition and: 1. Energizes permanently connected loads in ≤ [10] seconds, 2. Energizes auto-connected emergency loads through load sequencer, 3. Achieves steady state voltage ≥ [~~3740~~3950] V and ≤ [~~4580~~4370] V, 4. Achieves steady state frequency ≥ [~~58.8~~59.6] Hz and ≤ [~~61.2~~60.4] Hz, and 5. Supplies permanently connected [and auto-connected] emergency loads for ≥ 5 minutes.	[[18] months OR In accordance with the Surveillance Frequency Control Program]

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.8.1.20	-----------------------------NOTE----------------------------- All DG starts may be preceded by an engine prelube period. --- Verify when started simultaneously from standby condition, each DG achieves: a. In ≤ [10] seconds, voltage ≥ [3740] V and frequency ≥ [58.8] Hz and b. Steady state voltage ≥ [~~3744~~3950] V and ≤ [~~4576~~4370] V, and frequency ≥ [~~58.8~~59.6] Hz and ≤ [~~61.2~~60.4] Hz.	[10 years OR In accordance with the Surveillance Frequency Control Program]

BASES

ACTIONS (continued)

H.1

Condition H corresponds to a level of degradation in which all redundancy in the AC electrical power supplies has been lost. At this severely degraded level, any further losses in the AC electrical power system will cause a loss of function. Therefore, no additional time is justified for continued operation. The unit is required by LCO 3.0.3 to commence a controlled shutdown.

SURVEILLANCE REQUIREMENTS

The AC sources are designed to permit inspection and testing of all important areas and features, especially those that have a standby function, in accordance with 10 CFR 50, Appendix A, GDC 18 (Ref. 8). Periodic component tests are supplemented by extensive functional tests during refueling outages (under simulated accident conditions). The SRs for demonstrating the OPERABILITY of the DGs are in accordance with the recommendations of Regulatory Guide 1.9 (Ref. 3), Regulatory Guide 1.108 (Ref. 9), and Regulatory Guide 1.137 (Ref. 10), as addressed in the FSAR.

~~Where the SRs discussed herein specify voltage and frequency tolerances, the following is applicable. The minimum steady state output voltage of [3740] V is 90% of the nominal 4160 V output voltage. This value, which is specified in ANSI C84.1 (Ref. 11), allows for voltage drop to the terminals of 4000 V motors whose minimum operating voltage is specified as 90% or 3600 V. It also allows for voltage drops to motors and other equipment down through the 120 V level where minimum operating voltage is also usually specified as 90% of name plate rating. The specified maximum steady state output voltage of [4756] V is equal to the maximum operating voltage specified for 4000 V motors. It ensures that for a lightly loaded distribution system, the voltage at the terminals of 4000 V motors is no more than the maximum rated operating voltages. The specified minimum and maximum frequencies of the DG are 58.8 Hz and 61.2 Hz, respectively. These values are equal to ± 2% of the 60 Hz nominal frequency and are derived from the recommendations given in Regulatory Guide 1.9 (Ref. 3).~~

SR 3.8.1.1

This SR ensures proper circuit continuity for the offsite AC electrical power supply to the onsite distribution network and availability of offsite AC electrical power. The breaker alignment verifies that each breaker is in its correct position to ensure that distribution buses and loads are connected to their preferred power source, and that appropriate independence of offsite circuits is maintained. [The 7 day Frequency is

BASES

SURVEILLANCE REQUIREMENTS (continued)

adequate since breaker position is not likely to change without the operator being aware of it and because its status is displayed in the control room.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

-----------------------------------REVIEWER'S NOTE-----------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
--]

SR 3.8.1.2 and SR 3.8.1.7

These SRs help to ensure the availability of the standby electrical power supply to mitigate DBAs and transients and to maintain the unit in a safe shutdown condition.

To minimize the wear on moving parts that do not get lubricated when the engine is not running, these SRs are modified by a Note (Note 1 for SR 3.8.1.2 and Note for SR 3.8.1.7) to indicate that all DG starts for these Surveillances may be preceded by an engine prelube period and followed by a warmup period prior to loading.

For the purposes of SR 3.8.1.2 and SR 3.8.1.7 testing, the DGs are started from standby conditions. Standby conditions for a DG mean that the diesel engine coolant and oil are being continuously circulated and temperature is being maintained consistent with manufacturer recommendations.

[In order to reduce stress and wear on diesel engines, some manufacturers recommend a modified start in which the starting speed of DGs is limited, warmup is limited to this lower speed, and the DGs are gradually accelerated to synchronous speed prior to loading. These start procedures are the intent of Note 2, which is only applicable when such modified start procedures are recommended by the manufacturer.]

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.8.1.2 requires that the DG starts from standby conditions and achieves nominal design voltage and frequency. SR 3.8.1.2 is consistent with the guidance for the monthly test provided in Section 2.2.1, "Start Test," of Regulatory Guide 1.9 (Ref. 3), which only requires that design voltage and frequency be attained.

SR 3.8.1.7 requires that the DG starts from standby conditions and achieves required voltage and frequency within 10 seconds. The 10 second start requirement supports the assumptions of the design basis LOCA analysis in the FSAR, Chapter [15] (Ref. 5). SR 3.8.1.7 is consistent with the guidance for the six month test provided in Section 2.2.3, "Fast Start Test," of Regulatory Guide 1.9 (Ref. 3), which requires verification that the DG reaches the required voltage and frequency within acceptable limits and time as defined in the plant technical specifications.

~~The 10 second start requirement is not applicable to SR 3.8.1.2 (see Note 2) when a modified start procedure as described above is used. If a modified start is not used, the 10 second start requirement of SR 3.8.1.7 applies.~~

The criteria of achieving $\geq$ [3740] V and $\geq$ [58.8] Hz in $\leq$ [10] seconds when a DG is started from a standby condition are starting and accelerating design criteria for the DG that are specified to confirm the capability of the DG to recover from a loading transient. The -10% for voltage and the -2% for frequency are consistent with the guidance provided in Paragraph 1.4, of Regulatory Guide 1.9 (Ref. 3).

SR 3.8.1.7 also demonstrates that the DG can achieve steady state voltage and frequency within the specified band around the nominal values of [4160] V and [60] Hz. The band placed around these nominal values is based on the capability of the voltage regulator and governor. The voltage and frequency bands are determined in accordance with WCAP-17308-P (Ref. 11). WCAP-17308-P provides the methodology to evaluate the impact of variations in voltage and frequency, due to the voltage regulator and governor, on the following:

- Pump flow and developed head to adjust pump Inservice Testing (IST) curves,
- DG loading calculations,
- DG fuel consumption calculations,
- Motor Operated Valve (MOV) performance, and
- Ventilation fans credited in the dose analyses.

Since SR 3.8.1.7 requires a 10 second start and that steady state voltage and frequency be achieved within a specified band around the nominal values, it is more restrictive than SR 3.8.1.2, and it may be performed in lieu of SR 3.8.1.2.

~~In addition to the SR requirements, the time for the DG to reach steady state operation, unless the modified DG start method is employed, is periodically monitored and the trend evaluated to identify degradation of governor and voltage regulator performance.~~

[The 31 day Frequency for SR 3.8.1.2 is consistent with Regulatory Guide 1.9 (Ref. 3). The 184 day Frequency for SR 3.8.1.7 is a reduction in cold testing consistent with Generic Letter 84-15 (Ref. 7). These Frequencies provide adequate assurance of DG OPERABILITY, while minimizing degradation resulting from testing.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

---------------------------------REVIEWER'S NOTE---------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
--]

SR 3.8.1.3

This Surveillance verifies that the DGs are capable of synchronizing with the offsite electrical system and accepting loads greater than or equal to the equivalent of the maximum expected accident loads. A minimum run time of 60 minutes is required to stabilize engine temperatures, while minimizing the time that the DG is connected to the offsite source.

BASES

SURVEILLANCE REQUIREMENTS (continued)

Although no power factor requirements are established by this SR, the DG is normally operated at a power factor between [0.8 lagging] and [1.0]. The [0.8] value is the design rating of the machine, while the [1.0] is an operational limitation [to ensure circulating currents are minimized]. The load band is provided to avoid routine overloading of the DG. Routine overloading may result in more frequent teardown inspections in accordance with vendor recommendations in order to maintain DG OPERABILITY.

[The 31 day Frequency for this Surveillance is consistent with Regulatory Guide 1.9 (Ref. 3).

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

---------------------------------REVIEWER'S NOTE---------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
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This SR is modified by four Notes. Note 1 indicates that diesel engine runs for this Surveillance may include gradual loading, as recommended by the manufacturer, so that mechanical stress and wear on the diesel engine are minimized. Note 2 states that momentary transients, because of changing bus loads, do not invalidate this test. Similarly, momentary power factor transients above the limit do not invalidate the test. Note 3 indicates that this Surveillance should be conducted on only one DG at a time in order to avoid common cause failures that might result from offsite circuit or grid perturbations. Note 4 stipulates a prerequisite requirement for performance of this SR. A successful DG start must precede this test to credit satisfactory performance.

SR 3.8.1.4

This SR provides verification that the level of fuel oil in the day tank [and engine mounted tank] is at or above the level at which fuel oil is automatically added. The level is expressed as an equivalent volume in gallons, and is selected to ensure adequate fuel oil for a minimum of 1 hour of DG operation at full load plus 10%.

BASES

SURVEILLANCE REQUIREMENTS (continued)

[The 31 day Frequency is adequate to assure that a sufficient supply of fuel oil is available, since low level alarms are provided and facility operators would be aware of any large uses of fuel oil during this period.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

--------------------------------REVIEWER'S NOTE--------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
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SR 3.8.1.5

Microbiological fouling is a major cause of fuel oil degradation. There are numerous bacteria that can grow in fuel oil and cause fouling, but all must have a water environment in order to survive. Removal of water from the fuel oil day [and engine mounted] tanks eliminates the necessary environment for bacterial survival. This is the most effective means of controlling microbiological fouling. In addition, it eliminates the potential for water entrainment in the fuel oil during DG operation. Water may come from any of several sources, including condensation, ground water, rain water, contaminated fuel oil, and breakdown of the fuel oil by bacteria. Frequent checking for and removal of accumulated water minimizes fouling and provides data regarding the watertight integrity of the fuel oil system. [The Surveillance Frequency of 31 days is established by Regulatory Guide 1.137 (Ref. 10). This SR is for preventative maintenance.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

--------------------------------REVIEWER'S NOTE--------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
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BASES

SURVEILLANCE REQUIREMENTS (continued)

The presence of water does not necessarily represent failure of this SR, provided the accumulated water is removed during the performance of this Surveillance.

SR 3.8.1.6

This Surveillance demonstrates that each required fuel oil transfer pump operates and transfers fuel oil from its associated storage tank to its associated day tank. This is required to support continuous operation of standby power sources. This Surveillance provides assurance that the fuel oil transfer pump is OPERABLE, the fuel oil piping system is intact, the fuel delivery piping is not obstructed, and the controls and control systems for automatic fuel transfer systems are OPERABLE.

[The Frequency for this SR is variable, depending on individual system design, with up to a [92] day interval. The [92] day Frequency corresponds to the testing requirements for pumps as contained in the ASME Code (Ref. ~~11~~12); however, the design of fuel transfer systems is such that pumps operate automatically or must be started manually in order to maintain an adequate volume of fuel oil in the day [and engine mounted] tanks during or following DG testing. In such a case, a 31 day Frequency is appropriate. Since proper operation of fuel transfer systems is an inherent part of DG OPERABILITY, the Frequency of this SR should be modified to reflect individual designs.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

--------------------------------REVIEWER'S NOTE--------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
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SR 3.8.1.7

See SR 3.8.1.2.

BASES

SURVEILLANCE REQUIREMENTS (continued)

[SR 3.8.1.8

Transfer of each [4.16 kV ESF bus] power supply from the normal offsite circuit to the alternate offsite circuit demonstrates the OPERABILITY of the alternate circuit distribution network to power the shutdown loads. [The [18 month] Frequency of the Surveillance is based on engineering judgment, taking into consideration the unit conditions required to perform the Surveillance, and is intended to be consistent with expected fuel cycle lengths. Operating experience has shown that these components usually pass the SR when performed at the [18 month] Frequency. Therefore, the Frequency was concluded to be acceptable from a reliability standpoint.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

-----------------------------------REVIEWER'S NOTE-----------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
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This SR is modified by a Note. The reason for the Note is that, during operation with the reactor critical, performance of this SR could cause perturbations to the electrical distribution systems that could challenge continued steady state operation and, as a result, unit safety systems. This restriction from normally performing the Surveillance in MODE 1 or 2 is further amplified to allow the Surveillance to be performed for the purpose of reestablishing OPERABILITY (e.g., post work testing following corrective maintenance, corrective modification, deficient or incomplete surveillance testing, and other unanticipated OPERABILITY concerns) provided an assessment determines plant safety is maintained or enhanced. This assessment shall, as a minimum, consider the potential outcomes and transients associated with a failed Surveillance, a successful Surveillance, and a perturbation of the offsite or onsite system when they are tied together or operated independently for the Surveillance; as well as the operator procedures available to cope with these outcomes. These shall be measured against the avoided risk of a plant shutdown and startup to determine that plant safety is maintained or enhanced when the Surveillance is performed in MODE 1 or 2. Risk insights or deterministic methods may be used for this assessment.] Credit may be taken for unplanned events that satisfy this SR.

SURVEILLANCE REQUIREMENTS (continued)

SR 3.8.1.9

Each DG is provided with an engine overspeed trip to prevent damage to the engine. Recovery from the transient caused by the loss of a large load could cause diesel engine overspeed, which, if excessive, might result in a trip of the engine. This Surveillance demonstrates the DG load response characteristics and capability to reject the largest single load without exceeding predetermined voltage and frequency and while maintaining a specified margin to the overspeed trip. [For this unit, the single load for each DG and its horsepower rating is as follows:] This Surveillance may be accomplished by:

a. Tripping the DG output breaker with the DG carrying greater than or equal to its associated single largest post-accident load while paralleled to offsite power, or while solely supplying the bus, or

b. Tripping its associated single largest post-accident load with the DG solely supplying the bus.

As required by IEEE-308 (Ref. ~~12~~13), the load rejection test is acceptable if the increase in diesel speed does not exceed 75% of the difference between synchronous speed and the overspeed trip setpoint, or 15% above synchronous speed, whichever is lower.

The time, voltage, and frequency tolerances specified in this SR are derived from Regulatory Guide 1.9 (Ref. 3) recommendations for response during load sequence intervals. The 3 seconds specified is equal to 60% of a typical 5 second load sequence interval associated with sequencing of the largest load. The voltage and frequency specified are consistent with the design range of the equipment powered by the DG. SR 3.8.1.9.a corresponds to the maximum frequency excursion, while SR 3.8.1.9.b and SR 3.8.1.9.c are steady state voltage and frequency values to which the system must recover following load rejection. [The [18 month] Frequency is consistent with the recommendation of Regulatory Guide 1.108 (Ref. 9).

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

BASES

SURVEILLANCE REQUIREMENTS (continued)

---------------------------------REVIEWER'S NOTE----------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
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This SR is modified by two Notes. The reason for Note 1 is that during operation with the reactor critical, performance of this SR could cause perturbations to the electrical distribution systems that could challenge continued steady state operation and, as a result, unit safety systems. This restriction from normally performing the Surveillance in MODE 1 or 2 is further amplified to allow the Surveillance to be performed for the purpose of reestablishing OPERABILITY (e.g., post work testing following corrective maintenance, corrective modification, deficient or incomplete surveillance testing, and other unanticipated OPERABILITY concerns) provided an assessment determines plant safety is maintained or enhanced. This assessment shall, as a minimum, consider the potential outcomes and transients associated with a failed Surveillance, a successful Surveillance, and a perturbation of the offsite or onsite system when they are tied together or operated independently for the Surveillance; as well as the operator procedures available to cope with these outcomes. These shall be measured against the avoided risk of a plant shutdown and startup to determine that plant safety is maintained or enhanced when the Surveillance is performed in MODE 1 or 2. Risk insights or deterministic methods may be used for this assessment. Credit may be taken for unplanned events that satisfy this SR.

Note 2 ensures that the DG is tested under load conditions that are as close to design basis conditions as possible. When synchronized with offsite power, testing should be performed at a power factor of ≤ [0.9]. This power factor is representative of the actual inductive loading a DG would see under design basis accident conditions. Under certain conditions, however, Note 2 allows the Surveillance to be conducted at a power factor other than ≤ [0.9]. These conditions occur when grid voltage is high, and the additional field excitation needed to get the power factor to ≤ [0.9] results in voltages on the emergency busses that are too high. Under these conditions, the power factor should be maintained as close as practicable to [0.9] while still maintaining acceptable voltage limits on the emergency busses. In other circumstances, the grid voltage may be such that the DG excitation levels needed to obtain a power factor of [0.9] may not cause unacceptable voltages on the emergency busses, but the excitation levels are in excess of those recommended for the DG. In such cases, the power factor shall be maintained as close as practicable to [0.9] without exceeding the DG excitation limits.

BASES

SURVEILLANCE REQUIREMENTS (continued)

----------------------------------REVIEWER'S NOTE----------------------------------
The above MODE restrictions may be deleted if it can be demonstrated to the staff, on a plant specific basis, that performing the SR with the reactor in any of the restricted MODES can satisfy the following criteria, as applicable:

a. Performance of the SR will not render any safety system or component inoperable,

b. Performance of the SR will not cause perturbations to any of the electrical distribution systems that could result in a challenge to steady state operation or to plant safety systems, and

c. Performance of the SR, or failure of the SR, will not cause, or result in, an AOO with attendant challenge to plant safety systems.

SR 3.8.1.10

This Surveillance demonstrates the DG capability to reject a full load without overspeed tripping or exceeding the predetermined voltage limits. The DG full load rejection may occur because of a system fault or inadvertent breaker tripping. This Surveillance ensures proper engine generator load response under the simulated test conditions. This test simulates the loss of the total connected load that the DG experiences following a full load rejection and verifies that the DG does not trip upon loss of the load. These acceptance criteria provide for DG damage protection. While the DG is not expected to experience this transient during an event and continues to be available, this response ensures that the DG is not degraded for future application, including reconnection to the bus if the trip initiator can be corrected or isolated.

[The [18 month] Frequency is consistent with the recommendation of Regulatory Guide 1.108 (Ref. 9) and is intended to be consistent with expected fuel cycle lengths.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

BASES

SURVEILLANCE REQUIREMENTS (continued)

-----------------------------------REVIEWER'S NOTE-----------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
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This SR has been modified by two Notes. The reason for Note 1 is that during operation with the reactor critical, performance of this SR could cause perturbation to the electrical distribution systems that could challenge continued steady state operation and, as a result, unit safety systems. This restriction from normally performing the Surveillance in MODE 1 or 2 is further amplified to allow the Surveillance to be performed for the purpose of reestablishing OPERABILITY (e.g., post work testing following corrective maintenance, corrective modification, deficient or incomplete surveillance testing, and other unanticipated OPERABILITY concerns) provided an assessment determines plant safety is maintained or enhanced. This assessment shall, as a minimum, consider the potential outcomes and transients associated with a failed Surveillance, a successful Surveillance, and a perturbation of the offsite or onsite system when they are tied together or operated independently for the Surveillance; as well as the operator procedures available to cope with these outcomes. These shall be measured against the avoided risk of a plant shutdown and startup to determine that plant safety is maintained or enhanced when the Surveillance is performed in MODE 1 or 2. Risk insights or deterministic methods may be used for this assessment. Credit may be taken for unplanned events that satisfy this SR. Note 2 ensures that the DG is tested under load conditions that are as close to design basis conditions as possible. When synchronized with offsite power, testing should be performed at a power factor of ≤ [0.9]. This power factor is representative of the actual inductive loading a DG would see under design basis accident conditions. Under certain conditions, however, Note 2 allows the Surveillance to be conducted at a power factor other than ≤ [0.9]. These conditions occur when grid voltage is high, and the additional field excitation needed to get the power factor to ≤ [0.9] results in voltages on the emergency busses that are too high. Under these conditions, the power factor should be maintained as close as practicable to [0.9] while still maintaining acceptable voltage limits on the emergency busses. In other circumstances, the grid voltage may be such that the DG excitation levels needed to obtain a power factor of [0.9] may not cause unacceptable voltages on the emergency busses, but the excitation levels are in excess of those recommended for the DG. In such cases, the power factor shall be maintained as close as practicable to [0.9] without exceeding the DG excitation limits.

SURVEILLANCE REQUIREMENTS (continued)

---------------------------------REVIEWER'S NOTE---------------------------
The above MODE restrictions may be deleted if it can be demonstrated to the staff, on a plant specific basis, that performing the SR with the reactor in any of the restricted MODES can satisfy the following criteria, as applicable:

a. Performance of the SR will not render any safety system or component inoperable,

b. Performance of the SR will not cause perturbations to any of the electrical distribution systems that could result in a challenge to steady state operation or to plant safety systems, and

c. Performance of the SR, or failure of the SR, will not cause, or result in, an AOO with attendant challenge to plant safety systems.

SR 3.8.1.11

As required by Regulatory Guide 1.108 (Ref. 9), paragraph 2.a.(1), this Surveillance demonstrates the as designed operation of the standby power sources during loss of the offsite source. This test verifies all actions encountered from the loss of offsite power, including shedding of the nonessential loads and energization of the emergency buses and respective loads from the DG. It further demonstrates the capability of the DG to automatically achieve the required voltage and frequency within the specified time.

The DG autostart time of [10] seconds is derived from requirements of the accident analysis to respond to a design basis large break LOCA. The Surveillance should be continued for a minimum of 5 minutes in order to demonstrate that all starting transients have decayed and stability is achieved.

The requirement to verify the connection and power supply of permanent and autoconnected loads is intended to satisfactorily show the relationship of these loads to the DG loading logic. In certain circumstances, many of these loads cannot actually be connected or loaded without undue hardship or potential for undesired operation. For instance, Emergency Core Cooling Systems (ECCS) injection valves are not desired to be stroked open, or high pressure injection systems are not capable of being operated at full flow, or residual heat removal (RHR) systems performing a decay heat removal function are not desired to be realigned to the ECCS mode of operation. In lieu of actual demonstration

SURVEILLANCE REQUIREMENTS (continued)

of connection and loading of loads, testing that adequately shows the capability of the DG systems to perform these functions is acceptable. This testing may include any series of sequential, overlapping, or total steps so that the entire connection and loading sequence is verified.

SR 3.8.1.11 also demonstrates that the DG can achieve steady state voltage and frequency within the specified band around the nominal values of [4160] V and [60] Hz. The band placed around these nominal values is based on the capability of the voltage regulator and governor. The voltage and frequency bands are determined in accordance with WCAP-17308-P (Ref. 11). WCAP-17308-P provides the methodology to evaluate the impact of variations in voltage and frequency, due to the voltage regulator and governor, on the following:

- Pump flow and developed head to adjust pump Inservice Testing (IST) curves,
- DG loading calculations,
- DG fuel consumption calculations,
- Motor Operated Valve (MOV) performance, and
- Ventilation fans credited in the dose analyses.

[The Frequency of [18 months] is consistent with the recommendations of Regulatory Guide 1.108 (Ref. 9), paragraph 2.a.(1), takes into consideration unit conditions required to perform the Surveillance, and is intended to be consistent with expected fuel cycle lengths.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

---------------------------------REVIEWER'S NOTE----------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
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This SR is modified by two Notes. The reason for Note 1 is to minimize wear and tear on the DGs during testing. For the purpose of this testing, the DGs must be started from standby conditions, that is, with the engine coolant and oil continuously circulated and temperature maintained consistent with manufacturer recommendations. The reason for Note 2 is that performing the Surveillance would remove a required offsite circuit from service, perturb the electrical distribution system, and challenge safety systems. This restriction from normally performing the Surveillance in MODE 1 or 2 is further amplified to allow portions of the

Surveillance to be performed for the purpose of reestablishing OPERABILITY (e.g., post work testing following corrective maintenance, corrective modification, deficient or incomplete surveillance testing, and other unanticipated OPERABILITY concerns) provided an assessment determines plant safety is maintained or enhanced. This assessment shall, as a minimum, consider the potential outcomes and transients associated with a failed partial Surveillance, a successful partial Surveillance, and a perturbation of the offsite or onsite system when they are tied together or operated independently for the partial Surveillance; as well as the operator procedures available to cope with these outcomes. These shall be measured against the avoided risk of a plant shutdown and startup to determine that plant safety is maintained or enhanced when portions of the Surveillance are performed in MODE 1 or 2. Risk insights or deterministic methods may be used for the assessment. Credit may be taken for unplanned events that satisfy this SR.

SURVEILLANCE REQUIREMENTS (continued)

[SR 3.8.1.12

This Surveillance demonstrates that the DG automatically starts and achieves the required voltage and frequency within the specified time ([10] seconds) from the design basis actuation signal (LOCA signal) and operates for ≥ 5 minutes. The 5 minute period provides sufficient time to demonstrate stability. SR 3.8.1.12.d and SR 3.8.1.12.e ensure that permanently connected loads and emergency loads are energized from the offsite electrical power system on an ESF signal without loss of offsite power.

The requirement to verify the connection of permanent and autoconnected loads is intended to satisfactorily show the relationship of these loads to the DG loading logic. In certain circumstances, many of these loads cannot actually be connected or loaded without undue hardship or potential for undesired operation. For instance, ECCS injection valves are not desired to be stroked open, or high pressure injection systems are not capable of being operated at full flow, or RHR systems performing a decay heat removal function are not desired to be realigned to the ECCS mode of operation. In lieu of actual demonstration of connection and loading of loads, testing that adequately shows the capability of the DG system to perform these functions is acceptable. This testing may include any series of sequential, overlapping, or total steps so that the entire connection and loading sequence is verified.

The criteria of achieving ≥ [3740] V and ≥ [58.8] Hz in ≤ [10] seconds when a DG is started from a standby condition are starting and accelerating design criteria for the DG that are specified to confirm the capability of the DG to recover from a loading transient. The -10% for voltage and the -2% for frequency are consistent with the guidance provided in Paragraph 1.4, of Regulatory Guide 1.9 (Ref. 3).

SR 3.8.1.12 also demonstrates that the DG can achieve steady state voltage and frequency within the specified band around the nominal values of [4160] V and [60] Hz. The band placed around these nominal values is based on the capability of the voltage regulator and governor. The voltage and frequency bands are determined in accordance with WCAP-17308-P (Ref. 11). WCAP-17308-P provides the methodology to evaluate the impact of variations in voltage and frequency, due to the voltage regulator and governor, on the following:

- Pump flow and developed head to adjust pump Inservice Testing (IST) curves,
- DG loading calculations,
- DG fuel consumption calculations,
- Motor Operated Valve (MOV) performance, and
- Ventilation fans credited in the dose analyses.

[The Frequency of [18 months] takes into consideration unit conditions required to perform the Surveillance and is intended to be consistent with the expected fuel cycle lengths. Operating experience has shown that these components usually pass the SR when performed at the [18 month] Frequency. Therefore, the Frequency was concluded to be acceptable from a reliability standpoint.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

-----------------------------------REVIEWER'S NOTE-----------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
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BASES

SURVEILLANCE REQUIREMENTS (continued)

This SR is modified by two Notes. The reason for Note 1 is to minimize wear and tear on the DGs during testing. For the purpose of this testing, the DGs must be started from standby conditions, that is, with the engine coolant and oil continuously circulated and temperature maintained consistent with manufacturer recommendations. The reason for Note 2 is that during operation with the reactor critical, performance of this Surveillance could cause perturbations to the electrical distribution systems that could challenge continued steady state operation and, as a result, unit safety systems. This restriction from normally performing the Surveillance in MODE 1 or 2 is further amplified to allow portions of the Surveillance to be performed for the purpose of reestablishing OPERABILITY (e.g., post work testing following corrective maintenance, corrective modification, deficient or incomplete surveillance testing, and other unanticipated OPERABILITY concerns) provided an assessment determines plant safety is maintained or enhanced. This assessment shall, as a minimum, consider the potential outcomes and transients associated with a failed partial Surveillance, a successful partial Surveillance, and a perturbation of the offsite or onsite system when they are tied together or operated independently for the partial Surveillance; as well as the operator procedures available to cope with these outcomes. These shall be measured against the avoided risk of a plant shutdown and startup to determine that plant safety is maintained or enhanced when portions of the Surveillance are performed in MODE 1 or 2. Risk insights or deterministic methods may be used for the assessment.] Credit may be taken for unplanned events that satisfy this SR.

SR 3.8.1.13

This Surveillance demonstrates that DG noncritical protective functions (e.g., high jacket water temperature) are bypassed on a loss of voltage signal concurrent with an ESF actuation test signal. Noncritical automatic trips are all automatic trips except:

a. Engine overspeed;

b. Generator differential current;

[c. Low lube oil pressure;

d. High crankcase pressure; and

e. Start failure relay.]

BASES

SURVEILLANCE REQUIREMENTS (continued)

The noncritical trips are bypassed during DBAs and provide an alarm on an abnormal engine condition. This alarm provides the operator with sufficient time to react appropriately. The DG availability to mitigate the DBA is more critical than protecting the engine against minor problems that are not immediately detrimental to emergency operation of the DG.

[The [18 month] Frequency is based on engineering judgment, taking into consideration unit conditions required to perform the Surveillance, and is intended to be consistent with expected fuel cycle lengths. Operating experience has shown that these components usually pass the SR when performed at the [18 month] Frequency. Therefore, the Frequency was concluded to be acceptable from a reliability standpoint.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

----------------------------------REVIEWER'S NOTE-----------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
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The SR is modified by a Note. The reason for the Note is that performing the Surveillance would remove a required DG from service. This restriction from normally performing the Surveillance in MODE 1 or 2 is further amplified to allow the Surveillance to be performed for the purpose of reestablishing OPERABILITY (e.g., post work testing following corrective maintenance, corrective modification, deficient or incomplete surveillance testing, and other unanticipated OPERABILITY concerns) provided an assessment determines plant safety is maintained or enhanced. This assessment shall, as a minimum, consider the potential outcomes and transients associated with a failed Surveillance, a successful Surveillance, and a perturbation of the offsite or onsite system when they are tied together or operated independently for the Surveillance; as well as the operator procedures available to cope with these outcomes. These shall be measured against the avoided risk of a plant shutdown and startup to determine that plant safety is maintained or enhanced when the Surveillance is performed in MODE 1 or 2. Risk insights or deterministic methods may be used for this assessment. Credit may be taken for unplanned events that satisfy this SR.

SURVEILLANCE REQUIREMENTS (continued)

---------------------------------REVIEWER'S NOTE---------------------------------
The above MODE restrictions may be deleted if it can be demonstrated to the staff, on a plant specific basis, that performing the SR with the reactor in any of the restricted MODES can satisfy the following criteria, as applicable:

a. Performance of the SR will not render any safety system or component inoperable,

b. Performance of the SR will not cause perturbations to any of the electrical distribution systems that could result in a challenge to steady state operation or to plant safety systems, and

c. Performance of the SR, or failure of the SR, will not cause, or result in, an AOO with attendant challenge to plant safety systems.

SR 3.8.1.14

Regulatory Guide 1.108 (Ref. 9), paragraph 2.a.(3), requires demonstration that the DGs can start and run continuously at full load capability for an interval of not less than 24 hours, ≥ [2] hours of which is at a load equivalent to 110% of the continuous duty rating and the remainder of the time at a load equivalent to the continuous duty rating of the DG. The DG starts for this Surveillance can be performed either from standby or hot conditions. The provisions for prelubricating and warmup, discussed in SR 3.8.1.2, and for gradual loading, discussed in SR 3.8.1.3, are applicable to this SR.

The load band is provided to avoid routine overloading of the DG. Routine overloading may result in more frequent teardown inspections in accordance with vendor recommendations in order to maintain DG OPERABILITY.

[The [18 month] Frequency is consistent with the recommendations of Regulatory Guide 1.108 (Ref. 9), paragraph 2.a.(3), takes into consideration unit conditions required to perform the Surveillance, and is intended to be consistent with expected fuel cycle lengths.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

BASES

SURVEILLANCE REQUIREMENTS (continued)

-----------------------------------REVIEWER'S NOTE-----------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
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This Surveillance is modified by three Notes. Note 1 states that momentary transients due to changing bus loads do not invalidate this test. Similarly, momentary power factor transients above the power factor limit will not invalidate the test. The reason for Note 2 is that during operation with the reactor critical, performance of this Surveillance could cause perturbations to the electrical distribution systems that could challenge continued steady state operation and, as a result, unit safety systems. This restriction from normally performing the Surveillance in MODE 1 or 2 is further amplified to allow the Surveillance to be performed for the purpose of reestablishing OPERABILITY (e.g., post work testing following corrective maintenance, corrective modification, deficient or incomplete surveillance testing, and other unanticipated OPERABILITY concerns) provided an assessment determines plant safety is maintained or enhanced. This assessment shall, as a minimum, consider the potential outcomes and transients associated with a failed Surveillance, a successful Surveillance, and a perturbation of the offsite or onsite system when they are tied together or operated independently for the Surveillance; as well as the operator procedures available to cope with these outcomes. These shall be measured against the avoided risk of a plant shutdown and startup to determine that plant safety is maintained or enhanced when the Surveillance is performed in MODE 1 or 2. Risk insights or deterministic methods may be used for this assessment. Credit may be taken for unplanned events that satisfy this SR. Note 3 ensures that the DG is tested under load conditions that are as close to design basis conditions as possible. When synchronized with offsite power, testing should be performed at a power factor of ≤ [0.9]. This power factor is representative of the actual inductive loading a DG would see under design basis accident conditions. Under certain conditions, however, Note 3 allows the Surveillance to be conducted as a power factor other than ≤ [0.9]. These conditions occur when grid voltage is high, and the additional field excitation needed to get the power factor to ≤ [0.9] results in voltages on the emergency busses that are too high. Under these conditions, the power factor should be maintained as close as practicable to [0.9] while still maintaining acceptable voltage limits on the emergency busses. In other circumstances, the grid voltage may be such that the DG excitation levels needed to obtain a power factor of [0.9] may not cause unacceptable voltages on the emergency busses, but the excitation levels are in excess of those recommended for the DG. In such cases, the power factor shall be maintained close as practicable to [0.9] without exceeding the DG excitation limits.

SURVEILLANCE REQUIREMENTS (continued)

SR 3.8.1.15

This Surveillance demonstrates that the diesel engine can restart from a hot condition, such as subsequent to shutdown from normal Surveillances, and achieve the required voltage and frequency within [10] seconds. The [10] second time is derived from the requirements of the accident analysis to respond to a design basis large break LOCA.

The criteria of achieving ≥ [3740] V and ≥ [58.8] Hz in ≤ [10] seconds when a DG is started from a standby condition are starting and accelerating design criteria for the DG that are specified to confirm the capability of the DG to recover from a loading transient. The -10% for voltage and the -2% for frequency are consistent with the guidance provided in Paragraph 1.4, of Regulatory Guide 1.9 (Ref. 3).

SR 3.8.1.15 also demonstrates that the DG can achieve steady state voltage and frequency within the specified band around the nominal values of [4160] V and [60] Hz. The band placed around these nominal values is based on the capability of the voltage regulator and governor. The voltage and frequency bands are determined in accordance with WCAP-17308-P (Ref. 11). WCAP-17308-P provides the methodology to evaluate the impact of variations in voltage and frequency, due to the voltage regulator and governor, on the following:

- Pump flow and developed head to adjust pump Inservice Testing (IST) curves,
- DG loading calculations,
- DG fuel consumption calculations,
- Motor Operated Valve (MOV) performance, and
- Ventilation fans credited in the dose analyses.

[The [18 month] Frequency is consistent with the recommendations of Regulatory Guide 1.108 (Ref. 9), paragraph 2.a.(5).

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

---------------------------------REVIEWER'S NOTE----------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
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This SR is modified by two Notes. Note 1 ensures that the test is performed with the diesel sufficiently hot. The load band is provided to avoid routine overloading of the DG. Routine overloads may result in more frequent teardown inspections in accordance with vendor recommendations in order to maintain DG OPERABILITY. The requirement that the diesel has operated for at least [2] hours at full load conditions prior to performance of this Surveillance is based on manufacturer recommendations for achieving hot conditions. Momentary transients due to changing bus loads do not invalidate this test. Note 2 allows all DG starts to be preceded by an engine prelube period to minimize wear and tear on the diesel during testing.

SR 3.8.1.16

As required by Regulatory Guide 1.108 (Ref. 9), paragraph 2.a.(6), this Surveillance ensures that the manual synchronization and automatic load transfer from the DG to the offsite source can be made and the DG can be returned to ready to load status when offsite power is restored. It also ensures that the autostart logic is reset to allow the DG to reload if a

BASES

SURVEILLANCE REQUIREMENTS (continued)

subsequent loss of offsite power occurs. The DG is considered to be in ready to load status when the DG is at rated speed and voltage, the output breaker is open and can receive an autoclose signal on bus undervoltage, and the load sequence timers are reset.

[The Frequency of [18 months] is consistent with the recommendations of Regulatory Guide 1.108 (Ref. 9), paragraph 2.a.(6), and takes into consideration unit conditions required to perform the Surveillance.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

---------------------------------REVIEWER'S NOTE---------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
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This SR is modified by a Note. The reason for the Note is that performing the Surveillance would remove a required offsite circuit from service, perturb the electrical distribution system, and challenge safety systems. This restriction from normally performing the Surveillance in MODE 1 or 2 is further amplified to allow the Surveillance to be performed for the purpose of reestablishing OPERABILITY (e.g., post work testing following corrective maintenance, corrective modification, deficient or incomplete surveillance testing, and other unanticipated OPERABILITY concerns) provided an assessment determines plant safety is maintained or enhanced. This assessment shall, as a minimum, consider the potential outcomes and transients associated with a failed Surveillance, a successful Surveillance, and a perturbation of the offsite or onsite system when they are tied together or operated independently for the Surveillance; as well as the operator procedures available to cope with these outcomes. These shall be measured against the avoided risk of a plant shutdown and startup to determine that plant safety is maintained or enhanced when the Surveillance is performed in MODE 1 or 2. Risk insights or deterministic methods may be used for this assessment. Credit may be taken for unplanned events that satisfy this SR.

BASES

SURVEILLANCE REQUIREMENTS (continued)

[SR 3.8.1.17

Demonstration of the test mode override ensures that the DG availability under accident conditions will not be compromised as the result of testing and the DG will automatically reset to ready to load operation if a LOCA actuation signal is received during operation in the test mode. Ready to load operation is defined as the DG running at rated speed and voltage with the DG output breaker open. These provisions for automatic switchover are required by IEEE-308 (Ref. 13), paragraph 6.2.6(2).

The requirement to automatically energize the emergency loads with offsite power is essentially identical to that of SR 3.8.1.12. The intent in the requirement associated with SR 3.8.1.17.b is to show that the emergency loading was not affected by the DG operation in test mode. In lieu of actual demonstration of connection and loading of loads, testing that adequately shows the capability of the emergency loads to perform these functions is acceptable.

This testing may include any series of sequential, overlapping, or total steps so that the entire connection and loading sequence is verified.

[The [18 month] Frequency is consistent with the recommendations of Regulatory Guide 1.108 (Ref. 9), paragraph 2.a.(8), takes into consideration unit conditions required to perform the Surveillance, and is intended to be consistent with expected fuel cycle lengths.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

---------------------------------REVIEWER'S NOTE---------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
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This SR is modified by a Note. The reason for the Note is that performing the Surveillance would remove a required offsite circuit from service, perturb the electrical distribution system, and challenge safety systems. This restriction from normally performing the Surveillance in MODE 1 or 2 is further amplified to allow portions of the Surveillance to be performed for the purpose of reestablishing OPERABILITY (e.g., post work testing

SURVEILLANCE REQUIREMENTS (continued)

following corrective maintenance, corrective modification, deficient or incomplete surveillance testing, and other unanticipated OPERABILITY concerns) provided an assessment determines plant safety is maintained or enhanced. This assessment shall, as a minimum, consider the potential outcomes and transients associated with a failed partial Surveillance, a successful partial Surveillance, and a perturbation of the offsite or onsite system when they are tied together or operated independently for the partial Surveillance; as well as the operator procedures available to cope with these outcomes. These shall be measured against the avoided risk of a plant shutdown and startup to determine that plant safety is maintained or enhanced when portions of the Surveillance are performed in MODE 1 or 2. Risk insights or deterministic methods may be used for the assessment.] Credit may be taken for unplanned events that satisfy this SR.

<u>SR 3.8.1.18</u>

Under accident [and loss of offsite power] conditions loads are sequentially connected to the bus by the [automatic load sequencer]. The sequencing logic controls the permissive and starting signals to motor breakers to prevent overloading of the DGs due to high motor starting currents. The [10]% load sequence time interval tolerance ensures that sufficient time exists for the DG to restore frequency and voltage prior to applying the next load and that safety analysis assumptions regarding ESF equipment time delays are not violated. Reference 2 provides a summary of the automatic loading of ESF buses.

[The Frequency of [18 months] is consistent with the recommendations of Regulatory Guide 1.108 (Ref. 9), paragraph 2.a.(2), takes into consideration unit conditions required to perform the Surveillance, and is intended to be consistent with expected fuel cycle lengths.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

----------------------------------REVIEWER'S NOTE----------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
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BASES

SURVEILLANCE REQUIREMENTS (continued)

This SR is modified by a Note. The reason for the Note is that performing the Surveillance would remove a required offsite circuit from service, perturb the electrical distribution system, and challenge safety systems. This restriction from normally performing the Surveillance in MODE 1 or 2 is further amplified to allow the Surveillance to be performed for the purpose of reestablishing OPERABILITY (e.g., post work testing following corrective maintenance, corrective modification, deficient or incomplete surveillance testing, and other unanticipated OPERABILITY concerns) provided an assessment determines plant safety is maintained or enhanced. This assessment shall, as a minimum, consider the potential outcomes and transients associated with a failed Surveillance, a successful Surveillance, and a perturbation of the offsite or onsite system when they are tied together or operated independently for the Surveillance; as well as the operator procedures available to cope with these outcomes. These shall be measured against the avoided risk of a plant shutdown and startup to determine that plant safety is maintained or enhanced when the Surveillance is performed in MODE 1 or 2. Risk insights or deterministic methods may be used for this assessment. Credit may be taken for unplanned events that satisfy this SR.

---------------------------------REVIEWER'S NOTE---------------------------------
The above MODE restrictions may be deleted if it can be demonstrated to the staff, on a plant specific basis, that performing the SR with the reactor in any of the restricted MODES can satisfy the following criteria, as applicable:

a. Performance of the SR will not render any safety system or component inoperable,

b. Performance of the SR will not cause perturbations to any of the electrical distribution systems that could result in a challenge to steady state operation or to plant safety systems, and

c. Performance of the SR, or failure of the SR, will not cause, or result in, an AOO with attendant challenge to plant safety systems.

SR 3.8.1.19

In the event of a DBA coincident with a loss of offsite power, the DGs are required to supply the necessary power to ESF systems so that the fuel, RCS, and containment design limits are not exceeded.

BASES

SURVEILLANCE REQUIREMENTS (continued)

This Surveillance demonstrates the DG operation, as discussed in the Bases for SR 3.8.1.11, during a loss of offsite power actuation test signal in conjunction with an ESF actuation signal. In lieu of actual demonstration of connection and loading of loads, testing that adequately shows the capability of the DG system to perform these functions is acceptable. This testing may include any series of sequential, overlapping, or total steps so that the entire connection and loading sequence is verified.

SR 3.8.1.19 also demonstrates that the DG can achieve steady state voltage and frequency within the specified band around the nominal values of [4160] V and [60] Hz. The band placed around these nominal values is based on the capability of the voltage regulator and governor. The voltage and frequency bands are determined in accordance with WCAP-17308-P (Ref. 11). WCAP-17308-P provides the methodology to evaluate the impact of variations in voltage and frequency, due to the voltage regulator and governor, on the following:

- Pump flow and developed head to adjust pump Inservice Testing (IST) curves,
- DG loading calculations,
- DG fuel consumption calculations,
- Motor Operated Valve (MOV) performance, and
- Ventilation fans credited in the dose analyses.

[The Frequency of [18 months] takes into consideration unit conditions required to perform the Surveillance and is intended to be consistent with an expected fuel cycle length of [18 months].

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

-----------------------------------REVIEWER'S NOTE-----------------------------------
Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.
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This SR is modified by two Notes. The reason for Note 1 is to minimize wear and tear on the DGs during testing. For the purpose of this testing, the DGs must be started from standby conditions, that is, with the engine coolant and oil continuously circulated and temperature maintained consistent with manufacturer recommendations for DGs. The reason for Note 2 is that the performance of the Surveillance would remove a required offsite circuit from service, perturb the electrical distribution system, and challenge safety systems. This restriction from normally performing the Surveillance in MODE 1 or 2 is further amplified to allow portions of the Surveillance to be performed for the purpose of reestablishing OPERABILITY (e.g., post work testing following corrective maintenance, corrective modification, deficient or incomplete surveillance testing, and other unanticipated OPERABILITY concerns) provided an assessment determines plant safety is maintained or enhanced. This assessment shall, as a minimum, consider the potential outcomes and transients associated with a failed partial Surveillance, a successful partial Surveillance, and a perturbation of the offsite or onsite system when they are tied together or operated independently for the partial Surveillance; as well as the operator procedures available to cope with

SURVEILLANCE REQUIREMENTS (continued)

these outcomes. These shall be measured against the avoided risk of a plant shutdown and startup to determine that plant safety is maintained or enhanced when portions of the Surveillance are performed in MODE 1 or 2. Risk insights or deterministic methods may be used for the assessment. Credit may be taken for unplanned events that satisfy this SR.

SR 3.8.1.20

This Surveillance demonstrates that the DG starting independence has not been compromised. Also, this Surveillance demonstrates that each engine can achieve proper speed within the specified time when the DGs are started simultaneously.

The criteria of achieving ≥ [3740] V and ≥ [58.8] Hz in ≤ [10] seconds when a DG is started from a standby condition are starting and accelerating design criteria for the DG that are specified to confirm the capability of the DG to recover from a loading transient. The -10% for voltage and the -2% for frequency are consistent with the guidance provided in Paragraph 1.4, of Regulatory Guide 1.9 (Ref. 3).

SR 3.8.1.20 also demonstrates that the DG can achieve steady state voltage and frequency within the specified band around the nominal values of [4160] V and [60] Hz. The band placed around these nominal values is based on the capability of the voltage regulator and governor. The voltage and frequency bands are determined in accordance with WCAP-17308-P (Ref. 11). WCAP-17308-P provides the methodology to evaluate the impact of variations in voltage and frequency, due to the voltage regulator and governor, on the following:

- Pump flow and developed head to adjust pump Inservice Testing (IST) curves,
- DG loading calculations,
- DG fuel consumption calculations,
- Motor Operated Valve (MOV) performance, and
- Ventilation fans credited in the dose analyses.

[The 10 year Frequency is consistent with the recommendations of Regulatory Guide 1.108 (Ref. 9).

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

----------------------------------REVIEWER'S NOTE----------------------------------

Plants controlling Surveillance Frequencies under a Surveillance Frequency Control Program should utilize the appropriate Frequency description, given above, and the appropriate choice of Frequency in the Surveillance Requirement.

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This SR is modified by a Note. The reason for the Note is to minimize wear on the DG during testing. For the purpose of this testing, the DGs must be started from standby conditions, that is, with the engine coolant and oil continuously circulated and temperature maintained consistent with manufacturer recommendations.

REFERENCES

1. 10 CFR 50, Appendix A, GDC 17.
2. FSAR, Chapter [8].
3. Regulatory Guide 1.9, Rev. 3.
4. FSAR, Chapter [6].
5. FSAR, Chapter [15].

BASES

REFERENCES (continued)

6. Regulatory Guide 1.93, Rev. 0, December 1974.

7. Generic Letter 84-15, "Proposed Staff Actions to Improve and Maintain Diesel Generator Reliability," July 2, 1984.

8. 10 CFR 50, Appendix A, GDC 18.

9. Regulatory Guide 1.108, Rev. 1, August 1977.

10. Regulatory Guide 1.137, Rev. [ ], [date].

11. WCAP-17308-P, "Treatment of Diesel Generator (DG) Technical Specification Frequency and Voltage Tolerances," Revision **X**, **[DATE]**.

12. ASME Code for Operation and Maintenance of Nuclear Power Plants.

~~12~~13. IEEE Standard 308-1978.