52-002

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

March 11, 1999

MEMORANDUM TO: Francis Akstulewicz, Acting Chief
Generic Issues and Environmental Projects Branch
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

FROM: Peter C. Wen, Project Manager Peter C. Wen
Generic Issues and Environmental Projects Branch
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

SUBJECT: SUMMARY OF FEBRUARY 25, 1999, MEETING WITH ABB COMBUSTION ENGINEERING REGARDING ISSUES RELATED TO ABB -CE's CROSSFLOW ULTRASONIC FLOW MEASUREMENT DEVICE

On February 25, 1999, a public meeting was held at the U.S. Nuclear Regulatory Commission's (NRC's) offices in Rockville, Maryland, between members of ABB Combustion Engineering Nuclear Power (ABB-CE), Advanced Measurement Analysis Group (AMAG), utility, and NRC staff. Attachment 1 lists attendees at the meeting. Most portions of the meeting involved discussion of proprietary information. Attachment 2 is a copy of the non-proprietary material handed out at the meeting.

The purpose of the meeting was to provide an opportunity for ABB-CE and AMAG to brief the staff on the capabilities of the ABB-CE/AMAG CROSSFLOW flow measurement system. As proposed by the vendor, the CROSSFLOW system would be used to support a licensing/technical basis for an exemption request from the Appendix K ECCS requirement regarding the 2% core thermal power uncertainty.

During the meeting, ABB-CE discussed CROSSFLOW's historical development and operating experience. AMAG also demonstrated how the CROSSFLOW system processed data from the ultrasonic transducers through a proprietary computer program to determine feedwater flowrate.

The major discussion was centered around the issues related to increasing licensed thermal power by reducing feedwater flow measurement uncertainty by using the CROSSFLOW measurement system. These discussions are summarized as follows:

- ABB-CE indicated that the increase in licensed thermal power would be justified based on the improved feedwater measurement accuracy provided by the CROSSFLOW measurement system. ABB-CE intends to submit to the staff a generic topical report for the CROSSFLOW system in support of licensee's individual power uprate initiatives.

D103

- It was suggested that the topical report contain performance information for CROSSFLOW including basic hardware information and other accompanying issues including system reliability, operation, and maintenance practices. ABB-CE stated that all the necessary information is available; all it needs is to package the report in the appropriate format.

- The staff noted that the Commission has recently approved a rulemaking plan for modifying Appendix K to relax the required assumption in ECCS analyses that the plant is operating at 1.02 times licensed power. In the interim period, the staff will entertain exemption requests from plants that can justify a lower assumed power level. However, without a lead plant requesting an exemption, the ABB-CE's topical report on the CROSSFLOW would not receive a priority review. It was agreed that the review of the topical report could occur prior to and separate from a licensee submittal for a power uprate. The staff also pointed out that each licensee still has to meet all of the non-Appendix K requirements for a power uprate even after an exemption is in hand or after Appendix K has been amended by rulemaking.

The representatives of the NRC, ABB-CE, AMAG, and utility agreed that this meeting was useful in accelerating the information exchange.

Attachments: As stated

cc w/atts: Mr. Charles B. Brinkman, Director
Washington Operations
ABB-Combustion Engineering, Inc.
12300 Twinbrook Parkway, Suite 330
Rockville, Maryland 20852

Mr. Ian C. Rickard, Director
Nuclear Licensing
ABB-Combustion Engineering, Inc.
Post Office Box 500
2000 Day Hill Road
Windsor, Connecticut 06095-0500

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NRC/ABB-CE MEETING ON CROSSFLOW MEASUREMENT
LIST OF ATTENDEES
February 25, 1999

NAME	ORGANIZATION
Jared Wermiel	NRR/SRXB
Ralph Caruso	NRR/SRXB
Joe Donoghue	NRR/SRXB
Cliff Doutt	NRR/HICB
Peter Wen	NRR/RGEB
Rhonda Doney	ABB-CE
Chip French	ABB-CE
Charles Brinkman	ABB-CE
Jeffery Isakson	ABB-CE
Armando Lopez	AMAG
Garth Richmond	Winston & Strawn
John Shaw	BG&E
Herb Estada	Caldon

Attachment 1

ABB COMBUSTION ENGINEERING NUCLEAR POWER

AND

ADVANCED MEASUREMENT ANALYSIS GROUP, INC.

Introduce

CROSSFLOW

Improved Technology for Reducing Flow and Power Measurement Uncertainties in Nuclear Power Plants

Attachment 2

AGENDA

- Introductions
- Goals of Meeting
- Background of ABB Activities
- CROSSFLOW Technology
  - Historical Development
  - Principle Of Operation
  - Operating Experience
  - Calibration
  - Error Analysis
- CROSSFLOW Demonstration
- Summary and Action Items

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INTRODUCTIONS

Rhonda Doney, Director Primary Systems, ABB

Chip French, CROSSFLOW Program Manager, ABB

Armando Lopez, Vice President Technical Development, AMAG

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GOALS OF MEETING

- Provide Overview on ABB Activities Associated with Potential Exemption Request
- Introduce NRC to CROSSFLOW
- Solicit NRC Guidance on Form and Content of Information Needed to be "Comfortable" with Performance of Hardware

BACKGROUND OF ABB ACTIVITIES

- September 98: ABB Review of TU Submittal
- October 98:
  - ABB Proposal to CEOG, "Feasibility Study for Power Uprate Due to Reduced Power Measurement Uncertainty"
  - CEOG Opts to Consider at 2/99 Meeting
  - Notice of Rulemaking
- November 98:
  - ABB Recommends CEOG Begin Work on Two Part Topical Report.
    - Part 1: Fuel and Licensing
    - Part 2: Performance Capabilities of CROSSFLOW
  - Non CE Owners / Current and Potential CROSSFLOW Users Express Interest in Initiative
  - CEOG Recommends Advocacy Paper in Lieu of Topical
  - To Serve non-CEOG Customer Needs, ABB Plans to Move Forward With "Part 2" of Topical Report

THE TEAM

RELOAD ANALYSIS SUPPLIER

- Generic Reload Analysis Methodology and Licensing Issues
- Plant Specific Licensing Issues

HARDWARE / INSTRUMENTATION SUPPLIER

- Generic Accuracy
- Plant Specific Accuracy

LICENSEE / UTILITY APPLICATIONS

- Power Uprate
- Margin

Initial Conclusion: No immediate show stoppers if safety analysis and licensing issues can be appropriately addressed.

BACKGROUND OF ABB ACTIVITIES

- December 98:
  - Guidance from NRC (Reference Dec. 8 letter) Indicates Origin and Use of 2% in Licensing Analysis is a Key Issue
  - Reg. Guide 1.174 Risk Assessment is Important
  - Not in the Business of "Licensing Instruments" (e.g., Venturis)
  - Topical Report on Licensing Issues with Lead Plant Request is a Must

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BACKGROUND OF ABB ACTIVITIES

- January 99: ABB Reissues Proposal to CEOG with Following Tasks:
  - Task 1:
    - Develop licensing / technical basis for exemption from Appendix K and increase in licensed power of up to 1% (2 months)
    - Research origin and basis of 2%
    - Investigate impact of reduced power measurement uncertainty (PMU) and increase in licensed power on plant, fuel, safety and setpoint analyses.
    - Investigate potential for improved margin
    - Develop a correlation for reduced PMU as a function of feedwater flow measurement uncertainty
    - Evaluate PSA using Reg. Guide 1.174 requirements

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BACKGROUND OF ABB ACTIVITIES

- January 99: (continued)
  - Task 2: Document Performance Accuracy of CROSSFLOW
  - Task 3: Prepare Generic Topical (1 month)
  - Task 4: NRC Review of Generic Topical (6-9 months)
  - Task 5: Prepare Submittal for Lead Plant Exemption Request and Power Uprate (2 months)

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BACKGROUND OF ABB ACTIVITIES

- February 99:
  - No Lead CEOG Plant at This Time, Vote on Initiative This Week
  - Current Candidates Include Calvert Cliffs, WSES, ANO2 for Potential Uprate
  - Non-CEOG Plants Have More Urgent Interest / Needs
  - Today's Meeting Intended to Support More Immediate Needs in Industry

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CROSSFLOW

HISTORICAL DEVELOPMENT

AND

OPERATING EXPERIENCE

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What is Cross-Correlation?

- A Mathematical Process for Determining the Similarity Between Two Random Signals
- Applications:
  - Noise Analysis for Instrumentation
  - Mixing Length
  - Pulse Timing
  - Flow Measurement

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Historical Development of the Method of Cross-Correlation for Flow Measurement

- England Multiphase Flow
  - First Used to Measure the Flow of Coal or Sand Water Mixtures
- General Electric of Canada
  - GEC Started Development in 1972 to Measure Single Phase Flow for Heavy Water Production
- Ontario Hydro
  - First Applied the Technology in 1984 to Measure Feedwater Flow
- AMAG
  - Obtained a Government Grant in 1994 to Understand the Physics of the Process

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Principle of Operation

Transit-Time Versus Cross-Correlation

- Transit-Time Measures the Difference in Time for an Acoustical Signal to Travel Upstream and Downstream
- Cross-Correlation Measures the Velocity of Eddies within the Fluid

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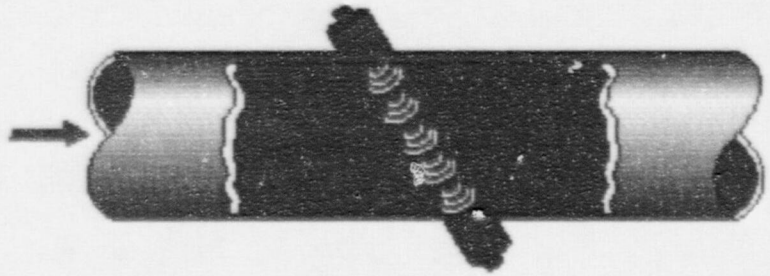
Transit-Time Technology



- Flow Equation:

$$W_{Transit\text{-}Time} = C_0 A_P \cdot \rho \cdot \frac{L}{2\cos\theta} \left[\frac{t_{US} - t_{DS}}{t_{DS} \cdot t_{US}} \right]$$

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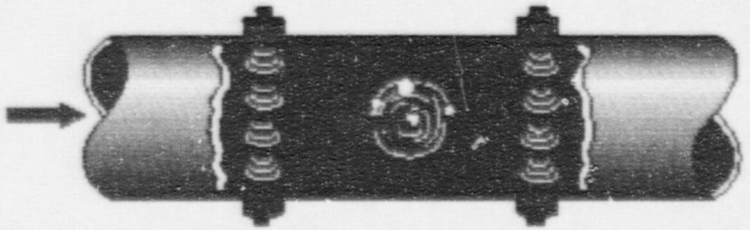
Cross-Correlation Technology



- Flow Equation:

$$W_{\text{Cross-Correlation}} = C_0 \frac{A \cdot \rho \cdot L}{\Delta t}$$

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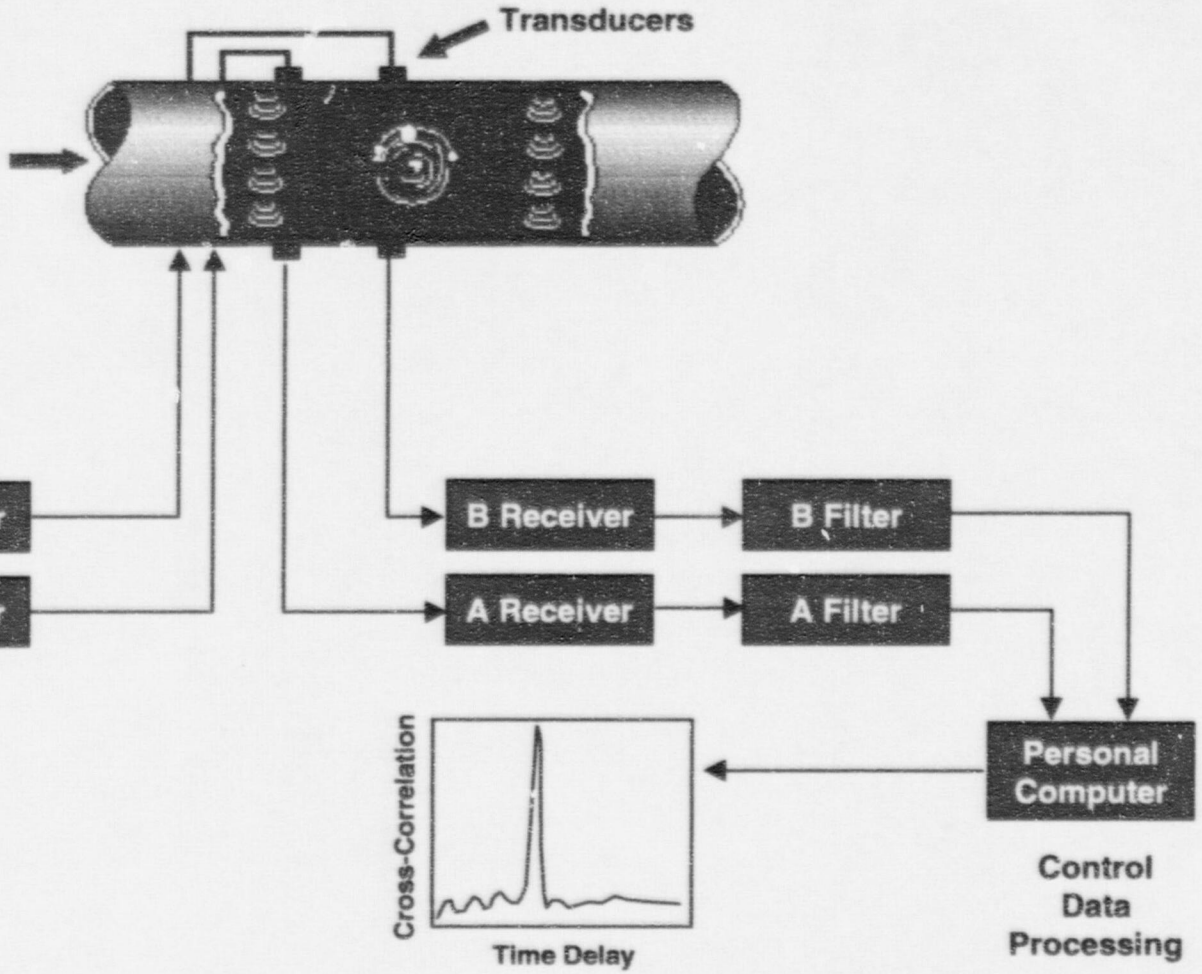
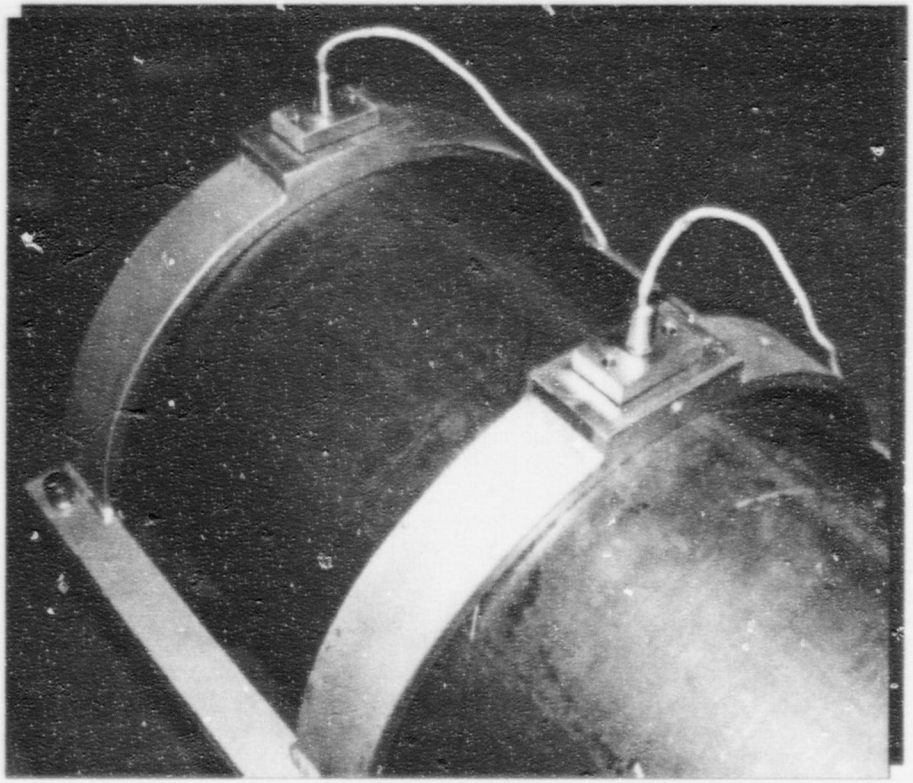
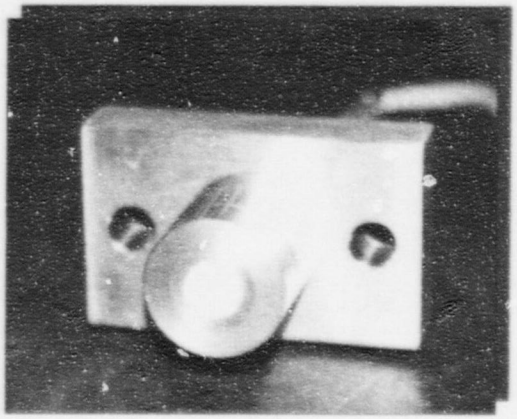
Cross-Correlation Block Diagram

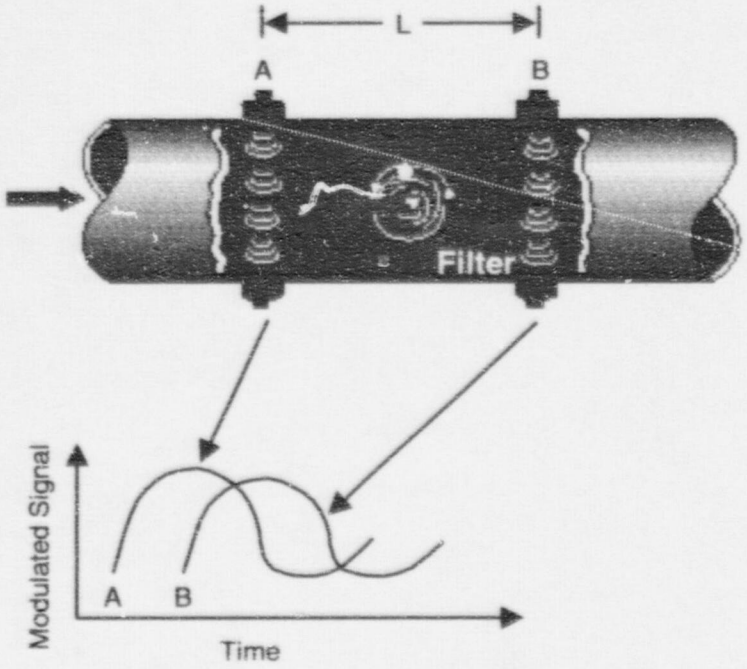


Transducer / Bracket Hardware

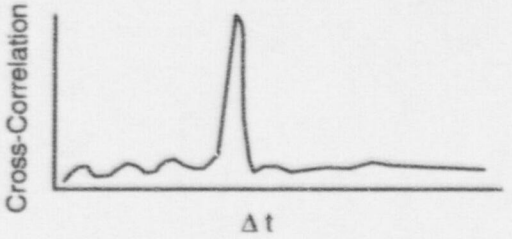




Cross-Correlation Numerical Process



$$\int f_A(t+\Delta t) \cdot f_B(t)\, dt$$



$$\text{Velocity} = \frac{L}{\Delta t}$$

- The Modulated Signals from the Upstream and Downstream Transducers are Displaced in Time by the Time that it Takes for the Eddies to Pass Between the Two Transducer Sets

Cross-Correlation Velo[illegible] Profile Correction Factor

- For Fully Developed Flow, The Cross-Correlation Velocity Profile Correction Factor is Uniquely Related to the Reynolds Number of the Fluid
- This Provides a Greater Level of Confidence When Extrapolating Laboratory Calibration Data to Plant Operating Conditions

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Alden Research Laboratory

Reynolds No.	Weigh Tank Flow (GPM)	CROSSFLOW Flow (GPM)	Difference (%)
6,963,000	17,645.6	17,652.1	+0.04
786,500	489.8	489.6	-0.04
2,261,100	1,426.0	1,424.8	-0.08
786,500	489.8	490.2	+0.08

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NIST Test Results

- Participating Vendors:
  - Advanced Measurement Analysis Group - Toronto
  - Controlotron - Hauppauge, New York
  - Krohne - Peabody, Massachusetts
  - Mesa Labs - Lakewood, Colorado
  - Panametrics - Waltham, Massachusetts

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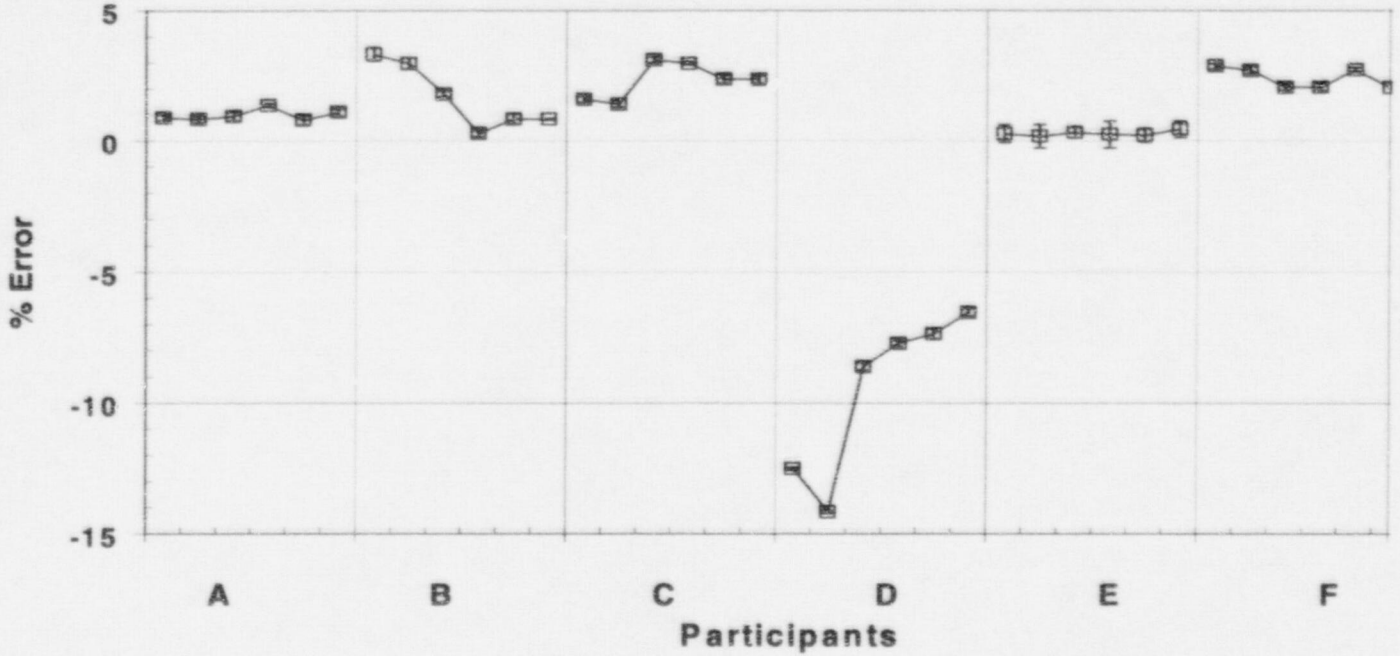
NIST Test Results

- Comparison of Test Results for a Reynolds Number of 400,000



Everest Laboratory Test Results

Test #	Date	Reynolds Number	CROSSFLOW	CHATOU	DIFF(%)
1	9-Sep	$1.3*10^6$	1082.73	1084.54	0.17%
2	9-Sep	$1.1*10^6$	901.19	902.7	0.17%
3	9-Sep	$0.86*10^6$	701.21	699.73	-0.21%
4	10-Sep	$0.73*10^6$	589.43	590.53	0.19%

Average Difference 0.08% Standard Deviation ±0.19%

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Everest Laboratory Test Results

- Reproducibility Tests

Test #	Comments	CROSSFLOW	CHATOU	DIFF(%)
1	Probes removed and re-installed.	1076.82	1079.46	0.24%
2	Probes removed. Frame loosened & reinstalled.	1077.[illegible]	1079.49	0.10%
3	Probes removed. Frame loosened, displaced, reinstalled.	1078.61	1079.59	0.09%
4	Probes removed. Frame loosened, rotated, reinstalled.	1076.73	1079.59	0.26%
5	Probes removed. Frame loosened, removed, re-installed.	1078.57	1079.56	0.09%
6	Probes removed. Frame loosened, move sideways, reinstalled.	1080.57	1079.70	-0.08%
7	Probes removed, Frame Loosened, rotated and moved sideways, reinstalled.	1078.99	1079.58	0.05%
8	Rec & trans probes interchanged. Frame loosened & reinstalled.	1080.78	1079.59	-0.11%
9	Probes removed. Frame loosened, rotated, displaced, reinstalled.	1080.86	1079.58	-0.12%
			Average Difference = 0.07% **Std Deviation = +/-0.15%**	

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Comparison of CROSSFLOW Measurements with Plant Data

- Diablo Canyon Unit 2
  - Reynolds Number 25,000,000
  - Plant Flow (k#/hr) 14,854
  - CROSSFLOW (k#/hr) 14,850
  - Difference -0.03%

- Shearon Harris *

– Plant Flow B and C Loops (k#/hr)	4,051	4,104
– CROSSFLOW B and C Loops (k#/hr)	4,047	4,107
– Difference	0.10%	-0.07%

* Single Day Demonstration

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Operating Experience

- Plants Where CROSSFLOW Has Been Used To Verify Feedwater Flow
  - Arkansas Nuclear One, Unit 1
  - Brunswick, Units 1 and 2
  - Davis Besse
  - Canada
    - Ontario Hydro (20 Plants), Point LePreau, Gentilly
  - Argentina - Embalse NPP
  - Romania - Cernavoda NPP
  - Brazil - Angra I

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Operating Experience

- Plants Where CROSSFLOW Is Being Used To Correct for Feedwater Venturi Fouling in the United States
  - Diablo Canyon, Unit 2
  - Palisades
  - Pilgrim
  - San Onofre, Units 2 and 3

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Operating Experience

- Plants Where CROSSFLOW Is Currently Being Installed
  - Vermont Yankee
  - Duane Arnold
  - Dresden, Units 2 and 3
  - Braidwood, Units 1 and 2
  - Byron, Units 1 and 2
  - LaSalle, Units 1 and 2

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Future Applications

- Reactor Power Uprate
  - CROSSFLOW can be Used Today to Correct for Venturi Fouling and in the Future for Power Uprate.
- Reactor Coolant Flow
  - ABB is Currently Working With EdF to Measure Reactor Coolant Flow

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CROSSFLOW

CLOSED SESSION

CALIBRATION AND ERROR ANALYSIS

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Derivation of the Velocity Profile Correction Factor

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Data Analysis

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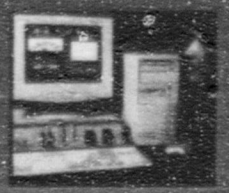

Weigh Tank Data

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Equation for the Velocity Profile Correction Factor

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Error Analysis

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System Stability

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System Stability

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NRC Observations and Suggestions

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