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WSRC-TR-92-534
Task No.: 92-104-1

KEYWORDS:
ONSET OF FLOW INSTABILITY
ONSET OF SIGNIFICANT VOID
DEMAND CURVES
LOSS OF COOLANT ACCIDENT
ANNULUS

RETENTION:
PERMANENT

EXPERIMENTAL ONSET OF FLOW INSTABILITY TESTING
BY CREARE, INC. (U)

by
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Author

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SUMMARY

Flow excursions can occur during subcooled heated flow if the supply system is not adequate to meet the heated channel pressure demand. Available experimental flow instability (FI) data for ribbed annuli such as used in the SRS production reactors is very limited. Creare Inc. completed a series of FI tests which included two annular geometries; one of these included metallic ribs which separated the annulus into four sub-channels. This report summarizes the results of the onset of flow instability (OFI) testing which was completed by Creare in support of the SRS Reactor Restart Program. A copy of the final test report has been attached and the archival locations for the supporting documentation and electronic test data is also included.

The purpose of this report is to:

- Archive the Creare Program data;
- Inspect the data which has been archived;
- Review the results presented by Creare;
- Evaluate if the Creare Program data may be used in critical applications.

INTRODUCTION

Ledinegg [1] identified a mechanism for subcooled flow in heated channels to undergo a sudden large amplitude excursion to a new, stable operating condition. This instability is characterized by a rapid shift in the operating condition from subcooled boiling to high quality steam. The demand curve for heated channels at subcooled conditions is very similar to that of an unheated demand curve as long as the flow velocity is high. As the flow velocity is decreased the similarity between the heated and unheated demand curves will cease. The heated demand curve will pass through a minimum as shown in Figure 1. This minimum is created by an increase in the frictional pressure drop caused by vapor effectively roughening the pipe wall and an increase in the acceleration pressure drop resulting from the generation of vapor. If the supply system is not adequate to meet the demand curve conditions a sudden large amplitude excursion to a new, stable operating condition will occur. This instability is characterized by a rapid shift in the operating condition from subcooled boiling to steam.

Creare, working in conjunction with Stern Laboratories, produced 19 demand curves in two different annuli geometries. The first geometry was a "pure" annulus with the exception of centering pins (0.094" diameter for first construction and 0.109" x 0.75" long for second construction) which were used to hold the inner annulus pipe in position. The second geometry included four ribs which were an integral part of the inner annulus. Heat was generated in both the inner and outer annular walls using resistance element heaters which were electrically isolated from the wetted aluminum.

The results of the test program were transmitted to SRS by Creare in a single report. The report was issued in 3 volumes. In addition nine 3-1/4" micro floppy disks which contained the reduced experimental data and a large collection of backup documentation were also shipped.

PRESENTATION

The final Creare report which was issued to SRS with a document number of TN-499 has been reproduced in Books 2, 3, and 4. (This manuscript with appendices is Book 1.) The term books has been used to differentiate it from the term volumes which was used in TN-499. Book 5 contains a listing of all supporting documents which were transmitted by Creare to SRS. These records are filed as Task Number 92-104-1. Books 6, 7, and 8 contain printed versions of the reduced data which was provided by Creare. Table 1 summarizes the document numbers which have been assigned to information which was directly generated as a result of the Creare test program. The reports (books) are available from the SRS records repository. The electronic medium have been stored as part of the Heat Transfer Laboratory (HTL), Building 786-A, electronic records.

The reports in Books 2, 3 and 4 were transmitted from Francis X. Dolan, Project Engineer, Creare, to D. Allan Coutts, SRS on September 15, 1992. The document list in Book 5 was transmitted with the backup documentation in a fire resistant safe. This safe was shipped from Creare to the HTL by motor carrier along with all of the testing equipment which Creare returned to SRS.

ANALYSIS

Chen and King [2] demonstrated that the calculated condition at OSV (a local phenomena) is a successful precursor to OFI (a global phenomena) using annular data which was generated by Columbia University in 1963. The goal of the Creare test program was to produce demand curves in a test channel with aluminum walls and aluminum ribs which quadrisect the annulus into four subchannels. This data would then be used to further justify the conclusions of Chen and King. Saha and Zuber [3] proposed that for OSV to occur the local Stanton number must exceed 0.0065. The Stanton number is defined as:

$$St = \frac{\phi}{G c_p (T_s - T_f)}$$

This value is calculated at local conditions. Each of the quantities in the Stanton number can vary in a segmented annulus. Because of this a different Stanton number is expected for each subchannel at every operating condition. Creare appears to have calculated the Stanton number based on the subchannel averaged conditions. Direct comparison of the Stanton numbers (at the demand curve minimum) computed by Creare with expected Stanton number based on the the modified Saha and Zuber correlation as used by FLOWTRAN are not necessarily appropriate.

The data disks were transmitted from Francis X. Dolan, Project Engineer, Creare, to Zafar Qureshi, SRS on November 5, 1990. The disks are DOS compatible. A conversion was necessary to allow the files to be handled on Macintosh systems. This conversion was completed using Apple File Exchanger, version 6.0.3. The data was extracted from the original disks and written to an internal harddrive on a Macintosh IIfx with System 7.0 operating system. The data files were then written from the harddrive to a laser optical disk. The tabular data in Book 6 for Disk 1 was printed from

the files which were on the laser disk. Disks 2 through 9 were printed from the harddrive files. This was necessary because the laser drive unit (the worm) was not continuously available.

Microsoft Word was used to print the data files in Books 6 through 8. It was necessary to reformat each file prior to printing. The format to allow printing was:

Font:	Courier
Size:	10
Top Margin:	1"
Bottom Margin:	0.75"
Side Margins:	1"
Borders:	Plain Box

The technical review of the information in this report consisted of the checks in Table 2.

RESULTS

The data in Table 4.1 of Book 2 for two tests (Non-ribbed test series 1A and ribbed test series 1A) were compared with the data in Book 3. These comparisons are presented in Table 3. Selected values from Book 3 were also verified. These are listed in Appendices A and B. With the exception of local exit pressure measurements, all variations in the Table 3 data are probably due to roundoff error. The local exit pressures have an unexplained bias. The difference is either 0.2 or 0.3 psi. It is possible that an undiscussed elevation correction has been introduced while converting from the Book 3 reduced data to the data presented in Table 4.1 of Book 2, or that the value was calculated from other measurements. Since the variation is less than the stated uncertainty for the measurements this minor variation should not be considered significant.

The channel pressure drop is presented in two forms in the Books 3 and 4. The value is presented in both inches of water and psi. The conversion from inches of water to psi is not provided, however if a water density of 62.42 #/ft³ is assumed the two values agree. That this conversion value is not explicitly provided should not impact the quality of the data.

The tabular value SD which is presented in Books 3 and 4 is described as the "standard deviation of the average value calculated from the 50 readings, engineering units." Common standard deviations used in testing include the sample standard deviation [4], S, and standard deviation of the mean [5], S_m. These terms are calculated as:

$$S^2 = \frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N - 1} \quad S_m = \frac{S}{\sqrt{N}}$$

It is not clear which statistic is meant by the standard deviation of the average value. Since each sample included 50 readings, these two values (S and S_m) vary by a factor of about 7. It is assumed (See Appendices A and B for the justification) that the term

SD is the sample standard deviation¹. This assumption may have a significant impact on the uncertainties and safety margins which must be applied when the data in this report is used for design purposes. If the term SD is actually the sample deviation of the mean then the sample confidence interval would be understated by 700%.

It has not been possible to determine how the uncertainties tabulated in Books 3 and 4 were computed. Several variations were attempted (See Appendices A and B), however, none successfully reproduced the stated values.² This discrepancy does not invalidate the use of the Create data for critical applications as described in the WSRC Manual 1Q. There is nothing in any of the documents that suggests that the data is questionable, rather the requirement in Procedure QAP 3-1 for the test data to be subject to a verified error analysis has not been met. It should be noted that QAP 3-1 requires that the error analysis should become part of the design records. As such, this verification effort is beyond the scope of a data archival report. When the data in this report must be used for critical applications it will be necessary to generate a verified error analysis.

The local measured pressures near the inlet and exit of the channel were compared to the measured pressure drop in Appendices A and B. The calculated pressure drop using the local measurements equaled the measured pressure drops within the stated uncertainties of the instruments.

The uncertainty estimates for the Velocity 1 were checked by independent calculation, using the stated pressure uncertainties of instrument PFM000001. The stated velocity uncertainty for data file Feb01_09 is 14.2%; this is slightly higher than that estimated in Appendix A, 13.8%. No reason could be identified for this variation, but it is within the accuracy of the calculation. For data file Aug01_08 the stated uncertainty was 16.0%, while the calculated value was 15.9%. This variation was probably due to roundoff. This indicates that the various uncertainties used in the Create reports should be verifiable if sufficient resources are applied.

Selective magnetic medium data printed in Books 6 through 8 were compared with the magnetic medium data presented in Books 3 and 4. The selections were made randomly. This comparison only includes one-third of the data files (.SM1 type). The Create final report did not include two of the three files which were prepared for each test. The three files are: .SM1, .SM2 and .DIF. These files are described in Book 3. The description is repeated below:

"A test is comprised of a period of 300 seconds of steady-state operation of the flow loop and steady annulus boundary conditions, during which time data are automatically recorded by the data acquisition computer. At the conclusion of the test the data are reduced to average values of each measurement for the first 5 seconds of the recording interval and for the last 5 seconds. The differences between these averages are also

¹ Z. H. Qureshi confirmed this assumption with F. X. Dolan in an April 1993 phone conversation.
² Z. H. Qureshi reports that the percentage of reading uncertainties listed in Table 2.7 of Book 2 must be adjusted to conform to the instrument's actual range. A discrepancy will result if the start of the range is non-zero. The information to complete these calculations should be in the task records. This is based on an April 1993 phone conversation with F. X. Dolan.

computed. The average values and differences are then written into data summary tables called **.SM1** and **.SM2** and **.DIF** files."

The **.SM2** and **.DIF** files in Books 6, 7 and 8 have been checked to ensure that the columns correctly contain either numeric or alpha/numeric data as appropriate.

DISCUSSION

The checks in Table 2 were considered adequate to verify that the test data presented in Books 2, 3, 4, 6, 7 and 8 are appropriate for use in critical applications as discussed in WSRC Manual 1Q, Procedure QAP 2-2. Critical applications as defined by WSRC 1Q are those where errors may have any of the following consequences:

- pose a significant safety hazard with the potential for serious injury
- risk significant financial loss greater than \$500,000
- cause a hazardous release of radioactive, or other hazardous material to the environment or cause a hazardous exposure of employees to these materials
- unplanned nuclear criticality
- result in a loss of special nuclear material or the accountability thereof.

The calculations by ANNULUS and the documentation in Appendix A and B of Book 2 have not been reviewed and should not be considered critical data. This critical data conclusion assumes that a logical and defensible design basis which includes applicable safety margins is developed. The development of safety margins and design bases is beyond the scope of this document.

Not all of the data files contained in Books 3 and 4 are available on disk. Data for files Nov13_01, Jan31_19, and Jul31_23 are available in Book 4 however no electronic records were transmitted to SRS.

Creare presents four conclusions in Book 2.

1. The effect of ribs in the test geometry seems to be the most important with respect of the key result -- the location of OFI.
2. The effect of power tilt requires further study. The experiments show little effect of power tilt, but that appears to be a function of the particular configuration tested.
3. The effect of heat flux, inlet pressure, and asymmetric heating are consistent with expected trends based upon the analytical work.
4. "The effect of dissolved helium does not appear to be significant."

Table 4.1 in Book 2 supports this generalized statement (Conclusion 1); however, the lowest recorded Stanton number (0.00330) at OFI for non-ribbed annulus falls well below the other non-ribbed data and much of the ribbed data. Since no explanation is presently available to account for this variation, the demonstration of a rib effect in annular channels (Conclusion 1) should be considered inconclusive.

Conclusion 2 is justified. There is no decisive data which demonstrates the effect of power tilt.

The calculated pressure drops presented in Books 3 and 4 match the data well enough to support Conclusion 3.

The figures presented in Book 2 do not support or refute Conclusion 4. When data is plotted for the six tests with similar boundary conditions (See Tables 4 and 5) a helium effect on OFI is not readily observable because of test to test variations. See Figures 2 and 3 that present the effect of helium on velocity and the Stanton number at the demand curve minimum.

These two figures present some distressing information related to the Creare test program. The variation of the velocity and Stanton Number at the demand curve minimum is much higher than expected. The measurement uncertainties for the velocity was stated at approximately 15% and the measurement uncertainties for the Stanton Number was stated at 10 to 20%. The confidence values to contain the available data (Table 6) are much higher than these measurement uncertainties. While there is some variation in the variables as presented in Table 5, the results in Table 6 indicate that additional evaluation of the data is appropriate. Because of this unexplained variation, the conclusion on helium saturation pressure effects on the demand curve minimum may require additional review.

Unexpected variations in the test results (Stanton number at OFI) were earlier identified in Reference 8, which recommend repeating tests 1A and 15. These tests were not repeated.

CONCLUSIONS

1. The experimental data in Books 2, 3, 4, 6, 7, and 8 should be considered appropriate for use in critical applications at SRS.
2. The data in this report must be subject to a verified error analysis prior to its use in critical applications.
3. Additional analysis of the present data is warranted to evaluate the unexplained variation in the measured velocity and Stanton number at the demand curve minimum under similar operating conditions.
4. The conclusion (#4 in Book 2) that helium does not affect the conditions at OFI is justified at the present level of analysis.
5. The Stanton number OFI thresholds calculated from the data in Books 3 & 4 were calculated at azimuthal values rather than local values. This deviates from the modified OSV criteria used to set SRS production reactor limits.

RECOMMENDATIONS

1. Complete a comprehensive data verification and uncertainty analysis for all of the Creare data which is to be used in critical applications.

Items which should be included in this review are:

- Has an elevation correction been included in the local exit pressure measurements?
 - What is the appropriate conversion between inches of water and psi (i.e., at what water temperature)?
 - How was the helium saturation pressure converted from gage to absolute?
 - Can the low Stanton number (0.00330) for the non-ribbed annuli be explained?
2. Calculate the local Stanton number at the demand curve minimum for each test to verify the SRS modified OSV criteria.

NOMENCLATURE

A_f	flow area
c_p	local specific heat
c_{ps}	specific heat of the fluid calculated at the local saturation temperature
D_e	hydraulic diameter
G	mass flux
k_s	thermal conductivity of the fluid calculated at the local saturation temperature
N	total number of samples
ΔP	pressure drop
Pe	Peclet number
Q	flow
S	sample standard deviation
SD	standard deviation of the average
S_m	standard deviation of the sample mean
St	Stanton number
T_f	local bulk fluid temperature
T_s	local saturation temperature
v	velocity
x_i	a single value from a set of data
ϕ	heat flux
ρ	density of liquid
ω	uncertainty

REFERENCES

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2. Chen, Kuo-Fu, and J. F. King, *FLOWTRAN Benchmarking with Onset of Flow Instability Data from 1963 Columbia University Experiment*, DPST-88-666, October 1988.

- 3 Saha, P. and N. Zuber, "Point of Net Vapor Generation and Vapor Void Fraction in Subcooled Boiling", *Proceedings of the 5th International Heat Transfer Conference*, Tokyo, Japan, September 3-7, 1974, pages 175-179.
- 4 Figliola, Richard S., and Donald E. Beasley, *Theory and Design for Mechanical Measurements*, John Wiley & Sons, New York, 1991.
- 5 Holman, J. P., *Experimental Methods for Engineers*, 3rd Ed., McGraw-Hill Book Co., 1978.
- 6 Hahn, Gerald J., "Statistical Intervals", Harrison M. Wadworth, *Statistical Methods for Engineers and Scientists*, McGraw-Hill Publishing Co., New York, 1990, pp 5.1-5.13.
- 7 FLOWTRAN Manual, DPSTM-140, Rev 0, Version 16.2, 8/21/89.
- 8 IOM to J. D. Metzger, from C. A. Nash, Comments on Review of Creare Stanton Number Calculations, NES-ETH-900312, 9/27/90.

Table 1		
Document Numbers		
Document Number	Book/Disk	Title
WSRC-TR-92-534	Book 1	Final report
WSRC-TR-92-534	Book 2	Volume 1 of Creare Final Report TN-499
WSRC-TR-92-534	Book 3	Volume 2 of Creare Final Report TN-499
WSRC-TR-92-534	Book 4	Volume 3 of Creare Final Report TN-499
WSRC-TR-92-534	Book 5	Listing of backup documentation provided SRS by Creare
WSRC-TR-92-534	Book 6	Tabular data from data disk 1, 2 and 3
WSRC-TR-92-534	Book 7	Tabular data from data disk 4, 5, and 6
WSRC-TR-92-534	Book 8	Tabular data from data disk 7, 8, and 9
WSRC-EM-92-308	Disk 1	Reduced test data provided by Creare
WSRC-EM-92-309	Disk 2	Reduced test data provided by Creare
WSRC-EM-92-310	Disk 3	Reduced test data provided by Creare
WSRC-EM-92-311	Disk 4	Reduced test data provided by Creare
WSRC-EM-92-312	Disk 5	Reduced test data provided by Creare
WSRC-EM-92-313	Disk 6	Reduced test data provided by Creare
WSRC-EM-92-314	Disk 7	Reduced test data provided by Creare
WSRC-EM-92-315	Disk 8	Reduced test data provided by Creare
WSRC-EM-92-316	Disk 9	Reduced test data provided by Creare
		Copies of Disks 1 through 9 on HTL worm drive format
AX721102		Procurement records
Task 92-104-1		Backup documentation.

Table 2		
Technical Review Checks		
Check	Number of Checks	Type of Check
Verify diametral average heat flux calculation	2	Independent calculation
Verify outlet average temperature calculation	2	Independent calculation
Verify helium saturation pressure calculation	2	Independent calculation
Verify Stanton number calculation	2	Independent calculation
Verify Peclet number calculation	2	Independent calculation
Verify tabulated uncertainty values	2	Independent calculation
Complete a pressure summation check	2	Calculation
Verify the velocity calculation	2	Independent calculation
Verify electronic media files (.SM1 type)	1 per file	Match data in random locations
Verify electronic media files (.SM2 and .DIF type)	each file	Verify columns have numeric or alpha/numeric data as applicable
Evaluate if conclusions are supported by data	all	Independent evaluation
Evaluate general technical content	all	Read documents for understanding

Table 3						
Comparison of Data Presented in Book 2 and the Reduced Data in Book 3						
Condition	Non-ribbed			Ribbed		
Test series	1A			1A		
Test (data file)	Feb01_09			Aug01_08		
	Book 2, Table 4.1	Book 3	Error % (Comment)	Book 2, Table 4.1	Book 3	Error % (Comment)
Diametral Average Heat Flux, kBtu/hr-ft ²	100.7	100.66	0.04 (1)	100.9	100.95	0.04 (1)
Heat Flux Distribution	uniform	uniform	-	uniform	uniform	-
Velocity, fps	3.49	3.4857	0.12 (1)	3.27	3.2735	0.11 (1)
Inlet Temperature, F	87.7	87.69	0.01 (1)	87.2	87.17	0.03 (1)
Outlet Average Temperature, F	236.8	236.73	0.03 (1)	244.9	244.93	0.01 (1)
Inlet Pressure, psia	40.4	40.4387	0.10 (2)	40.1	40.0797	0.05 (2)
Exit Pressure, psia	45.4	45.2085	0.42 (3)	45.3	45.0459	0.56 (3)
Helium Saturation Pressure, psia	19.6	19.6	0.00 (4)	19.6	19.6	0.00 (4)
Stanton Number	0.00330	0.003328	0.85 (1)	0.00451	0.004556	1.02 (1)
Peclet Number	88500	88120	0.43 (1)	73800	73340	0.623 (1)

Comments

1. Error is considered the result of roundoff.
2. During preparation of Book 1, the inlet pressure was assumed to be based on instrument PAB000136. After subsequent review, the use of the data from instrument PIN000001 was found to provide good results.
3. The reason for the error could not be identified and was larger than that expected due to roundoff. The difference may be the result of an elevation correction which was not discussed in Books 2, 3 or 4.
4. The barometric pressure was assumed to be 14.6 psia.

Table 4		
Test Files Used for Helium Effect Evaluation		
Test	Geometry	Build
Nov14_13	Non-ribbed	1
Feb01_09	Non-ribbed	2
Feb06_08	Non-ribbed	2
May03_21	Ribbed	3
May08_08	Ribbed	3
Aug01_08	Ribbed	4
Aug16_06	Ribbed	4
Aug17_31	Ribbed	4
Aug17_37	Ribbed	4

Table 5			
Range of Fixed Variables for Hellum Effect Evaluation			
Variable	Mean	Minimum	Maximum
Diametral average heat flux, kBtu/hr-ft ²	100.71	99.60	101.40
Velocity, fps	3.30	3.02	3.49
Inlet Temperature, F	86.80	85.10	87.70
Outlet Temperature, F	243.41	236.60	256.50
Inlet Pressure, psia	40.14	40.00	40.40
Exit Pressure, psia	45.28	44.80	45.90

Table 6					
Tolerance Intervals for Velocity and Stanton Number at OFI for the Test Runs in Table 4					
Geometry	Number of Samples	Student's t	Average	Sample Standard Deviation	Sample Confidence Interval (95% coverage)
Velocity					
Ribbed	6	3.365	3.19 fps	0.258 fps	27%
Non-ribbed	3	6.965	3.35 fps	0.101 fps	21%
Stanton Number					
Ribbed	6	3.365	0.00616	0.00249	136%
Non-ribbed	3	6.965	0.00388	0.00055	99%

Figure 3, Effect of Helium Saturation Pressure on the Stanton Number at the Demand Curve Minimum

Appendix A

Independent Review Calculations for Test Feb01_09

Summary - Selected data from test Feb01_09 are listed in Table A1. This data has been used for the calculations presented in this Appendix. The parameters presented in Table 3 which could be directly compared without calculations were the heat flux distribution, velocity, inlet temperature, inlet pressure, and outlet pressure.

Diametral Average Heat Flux - A sample diametral heat flux calculation was not provided in the Creare reports, the diametral heat flux used for comparisons was calculated from the data in Table A1 as shown below:

$$\phi = \frac{\left(100.8289 \frac{\text{Btu}}{\text{hr-ft}^2}\right)(2.368") + \left(100.5210 \frac{\text{Btu}}{\text{hr-ft}^2}\right)(2.894")}{2.368" + 2.894"} \\ = 100.66 \frac{\text{Btu}}{\text{hr-ft}^2}$$

Outlet Average Temperature - The outlet temperature was calculated as the arithmetic mean of the temperature measurements TAF130136, TAF130048, TAF130224, and TAF130312. This mean was 236.73 F.

Helium Saturation Pressure - The method used by Creare to convert the helium saturation pressure reported in Books 3 and 4 in units of psig to units of psia as presented in Book 2 was not presented. If the barometric pressure is assumed as 14.6 psia then there is no problem in completing the conversion.

Stanton Number - Creare defined the Stanton number as:

$$St = \frac{\phi}{G c_{ps} (T_s - T_i)}$$

It is important to note that the fluid properties were evaluated at the annulus exit saturation temperature. While Saha and Zuber [3] do not explicitly specify that the fluid properties be taken at the local bulk conditions, it seems implied by their energy balance equation which was used to calculate the equilibrium vapor quality at the point of net vapor generation. The Stanton number will be calculated using both methods.

The mass flux, G, was calculated based on the inlet fluid properties and Velocity 1. The fluid properties used for calculations are tabulated in Table A2.

The Stanton number based on the fluid properties calculated at the saturated temperature is:

$$St = \frac{\left(100.7 \frac{\text{kBtu}}{\text{hr-ft}^2}\right)\left(3154 \frac{\text{W/m}^2}{\text{kBtu/hr-ft}^2}\right)}{\left(994.80 \frac{\text{kg}}{\text{m}^3}\right)\left(\frac{3.4857 \text{ fps}}{3.281 \text{ ft/m}}\right)\left(4280 \frac{\text{J}}{\text{kg-C}}\right)\left(\frac{274.71 - 236.73\text{F}}{1.8 \text{ F/C}}\right)} \\ = 0.003328$$

The Stanton number based on the fluid properties calculated at the local bulk temperature is:

$$St = \frac{(100.7 \frac{\text{kBtu}}{\text{hr-ft}^2})(3154 \frac{\text{W}}{\text{m}^2})}{(994.80 \frac{\text{kg}}{\text{m}^3})(\frac{3.4857 \text{ fps}}{3.281 \text{ ft/m}})(4237 \frac{\text{J}}{\text{kg-C}})(\frac{274.71 - 236.73\text{F}}{1.8 \text{ F/C}})}$$

$$= 0.003361$$

The specific heat used by FLOWTRAN (7) is assumed constant (4186.8164 J/kg-C). The FLOWTRAN calculated Stanton number would be 0.003436.

The variation from the local property Stanton number value would be:

Saturated properties	-1.0%
Local bulk properties	0.0%
FLOWTRAN	+2.2%

Peclet Number - Creare defined the Peclet number as:

$$Pe = \frac{G c_{ps} D_e}{k_s}$$

As with the Stanton number, the fluid properties were evaluated at the annulus exit saturation temperature. The hydraulic radius used in the calculation was 0.044 ft as given by Equation 2 in Book 2 rather than the 0.0438 ft tabulated in Book 3. The Peclet number based on the fluid properties calculated at the saturated temperature is:

$$Pe = \frac{(994.80 \frac{\text{kg}}{\text{m}^3})(\frac{3.4857 \text{ fps}}{3.281 \text{ ft/m}})(4280 \frac{\text{J}}{\text{kg-C}})(\frac{0.044 \text{ ft}}{3.281 \text{ ft/m}})}{0.68842 \frac{\text{W}}{\text{m-C}}}$$

$$= 88120$$

The Peclet number based on the fluid properties calculated at the local bulk temperature is:

$$Pe = \frac{(994.80 \frac{\text{kg}}{\text{m}^3})(\frac{3.4857 \text{ fps}}{3.281 \text{ ft/m}})(4237 \frac{\text{J}}{\text{kg-C}})(\frac{0.044 \text{ ft}}{3.281 \text{ ft/m}})}{0.68550 \frac{\text{W}}{\text{m-C}}}$$

$$= 87600$$

These two values differ by 0.6 percent.

Channel Pressure Drop - The channel pressure drop is presented in two forms: inches of water and psi. The conversion from inches of water to psi is not provided, however if a water density of 62.42 #/ft³ is assumed the two values agree. The tabular value, SD is described as the "standard deviation of the average value calculated from the 50 readings, engineering units." Common standard deviations used in testing

include the sample standard deviation [4], S , and standard deviation of the mean [5], S_m .

$$S^2 = \frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N - 1} \quad S_m = \frac{S}{\sqrt{N}}$$

It is not clear which statistic is meant by the standard deviation of the average value, S_m . The data provided for instrument PAN000136 is:

Maximum value	-135.5771 °H ₂ O
Minimum value	-131.9150 °H ₂ O
Average	-133.9750 °H ₂ O
SD	0.8233 °H ₂ O
Uncertainty	4.9314 °H ₂ O

If the value of SD is considered a standard deviation of the mean then the sample standard deviation for the 50 samples would be 5.82 °H₂O. Since the difference between the mean and the two extremes is 1.6021 and 2.0600, it is unlikely that the sample confidence interval (twice the sample standard deviation) [6] would be 11.64 °H₂O.

The value of SD has therefore been assumed to represent the sample standard deviation. The confidence interval to contain the mean (twice the standard deviation of the mean) would then be 0.2329 °H₂O.

It has not been possible to determine how the uncertainty was computed by Creare. This evaluation has been completed for several instruments, the results were similar for most. The uncertainties for instrument PAN000136 have been separated into a fixed (4.9 °H₂O) and a variable term (0.25% of reading). These values are stated at the 95% confidence level (i.e. 2σ). Combining these two values using the Root-Sum-Square method:

$$\omega = \sqrt{(4.9)^2 + \left[(133.9750) \left(\frac{0.25\%}{100\%} \right) \right]^2} \\ = 4.9114 \text{ °H}_2\text{O}$$

If the uncertainty calculated as the sample standard deviation is also included:

$$\omega = \sqrt{(4.9)^2 + \left[(133.9750) \left(\frac{0.25\%}{100\%} \right) \right]^2 + [2.0 (0.82330)]^2} \\ = 5.1801 \text{ °H}_2\text{O}$$

If the variable uncertainties are treated as confidence intervals:

$$\omega = \sqrt{(4.9)^2 + \left[\frac{(133.9750) \left(\frac{0.25\%}{100\%} \right)}{\sqrt{50}} \right]^2 + \left[2.0 \left(\frac{0.82330}{\sqrt{50}} \right) \right]^2} \\ = 4.9058 \text{ °H}_2\text{O}$$

If only the sample standard deviation is treated as a confidence interval:

$$\omega = \sqrt{(4.9'')^2 + \left[(133.9750'')\left(\frac{0.25\%}{100\%}\right)\right]^2 + \left[2.0\left(\frac{0.82330''}{\sqrt{50}}\right)\right]^2}$$

$$= 4.9170''\text{H}_2\text{O}$$

None of the above values equal the tabulated value provided by Creare.³

Pressure Summation - The pressure taps for the differential pressure instrument PAN000136 were at 1.75" and 152.75" from the start of the heated length in the 136° circumferential location. The taps for local pressure instruments PAB000136 and PAB125136 were at 1.75 and 146.75" from the start of the heated length. The differential pressure instrument PAN130136 spanned the taps between 146.75 and 152.75" in the 136° circumferential location.

The pressure difference between the inlet and the outlet coupled with the pressure drop measured by PAN130136 should equal the overall measured pressure drop.

$$\Delta P = 40.6122 \text{ psi} - 45.2085 \text{ psi} - (4.5284''\text{H}_2\text{O})\left(\frac{0.03612 \text{ psi}}{''\text{H}_2\text{O}}\right)$$

$$= -4.7599 \text{ psi}$$

$$\omega = \sqrt{(0.58882 \text{ psi})^2 + (0.59091 \text{ psi})^2 + \left[(0.87007''\text{H}_2\text{O})\left(\frac{0.03612 \text{ psi}}{''\text{H}_2\text{O}}\right)\right]^2}$$

$$= 0.8348 \text{ psi}$$

The measured pressure drop (PAN000136) is -4.8380 ± 0.1781 psi and is equal to the calculated value (within the stated uncertainties).

Velocity - A sample calculation for the velocity was not provided. The channel flow rate was apparently measured using flow nozzles and pressure transducers. The averaged tabular data from instrument PFM000001 is listed in inches of water. While it is not possible to reproduce the actual calculation of the velocity it is possible to reproduce the uncertainty calculation. The velocity solution is assumed in the form:

$$v = \frac{Q}{A_t} = K \frac{\sqrt{\Delta P}}{A_t}$$

The value of K can be estimated from the Feb01_09 test data.

³

Z. H. Qureshi reports that the percentage of reading uncertainties listed in Table 2.7 of Book 2 must be adjusted to conform to the instrument's actual range. A discrepancy will result if the start of the range is non-zero. The information to complete these calculations should be in the task records. This is based on an April 1993 phone conversation with F. X. Dolan.

$$K = \frac{(3.4857 \text{ fps})(0.0151 \text{ ft}^2)}{\sqrt{1.83135} \text{H}_2\text{O}}$$

$$= 0.03908 \frac{\text{ft}^3}{\text{s} \sqrt{\text{H}_2\text{O}}}$$

The partial derivatives of the velocity equation are:

$$\frac{\partial v}{\partial \Delta P} = \frac{-K}{2 A_f \sqrt{\Delta P}} \quad \frac{\partial v}{\partial A_f} = \frac{-K \sqrt{\Delta P}}{A_f^2}$$

The uncertainty terms are summarized in Table A3. It has been assumed that any uncertainty in the value of K has been eliminated by a loop calibration process. If the uncertainties are combined using the Root-Sum-Square method then:

$$\omega = \left[\left(\left[\frac{0.03908}{2(0.0151)\sqrt{1.83135}} \right] [0.500] \right)^2 + \left(\left[\frac{(0.03908)\sqrt{1.83135}}{(0.0151)} \right] [0.0005] \right)^2 \right]^{1/2}$$

$$= [0.2308 + 0.0000]^{1/2}$$

$$= 0.480 \text{ fps or } 13.78\%$$

This is close to the stated value of 14.2158 percent.

Table A1			
Selected data from Test Feb01_09			
Parameter	Value	Standard Deviation	Measurement Uncertainty
Velocity 1, fps	3.4857	-	±14.2158%
Pressure drop, psi	-4.8392	-	-
Saturation temperature at exit, F	274.7266	-	-
Inner heat flux, kBtu/hr-ft ²	100.8289	-	±1.5659%
Outer heat flux, kBtu/hr-ft ²	100.5210	-	±1.5532%
Hydraulic diameter, feet	0.0438	-	-
TIN00001, inlet fluid temperature, F	87.6897	0.15142	±1.9002
TAF130136, outlet fluid temperature, F	231.6755	0.46540	±1.9175
TAF130048, outlet fluid temperature, F	244.3002	0.48828	±1.9204
TAF130224, outlet fluid temperature, F	226.3659	0.51117	±1.9164
TAF130312, outlet fluid temperature, F	244.5651	0.49166	±1.9204
PAB000316, inlet pressure, psia	40.6122	0.74124	±0.58882
PIN000001, inlet pressure, psia	40.4387	0.13317	±0.75678
PAB125136, outlet pressure, psia	45.2085	0.049709	±0.59091
PAN000136, pressure drop, °H ₂ O	-133.9750	0.82330	±4.9314
PAN130136, pressure drop, °H ₂ O	-4.5284	0.32423	±0.87007
PFM000001, flow, °H ₂ O	1.8135	0.076263	±0.50002
He saturation pressure, psig	5	-	-

Table A2			
Fluid Property Values			
Temperature, C (F)	Density [7] kg/m³	Specific Heat [4] J/kg-C	Thermal Conductivity [7] W/m-C
30.94 (87.69)	994.80	4182	0.61912
113.74 (236.73)	948.39	4237	0.68550
134.85 (274.73)	931.53	4280	0.68842

Table A3				
Uncertainty Values for Velocity Prediction for Test Feb01_09				
Parameter	Value	Bias	Precision	Combined
Area	0.0151 ft ²	±0.0005 ft ²	0	0.0005 ft ²
Pressure drop	1.8135 °H ₂ O	0.5 °H ₂ O	0.25% reading	0.50002 °H ₂ O

Appendix B

Independent Review Calculations for Test Aug01_08

Summary - Selected data from test Aug01_08 are listed in Table B1. This data has been used for the calculations presented in this Appendix. The parameters presented in Table 3 which could be directly compared without calculations were the heat flux distribution, velocity, inlet temperature, inlet pressure, and outlet pressure.

Diametral Average Heat Flux - A sample diametral heat flux calculation was not provided in the Creare reports, the diametral heat flux used for comparisons was calculated from the data in Table B1 as shown below:

$$\phi = \frac{(101.0104 \frac{\text{Btu}}{\text{hr-ft}^2})(2.353") + (100.9008 \frac{\text{Btu}}{\text{hr-ft}^2})(2.896")}{2.353" + 2.896"} \\ = 100.95 \frac{\text{Btu}}{\text{hr-ft}^2}$$

Outlet Average Temperature - The outlet temperature was calculated as the arithmetic mean of the temperature measurements TAF130136, TAF130048, TAF130224, and TAF130312. This mean was 244.93 F.

Helium Saturation Pressure - The method used to by Creare to convert the helium saturation pressure reported in Books 3 and 4 in units of psig to units of psia as presented in Book 2 was not presented. If the barometric pressure is assumed as 14.6 psia then there is no problem in completing the conversion.

Stanton Number - Creare defined the Stanton number as:

$$St \equiv \frac{\phi}{G c_{ps} (T_s - T_i)}$$

It is important to note that the fluid properties were evaluated at the annulus exit saturation temperature. While Saha and Zuber [3] do not explicitly specify that the fluid properties be taken at the local bulk conditions, it seems implied by their energy balance equation which was used to calculate the equilibrium vapor quality the the point of net vapor generation. The Stanton number will be calculated using both methods.

The mass flux, G, was calculated based on the inlet fluid properties and Velocity 1. The fluid properties used for calculations are tabulated in Table B2.

The Stanton number based on the fluid properties calculated at the saturated temperature is:

$$St = \frac{(100.9 \frac{\text{kBtu}}{\text{hr-ft}^2})(3154 \frac{\text{W/m}^2}{\text{kBtu/hr-ft}^2})}{(994.91 \frac{\text{kg}}{\text{m}^3})(3.2735 \frac{\text{fps}}{3.281 \text{ ft/m}})(4279 \frac{\text{J}}{\text{kg-C}})(\frac{274.51 - 244.93\text{F}}{1.8 \text{ F/C}})} \\ = 0.004556$$

The Stanton number based on the fluid properties calculated at the local bulk temperature is:

$$St = \frac{(100.9 \frac{\text{kBtu}}{\text{hr-ft}^2})(3154 \frac{\text{W}}{\text{m}^2})}{(994.91 \frac{\text{kg}}{\text{m}^3})(\frac{3.2735 \text{ fps}}{3.281 \text{ ft/m}})(4244 \frac{\text{J}}{\text{kg-C}})(\frac{274.51 - 244.93\text{F}}{1.8 \text{ F/C}})}$$

$$= 0.004597$$

The specific heat used by FLOWTRAN [7] is assumed constant (4186.8164 J/kg-C). The FLOWTRAN calculated Stanton number would be 0.004660.

The variation from the local property Stanton number value would be:

Saturated properties	-0.9%
Local bulk properties	0.0%
FLOWTRAN	+1.4%

Peclet Number - Creare defined the Peclet number as:

$$Pe \equiv \frac{G c_{ps} D_e}{k_s}$$

As with the Stanton number, the fluid properties were evaluated at the annulus exit saturation temperature. The hydraulic radius used in the calculation was 0.044 ft as given by Equation 2 in Book 2 rather than the 0.0438 ft tabulated in Book 3. The Peclet number based on the fluid properties calculated at the saturated temperature is:

$$Pe = \frac{(994.91 \frac{\text{kg}}{\text{m}^3})(\frac{3.2735 \text{ fps}}{3.281 \text{ ft/m}})(4279 \frac{\text{J}}{\text{kg-C}})(\frac{0.039 \text{ ft}}{3.281 \text{ ft/m}})}{0.68842 \frac{\text{W}}{\text{m-C}}}$$

$$= 73340$$

The Peclet number based on the fluid properties calculated at the local bulk temperature is:

$$Pe = \frac{(994.91 \frac{\text{kg}}{\text{m}^3})(\frac{3.2735 \text{ fps}}{3.281 \text{ ft/m}})(4244 \frac{\text{J}}{\text{kg-C}})(\frac{0.039 \text{ ft}}{3.281 \text{ ft/m}})}{0.68842 \frac{\text{W}}{\text{m-C}}}$$

$$= 72900$$

These two values differ by 0.5 percent.

Channel Pressure Drop - The channel pressure drop is presented in two forms: inches of water and psi. The conversion from inches of water to psi is not provided, however if a water density of 62.42 #/ft³ is assumed the two values agree. The tabular value, SD is described as the "standard deviation of the average value calculated from

the 50 readings, engineering units." Common standard deviations used in testing include the sample standard deviation [4], S and standard deviation of the mean [5], S_m .

$$S^2 = \frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N - 1} \quad S_m = \frac{S}{\sqrt{N}}$$

It is not clear which statistic is meant by the standard deviation of the average value, SD. The data provided for instrument PAN000136 is:

Maximum value	-136.8970 °H ₂ O
Minimum value	-131.4039 °H ₂ O
Average	-133.6011 °H ₂ O
SD	1.1662 °H ₂ O
Uncertainty	4.9313 °H ₂ O

If the value of SD is considered a standard deviation of the mean then the sample standard deviation for the 50 samples would be 8.25°H₂O. Since the difference between the mean and the two extremes is 3.2959 and 2.1972, it is unlikely that the sample confidence interval (twice the sample standard deviation) [6] would be 16.49°H₂O.

The value of SD has therefore been assumed to represent the sample standard deviation. The confidence interval to contain the mean (twice the standard deviation of the mean) would then be 0.3299°H₂O.

Pressure Summation - The pressure taps for the differential pressure instrument PAN000136 were at 1.75" and 152.75" from the start of the heated length in the 136° circumferential location. The taps for local pressure instruments PAB000136 and PAB125136 were at 1.75 and 146.75" from the start of the heated length. The differential pressure instrument PAN130136 spanned the pas between 146.75 and 152.75" in the 136° circumferential location.

The pressure difference between the inlet and the outlet coupled with the pressure drop measured by PAN130136 should equal the overall measured pressure drop.

$$\begin{aligned} \Delta P &= 40.3552 \text{ psi} - 45.0459 \text{ psi} - (1.9651^\circ\text{H}_2\text{O}) \left(\frac{0.03612 \text{ psi}}{^\circ\text{H}_2\text{O}} \right) \\ &= -4.7617 \text{ psi} \\ \omega &= \sqrt{(0.58871 \text{ psi})^2 + (0.59083 \text{ psi})^2 + \left[(0.87001^\circ\text{H}_2\text{O}) \left(\frac{0.03612 \text{ psi}}{^\circ\text{H}_2\text{O}} \right) \right]^2} \\ &= 0.8347 \text{ psi} \end{aligned}$$

The measured pressure drop (PAN000136) is -4.8257±0.1781 psi and is equal to the calculated value (within the stated uncertainties).

Velocity - A sample calculation for the velocity was not provided. The channel flow rate was apparently measured using flow nozzles and pressure transducers. The

averaged tabular data from instrument PFM000001 is listed in inches of water. While it is not possible to reproduce the actual calculation of the velocity it is possible to reproduce the uncertainty calculation. The velocity solution is assumed in the form:

$$v = \frac{Q}{A_f} = K \frac{\sqrt{\Delta P}}{A_f}$$

The value of K can be estimated from the Aug01_08 test data.

$$\begin{aligned} K &= \frac{(3.2735 \text{ fps})(0.0150 \text{ ft}^2)}{\sqrt{1.5723} \text{ H}_2\text{O}} \\ &= 0.03916 \frac{\text{ft}^3}{\text{s} \sqrt{\text{H}_2\text{O}}} \end{aligned}$$

this is within 0.2% of the value calculated in Appendix A. The partial derivatives of the velocity equation are:

$$\frac{\partial v}{\partial \Delta P} = \frac{-K}{2 A_f \sqrt{\Delta P}} \quad \frac{\partial v}{\partial A_f} = \frac{-K \sqrt{\Delta P}}{A_f^2}$$

The uncertainty terms are summarized in Table B3. It has been assumed that any uncertainty in the value of K has been eliminated by a loop calibration process. If the uncertainties are combined using the Root-Sum-Square method then:

$$\begin{aligned} \omega &= \left[\left(\left[\frac{0.03916}{2 (0.0150) \sqrt{1.5723}} \right] [0.500] \right)^2 + \left(\left[\frac{(0.03916) \sqrt{1.5723}}{(0.0150)} \right] [0.0002] \right)^2 \right]^{1/2} \\ &= [0.2709 + 0.0000]^{1/2} \\ &= 0.520 \text{ fps or } 15.90\% \end{aligned}$$

This compares very favorably with the stated value of 15.9876 percent.

Table B1			
Selected data from Test Aug01_08			
Parameter	Value	Standard Deviation	Measurement Uncertainty
Velocity 1, fps	3.2735	-	±15.9876%
Pressure drop, psi	-4.8257	-	-
Saturation temperature at exit, F	274.5080	-	-
Inner heat flux, kBtu/hr-ft ²	101.0104	-	±14119%
Outer heat flux, kBtu/hr-ft ²	100.9008	-	±1.5432%
Hydraulic diameter, feet	0.0390	-	-
TIN00001, inlet fluid temperature, F	87.1651	0.12664	±1.9002
TAF130136, outlet fluid temperature, F	237.8820	0.61390	±1.9189
TAF130048, outlet fluid temperature, F	252.5833	0.48068	±1.9223
TAF130224, outlet fluid temperature, F	232.0694	0.43451	±1.9176
TAF130312, outlet fluid temperature, F	257.1989	0.56810	±1.9235
PIN000001, inlet pressure, psia	40.0797	0.070664	±0.75666
PAB000316, inlet pressure, psia	40.3552	0.062595	±0.58871
PAB125136, outlet pressure, psia	45.0459	0.079690	±0.59083
PAN000136, pressure drop, °H ₂ O	-133.6011	1.1662	±4.9313
PAN130136, pressure drop, °H ₂ O	-1.9651	1.5864	±0.87001
PFM00001, flow, °H ₂ O	1.5723	0.078930	±0.50002
He saturation pressure, psig	5	-	-

Table B2			
Fluid Property Values			
Temperature, C (F)	Density [7] kg/m³	Specific Heat [4] J/kg-C	Thermal Conductivity [7] W/m-C
30.65 (87..17)	994.91	4181.64	0.61873
118.30 (244.93)	944.93	4244	0.68659
134.73 (274.51)	931.63	4279	0.68842

Table B3				
Uncertainty Values for Velocity Prediction for Test Aug01_08				
Parameter	Value	Bias	Precision	Combined
Area	0.0150 ft ²	±0.0002 ft ²	-	±0.0002 ft ²
Pressure drop	1.5723°H ₂ O	±0.5°H ₂ O	0.25% rd	±0.50002°H ₂ O

Appendix C
Directory of Electronic Data Files by Disk Number

DIRECTORY FOR DATA DISK #1

DATA FILE	SIZE
NOV13-02.DIF	7089
NOV13-02.SM1	13020
NOV13-02.SM2	13020
NOV13-03.DIF	7089
NOV13-03.SM1	13020
NOV13-03.SM2	13020
NOV13-04.DIF	7089
NOV13-04.SM1	13020
NOV13-04.SM2	13020
NOV13-05.DIF	7089
NOV13-05.SM1	13020
NOV13-05.SM2	13020
NOV13-06.DIF	7089
NOV13-06.SM1	13020
NOV13-06.SM2	13020
NOV13-07.DIF	7089
NOV13-07.SM1	13020
NOV13-07.SM2	13020
NOV13-08.DIF	7089
NOV13-08.SM1	13020
NOV13-08.SM2	13020
NOV13-09.DIF	7089
NOV13-09.SM1	13020
NOV13-09.SM2	13020
NOV13-10.DIF	7089
NOV13-10.SM1	13020
NOV13-10.SM2	13020
NOV13-11.DIF	7089
NOV13-11.SM1	13020
NOV13-11.SM2	13020
NOV13-12.DIF	7089
NOV13-12.SM1	13020
NOV13-12.SM2	13020
NOV13-13.DIF	7089
NOV13-13.SM1	13020
NOV13-13.SM2	13020
NOV13-14.DIF	7089
NOV13-14.SM1	13020
NOV13-14.SM2	13020
NOV13-15.DIF	7089
NOV13-15.SM1	13020
NOV13-15.SM2	13020
NOV13-16.DIF	7089
NOV13-16.SM1	13020
NOV13-16.SM2	13020
NOV13-17.DIF	7089
NOV13-17.SM1	13020
NOV13-17.SM2	13020
NOV13-18.DIF	7089
NOV13-18.SM1	13020
NOV13-18.SM2	13020
NOV13-19.DIF	7089
NOV13-19.SM1	13020
NOV13-19.SM2	13020
NOV14-02.DIF	7089
NOV14-02.SM1	13020
NOV14-02.SM2	13020
NOV14-03.DIF	7089
NOV14-03.SM1	13020
NOV14-03.SM2	13020
NOV14-04.DIF	7089
NOV14-04.SM1	13020
NOV14-04.SM2	13020
NOV14-05.DIF	7089
NOV14-05.SM1	13020
NOV14-05.SM2	13020

DIRECTORY FOR DATA DISK #1

DATA FILE	SIZE
NOV14_06.DIF	7089
NOV14_06.SM1	13020
NOV14_06.SM2	13020
NOV14_07.DIF	7089
NOV14_07.SM1	13020
NOV14_07.SM2	13020
NOV14_08.DIF	7089
NOV14_08.SM1	13020
NOV14_08.SM2	13020
NOV14_09.DIF	7089
NOV14_09.SM1	13020
NOV14_09.SM2	13020
NOV14_11.DIF	7089
NOV14_11.SM1	13020
NOV14_11.SM2	13020
NOV14_12.DIF	7089
NOV14_12.SM1	13020
NOV14_12.SM2	13020
NOV14_13.DIF	7089
NOV14_13.SM1	13020
NOV14_13.SM2	13020
NOV14_14.DIF	7089
NOV14_14.SM1	13020
NOV14_14.SM2	13020
NOV14_15.DIF	7089
NOV14_15.SM1	13020
NOV14_15.SM2	13020

DIRECTORY FOR DATA DISK #2

DATA FILE	SIZE
FEB01-01.DIF	7089
FEB01-01.SM1	13020
FEB01-01.SM2	13020
FEB01-02.DIF	7089
FEB01-02.SM1	13020
FEB01-02.SM2	13020
FEB01-03.DIF	7089
FEB01-03.SM1	13020
FEB01-03.SM2	13020
FEB01-04.DIF	7089
FEB01-04.SM1	13020
FEB01-04.SM2	13020
FEB01-05.DIF	7089
FEB01-05.SM1	13020
FEB01-05.SM2	13020
FEB01-06.DIF	7089
FEB01-06.SM1	13020
FEB01-06.SM2	13020
FEB01-07.DIF	7089
FEB01-07.SM1	13020
FEB01-07.SM2	13020
FEB01-08.DIF	7089
FEB01-08.SM1	13020
FEB01-08.SM2	13020
FEB01-09.DIF	7089
FEB01-09.SM1	13020
FEB01-09.SM2	13020
FEB01-10.DIF	7089
FEB01-10.SM1	13020
FEB01-10.SM2	13020
FEB01-11.DIF	7089
FEB01-11.SM1	13020
FEB01-11.SM2	13020
JAN31-01.DIF	7089
JAN31-01.SM1	13020
JAN31-01.SM2	13020
JAN31-02.DIF	7089
JAN31-02.SM1	13020
JAN31-02.SM2	13020
JAN31-03.DIF	7089
JAN31-03.SM1	13020
JAN31-03.SM2	13020
JAN31-04.DIF	7089
JAN31-04.SM1	13020
JAN31-04.SM2	13020
JAN31-05.DIF	7089
JAN31-05.SM1	13020
JAN31-05.SM2	13020
JAN31-06.DIF	7089
JAN31-06.SM1	13020
JAN31-06.SM2	13020
JAN31-07.DIF	7089
JAN31-07.SM1	13020
JAN31-07.SM2	13020
JAN31-08.DIF	7089
JAN31-08.SM1	13020
JAN31-08.SM2	13020
JAN31-09.DIF	7089
JAN31-09.SM1	13022
JAN31-09.SM2	13020
JAN31-10.DIF	7089
JAN31-10.SM1	13020
JAN31-10.SM2	13020
JAN31-11.DIF	7089
JAN31-11.SM1	13020
JAN31-11.SM2	13020

DIRECTORY FOR DATA DISK #2

DATA FILE	SIZE
JAN31_12.DIF	7089
JAN31_12.SM1	13021
JAN31_12.SM2	13020
JAN31_13.DIF	7089
JAN31_13.SM1	13020
JAN31_13.SM2	13020
JAN31_14.DIF	7089
JAN31_14.SM1	13020
JAN31_14.SM2	13020
JAN31_15.DIF	7089
JAN31_15.SM1	13020
JAN31_15.SM2	13020
JAN31_16.DIF	7089
JAN31_16.SM1	13020
JAN31_16.SM2	13020
JAN31_17.DIF	7089
JAN31_17.SM1	13020
JAN31_17.SM2	13020
JAN31_18.DIF	7089
JAN31_18.SM1	13020
JAN31_18.SM2	13020

DIRECTORY FOR DATA DISK #3

DATA FILE	SIZE
FE305_01.DIF	7089
FE305_01.SM1	13020
FE305_01.SM2	13020
FE305_02.DIF	7089
FE305_02.SM1	13020
FE305_02.SM2	13020
FE305_03.DIF	7089
FE305_03.SM1	13020
FE305_03.SM2	13020
FE305_04.DIF	7089
FE305_04.SM1	13020
FE305_04.SM2	13020
FE305_05.DIF	7089
FE305_05.SM1	13020
FE305_05.SM2	13020
FE305_06.DIF	7089
FE305_06.SM1	13020
FE305_06.SM2	13020
FE305_07.DIF	7089
FE305_07.SM1	13020
FE305_07.SM2	13020
FE305_08.DIF	7089
FE305_08.SM1	13020
FE305_08.SM2	13020
FE305_09.DIF	7089
FE305_09.SM1	13020
FE305_09.SM2	13020
FE305_10.DIF	7089
FE305_10.SM1	13020
FE305_10.SM2	13020
FE305_11.DIF	7089
FE305_11.SM1	13020
FE305_11.SM2	13020
FE305_12.DIF	7089
FE305_12.SM1	13020
FE305_12.SM2	13020
FE305_13.DIF	7089
FE305_13.SM1	13020
FE305_13.SM2	13020
FE305_14.DIF	7089
FE305_14.SM1	13020
FE305_14.SM2	13020
FE305_15.DIF	7089
FE305_15.SM1	13020
FE305_15.SM2	13020
FE306_01.DIF	7089
FE306_01.SM1	13020
FE306_01.SM2	13020
FE306_02.DIF	7089
FE306_02.SM1	13020
FE306_02.SM2	13020
FE306_03.DIF	7089
FE306_03.SM1	13020
FE306_03.SM2	13020
FE306_04.DIF	7089
FE306_04.SM1	13020
FE306_04.SM2	13020
FE306_05.DIF	7089
FE306_05.SM1	13020
FE306_05.SM2	13020
FE306_06.DIF	7089
FE306_06.SM1	13020
FE306_06.SM2	13020
FE306_07.DIF	7089
FE306_07.SM1	13020
FE306_07.SM2	13020

DIRECTORY FOR DATA DISK #3

DATA FILE	SIZE
FEB06_08.DIF	7089
FEB06_08.SM1	13020
FEB06_08.SM2	13020
FEB06_10.DIF	7089
FEB06_10.SM1	13020
FEB06_10.SM2	13020
FEB08_01.DIF	7089
FEB08_01.SM1	13020
FEB08_01.SM2	13020
FEB08_02.DIF	7089
FEB08_02.SM1	13020
FEB08_02.SM2	13020
FEB08_03.DIF	7089
FEB08_03.SM1	13020
FEB08_03.SM2	13020
FEB08_04.DIF	7089
FEB08_04.SM1	13020
FEB08_04.SM2	13020
FEB08_05.DIF	7089
FEB08_05.SM1	13020
FEB08_05.SM2	13020
FEB08_06.DIF	7089
FEB08_06.SM1	13020
FEB08_06.SM2	13020
FEB08_07.DIF	7089
FEB08_07.SM1	13020
FEB08_07.SM2	13020
FEB08_08.DIF	7089
FEB08_08.SM1	13020
FEB08_08.SM2	13020
FEB08_09.DIF	7089
FEB08_09.SM1	13020
FEB08_09.SM2	13020
FEB08_10.DIF	7089
FEB08_10.SM1	13020
FEB08_10.SM2	13020
FEB08_11.DIF	7089
FEB08_11.SM1	13020
FEB08_11.SM2	13020

DIRECTORY FOR DATA DISK #4

DATA FILE	SIZE
MAY01_01.DIF	7091
MAY01_01.SM1	13021
MAY01_01.SM2	13020
MAY01_02.DIF	7089
MAY01_02.SM1	13020
MAY01_02.SM2	13020
MAY01_03.DIF	7089
MAY01_03.SM1	13020
MAY01_03.SM2	13020
MAY01_04.DIF	7089
MAY01_04.SM1	13021
MAY01_04.SM2	13020
MAY01_05.DIF	7089
MAY01_05.SM1	13021
MAY01_05.SM2	13023
MAY01_06.DIF	7089
MAY01_06.SM1	13020
MAY01_06.SM2	13022
MAY01_07.DIF	7089
MAY01_07.SM1	13021
MAY01_07.SM2	13020
MAY01_08.DIF	7089
MAY01_08.SM1	13021
MAY01_08.SM2	13021
MAY01_09.DIF	7089
MAY01_09.SM1	13020
MAY01_09.SM2	13020
MAY01_10.DIF	7089
MAY01_10.SM1	13021
MAY01_10.SM2	13022
MAY01_11.DIF	7089
MAY01_11.SM1	13021
MAY01_11.SM2	13021
MAY01_12.DIF	7089
MAY01_12.SM1	13021
MAY01_12.SM2	13020
MAY01_13.DIF	7089
MAY01_13.SM1	13020
MAY01_13.SM2	13023
MAY01_14.DIF	7090
MAY01_14.SM1	13020
MAY01_14.SM2	13022
MAY01_15.DIF	7089
MAY01_15.SM1	13020
MAY01_15.SM2	13020
MAY01_16.DIF	7089
MAY01_16.SM1	13021
MAY01_16.SM2	13021
MAY01_17.DIF	7089
MAY01_17.SM1	13020
MAY01_17.SM2	13021
MAY01_18.DIF	7089
MAY01_18.SM1	13021
MAY01_18.SM2	13022
MAY03_11.DIF	7089
MAY03_11.SM1	13020
MAY03_11.SM2	13020
MAY03_12.DIF	7089
MAY03_12.SM1	13020
MAY03_12.SM2	13020
MAY03_13.DIF	7089
MAY03_13.SM1	13020
MAY03_13.SM2	13020
MAY03_14.DIF	7089
MAY03_14.SM1	13020
MAY03_14.SM2	13020

DIRECTORY FOR DATA DISK #4

DATA FILE	SIZE
MAY03_15.DIF	7089
MAY03_15.SM1	13020
MAY03_15.SM2	13020
MAY03_16.DIF	7089
MAY03_16.SM1	13020
MAY03_16.SM2	13020
MAY03_17.DIF	7089
MAY03_17.SM1	13020
MAY03_17.SM2	13020
MAY03_18.DIF	7089
MAY03_18.SM1	13020
MAY03_18.SM2	13020
MAY03_19.DIF	7089
MAY03_19.SM1	13020
MAY03_19.SM2	13020
MAY03_20.DIF	7089
MAY03_20.SM1	13020
MAY03_20.SM2	13020
MAY03_21.DIF	7089
MAY03_21.SM1	13020
MAY03_21.SM2	13020

DIRECTORY FOR DATA DISK #5

DATA FILE	SIZE
MAY07_01.DIF	7089
MAY07_01.SM1	13020
MAY07_01.SM2	13020
MAY07_02.DIF	7089
MAY07_02.SM1	13020
MAY07_02.SM2	13020
MAY07_03.DIF	7089
MAY07_03.SM1	13020
MAY07_03.SM2	13020
MAY07_04.DIF	7089
MAY07_04.SM1	13020
MAY07_04.SM2	13020
MAY07_05.DIF	7089
MAY07_05.SM1	13020
MAY07_05.SM2	13020
MAY07_06.DIF	7089
MAY07_06.SM1	13020
MAY07_06.SM2	13020
MAY07_07.DIF	7089
MAY07_07.SM1	13020
MAY07_07.SM2	13020
MAY07_08.DIF	7089
MAY07_08.SM1	13020
MAY07_08.SM2	13020
MAY07_09.DIF	7089
MAY07_09.SM1	13020
MAY07_09.SM2	13020
MAY08_01.DIF	7089
MAY08_01.SM1	13020
MAY08_01.SM2	13020
MAY08_02.DIF	7089
MAY08_02.SM1	13020
MAY08_02.SM2	13020
MAY08_03.DIF	7089
MAY08_03.SM1	13020
MAY08_03.SM2	13020
MAY08_04.DIF	7089
MAY08_04.SM1	13020
MAY08_04.SM2	13020
MAY08_05.DIF	7089
MAY08_05.SM1	13020
MAY08_05.SM2	13020
MAY08_06.DIF	7089
MAY08_06.SM1	13020
MAY08_06.SM2	13020
MAY08_07.DIF	7089
MAY08_07.SM1	13020
MAY08_07.SM2	13020
MAY08_08.DIF	7089
MAY08_08.SM1	13020
MAY08_08.SM2	13020

DIRECTORY FOR DATA DISK #6

DATA FILE	SIZE
AUG01_01.DIF	7089
AUG01_01.SM1	13020
AUG01_01.SM2	13020
AUG01_02.DIF	7089
AUG01_02.SM1	13020
AUG01_02.SM2	13020
AUG01_03.DIF	7089
AUG01_03.SM1	13020
AUG01_03.SM2	13020
AUG01_04.DIF	7089
AUG01_04.SM1	13020
AUG01_04.SM2	13020
AUG01_05.DIF	7089
AUG01_05.SM1	13020
AUG01_05.SM2	13020
AUG01_06.DIF	7089
AUG01_06.SM1	13020
AUG01_06.SM2	13020
AUG01_07.DIF	7089
AUG01_07.SM1	13020
AUG01_07.SM2	13020
AUG01_08.DIF	7089
AUG01_08.SM1	13020
AUG01_08.SM2	13020
AUG01_10.DIF	7089
AUG01_10.SM1	13020
AUG01_10.SM2	13020
AUG01_11.DIF	7089
AUG01_11.SM1	13020
AUG01_11.SM2	13020
AUG01_12.DIF	7089
AUG01_12.SM1	13020
AUG01_12.SM2	13020
AUG01_13.DIF	7089
AUG01_13.SM1	13020
AUG01_13.SM2	13020
AUG01_14.DIF	7089
AUG01_14.SM1	13020
AUG01_14.SM2	13020
AUG01_15.DIF	7089
AUG01_15.SM1	13020
AUG01_15.SM2	13020
AUG01_16.DIF	7089
AUG01_16.SM1	13020
AUG01_16.SM2	13020
AUG01_17.DIF	7089
AUG01_17.SM1	13020
AUG01_17.SM2	13020
AUG01_18.DIF	7089
AUG01_18.SM1	13020
AUG01_18.SM2	13020
AUG01_19.DIF	7089
AUG01_19.SM1	13020
AUG01_19.SM2	13020
JUL31_01.DIF	7089
JUL31_01.SM1	13021
JUL31_01.SM2	13020
JUL31_02.DIF	7089
JUL31_02.SM1	13021
JUL31_02.SM2	13020
JUL31_03.DIF	7089
JUL31_03.SM1	13020
JUL31_03.SM2	13021
JUL31_04.DIF	7089
JUL31_04.SM1	13021
JUL31_04.SM2	13020

DIRECTORY FOR DATA DISK #6

DATA FILE	SIZE
JUL31_05.DIF	7089
JUL31_05.SM1	13020
JUL31_05.SM2	13020
JUL31_06.DIF	7089
JUL31_06.SM1	13020
JUL31_06.SM2	13020
JUL31_07.DIF	7089
JUL31_07.SM1	13020
JUL31_07.SM2	13020
JUL31_08.DIF	7089
JUL31_08.SM1	13020
JUL31_08.SM2	13020
JUL31_09.DIF	7089
JUL31_09.SM1	13020
JUL31_09.SM2	13021
JUL31_10.DIF	7089
JUL31_10.SM1	13020
JUL31_10.SM2	13020
JUL31_11.DIF	7089
JUL31_11.SM1	13020
JUL31_11.SM2	13020
JUL31_12.DIF	7089
JUL31_12.SM1	13020
JUL31_12.SM2	13020
JUL31_13.DIF	7089
JUL31_13.SM1	13020
JUL31_13.SM2	13020
JUL31_14.DIF	7089
JUL31_14.SM1	13020
JUL31_14.SM2	13020
JUL31_15.DIF	7089
JUL31_15.SM1	13020
JUL31_15.SM2	13020
JUL31_16.DIF	7089
JUL31_16.SM1	13020
JUL31_16.SM2	13020
JUL31_17.DIF	7089
JUL31_17.SM1	13022
JUL31_17.SM2	13023
JUL31_18.DIF	7089
JUL31_18.SM1	13020
JUL31_18.SM2	13021
JUL31_19.DIF	7089
JUL31_19.SM1	13020
JUL31_19.SM2	13020
JUL31_20.DIF	7089
JUL31_20.SM1	13021
JUL31_20.SM2	13020
JUL31_21.DIF	7089
JUL31_21.SM1	13020
JUL31_21.SM2	13020
JUL31_22.DIF	7089
JUL31_22.SM1	13020
JUL31_22.SM2	13020

DIRECTORY FOR DATA DISK #7

DATA FILE	SIZE
AUG01_21.DIF	7089
AUG01_21.SM1	13020
AUG01_21.SM2	13020
AUG01_22.DIF	7089
AUG01_22.SM1	13020
AUG01_22.SM2	13020
AUG01_23.DIF	7089
AUG01_23.SM1	13020
AUG01_23.SM2	13020
AUG01_24.DIF	7089
AUG01_24.SM1	13020
AUG01_24.SM2	13020
AUG01_25.DIF	7089
AUG01_25.SM1	13020
AUG01_25.SM2	13020
AUG01_26.DIF	7089
AUG01_26.SM1	13020
AUG01_26.SM2	13020
AUG01_27.DIF	7089
AUG01_27.SM1	13020
AUG01_27.SM2	13020
AUG14_01.DIF	7089
AUG14_01.SM1	13020
AUG14_01.SM2	13020
AUG14_02.DIF	7089
AUG14_02.SM1	13020
AUG14_02.SM2	13020
AUG14_03.DIF	7089
AUG14_03.SM1	13020
AUG14_03.SM2	13020
AUG14_04.DIF	7089
AUG14_04.SM1	13020
AUG14_04.SM2	13020
AUG14_05.DIF	7089
AUG14_05.SM1	13020
AUG14_05.SM2	13020
AUG14_06.DIF	7089
AUG14_06.SM1	13020
AUG14_06.SM2	13020
AUG14_07.DIF	7089
AUG14_07.SM1	13020
AUG14_07.SM2	13020
AUG14_08.DIF	7089
AUG14_08.SM1	13020
AUG14_08.SM2	13020
AUG14_09.DIF	7089
AUG14_09.SM1	13020
AUG14_09.SM2	13020
AUG14_10.DIF	7089
AUG14_10.SM1	13020
AUG14_10.SM2	13020
AUG14_11.DIF	7089
AUG14_11.SM1	13020
AUG14_11.SM2	13020
AUG14_12.DIF	7089
AUG14_12.SM1	13020
AUG14_12.SM2	13020
AUG14_13.DIF	7089
AUG14_13.SM1	13020
AUG14_13.SM2	13020
AUG14_14.DIF	7089
AUG14_14.SM1	13020
AUG14_14.SM2	13020
AUG14_15.DIF	7089
AUG14_15.SM1	13020
AUG14_15.SM2	13020

DIRECTORY FOR DATA DISK #7

DATA FILE	SIZE
AUG14_16.DIF	7089
AUG14_16.SM1	13020
AUG14_16.SM2	13020
AUG15_01.DIF	7089
AUG15_01.SM1	13020
AUG15_01.SM2	13020
AUG15_02.DIF	7089
AUG15_02.SM1	13020
AUG15_02.SM2	13020
AUG15_03.DIF	7089
AUG15_03.SM1	13020
AUG15_03.SM2	13020
AUG15_04.DIF	7089
AUG15_04.SM1	13020
AUG15_04.SM2	13020
AUG15_05.DIF	7089
AUG15_05.SM1	13020
AUG15_05.SM2	13020
AUG15_06.DIF	7089
AUG15_06.SM1	13020
AUG15_06.SM2	13020
AUG15_07.DIF	7089
AUG15_07.SM1	13020
AUG15_07.SM2	13020
AUG15_08.DIF	7089
AUG15_08.SM1	13020
AUG15_08.SM2	13020
AUG15_09.DIF	7089
AUG15_09.SM1	13020
AUG15_09.SM2	13020
AUG15_10.DIF	7089
AUG15_10.SM1	13020
AUG15_10.SM2	13020
AUG15_11.DIF	7089
AUG15_11.SM1	13020
AUG15_11.SM2	13020
AUG15_12.DIF	7089
AUG15_12.SM1	13020
AUG15_12.SM2	13020

DIRECTORY FOR DATA DISK #8

DATA FILE	SIZE
AUG15_13.DIF	7089
AUG15_13.SM1	13020
AUG15_13.SM2	13020
AUG15_14.DIF	7089
AUG15_14.SM1	13020
AUG15_14.SM2	13020
AUG15_15.DIF	7089
AUG15_15.SM1	13020
AUG15_15.SM2	13020
AUG15_16.DIF	7091
AUG15_16.SM1	13020
AUG15_16.SM2	13020
AUG15_21.DIF	7089
AUG15_21.SM1	13020
AUG15_21.SM2	13020
AUG15_22.DIF	7089
AUG15_22.SM1	13020
AUG15_22.SM2	13020
AUG15_23.DIF	7089
AUG15_23.SM1	13020
AUG15_23.SM2	13020
AUG15_24.DIF	7089
AUG15_24.SM1	13020
AUG15_24.SM2	13020
AUG15_25.DIF	7089
AUG15_25.SM1	13020
AUG15_25.SM2	13020
AUG15_26.DIF	7089
AUG15_26.SM1	13020
AUG15_26.SM2	13020
AUG16_01.DIF	7089
AUG16_01.SM1	13020
AUG16_01.SM2	13020
AUG16_02.DIF	7089
AUG16_02.SM1	13020
AUG16_02.SM2	13020
AUG16_03.DIF	7089
AUG16_03.SM1	13020
AUG16_03.SM2	13020
AUG16_04.DIF	7089
AUG16_04.SM1	13020
AUG16_04.SM2	13020
AUG16_05.DIF	7089
AUG16_05.SM1	13020
AUG16_05.SM2	13020
AUG16_06.DIF	7089
AUG16_06.SM1	13020
AUG16_06.SM2	13020
AUG16_07.DIF	7089
AUG16_07.SM1	13020
AUG16_07.SM2	13020
AUG17_01.DIF	7089
AUG17_01.SM1	13020
AUG17_01.SM2	13020
AUG17_02.DIF	7089
AUG17_02.SM1	13020
AUG17_02.SM2	13020
AUG17_03.DIF	7089
AUG17_03.SM1	13020
AUG17_03.SM2	13020
AUG17_04.DIF	7089
AUG17_04.SM1	13020
AUG17_04.SM2	13020
AUG17_05.DIF	7089
AUG17_05.SM1	13020
AUG17_05.SM2	13020

DIRECTORY FOR DATA DISK #8

DATA FILE	SIZE
AUG17 06.DIF	7089
AUG17 06.SM1	13020
AUG17 06.SM2	13020
AUG17 07.DIF	7089
AUG17 07.SM1	13020
AUG17 07.SM2	13020
AUG17 08.DIF	7089
AUG17 08.SM1	13020
AUG17 08.SM2	13020
AUG17 09.DIF	7089
AUG17 09.SM1	13020
AUG17 09.SM2	13020
AUG17 10.DIF	7089
AUG17 10.SM1	13020
AUG17 10.SM2	13020
AUG17 11.DIF	7089
AUG17 11.SM1	13020
AUG17 11.SM2	13020
AUG17 12.DIF	7089
AUG17 12.SM1	13020
AUG17 12.SM2	13020
AUG17 13.DIF	7089
AUG17 13.SM1	13020
AUG17 13.SM2	13020
AUG17 14.DIF	7089
AUG17 14.SM1	13020
AUG17 14.SM2	13020
AUG17 15.DIF	7089
AUG17 15.SM1	13020
AUG17 15.SM2	13020
AUG17 16.DIF	7089
AUG17 16.SM1	13020
AUG17 16.SM2	13020
AUG17 17.DIF	7089
AUG17 17.SM1	13020
AUG17 17.SM2	13020

DIRECTORY FOR DATA DISK #9

DATA FILE	SIZE
AUG17_18.DIF	7089
AUG17_18.SM1	13020
AUG17_18.SM2	13020
AUG17_19.DIF	7089
AUG17_19.SM1	13020
AUG17_19.SM2	13020
AUG17_20.DIF	7089
AUG17_20.SM1	13020
AUG17_20.SM2	13020
AUG17_21.DIF	7089
AUG17_21.SM1	13020
AUG17_21.SM2	13020
AUG17_22.DIF	7089
AUG17_22.SM1	13020
AUG17_22.SM2	13020
AUG17_23.DIF	7089
AUG17_23.SM1	13020
AUG17_23.SM2	13020
AUG17_24.DIF	7089
AUG17_24.SM1	13020
AUG17_24.SM2	13020
AUG17_25.DIF	7089
AUG17_25.SM1	13020
AUG17_25.SM2	13020
AUG17_26.DIF	7089
AUG17_26.SM1	13020
AUG17_26.SM2	13020
AUG17_27.DIF	7089
AUG17_27.SM1	13020
AUG17_27.SM2	13020
AUG17_28.DIF	7089
AUG17_28.SM1	13020
AUG17_28.SM2	13020
AUG17_29.DIF	7089
AUG17_29.SM1	13020
AUG17_29.SM2	13020
AUG17_30.DIF	7089
AUG17_30.SM1	13020
AUG17_30.SM2	13020
AUG17_31.DIF	7089
AUG17_31.SM1	13020
AUG17_31.SM2	13020
AUG17_32.DIF	7089
AUG17_32.SM1	13020
AUG17_32.SM2	13020
AUG17_33.DIF	7089
AUG17_33.SM1	13020
AUG17_33.SM2	13020
AUG17_34.DIF	7089
AUG17_34.SM1	13020
AUG17_34.SM2	13020
AUG17_35.DIF	7089
AUG17_35.SM1	13020
AUG17_35.SM2	13020
AUG17_36.DIF	7089
AUG17_36.SM1	13020
AUG17_36.SM2	13020
AUG17_37.DIF	7089
AUG17_37.SM1	13020
AUG17_37.SM2	13020

Appendix D
Comparison of Printed and Electronic Data Files

Book Number	Disk Number	Chapter Number	File Number	Column Location	Row Location	Book 3 or 4 Data
3	1	1	Nov14_02	4	160	-0.3997
3	1	1	Nov14_03	5	20	0.16084
3	1	1	Nov14_04	4	97	5.2676
3	1	1	Nov14_05	5	127	3.4681e-03
3	1	1	Nov14_06	2	63	2.0996
3	1	1	Nov14_07	6	69	0.0000e+00
3	1	1	Nov14_08	1	98	PAB000136
3	1	1	Nov14_09	4	141	128.5323
3	1	1	Nov14_11	1	53	TSI000001
3	1	1	Nov14_12	2	29	40.0646
3	1	1	Nov14_13	2	108	-6.8652
3	1	1	Nov14_14	1	96	PAB000136
3	1	1	Nov14_15	4	57	88.2431
3	2	2	Feb01_01	2	51	117.7159
3	2	2	Feb01_02	3	50	132.6199
3	2	2	Feb01_03	3	126	-0.0098
3	2	2	Feb01_04	4	81	-18.1642
3	2	2	Feb01_05	3	72	1.2451
3	2	2	Feb01_06	5	131	5.1268e-01
3	2	2	Feb01_07	5	4	5.3277e-01
3	2	2	Feb01_08	6	36	1.9087e+00
3	2	2	Feb01_09	6	65	0.0000e+00
3	2	2	Feb01_10	5	96	9.1844e-01
3	2	2	Feb01_11	6	12	1.9298e+00
3	3	3	Feb05_01	5	114	1.0763e-01
3	3	3	Feb05_02	1	10	TAO090136
3	3	3	Feb05_03	4	134	133.0568
3	3	3	Feb05_04	4	130	130.4238
3	3	3	Feb05_05	4	15	37.4317
3	3	3	Feb05_06	5	29	1.0980e-01
3	3	3	Feb05_07	5	124	3.5895e-03
3	3	3	Feb05_08	4	119	1292.3109
3	3	3	Feb05_09	4	158	107.6232
3	3	3	Feb05_10	6	163	4.2055e+00
3	3	3	Feb05_11	3	52	155.2162
3	3	3	Feb05_12	3	150	107.1101
3	3	3	Feb05_13	1	113	VPW000002
3	3	3	Feb05_14	2	49	161.6983
3	3	3	Feb05_15	1	28	TRT125000
3	3	4	Feb06_01	1	57	TAF02136
3	3	4	Feb06_02	3	149	95.0947
3	3	4	Feb06_03	2	68	0.7715
3	3	4	Feb06_04	3	79	1.2354
3	3	4	Feb06_05	1	61	EMPTY
3	3	4	Feb06_06	3	150	107.7524
3	3	4	Feb06_07	4	133	126.1641
3	3	4	Feb06_08	3	93	-5.8099
3	3	4	Feb06_10	3	75	2.1631
3	3	5	Feb08_01	3	16	156.5175
3	3	5	Feb08_02	6	150	4.3662e+00

Book Number	Disk Number	Chapter Number	File Number	Column Location	Row Location	Book 3 or 4 Data
3	3	5	Feb08 03	1	107	EMPTY
3	3	5	Feb08 04	6	96	8.7007e-01
3	3	5	Feb08 05	3	28	257.9147
3	3	5	Feb08 06	2	100	42.3253
3	3	5	Feb08 07	4	7	224.2557
3	3	5	Feb08 08	5	109	2.1703e-03
3	3	5	Feb08 09	1	68	EMPTY
3	3	5	Feb08 10	1	34	TAF090136
3	3	5	Feb08 11	2	116	VPW000005
3	4	6	May03 11	4	48	114.0418
3	4	6	May03 12	3	107	0.0098
3	4	6	May03 13	4	44	117.7754
3	4	6	May03 14	1	143	IHT000016
3	4	6	May03 15	2	33	183.6788
3	4	6	May03 16	1	33	TAF080136
3	4	6	May03 17	3	14	245.6867
3	4	6	May03 18	2	56	65.7283
3	4	6	May03 19	2	125	-0.0195
3	4	6	May03 20	5	74	2.3675e-03
3	4	6	May03 21	5	36	1.1775e+00
3	5	7	May07 01	5	44	1.7638e-01
3	5	7	May07 02	2	138	134.9309
3	5	7	May07 03	5	59	1.9947e-01
3	5	7	May07 04	2	137	130.5025
3	5	7	May07 05	2	34	140.4213
3	5	7	May07 06	3	69	1.8848
3	5	7	May07 07	4	90	-5.0945
3	5	7	May07 08	2	58	251.5484
3	5	7	May07 09	6	150	4.2360e+00
3	5	8	May08 01	4	34	100.8885
3	5	8	May08 02	5	39	1.4031e-01
3	5	8	May08 03	6	2	1.9002e+01
3	5	8	May08 04	5	157	4.7973e-01
3	5	8	May08 05	3	129	134.5929
3	5	8	May08 06	1	114	VPW000003
3	5	8	May08 07	1	157	IHT000030
3	5	8	May08 08	6	77	0.0000e+00
3	6	9	Aug01 01	5	66	0.0000e+00
3	6	9	Aug01 02	6	78	0.0000e+00
3	6	9	Aug01 03	2	85	1.8018
3	6	9	Aug01 04	3	26	181.9138
3	6	9	Aug01 05	5	147	5.0262e-01
3	6	9	Aug01 06	4	24	187.0371
3	6	9	Aug01 07	4	7	209.9252
3	6	9	Aug01 08	2	147	105.6077
3	6	10	Aug01 10	1	16	TAO125136
3	6	10	Aug01 11	3	111	0.0049
3	6	10	Aug01 12	3	32	124.4655
3	6	10	Aug01 13	5	5	5.7176e-01
3	6	10	Aug01 14	6	159	4.3720e+00

Book Number	Disk Number	Chapter Number	File Number	Column Location	Row Location	Book 3 or 4 Data
3	6	10	Aug01 15	3	49	281.9731
3	6	10	Aug01 16	4	4	87.7484
3	6	10	Aug01 17	2	109	0.0000
3	6	10	Aug01 18	1	150	IHT000023
3	7	10	Aug01 19	5	156	7.5856e-01
3	7	11	Aug01 21	5	103	5.6722e-02
3	7	11	Aug01 22	2	21	154.8192
3	7	11	Aug01 23	2	90	-6.1116
3	7	11	Aug01 24	6	26	1.9314e+00
3	7	11	Aug01 25	2	133	-1.6226
3	7	11	Aug01 26	6	141	4.4792e+00
3	7	11	Aug01 27	3	42	239.9919
4	7	12	Aug15 01	5	62	2.4484e-03
4	7	12	Aug15 02	4	80	36.1738
4	7	12	Aug15 03	1	143	IHT000016
4	7	12	Aug15 04	5	159	5.0186e-01
4	7	12	Aug15 05	1	123	IPW000006
4	7	12	Aug15 06	3	47	39.8352
4	7	12	Aug15 07	4	24	165.0095
4	7	12	Aug15 08	6	68	0.0000e+00
4	7	12	Aug15 09	6	48	1.9215e+00
4	7	12	Aug15 10	1	17	TAO130136
4	7	12	Aug15 11	4	153	104.8008
4	7	12	Aug15 12	3	37	217.3546
4	8	13	Aug15 13	6	55	1.9000e+00
4	8	13	Aug15 14	4	9	34.2478
4	8	13	Aug15 15	1	94	PAN120224
4	8	13	Aug15 16	4	32	164.1437
4	8	13	Aug15 21	3	76	1.7383
4	8	13	Aug15 22	4	83	-4.1581
4	8	13	Aug15 23	4	85	-0.8535
4	8	13	Aug15 24	4	29	255.1373
4	8	13	Aug15 25	4	89	-1.4229
4	8	13	Aug15 26	2	118	1504.9567
4	8	14	Aug16 01	5	57	1.5575e-01
4	8	14	Aug16 02	6	122	2.8391e+00
4	8	14	Aug16 03	2	32	127.1166
4	8	14	Aug16 04	1	132	IHT000005
4	8	14	Aug16 05	6	84	8.7023e-01
4	8	14	Aug16 06	3	30	40.0646
4	8	14	Aug16 07	3	60	3.8770
4	8	15	Aug17 01	6	68	0.0000e+00
4	8	15	Aug17 02	5	62	3.2554e-03
4	8	15	Aug17 03	5	152	4.5170e-01
4	8	15	Aug17 04	5	34	2.5108e-01
4	8	15	Aug17 05	5	157	7.0433e-01
4	8	15	Aug17 06	1	87	PAN110136
4	8	15	Aug17 07	3	12	255.8337
4	8	15	Aug17 08	6	3	1.9002e+00
4	8	16	Aug17 09	2	125	-0.0195
4	8	16	Aug17 10	2	124	-0.0293
4	8	16	Aug17 11	4	154	156.2597

Book Number	Disk Number	Chapter Number	File Number	Column Location	Row Location	Book 3 or 4 Data
4	8	16	Aug17 12	4	75	1.9124
4	8	16	Aug17 13	4	148	-1.4695
4	8	16	Aug17 14	4	130	229.2194
4	8	16	Aug17 15	6	79	0.0000e+00
4	8	16	Aug17 16	4	116	243.8828
4	8	16	Aug17 17	4	33	272.8363
4	8	17	Aug17 18	5	18	3.0849e-01
4	8	17	Aug17 19	1	60	EMPTY
4	8	17	Aug17 20	3	141	247.4835
4	8	17	Aug17 21	2	11	251.8904
4	8	17	Aug17 22	5	151	5.5978e-01
4	8	17	Aug17 23	6	100	5.8818e-01
4	8	17	Aug17 24	4	40	227.4071
4	8	17	Aug17 25	1	111	EMPTY
4	8	18	Aug17 26	1	125	EMPTY
4	8	18	Aug17 27	1	100	PAB125136
4	8	18	Aug17 28	1	133	IHT000006
4	8	18	Aug17 29	5	40	6.5182e-01
4	8	18	Aug17 30	1	95	PAN130224
4	8	18	Aug17 31	4	53	60.7611
4	8	19	Aug17 32	2	84	39.3913
4	8	19	Aug17 33	2	119	1276.9558
4	8	19	Aug17 34	6	149	4.2054e+00
4	8	19	Aug17 35	5	108	1.8412e+00
4	8	19	Aug17 36	1	100	PAB125136
4	8	19	Aug17 37	4	145	108.2762
4	.	20	Nov13 01	4	3	84.8535
4	1	20	Nov13 02	4	100	23.8575
4	1	20	Nov13 03	6	146	4.1000e+00
4	1	20	Nov13 04	1	152	IHT000025
4	1	20	Nov13 05	2	85	21.1504
4	1	20	Nov13 06	2	49	30.3254
4	1	20	Nov13 07	4	134	0.1494
4	1	20	Nov13 08	5	117	9.6855e-02
4	1	20	Nov13 09	1	72	EMPTY
4	1	20	Nov13 10	3	77	0.5273
4	1	20	Nov13 11	2	76	0.5029
4	1	20	Nov13 12	4	117	0.2139
4	1	20	Nov13 13	5	29	1.3173e-01
4	1	20	Nov13 14	3	98	40.5452
4	1	20	Nov13 15	1	62	EMPTY
4	1	20	Nov13 16	1	121	IPW000004
4	1	20	Nov13 17	4	52	85.0117
4	1	20	Nov13 18	5	18	4.0400e-01
4	1	20	Nov13 19	6	23	1.9001e+01
4	2	20	Jan31 01	4	96	45.5950
4	2	20	Jan31 02	6	136	4.1000e+00
4	2	20	Jan31 03	2	143	-0.3153
4	2	20	Jan31 04	5	121	2.5800e-01
4	2	20	Jan31 05	2	105	214.8680
4	2	20	Jan31 06	6	88	8.7020e-01
4	2	20	Jan31 07	2	94	6.2342

Book Number	Disk Number	Chapter Number	File Number	Column Location	Row Location	Book 3 or 4 Data
4	2	20	Jan31 08	2	109	0.0000
4	2	20	Jan31 09	5	108	2.6610e-01
4	2	20	Jan31 10	1	60	EMPTY
4	2	20	Jan31 11	4	158	0.0833
4	2	20	Jan31 12	4	120	-0.9048
4	2	20	Jan31 13	3	91	-5.6009
4	2	20	Jan31 14	2	66	0.3613
4	2	20	Jan31 15	4	119	-4.4973
4	2	20	Jan31 16	2	81	-20.5650
4	2	20	Jan31 17	1	107	EMPTY
4	2	20	Jan31 18	4	10	87.5365
4	0	20	Jan31 19	6	147	4.1000e+00
4	4	20	May01 01	6	68	0.0000e+00
4	4	20	May01 02	6	27	1.9002e+00
4	4	20	May01 03	5	91	1.3627e-01
4	4	20	May01 04	5	96	1.8238e-01
4	4	20	May01 05	3	85	23.7202
4	4	20	May01 06	4	31	86.6870
4	4	20	May01 07	3	152	0.1352
4	4	20	May01 08	4	154	-0.0418
4	4	20	May01 09	3	122	-0.0751
4	4	20	May01 10	1	41	TAF130136
4	4	20	May01 11	1	124	EMPTY
4	4	20	May01 12	3	14	87.3251
4	4	20	May01 13	4	117	-0.0224
4	4	20	May01 14	3	80	-16.6920
4	4	20	May01 15	5	155	1.1334e-01
4	4	20	May01 16	5	2	2.1194e-01
4	4	20	May01 17	6	23	1.9002e+00
4	4	20	May01 18	2	93	41.9721
4	6	20	Jul31 01	5	89	1.0107e-01
4	6	20	Jul31 02	1	21	TA0130224
4	6	20	Jul31 03	3	99	30.6266
4	6	20	Jul31 04	4	76	0.5569
4	6	20	Jul31 05	2	22	85.8685
4	6	20	Jul31 06	4	75	0.5371
4	6	20	Jul31 07	4	146	-0.1297
4	6	20	Jul31 08	3	18	74.0284
4	6	20	Jul31 09	1	117	VPW000006
4	6	20	Jul31 10	3	21	87.3196
4	6	20	Jul31 11	4	107	0.0027
4	6	20	Jul31 12	5	25	1.9573e-01
4	6	20	Jul31 13	5	85	4.7782e-02
4	6	20	Jul31 14	5	44	2.3607e-01
4	6	20	Jul31 15	2	86	-4.5255
4	6	20	Jul31 16	5	119	1.0839e+00
4	6	20	Jul31 17	4	129	-0.0035
4	6	20	Jul31 18	5	136	7.9017e-02
4	6	20	Jul31 19	3	86	0.0522
4	6	20	Jul31 20	6	89	8.7001e-01
4	6	20	Jul31 21	4	160	-0.0024
4	6	20	Jul31 22	2	92	-7.4473

Book Number	Disk Number	Chapter Number	File Number	Column Location	Row Location	Book 3 or 4 Data
4	.	20	Ju131 23	1	149	IHT000022
4	7	20	Aug14 01	6	26	1.9002e+00
4	7	20	Aug14 02	2	43	86.3120
4	7	20	Aug14 03	4	90	15.4643
4	7	20	Aug14 04	2	27	87.1510
4	7	20	Aug14 05	3	128	0.1841
4	7	20	Aug14 06	4	156	-0.0475
4	7	20	Aug14 07	5	92	7.7621e-02
4	7	20	Aug14 08	3	64	0.3564
4	7	20	Aug14 09	4	68	0.4346
4	7	20	Aug14 10	1	119	IPW000002
4	7	20	Aug14 11	5	126	2.7902e-03
4	7	20	Aug14 12	5	135	9.7377e-02
4	7	20	Aug14 13	3	122	-3.0139
4	7	20	Aug14 14	3	9	87.4517
4	7	20	Aug14 15	4	137	-0.0724
4	7	20	Aug14 16	2	109	0.0049

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