R4-6B5

33

JOHNSTON PUMP COMPANY
NUCLEAR SERVICE DIVISION
2601 EAST 34TH ST
CHATTANOOGA, TN, 37407
TEL. (423) 629-1415
FAX. (423) 698-1457

Thomas R. Smith
Nuclear Service Manager
423-595-1875 Cell
tsmith@flow-products.com

27 July 2004

Mr. Kent Sutton
Nebraska Public Power District
Cooper Nuclear Station
2 Miles South of Brownville
Brownville, NE 68321

Dear Mr. Sutton:

Attached is Johnston Pump Company's written report documenting engineering's review of the white paper provided by Cooper Nuclear Station. In accordance with your purchase order 4500041514, resumes are at the back of the report.

Should you have any further questions please contact myself or Jerry Harrelson.

Respectfully,

Thomas R. Smith

Cc : Paul Beinecke, JPC Chattanooga Engineering Manager
Cooper Job File

Attachment ; Report Serial No.: JP04-20

Information in this record was deleted in accordance with the Freedom of Information Act, exemptions 6
FOIA-2006-0007

Q-7

Johnston Pump Company

Comments Regarding Short Term Dry-run of Rubber Column Bearings

Cooper Nuclear Station, Nebraska Public Power District

Byron Jackson 28KXL 1-STG, Chattanooga Service Center

Report Serial No.: JP04-20

Certification (when Applicable)	
This document is certified to be in compliance with the applicable purchase order, specifications and additional requirements specified by the customer. **Professional Engineer** **Date**	**Originating Department:** Engineering Dept., Brookshire. **Revision No.: 00** **Prepared By:** Michael Cugal, PE. **Initial:** MC **Date:** 07/16/04 **Checked By:** Lanka Pamula, P.E. **Initial:** 7/16/04

Johnston Pump Company

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Table of Contents

JOHNSTON PUMPS

800 Koomey Road
Brookshire, TX 77423

Tel: (800) 926-6688
Fax: (281) 934-6056

Comments on Short-term Dry-run			
Job Number		Customer	NPPD – Cooper Nuclear Station
Pump Size and Model	BJ 28KXL 1-STG	Project Manager	Jerry Harrelson

1. Introduction

The purpose of this report is to provide comments to the following question:

Given conditions that existed at Cooper Nuclear Station(1), will the Service Water pumps(2) continue to function 48 hours after Gland Water flow is reduced to zero flow for 90 minutes and then restored to normal?

(1) During January 21, 2004 - February 11, 2004:

River water level 875.5 MSL - 877.5 MSL.
Service water temperature <45°F.
Pump running at capacity (5500 gpm).
Average discharge pressure 50 psig average.
Gland water flow ~6-8 gpm to the enclosing tube (16-24 psi).
Vibration (IST) normal.

(2) Byron Jackson 28KXL 1-Stage VCT pumps with 1180 rpm, 300 Hp Motors.

The following material conditions existed as of February 2003: 1). New pump assembly, packing, coupling, shafts, cutlass bearings, and impeller. 2). Rebuilt outer column, discharge nozzle, registers, and spider bushing supports.

2. Discussion

Background

The function of the Gland Water flow is to provide clean water lubrication to the pump's stuffing box area, and column bearings during the pump operation.

In vertical pumps, the column bearings provide "bumper" bearing support. Due to negligible pressure differences across the bearings, they do not behave as typical hydrostatic bearings. However, a thin fluid film between the bearing and the shaft results in some bearing damping and fluid stiffness.

For the subject pump, at the given river level, if the gland water flow is stopped, the top 7 bearings (including the stuffing box bearing) would not receive the lubrication. The bottom 5 bearings (3 bottom column bearings and 2 bowl bearings) would be submerged in the pumping fluid.

In order to provide the answer to the posed question, we undertook the following steps:

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Job Number		Customer	NPPD – Cooper Nuclear Station
Pump Size and Model	8J 28KXL 1-STG	Project Manager	Jerry Harrelson

1. Technical assessment by the Johnston Pump engineering staff.
2. General review and study of the field repair history of similar cases.
3. Rotor dynamics analysis.

2.1 Technical assessment

After the gland flow is stopped, the packing box area will not receive proper lubrication and cooling flow, and the top 6 column bearings will not receive lubrication. The packing box bearing will heat up due to contact from the shaft. The effect of this could depend on the amount and force of the contact with the rotating shaft. If the shaft rotates without much wobble, it is conceivable that damage to the bearing or shaft can be minimal. If the shaft contacts the stuffing box bearing constantly, the packing gland will get over-heated and dry, and the bearing clearance will increase.

A typical vertical shaft is in tension and, in theory, it will rotate freely without any contact if the alignment and register fits are true and no manufacturing and machining tolerances exist. In real operation, however, the residual unbalance of the rotor, some hydraulic unbalance, allowable manufacturing tolerances, and the natural frequency of the rotor could cause the rotor to wobble and contact the column bearings. If lubrication to the bearings is not present, we can foresee local heating of the rubber bearings and weakening of the rubber material. The constant contact with the shaft could result in loss of the bearing material. The severity of the material loss would highly depend on the nature and amount of contact. However, we do believe that in general the bearing clearances will increase significantly due to the contact of the shaft.

When the bearing clearances increase, the pump can experience higher vibration of the pump shaft and possibly the pump structures in general. The severity and effect of the vibration are difficult to predict, but a catastrophic pump failure within 90 minutes of operation without the gland water supply and subsequent 48 hours of operation with the gland water supply is not likely to happen due to the vibration from increased bearing clearances.

There is a remote chance of a pump shaft seizure when it is operated without lubrication against rubber bearings. However, the probability of a seizure is very low if the pump does not have to stop and restart.

2.2 Field repair history

We were not able to locate any written repair report that dealt with the exact nature of this case. No record was found where the exact duration of the dry-running was documented. Our assessment was based on verbal communications with various Johnston Pump service centers. In most cases, operating pumps without lubrication to the rubber bearings resulted in severe damage to the column bearings and shafts. In some cases of pump failure, the shaft was seized, but the duration of the operation seemed to have been longer than a day or so.

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Comments on Short-term Dry-run

Job Number		Customer	NPPD – Cooper Nuclear Station
Pump Size and Model	BJ 28KXL 1-STG	Project Manager	Jerry Harrelson

Our interviews with senior field service technicians resulted in similar conclusions. In their experience, when the gland water supply is stopped, the rubber bearings get over-heated, and in some cases they have seen smoke coming out of the column. In most cases, the pump will begin to vibrate, and eventually it will be pulled for a repair. There were some cases where one or two bearings were completely damaged and pumps operated for over 48 hours. The general opinion of the service technicians is that the pump could have survive the 90 minutes of dry-operation though the bearings may have gotten severely damaged, and operation of the pump for the subsequent 48 hours with re-introduction of the gland water supply would have been possible.

2.3 Rotor dynamics analysis

We believe that the loss of gland water supply will cause loss of bearing damping effect (by losing the fluid film between the bearing and shaft) and could open up the running clearances (which will change the bearing stiffness). In order to study the rotor dynamics behavior in more detail, we conducted a lateral rotor dynamics analysis (report JP04-18).

Due to time constraints and the unavailability of some pertinent geometry information (i.e, motor rotor details), we had to use this study diligently. Our conclusions from the analysis are as follows:

- It is quite typical for a vertical pump rotor system to have a number of critical speeds that are close to the excitation frequency. Such a case was proven to be true in this analysis. In this study, we focused on the modal shapes of the rotor in order to study the effect of the shaft and bearing contact.
- The baseline analysis (pump in normal operating condition with gland water supply) indicated that there is indeed a natural frequency mode within 4.5% of the running frequency. The mode shape, however, indicated that the shaft and the inner column deflect in the same phase, providing a non-contacting mode (refer to report JP04-18).
- The worst case analysis (pump without gland water supply and assuming all 7 top bearings are lost and do not provide any bearing support) indicated that a higher mode natural frequency is near the running speed (within 6 %), and that the deflection mode of the shaft and inner column are not in the same phase. This would indicate a contact between the shaft and bearing, and that severe damages to the bearings can be expected.
- Based on the mode shape analysis, we believe that the worst case scenario would not happen during the pump operation. The mode shape indicated that two bearings may have come in severe contact with the shaft, but not all dry-running bearings would have been damaged.

Our conclusion based on the rotor analysis is that when the pump is run dry some shaft contact with the bearings will occur. Based on the modal shape in the worse case scenario, we believe that contact will be made on some of the bearings, but loss of all column bearing support is not likely to happen.

Based on the modal shape analysis, the inner column mode shape was detected near the running speed. If the inner column fails, the result could be a re-supply of the lubrication to the column bearings as the discharge

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pressure pushes the fluid into the column. This would become somewhat beneficial in this case (depending on the nature of the failure), as it would introduce the lubrication and damping back to the column bearings.

3.0 Summary and conclusions

It is general knowledge and recommended practice never to operate a vertical pump with rubber bearings without proper lubrication. We wish to clearly state that the evaluations and statements of this report regarding this issue does not change such views. We also wish to state that the statements and summary of this report are intended only to share our views on this particular operation case, and we do not recommend or accept any future operation of the pump without the gland water supply for any length of time without a change to the existing pump bearing design.

Our database search and study of past field service records (written and verbal) did show that some damage to the bearings and/or shaft can occur due to the lack of pump gland water supply. However, we do not have conclusive data which indicates a catastrophic pump failure would have resulted within 90 minutes of operation without the gland water supply and subsequent 48 hours with re-supply of gland water. Our rotor dynamics analysis indicated that it is highly unlikely to damage all top rubber bearings subjected to the dry-running condition.

We believe that given the ample motor horsepower and the good existing maintenance practice in this case (alignment, good fits and registers, etc.), the pump could have survived the 90 minutes of "dry" operation. When the gland water supply was re-introduced, the pump could have operated (possibly with higher vibration and some damaged bearings) for an additional 48 hours.

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Your Internal Billing Reference OPTIONAL

To

Recipient's Name ATTN: KENT SUTTON Phone (402-825-5105

Company NEBRASKA PUBLIC POWER DISTRICT

Address COOPER NUCLEAR STATION

Address 2 MILES SOUTH OF BROWNVILLE

City BROWNVILLE, State NE ZIP 68321

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* Call for Confirmation

5 Packaging

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Ex. 6

Nirmal Ganatra

MS, EIT

Experience

Flow Products, Inc.

March 2002 - Present — *Design Engineer* — Brookshire, TX

Responsible for the development of custom-engineered Vertical Pumps by performing Engineering Analysis and Design including:

- Rotordynamic Analysis including lateral & torsional natural frequency and mode shape analysis, torsional forced response analysis for VFD applications and shaft-life determination through transient torsional analysis
- Finite Element Analysis involving calculations for determining static stresses and deflected shapes, structural natural frequencies and mode shapes, etc.
- Computational Fluid Dynamics Analysis for the design and correction of sumps under adverse flow conditions
- Vibration Measurement using accelerometers, proximity probes, OROS vibration equipment and traditional vibration meters
- 2D Drafting & 3D Modeling - Possess a solid base in the development of Parametric Drawings using the Excel-to-Model concept
- Generation of Bills of Materials and Part Drawings to process orders for Vertical Pumps

Turbomachinery Laboratory – Texas A&M University

August 2000 - March 2002 — *Graduate Research Assistant* — College Station, TX

Developed codes using VBA-Excel to be incorporated into XLTRC-Torsion, a suite of Computer Codes for Torsional Analysis of long drive trains. The research project was supported by the Turbomachinery Research Consortium (TRC) at Texas A&M University.

Matrix Electronics

June 1999 - July 2000 — *Automation Engineer* — Navi Mumbai, India

Performed Design Calculations and Computer Programming in C++ facilitating customization of Data Acquisition (DAQ) Systems for performing tests on Turbines, I.C. Engines and Pumps for Real-Time Control of Testing and Display of Results.

Pratibha Pipes & Structural Private Limited

June 1997 - June 1999 — *Engineering Trainee* — Navi Mumbai, India

Underwent two-year part-time training in the Design and Manufacture of pipes, pressure vessels and other fabrication work undertaken by the company.

Education

The University of Texas at Arlington

Expected Graduation: May 2006 — *Master of Business Administration (Online)* — Arlington, TX

The University of Texas MBA Online program is a unique collaboration among eight UT component universities that offer interactive Web-based courses. These courses can be effectively pursued from any part of the world.

Texas A&M University

May 2003 — *Master of Science* — College Station, TX

Majored in Mechanical Engineering with a GPA of 3.59/4.00. Research on Torsional Vibration Analysis included authoring a thesis entitled "Validation of Computer-Generated Results with Experimental Data obtained for Torsional Vibration of Synchronous Motor-Driven Turbomachinery".

University of Mumbai

[redacted] — *Bachelor of Engineering (Mechanical)* — Mumbai, India

Ex. 6

Ranked First in the College with 74.32% marks and Sixth in the University among 642 students to receive a "First Class with Distinction".

K. J. Somaiya Polytechnic

[redacted] — *Diploma in Mechanical Engineering* — Mumbai, India

Ex. 6

Ranked Third in the Dept. of Mech. Eng. among 72 students, while scoring 74.09% marks and receiving a "First Class".

Selected Projects

- Design Project for Schlumberger Limited: "Design of an electrically operated valve for regulating pressurized flow in the Modular Dynamic Tester (MDT)", conducted as a part of the Advanced Computer-Aided Engineering course at Texas A&M University during Spring 2001.
- Fabrication of a Pelton Wheel Test Rig with Complete Automation of Testing on it: Final year Bachelors' project conducted while at the University of Mumbai.

Computation Skills

- Engineering Software: XLRotor, XLTRC^2, SolidWorks, CosmosWorks, Pro/E, AutoCAD, CFX, Algor, Maple, MathCAD
- Programming: C/C++, BASIC, Visual Basic, VBA-Excel
- Web-page Development Software: Java, HTML, FrontPage, Adobe PhotoShop
- Databases: Oracle, FoxPro, dBase

Recent Courses Attended

- The Relationship of Vibration to Problems in Centrifugal Pumps – 20th International Pump Users Symposium, Turbomachinery Lab, Texas A&M University, College Station, TX, March 2003.
- CFX-5 Introductory Course – AEA Technologies Engineering Software, Inc., Pittsburg, PA, January 2003.

Affiliations

American Society of Mechanical Engineers, Phi Kappa Phi Honor Society, India Business & Technology Consortium, Lions Club.

Publication

Ganatra, N.K., Patrikar, S.M., Kulkarni, S.V., Rodrigues, A.D.J., Wagle, S.S., Wagle, S.S., "Constant Speed Test on a Computerized Pelton Wheel Test Rig", Proceedings of the 26th National Conference on Fluid Mechanics and Fluid Power, IIT-Kharagpur, India, 1999.

Lanka Pannila P.E.
Flow Products Inc.
[redacted]
Office 281 934 6353 lpannila@flow-products.com

Ex. 6

EDUCATION:

Ex. 6

B. S. in Mechanical Engineering [redacted] University of Peredeniya, Sri Lanka
M. S. in Engineering & Technology 1991 to 1993 Ohio University, Athens. OH.
Professional Engineer, State of Oregon.

SUMMARY OF QUALIFICATIONS:

BSME and MS in Mechanical Engineering.
Extensive experience with API pump design, testing and troubleshooting.
Extensive experience in boiler feed, pipeline, circulator & booster pump design.
Vertical and horizontal pump application experience.
API, ASTM, ASME, HI, AWWA, UBC, OSHA specification experience.
Extensive experience in FEA, 3D solid modeling and design optimization.
Rotor-dynamic analysis and vibration analysis.
Product design, development and cost reduction.
Project management and team leadership.
Hydraulic, electrical, foundry and computer experience.
Worked as a discussion group leader at Pump Symposium

JOHNSTON PUMP CO. (Div. of Flow Products Inc.)
Engineering Manager: April 2000 to Present

Flow Product's Johnston Pump division make large vertical pumps for power, gas, petrochemical and municipal markets. As the engineering manager, I am responsible for vertical pump design work, new product development, worldwide technical support, test lab and service center support. I supervise a team of 10 engineers and 3 field service technicians. During last twelve months, I have improved on time delivery of engineering design from 50% to 95%, reduced engineering errors by 70% and reduce engineering cost by 16%.

I trained engineers to perform advance analyses and eliminated sub contract work. Introduced 3D modeling in place of 2D drafting. Standardized fabricated components and designed parametric drafting tools to reduce cost. Reduced casting costs by using new designs and offshore foundries. Helped business unit to win large orders by providing new product designs and proposals. I improved work quality and responsiveness to our customers, business unit, machine shop, and test lab. I hired talented engineers and responsible for training & mentoring.

I reduced field service problems by initiating corrective actions to prevent re-occurrence. Helped service centers with technical support in repairing vertical and horizontal pumps. Trained service center personnel and provide technical support on horizontal pump repairs for them to break in to horizontal pump repair business.

Introduced a new circulator pump with low shut off head to the market. Introduced a new method to analyze large sumps using CFD instead of expensive and time-consuming model testing.

JOHNSTON PUMP CO. (Div. Of Flow Products Inc.)
Senior Design Engineer: Aug 1998 to April 2000

I supported the design-engineering group with advanced calculations such as lateral and torsional critical speed, structural natural frequency, pressure boundary etc. and helped with design reviews. Designed vertical pumps to meet API and HI standards. Supported field service dept in rectifying field problems, field modifications and to find the best corrective action. Introduced a novel method to accurately predict discharge head natural frequencies. Supported test lab on difficult vibration and hydraulic performance problems. Helped sales engineers and customers with proposals and application engineering problems.

David Brown Pumps
Senior Design Engineer: 1997 to 1998

I was responsible for large projects including engineering and project management. Designed horizontal multistage pumps for API market. Performed all calculations to design pump shafts, base plates, pressure containing parts and wrote specifications for buy out parts such as lube systems, mechanical seals, turbines motors, gear boxes, switch gear and instrumentation. Resolved manufacturing problems and performance test issues. I designed pumps for Exxon Diana Project and was responsible for the complete project. For this project I designed 4, 13 stg high pressure pumps from scratch, API lube system 3 point mount base plate for floating applications. Corrected bearing housing/base plate resonance vibration problems encountered at lab testing.

Designed all pumps for Exxon Baton Rough refinery upgrade project. Designed manufactured and supplied 4 new pump units and upgraded several existing pumps to obtain higher capacity.

I performed pump testing and corrected mechanical and hydraulic test problems. Helped after market team with engineering calculations to re-rate existing pumps.

Sulzer Pumps
Project Engineer:1995 to 1997

Performed torsional and lateral critical speed calculations for horizontal and vertical multistage pumps. Idesigned boiler feed, pipeline and transfer pumps to API 7th edition. Designed new, cost effective base plates for process pumps to satisfy API 1X and 2X nozzle loads. Performed structural and natural frequency analysis for pump components using ANSYS finite element software. I corrected difficult field and test vibration test problems. Worked on a special cost reduction team to reduce MSD pump line's cost by 30%. Wrote engineering procedures and standards.

David Brown Pump
Design Engineer: 1993 to 1995

Designed multistage horizontal and vertical centrifugal pumps per API and customer specifications. Designed all components, prepared bill of materials and specifications for buy out parts. Performed witness performance testing. Managed projects from start to end and attended technical/scheduling meetings with customers. Witnessed buy out part testing such as motors gears and turbines. Design spread sheets to perform pressure boundary calculations, test calculations, structural calculations etc.

Ohio University
Research Assistant: 1991 to 1993

Worked on Ohio Department of Transportation (ODOT) funded project to find the feasibility of using solar energy in highway rest areas. Installed solar collectors, associated equipment and data acquisition system. Monitored 2 test areas and collected data for a year. Simulated the solar system using TRANSYS computer code and validated test data. Submitted monthly progress reports and final recommendations to ODOT.

Samuel Sons & Co Ltd. 1985 to 1991
R & D Engineer / Senior Engineer / Foundry Manager

Designed self and non-self priming centrifugal water pumps for agricultural industry. Developed a computer program to generate vane profiles of impeller and volute vanes. Designed paddy threshers and transplanters. Re-organized managed company's cast iron foundry for a year.

Metalix Engineering Co. 1983 to 19985
Development Engineer

I designed motor control center, main control panels large industries using Klockner Mouler switchgear. Design and developed a new automatically controlled power factor correction capacitor bank to reduce kVA with varying power demand.

COMPUTER EXPERIENCE:

- Proficient and trained Solid Works user. Introduced 3D modeling and FEM analysis to the present company.
- Highly experienced with COSMOS and ANSYS finite element software.
- XLRotor rotor dynamic analysis software.
- Proficient in Excel, Lotus, MS Word, MS Project, Outlook and Front Page.
- Microsoft NT, 98 & DOS, Unix and VMS experience.
- Flow Works computational fluid dynamic (CFD) software.

Michael Cugal, P. E.

[redacted]

Ex. 6

Experience

Flow Products, Inc., Johnston Pump Company, TX: April, 2003 – Present
Senior Hydraulic Engineer, Engineering Group

Flowserve Corporation, Pump Division, Vernon, CA: June, 2002 – March, 2003
Supervisor, Engineering III / Product Engineering

- Rationalize engineering design standards from former IDP and Flowserve.
- Perform product cross training.
- Coordinate engineering improvements and create bulletins and procedures to establish best practices.
- Reduce 20% of engineering lead time implementing design standards for the different product lines and continuous training.
- Reduce 20% number of errors from last year, by the automation of engineering calculations and creating a database of design practices to help order processing.
- Drive CIP (continuous improvement process) throughout engineering, identifying opportunities for improvements and establishing metrics.
- Identify and implement cost reduction opportunities in the different product lines from feedback of vendors, manufacturing, supplier chain, quality, test department and customer service.

Flow Products, Inc., Johnston Pump Company, TX: June, 2001 – June, 2002
Senior Hydraulic Engineer, Engineering Group

- Was directly responsible for pump hydraulic design, development, performance, and test department technology for Johnston Pump Company.
- Supervised test department engineering group.
- Provided engineering support to project engineering group, service centers, field services, Project Managers, Applications and Engineering, and Sales Engineers.
- Used CFD codes (CFX-TASCFLOW and CFX-5) to improve, analyze, and support engineering and sales.
- Supported monthly shipment goals with pump 1st time pass efforts (Improved 1st time pump test pass rate from 64% to 84%.)

Flowserve Corporation, Pump Division, Vernon, CA: 1988 – 2001
Project Engineer, Technology Department: 1996 – 2001

- Managed project engineering, schedules, and budgets. Prepare and submit status and progress reports as required.
- Performed engineering design reviews, design calculations, design analyses, performance and economic evaluations as required to ensure optimal function, appearance, manufacturability, cost, and value of components and assemblies. Perform inspections and tests; troubleshoot shop and field problems as needed.

Achievements:

- Used a CFD code (CFX-TASCFLOW) to design a high efficiency cryogenic turbo expander (89% - prototype).
- Successfully designed and tested a single-stage high-head low-flow pump (350 GPM, 400 Ft HD), and led a team to develop and test an 8-stage prototype pump.
- Managed a project to develop programs to reduce CFD usage lead-time from 4-5 weeks to 1-2 days.

- Designed a 34" (casing) split case double suction pump for Hyosung Ebara Co.
- Designed a new impeller for the US NAVY.

Senior Design Engineer, R&D Group: 1993-1996

- Used a Quasi-3D computer program to design a low $NPSH_R$ boiler feed pump impeller for a nuclear power plant.
- Selected and provided proposal curves for 40 vertical pumps for the Colorado River Municipal Water District's O.H. IVIE Pipeline project.

Design Engineer, R&D Group: 1992–1993

- Developed and tested R&D prototype sealless magnetic drive pump for API market.

Design Engineer, Technical Services Group: 1990–1992

- Managed a project to design, develop, and test high efficiency vertical pump. The new vertical diffuser casing design yielded 3 percentage points of improvement in efficiency (from 87% to 90%).

Co-Op Engineer, Technical Services Group: 1988–1990

- Wrote pre and post processing routines in FORTRAN to work with the in-house finite element structural analysis code. Resulting code was distributed to other facilities in Holland, Mexico, and San Jose, CA.
- Worked in Process Engineering Group, Nuclear Valve Group, and Test Department in a rotational program.

Education

California State Polytechnic University, Pomona
Bachelor of Science in Mechanical Engineering [redacted] Ex.6

Continuing Education Courses:

- "Applied 3D Techniques for Turbomachinery", Concepts ETI, 1993.
- "Centrifugal Pump Design and Performance", Concepts ETI, 1992.
- "Computational Fluid Dynamics: Theory, Computer Codes & Applications", University of California, Los Angeles, 1991.

Publications

Authored and presented following technical papers:

- "CFD Analysis of Mixed Flow Impeller", 1996 ASME Conference, San Diego, CA
- "Performance Prediction from Shutoff to Runout Flow of Horizontal Centrifugal Pump", 1997 ASME Conference, Vancouver, B.C.
- "Redesign of Boilerfeed pump Impeller", 1997 ASME Conference, Vancouver, B.C.
- "Flow Visualization of Boilerfeed pump suction Impeller", 1998 Texas A&M Pump Users Symposium

Memberships

Registered Professional Engineer in Mechanical Engineering, California
Texas A&M Pump Symposium Vertical Pump Discussion Leader (2002).
Lifetime member of Tau Beta Pi, engineering honor society.
Member of Pi Tau Sigma, mechanical engineering society.
Member of American Society of Mechanical Engineers.

Skills

Proficient in CFX-TASCFLOW, Computational Fluid Dynamics (CFD) code
Proficient in Personal Computers and general Microsoft Office programs as well as; Unigraphics, AutoCAD, Mechanical Desktop, and MS Powerpoint/ Project

Johnston Pump Company

Lateral Vibration Analysis for

Nebraska Public Power District - Cooper Nuclear Station

Johnston Pump Serial No. 02JC1130S – 1134S

Report Serial No.: JP04-18

Certification (when Applicable)	
This document is certified to be in compliance with the applicable purchase order, specifications and additional requirements specified by the customer. **Professional Engineer** **Date**	**Originating Department:** Engineering Dept., Brookshire. **Revision No.:** 00 **Prepared By:** Nirmal Ganatra **Initial:** **Date:** 07/14/04 **Checked By:** Lanka Pannila, P.E. **Initial:** 7/14/04