NRC Question 1

Question: (State Question from Matrix)

If the pump tripped at high vibes can it restart?

Answer and Basis: If the pump were immediately restarted, it probably would not restart due to the thermal expansion of the shaft forcing the impeller into the bowl liner. The pump motor would probably trip on instantaneous overcurrent. If the pump sat idle for some period of time, at least several minutes, the temperature of the shaft would have time to cool down and shrink creating a clearance between the impeller and bowl liner. If gland water were introduced to the pump prior to restarting it, the shaft would shrink enough to allow the pump to be restarted almost immediately due to the increased impeller to bowl liner clearance.

Name, Title and Date: Dwight Vorpahl, Senior Staff Engineer 9/21/04

Sign: Dwight J Vorpahl

Provide Copy to Paul Fleming

J-9

NRC Question 3

Question:

If two pumps are operating is there a potential synergistic effect from high vibrations?

Answer and Basis:

No adverse synergistic effect from high vibrations would be expected to occur.

During the 90 minute portion of the pump test when gland water was isolated, high acceleration levels (7.02g maximum) on the pump structure occurred at frequencies between 70-80 hz. At these high frequency levels, the Intake Structure is not susceptible to amplification. The service water pumps/motors have a relatively small mass compared to the mass of the supporting Intake Structure, therefore, vibratory energy from the pumps would not be effectively transferred between the two pumps. Consequently, the vibrating pumps would not cause any adverse structural response to the building structure or from one pump to the other. Since both pumps are supported similarly from the Intake Structure floor slab and walls, no adverse interaction (pump/motor or structure failure) would be expected even from two vibrating pumps.

Reinforced concrete building structures, including the Intake Structure, typically respond with amplification, including high displacements, at low frequencies (<10 hz). During the pump test, no adverse structural damage occurred to the pump column, pump column anchorage, or motor and pump discharge head support structure. This fact supports the contention that no pump supporting structure amplification would be expected. In addition, the Intake Structure and service water pump configuration are more robust and have more mass than the test configuration. Consequently, any response to the vibrating pumps in the Intake Structure should be less severe than for the test configuration.

Name, Title and Date:

Perry K. Adelung; Senior Civil/Structural Engineer;
John Charterina; Equipment Reliability Engineering Supervisor;
9-22-04

Sign: Perry K. Adelung 9-22-04

Sign: John Charterina 9.22.04

NRC Question 5

Question: (State Question from Matrix)

Differences between motor bearings (square –vs- round) and oil sample results.

Answer and Basis:
The bearing differences between the square and round motors are judged not to have an effect on the test performed at RTS. The bearing locations in both motors are similar, the thrust bearings in both motors are identical and the differences in the guide bearings are negligible. Additionally the oil sample results showed no signs of bearing degradation.

<u>Service Water Pump Motor Bearing Differences</u>
The Service Water pump motors currently installed at CNS and the motor used in the test performed by RTS are equivalent but not identical. This paper serves to evaluate and differences in bearing location and possible differences between the bearings used in each motor.

The model numbers for each of the motors are:
GE Model Number 5K6328XC234A – Round Motor (original SW pump motors)
GE Model Number 5KS511DT7403HB – Square Motor (spare)

<u>Motor Bearing Location</u>
Each motor has one lower deep groove ball bearing which limits axial rotor motion (guide bearing) and two angular contact ball bearings (stacked together) which are used as a thrust bearing.

The location of the guide bearing for the round motor is just above the mounting flange and the thrust bearings are located just below the top of the motor. The exact locations of the bearings in the square motor are not precisely known. However, the bearings are typically located at the ends of the motor (as they are in the round motor) and this is further supported by the location of the oil reservoirs (the bearings are oil lubricated) which are at the ends of the square motor. Since the square motor is approximately 5 inches taller than the round motor it can be concluded that the maximum difference between the thrust and guide bearings in the square motor is 5 inches longer than that of the round motor.

As the bearing placement in both motors is consistent, it is judged that any small difference in the distance between the bearings between the two motors would have a negligible effect on the test performed at RTS.

Bearing Information

CNS Vendor Manual 1701 and the work history for the Service Water motors show that the thrust bearing for the installed Service Water Pump Motors is a SKF 7230 BCBM. Information on the square (test) motor thrust bearings was obtained from the manufacturer (GE) and these bearings were also found to be SKF model 7230 BCBM.

Thrust Bearing Information

Type – Single Row Angular Contact Ball Bearing
Bore Diameter – 150 mm (5.9055 inches)
Outer Bearing Diameter – 270 mm (10.6299 inches)
Bearing Width – 45 mm (1.7717 inches) .
Load Rating – 43,600 lbf (dynamic), 50,000 lbf (static)
Speed Rating – 1700 RPM (grease lubricated), 2400 RPM (oil lubricated)
Weight – 25.4 pounds
Material

- Races – SAE 52100 bearing steel
- Balls – SAE 52100 bearing steel
- Cage – Brass

Suffix Designation – BCBM: standard internal clearances, brass cage

There is no difference between the thrust bearings in either the square or round motor.

Guide Bearings

CNS Vendor Manual 1701 and the work history for the Service Water motors show that the guide bearing for the installed Service Water Pump Motors is a SKF 6220J. Information on the square (test) motor guide bearing was obtained from the manufacturer (GE) and this bearing was found to be SKF model 6219.

Round Motor Guide Bearing – SKF model 6220J

Type – Single Row Deep Groove Ball Bearing
Bore Diameter – 100 mm (3.937 inches)
Outer Bearing Diameter – 180 mm (7.0866 inches)
Bearing Width – 34 mm (1.3386 inches)
Load Rating – 124,000 lbf (dynamic), 93,000 lbf (static)
Speed Rating – 3400 RPM (grease lubricated), 4000 RPM (oil lubricated)
Weight – 6.95 pounds
Material

- Races – SAE 52100 bearing steel
- Balls – SAE 52100 bearing steel
- Cage – Pressed Steel (as designated by the 'J' suffix)

Square Motor Guide Bearing – SKF model 6619/C3S1

Type – Single Row Deep Groove Ball Bearing
Bore Diameter – 95 mm (3.7402 inches)
Outer Bearing Diameter – 170 mm (6.6929 inches)
Bearing Width – 32 mm (1.2598 inches)
Load Rating – 108,000 lbf (dynamic), 81,500 lbf (static)
Speed Rating – 3600 RPM (grease lubricated), 4300 RPM (oil lubricated)
Weight – 5.73 pounds
Material

- Races – SAE 52100 bearing steel
- Balls – SAE 52100 bearing steel
- Cage – Brass

Suffix Designation – C3: Bearing internal clearance greater than normal
S1: Bearing rings or washers dimensionally stabilized for use at operating temperatures up to +200°C

Guide Bearing Differences

The lower bearings for the square and round motors are both single row deep groove ball bearings but they are not physically the same size. The bore and outside diameters as well as the bearing width are all slightly (the largest variation is 5mm) larger for the bearing in the round motor. This increase in bearing size is judged to have no effect on the test performed by RTS as the change in dimension is almost negligible.

The load ratings (both dynamic and static) of the bearing in the square motor are less than those of the round motor bearings. Therefore, using the square motor lower bearing would be more conservative as it would fail under a smaller load.

The cage material for both bearings is different. This difference (brass versus steel) is judged to have no effect on the test performed at RTS as the function of the cage is to position the balls in the bearing and the cage material has no effect on any critical characteristic of the bearing.

The C3S1 suffix on the square motor bearings specifies a greater than normal internal bearing clearance and that the bearing is capable of operating at temperatures of over 200°C (the motor operates at temperatures much less than this). The internal clearance on the square motor bearing being larger than that of the bearing on the round motor is judged to have no effect on the test as the side loading of this motor should be minimal. The greater internal clearance on the square motor would result in more axial 'play' in the square motor. This would result in more give at the lower guide bearing and would be more conservative as it would allow more shaft (both motor and pump) deflection than the motors installed in the plant.

Oil Sample Results

The oil sample results are attached and show no bearing degradation.

References
CNS Vendor manual 1701 Revision 5
Master Data (Material Numbers 4004771 and 4022530)
Work Order 4195971
MWR's 84-0403, 84-1580, 84-3310, 87-0827, 88-1185, 88-1646, 88-1828, 88-4995, 93-1354, 99-0032 and 00-2833
Drawing G0800*148C6900AP Sheet 1, Revision 4 (Ret. #452225654)
Drawing G0800*992C553AE, Revision N03 (Ret. #452009042)
Oil Sampling Analysis

Name, Title and Date:
Gabriel G. Gardner
Equipment Reliability Department – Maintenance Support Engineer
September 23, 2004

Sign:

Provide Copy to Paul Fleming

PdMA Corporation - Oil Analysis Data Sheet Report

NEBRASKA PUBLIC POWER

Sample ID: SQ-MOTOR-U **Description:** SQUARE MOTOR SPECIAL UPPER

Manufacturer: MOBIL **Oil Type:** DTE 797 **Grade:** 32.0

Lab Number / Sample Date		Units	206101 09/13/04
EAR METALS			
Iron	Fe	ppm	1
Chromium	Cr	ppm	0
Molybdenum	Mo	ppm	0
Aluminum	Al	ppm	0
Copper	Cu	ppm	1
Lead	Pb	ppm	0
Tin	Sn	ppm	0
Silver	Ag	ppm	0
Nickel	Ni	ppm	0
Vanadium	V	ppm	0
Titanium	Ti	ppm	0
Manganese	Mn	ppm	0
Cadmium	Cd	ppm	0
ONTAMINANT METALS			
Silicon	Si	ppm	0
Sodium	Na	ppm	0
Boron	B	ppm	0
DDITIVE METALS			
Magnesium	Mg	ppm	0
Calcium	Ca	ppm	0
Barium	Ba	ppm	0
Phosphorus	P	ppm	1
..nc	Zn	ppm	1
..METALLIC CONT.			
Water		% vol	Nil
Solids		% vol	<0.1
JBE DATA			
Viscosity @ 40'C		cSt	29.8
Total Acid Number		mg KOH/g	0.07
ARTICLE COUNT			
5		/ml	2380
10		/ml	399
15		/ml	73
20		/ml	28
30		/ml	12
40		/ml	0
NFRARED			
Hydroxy			0.000
Antiwear Loss			0.323
Oxidation			0.342
Nitration			0.568
Oxidation/Sulfate			0.251

PdMA Corporation - Oil Analysis Data Sheet Report

NEBRASKA PUBLIC POWER

Sample ID: SQ-MOTOR-U **Description:** SQUARE MOTOR SPECIAL UPPER

M[illegible]ufacturer: MOBIL **Oil Type:** DTE 797 **Grade:** 32.0

Lab Number		206101
Sample Date	**Units**	09/13/04

Severity: (N) - Normal

Recommended Action:

Continue sampling to track/trend data.

Data Interpretation:

Based on the results of the analyses performed on this sample the unit and lube appear satisfactory for continued usage.

PdMA Corporation - Oil Analysis Data Sheet Report

NEBRASKA PUBLIC POWER

Sample ID: SQ-MOTOR-L **Description:** SQUARE MOTOE SPECIAL LOWER

Ma--ufacturer: MOBIL **Oil Type:** DTE 797 **Grade:** 32.0

		Lab Number Sample Date	Units	206102 09/13/04
EAR METALS				
Iron	Fe		ppm	1
Chromium	Cr		ppm	0
Molybdenum	Mo		ppm	0
Aluminum	Al		ppm	0
Copper	Cu		ppm	0
Lead	Pb		ppm	0
Tin	Sn		ppm	0
Silver	Ag		ppm	0
Nickel	Ni		ppm	0
Vanadium	V		ppm	0
Titanium	Ti		ppm	0
Manganese	Mn		ppm	0
Cadmium	Cd		ppm	0
ONTAMINANT METALS				
Silicon	Si		ppm	0
Sodium	Na		ppm	0
Boron	B		ppm	0
DDITIVE METALS				
Magnesium	Mg		ppm	0
Calcium	Ca		ppm	0
Barium	Ba		ppm	0
Phosphorus	P		ppm	1
Zinc	Zn		ppm	1
ETALLIC CONT.				
Water			% vol	Nil
Solids			% vol	<0.1
JBE DATA				
Viscosity @ 40'C			cSt	30.0
Total Acid Number			mg KOH/g	0.07
ARTICLE COUNT				
5			/ml	1203
10			/ml	127
15			/ml	24
20			/ml	12
30			/ml	3
40			/ml	1
NFRARED				
Hydroxy				0.000
Antiwear Loss				0.323
Oxidation				0.341
Nitration				0.566
Oxidation/Sulfate				0.252

PdMA Corporation - Oil Analysis Data Sheet Report

NEBRASKA PUBLIC POWER

Sample ID: SQ-MOTOR-L **Description:** SQUARE MOTOE SPECIAL LOWER

M ıfacturer: MOBIL **Oil Type:** DTE 797 **Grade:** 32.0

Lab Number Sample Date	Units	206102 09/13/04

Severity: (N) - Normal

Recommended Action:

Continue sampling to track/trend data.

Data Interpretation:

Based on the results of the analyses performed on this sample the unit and lube appear satisfactory for continued usage.

NRC Question 6

Question: (State Question from Matrix)

Any other overload protection schemes?

Answer and Basis:

There are no overloads on these motors.

NEDC 86-105B is the calculation for coordination of the trips for the 4160 VAC.

Name, Title and Date:

Michael P Baldwin –Acting Supervisor -PED Electrical and I&C 9/23/04.

Sign: T S Hottaway for M. Baldwin via telecon

Provide Copy to Paul Fleming

NRC Question 7

Question: (State Question from Matrix)

48 hour basis was maintenance capability – what is the normal time to perform that maintenance (replace pump/motor) and would there be any complications with an adjacent pump operating (under emergency conditions)?

Answer and Basis: The normal time to replace a SW pump and motor is approximately 48 hours. The replacements are normally performed on dayshifts working 4, 12 hour days.

Under emergency conditions, the Mechanical Maintenance departments believes a pump and motor replacement can be performed around the clock in a period of approximately 24 hours. A complete set of pump replacement parts is normally available in the warehouse and was available during the time period the condition being discussed existed.

There are no complications with an adjacent pump operating. When SW pumps are normally overhauled, the adjacent pump is normally operating.

There may be complications with utilizing the 35 ton intake structure crane during a pump replacement in emergency conditions. This crane is fed from nonessential power. The power to the crane will be lost during a LOOP. It may take up to 12 hours to reestablish power to the intake structure crane.

Assuming it conservatively takes up to 36 hours to replace a pump and motor and up to 12 hours to establish power to the intake structure crane, a pump can be replaced in less than 48 hours under emergency conditions.

Name, Title and Date: Dwight Vorpahl, SW System Engineer 9/23/04

Sign:

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Shaft Material
Hardened
410 SS

NRC Question 8

Question: (State Question from Matrix)

If using fire service water to recover GW, then what was the delta-T and would that temperature difference cause a further problem?

Answer and Basis:

If fire water was used to recover gland water early in the event where the shaft has not heated up, the firewater would be initially close to ambient temperature (~70 deg F) due to stagnant water in the piping in the SW pump room and would slowly cool down to ~55 deg F due to the buried fire water supply pipe. This would cause the shaft to expand comparing it to the water temperature that existed at the time of the event (~40 deg F) This 30 deg F and 15 deg F delta may cause the shaft to expand up to 0.045". However, the clearance at this point was approximately 0.80" - ~0.030" (downthrust) = 0.050". Therfore if the shaft were to expand approximately another 0.045", the impeller would not hit the liner.

If fire water was used to recover gland water during the impeller rubbing event, the shaft would immediately start to cool and shrink, increasing the bowl to liner clearance. Therefore there would be no affect since the impeller has already worn into the liner and the clearance has increased.

If fire water was used to recover gland water after the event, the firewater would be initially close to ambient temperature (~70 deg F) due to stagnant water in the piping in the SW pump room and would slowly cool down to ~55 deg F due to the buried fire water supply pipe. This would cause the shaft to expand comparing it to the water temperature that existed at the time of the event (~40 deg F) This 30 deg F and 15 deg F delta may cause the shaft to expand up to 0.045". However, the clearance at this point was approximately 0.118" - ~0.030" (downthrust) = 0.088". Therfore if the shaft were to expand approximately another 0.045", the impeller would not hit the liner.

Name, Title and Date: Dwight Vorpahl, SW System Engineer 09/23/04

Sign: Dwight Vorpahl

Provide Copy to Paul Fleming

How would Operations respond to the Overload/ Ground Annunciator?

If the running SW pump is the only available pump and supplying cooling water to the Emergency Diesel Generator, then it would continue to be run.

Alarm card would be referenced for guidance. Continue to monitor DG loading and SW pump amps, and assess and evaluate plant conditions. Dispatch operator, if not already in the SWPR to check local operation of the pump. If the pump was to trip and the second pump was available to be started, then the second pump would be started based on Crew supervision judgment. There is possibility of starting the 2nd pump and securing the pump with high amps also based on crew supervision judgment.

Basis: Plant conditions require SW cooling to supply the EDG's. Continue to monitor the pump for worsening conditions, while investigation is ongoing into the high amp condition. Operating judgment of amps off scale could lead to the 2nd pump being started before the first pump is turned off.

Provide Name, Title and Date: Dan Goodman Control Room Supervisor 9-24-04

Sign Dan Goodman 9-24-04

Provide Copy to Paul Fleming

TO Re-open SW-MO-37
23-8-3
5.2 SW

How would Operations respond to High Amps or High Vibrations?

If the running SW pump is the only available pump and supplying cooling water to the Emergency Diesel Generator, then it would continue to be run.

Operations would monitor EDG loading, SW pump amps, discharge pressure and validate the amp/vibration condition. Dispatch NLO to the SWPR, if not already on location, to check condition of pump. Crew supervision may elect to start the 2^{nd} pump and then secure the pump with the high amps. Crew supervision may also allow the pump with high amps to be run indefinitely.

Basis: Plant conditions require SW cooling to supply the EDG's. Continue to monitor the pump for worsening conditions, while investigation is ongoing into the high amp condition. Operating judgment of amps off scale could lead to the 2^{nd} pump being started before the first pump is turned off.

Provide Name, Title and Date: Dan Goodman Control Room Supervisor 9-24-04

Sign Dan Goodman 9-24-04

Provide Copy to Paul Fleming

NRC Question 4

Question: (State Question from Matrix)

Compare natural frequency of test configuration to insitu configuration.

Answer and Basis:

SEE ATTACHED

Name, Title and Date:

JOHN CHARTERINA, ER SUPERVISOR 9/23/04

Sign:

JCharterina

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The natural frequency of the test configuration is unique in that it has an overall resonance (natural frequency) of 20 Hz, which happens to be very near the motor/pump operating speed of 1195 rpm (19.92 Hz). This is primarily due to the contribution from the motor to the overall resonance. This was expected since that motor, when previously used in the plant, also produced an overall natural frequency near 20 Hz.

Weights were added to the test configuration to shift the resonance response away from operating speed. This resulted in a 15% frequency shift. The final test configuration frequency response was measured at about 17 Hz.

The insitu configuration used a different style motor. An impact test performed on the insitu configuration found that the overall natural frequency is more than 15% away from the operating speed (1180 rpm).

Both configurations, the test configuration and the insitu configuration, have natural frequencies far enough away from running speed to minimize any motor resonance amplification.

NRC Question 2

Question: (State Question from Matrix)

Given a LOOP, what is the EDG loading at the time of high amps?

Answer and Basis:

The EDG loading is calculated as bounding number based on the most limiting accident sequence, which is the LOCA. This accident sequence uses the most equipment simultaneously, and thereby provides the maximum loading on the EDG. The major loads during this maximum are one CS, one RHR, one SWBP, one SW, one REC, one SGT, and essential 480 buss loads from the vital busses. This maximum loading occurs after the first 10 minutes when it is assumed that one RHR pump has been secured and one SWBP has been started. This results in a maximum loading of DG2 of 3865 MW, which is below the 4 MW continuous rating for the unit.

Since this scenario is a loss of offsite power, plant trip, and failure of DG1, the loads on the DG will be significantly less than the bounding calculation. The loads that would automatically be on for this event would be one REC, one SW, and one SGT (a Group VI from the LOSP would automatically start the fans) plus essential 480 loads from the vital buses.

Based on Operations input, one additional REC pump, one additional RHR pump and one additional SWBP would most likely be added in the first 90 minutes to support suppression pool cooling.

The observed amps for the SW pump in the test did not exceed twice the normal amps, and therefore will be conservatively assumed to be equivalent to two SW pumps.

In addition, to maximize the loading it is assumed in this evaluation that based on the alarm function of the high amps observed on the SW pump, one additional SW pump would be started prior to securing the high amperage SW pump. Since the peak currents would not occur concurrently, this results in an equivalent of three SW pumps.

Therefore this represents a delta from the maximum loading of one less CS pump, one more REC pump, and two more SW pumps.

Operators are trained to 5.3EMPWR which allows operations to add additional loads provided they maintain below the applicable ratings for the DG. Included in this procedure is guidance that identifies the power requirements for the load attached to the DG unit, so that the appropriate amount could be taken off of the DG unit before adding any additional loads.

From the above the loads and 5.3EMPWR the load would be:

3865 KW (Worst case bounding loading for a LOCA)
-1045.3 KW (Core Spray)
+ 259.5 KW (one SW)
+ 259.5 KW (one SW)
+ 63.1 KW (one REC)
3401.8 KW

Since the new loading is less than the bounding DG loading, and the both are less than the rating of the DG unit, the additional amps observed during the testing will not impact DG loading.

Name, Title and Date:

Dan Buman – Assistant DED Manager 9/24/04

Sign:

Provide Copy to Paul Fleming