CROSSFLOW Task Force

NRC UFM Meeting

September 17, 2004

Tim Long
Southern Nuclear Operating Company

Chairman, Westinghouse Owners Group
CROSSFLOW Task Force

WOG CROSSFLOW Task Force
NRC UFM Public Meeting
September 17, 2004

- CROSSFLOW Users are taking a proactive approach to recent industry issues.
  - CROSSFLOW User Communications Recent Experiences
    - Signal Interference
      - TB-03-6, "CROSSFLOW Ultrasonic Flow Measurement System Signal Issues", September 5, 2003.
      - NSAL-03-12, "CROSSFLOW Ultrasonic Flow Measurement System Flow Signal Interference Issues", December 5, 2003.
    - Configuration/Alignment Sensitivity Observations
      - TB-04-4, "Information Regarding Recent CROSSFLOW Ultrasonic Flow Measurement System Performance Observations", February 12, 2004
    - Operation Experience
      - INPO SER 3-04
- Users address issues via Operating Experience and individual site corrective action programs
- WOG CROSSFLOW Task Force was established to address gaps in user experience base and share lessons learned
  - Resource for current and future CROSSFLOW UFM Users

WOG CROSSFLOW Task Force
NRC UFM Public Meeting
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- Utilities that comprised the longstanding CROSSFLOW Users Group now make up the CROSSFLOW Task Force under the Westinghouse Owners Group
  - Formed May 2004
- Mission
  - Support safe and reliable plant operations
  - Provide a forum for joint discussion and resolution of issues/concerns
  - Share best practices and lessons learned
  - Provide potential opportunity to share generic costs and address emerging issues collectively
  - Provide structured environment to share pertinent information among CROSSFLOW Users, Westinghouse, and AMAG
- Through the pursuit of lessons learned and improved understanding of CROSSFLOW technology, management of the UFM is continuously improved for problem identification, diagnosis, and resolution of operational issues

WOG CROSSFLOW Task Force
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CROSSFLOW Task Force Representatives:

- 14 - Sites
- 24 - Units

Name	Utility/Group
Steve Smith	CEG
Dave Dvorka	CEG
William Kouba	EXELON
Bradley Berles	NMC
Russell Haverson	NMC
William Phillips (Vice Chairman)	OPPD
Joseph Gasper	OPPD
Victor Foster	PG&E
Jack Southers	PSEG
Frank Todd	PSEG
Michael Schwaebe	SCE
Tim Long *(Chairman)*	SNC
Dan Sicking	STP
Kenneth Taplett	STP
Westinghouse	WEC
Advance Measurement and Analysis Group	AMAG

WOG CROSSFLOW Task Force
Focus Areas

Technical & Licensing Basis	Installation and Application that Assures Design Basis (Validate)	Operational Considerations (assurance that design basis is maintained)
• CENPD-397-P-A, Rev. 1 • NRC Safety Evaluation Report (SER) • 10 CFR 50, Appendix K • Plant Specific MUR SER	• Provide reasonable assurance of proper CROSSFLOW installation/application (e.g., use of corroborating information) • Use of procedures/guidelines	• Maintenance and troubleshooting • System/data monitoring • Alarm limits • PWR/BWR considerations • Feedwater pump type (electric/steam driven) • Changing system alignments • Frequency spectrum checks (initial and periodic follow-ups)

Technical and Licensing Basis

- CROSSFLOW Baseline Installation Criteria
  - CENPD-397-P-A, Rev. 1 identifies the manners in which an installation location is selected.
    - Stable turbulent flow profile in isothermal subcooled liquid at the meter installation location.
      - L/D ≥15 diameters downstream from a simple 90° elbow
    - In-situ calibration
    - Scale model hydraulic testing

Technical and Licensing Basis

Laboratory Test and Plant Data

- Numerous tests have been performed to validate the CROSSFLOW meter underlying technology and to confirm meter accuracy.
- The data includes both hydraulic laboratory test data and field comparisons (i.e., operating plant data).

Ontario Hydo	Alden Labs
NIST	Toshiba
EdF	Angra
Diablo Canyon	Shearon Harris
Kewaunee	

Technical and Licensing Basis

Laboratory Test and Plant Data

- Alden Laboratory
  - Calibration Test (May 1996)
  - Verification Test (January 1997)
- Toshiba High Temperature Laboratory
  - Verification Test (September 2002)
- Diablo Canyon Field Comparison (1995)
  - Comparison with recently calibrated ASME flow sections with an upstream flow straightener
  - Operating Reynolds number was ~25 million.
  - Post plant test verification performed at Alden Labs
- Kewaunee (2002)
  - Comparison with an ASME flow section with an upstream flow straightener.
  - Operating Reynolds number is ~20 million.

Technical and Licensing Basis

- Current On-going Activities to Strengthen Basis
  - Velocity Profile Correction Factor Test
    - Enhance hydraulic model test methodology
      - Improve data acquisition
      - Reduce uncertainty of extrapolating to field conditions
      - Validate the extrapolation methodology by comparing the predicted lab calibration with a calibration obtained from an in-situ installation
  - Computational Fluid Dynamic Analyses
    - Use as screening tool for determining need for scale model hydraulic test
    - Investigate the potential for thermal streaming

Installation and Application

- Current Installations
  - Checked for Signal contamination
  - Re-Validation of Current Installations
- Improved Installation Procedures for Future Applications
  - Revised installation process procedure to incorporate new information and lessons learned.
- Signal Contamination
  - Developing new software to detect and alert users to signal contamination
- Surveillance Guidelines
  - Developing periodic surveillance guidelines
  - Signal contamination
- Lessons learned may be applied to current installations

Operational Considerations

- Considerations to be a major focus and an integral part of the WOG CROSSFLOW User Guidelines
  - Operational experiences shared between CROSSFLOW Users
  - PWR/BWR considerations
  - System Configuration
  - Periodic or continuous system/data monitoring
  - Alarm limits - correction factor limits are established within plant specific uncertainty analysis
  - Periodic CROSSFLOW system operation verification – vendor recommended system checks, surveillances and calibrations.
  - Logical checks for reasonability of corrected flow
    - Turbine cycle heat rate testing
    - Turbine 1st stage pressure correlation
    - Nuclear instrumentation
    - Primary loop temperatures
    - Control valve position
    - Steam flow vs. feedwater monitoring and trending

Key Milestones

- Re-evaluate plant specific installation baselines in light of revised installation procedures and lessons learned
  - Draft's on Appendix K MUR Power Uprates Issued – September 17, 2004
  - Draft's on Power Recovery to be issued – September 2004
- Enhance hydraulic model test methodology
  - Work in progress – December 2004
- Issue revised software for signal contamination
  - Includes independent review and lab testing
  - Work in progress – Fall 2004

Summary

WOG Perspective

- The operational and regulatory significance of the concerns are acknowledged
- Stakeholders of the CROSSFLOW UFM technology are taking a proactive approach to resolution
  - Individual site assessments in response to initial vendor and INPO notifications
  - WOG and Westinghouse/AMAG Activities are aggressively addressing concerns
    - Strengthening Licensing Basis
      - Additional Laboratory Testing
    - Strengthening Design Basis
      - Improved Installation Guideline
      - Baseline Re-Validation
      - WOG CROSSFLOW User Guidelines
    - Operational Considerations
      - WOG CROSSFLOW User Guidelines
      - Sharing Lesson Learned
- The severity level for the potential NRC generic correspondence should consider information already accumulated by the NRC through notices, as well as vendor and public meetings, oversight by industry groups such as INPO, the safety significance and the level of commitment by the utilities/vendors to resolve the concerns and share information.

Exelon Nuclear

NRC Meeting with Licensees Using Ultrasonic Flow Measurement Devices
September 17, 2004

Byron/Braidwood Thermal Power Measurement

Bill Kouba

UFM Background/Timeline

Exelon Nuclear

UFM Implementation at Byron / Braidwood Stations

- Purpose of the UFMs was to more accurately measure feedwater flow
- Installation was not part of a Measurement Uncertainty Recapture Uprate
- UFMs brackets installed on each of the Main Feedwater Branch Lines supplying the Steam Generators with data taken by "portable" electronics
- Correction factors determined periodically or as driven by a defined change in power (potential de-fouling event) controlled by site implementing procedures.
- Correction factor manually input in the site's calorimetric to correct feed flow
- Installation the same at Byron Units 1&2 and Braidwood 1&2

UFM Background/Timeline

Exelon. Nuclear

- UFMs reviewed, installed, and tested at Braidwood in June 1999 and Byron in May 2000
  - Installation in accordance with AMAG procedures
- Electrical output differences identified between Braidwood and Byron
  - Upon initial installation and following five percent power uprate
- Multiple evaluations conducted from 1999 through 2003 to determine reason for differences in electrical output
- Header comparison testing with individual feedwater lines in 2003 identified preliminary root cause
- Tracer testing at Byron Units 1 and 2 in 2004 identified additional issues

UFM Technical Reviews/Actions

Exelon Nuclear

- Multiple evaluations were conducted from 1999 to 2003 to determine reason for differences in electrical output, including the following:
  - Dual instrument test with UFMs
  - Validation test to verify data acquisition based on venturi cleaning methods
  - Internal and external design review of secondary plant parameters, fuel utilization, heat rates, and procedures
  - Installation and operational criteria verification including piping, transducers, cables, software, and test procedures
  - Calorimetric comparisons between units
  - Review of fuel burn-up anomalies
  - Comparison test between common feedwater header & individual feedwater lines
  - Monitor of data with continuous data link to UFM vendor
  - Expanded UFM comparisons between common header UFM and sum of individual feedwater line UFMs

UFM Technical Reviews/Actions

Exelon Nuclear

- UFM comparisons on common feedwater headers in 2003
  - Perform comparison between common header UFM and sum of individual feedwater line UFMs at Braidwood and Byron
  - Braidwood comparison test showed good correlation
  - Comparison of common feedwater header UFM to sum of individual feedwater line UFMs failed criteria for Byron Unit 1
  - Signal noise observed on some individual feedwater line UFMs
- Power reduced at Byron and Braidwood based on concern with flow measurement accuracy
- Preliminary Technical Root Cause
  - Correction factor error caused by hydraulic pressure pulses (induced acoustic noise)
    - This impacted time delay used to calculate feedwater flow
  - Root cause was validated by an external independent reviewer

UFM Technical Reviews/Actions

Exelon Nuclear

- Permanent systems installed on Byron and Braidwood Common Headers in 2004
  - Common Headers noise free
  - Assessment of installations performed
- Decision to perform independent validation test (tracer) prior to implementation
  - Projected MWe difference based on initial data
  - Projected Performance above thermal kit based on initial data
  - During final stage heater isolation to support installation of tracer test taps, a shift in the Correction Factors was noted
- Tracer testing
  - The feedwater flow test simultaneously measured feedwater flow by the installed feedwater system flow venturis, tracer, and UFMs
  - Comparison between flow venturis, alternate power measurements, and the tracer test indicated the UFMs on both Byron units were under-metering feedwater flow
  - Subsequent hydraulic testing indicated the velocity profile was not developed sufficiently to provide an accurate VPCF at the current meter location due to the upstream feedwater configuration

Organizational Reviews/Actions

Exelon Nuclear

- Case study of lessons learned
  - Organizational effectiveness/decisions
  - Structured sessions with broad range of personnel to reinforce expectations
- Broaden use of principles for effective decision making
- Apply resources for technical issue resolution
  - Formalized expectations for resources applied to unresolved technical issues and routinely review outstanding issues
- Risk assessment for unresolved issues in the Corrective Action Program

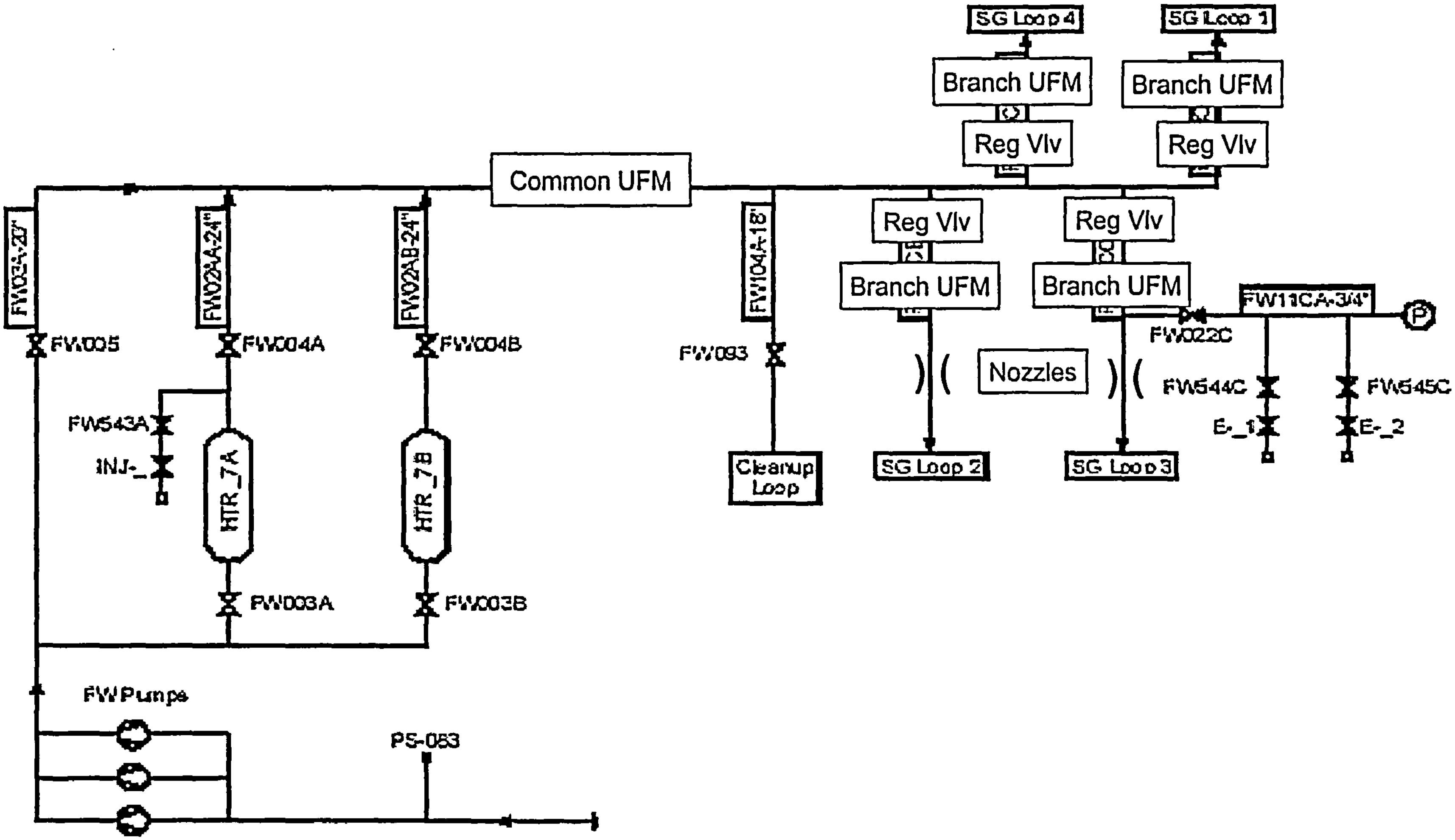
Summary

Exelon Nuclear

- Site, corporate, and vendor investigation have identified that hydraulic noise and the lack of fully developed velocity profile as contributors to UFM performance issues at Byron and Braidwood
- Self-critical approach taken to assess organizational issues
- There are no immediate plans for re-implementation at Byron or Braidwood
- Industry group actions in progress to apply lessons learned
  - INPO
  - WOG

Byron Feedwater System

Exelon Nuclear



Byron Generating Station: Injection and Sample Tap Arrangement
(Unit Identifier omitted)

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OPPD Omaha Public Power District

NRC MEETING WITH LICENSEES USING ULTRASONIC FLOW MEASUREMENT DEVICES (UFMS)

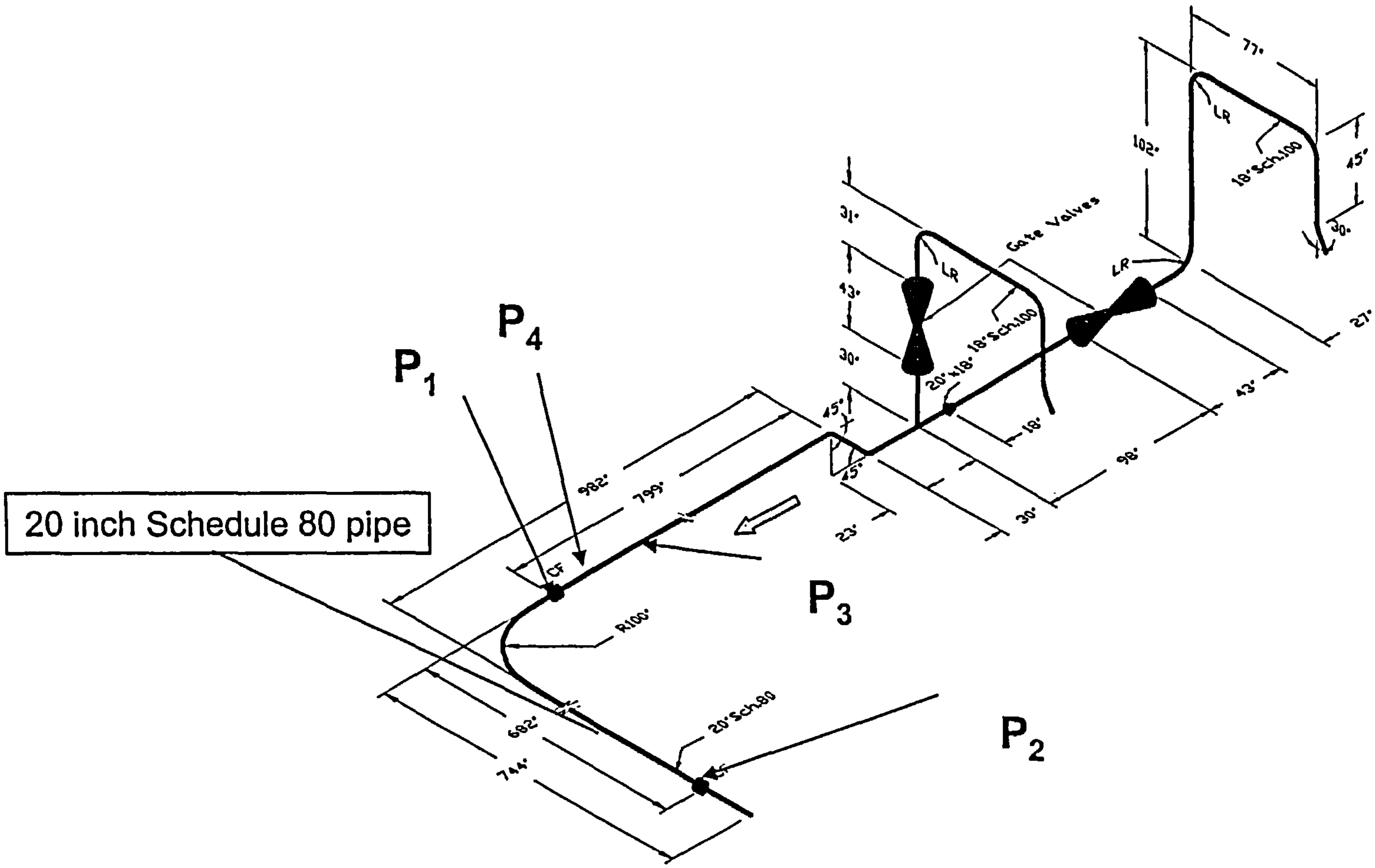
September 17, 2004

Ft. Calhoun Station UFM <u>Commissioning</u> Experience

Joe Gasper

OPPD
Omaha Public Power District

Feedwater System



3 ~55% capacity electric motor feedwater pumps

Initial Installation

- Proof of principle test conducted in November 2002 with meter at P1
  - Location ~ 46 L/D downstream from 45° elbow
  - Results were within 0.25% of venturi flow
- A "permanent" meter, installed at location P1 in December 2003.
- A step change in C_f observed when feedwater pumps were rotated in January 2004

Feed Pump Rotation

- C_f is dependent on feedwater pump combinations
  - Hydraulic noise contamination identified
  - A second "permanent" meter at location P2
    - Hydraulic noise reduced
    - Unstable velocity profile
    - Abandoned location P2 due to increased C_f uncertainty
  - CFD analysis and laboratory testing indicate velocity profile is stable at P1

Omaha Public Power District

Meter Relocation

- A “permanent” meter installed at location P3
  - ~ 6 L/D upstream of the P1 location
  - The calculated feedwater flow at location P3 was statistically different from that calculated at the P1 location.
  - A flow disturbance was identified inside the pipe at P1
- The “permanent” meter at location P1 was moved to location P4 ~ 5L/D downstream of the P3

Results

- Feedwater flow at locations P3 and P4 agree. Therefore, meters are mounted in a region of flow with a stable velocity profile.
- Meters are affected by noise contamination
- Methods have been demonstrated to filter noise contamination
- “Noise free” C_f is independent of pump combinations

On Going Activities

- Methods to filter noise contamination are undergoing further lab testing and validation

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Lessons Learned

- During proof of principle testing leading to permanent installation:
  - Validate installation for all feedwater system alignments
  - Investigate system for noise contamination