Effluent Treatment Facility Waste Stream Stabilization Testing

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[5] *Fluor Federal Services, Inc., Richland, Washington*

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The Effluent Treatment Facility (ETF) in the 200E Area of Hanford is considering converting several liquid waste streams from evaporator operations into a solid cementitious material waste form. The cementitous material/waste mixture will be poured into monoliths and sealed for land disposal at the Hanford Site.

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The Goal

- Concentrated Basin 42 Waste Water
- Waste Treatment and Immobilization Plant (WTP) Secondary Waste
- Demonstration Bulk Vitrification System (DBVS) Secondary Waste
- Testing and Results

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Basin 42

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Simulant

Compound	25% Total Solids Concentration (gm/kg)	40% Total Solids Concentration (gm/kg)
$CaOH_2$	5.51	8.81
Na_2SO_4	5.29	8.46
NaOH	10.08	16.13
$MgCl_2$	2.26	3.62
$Mg(NO_3)_2$	0.83	1.34
NaCl	0.00	0.00
$NaNO_3$	1.54	2.46
$(NH_4)_2SO_4$	219.45	351.12
NH_4OH	4.39	7.03
KOH	0.65	1.05
H_2O	750	600

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Trial Formulations (40 wt% Simulant)

- Simulant to SECAR®[1] 51 ratio 1.4
- Brine to solid ratios varied from 0.5 to 1.1
- Balance of mix DRF

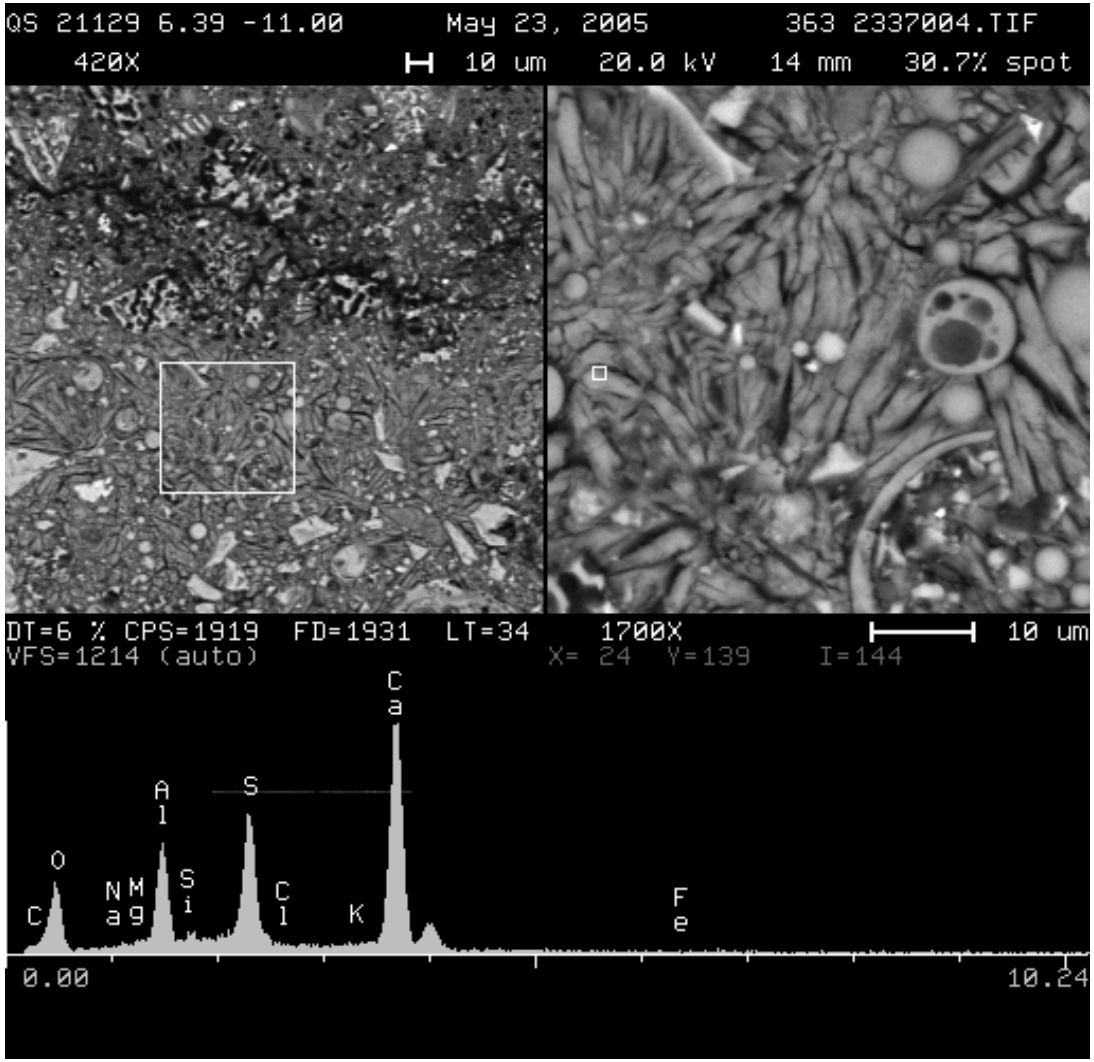
[1]SECAR® is a registered trademark of Lafarge Calcium Aluminates, Inc., Chesapeake, Virginia.

Trial Formulations (25 wt% Simulant)

- Simulant to SECAR®[1] 51 ratios ranged from 2.2 to 1.3
- Simulant/solid ratios 0.6 to 0.8
- Balance of formulation was dry reagent formulation (DRF)

[1]SECAR® is a registered trademark of Lafarge Calcium Aluminates, Inc., Chesapeake, Virginia.

Basin 42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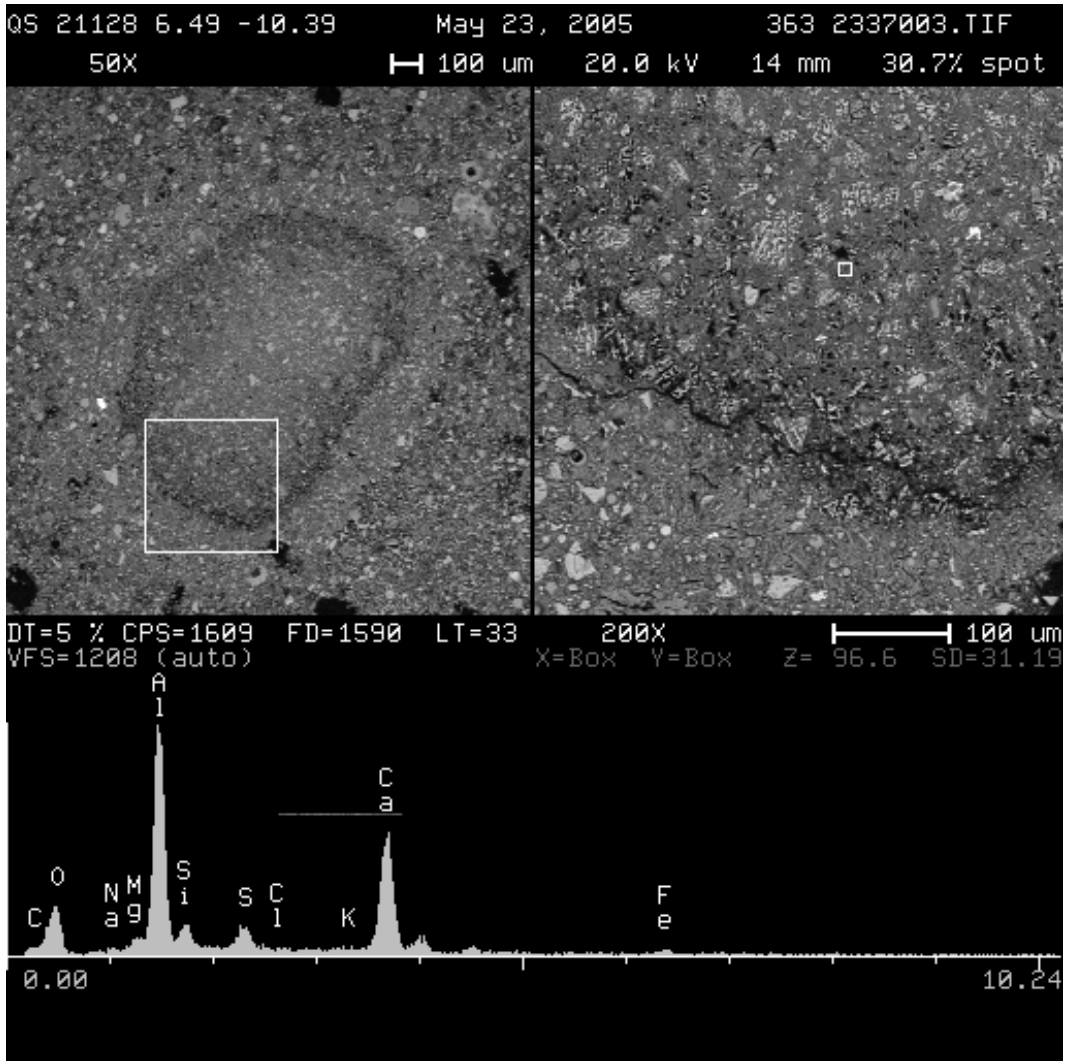
Basin 42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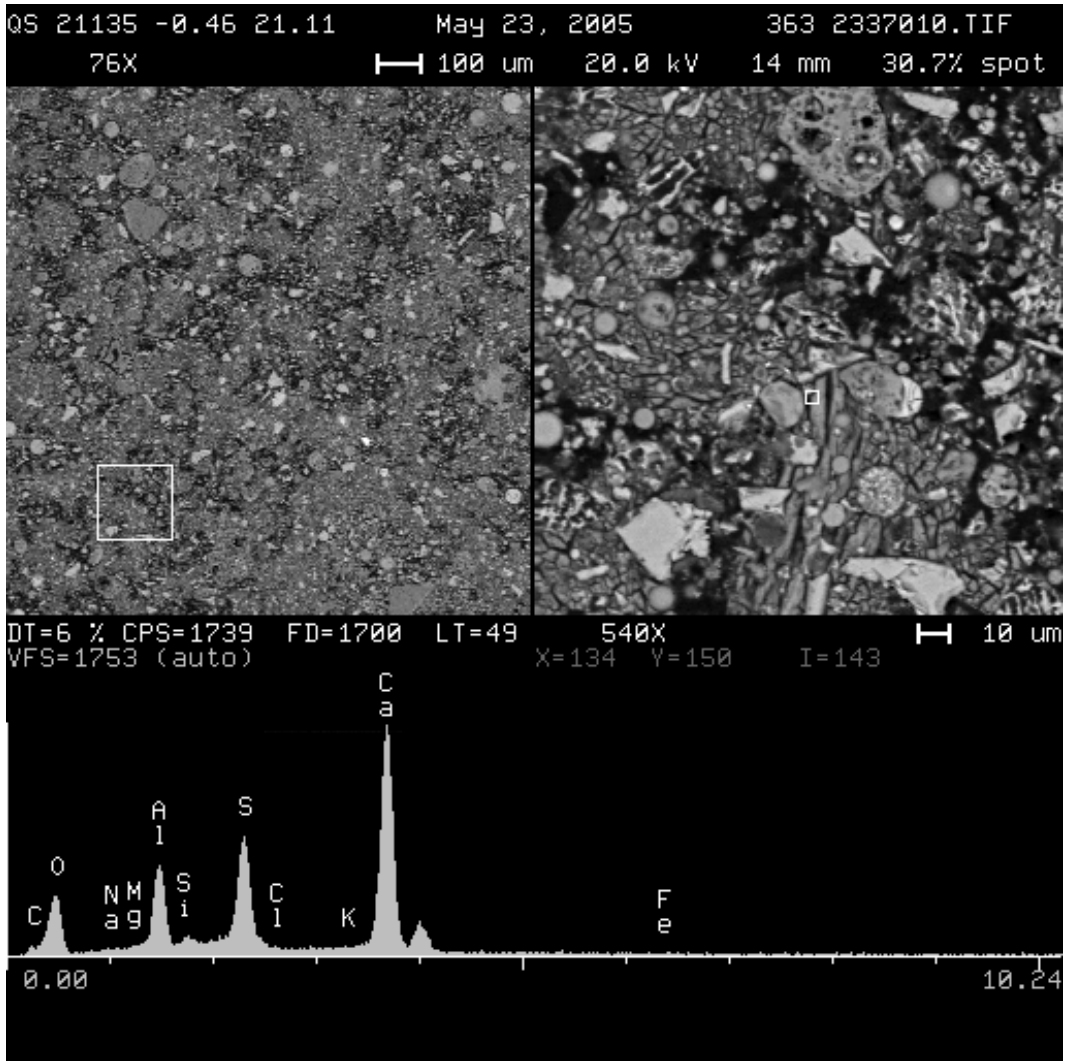
Basin 42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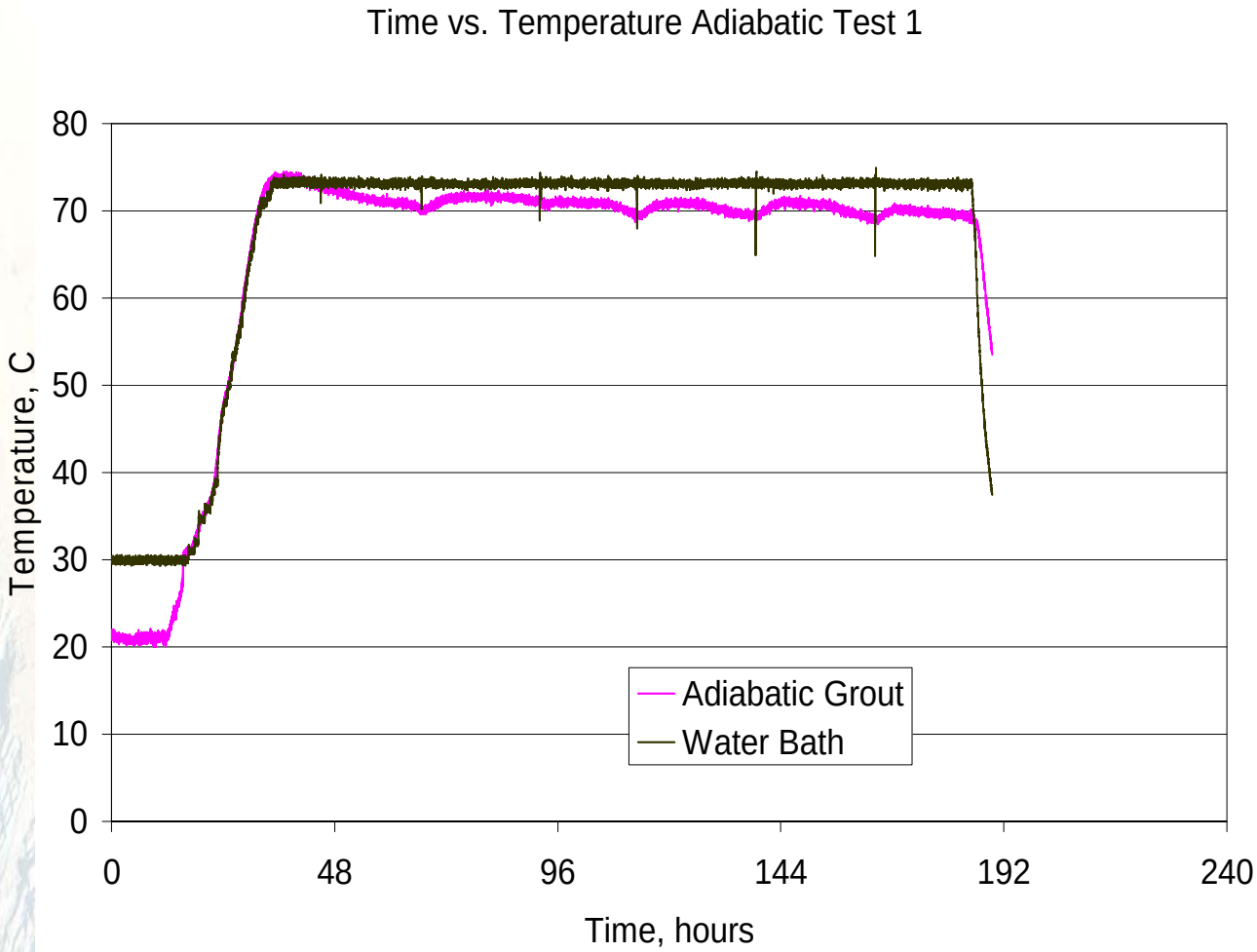
10.24

Temperature Rise During Adiabatic Curing (40 wt%)



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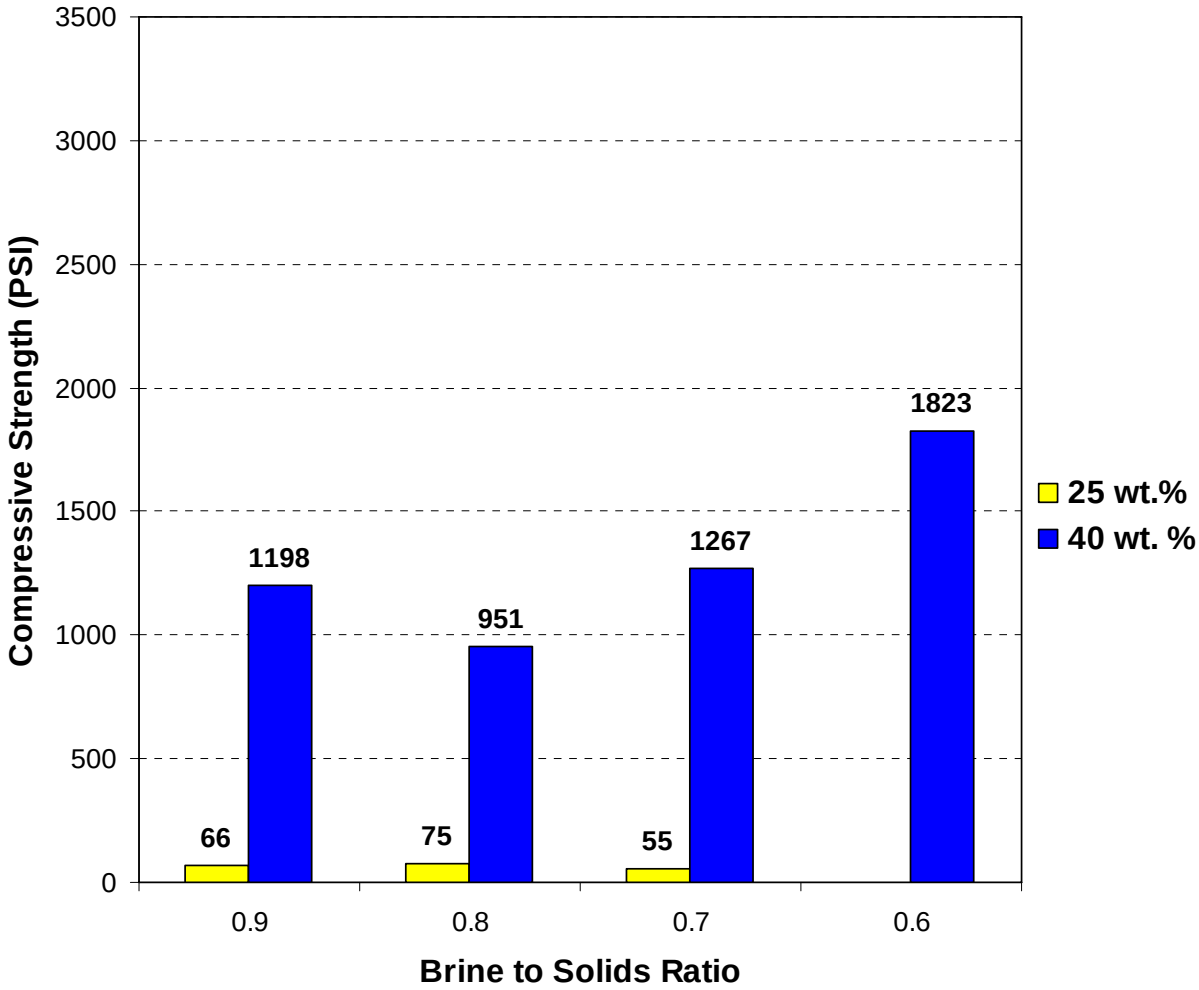
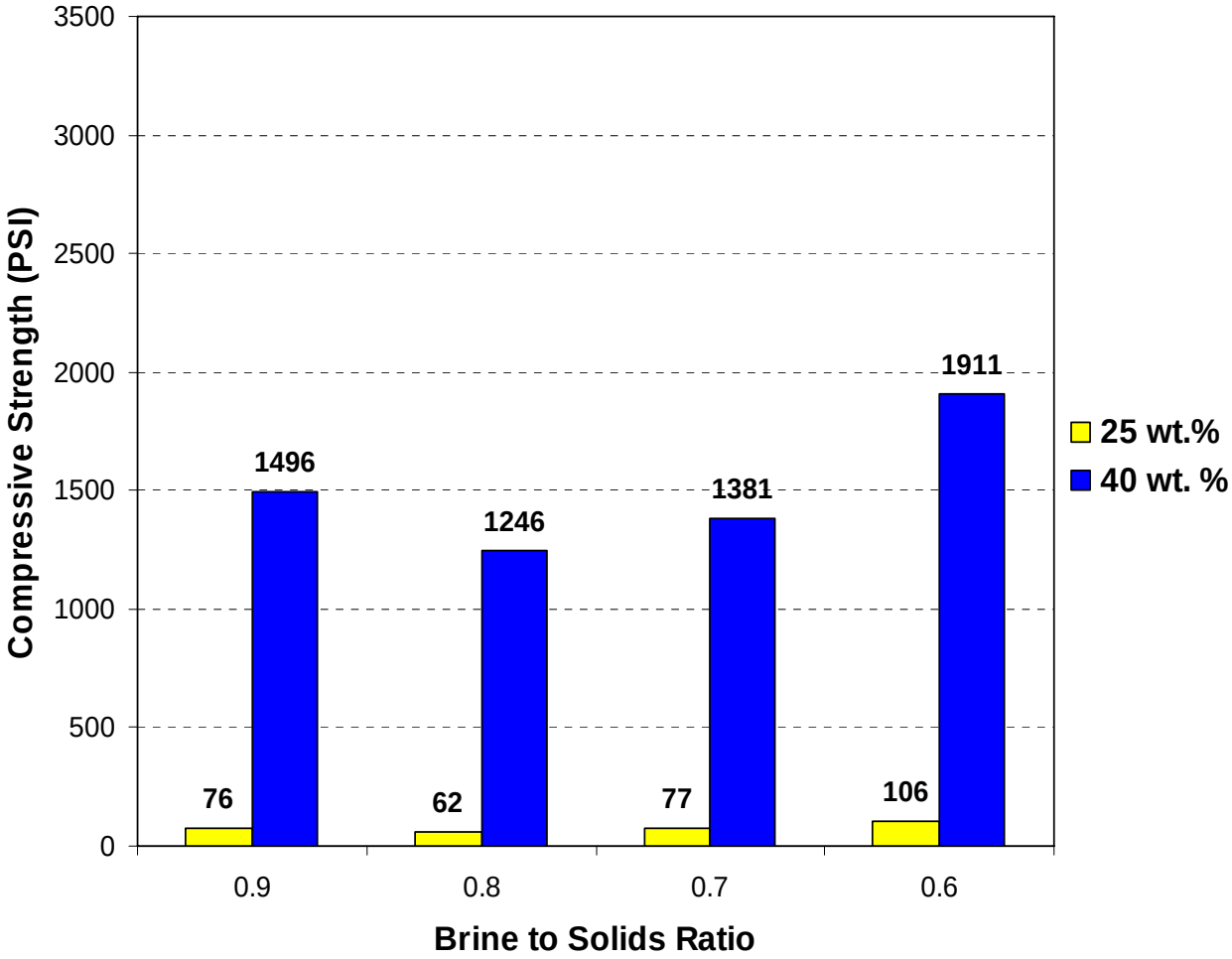


Cured 28 Days



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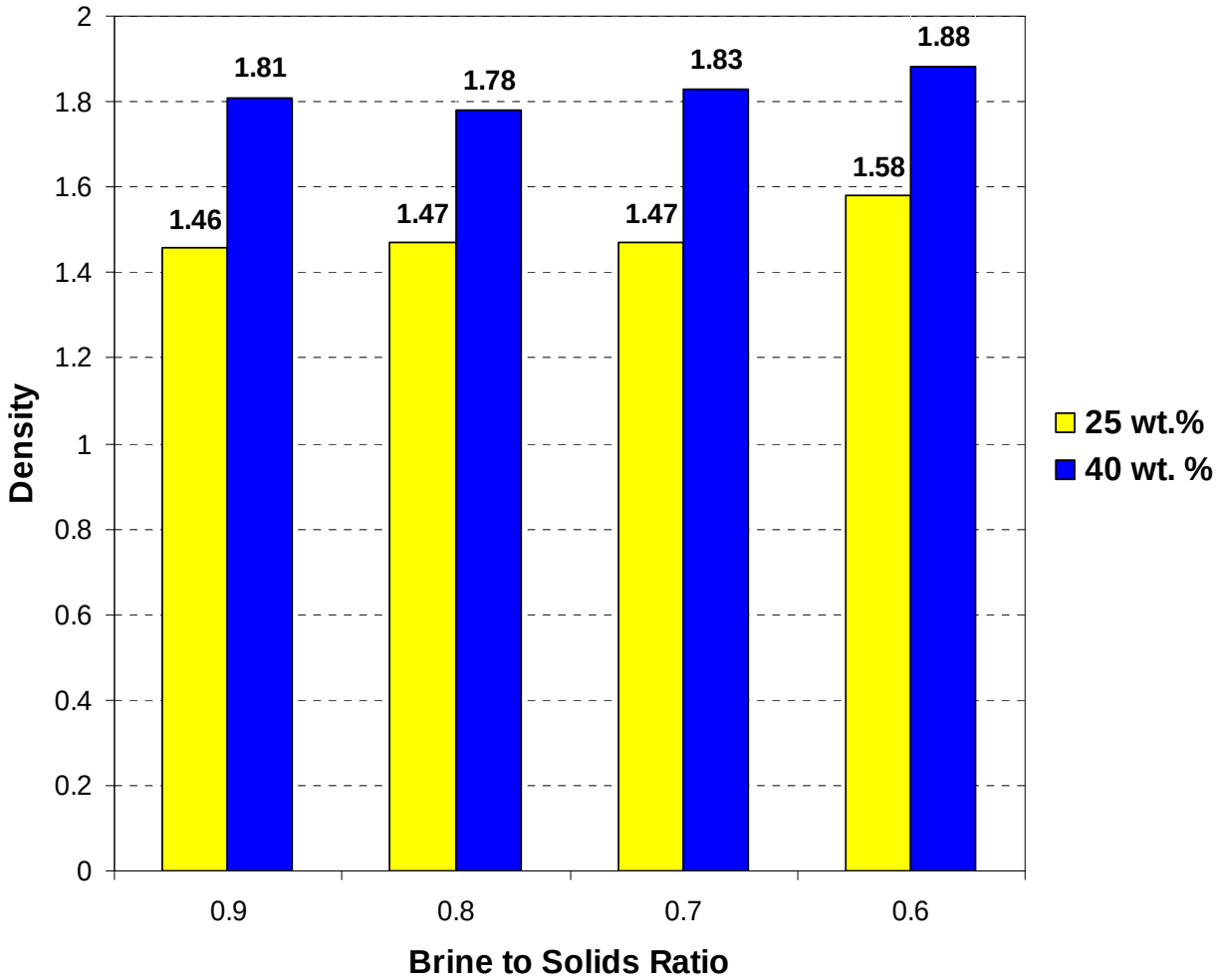

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WTP

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Brine Simulant

Compound	25% Total Solids Concentration (gm/kg)	40% Total Solids Concentration (gm/kg)
NaCl	0.03	0.05
Na_2CO_3	5.94	9.50
$NaNO_2$	0.06	0.09
$NaNO_3$	0.89	1.42
Na_3PO_4	0.01	0.02
Na_2SO_4	150.94	241.51
NaOH	2.37	3.80
$(NH_4)_2SO_4$	89.75	143.60
H_2O	750	600

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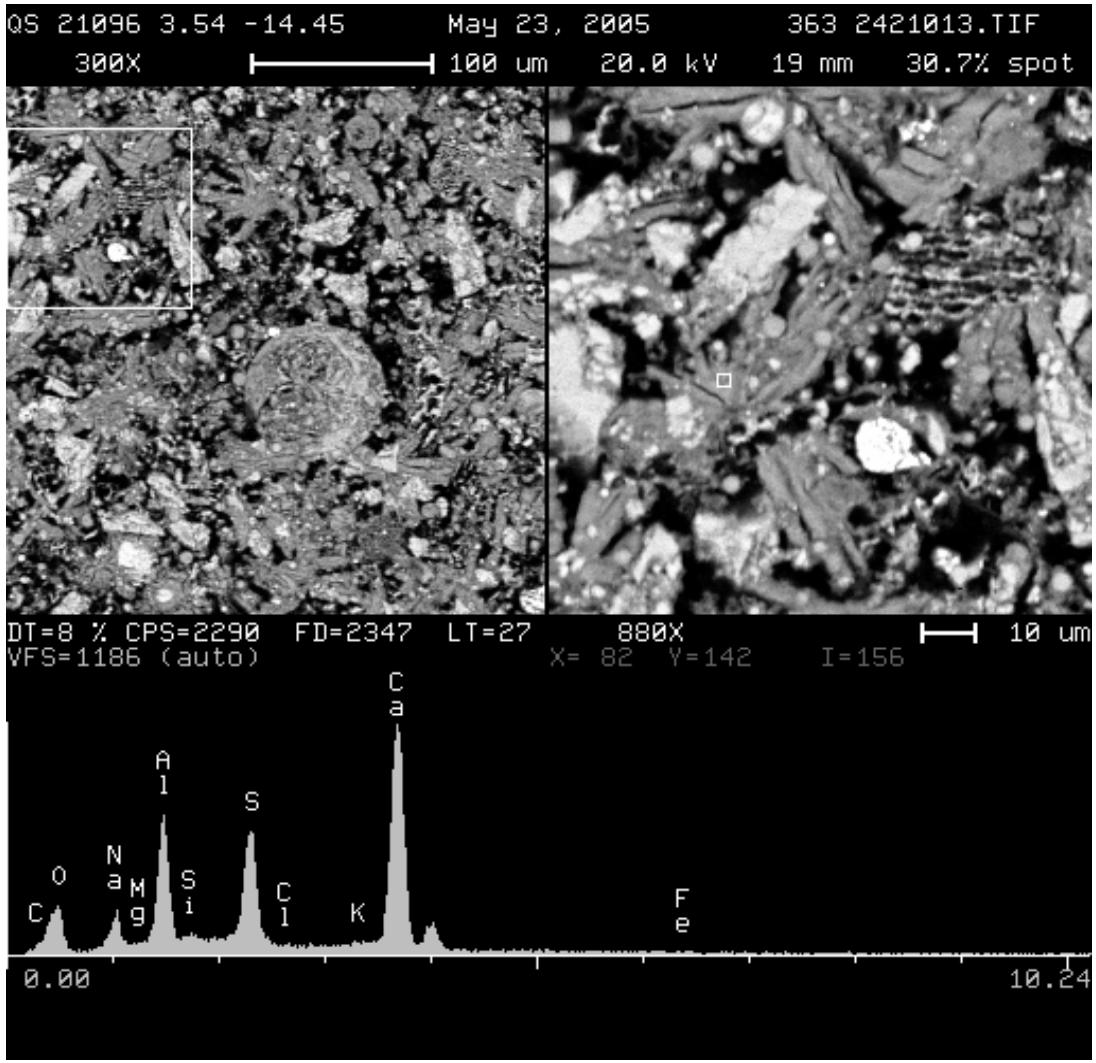
Formulation (40 wt% Simulant)

- Based on mixture of SECAR®[1] 51 and DRF
- Brine solid ratio varied 0.5 to 1.1
- Brine to SECAR®[1] 51 ratio held at ~2.1

[1]SECAR® is a registered trademark of Lafarge Calcium Aluminates, Inc., Chesapeake, Virginia.

WTP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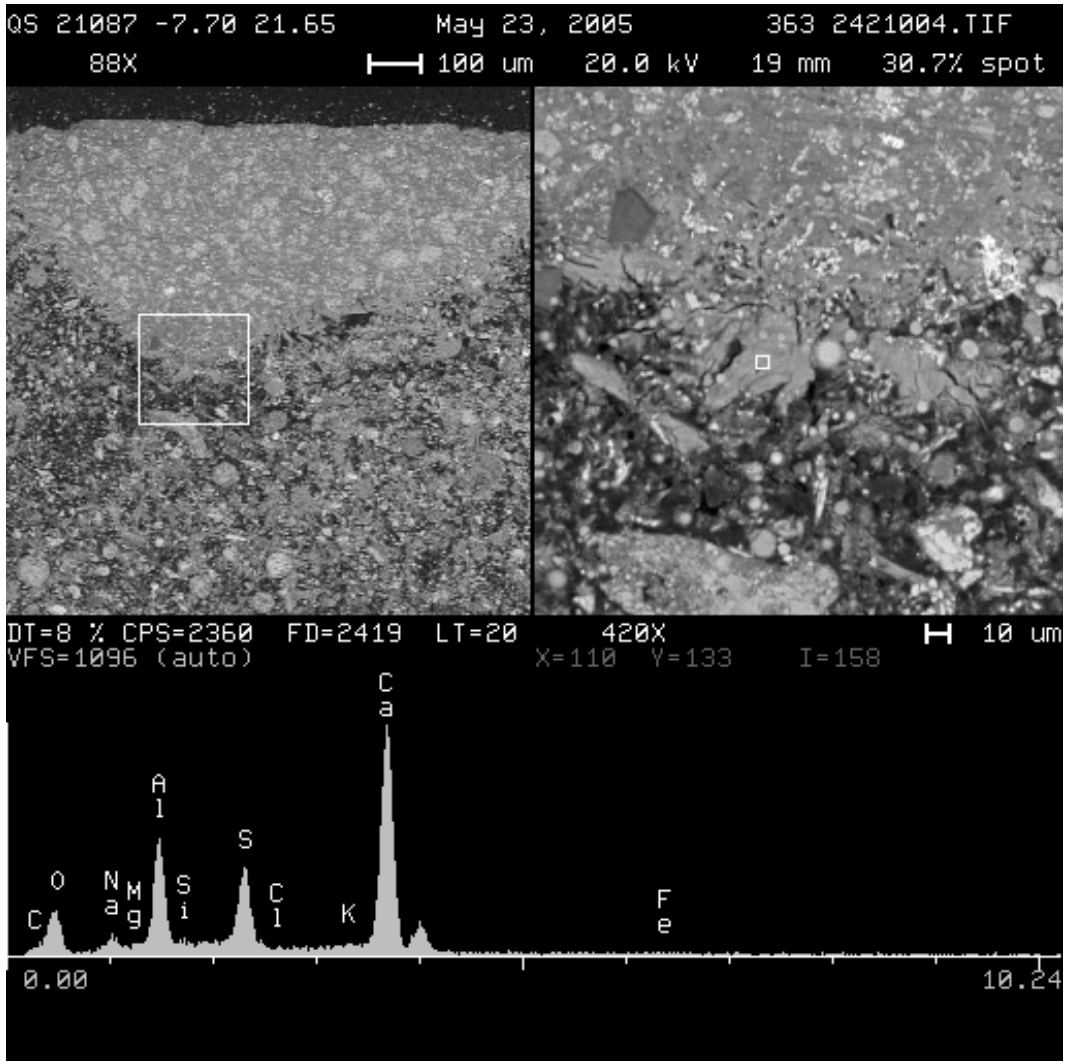
WTP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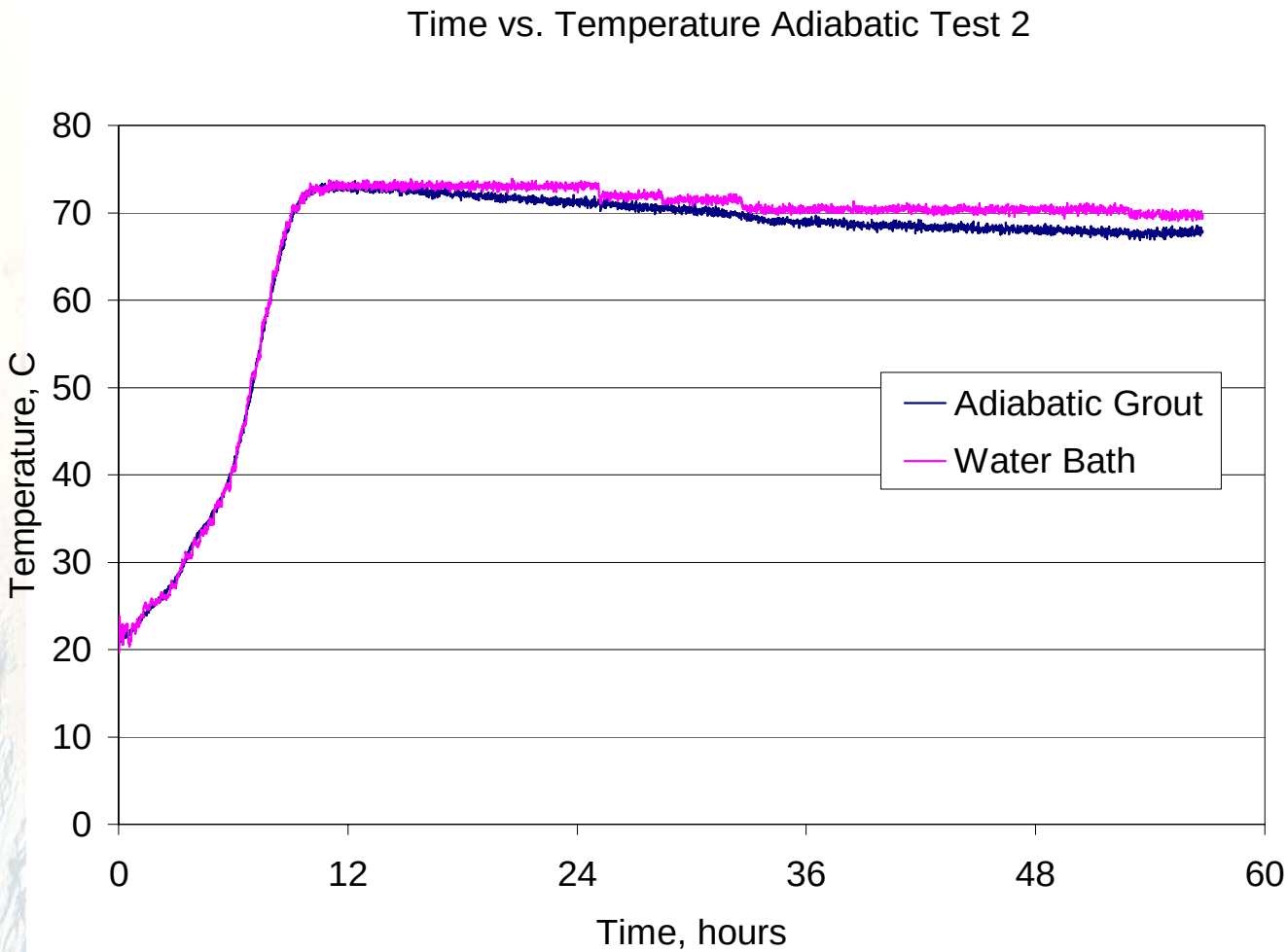
Temperature Rise During Adiabatic Curing (40 wt%)



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DBVS

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Bulk Vitrification Scrubber Simulant

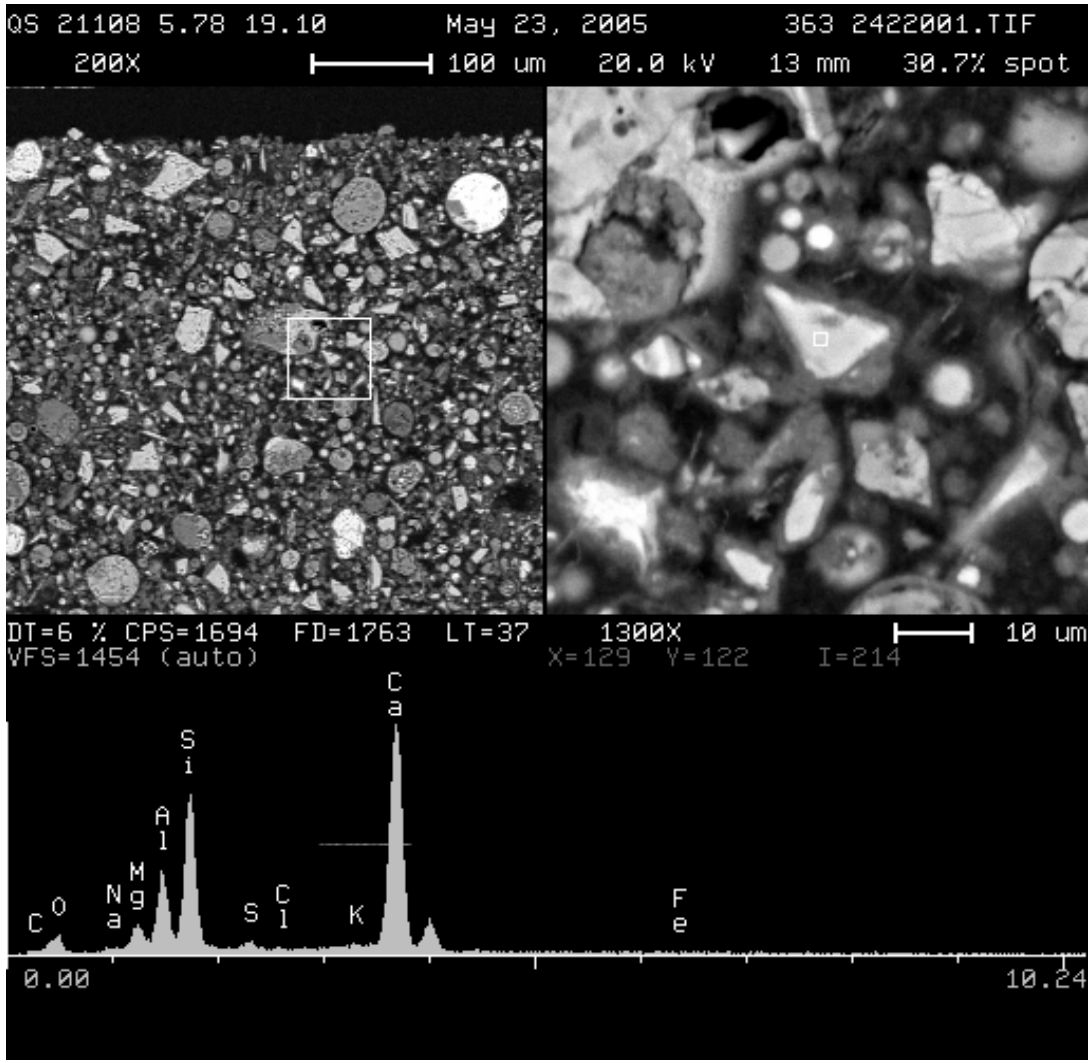
Compound	25% Total Solids Concentration (gm/kg)	40% Total Solids Concentration (gm/kg)
NaOH	38.55	61.69
Na_2SO_4	7.70	12.31
NaCl	0.19	0.31
$NaNO_3$	52.88	84.61
Na_2CO_3	150.67	241.08
H_2O	750	600

Trial Formulations (25 wt% Simulant)

- Simulant to SECAR®[1] 51 ratio 65
- Simulant/solid ratios 0.5 to 1.1
- Balance of mix based on DRF

[1]SECAR® is a registered trademark of Lafarge Calcium Aluminates, Inc., Chesapeake, Virginia.

DVBS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10.24

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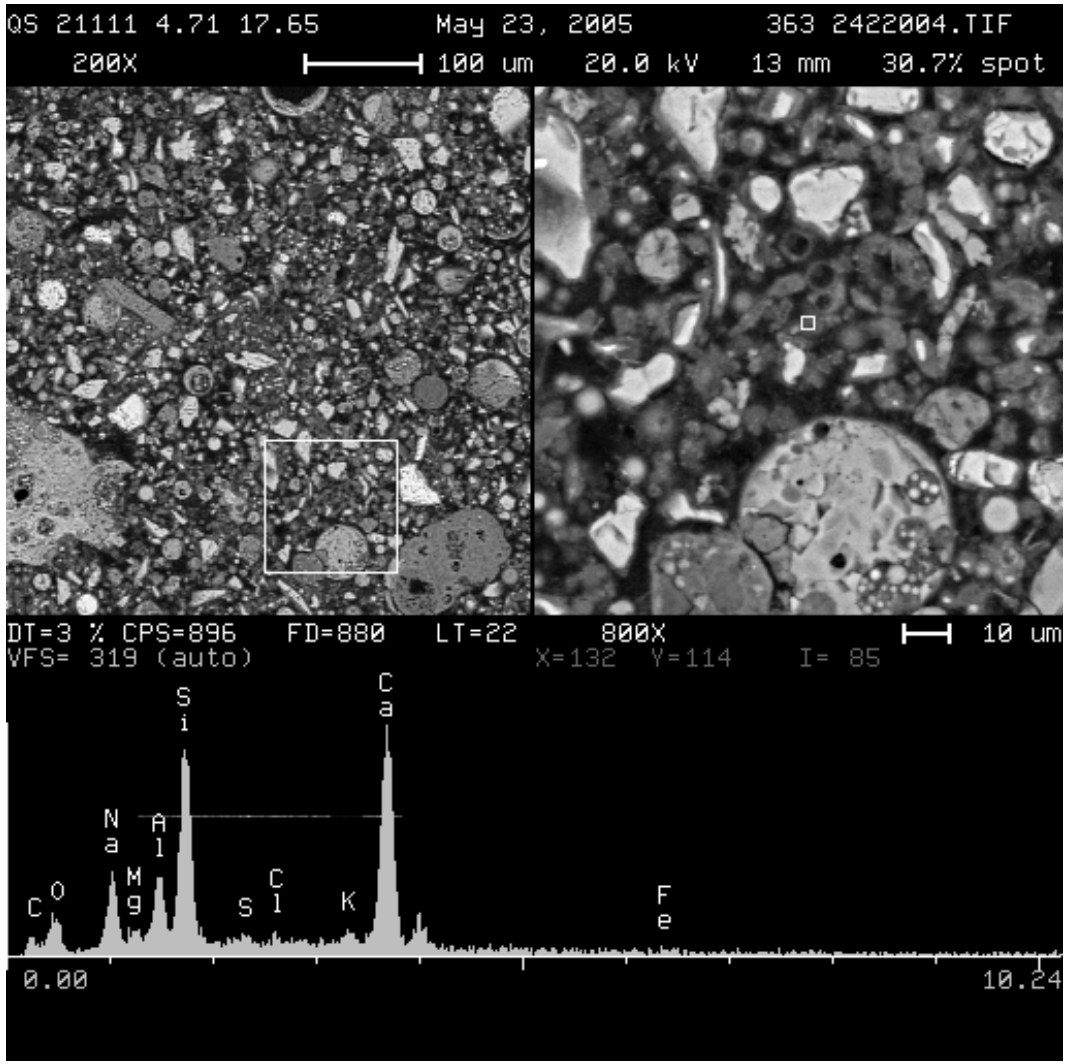
DVBS



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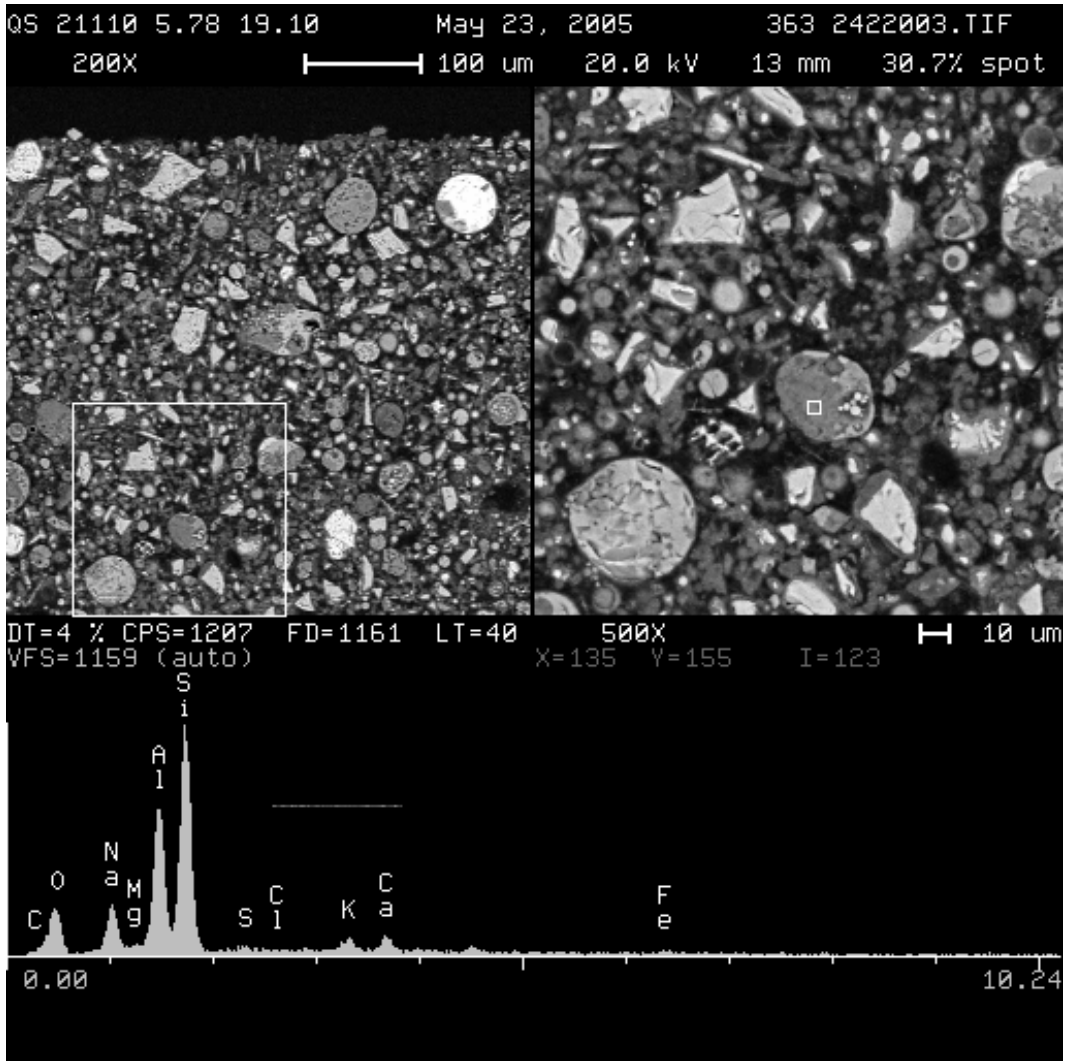
DVBS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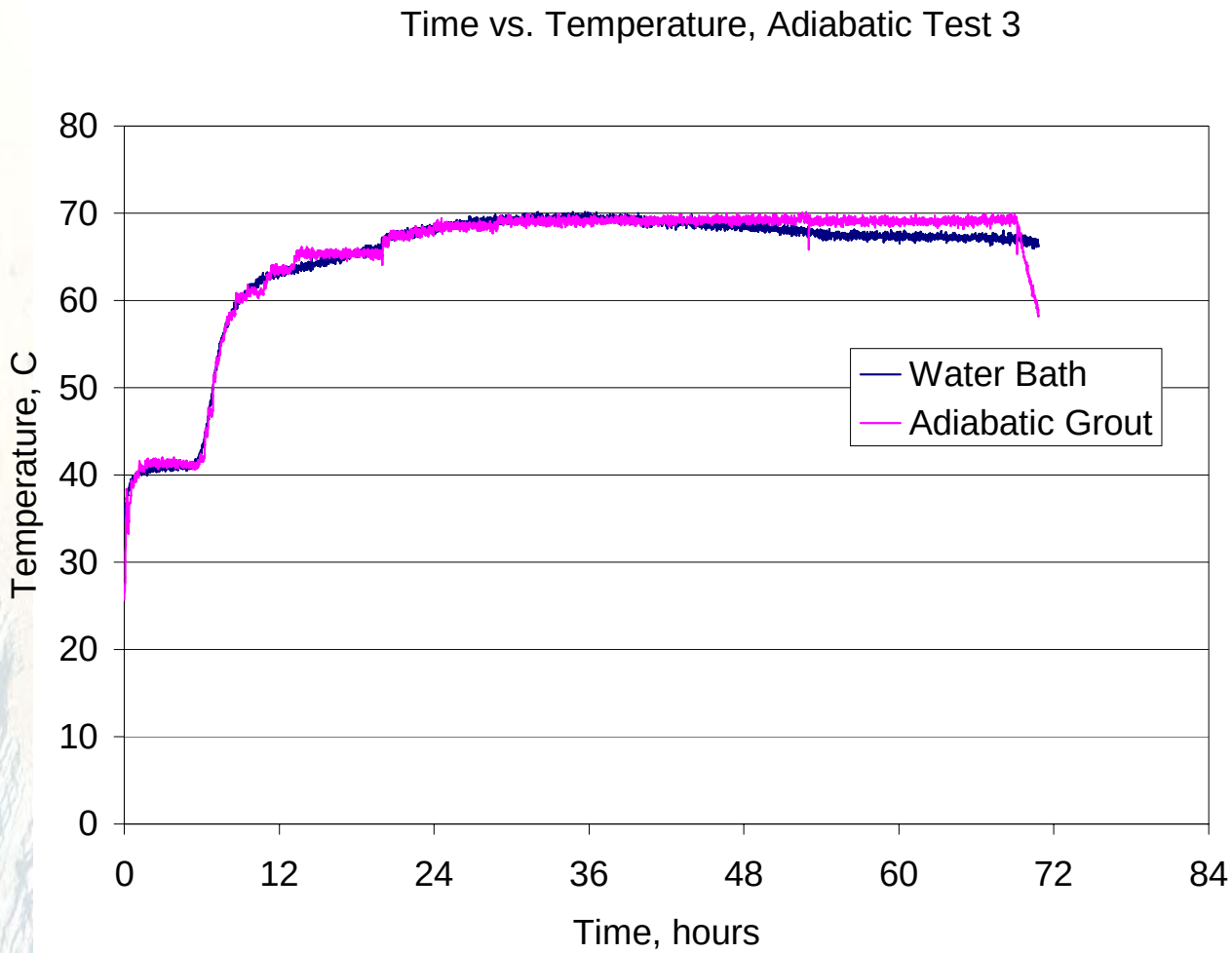
10.24

Temperature Rise During Adiabatic Curing (25 wt%)



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Testing and Results

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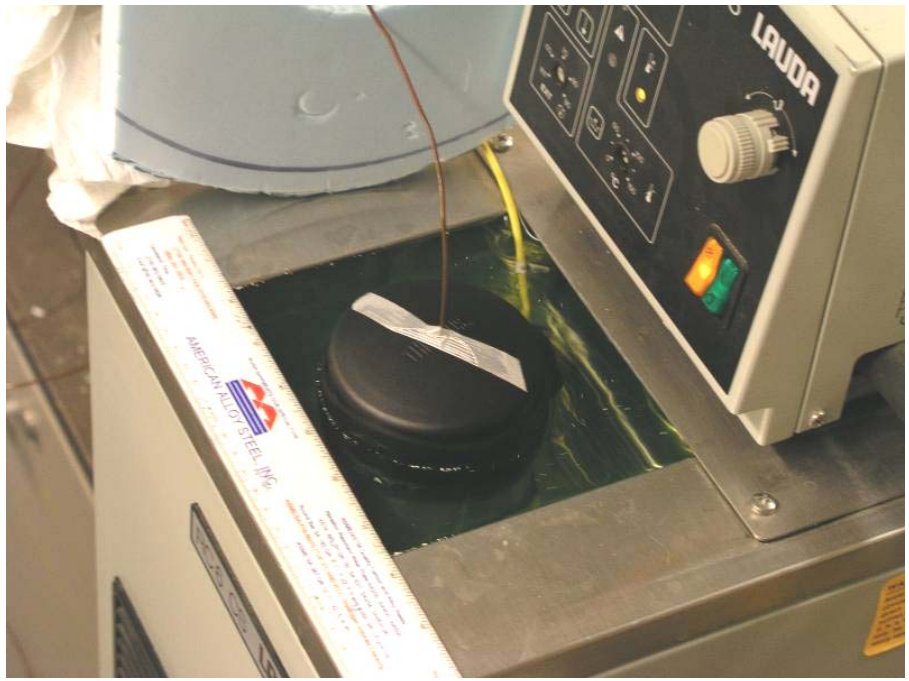
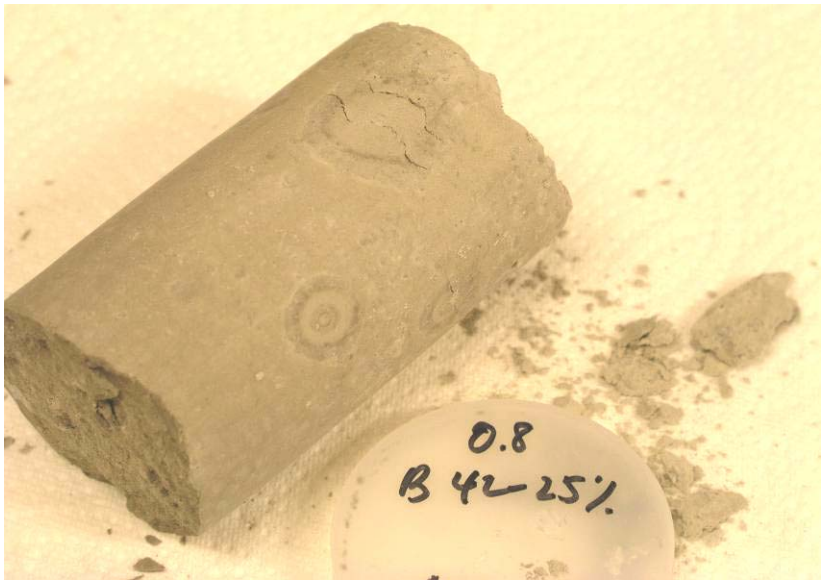
Adiabatic Temperature Cure

- Thermal Vessel
  - 20 in^3 volume
- Thermocouples

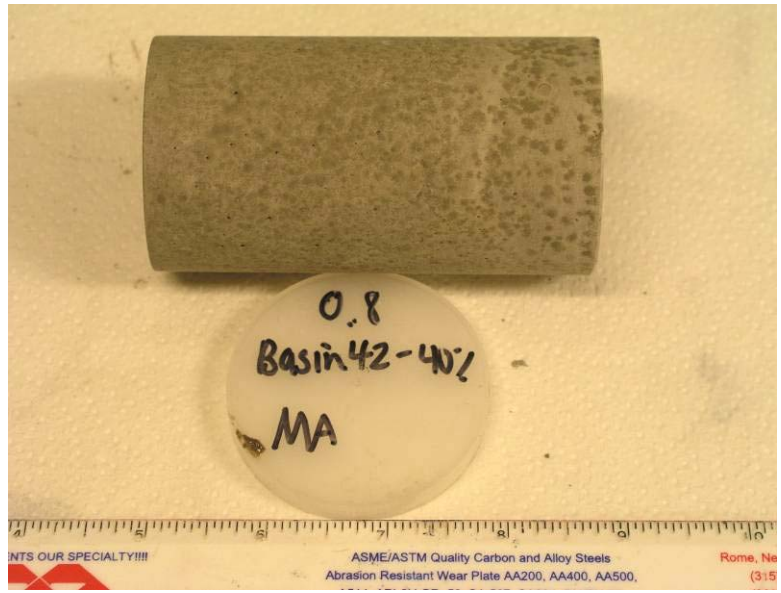


[2]LAUDA is a registered trademark of Dr. R. Wobser, GmbH & Co. KG Ltd. FR Germany.

Samples Removed from Mold



The top and bottom crumbled when removed. Nodules and blemishes were found on surface.



Surface was hard and maintained shape during handling.

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Simulant Spikes

Arsenic	500 mg/L
Barium	10,000 mg/L
Cadmium	100 mg/L
Chromium	500 mg/L
Lead	500 mg/L
Mercury	20 mg/L
Selenium	100 mg/L
Silver	500 mg/L

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Formulations Selected for Further Study

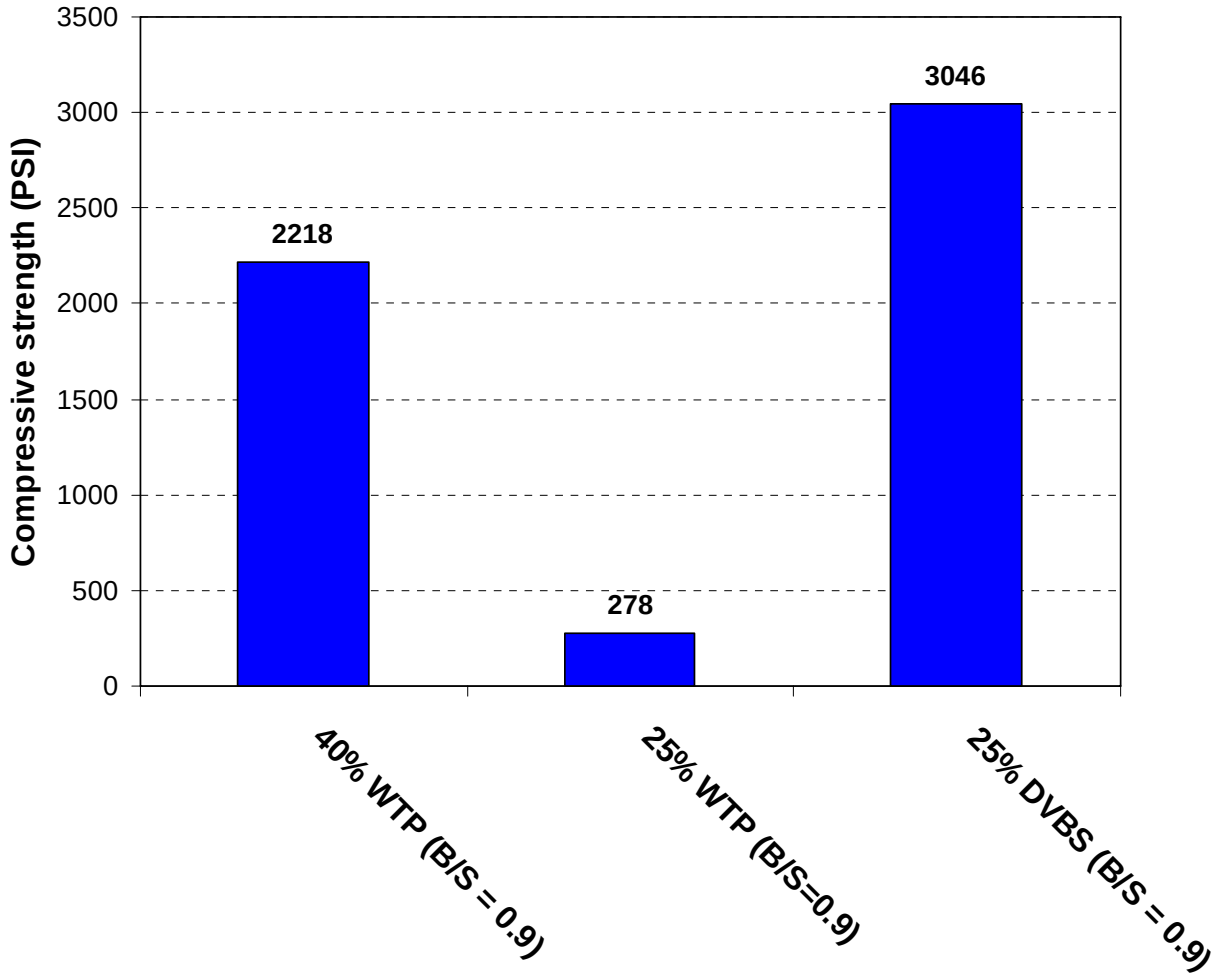
Simulant	DVBS	WTP		Basin 42	
	25 wt%	25 wt%	40 wt%	25 wt%	40 wt%
Brine	44.44	44.44	47.37	47.37	47.37
Secar®[1] 51	0.68	21.40	36.48	21.29	34.07
DRF	54.87	34.16	16.15	31.34	18.57
B/S	0.80	0.80	0.90	0.90	0.90

[1]SECAR® is a registered trademark of Lafarge Calcium Aluminates, Inc., Chesapeake, Virginia.

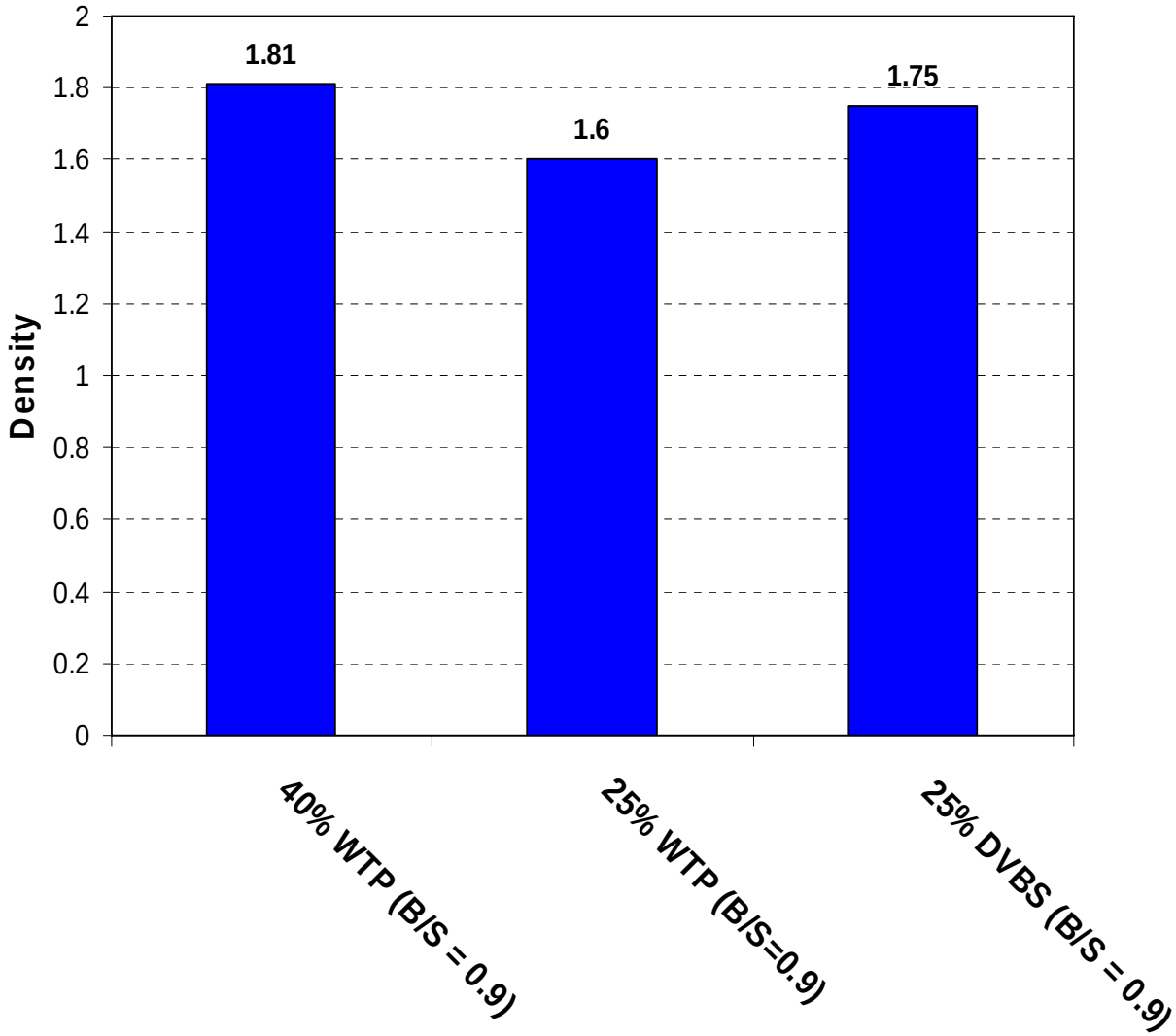
TCLP Testing Results

(mg/L)	EPA* (mg/L)	Basin 42 (mg/L)		WTP (mg/L)		DBVS (mg/L)	Spike (mg/L)
		25 wt%	40 wt%	25 wt%	40 wt%	25 wt%	
Beryllium	<1.22	0.000459	0.00113	<0.002	0.000072	<0.002	
Chromium	<0.60	0.632	0.725	4.37	2.52	2.31	500
Nickel	<11.0	0.0989	0.206	0.0497	0.0258	0.0268	
Zinc	<4.3	0.0525	0.0755	0.0485	0.0464	0.0423	
Arsenic	<5.0	0.247	1.17	0.0495	0.0718	0.103	500
Selenium	<5.7	0.0402	0.119	0.237	0.192	0.181	
Silver	<0.14	0.00322	0.000756	0.000682	0.000331	0.000344	500
Cadmium	<0.11	0.191	0.113	0.00177	0.000449	0.000611	100
Antimony	<1.15	0.001571	0.000132	0.00343	0.000241	0.000298	
Barium	<21.0	0.119	0.0887	0.0448	0.0472	0.0485	10,000
Mercury	<0.025	0.0034	0.00284	0.00107	0.000814	0.000734	20
Thallium	<0.20	0.000414	0.000137	<0.006	<0.006	<0.006	
Lead	<0.75	0.0471	0.32	<0.0002	<0.0002	0.000082	500
Uranium		0.00165	0.0119	0.00109	0.000184	0.000224	0.625
Cesium		0.0408	0.00764	0.00374	0.0229	0.0225	

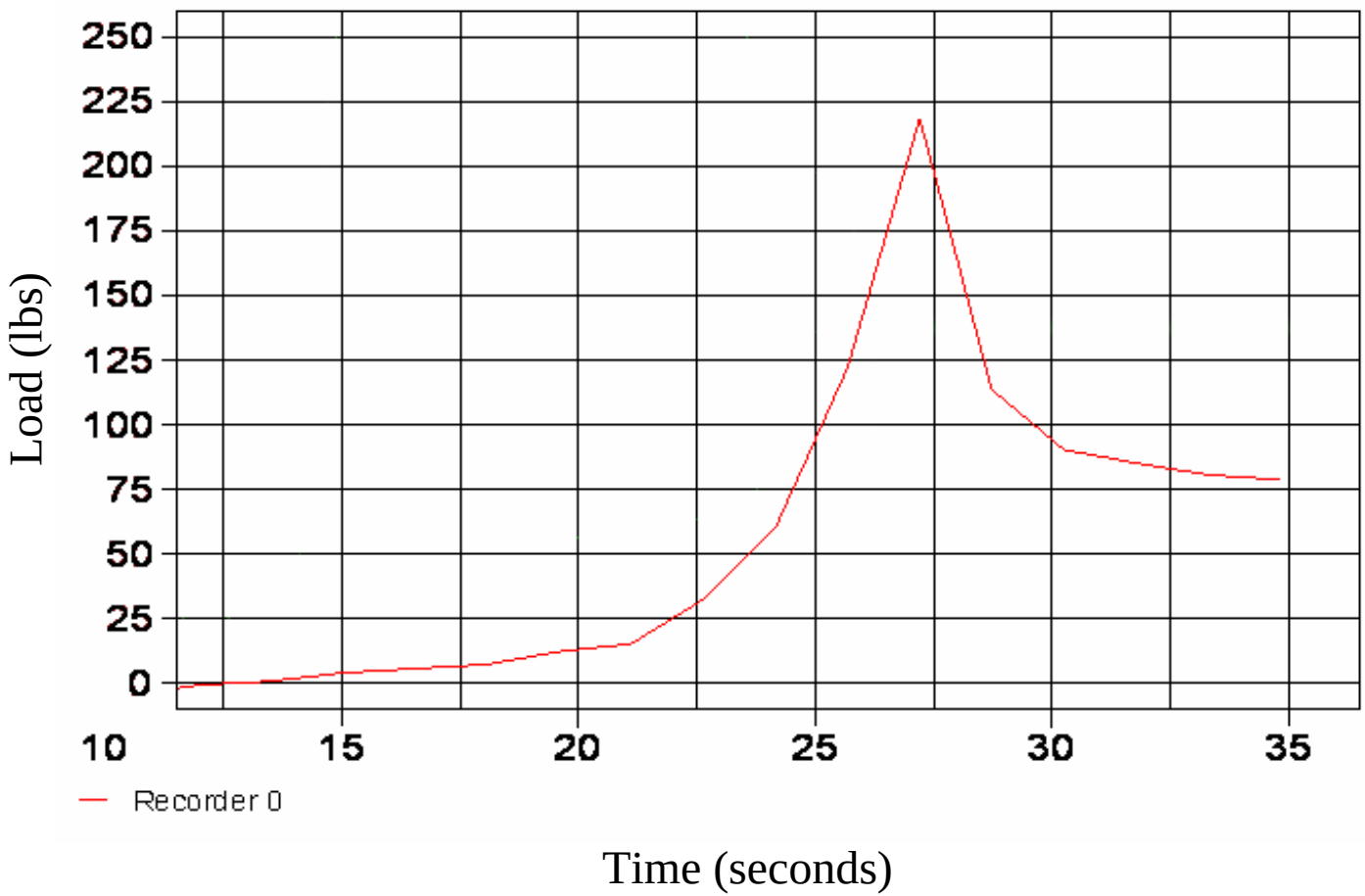
WTP and DVBS Cured 28 Days



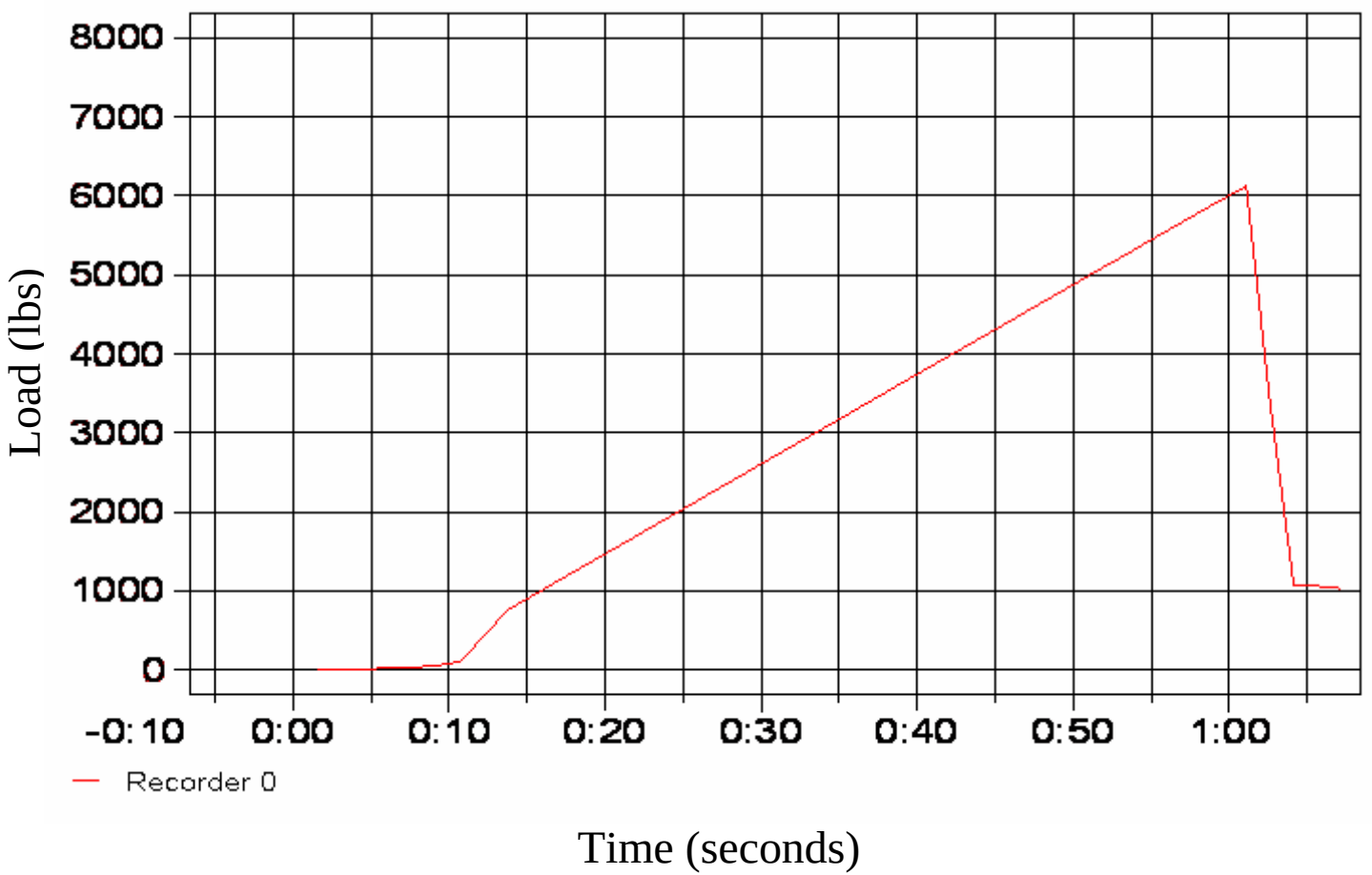
WTP and DVBS Cured 28 Days



Load vs. Time Curve (Max Load = 218 lb)



Load vs. Time Curve (Max Load = 6,123 lb)



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Summary

- All formulations exhibited an optimum mixing using a brine/solids ratio in the 0.8-0.9 range
- Small amount of bleed water was noticed shortly after mixing
  - Typically reabsorbed within a few hours
- Brines with the higher loading gave higher strengths
  - Selected for further testing

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Summary

- No formulations tested showed excessive bleed water
- Highest bleed water = 1.36%
- All formulations tested showed zero expansions and slight shrinkage

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Summary

- All formulations tested exceeded the 40 CFR 268.48 limits for chromium
  - Likely due to C^{r6+} being used as the spike
  - Others have noted that the only way to stabilize C^{r6+} containing wastes is to pretreat the waste to reduce the chrome to Cr^{3+}
- Basin 42 formulations also failed to meet the 40 CFR 268.48 limit for cadmium
- In all cases the brines were spiked at levels of at least 100 times the 40 CFR 268.48 levels
- In some cases the spikes were more that 800 times the levels
- Even with the high spike levels all of the grouts met the Washington Administrative Code (WAC) 173-303, "Dangerous Waste Regulations"

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Summary

- All formulations tested reached temperatures higher than 70 °C during adiabatic curing
  - Temperature range at which ettringite could be expected to start to break down
  - If this occurs there is potential for “delayed ettringite formation” that could lead to cracking and deterioration of the physical properties at later ages.

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Future Work

- Plans to go to full scale testing are underway.

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