ATTACHMENT 3

CALDON

Caldon Experience in Nuclear Feedwater Flow Measurement

TITLE

23 pages

TL Date

B-84

LEFM STORY

The LEFM Story is an advanced technology story. Originally developed to measure water velocities over missile hatches on the George Washington Class Nuclear Submarine, the LEFM was later applied to accurate flow measurement challenges in rivers, open channels, large pipes in hydroelectric generating facilities, high temperature reactor coolant systems, and feedwater systems in nuclear power plants.

The LEFM was first applied in a commercial power plant in 1974 where it was used to measure Reactor Coolant Flow in the Prairie Island Unit 2 Nuclear Plant. This version of the LEFM was called a Chordal System because it made velocity measurements at four "chords" of the circular cross section of the pipe. The results were used to determine Reactor Coolant Pump curves that are still used today.

The LEFM Chordal Technology was applied to measure feedwater flow in 1977. Venturi fouling had been identified as a significant bias source resulting in decreased power output in nuclear plants. LEFM technology was used to correct biases caused by venturi fouling and recover lost MW. Ultrasonic feedwater temperature measurement capability to within ± 1°F was soon added to the LEFM.

Caldon purchased the LEFM technology from Westinghouse in 1989 in an asset transfer transaction. A completely new electronic platform, taking advantage of the latest microprocessor technology was introduced by Caldon in 1990. This electronic unit was called the LEFM 8300 and its increased flexibility allowed Caldon engineers to use LEFM technology in new ways and in new applications.

The first radical new application was the LEFM External Feedwater Flow and Temperature System. The External LEFM has the advantage of being installed on existing pipes without shutting down the plant. The LEFM External System was introduced in 1991 for MW recovery. Its feedwater mass flowrate accuracy is ± 1% and measures temperature typically within 1.5°F. The chief uncertainty for the LEFM External System is the knowledge of the hydraulic velocity profile. This uncertainty is bounded through extensive parametric site specific model testing.

Mil-Spec External Flowmeter

Another variant of the LEFM External technology was ruggedized to become the world's only MIL-SPEC ultrasonic flowmeter. This product is used on the latest generation Seawolf and Virginia Class submarines for the U.S. Navy in the Trim and Drain System. This model, called the LEFM 8400M, meets stringent requirements for shock, vibration, EMI/RFI, salt spray, and temperature.

RCS Flow and Temperature

A version of the LEFM External technology was applied to RCS temperature and flow measurement in 1995. Pilot measurements were made at the R.E. Ginna Plant and Watts Bar Plant during hot functional testing.

Appendix K Uprates

Caldon introduced the concept of Appendix K uprates to the NRC and utility customers in 1994. Appendix K uprates take advantage of the increased accuracy of the LEFM Chordal technology to increase licensed power and improve safety at the same time. The LEFM□ Topical Report ER-80P was submitted to the NRC for review in 1997 and approved for 1% Uprates in 1999. Comanche Peak Unit 2, the lead plant for Appendix K Uprates increased power in October 1999. In January of 2001, based on the new Appendix K Ruling of June of 2000, Watts Bar was approved for a 1.4% Appendix K Uprate using the LEFM□.

Caldon introduced the even more accurate LEFM CheckPlus System in 2001. The major improvements in the LEFM CheckPlus are more accurate measurement of velocity profiles and reduced sensitivity to changes in velocity profiles. Redundancy is another important feature of the LEFM CheckPlus System. The LEFM CheckPlus System was approved by the NRC for uprates up to 1.7% in December 2001.

New Developments

New applications for the LEFM technology include high temperature gas and steam flow. Development work is proceeding at Caldon to achieve the same high accuracies in tough applications that Caldon is known for.

Caldon Experience TimeLine

1962: LEFM developed for George Washington Class Submarine

1974: LEFM chordal technology applied to RCS flow measurement Prairie Island 2

1977: LEFM chordal technology applied to feedwater flow measurement ± 0.5%

1978: LEFM chordal technology used for feedwater temperature measurement

1989: Caldon, Inc. purchases LEFM technology from Westinghouse Electric

1990: Caldon introduces LEFM Model 8300 Electronic Unit

1991: Caldon introduces LEFM External feedwater flow and temperature measurement system for megawatt recovery

1992: Caldon retrofits first LEFM system at Comanche Peak for megawatt recovery

1994: Mil-Spec LEFM 8400 developed for Seawolf and Virginia Class submarines
Caldon introduces Appendix K uprate concept to NRC and utility customers

1995: LEFM external technology applied to RCS temperature and flow measurement at Ginna and Watts Bar

1999: NRC approves LEFM Check for Appendix K Power Uprates to 1%, first uprate granted at Comanche Peak

2000: Caldon introduces LEFM CheckPlus technology for accuracy to ± 0.3%

2001: NRC approved LEFM Check for 1.4% Appendix K Uprates
NRC approved LEFM CheckPlus for 1.7% Appendix K Uprates

2004: NRC Allegation Task Group reaffirms initial findings on suitability of LEFM Check and CheckPlus uprates

2006: NRC issues final SER affirming LEFM CheckPlus System for MUR uprates to 1.7%

LEFM FACTS AND DATA

LEFM Systems for MW Recovery

LEFM Systems are used for on-line calibration of installed differential pressure instrumentation. Differential Pressure type instruments are subject to drift, bypass, and fouling which often changes over time. This creates the need to calibrate differential pressure type measurements on-line to maximize MW production. A few cases of biases caused by different effects are provided for reference in the section called "Changes in nozzle bias".

Caldon is the world leader in MW Recovery Systems.

External LEFM Systems have:

- Been used to quantify biases in differential pressure type devices in 53 nuclear plants
- Been permanently installed in 33 nuclear plants for on-line calibration of plant venturis
- Identified 435 MW for recovery

Figure 1 lists the Peak MW recovered in permanent installations and Figure 2 lists the MW for recovery that have been identified in test installations of External Systems.

Utility	Plant	MW Recovered
TVA Nuclear	Sequoyah 1	7
TVA Nuclear	Sequoyah 2	18
TVA Nuclear	Watts Barr	18
Dominion Energy	Millstone 3	16
Constellation Energy Group	Nine Mile Point 1	7
Constellation Energy Group	Nine Mile Point 2	11
Florida Power & Light Co.	St. Lucie 2	18
Entergy Nuclear	FitzPatrick	16
Entergy Nuclear	River Bend	14
Entergy Nuclear	Grand Gulf	10
Exelon	Quad Cities 1	8
Exelon	Quad Cities 2	11
Electrabel	Doel 1	7
Electrabel	Doel 2	0
Electrabel	Doel 3	5
Electrabel	Doel 4	0*
South Carolina Electric & Gas Co.	V.C. Summer	7
Almaraz-Trillo NPP AIE	Trillo 1	10
Arizona Public Service Co.	Palo Verde 1	14
Arizona Public Service Co.	Palo Verde 2	19
Arizona Public Service Co.	Palo Verde 3	30
Asociacion Nuclear Asco - Vandellos II	Vandellos Unit 2	20
Iberdrola, S.A.	Cofrentes	9
FirstEnergy	Perry 1	0
Chubu Electric	Hamaoka 3	8
Tokyo Electric Power Co.	Kashiwazaki Kariwa 1	4
Tokyo Electric Power Co.	Kashiwazaki Kariwa 2	0*
Tokyo Electric Power Co.	Kashiwazaki Kariwa 4	10
Tokyo Electric Power Co.	Kashiwazaki Kariwa 5	0*
Tokyo Electric Power Co.	1 Fukushima Daichi 5	2
Tokyo Electric Power Co.	2 Fukushima Daichi 1	0*
Tokyo Electric Power Co.	Kashiwazaki Kariwa 7	8
Tokyo Electric Power Co.	1 Fukushima Daichi 4	0*
0* Venturi biased low	**Total MW Recovered**	**307**

Figure 1: LEFM External System Installations and Megawatts Recovered

Utility	Plant	MW Identified
Progress Energy	Shearon Harris	27
Entergy Nuclear	Waterford	7
Entergy Nuclear	ANO 1	14
Omaha Public Power District	Fort Calhoun	3
Florida Power & Light Co.	Turkey Point 4	7
Exelon	Dresden 3	15
Exelon	Clinton	0
Constellation Energy Group	Calvert Cliffs 2	14
Electrabel	Tihange 1	7
Electrabel	Tihange 2	4
Electrabel	Tihange 3	4
FirstEnergy	Davis Besse	3
Dominion Energy	North Anna 2	19
Dominion Energy	North Anna 1	4
Nebraska Public Power District	Cooper	0
Almaraz-Trillo NPP AIE	Almaraz Unit 1	0
Florida Power & Light Co.	St. Lucie Unit 1	0*
Asociacion Nuclear Asco - Vandellos II, A.I.E.	ASCO 1	0*
Asociacion Nuclear Asco - Vandellos II, A.I.E.	ASCO 2	0*
Progress Energy	Brunswick	0*
0* Venturi biased low	**Total MW Identified**	**128**

Figure 2: LEFM External System Flow Test and Lost Megawatts Identified

LEFM Chordal Systems have also been used for MW Recovery

LEFM Chordal Systems have:

- Been installed in 32 nuclear power plants
- Been used to recover 61 MW through on-line calibration of plant differential pressure instruments.

Figure 3 lists the MW recovered by site through calibration of the differential pressure instruments.

Utility	Plant	MW Identified
Entergy Nuclear	Indian Point 2	5
Entergy Nuclear	Indian Point 3	10
FPL Energy	Seabrook	5
Nuclear Management Company, LLC	Point Beach 1	0*
Nuclear Management Company, LLC	Point Beach 2	0*
Rochester Gas and Electric Corp.	Ginna	0*
TXU Energy	Comanche Peak 1	9
TXU Energy	Comanche Peak 2	7
Public Service Enterprise Group, Inc.	Salem 1	0*
Public Service Enterprise Group, Inc.	Salem 2	0*
Nuclear Management Company, LLC	Prairie Island 2	0*
TVA Nuclear	Watts Bar	N/A
FirstEnergy	Beaver Valley 1	2
FirstEnergy	Beaver Valley 2	0*
PPL	Susquehana 1	3
PPL	Susquehana 2	7
Iberdrola, S.A.	Cofrentes	N/A
Asociacion Nuclear Asco - Vandellos II, A.I.E.	Vandellos 2	0*
TVA Nuclear	Sequoyah 1	N/A
TVA Nuclear	Sequoyah 2	N/A
Entergy Nuclear	Grand Gulf	N/A
Entergy Nuclear	Waterford	4
Indiana Michigan Power Co.	DC Cook 1	7
Indiana Michigan Power Co.	DC Cook 2	1
Asociacion Nuclear Asco - Vandellos II, A.I.E.	Asco 1	0*
Entergy Nuclear	River Bend	N/A
Exelon	Peach Bottom 2	0*
Exelon	Peach Bottom 3	0
Progress Energy	Robinson	1
FirstEnergy	Davis Besse	0*
Shikoku Electric Power Co., Inc.	Ikata 2	0*
Asociacion Nuclear Asco - Vandellos II, A.I.E.	Asco 2	0*
Dominion Energy	Millstone 3	N/A
0* Venturi biased low	**Total MW Identified**	**61**

N/A - MW already recovered by External LEFM System

Figure 3: LEFM Chordal System Installation and Megawatts Recovered

LEFM Systems for Appendix K Uprates

Caldon pioneered efforts to gain approval for the Appendix K Uprate Concept, and today is the leading supplier of Appendix K Uprate Systems. The LEFM□ System is a chordal type design and has been approved for uprates up to 1.4% based on accuracies better than 0.5%. The LEFM CheckPlus System is accurate to better than 0.3% and has been approved for uprates up to 1.7%.

LEFM□ and LEFM CheckPlus Systems have:

- Been purchased for 34 plants
- Uprated 25 plants by 368 MW

Figure 4 shows the status as of January 1, 2005 for Appendix K power uprates.

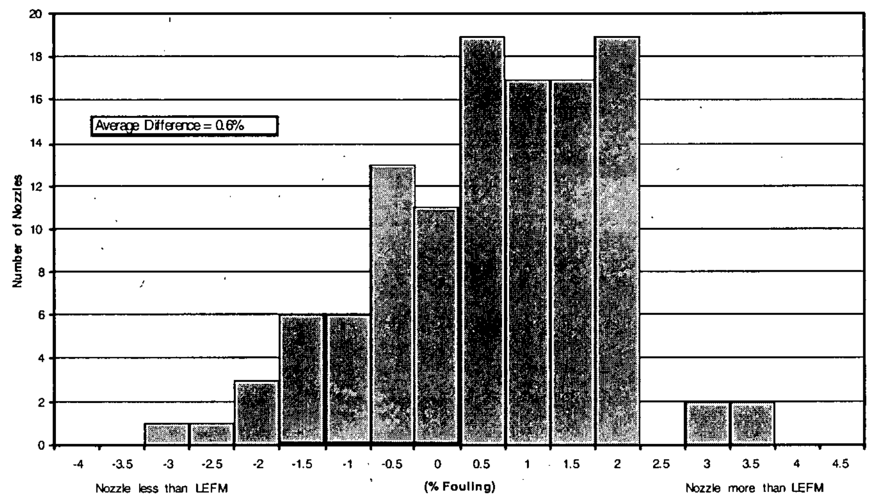
Utility	Plant	System	MW Uprated	% Uprate
TXU Energy	Comanche Peak 1	LEFM☐	16	1.40%
TXU Energy	Comanche Peak 2	LEFM☐	16	1.40%
TVA Nuclear	Watts Bar	LEFM☐	16	1.40%
FirstEnergy	Beaver Valley 1	LEFM☐	11	1.40%
FirstEnergy	Beaver Valley 2	LEFM☐ +	12	1.40%
PPL	Susquehana 1	LEFM☐	15	1.40%
PPL	Susquehana 2	LEFM☐	15	1.40%
Entergy Nuclear	Grand Gulf	LEFM☐ +	20	1.65%
FirstEnergy	Davis Besse	LEFM☐ +	*	1.60%
TVA Nuclear	Sequoyah 1	LEFM☐	16	1.30%
TVA Nuclear	Sequoyah 2	LEFM☐	16	1.30%
Entergy Nuclear	Waterford	LEFM☐ +	16	1.50%
Iberdrola, S.A.	Cofrentes	LEFM☐ +	18	1.70%
Asociacion Nuclear Asco - Vandellos II, A.I.E.	Vandellos 2	LEFM☐ +	15	1.40%
Asociacion Nuclear Asco - Vandellos II, A.I.E.	Asco 1	LEFM☐ +	14	1.40%
Asociacion Nuclear Asco - Vandellos II, A.I.E.	Asco 2	LEFM☐ +	14	1.40%
Nuclear Management Company, LLC	Point Beach 1	LEFM☐	7	1.40%
Nuclear Management Company, LLC	Point Beach 2	LEFM☐	7	1.40%
Entergy Nuclear	Indian Point 3	LEFM☐	14	1.40%
Entergy Nuclear	River Bend	LEFM☐ +	13	1.60%
Progress Energy	Robinson	LEFM☐ +	12	1.64%
Indiana Michigan Power Co.	DC Cook 1	LEFM☐ +	17	1.66%
Indiana Michigan Power Co.	DC Cook 2	LEFM☐ +	18	1.66%
Exelon	Peach Bottom 2	LEFM☐ +	18	1.70%
Exelon	Peach Bottom 3	LEFM☐ +	18	1.70%
Entergy Nuclear	Indian Point 2	LEFM☐	14	1.40%
Dominion Energy	Millstone 3	LEFM☐ +	*	1.70%
Shikoku Electric Power Co., Inc.	Ikata 2	LEFM☐ +	N/A	N/A
Progress Energy	Crystal River	LEFM☐ +	-	1.64%
Progress Energy	Shearon Harris	LEFM☐ +	-	1.64%
Progress Energy	Brunswick 1	LEFM☐ +	-	1.64%
Progress Energy	Brunswick 2	LEFM☐ +	-	1.64%
Shikoku Electric Power Co., Inc.	Ikata 1	LEFM☐ +	N/A	N/A
Shikoku Electric Power Co., Inc.	Ikata 3	LEFM☐ +	N/A	N/A
	Total MW Uprated		**368**	

** Installed but have not yet received SER (approval for uprate)*
♦ Received SER by have not yet installed the system
• Purchased the system but have not installed or received SER
- Orders expected
N/A Not using for MUR

Figure 4: LEFM☐ and LEFM CheckPlus System Installations and Megawatts Uprated

LEFM EXTERNAL VS. PLANT DIFFERENTIAL DEVICE DATA

The LEFM External meter has been used in 53 nuclear plants worldwide. Figure 5 shows the results in the form of a histogram. These results are a snapshot. It is well known that venturi biases resulting from fouling and bypass flow are dynamic. Caldon has published reports (ER-262) and papers documenting that external systems are subject to dynamic biases owing to changes in velocity profiles. While these changes can be bounded within ± 1% through rigorous parametric hydraulic modeling, they can lead to additional dynamic differences.



** Locations with header LEFM Systems assign equal difference values to all nozzles.*

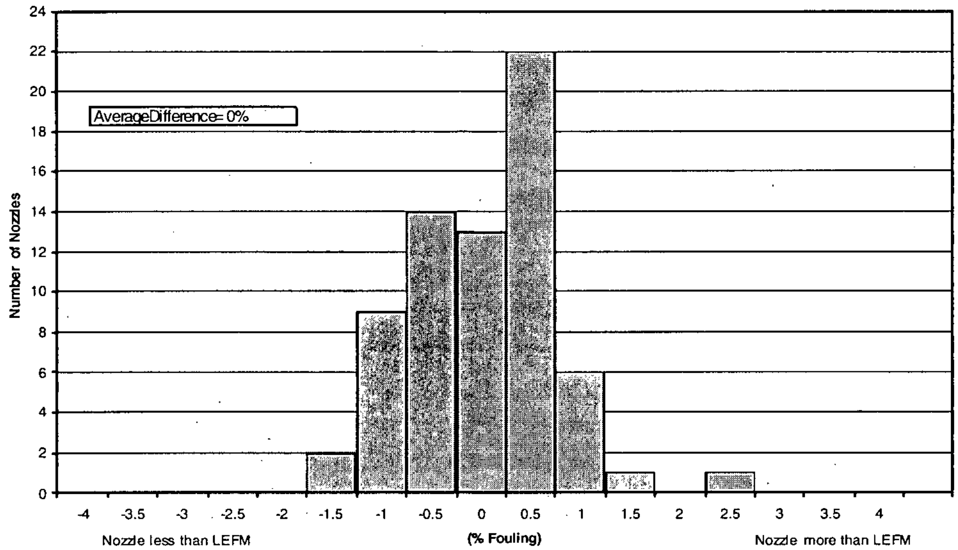
Figure 5: Comparison of Nozzle and LEFM External Flow Indications

LEFM CHORDAL VS. PLANT DIFFERENTIAL DEVICE DATA

The LEFM Chordal technology (8300, □ , and CheckPlus) has been used to recover power and uprate plants. Figure 6 is a histogram of the comparison data between the LEFM chordal technologies and plant differential pressure measurements.

Conclusions from the data are:

- Biases owing to fouling have probably been reduced over the years owing to improved water chemistry.
- The spread in actual nozzle uncertainty is ± 1.4% and is approximated by a normal distribution.



** Locations with header LEFM Systems assign equal difference values to all nozzles.*

Figure 6: Comparison of Nozzle and LEFM Chordal Flow Indications

CHANGES IN NOZZLE BIASES

The most common cause of changes in nozzle bias is the phenomenon of fouling. Fouling induced biases have proven to be difficult to predict, both in magnitude and in variation over a fuel cycle.

Long term comparison of data from LEFM, nozzles, and other plant instruments have confirmed the presence of fouling in at least 21 plants (Figure 7). The average value is 1.0%. In addition, Duane Arnold, Susquehanna, and Diablo Canyon have also reported dynamic fouling on the order of 1-2%. The average change in bias observed in 4 BWR's with the LEFM is 0.6%. The average change in bias observed in 17 PWR's is 1.0%

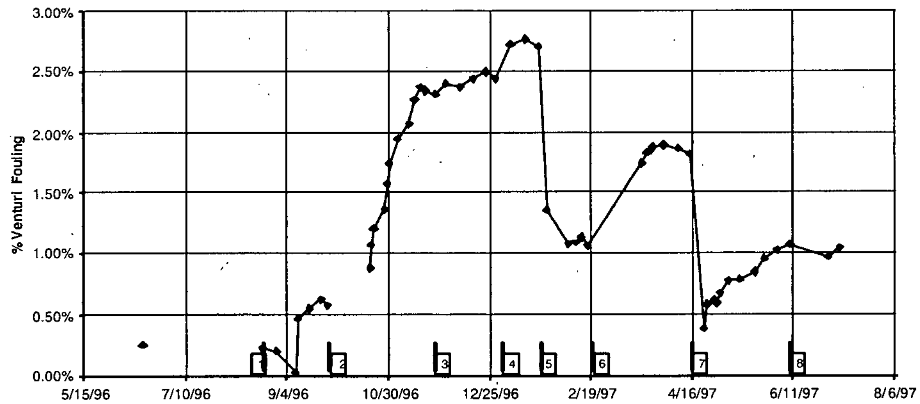
Utility	Plant	Bias Range
TVA Nuclear	Sequoyah 1	1.4%
TVA Nuclear	Sequoyah 2	1.4%
TVA Nuclear	Watts Bar	2.6%
Northeast Utilities	Millstone 3	1.4%
Niagara Mohawk Power Corp.	Nine Mile Point 1	0.7%
Niagara Mohawk Power Corp.	Nine Mile Point 2	1.0%
Florida Power & Light	St. Lucie Unit 2	2.0%
Entergy Operations, Inc.	River Bend	0.2%
Entergy Operations, Inc.	Grand Gulf	0.5%
Entergy Operations, Inc.	ANO 1	0.5%
Electrabel S.A.	Doel 1	1.0%
Electrabel S. A.	Doel 2	1.0%
South Carolina Electric & Gas	V.C. Summer	0.1%
Centrale de Trillo	Trillo 1	0.25%
Entergy Operations, Inc.	Indian Point 2	0.2%
North Atlantic Energy Service Corp.	Seabrook	0.2%
TXU	Comanche Peak 1	1.0%
TXU	Comanche Peak 2	1.0%
Nuclear Management Company, LLC	Prairie Island 2	0.25%
Arizona Public Service Co.	Palo Verde 1	2.0%
Arizona Public Service Co.	Palo Verde 2	1.5%

Figure 7: Plants in Which Nozzle Bias Swings During Fuel Cycle

Changes in Nozzle Biases-Case Studies

A growing number of cases where nozzle biases change over the course of a cycle have been documented both for BWR's and PWR's. Data from several cases are shown in Figures 8,9,10.

Figure 8 shows changes in feedwater fouling at Watts Bar Nuclear Plant during the first cycle of operation. Sensitivity to plant trips and downpowers are of particular interest. These reflect the dependence of fouling on water chemistry. Fouling up to 2.5% was verified and recovered during the cycle.



Notes:
1. Plant starts steady state operation.
2. MidCyle Outage on 10/1/96.
3. Downpower to 50% on 11/28/96.
4. Turbine inlet valve testing on 12/30/96.
5. Plant tripped on 1/22/97 and then tripped again on 1/27/97.
6. Plant tripped on 3/3/97 and in outage for several weeks. During this outage the venturis were exposed to air.
7. Plant tripped on 4/20/97.
8. Plant runback to approximately 50% power on 6/17/97.

Figure 8: Feedwater Fouling at Watts Bar Nuclear Plant

Figure 9 shows nozzle bias changes at Nine Mile Point 2 over an 8 month period. The effect represented as a flow correction factor, is shown for each of the two nozzles (Line A and Line B). The nozzles in both lines show changes of 0.75% to 1.0% over the course of the cycle. Also of note is the 2% variation in Line A for a period of 2 months.

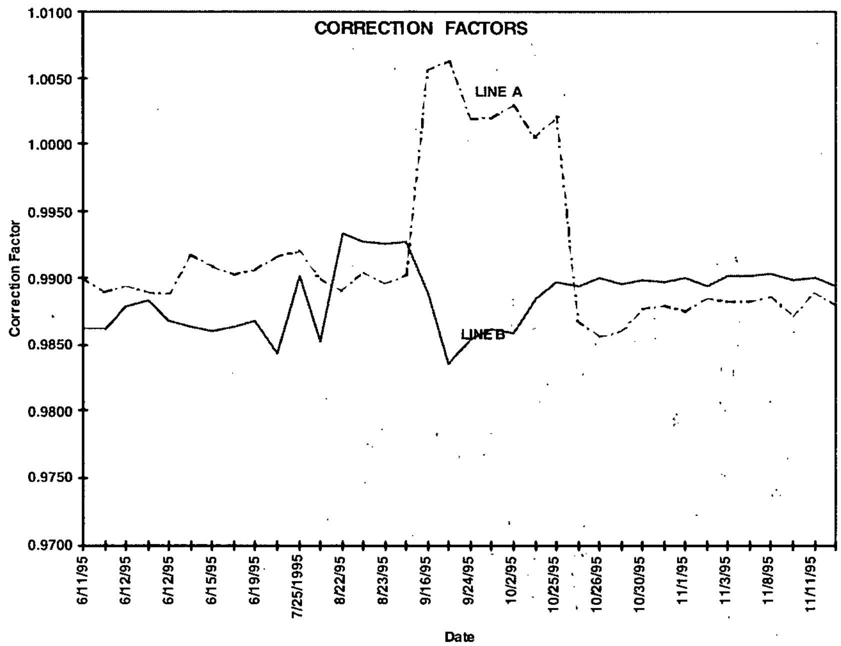


Figure 9. Feedwater Flow Correction Factor at Nine Mile Point 2

In at least one case, at Millstone 3, the development of nozzle fouling was observed during power ascension (Figure 10).

A small zero offset bias in the DP transmitters is apparent at low flow conditions. A significant change in the nozzle bias occurs between 340° and 400°F as Ph conditions for fouling become favorable. A rapid acceleration in fouling occurs between 400°F and the 437°F full power temperature.

Over 1.2% fouling occurred during this power ascension, before full power was reached. Fouling which occurs during power ascension is nearly impossible to detect by trending other plant indicators. Because of the absolute accuracy and repeatability of the LEFM however, it can be measured accurately as shown here.

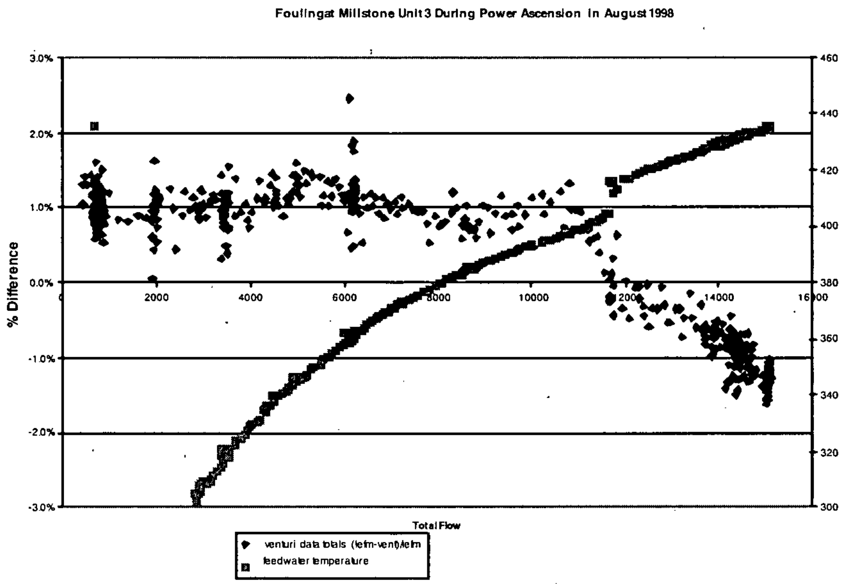


Figure 10. Effect of Fouling and De-fouling of the Feed Flow-Measurement -Nozzles on Plant Output

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The recalibration of plant instruments can also be a cause for a change in nozzle bias. One such case is shown for a BWR plant where the recalibration of a DP transmitter caused a conservative shift of 1.44% (Figure 11).

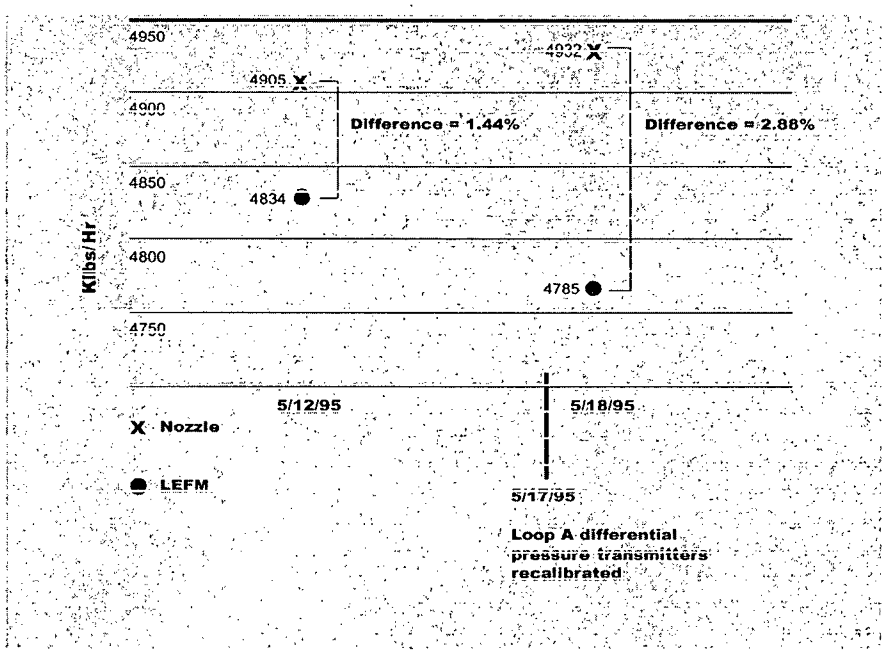

Figure 11: LEFM vs. Plant Flows, Loop A

CHANGES IN EXTERNAL SYSTEM BIASES

Caldon has developed extensive and significant experience in understanding and bounding the sensitivities and uncertainties in External and Chordal ultrasonic technologies. An extensive study of these effects is documented and has been made available to the public in ER-262. Contact Caldon or visit our website for a copy of this report.

Figure 12 shows the effects of swirl on an external ultrasonic measurement system. In this case, a change in hydraulic profile increased the swirl present 45 diameters downstream from a bend. The net effects were:

- LEFM□ meter factor change of 0.06%
- External meter factor change of 1.4%

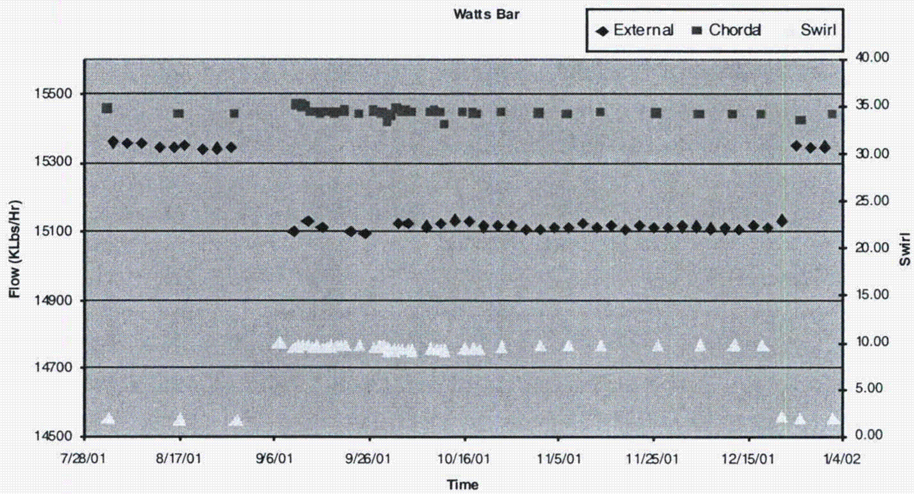

Figure 12: Change in Velocity Profile at Watts Bar

TEMPERATURE MEASURMENT BIASES ALL PLANTS

LEFM Systems measure temperature by means of a correlation with the velocity of ultrasound. The uncertainty of LEFM temperature readings over the range of conditions found in feedwater lines is ±1°F.

For the 46 plants from which final feedwater temperature LEFM and plant data are available, plant temperature indications (usually RTD's) ranged from 2.5°F low to 2.5°F high with on average, a 0.2°F high reading (Figure 13).

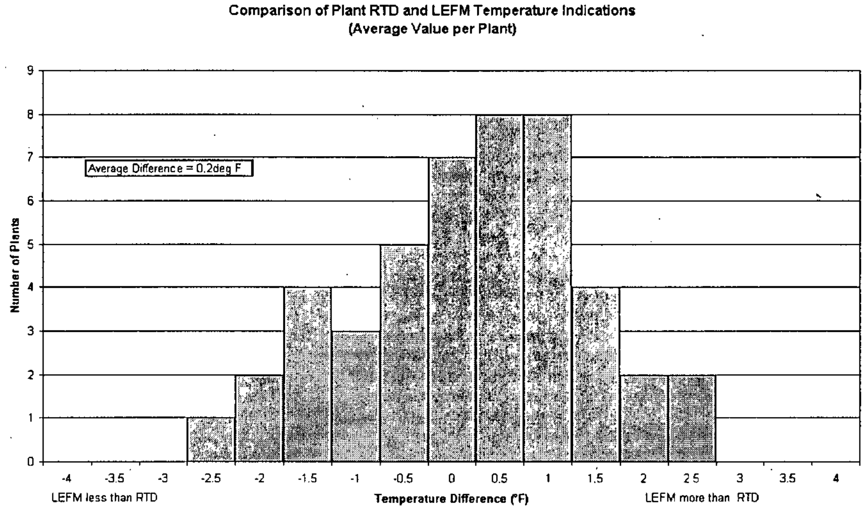

Figure 13: Comparison of Plant RTD and LEFM Temperature Indications (Average Value per Plant)

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LABORATORY TESTING

LEFM Flow Measurement Systems have been extensively tested at Alden Research Laboratories (ARL). The results are traceable to NIST Standards. Over 10,000 tests have been conducted with over 500 different piping configurations.

A typical result of this testing is shown below (Figure14). The data are for three LEFM's removed from a nuclear power plant, tested at ARL, and reinstalled. The LEFM readings were within 0.06% of the ARL weigh tank readings.

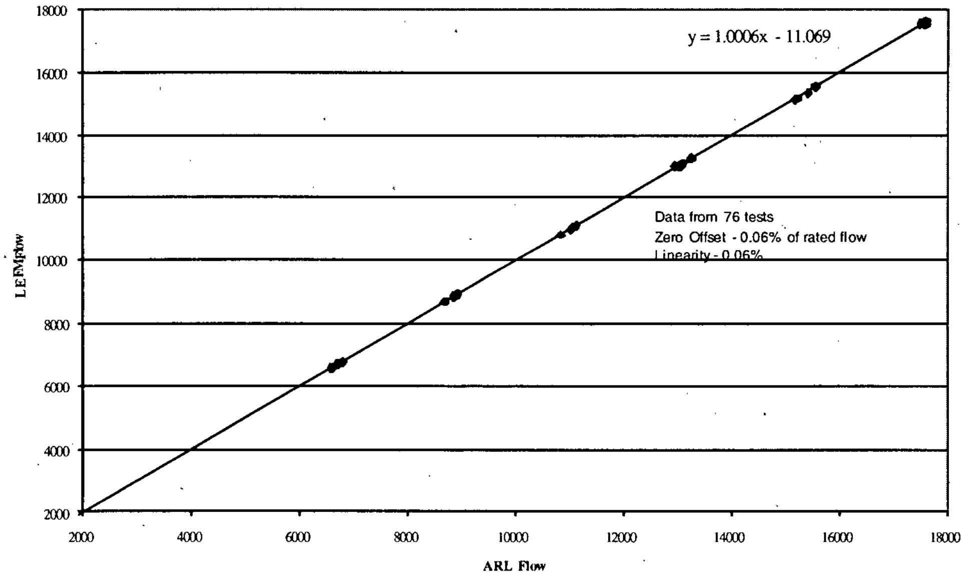

Figure 14: LEFM Performance vs. ARL Weigh Tank

LER HISTORY WITH NOZZLES

Inaccuracies in feedwater flow nozzles and temperature indications can lead to overpower events. A review of LEFM's for sustained overpower events from 1982 and 1999 (Figure 15) shows 38 events associated with inaccurate (non-conservative) feedwater and temperature measurements or calculations. All of these events could have been prevented if an LEFM had been continuously monitoring feedwater flow rates.

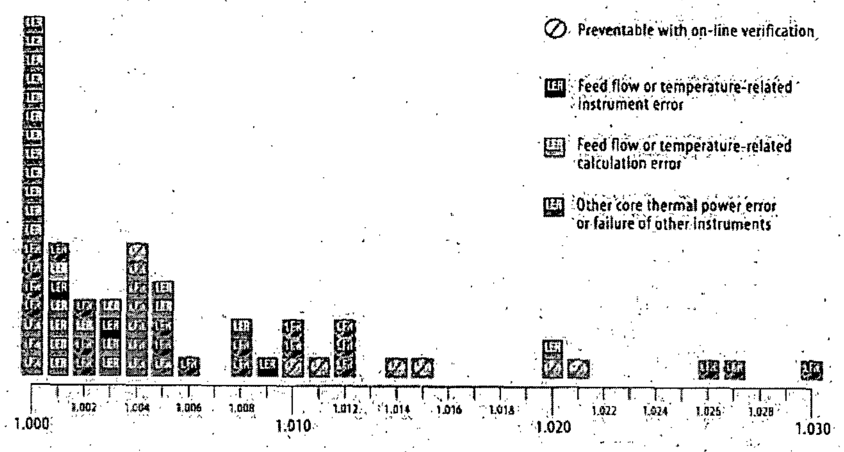

Figure 15: Sustained Overpower Events Reported in LER's (1982 –1999)

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LEFM DESIGN STANDARDS

Caldon uses the Codes and Standards shown in Figure 16 for the design and manufacture of LEFM Systems.

ANSI/ISO/ASQC Q9001	Quality Systems – Model for Quality Assurance in Design, Development, Production, Installation and Service
10CFR50 Appendix B	Quality Assurance Criteria for Nuclear Power Plants
10CFR21	Reporting of Defects and Nonconformance
ANSI N45.2	Quality Assurance program requirements for Nuclear Power Plants (V & V software only)
ASME B31.1 – 2001	ASME Code for Pressure Piping
ASME NQA-1-1999 Addenda Subpart 2.7	Quality Assurance Requirement of Computer Software for Nuclear Facility Applications
ASME NQA-1-1997	Quality Assurance Requirements for Spool Piece Design, Material procurement and Product inspection and tests
ANSI/IEEE-7-4.3.2 1993	Criteria for Programmable Digital Computer Systems in Safety Systems of Nuclear Power Generating Stations. Annex E only.
ASME PTC 19.1	ASME Performance Test Code for Measurement Uncertainty
MIL-C17/176D 6/90	Cables, Radio Frequency, Flexible, Twin M17/176-00003
MIL-C17/186B 91	Cables, Radio Frequency, Flexible, Twin 78 Ohms, M17/186-00001
EIA RS-232C-1969	Interface Between Data Terminal and Communication Equipment Employing Serial Binary Data Interchange
EIA RS-422-1975	Electrical Characteristics of Balanced Voltage Digital Interface Circuits
ANSI/EIA-310-D-1992	Cabinets, Racks, Panels and Equipment Standards
NEC 1993	Article 240 – Over Current Protection Article 250 - Grounding Article 300 - Wiring Methods
EPRI TR-102323 Rev. 1 (1/97)	Guidelines for Electromagnetic Interference testing in power plants (Guideline states susceptibility required for safety related systems only) – Special Configurations available which meet susceptibility requirements.
EPRI TR-103291s-V1-3	Handbook for Verification and Validation of Digital Systems
IEEE Std. 1050-1989	Guide for instrumentation and control for equipment grounding in generation stations.

Figure 16: Caldon LEFM Design and Manufacture Standards

SERVICES

Caldon's experience in Nuclear Power Plants has led to the development of a wide range of services and documentation.

Support Services

Caldon provides a full range of services to support customers.

- A group of service engineer specialists to install, test, commission, and repair LEFM Systems
- Classroom hands-on training of customer personnel
- Stock supply of emergency spare parts
- A monitoring program permits each LEFM System to be regularly checked for accuracy of flow measurement and component degradation

Design Basis Document

- A comprehensive "Design Basis Document", including a bottom-up analysis of uncertainties, is provided for each system installed to recover megawatts
- The profile factor used to calibrate LEFM Systems is determined from flow data taken at Alden Research Laboratories under conditions replicating plant piping.