Initial draft of ML060400418 2/6/06
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Attachment

Meeting at Alden Research Laboratory, Inc. On January 17 and 18, 2006 to Review Application of the Caldon Checkplus Ultrasonic Flow Meter (UFM) for a Power Uprate at the Seabrook Nuclear Power Plant

1 SUMMARY AND CONCLUSIONS

The subject meeting was held to obtain additional information as discussed during the Reference A and B meeting held at NRC's Headquarters on December 16, 2005. Attendance is identified in Attachments 1 and 2.

Jim Nystrom, the Senior Vice President of Alden Labs, provided an analysis of the facility that supported an uncertainty of 0.088 percent in determination of the volume of water collected during each test run (Reference C). I believe the result is consistent with the National Institute of Standards and Technology (NIST) guidance that is applied to operation of the Alden Facility and I conclude this uncertainty is appropriate for use in evaluation of the Caldon Checkplus UFM.

A total of 175 tests were conducted with about 2000 to 6000 data points per test, depending upon flow rate. The tests covered a wide range of configurations and flow rates designed to bracket conditions that might be encountered in the Seabrook application. This included flow rates significantly below what would be encountered at Seabrook, but the maximum flow rate did not achieve a value equal to Seabrook operation at full power because this was outside the range capability of Alden Laboratory. Interestingly, there was a test series where swirl was deliberately introduced. The poorest correlation in all tests required a correction factor of 1.0048 to obtain agreement between the Checkplus flowrate prediction and the flowrate determined during the Alden tests. This close agreement between indicated and actual flow rate places less demand upon Checkplus correction than would be the case if the Checkplus was less accurate.

Caldon uses the Checkplus output to compensate for flowrate changes and swirl and no longer uses a Reynolds number extrapolation to extrapolate UFM correction factor to plant conditions. This approach appears promising but I have not completed my evaluation of these processes and have not reached any findings. Consequently, there is little coverage of these topics in this report.

I have identified no significant problems with use of Checkplus at Seabrook. We tentatively scheduled a final meeting at Seabrook on March 21 and 22, 2006, should an additional meeting be necessary. Our schedule is to complete the safety evaluation report by May 31, 2006. This is contingent upon receiving the Alden test report with associated analyses, and any additional information that is found to be needed during our ongoing review, by March 31, 2006. If such material is received earlier than anticipated, then we will attempt to complete our review earlier.

2 THE ALDEN RESEARCH LABORATORY TEST FACILITY

Figure 1 is a generic sketch of the test facility used for the Seabrook UFM testing. Flow in the

test sections starts with a pair of pumps in the lower left, passes through the test sections, through the breakdown (throttle) valves, through the switchway (diverter), and either into the weighing

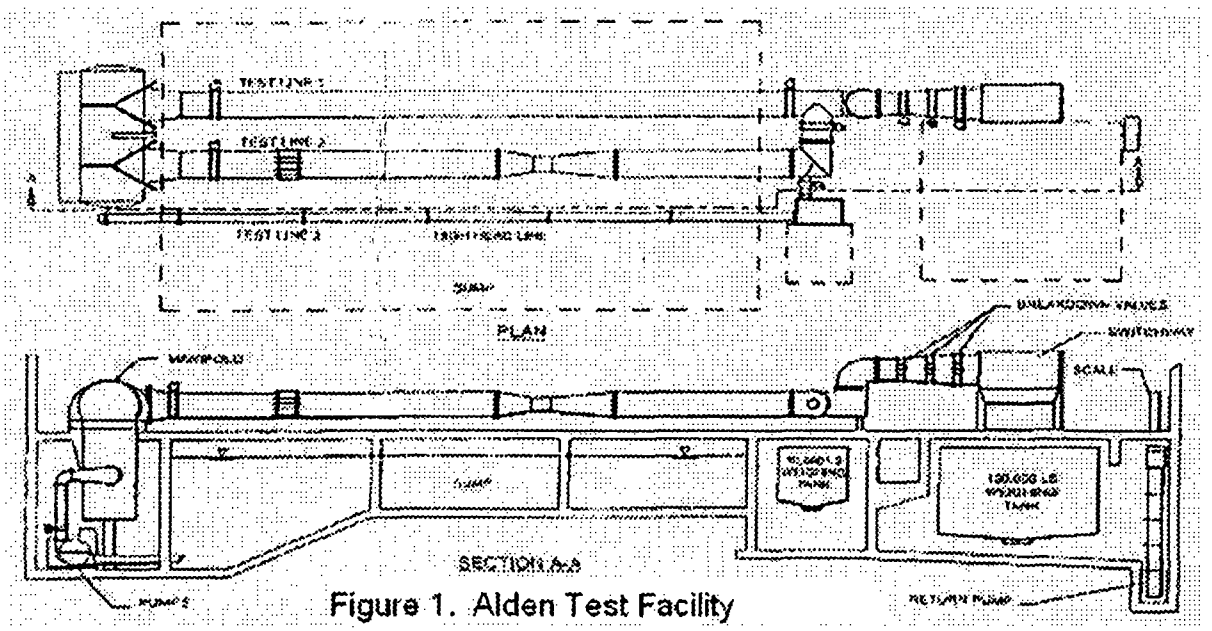
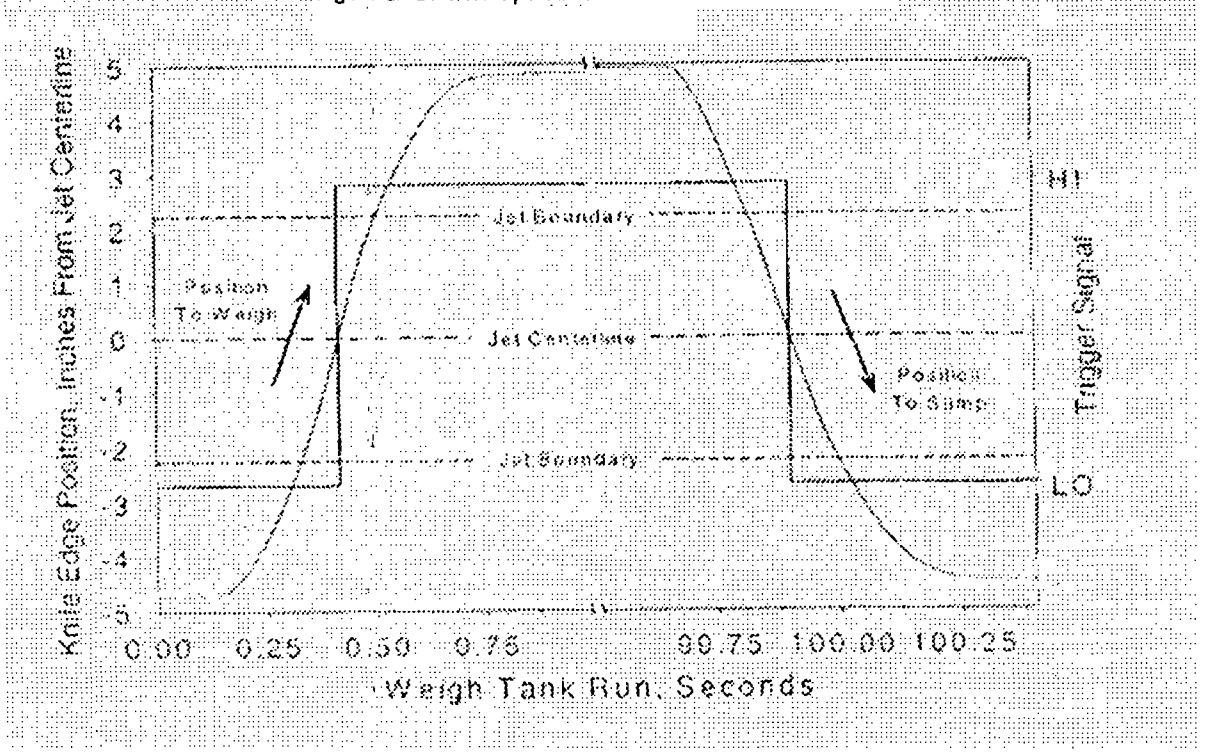


Figure 1. Alden Test Facility

tank or into the sump. The outlet from the breakdown valves is at atmospheric pressure and activities in the switchway have no influence on flow rate. The switchway consists of a manifold where water drops vertically onto a knife edge diverter plate that sends flow to the weighing tank or to the sump. During steady state operation, the knife edge is out of the flow stream. During switching, the knife edge accelerates to a constant rate prior to entering the flow stream and decelerates after leaving the flow stream as illustrated in Figure 2. This restricts diverter interaction with the flowstream during diverter movement to times when diverter movement is constant. Hence, by recording time in the center of the diverter movement for both initiation and termination of weighing tank fill, in the ideal sense, error due to switching is eliminated as is illustrated in Figure 2. In practice, the standard deviation due to the diverter is 0.0100 percent, a small contribution to the overall standard deviation of 0.044 percent (uncertainty of 0.088 percent or two standard deviations). The other contributors to uncertainty are routine such as due to mass, time, water density, buoyancy due to air, and traceability to standards, and are not addressed further here.

Flow from the pumps into the manifold and from the manifold into the two test sections occurs over a short path with abrupt turns. This introduces the possibility of noise, poorly developed flow profiles, and swirl in the test sections; all items of concern with UFMs but that are of lesser concern with testing other devices.

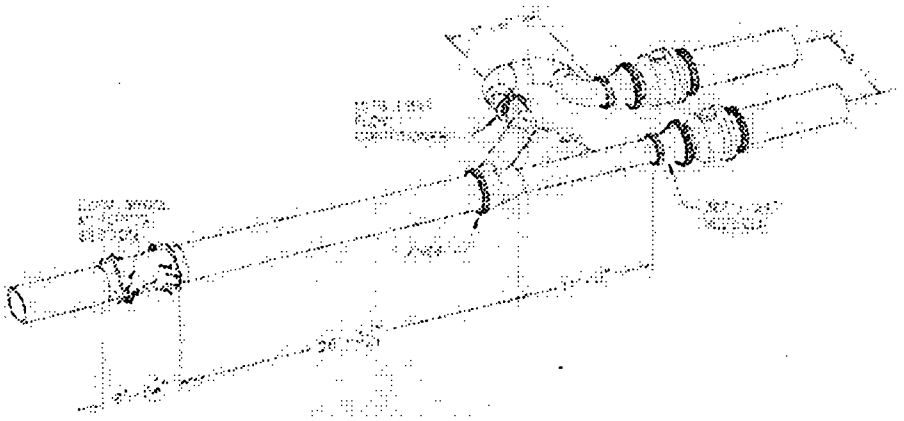
Figure 2. Diverter Operation



3 THE SEABROOK TESTS

The Alden test configuration for the Seabrook tests is shown in Figure 3. Flow is from right to left with two 24 inch pipes connecting to a 36 inch pipe that contains the CheckPlus UFM.

Figure 3. Seabrook Test Configuration



The preliminary test results are summarized in the following table, with five individual tests conducted for each test entry, and each individual test consisting of at least 2000 flow rate measurements[1]:

Test	Description	Flow Split	Approx Flow Rate, gpm	Min / Max Correction Factor
A-1	Straight 36 inch pipe run of about 49 feet Line 1 omitted.	N/A	2010 6470 11020 15440 19980	1.0024/1.0041 1.0017/1.0041 1.0029/1.0042 1.0031/1.0048 1.0029/1.0040
B-1	Plant Model	50/50	1990 6510 11080 15520 19610	1.0003/1.0029 1.0021/1.0034 1.0023/1.0037 1.0027/1.0037 1.0029/1.0037
B-2	Flow Split A	25/75	2006 6520 10985 15550 19960	1.0029/1.0035 1.0021/1.0033 1.0029/1.0045 1.0029/1.0040 1.0028/1.0037
B-3	Flow Split B	75/25	1949 6509 11065 15530 18880	1.0003/1.0014 1.0018/1.0034 1.0023/1.0034 1.0021/1.0037 1.0024/1.0039
B-4	Remove Mitsubishi Flow Conditioner	50/50	1990 6510 10965 15530 19770	1.0023/1.0027 1.0030/1.0033 1.0029/1.0036 1.0033/1.0044 1.0024/1.0035

[1]More than 2000 measurements are obtained at the highest flow rate. The number of measurements is a direct function of the time it takes to fill the weigh tank, a time that increases as the flow rate decreases. Thus, the results of each test run are based on a good statistical sample.

Test	Description	Flow Split	Approx Flow Rate, gpm	Min / Max Correction Factor
-	Place half-moon plate covering bottom half of pipe in Flow Conditioner location	50/50	2030	1.0005/1.0025
			6540	1.0017/1.0041
			11040	1.0018/1.0044
			15360	1.0017/1.0029
			19300	1.0022/1.0036
		Full flow through half-moon	11070	1.0004/1.0013
			15560	1.0011/1.0025
			17080	0.9992/1.0014
Replace two Transducers	See A-1	N/A	15580	1.0032 / 1.0046
			20050	1.0026 / 1.0037

A cursory review of the configurations, data, and supporting information lead to the following preliminary conclusions:

1. Seabrook's specifications for the Checkplus are 16,400,000 lbs/hr @ 447 °F (Reference D). This corresponds to close to 40,000 gpm or 20,000 gpm per feedwater train. With the exception of Test B-4 with full flow through the half-moon, the B series tests are with flow rates of roughly half what Seabrook specified for total flowrate capability. This is an open item that we are reviewing.

2. Water temperature during the tests was approximately 95 °F. The operational specification is 447 °F. This is an open item that we are reviewing.

3. Test A-1 covers the extreme condition of feedwater limited to one feedwater path. The full flow test through the half-moon covers the extreme condition of feedwater from the other feedwater path with the additional complication of introduction of swirl. These bracket the operational configurations that will be encountered during plant operation.

4. The tests provide Checkplus characteristics over a wide range of flow rates.

5. The poorest correlation in all tests requires a correction factor of 1.0048. For this case, the uncorrected Checkplus error is 0.48 percent if the test uncertainty of 0.088 percent is neglected. This close agreement between indicated and actual flow rate places less demand upon Checkplus correction than would be the case if the Checkplus was less accurate.

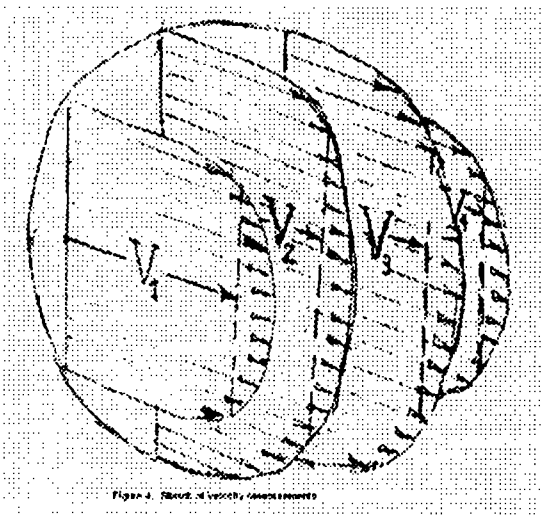
6. The Checkplus is relatively insensitive to change in flow rate over a wide range.

7. The Checkplus is relatively insensitive to swirl. (Some swirl is introduced at the entrance to the test sections due to the test facility. Quantitative information is expected.)

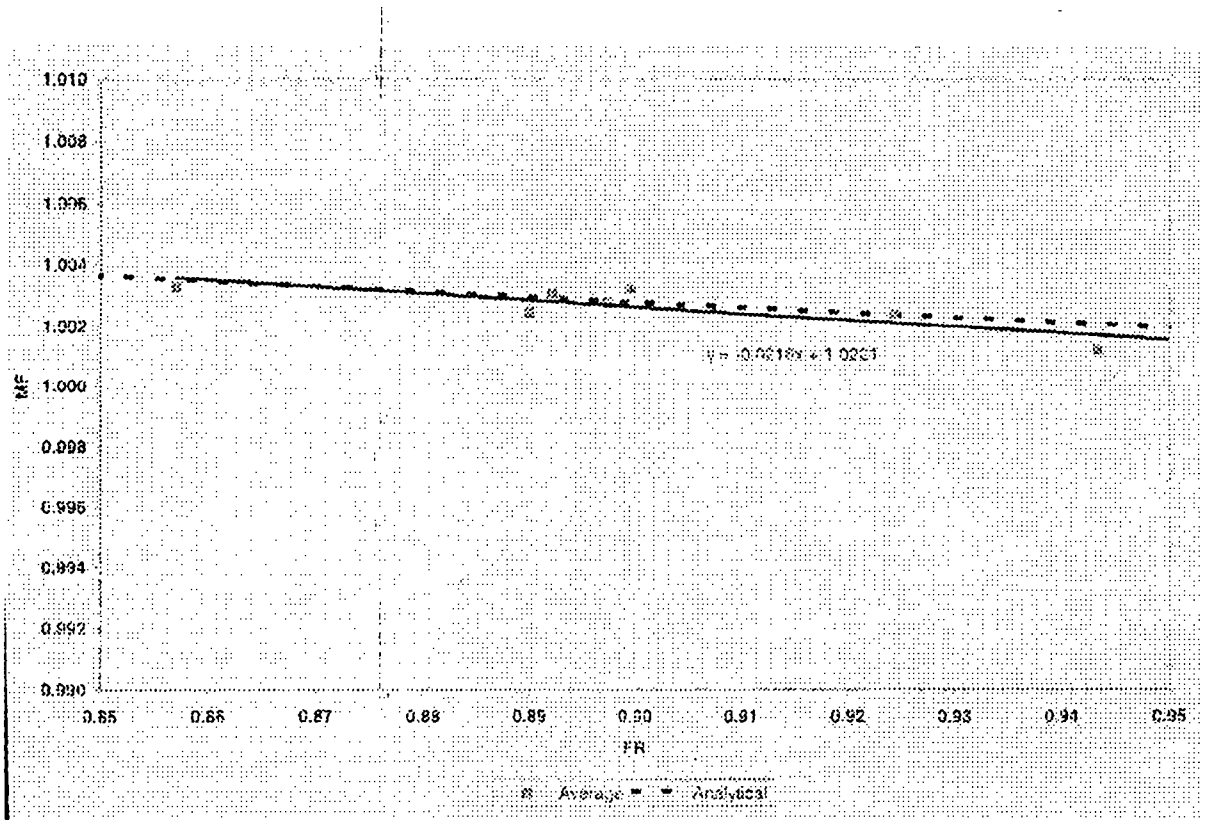
8. The Checkplus is relatively insensitive to changes in feedwater configuration.

9. There is essentially no change in Checkplus indication when two transducers are replaced. (There were only two transducers on hand during the tests. More data are to be provided that addresses transducer changes.)

The Caldon UFM provides either four or eight average velocities as illustrated in Figure 4 for the four velocity design. Caldon then defines a "Flatness Ratio" (FR) as the sum of the center velocities (V_2 and V_3) divided by the sum of the outer velocities (V_1 and V_4) for the four path UFM, with a similar definition for the Checkplus eight path UFM. It uses this parameter to assess UFM behavior and to address characteristics under different flow conditions. With this approach, for example, Reynolds number extrapolations are no longer used.



As a further example, preliminary test results are provided in Figure 5 that show correction factor (that Caldon defines as MF) as a function of FR for a range of conditions. Further, Caldon has also used Checkplus results to determine the influence of swirl on correction factor.



REFERENCES

A "Summary of December 16, 2005, Meeting with FPL Energy Seabrook, LLC to Discuss Measurement Uncertainty Recapture Power Uprate Licnse Amendment Request (TAC No. MC8434," NRC, ADAMS Number ML060030107 (Slides used at the meeting are ML060130031 and Meeting Attendance is ML060130033), January 11, 2006.

B Hauser, Ernie, "Trip Report #1770, NRC / Seabrook Meeting of December 16, 2005," Caldon, January 5, 2005.

C "Uncertainty Analysis of Flow Measurement, 100,000 Lb Weigh Tank," Presentation At Alden Research Laboratory, Inc., January 18, 2006.

D "Caldon Proprietary Information Package for Seabrook/NRC Meeting, December 16, 2005," Tab 10, FP&L Purchase Specification S-X-1-E-0139 Rev. 00, "Ultrasonic Feedwater Flow Metering System."

ATTACHMENT 1. ATTENDANCE SHEET ON JANUARY 17, 2006

Name	Organization	Position
Gregg Sessler	FPLE	FW System Eng
Kerry Walton	Southern Nuclear	UFM Proj Eng, Vogtle Upgrade
Kenji Tominaga	Hitachi / Canada	C&IE Eng
Warren Lyon	USNRC	Sr React Eng
Bob Dean	FPLE	Cognizant Design Engineer
Ian Watters	FPLE	Project Engineer, Power Uprate
Don Nowicki	FPLE	Oversight, Sr Engineer
Mike McMahon	CEG-Corporate Engineering	G-S Corp Eng
Mike O'Keefe	FPLE	Reg Comp Supv
Howard Onorano	FPLE	Power Uprate Engineer
Herb Estrada	Caldon	Chief Engr
Don Augenstew	Caldon	Mgr Engr
Ernie Hauser	Caldon	VP Nuclear
Also present, but did not sign attendance list		
James Nystrom	Alden	Sr Vice President

ATTACHMENT 2. ATTENDANCE SHEET ON JANUARY 18, 2006

Name	Organization
Kerry Walton	Southern Nuclear
Warren Lyon	USNRC
Don Nowicki	FPLE
Mike McMahon	CEG-Corporate Engineering
Howard Onorano	FPLE
Herb Estrada	Caldon
Ernie Hauser	Caldon
James Nystrom	Alden
Steve Hale	FPL Energy