A BNFL Group Company

CROSSFLOW Ultrasonic Flow Measurement System

CROSSFLOW Status Update

May 25, 2004

NRC/WOG/Westinghouse Meeting – May 25

- Purpose:
  - Continue to inform NRC Staff of actions being implemented to ensure that CROSSFLOW Systems in operating plants continue to meet their design and licensing basis.

- Objectives:
  - Define role of WOG in managing regulatory interface.
  - Provide operating experience information from CROSSFLOW users.
  - Provide technical information and update on action plans.
  - Understand and address NRC Staff concerns.

CROSSFLOW **Status Update**

- Agenda
  - Introduction and Recent CROSSFLOW Experience
  - Overview of CROSSFLOW System
  - WOG CROSSFLOW Task Force
  - Operating Experience
  - CROSSFLOW Technology Laboratory Test and Plant Data
  - Action Plans Status Update
  - Summary and Future NRC Interactions

Introduction
and
Recent CROSSFLOW Experience

CROSSFLOW **Status Update**

- Westinghouse/AMAG stand firmly behind the CROSSFLOW Ultrasonic Flow Measurement System and its ability to deliver its intended design function of providing highly accurate feedwater flow measurement.
- CROSSFLOW is based upon a well founded theoretical basis and is supported by confirmatory laboratory and in-plant data.
- Westinghouse/AMAG are aggressively implementing actions to address feedwater system configuration / alignment issues as seen in specific plant installations.
- Westinghouse/AMAG will continue to support the NRC and our utility customers to reach full closure on any CROSSFLOW issues of concern.

CROSSFLOW **Status Update**

- CROSSFLOW User Communications Recent Experience
  - 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

CROSSFLOW Status Update

- Lessons Learned from Recent Experience

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  - Installation procedures need to be more robust.
    - Updated procedure has been prepared and issued.
  - Where a utility operates their feedwater system in more than one alignment, each alignment needs to be baselined if CROSSFLOW is to be used in that alignment.
  - Changes to feedwater system and/or components requires verification that CROSSFLOW remains within its design basis.
  - Prior to system commissioning always check for and document system noise.
  - More active sharing and documenting of utility operating experiences would be beneficial.

CROSSFLOW Status Update

- NRC UFM Task Group Interactions
  - In June 2003, Westinghouse/AMAG met with NRC and learned of an allegation regarding CROSSFLOW accuracy.
  - In October 2003, the NRC issued RAIs regarding the CROSSFLOW accuracy allegation.
  - In January 2004, Westinghouse/AMAG submitted responses to the allegation RAIs.
  - On March 5, 2004, Westinghouse received a NRC fax request for additional information regarding the allegation review.
  - On March 12, 2004, and March 26, 2004, Westinghouse/AMAG met with the UFM Task Group to respond to the RAIs.
  - In April 2004, NRC issued a draft version of the UFM Task Group Report.
    - Westinghouse/AMAG requested to review for technical accuracy and identification of proprietary information.
  - On April 22, 2004, Westinghouse/AMAG met with UFM Task Group to discuss technical issues covered in the draft report.
  - In May 2004, Westinghouse/AMAG provided formal comments.

Overview of CROSSFLOW System

CROSSFLOW **Status Update**

- Definitions
  - Two terms have been used in either the CROSSFLOW topical report, Westinghouse vendor notices and/or various interactions with the NRC that appear to be a source of confusion because they were not adequately defined previously.

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CROSSFLOW **Status Update**

- CROSSFLOW System Base Technology

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CROSSFLOW Status Update

- CROSSFLOW System Components

CROSSFLOW Status Update

- CROSSFLOW captures the signature at transducers A and B and calculates the travel time, Δt.
- Flow Equation $\longrightarrow$ $W_{fw} = C_o * A_p * \rho_{fw} * L/\Delta t$

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WOG CROSSFLOW Task Force

CROSSFLOW Status Update

- **WOG CROSSFLOW Task Force Initial Meeting May 12 & 13, 2004**
- **Meeting Attendees:**
  - **CROSSFLOW Users**
    - Constellation Generation Group
    - Entergy
    - Exelon
    - Nuclear Management Company
    - Omaha Public Power District
    - Public Service Enterprise Group
    - Southern Nuclear Operating Company
    - Southern California Edison
    - South Texas Project Nuclear Operating Company
  - **Westinghouse Electric Company LLC**
  - **Advanced Measurement and Analysis Group, Inc.**

CROSSFLOW **Status Update**

- **CROSSFLOW Task Force Mission**
  - Safe and reliable plant operations.
  - Provide a forum for joint discussion and resolution of issues/concerns, including NRC Staff concerns.
  - Share best practices and lessons learned.
  - Provide opportunity to address emerging issues collectively.
  - Provide structured environment to share pertinent information among CROSSFLOW Users, Westinghouse, and AMAG.

CROSSFLOW **Status Update**

- **WOG CROSSFLOW Task Force Presentations and Discussions**
  - Byron and Braidwood CROSSFLOW experience and status.
  - Ft. Calhoun experience and current activities.
  - NRC interactions.
  - Results of the Phase 1 and 2 Westinghouse CROSSFLOW action plans and recommendations.
  - Round table discussions concluded that while the CROSSFLOW topical report and SER constitutes the licensing foundations for CROSSFLOW the WOG should develop, share, and use operational information that addresses:

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CROSSFLOW **Status Update**

WOG CROSSFLOW Task Force
Participant Suggested Organization of Issues

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CROSSFLOW **Status Update**

– Provide reasonable assurance of proper CROSSFLOW installation/application (e.g., use of corroborating information)
  - The underlying cross-correlation technology theory and application is validated through comparison to laboratory test and/or plant data.

– Use of procedures/guidelines

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CROSSFLOW **Status Update**

- **Operational Issues (assurance that design basis is maintained)**
  - Industry issues addressed through plant corrective action program
  - Operational experiences shared between CROSSFLOW Users
  - PWR/BWR considerations
  - Feedwater pump type - electric (feedwater regulating valves) or steam driven
  - 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

CROSSFLOW Status Update

- **WOG CROSSFLOW Task Force Communications**

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- **Schedule**

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CROSSFLOW **Status Update**

- **Meeting Conclusions:**

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CROSSFLOW Operating Experience

Plant E. I. Hatch

CROSSFLOW Status Update

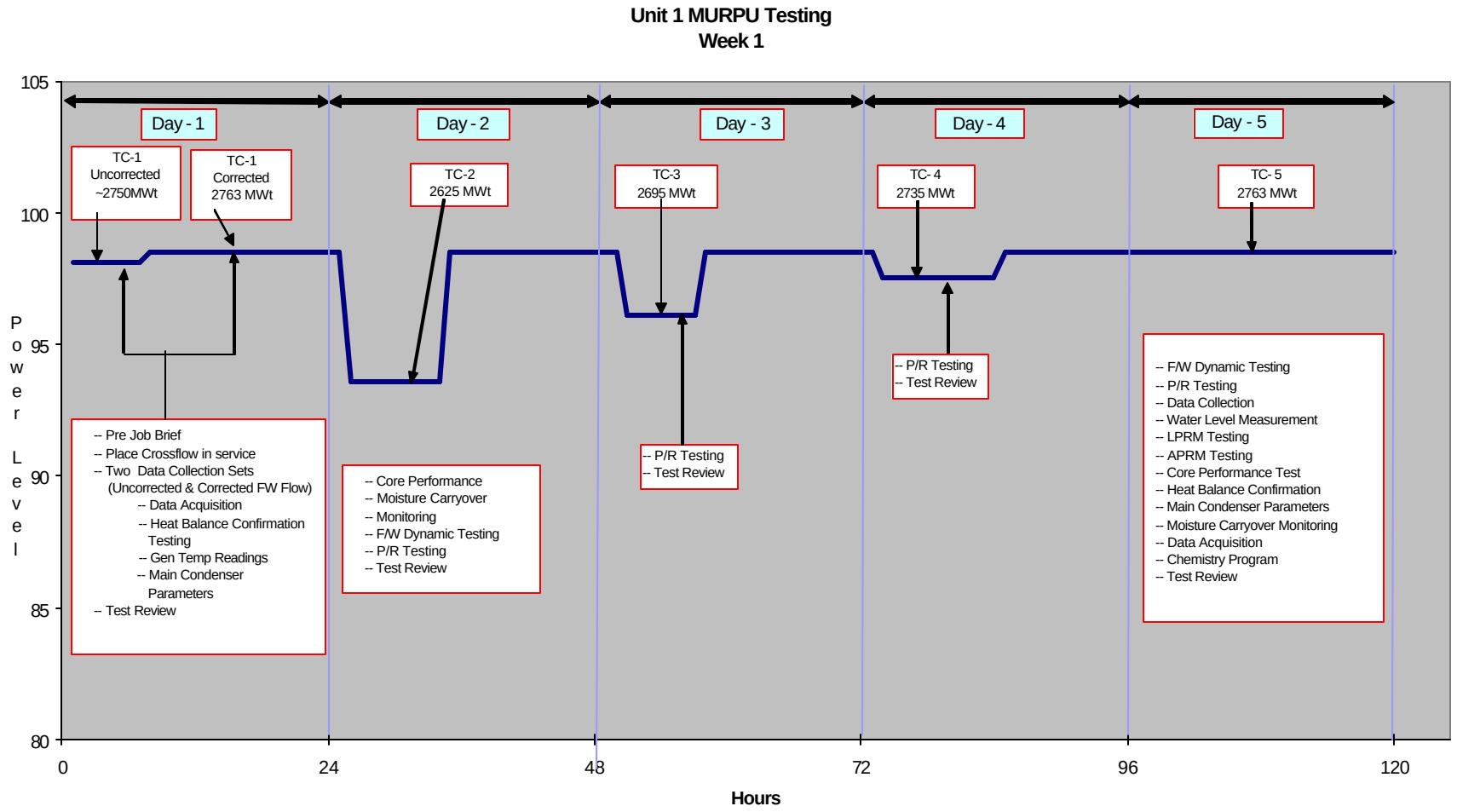
- **E. I. Hatch Operating Experience**
  - **E. I. Hatch Uprates**
    - 2436 MWt Original RTP
    - 5% Stretch Power Uprate 2558 MWt (1994-1995)
    - 8% Extended Power Uprate 2763 MWt (1998-1999)
    - 1.5% MUR Power Uprate 2804 MWt (2003-2004)
    - 15.1% Above original RTP
    - NRC RIS 2002-03 Reconciliation
  - **1.5% MUR Power Uprate**
    - CROSSFLOW Installation
      - UFM
      - UTM
      - Process Computer Interface

CROSSFLOW Status Update

- **E. I. Hatch Operating Experience**
  - 1.5% MUR Power Uprate
    - CROSSFLOW Installation
      - Additional pressure transmitters for density compensation
      - Unit 1 Total Loop Uncertainty = 0.457
      - Unit 2 Total Loop Uncertainty = 0.461
    - 72 Hour Allowed Outage Time
      - Technical Requirements Manual, Technical Surveillance Requirements and Technical Limiting Condition of Operation added for both units
        - » 1% power reduction if > 72 hrs (2777 MWth)
        - » 0.5% above previous Rated Thermal Power
      - Process Computer 72 hr clock automatically initiated
    - Unit 2 power ascension Fall of 2003
    - Unit 1 power ascension followed Spring 2004 Outage

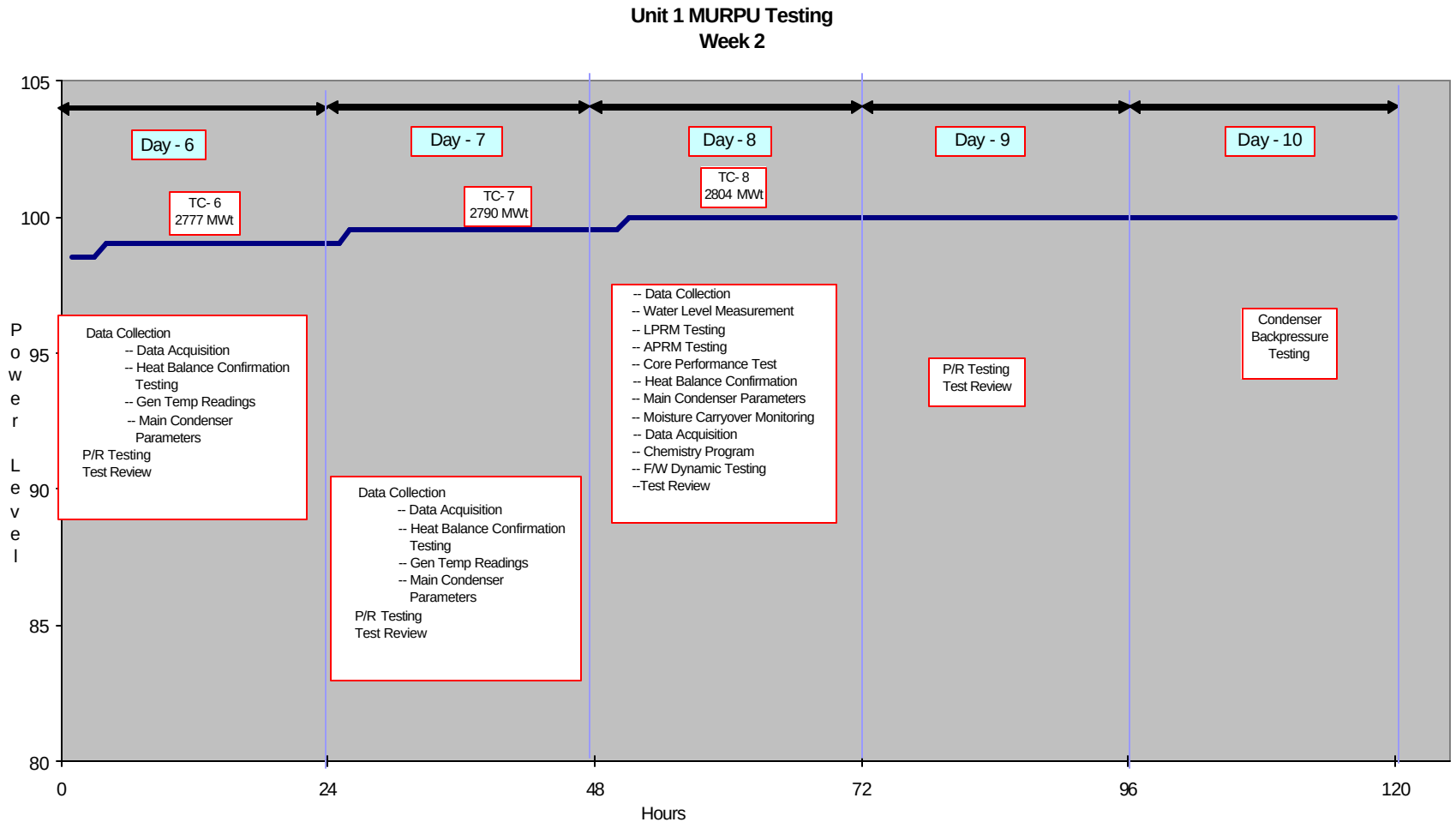
CROSSFLOW Status Update

- **E. I. Hatch Operating Experience**



CROSSFLOW Status Update

- **E. I. Hatch Operating Experience**



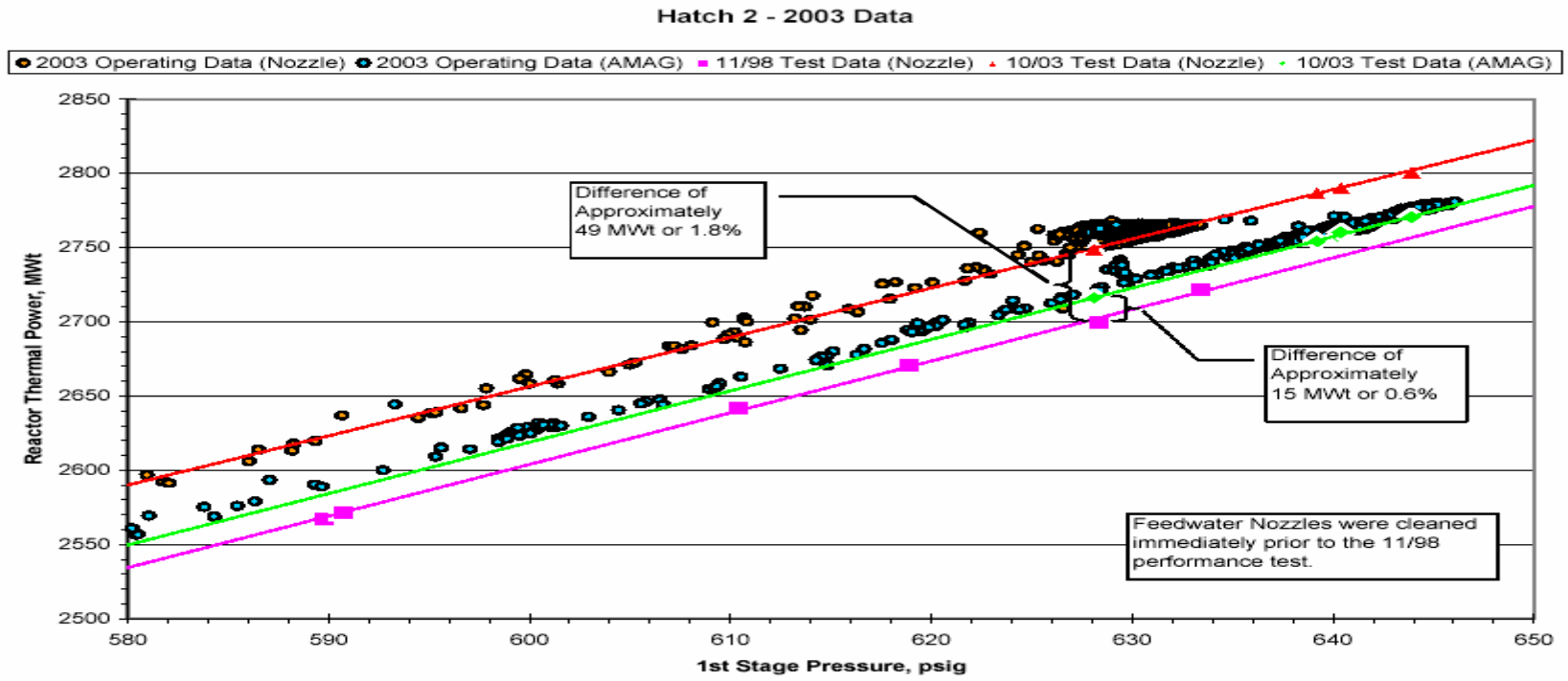
CROSSFLOW **Status Update**

- **E. I. Hatch Operating Experience**
  - Operational Practices
    - Core Thermal Power (CTP) performed by plant process computer
    - Plant Individual loops are corrected by CROSSFLOW system
    - Loop corrections are limited
      - Alarms if limits are exceeded
      - Requires review and justification to establish new limits
      - Correction factor
    - CROSSFLOW system is automatically removed from CTP computation if out of specification conditions exist.
    - CROSSFLOW system is a tool that corrects for plant instrument drift and nozzle fouling.
    - Tool for performance engineer but the result of CROSSFLOW input to CTP must be consistent with various other monitored plant parameters and indications.

CROSSFLOW Status Update

- **E. I. Hatch Operating Experience**

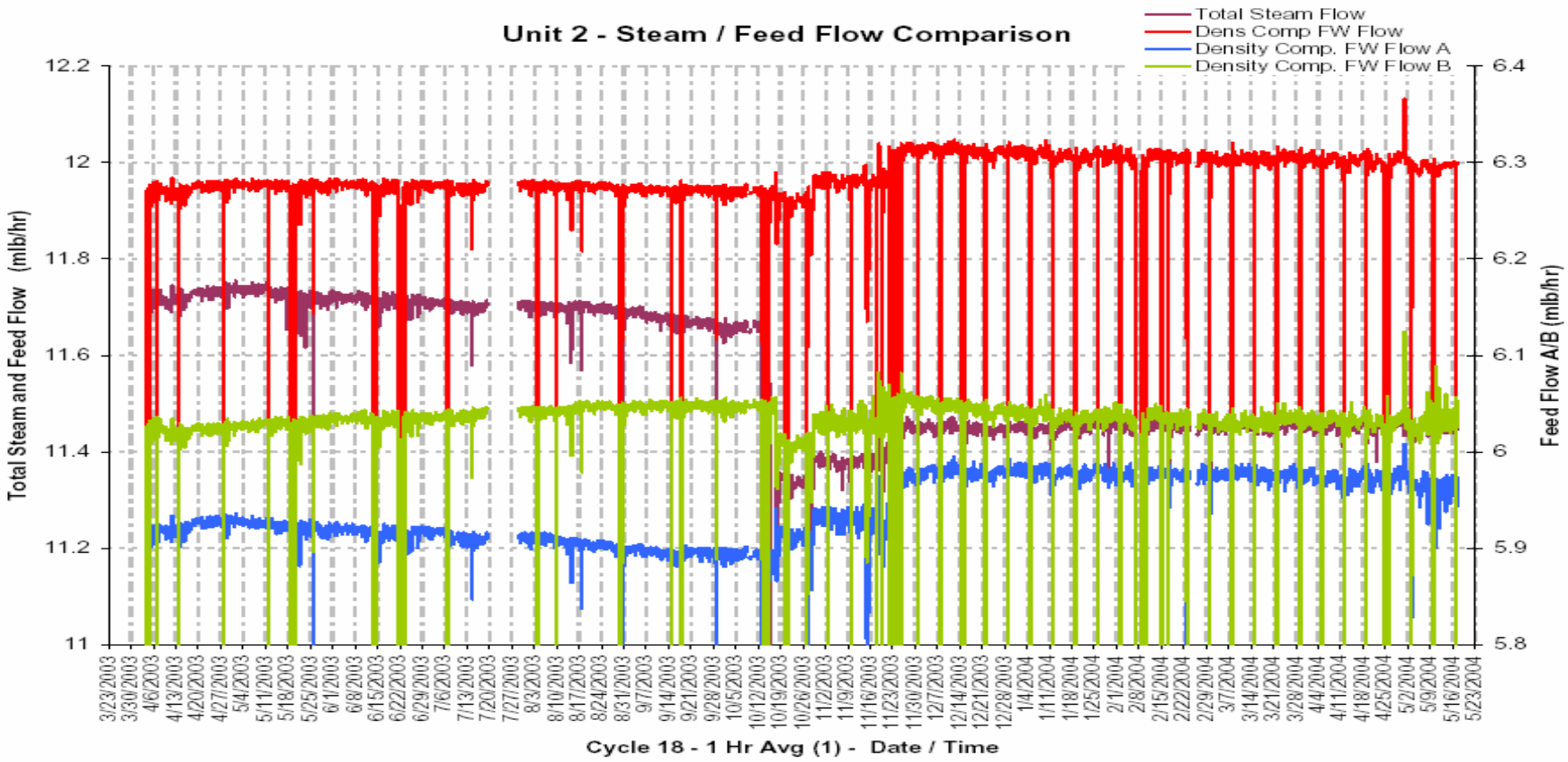
Figure 3



SCS/GPP Copy of u2 Cycle 18 1 Hr Avg Data 1.xls 1st vs Core MWt 2/18/2004

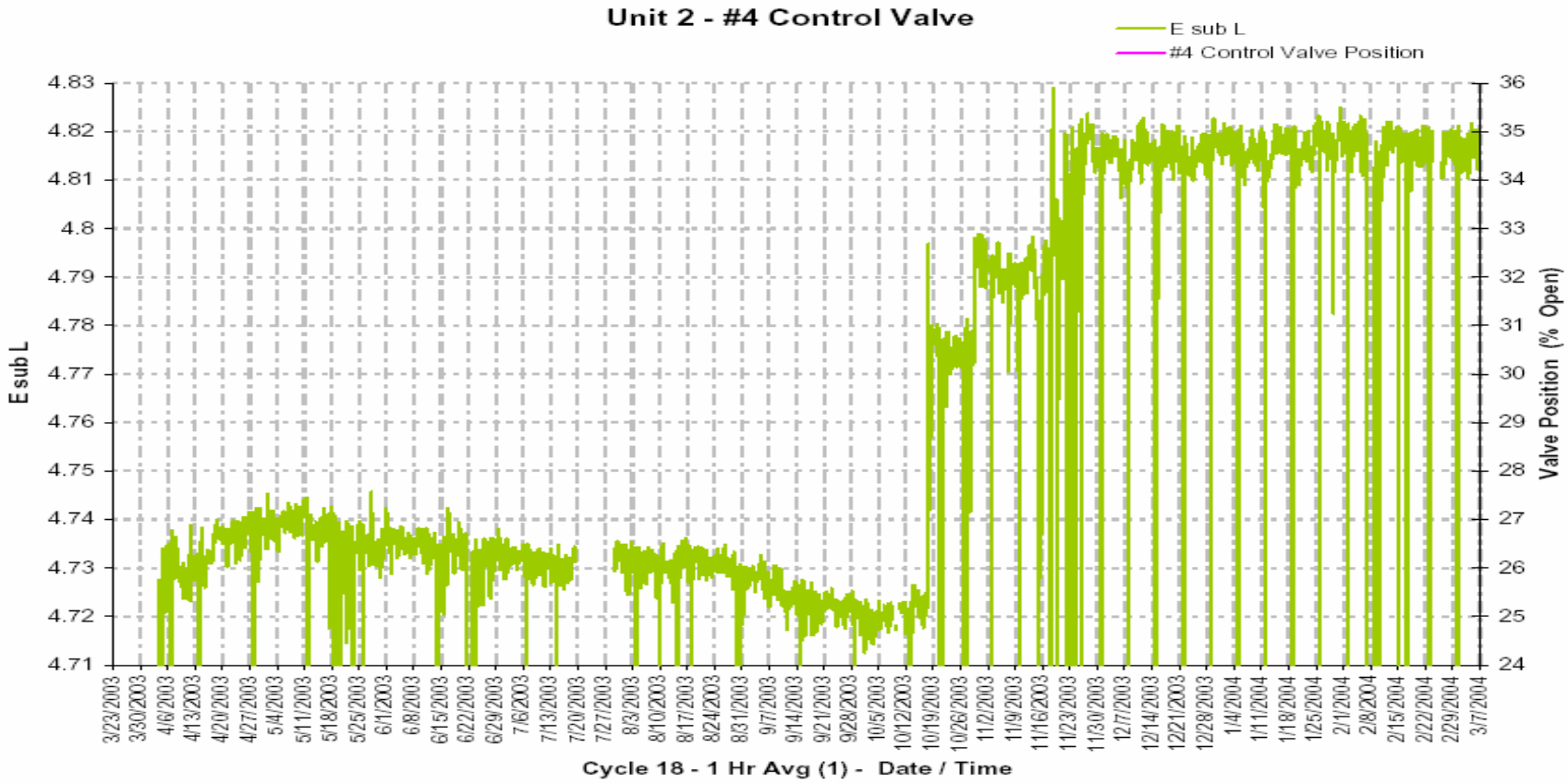
CROSSFLOW Status Update

- **E. I. Hatch Operating Experience**



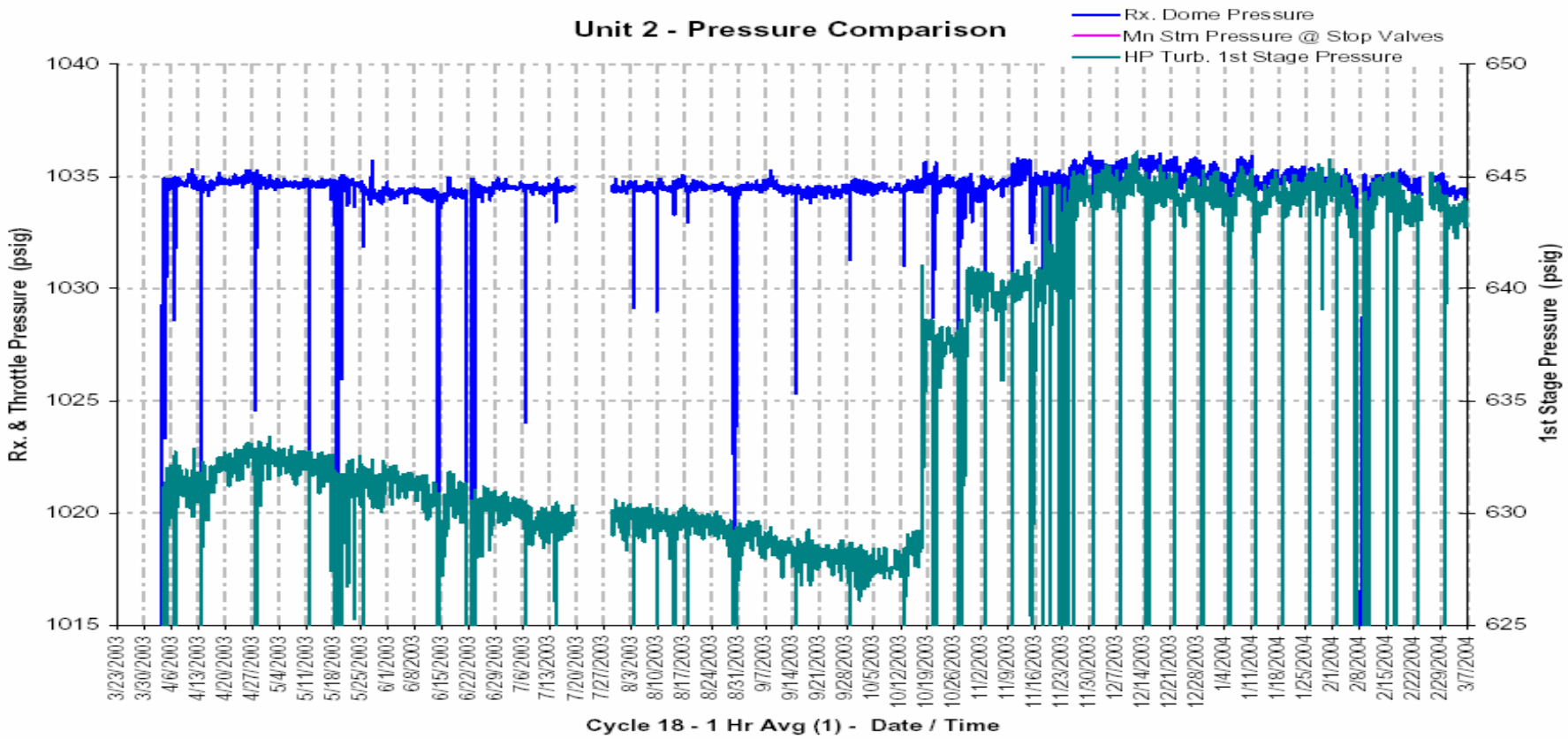
CROSSFLOW Status Update

- **E. I. Hatch Operating Experience**



CROSSFLOW **Status Update**

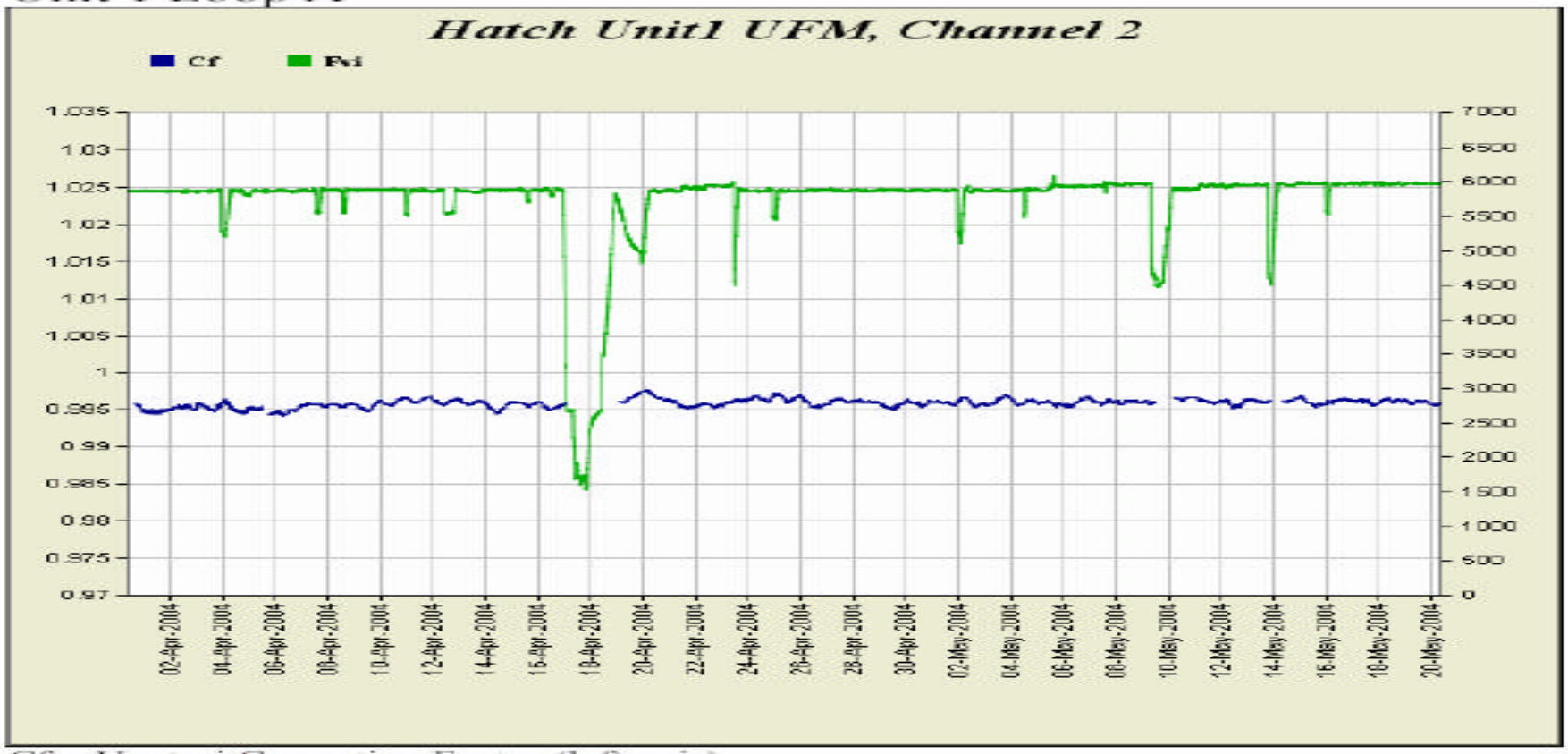
- **E. I. Hatch Operating Experience**



CROSSFLOW **Status Update**

- **E. I. Hatch Operating Experience**

Unit 1 Loop A

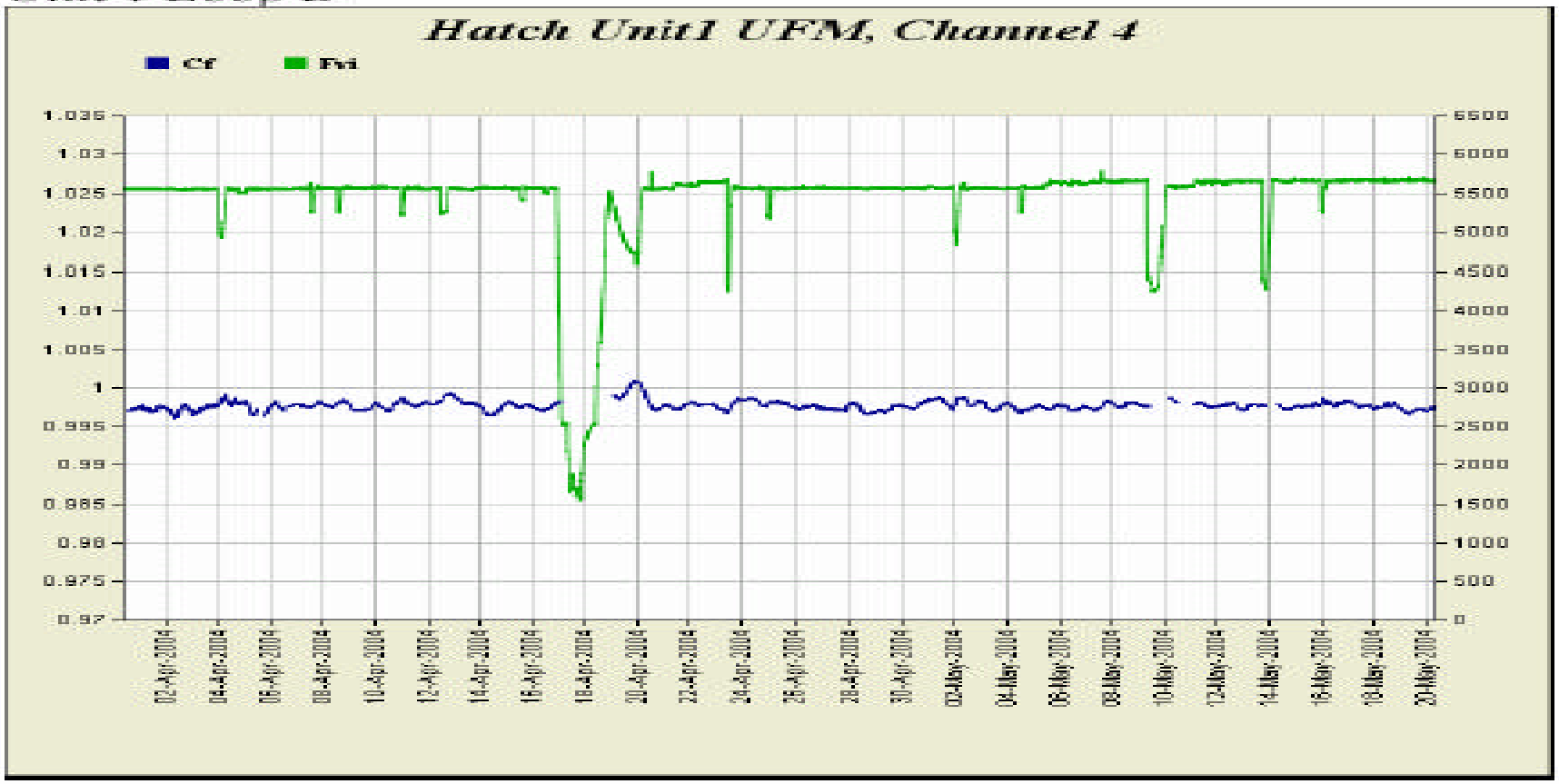


Cf – Venturi Correction Factor (left axis)
Fvi – Venturi readings (right axis)

CROSSFLOW **Status Update**

- **E. I. Hatch Operating Experience**

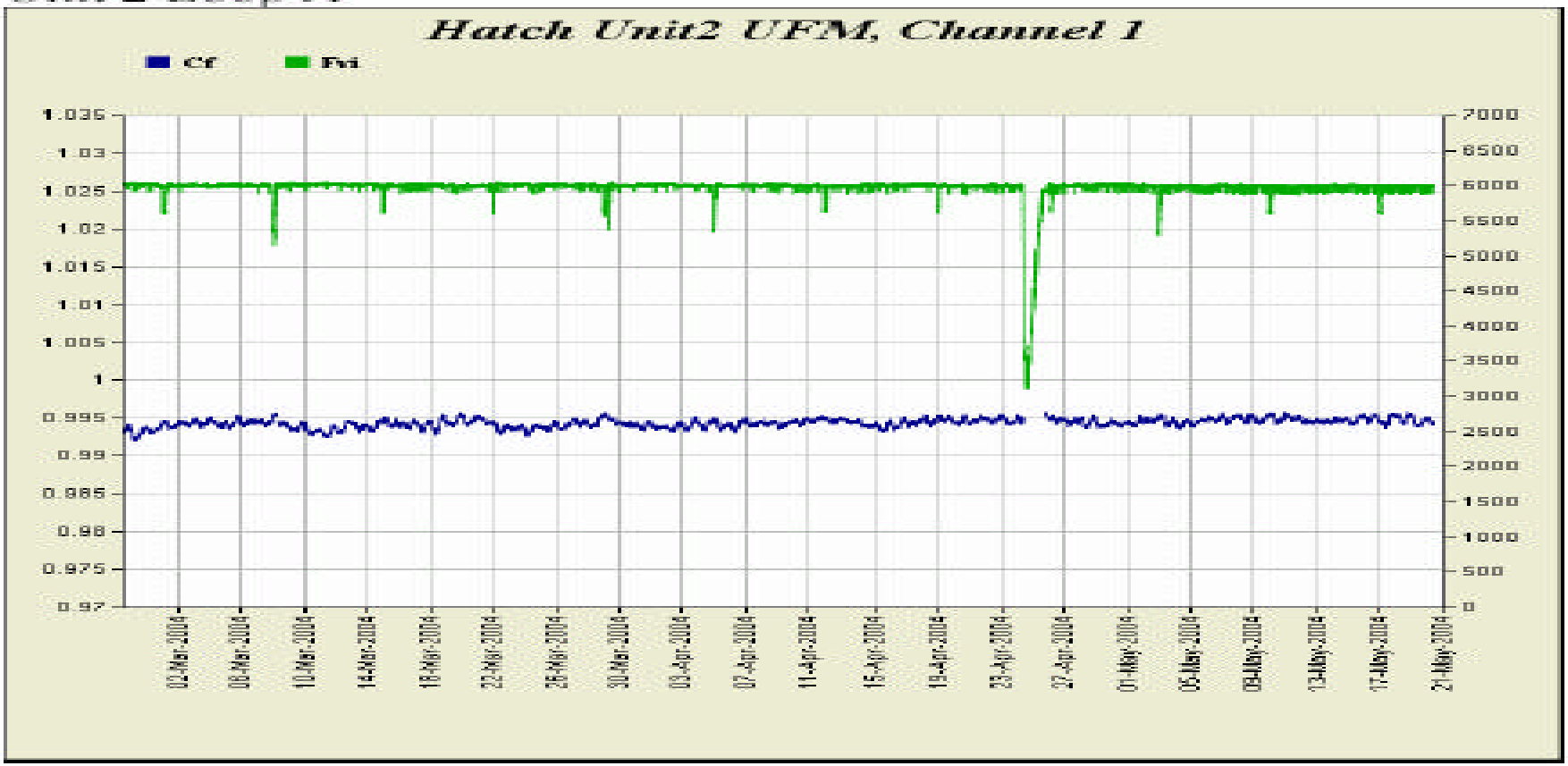
Unit 1 Loop B



CROSSFLOW **Status Update**

- **E. I. Hatch Operating Experience**

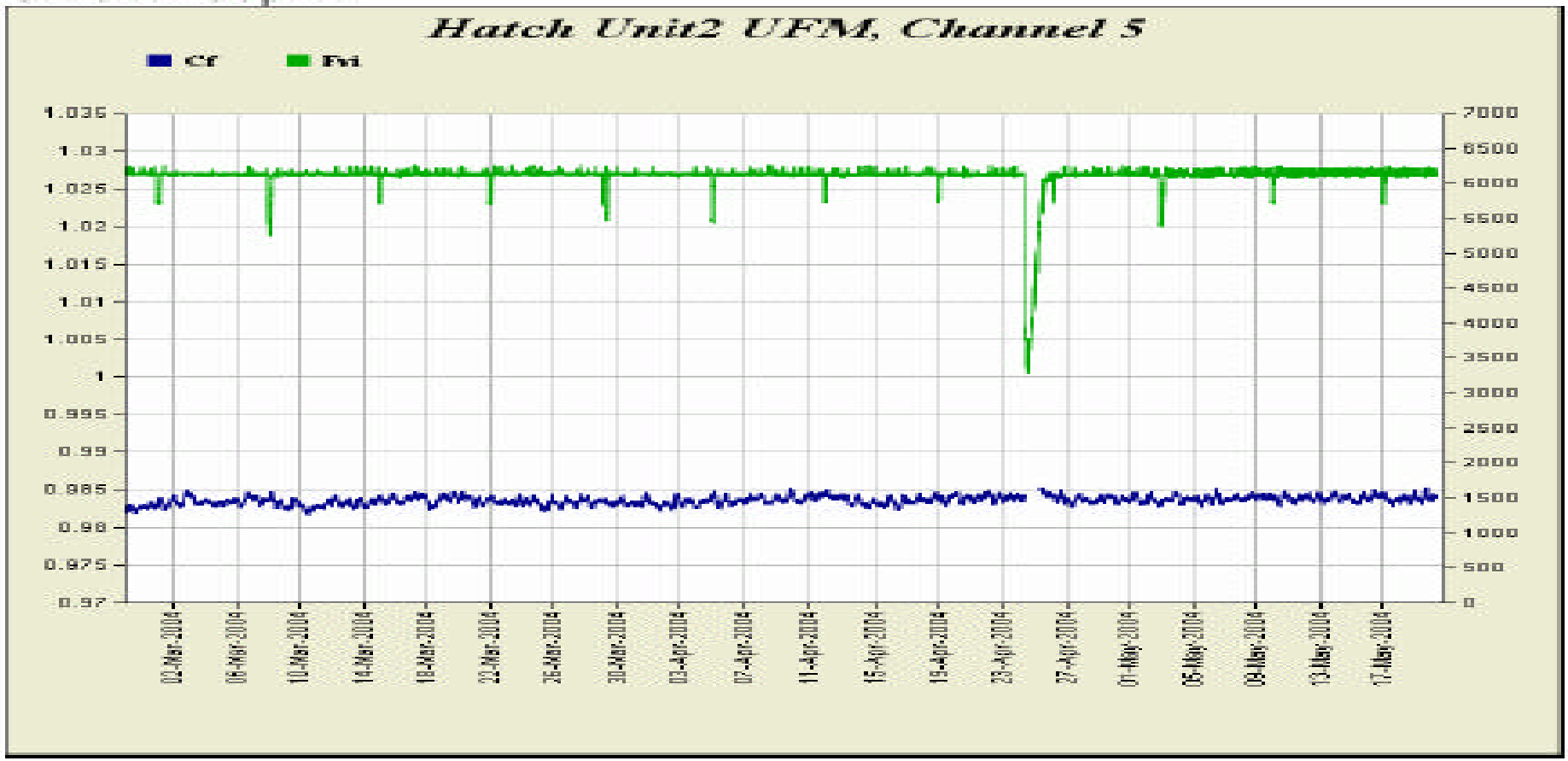
Unit 2 Loop A



CROSSFLOW **Status Update**

- **E. I. Hatch Operating Experience**

Unit 2 Loop B



CROSSFLOW Technology
Laboratory Test and Plant Data

CROSSFLOW **Status Update**

- CROSSFLOW Baseline Installation Criteria
  - CENPD-397-P-A, Rev. 1 identifies the manners in which an installation location is selected.

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CROSSFLOW **Status Update**

- Laboratory Test and Plant Data
  - Numerous tests have been performed to validate the CROSSFLOW meter underlying technology and to confirm meter accuracy.

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    - Data associated with some of the above tests is contained in the handout.

CROSSFLOW **Status Update**

Test Data and Extrapolation to High Re Number

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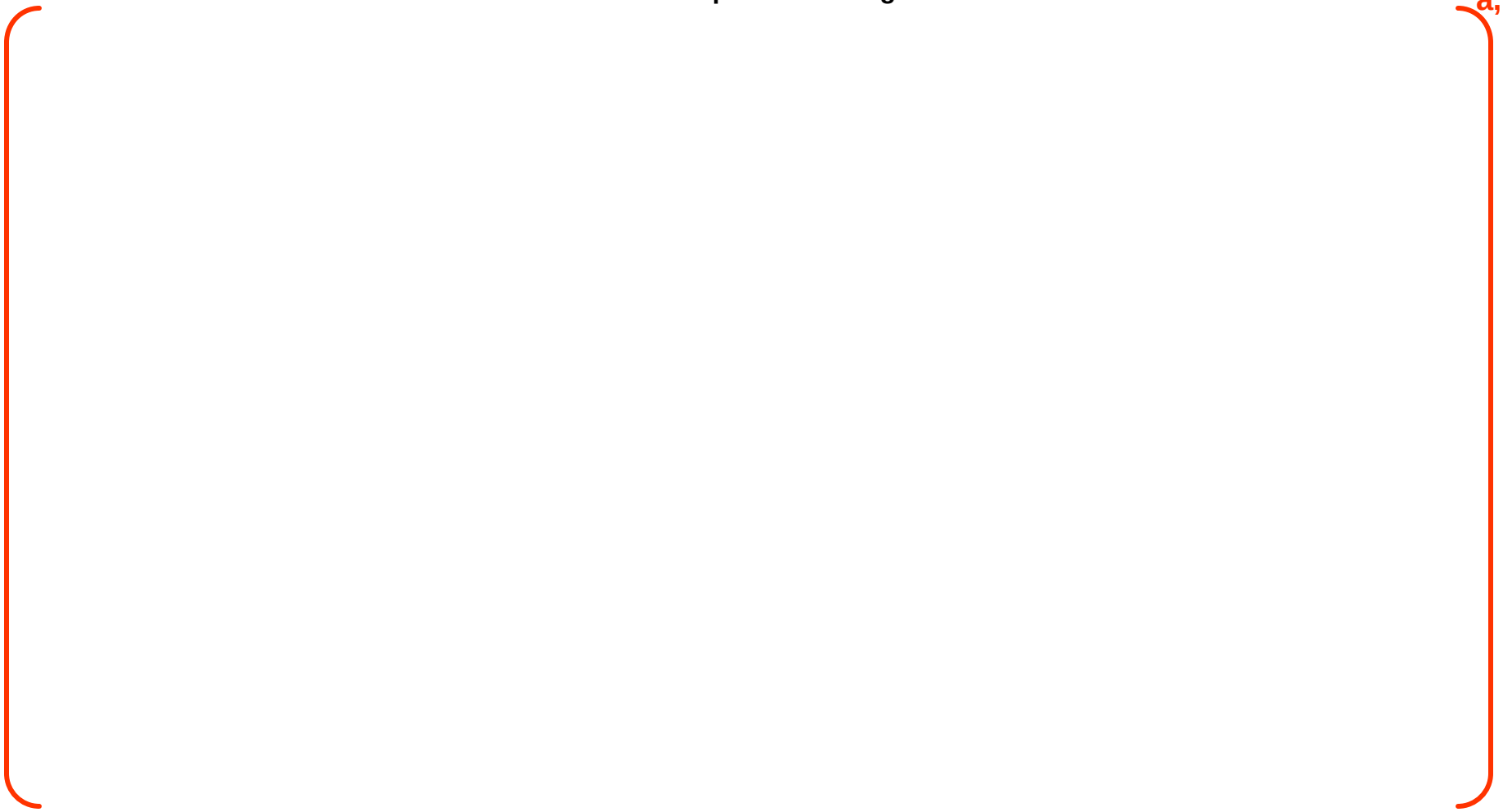

CROSSFLOW **Status Update**

- Laboratory Test and Plant Data (continued)

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CROSSFLOW **Status Update**

- Laboratory Test and Plant Data (continued)

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CROSSFLOW **Status Update**

- CROSSFLOW Baseline Confirmation – Summary

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Action Plans Status Update

CROSSFLOW **Status Update**

Generic Action Plan Phase 1

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CROSSFLOW **Status Update**

Generic Action Plan Phase 2

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CROSSFLOW **Status Update**

- Evaluate Operating Experience

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CROSSFLOW **Status Update**

- Evaluate Operating Experience (continued)

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CROSSFLOW **Status Update**

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CROSSFLOW **Status Update**

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CROSSFLOW **Status Update**

- Action Plan Key Milestones

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CROSSFLOW **Status Update**

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Summary and Future NRC Interactions

CROSSFLOW Status Update

- Summary and Future NRC Interactions
  - Westinghouse/AMAG stand firmly behind the CROSSFLOW System and its ability to deliver its intended design function of providing highly accurate feedwater flow measurement.
  - CROSSFLOW is based upon a well founded theoretical basis and is supported by confirmatory laboratory and in-plant data.
  - Westinghouse/AMAG are aggressively addressing feedwater system configuration / alignment issues as seen in specific plant installations.
  - Westinghouse/AMAG will support the NRC and our customers to reach full closure on CROSSFLOW issues.
  - A CROSSFLOW Task Force has been established as part of the Westinghouse Owner's Group (WOG).
  - Future NRC interactions will be addressed under the umbrella of the WOG CROSSFLOW Task Force.
  - Westinghouse/AMAG believes there is reasonable assurance CROSSFLOW systems are operating properly when operators follow the recommendations included in the vendor notices (i.e., Technical Bulletins and NSAL).

Supplemental Information

Recent CROSSFLOW Experience

CROSSFLOW **Status Update**

- 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

CROSSFLOW **Status Update**

- Recent CROSSFLOW Performance (continued)
  - In 2003, signal contamination was identified that impacted the CROSSFLOW determined venturi flow correction factor, C_f.
    - Signal contamination was identified at Byron and Braidwood Units 1 and 2 following system commissioning.
    - In each case, the CROSSFLOW Mounting/Transducer Support Frame (M/TSF) is installed on the individual feedwater lines.
    - The signal contamination was determined to be caused by acoustic noise resonating through the feedwater piping system over the frequency range utilized by CROSSFLOW.
    - The signal contamination was identified as a potential contributor that resulted in the plants operating in an overpower condition.

CROSSFLOW **Status Update**

- Recent CROSSFLOW Performance (continued)
  - In 2004, the venturi flow correction factor, C_f, determined by CROSSFLOW was observed to vary, outside of acceptable limits, when feedwater system equipment configuration/alignment is altered.
    - This condition was observed at Ft. Calhoun and Byron Units 1 and 2.
    - These observations were identified during commissioning of the CROSSFLOW system installations on the common header (i.e., before any licensed power increase was implemented).
    - Ft. Calhoun C_f Configuration/Alignment Sensitivity
      - A M/TSF is installed on each of the individual feedwater lines.
      - Three feedwater pumps are available permitting one pump to be out of service (e.g., for maintenance) without impacting feedwater system availability.
        - » Operationally, OPPD rotates the operating pump combinations in use at any given time. For example, A+B, A+C, B+C
        - » The installation baseline was for the A+B pump combination.
      - CROSSFLOW self-identified the out-of-limit C_f shift when the feedwater pump combination being employed was changed (e.g., to A+C or B+C).
      - It has been determined that the C_f shift most likely resulted from signal contamination from pressure wave caused by a 'strong' feedwater pump (C pump).

CROSSFLOW **Status Update**

- CROSSFLOW Performance (continued)
  - 2004 Configuration Sensitivity Discussion (continued)
    - Byron Units 1 and 2 C_f Configuration/Alignment Sensitivity
      - The CROSSFLOW M/TSF is located on the feedwater common header. This is a new installation location.
        - » The M/TSFs were originally located on the individual feedwater lines where signal contamination precluded their continued use.
      - CROSSFLOW self-identified the out-of-limit C_f shift when the last stage high pressure feedwater heater was bypassed.
      - To diagnose the cause of the venturi flow correction factor variation and determine differences in power output between Byron and Braidwood, Exelon had ABB conduct sodium tracer tests at both Byron units.
        - » The results of the tests showed a larger than expected discrepancy between the tracer and CROSSFLOW determined feedwater flow.
      - Piping design reviews, CFD modeling, and hydraulic laboratory testing have identified a lack of appropriate flow conditions at the meter location as potential causes. That is, stable (unchanging) turbulent single phase isothermal flow.

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