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LOT NO. 2 OF FRIT 202 FOR DWPF COLD RUNS (U)

by
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Westinghouse Savannah River Company
Savannah River Site
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MASTER

DOE Contract No. DE-AC09-89SR18035

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WSRC-TR-92-571
Revision 0

Keywords: DWPF, WAPS,
glass frit, analyses
Retention Time: Permanent

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April 5, 1993

R. Schumacher 4/5/93
Lot No. 2 of Frit 202 for DWPF Cold Runs - (U)

SUMMARY

The following report was prepared at the end of 1992 and summarizes the evaluation of the second lot sample of DWPF Frit 202 from Cataphote Inc. Publication of this report was delayed until the results from the carbon analyses could be included. To avoid confusion the frit specifications presented in this report were those available at the end of 1992. The specifications were slightly modified early in 1993.

The frit was received and evaluated for moisture, particle size distribution, organic-inorganic carbon and chemical composition. Moisture content and particle size distribution were determined on a representative sample at SRTC. The moisture content was within specification. The particle size determination indicated that there was a fraction of a percent more coarse frit (+80 mesh) than the specified amount. The fine end of the distribution was within specification. A representative sample was submitted to Corning Engineering Laboratory Services for chemical analyses. The sample was split and two dissolutions prepared. Each dissolution was analyzed on two separate days. The results indicate that there is a high probability (>95%) that the silica content of this frit was below the specification limit of 77.0 ± 1.0 wt%.

The average of the four analyzed values was 75.3 wt% with a standard deviation of 0.21 wt%. All other oxides were within the elliptical limits established for this product. Two control standard frit samples were submitted and analyzed at the same time. The silica determination for the Frit 202 Reference Standard was 1.5 wt% below the expected value and the total of all the oxides analyzed was approximately 98 wt%. This silica analysis appeared to be incorrect. A sample of 165 standard was also included as a control and this analysis provided the expected values.

DWPF Lot 1 was very similar to the Lot 1 sample which was also low in silica. This material was outside the elliptical band of acceptability. The vendor was notified that the material was not acceptable for DWPF cold runs but would be usable at TNX.

INTRODUCTION

In the DWPF, glass forming chemicals will be added to the waste in the form of premelted glass frit¹. On an oxide weight basis, DWPF glass will consist of approximately 64 wt% glass frit, 8 wt% precipitate hydrolysis aqueous product, and 28 wt% sludge. The glass frit and the precipitate hydrolysis aqueous product together make up what is called the glass-former composition. Glass Frit 202 was developed to provide a glass which is processable in the DWPF melter, compatible with a wide variety of projected waste types, and produces a waste form which has acceptable leach resistance.

The Waste Acceptance Preliminary Specifications, (WAPS)² require that the DWPF control the consistency of the waste glass product. As described in the Waste Form Compliance Plan (WCP)³, this will be achieved through control of the chemical composition of the glass product. Since the glass frit purchased by DWPF will constitute approximately two thirds of the glass product, control of the composition of the frit is an important part of meeting the WAPS. Current plans are to control the composition of the frit through the procurement specifications⁴ and chemical analyses of representative lot samples. A summary of the chemical and physical specifications for Frit 202 is presented in Table 1.

The total undesirable components is equal to 100 minus the actual analysis of the major oxide components as listed in Table 1 and includes but is not limited to Al, Fe, Mn, Ni, Cr, Pb, Ti, F, Cl. Additional undesirable components > 0.05 wt% shall be reported along with their amount in the certificate of conformance. The moisture content of each lot of material shall be less than 0.1 wt%. The equivalent carbon as measured by a Chemical Oxygen Demand (COD) shall be less than 0.1 wt% equivalent carbon. The particle size distribution of each lot of frit must be such that greater than or equal to 99.0 wt% passing through a Tyler 80 mesh screen, and less than 10 wt% passing through a Tyler 200 mesh screen. [Note: The Tyler and U.S. Standard are equivalent at 80 and 200 mesh openings.] The material must be free flowing.

Table 1
Chemical and Physical Specification Frit 202 (Dec.1992)

Component	Concentration (wt%)
SiO ₂	77.0 ± 1.0
Na ₂ O	6.0 ± 0.5
B ₂ O ₃	8.0 ± 0.5
Li ₂ O	7.0 ± 0.5
MgO	2.0 ± 0.25
Major Components	Sum of Above
Chemical	Maximum (wt%)
Al	1.0
Fe	0.2
Mn	0.2
Ni	0.2
Cr	0.1
Pb	0.1
Ti	0.15
F	0.05
Cl	0.05
Total Undesirable Component	2.25 (As Oxides)

A qualification sample of Cataphote Frit⁵ was evaluated at the end of 1989. The particle size distribution was within specification. The chemical analyses indicated that the silica level was at the lower end of the specification and may have been outside the limit by 0.1 wt%. The boron level was at the upper limit of the specification. The initial qualifications of all of the presently qualified frit vendors⁶ (Cataphote, Apec, and Ferro Corp.) was described. The first lot of Cataphote Frit 202 was unacceptable⁷ due to the silica level being below the specification limit. All of the other properties were within the specification. The following report describes the evaluation of the second lot of DWPF Frit 202 for Cold Runs.

EXPERIMENTAL

A sample of Cataphote DWPF Lot No. 2 was received at the Savannah River Technical Center on October 26, 1992. The sample was contained in a steel quart container inside a sealed steel one gallon container. The material was labeled as follows:

PROD. CODE SR FRIT 202
LOT 22010
DATE 10-22-92
OPER. J. PURVIS
QCTECH R. TRIGG
TA 00 717H

The material was opened and split into eight identical samples by the Quantachrome™ rotating riffler according to Glass Technology Procedure⁸ GTOP 3-024. All subsequent samples were obtained with the riffler. Two samples were immediately removed and the moisture for these samples was determined by the GTOP 3-013 procedures. After the moisture was determined the dry material was placed in a nest of sieves and mechanically classified on a Ro-Tap™ shaker for 15 minutes using the Ro-Tap™ procedures and the procedures outlined in ASTM C-429 and C-92.

A random sample from the riffler was sent to Corning Engineering Laboratory Services (CELS) Corning, New York, for complete chemical analysis. Two "standard" frit samples were included for control. One control sample consisted of Frit 202 Reference Standard while a second sample was the Frit 165 Standard. Both of these materials have been thoroughly analyzed and the results described previously.^{9,10} An additional sample was sent to the Savannah River Technology Center-Analytical Development Section for total organic and inorganic carbon determination. This test has been found to be comparable to the Chemical Oxygen Demand test⁹.

RESULTS AND DISCUSSION

Moisture and Particle Size Distribution

The moisture and measured particle size distribution for the two samples is presented in Table 2. The results from the two samples were in close agreement. The material was dry with less than the 0.1 wt% moisture. The coarse frit (greater than 80 mesh) was slightly greater than the 1 wt% specified. The fine end of the distribution was less than 10 wt%, as specified. The material met the moisture specification, however, the particle size was a fraction of a percent high on the coarse end.

Table 2
Moisture and Particle Size Distribution - DWPF Lot 2

Cataphote	Lot 2	Lot 2	Average	
E-51768-	139-2	139-3		
Moisture	<u>Wt%</u>	<u>Wt%</u>	<u>Wt%</u>	
	0.00	0.00	0.00	
Particle Size	<u>Wt%</u>	<u>Wt%</u>	<u>Wt%</u>	Cumulative <u>Wt%</u>
+45 Mesh	0.00	0.00	0.00	0.00
+80 Mesh	1.25	1.15	1.20	1.20
+100 Mesh	12.85	13.06	12.96	14.16
+200 Mesh	79.23	79.11	79.17	93.33
-200 Mesh	6.67	6.68	6.67	100.00

Organic and Inorganic Carbon

The total organic and inorganic carbon was determined by ADS with the total carbon analyzer. Three samples were submitted with a sample of Reference Standard 202. The results are presented in Table 3. The Reference Standard was the same order of magnitude as an evaluation of this material in January of 1990. The carbon content of Lot 2 was much less than 0.1 wt%.

Table 3				
Total Carbon Analyses of DWPF Lot 2 and Ref. Std 202 (ppm)				
Sample No.		Total Organic	Total Inorganic	Total Carbon
E-51768-139-5A	Lot 2	73	52	125
-5B	"	30	31	61
-5C	"	31	46	77
	Avg.	45	43	88 = 0.009 wt%
E-51768-139-RS	(Ref.Std.)	332	49	381 = 0.038 wt%
Ref.Std 202	(1/12/90)			336

Chemical Analysis

The preliminary qualitative analysis, which was conducted by CELS for the Lot 1 material was not conducted on the second lot. The CELS laboratory split each of the three frit samples and prepared two dissolutions. Each of the glass dissolutions were analyzed on two different days by Atomic Spectroscopy. The resulting four analyses for each sample were reported along with the averages and standard deviations. The complete chemical analyses as received from CELS are included as Appendix A. Table 4 presents a summary of the results obtained from the CELS analyses of DWPF Lot 2 and compares these values to the specification limits. Cataphote's analysis of this material is included and will be discussed in a future summary report.

Review of the analyses of the second lot of Frit 202, including Appendix A, indicated that the glass frit was very similar to Lot 1. The major oxides were within the specifications except SiO₂ which was 0.7 wt% below the minimum and B₂O₃ which was just slightly higher than the specification maximum by 0.13 wt%. The agreement between the four CELS measurements was again excellent. The undesirable oxides were also well within the 2.25 wt% limit at 1.04 wt%. The oxide sum totaled to 99.3 wt%. The residual material may include small amounts of CaO, BaO, ZrO₂, K₂O, SO₄, and some H₂O.

TABLE 4
Summary of CELS Chemical Analyses of DWPF Frit 202 Lot 2

E-51768-139-DWPF-2				CELS11/92			Cataphote
Species	Specification	Range	Range	Analysis			Analysis
	Amount	Minimum	Maximum	Average*	Std.Dev.	Rel. Std	11/23/92
Majors	(Wt%)	(Wt%)	(Wt%)	(Wt%)	(Wt%)	Dev.	(Wt%)
SiO ₂	77.0±1.0	76.0	78.0	75.3	0.206	0.27%	(76.90)
Na ₂ O	6.0±0.5	5.5	6.5	6.08	0.037	0.61%	5.87
Li ₂ O	7.0±0.5	6.5	7.5	6.93	0.044	0.63%	6.88
MgO	2.0±0.25	1.75	2.25	2.02	0.006	0.30%	1.98
B ₂ O ₃	8.0±0.5	7.5	8.5	8.63	0.010	0.12%	7.97
Total				98.96			99.60
Undesirable*	< 2.25		2.3	1.04			
	Max (Wt%)						
ZrO ₂				0.018	0.004		0.0055
Al ₂ O ₃	Al=1.0		1.89	0.31	0.012	3.87%	0.29
Fe ₂ O ₃	Fe=0.2		0.29	0.026	0.000		0.023
MnO	Mn=0.2		0.32	0.0006	0.000		0.001
NiO	Ni=0.2		0.25	0.0006	0.000		Ni=.0001
Cr ₂ O ₃	Cr=0.1		0.15	<.001	0.000		Cr=.0001
PbO	Pb=0.1		0.11	<.001	0.000		Pb=.0001
TiO ₂	Ti=0.15		0.25	0.0082	0.000		0.029
F	F=0.05		0.05	(ADS=.003)			0.05
Cl	Cl=0.05		0.05	(ADS=0.16)			0.009
Others >0.05							
K ₂ O							0.029
CaO							0.043
BaO							0.002
SO ₃				(ADS=<0.1)			0.05
Total Oxide Wt%				99.32			100.10
*Average of 2 dissolutions repeated 2 times (n=4)							
Moisture	< 0.1			0.0			
OOD	<0.1			(ADS=0.009)			
						(by differ.)	
Particle Size	Wt%			(SRTC)			
Through 80 M	≥ 99.0			98.8			
Through 200M	<10.0			6.67			

Table 5 presents a summary of the CELS analysis for the Reference Standard Frit 202 and compares the analyzed values to the "Best Estimate" composition⁸ which was obtained after numerous analyses at various laboratories. Review of this analysis did not show good agreement between the four silica measurements from CELS and the "Best Estimate" of the silica content. All of the other oxides did agree quite well with the best estimate values. In addition, it should be noted that the total of the analyzed oxides summed to only 98 wt%. It was felt after reviewing this analysis that the silica determination was in error for this particular analysis. This will be discussed in detail in the summary report. It should be noted that the ADS analysis of chlorine was quite high compared to the accepted value.

Table 5
Summary of CELS Chemical Analysis of 202 Reference Standard

E-51768-139-DWPF-2S			CELS 11/92			
Species	Specification	Best Est.	Analysis		Std.	
	Amount	Oct-90	Average	Diff.	Dev.	Rel Std.
Majors	(Wt%)	(Wt%)	(Wt%)	(Wt%)	(Wt%)	Dev.
SiO ₂	77.0±1.0	76.6	75.1	1.5	0.236	0.31%
Na ₂ O	6.0±0.5	5.9	5.88	0.02	0.033	0.56%
Li ₂ O	7.0±0.5	6.7	6.65	0.05	0.000	0.00%
MgO	2.0±0.25	2.0	2.03	-0.03	0.015	0.74%
B ₂ O ₃	8.0±0.5	7.7	7.72	-0.02	0.026	0.34%
Total		98.9	97.38	1.52		
Undesirable*	< 2.25	1.1	2.62	-1.52		
	Maximum					
ZrO ₂		0.02	0.027			
Al ₂ O ₃	1.89	0.40	0.43	-0.03	0.013	3.02%
Fe ₂ O ₃	0.29	0.03	0.031	0	0.000	
MnO	0.26	<.01	0.0014		0.000	
NiO	0.25	<.01	0.0006		0.000	
Cr ₂ O ₃	0.15	<.01	<.001		0.000	
PbO	0.11	0.01	0.013	0	0.000	
TiO ₂	0.25	0.11	0.11	0	0.000	
F	0.05	0.03	ADS = 0.03	0	0.000	
Cl	0.05	0.01	ADS = 0.15	-0.14	0.000	
Others >0.05						
K ₂ O		0.19				
CaO		0.12				
BaO		0.04				
Total Oxide		99.86	97.99	1.87		
Moisture						
CO ₂		<.02	(ADS <.04)			

Table 6 presents a summary for the CELS chemical analysis of the Frit 165 control glass. The sample of Frit 165 was carefully analyzed in 1985. The SiO₂ was determined ten times while the remainder of the major oxides were determined sixteen times. An additional four analyses of this glass were carried out in 1989 and 1990⁸. The recent CELS analysis is in excellent agreement with all of the previous analyses. The SiO₂ value of this analysis is 0.2 wt% below than the original 1985 analyses. The total for all the major oxides is identical. This analysis verifies the Lot 2 analysis.

Table 6
Summary of CELS Chemical Analysis of Frit 165

E-51768-139-165S2			CELS Analy.			
Species	CELS Average 3/15/85	Sigma	Average Nov-92	Diff.	Sigma	Rel. Std. Dev.
Majors	(Wt%)	(Wt%)	(Wt%)	(W%)	(Wt%)	
SiO ₂	68.89	0.075	68.7	0.2	0.299	0.44%
Na ₂ O	12.16	0.045	12.1	0.06	0.058	0.48%
Li ₂ O	6.96	0.029	6.87	0.09	0.068	0.99%
MgO	0.99	0.010	1.02	-0.03	0.010	0.98%
B ₂ O ₃	9.32	0.064	9.35	-0.03	0.035	0.37%
Total	99.31		99.3	0.02		
Undesirable*						
ZrO ₂	0.99	0.017	1.25	-0.26	0.015	1.20%
Al ₂ O ₃			0.037		0.004	10.81%
Fe ₂ O ₃			0.086		0.000	
MnO			0.0018		0.000	
NiO			0.0082		0.000	
Cr ₂ O ₃			0.016		0.000	0.00%
PbO			0.0046		0.000	
TiO ₂			0.003		0.000	
F						
Cl						
Others >0.05						
Total Oxides			99.45			

In general these chemical analyses appear to be accurate, however the silica analysis of the Reference Standard Frit 202 is suspect. The conclusion that the SiO₂ level for DWPF-2 was outside the specification is maintained and points out the difficulty in meeting multiple interrelated specifications. This has been thoroughly discussed in previous reports^{8,9}. In order to compensate for meeting the five interrelated specifications the rectangular specification limits were transformed to elliptical limits with an area increase of 25%. This should compensate for the requirement of meeting five major specifications. In addition there is a band on either side of the ellipse which describes the 95% confidence limits due to measurement variability (± 2 sigma). These ellipses are shown in Figure 1 along with the locations of DWPF-2, the 202 Reference Standard, and the "Best Estimate" value. Unfortunately, the Reference Standard silica analysis makes the analysis appear worse than it is.

Figure 1. Graphical Representation of Lot 2 and Ref. Std. 202 Plotted on Elliptical Limit Plots.

CONCLUSIONS

1. The particle size distribution of DWPF Frit 202 Lot 1 had a fraction of a percent more of the +80 mesh material than specified. The moisture content was well within the specification.
2. The total carbon content as measured by total carbon was much less than the specified 0.1 wt%.
3. The chemical analysis of DWPF Frit 202 Lot 1 shows that the chemical composition of the frit was low in SiO_2 . All other oxides, including B_2O_3 were within the specification or within the elliptical limits. Lot 2 was very similar to Lot 1.
4. The DWPF Frit 202 Lot 2 was not acceptable for DWPF Cold Runs but it was acceptable for use at TNX. The vendor was notified that the material was not acceptable.

QUALITY ASSURANCE

This work was a continuation of efforts under the Frit Qualification¹¹ and Errors of Frit¹² tasks. The procedures employed in this study were ASTM approved or as presented in the Glass Technology Procedures Manual⁷. Well documented controls were used for the chemical analyses and all data was documented¹⁴.

ACKNOWLEDGMENTS

The author wishes to acknowledge the efforts of Roberta Hooks for performing the physical evaluations of the frit and Carol Jantzen, who established the chemical analysis contract with CELS and was the Technical Representative.

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14. Notebook No. E-51768, DPSTN-4648, R.F. Schumacher.

APPENDIX A

Corning Incorporated
CELS—Laboratory Services
Technology Sales & Licensing
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Corning, New York 14831
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3/31/93
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DATE: November 20, 1992

TIME: 2:30 p.m.

TO: Ms. Carol Jantzen
WSRC

FAX No.: 803-725-4704

FROM: Linda P. Adams
Corning Incorporated

SUBJECT: Report: 3 DWPF Frit Samples #2

TOTAL Number of Pages to Follow: 4

COMMENTS:

Corning Incorporated
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CORNING

October 26, 1992

Dr. Carol M. Jantzen
WSRC
P.O. Box 616
Aiken, South Carolina 29808

CELS Client No.: 11988-040
Date Received : 06-NOV-92
Date Reported : 20-NOV-92
Reviewed & Approved by:

Subcontract No. AA07192N

Copy to: CELS File

Page 1 of 4

Linda P. Adams
Technical Sales
Engineer

SAMPLE IDENTIFICATION:

3 DWPF Frit Samples: DWPF 2
DWPF 2S
DWPF 165S

ANALYSIS REPORTED:

Exhibit

A Quantitative Chemical Analysis by
Atomic Spectroscopy

COMMENTS:

Client Purchase Order No. AA07192N

Direct questions regarding this report to Linda P. Adams, CELS office.

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3/31/93
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LABORATORY ANALYSIS REPORT

Page 2 of 4

CELS Client No.: 11988-040

Exhibit B: Quantitative Chemical Analysis by Atomic Spectroscopy

Sample Description: DWPF-2

Lab I.D. No.: 25675-92

Oxides	Dis 1 Day 1	Dis 2 Day 1	Dis 1 Day 2	Dis 2 Day 2	Mean	Std. Dev.
Al ₂ O ₃	0.30	0.32	0.30	0.32	0.31	0.012
Al	0.16	0.17	0.16	0.17	0.17	0.006
B ₂ O ₃	8.62	8.64	8.63	8.62	8.63	0.010
B	2.68	2.68	2.68	2.68	2.68	0.000
Cr ₂ O ₃	<0.001	<0.001	<0.001	<0.001	<0.001	0.000
Cr	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	0.000
Fe ₂ O ₃	0.026	0.026	0.026	0.026	0.026	0.000
Fe	0.018	0.018	0.018	0.018	0.018	0.000
Li ₂ O	6.91	6.98	6.88	6.95	6.93	0.044
Li	3.21	3.24	3.20	3.23	3.22	0.018
MgO	2.01	2.02	2.01	2.02	2.02	0.006
Mg	1.21	1.22	1.21	1.22	1.22	0.006
MnO	0.0006	0.0005	0.0006	0.0006	0.0006	0.000
Mn	0.0005	0.0004	0.0005	0.0005	0.0005	0.000
Na ₂ O	6.05	6.12	6.04	6.09	6.08	0.037
Na	4.49	4.54	4.48	4.51	4.51	0.026
NiO	0.0006	0.0005	0.0006	0.0006	0.0006	0.000
Ni	0.0005	0.0004	0.0005	0.0005	0.0005	0.000
PbO	<0.001	<0.001	<0.001	<0.001	<0.001	0.000
Pb	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	0.000
SiO ₂	75.1	75.5	75.4	75.1	75.3	0.206
Si	35.1	35.3	35.2	35.1	35.2	0.096
TiO ₂	0.0083	0.0083	0.0077	0.0086	0.0082	0.000
Ti	0.0050	0.0050	0.0046	0.0052	0.0050	0.000
ZrO ₂	0.014	0.016	0.023	0.018	0.018	0.004
Zr	0.010	0.012	0.017	0.013	0.013	0.003

Oxide Total 99.29

Dis 1 and Dis 2 - Dissolution 1 and 2
Day 1 and Day 2 - 1st and 2nd Analysis (re-run)

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3/31/93
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LABORATORY ANALYSIS REPORT

CELS Client No.: 11988-040

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Exhibit B: Quantitative Chemical Analysis by Atomic Spectroscopy

Sample Description: DWPF-2S

Lab I.D. No.: 25675-92

Oxides	Dis 1 Day 1	Dis 2 Day 1	Dis 1 Day 2	Dis 2 Day 2	Mean	Std. Dev.
Al ₂ O ₃	0.43	0.42	0.45	0.43	0.43	0.013
Al	0.23	0.22	0.24	0.23	0.23	0.008
B ₂ O ₃	7.75	7.70	7.74	7.70	7.72	0.026
B	2.41	2.39	2.40	2.39	2.40	0.010
Cr ₂ O ₃	<0.001	<0.001	<0.001	<0.001	<0.001	0.000
Cr	<0.0007	<0.0007	<0.0007	<0.0007	<0.0007	0.000
Fe ₂ O ₃	0.031	0.031	0.031	0.031	0.031	0.000
Fe	0.022	0.022	0.022	0.022	0.022	0.000
Li ₂ O	6.67	6.59	6.70	6.65	6.65	0.000
Li	3.10	3.06	3.11	3.09	3.09	0.000
MgO	2.04	2.01	2.04	2.02	2.03	0.015
Mg	1.23	1.21	1.23	1.22	1.22	0.010
MnO	0.0014	0.0013	0.0014	0.0013	0.0014	0.000
Mn	0.0011	0.0010	0.0011	0.0010	0.0011	0.000
Na ₂ O	5.85	5.90	5.92	5.86	5.88	0.033
Na	4.34	4.38	4.39	4.35	4.37	0.024
NiO	0.0006	0.0005	0.0006	0.0006	0.0006	0.000
Ni	0.0005	0.0004	0.0005	0.0005	0.0005	0.000
PbO	0.013	0.013	0.012	0.012	0.013	0.001
Pb	0.012	0.012	0.011	0.011	0.012	0.001
SiO ₂	75.1	74.9	75.4	74.9	75.1	0.236
Si	35.1	35.0	35.2	35.0	35.1	0.096
TiO ₂	0.11	0.11	0.11	0.11	0.11	0.000
Ti	0.066	0.066	0.066	0.066	0.066	0.000
ZrO ₂	0.027	0.026	0.027	0.027	0.027	0.000
Zr	0.020	0.019	0.020	0.020	0.020	0.000

97.97

Dis 1 and Dis 2 - Dissolution 1 and 2
 Day 1 and Day 2 - 1st and 2nd Analysis (read)

LABORATORY ANALYSIS REPORT

P. Schumacher
3/31/93
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CELS Client No.: 11988-040

Exhibit B: Quantitative Chemical Analysis by Atomic Spectroscopy

Sample Description: DWPF-165S

Lab I.D. No.: 25675-92

Oxides	Dis 1 Day 1	Dis 2 Day 1	Dis 1 Day 2	Dis 2 Day 2	Mean	Std. Dev.
Al ₂ O ₃	0.036	0.034	0.036	0.043	0.037	0.004
Al	0.019	0.018	0.019	0.023	0.020	0.002
B ₂ O ₃	9.34	9.40	9.34	9.32	9.35	0.035
B	2.90	2.92	2.90	2.89	2.90	0.013
Cr ₂ O ₃	0.016	0.016	0.016	0.016	0.016	0.000
Cr	0.011	0.011	0.011	0.011	0.011	0.000
Fe ₂ O ₃	0.084	0.092	0.083	0.083	0.086	0.000
Fe	0.059	0.064	0.058	0.058	0.060	0.000
Li ₂ O	6.85	6.78	6.91	6.93	6.87	0.068
Li	3.18	3.15	3.21	3.22	3.19	0.032
MgO	1.01	1.01	1.01	1.03	1.02	0.010
Mg	0.61	0.61	0.61	0.62	0.61	0.005
MnO	0.0017	0.0018	0.0018	0.0017	0.0018	0.000
Mn	0.0013	0.0014	0.0014	0.0014	0.0014	0.000
Na ₂ O	12.0	12.0	12.1	12.1	12.1	0.058
Na	8.90	8.90	8.98	8.98	8.94	0.040
NiO	0.0083	0.0084	0.0081	0.0081	0.0082	0.000
Ni	0.0065	0.0066	0.0064	0.0064	0.0065	0.000
PbO	0.0046	0.0047	0.0043	0.0046	0.0046	0.000
Pb	0.0043	0.0044	0.0040	0.0043	0.0043	0.000
SiO ₂	69.1	68.6	68.4	68.8	68.7	0.299
Si	32.3	32.1	32.0	32.2	32.2	0.129
TiO ₂	0.0028	0.0030	0.0030	0.0030	0.0030	0.000
Ti	0.0017	0.0018	0.0018	0.0018	0.0018	0.000
ZrO ₂	1.24	1.24	1.26	1.27	1.25	0.015
Zr	0.92	0.92	0.93	0.94	0.93	0.010

Total Oxide 99.42

Dis 1 and Dis 2 - Dissolution 1 and 2
 Day 1 and Day 2 - 1st and 2nd Analysis (read)

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