FRAMATOME COGEMA FUELS

November 22, 2000
GR00-182.doc

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Subject: Submittal of Topical Report BAW-10199P, Addendum 2, "Application of the BWU-Z CHF Correlation to the Mark-BW17 Fuel Design with Mid-Span Mixing Grids," October 2000.

Reference: Stuart A. Richards (NRC) to T. A. Coleman (FCF), Acceptance for Referencing of Licensing Topical Report BAW-10199P, Addendum 1, "The BWU Critical Heat Flux Correlations" (TAC NO. M96728), April 6, 2000.

Gentlemen:

Enclosed are fifteen (15) copies of Topical Report BAW-10199P, Addendum 2 and twelve (12) copies of Topical Report BAW-10199, Addendum 2. BAW-10199P, Addendum 2 replaces Appendix F of BAW-10199P, Addendum 1 in its entirety. These reports quantify the increase in CHF capability for the Mark-BW17 design with mid-span mixing grids.

The reference letter included the safety evaluation (SER) for BAW-10199P, Addendum 1. The SER approved the BWU-Z CHF correlation for application to fuel with the Mark-B11 spacer grid design. The SER contained the following statement, "The staff will continue its review of the applicability to Mark-BW fuel with MSM grids at a later date." BAW-10199P, Addendum 2 provides additional information to support continuation of that review.

The first application of BAW-10199P, Addendum 2 will be for the Dominion Generation North Anna Nuclear Plant. The BWU-Z CHF correlation will be used to support the license change request for incorporation of FCF fuel at North Anna. This license change request will be submitted in the first quarter of 2002. To support this submittal, approval of BAW-10199P is required by December 2001.

In accordance with 10 CFR 2.790, FCF requests that BAW-10199P, Addendum 2 be considered proprietary and withheld from public disclosure. An affidavit supporting this request is attached.

Very truly yours,

TAColeman

T. A. Coleman, Vice President
Government Relations

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extra cys advanced
to:
NRR/DSSA/SRXB

FRAMATOME
TECHNOLOGIES

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AFFIDAVIT OF THOMAS A. COLEMAN

A. My name is Thomas A. Coleman. I am Vice President of Government Relations for Framatome Cogema Fuels (FCF). Therefore, I am authorized to execute this Affidavit.

B. I am familiar with the criteria applied by FCF to determine whether certain information of FCF is proprietary and I am familiar with the procedures established within FCF to ensure the proper application of these criteria.

C. In determining whether an FCF document is to be classified as proprietary information, an initial determination is made by the Unit Manager, who is responsible for originating the document, as to whether it falls within the criteria set forth in Paragraph D hereof. If the information falls within any one of these criteria, it is classified as proprietary by the originating Unit Manager. This initial determination is reviewed by the cognizant Section Manager. If the document is designated as proprietary, it is reviewed again by personnel and other management within FCF as designated by the Vice President of Government Relations to assure that the regulatory requirements of 10 CFR Section 2.790 are met.

D. The following information is provided to demonstrate that the provisions of 10 CFR Section 2.790 of the Commission's regulations have been considered:

(i) The information has been held in confidence by FCF. Copies of the document are clearly identified as proprietary. In addition, whenever FCF transmits the information to a customer, customer's agent, potential customer or regulatory agency, the transmittal requests the recipient to hold the information as proprietary. Also, in order to strictly limit any potential or actual customer's use of proprietary information, the substance of the following provision is included in all agreements entered into by FCF, and an equivalent version of the proprietary provision is included in all of FCF's proposals:

"Any proprietary information concerning Company's or its Supplier's products or manufacturing processes which is so designated by Company or its Suppliers and disclosed to Purchaser incident to the performance of such contract shall remain the property of Company or its Suppliers and is disclosed in confidence, and Purchaser shall not publish or otherwise disclose it to others without the written approval of Company, and no rights, implied or otherwise, are granted to produce or have produced any products or to practice or cause to be practiced any manufacturing processes covered thereby.

Notwithstanding the above, Purchaser may provide the NRC or any other regulatory agency with any such proprietary information as the NRC or such other agency may require; provided, however, that Purchaser shall first give Company written notice of such proposed disclosure and Company shall have the right to amend such proprietary information so as to make it non-proprietary. In the event that Company cannot amend such proprietary information, Purchaser shall, prior to disclosing such information, use its best efforts to obtain a commitment from NRC or such other agency to have such information withheld from public inspection.

Company shall be given the right to participate in pursuit of such confidential treatment."

(ii) The following criteria are customarily applied by FCF in a rational decision process to determine whether the information should be classified as proprietary. Information may be classified as proprietary if one or more of the following criteria are met:

a. Information reveals cost or price information, commercial strategies, production capabilities, or budget levels of FCF, its customers or suppliers.

b. The information reveals data or material concerning FCF research or development plans or programs of present or potential competitive advantage to FCF.

c. The use of the information by a competitor would decrease his expenditures, in time or resources, in designing, producing or marketing a similar product.

d. The information consists of test data or other similar data concerning a process, method or component, the application of which results in a competitive advantage to FCF.

e. The information reveals special aspects of a process, method, component or the like, the exclusive use of which results in a competitive advantage to FCF.

f. The information contains ideas for which patent protection may be sought.

The document(s) listed on Exhibit "A", which is attached hereto and made a part hereof, has been evaluated in accordance with normal FCF procedures with respect to classification and has been found to contain information which falls within one or more of the criteria enumerated above. Exhibit "B", which is attached hereto and made a part hereof, specifically identifies the criteria applicable to the document(s) listed in Exhibit "A".

(iii) The document(s) listed in Exhibit "A", which has been made available to the United States Nuclear Regulatory Commission was made available in confidence with a request that the document(s) and the information contained therein be withheld from public disclosure.

(iv) The information is not available in the open literature and to the best of our knowledge is not known by Combustion Engineering, Siemens, General Electric, Westinghouse or other current or potential domestic or foreign competitors of Framatome Cogema Fuels.

(v) Specific information with regard to whether public disclosure of the information is likely to cause harm to the competitive position of FCF, taking into account the value of the information to FCF; the amount of effort or money expended by FCF developing the information; and the ease or difficulty with which the information could be properly duplicated by others is given in Exhibit "B".

E. I have personally reviewed the document(s) listed on Exhibit "A" and have found that it is considered proprietary by FCF because it contains information which falls within one or more of the criteria enumerated in Paragraph D, and it is information which is customarily held in confidence and protected as proprietary information by FCF. This report comprises information utilized by FCF in its business which afford FCF an opportunity to obtain a

AFFIDAVIT OF THOMAS A. COLEMAN (Cont'd.)

competitive advantage over those who may wish to know or use the information contained in the document(s).

THOMAS A. COLEMAN

State of Virginia)
) SS. Lynchburg
City of Lynchburg)

Thomas A. Coleman, being duly sworn, on his oath deposes and says that he is the person who subscribed his name to the foregoing statement, and that the matters and facts set forth in the statement are true.

THOMAS A. COLEMAN

Subscribed and sworn before me
this 22nd day of November 2000.

Notary Public in and for the City
of Lynchburg, State of Virginia.

My Commission Expires 8/31/01

EXHIBITS A & B

EXHIBIT A

BAW-10199P, Addendum 2, "Application of the BWU-Z CHF Correlation to theMark-BW17 Fuel Design with Mid-Span Mixing Grids."

EXHIBIT B

The above listed document contains information which is considered Proprietary in accordance with Criteria b, c, and d of the attached affidavit.

BAW-10199
Addendum 2
November 2000

Application of the BWU-Z CHF Correlation to the Mark-BW17 Fuel Design with Mid-Span Mixing Grids

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Addendum 2 to BAW-10199

Application of the BWU-Z CHF Correlation to the Mark-BW17 Fuel Design with Mid-Span Mixing Grids

Appendix F

Application of the BWU-Z CHF Correlation to the Mark BW17 Fuel Design with Mid-Span-Mixing Grids

Introduction

In 1992, FCF (then BWFC) conducted a series of tests at the Columbia University Heat Transfer Research Facility (HTRF) to qualify the Critical Heat Flux (CHF) capability of the Mark BW17 spacer grid design. In all, 12 tests representing 7 different geometrical configurations were conducted. All of these multipoint tests except for one utilized an axial grid spacing (pitch) of 20.5 inches with standard 2.25 inch length mixing vane grids. One test contained "mid-span-mixing" (MSM) grids placed in the middle of the spans 4, 5 and 6 (of 7 total). These MSM grids had the standard Mark BW17 mixing vane geometry, but were only about a half an inch in height.

Reference F-1 of this appendix used the local condition results of the Mark BW17 testing program with the existing BWCMV CHF correlation [F-2] to qualify both the standard and MSM configurations. In BAW 10199 [F-3], a new CHF correlation form (the BWU correlation, Section 1.4) was developed and a separate version was qualified for use with three different grid designs. The version qualified for use with the Mark BW17 design is termed BWU-Z. BWU-Z was qualified for the Mark BW17 grid with a 20.5 inch pitch (Table 4-1). As was shown in Reference F-1, the addition of MSM grids to the standard grid configuration substantially increases the CHF capability of the resulting configuration. It is the purpose of this document to quantify (in the form of a multiplier on BWU-Z) the increase in CHF capability for the Mark BW17 design with MSM grids.

For the purposes of this qualification, FCF conducted a second MSM test (FCF 43.0) with the guide tube cross-sectional geometry. The geometry of FCF 43.0 (FCF43) is exactly the same as tests BW 18.0 and BW 18.1 (BW18) except for the guide tube.

Test FCF43 was conducted 1) to show that guide tube MSM grid CHF performance was equivalent to unit cell performance, and 2) to extend the MSM data base to low pressures and low flows. (A high flow, high pressure point is one with a nominal flow greater than or equal to 1.0 million pounds per hour per square foot <u>and</u> a nominal

pressure greater than or equal to 1500 psia. All other data are low flow, low pressure.)

Test Description

All of the Mark BW17 CHF tests were performed at the Columbia University HTRF. The HTRF is a ten megawatt electric facility capable of testing full length (12 foot) rod arrays in up to a 6 by 6 matrix. HTRF testing conditions cover the full range of PWR operating conditions with pressures up to 2500 psia, mass velocities up to 3.5 million pounds per hour per square foot and inlet temperatures approaching saturation. A detailed description of the Columbia HTRF is provided in Reference F-4.

Individual CHF tests for the Mark BW17 design are summarized in Table F-1. Complete information, including shroud dimensions, power peaking information, form loss coefficients, is provided in Reference F-1.

Data Analysis

The bundle and cell geometry, the rod radial peaking values, the heater rod axial flux shape, the types, axial locations and form losses of spacer grids, and the thermocouple locations comprise the mathematical model for each separate test section. The data from each CHF observation within a test consists of the variables of test section power, flow, inlet temperature, pressure and CHF location (rod and axial location) and together define a data point.

Each test section is modeled for analysis with the LYNXT thermal-hydraulic computer code [F-5]. For each set of bundle data, LYNXT produces the local thermal-hydraulic conditions (mass velocity, thermodynamic quality, heat flux, etc.) The local condition results along with the test section global variables can then be analyzed against an existing CHF correlation or used to obtain optimized coefficients (a new correlation).

Method

The data analysis will be in two parts: 1) compare the common (duplicate) data in each test to show that they match, and 2) determine the MSM multiplier as follows:

Use the local conditions data from the MSM tests of Table F-1 with the BWU-Z correlation to obtain an MSM multiplier for the MSM configuration. The Design Limit DNBR for the MSM configuration is then shown to be less than or equal to the 1.19 value qualified in Table 4-1 of BAW 10199 [F-3] for the standard Mark BW17 design spaced at 20.5 inches. Additionally, the final mean M/P CHF ratio (with the MSM multiplier) must be shown to be greater than or equal to 1.0. These dual criteria insure conservatism of the application.

The applicable correlation is then

$$(Q_{chf})_{msm} = F_{msm} * FLS * Q_{unif} / F$$

where Q_{unif}, FLS and F are the original BWU-Z factors from BAW 10199 [F-3] and F_{msm} is determined in this analysis.

Analysis Results

Test FCF18 achieved 76 total CHF data. Of these, 73 were high flow, high pressure data and 3 low flow, low pressure data. Test FCF43 achieved 72 total CHF data. Of these, 53 were high flow, high pressure data and 19 low flow, low pressure data. There were 52 common points (i.e., the same inlet temperature, mass velocity and pressure) between the tests).

An analysis of common points with the unmodified BWU-Z correlation yields:

Test	Data	Mean M/P CHF	Std Deviation
FCF18	52	1.211	.131
FCF43	52	1.194	.098
MSM Data	104	1.203	.115

A one way Analysis of Variance (ANOVA) [F-7] with 1 and 102 degrees of freedom results in an F statistic of 0.579. The critical F value at the .05 level of confidence is 3.934.

This shows that there is no statistical difference in the test results.

Next, the local conditions analysis was performed with all the data as explained above to iterate to an F_{msm} value of 1.182. For this analysis, F_{msm} will be conservatively rounded to 1.180. The applicable results are documented in Tables F-2 and F-3 and presented graphically in Figures F-1 through F-4. The resulting design limit using the statistics shown in Table F-2 is

t, # of tests	2
n, # of data	148
N, degrees of freedom (n-1)	147
M/P, avg measured to predicted CHF	1.0138
S(M/P,N)	0.0920
K (147,0.95,0.95), one sided tolerance factor [F-6]	1.872

DNBR(L) = 1 / (M/P - K*S)
= 1 / [1.0138 - 1.872(.0920)] = 1.1882 < 1.190

Application

It has been shown that the CHF performance of the Mark BW17 design with MSM grids between the top 4 standard Mark BW17 grids (spans 4, 5 and 6) can be described with a simple modification to the BWU-Z correlation.

$$(Q_{chf})_{msm} = F_{msm} * FLS * Q_{unif} / F$$

where F_{msm} = 1.180. FLS, Q_{unif} and F are as defined for BWU-Z in Table 3-1 of BAW 10199 [F-3], with a grid spacing of 20.5 inches, and ranges of applicability as specified in Table 4-1 (also of BAW 10199).

For the analysis of grid spans not containing MSM grids, F_{msm} = 1.0 (i.e. no enhancement factor is applied). For the uppermost span, in which the end of heated length (EOHL) occurs less than one grid span beyond the last mixing grid, the effective grid spacing (distance from the last grid to the EOHL) is input rather than the 20.5 inch spacing factor.

References

F-1. D. A. Farnsworth and G. A. Meyer, "CHF Testing and Analysis of the Mark-BW Fuel Assembly Design," BAW-10189P-A, Babcock & Wilcox, January, 1996.

F-2. D. A. Farnsworth and G. A. Meyer, "BWCMV Correlation of Critical Heat Flux in Mixing Vane Grid Fuel Assemblies", BAW-10159P, Babcock & Wilcox, July, 1990.

F-3. D. A. Farnsworth and G. A. Meyer, "The BWU Critical Heat Flux Correlations," BAW-10199P-A, Framatome Cogema Fuels, August 1996.

F-4. C. F. Fighetti and D.G. Reddy, "Parametric Study of CHF Data," EPRI-NP-2609, 1982 (Volume 1 of 3).

F-5. J. H. Jones, K.J. Firth, J. R. Gloudemans and J. M. Alcorn, "LYNXT Core Transient Thermal-Hydraulic Program," BAW-10156-A, Rev. 1, B&W Fuel Company, August, 1993.

F-6. D. B. Owens, "Factors for One-Sided Tolerance Limits," Sandia Corporation Monograph, 1963.

F-7. Bernard Ostle, Statistics in Research, 2nd Edition, The Iowa State University Press, 1963.

Figure F-1 - Mid-Span-Minxing Grid
Measured to Predicted CHF versus Mass Velocity

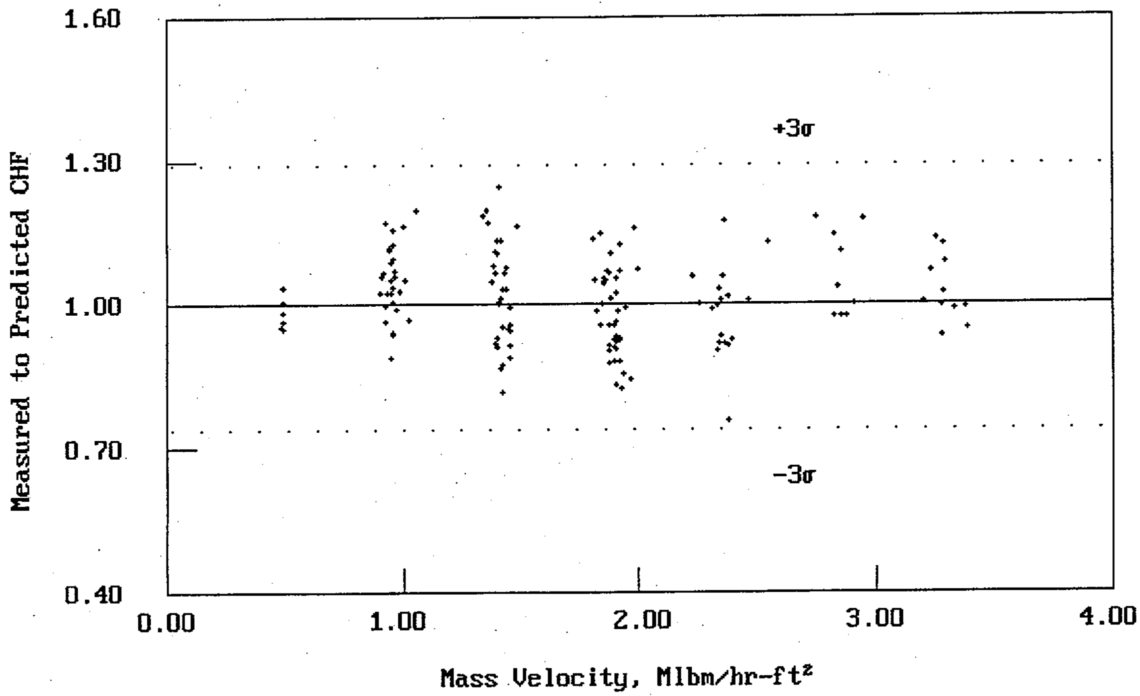

Figure F-2 - Mid-Span-Mixing Grid
Measured to Predicted CHF versus Quality

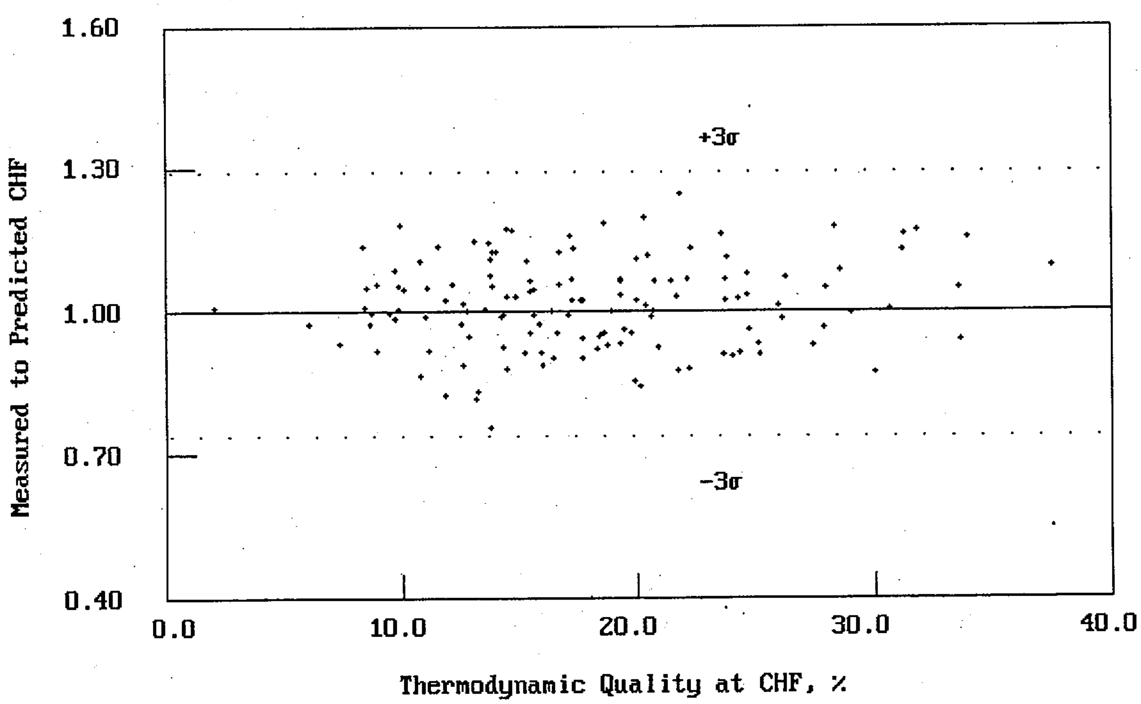

Figure F-3 - Mid-Span-Mixing Gird
Measured to Predicted CHF versus Pressure

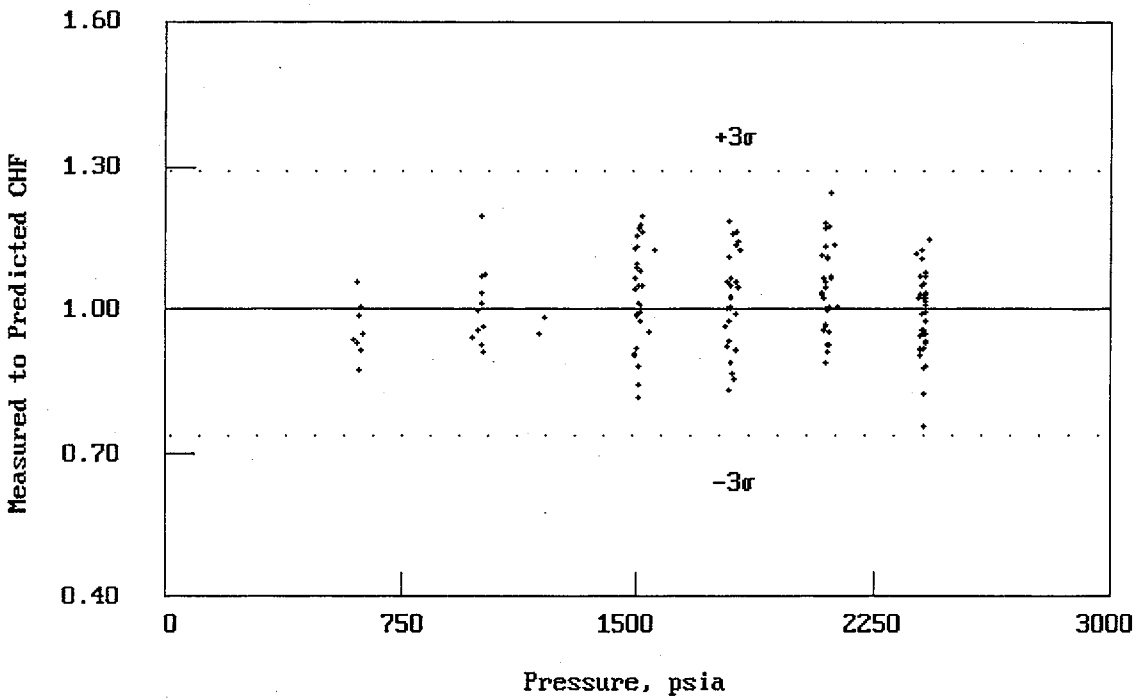

Figure F-4 - Mid-Span-Mixing Grid
M/P CHF - Accept Normality at 5% LEVEL

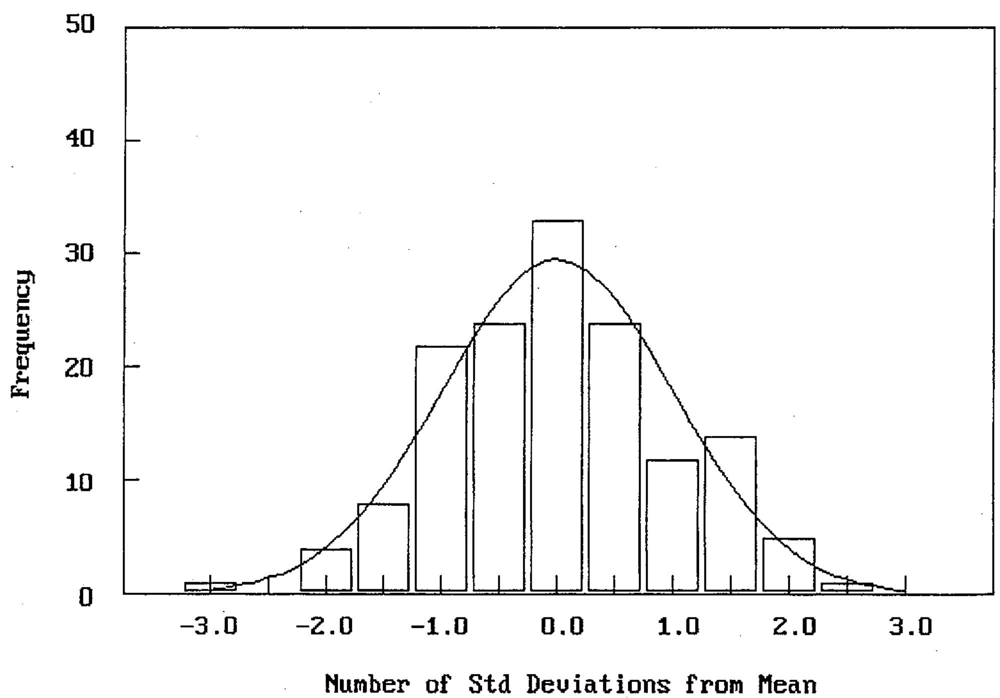

Table F-1

Mark BW17 CHF Test Summary

Test	Type [1]	Matrix	AFS [2]	Pin OD inch	Pitch inch	G/T OD inch	Heated Length inches	Grid Spacing inches
BW 12.0	Unit	5x5	1.55 Sym	.374	.422	---	143.4	20.5
BW 13.1	Unit	5x5	1.55 Sym	.374	.422	---	143.4	20.5
BW 14.1	G-T	5x5	1.55 Sym	.374	.422	.482	143.4	20.5
BW 15.1	C-U	5x5	1.55 Sym	.374	.422	- -	143.4	20.5
BW 16.0	C-R	5x5	1.55 Sym	.374	.422	---	143.4	20.5
BW 17.0	[3]W-H	5x5	1.55 Sym	.374	.422	- -	143.4	20.5
BW 18.0	[3]MSM	5x5	1.55 Sym	.374	.422	---	143.4	[4]20.5
BW 18.1	[3]MSM	5x5	1.55 Sym	.374	.422	---	143.4	[4]20.5
BW 19.0	G-T	5x5	1.55 Sym	.374	.422	.482	143.4	20.5
BW 20.0	SLB	5x5	1.55 Sym	.374	.422	---	143.4	20.5
BW 43.0	[3]MSM GT	5x5	1.55 Sym	.374	.422	.482	143.4	[4]20.5

[1] - G-T = Guide Tube, C-U = Cold Unit, C-R = Cold Row, Int = Intersection
MSM = Mid-Span-Mixer, SLB = Steam Line Break Conditions
[2] - Sym = Symmetric, Out = Outlet
[3] - Not in BWU-Z database
[4] - There are 7 grid spans (#1 at bottom, #7 at top). Non-structural mixing grids are positioned at the middle of spans 4, 5 and 6. Structural grids are spaced at 20.5 inches.

Table F-2

M/P CHF Results with F_{msm} = 1.180

Data in this Analysis	148
Mean M/P CHF Ratio	1.0138
Std Dev / Coef Var	0.0920 / 0.0907
Min / Max Values	0.7672 / 1.2409
Des Limit / Normality	1.188 / Accept
Data Out by Range, Outlier	0 / 0
CWF/Fmsm/Grid Ht	1.000/1.180/2.250
Mass Vel Range	0.471 to 3.385
Quality Range	-.0195 to .6797
Pressure Range	594 to 2425
BWU Correlation	Table 3-1

----------------Grouped by Mass Velocities--------------------

GROUP	DATA	AVG	S.D.	MAX	MIN	C.V.
0.5 Mass Vel						
1.0 Mass Vel						
1.5 Mass Vel						
2.0 Mass Vel			b,c,d			
2.5 Mass Vel						
3.0 Mass Vel						
3.5 Mass Vel						
All Mass Vel	148	1.0138	0.0920	1.241	0.767	0.091

--------------------Grouped by Pressures--------------------

GROUP	DATA	AVG	S.D.	MAX	MIN	C.V.
375 to 900						
900 to 1250						
1250 to 1650						
1650 to 1950			b,c,d			
1950 to 2250						
2250 to 3200						
All Pressures	148	1.0138	0.0920	1.241	0.767	0.091

--------------------Grouped by - Qualities-------------------

GROUP	DATA	AVG	S.D.	MAX	MIN	C.V.
Below 5% X						
5% to 10% X						
10% to 15% X						
15% to 20% X			b,c,d			
20% to 25% X						
25% to 30% X						
Above 30% X						
All Qualities	148	1.0138	0.0920	1.241	0.767	0.091

Table F-3

M/P CHF Results with F_{msm} = 1.180
Individual Results

ID	AFS	Type	M/P CHF	Meas CHF	Press	Mass Vel	Quality	Z chf	F Fact
43014	11	4							
43015	11	4							
43016	11	4							
43017	11	4							
43021	11	4							
43022	11	4							
43023	11	4							
43024	11	4							
43025	11	4							
43026	11	4							
43027	11	4							
43028	11	4							
43029	11	4							
43030	11	4							
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43072	11	4							
43073	11	4							
43074	11	4							
43075	11	4							
43076	11	4							

b,c,d

43077	11	4
43078	11	4
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43081	11	4
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18166	11	1
18167	11	1
18168	11	1
18169	11	1
18170	11	1
18171	11	1
18172	11	1
18173	11	1
18174	11	1
18175	11	1
18176	11	1

[b,c,d]