MetalTek INTERNATIONAL

Addendum to CA1323 9-8-05

This is to supplement and report our progress on this corrective action.

As previously committed, samples from A-1, C-4 and C-5 were sent to Wisconsin Centrifugal, our parent company, for independent analysis of all reported elements. The results indicated a discrepancy in the level of manganese in the results of the analyses performed by the two labs. Consistently, the Pevely lab measured Mn about 0.4 to 0.5% higher than WC measured. To confirm this information we sent three samples to an outside laboratory for wet chemistry analysis. The results correlated well with the results achieved at Wisconsin Centrifugal. See attached report.

In follow-up, samples from C-1, C-2 and C-3 were also sent for verification, with similar outcome. We then located and tested a sample from a test heat #21424 of CF8MNMNMOD made in January 2004. Testing indicated similar results.

It can be stated that, for at least the period of time comprising the Prototype and the Production to the repair of the Spectrometer, that our analysis of Manganese levels has been higher than the level actually present in the alloy. Typically, this deviation is on the order of 0.4-0.5%.

The spectrometer received the preventive maintenance on August 29, 2005. The report was submitted on September 2, 2005. The repair made to the optical card was determined to have rectified the previously reported issue with P and S reporting. No other mechanical or software problem that would affect Mn was determined at the time of the preventative maintenance.

In follow up to the Manganese discrepancy, the same samples were analyzed on the Pevely spectrometer. The levels reported after PM now correlate with the results from WC and the independent laboratory. Further investigation indicates that the BS180 standard used for type standardization may be sufficiently outside the range of Mn and inducing error. No other root cause has been determined, but the investigation continues.

In consideration of the erroneous Mn and other elemental readings, the following actions are proposed:

Create a type standard that closely matches the Mn in CF8MNMNMOD. (In process)
Request a revision to the chemistry range for Mn. (propose widening of Manganese since it has been proven to be effective at much lower concentrations than previously thought).
Have each heat of CF8MNMNMOD verified independently for balance of program.

C. Ruud

CC: Jim Galaske, Barry Craig, Joe Edwards, E.J. Kubick

Chemistry Check with WISCO

Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	C-5,I-1	Button #1	0.05	0.3	2.6	18.1	13.4	2.4	0.26	0.023	0.011	
CAF	C-5,I-1	Button #2	0.05	0.4	2.6	18.0	13.4	2.6	0.26	0.026	0.013	
WC	C-5,I-1	Button #2	0.02	0.3	2.2	18.2	13.5	2.4	0.25	0.025	0.010	
STL Wet	C-5,I-1	Button #1			2.2							
CAF	C-5,I-1	Button #1	*	0.3	2.3	18.3	13.4	2.4	*	0.029	0.012	re-run after PM

Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	C-5,I-3	Button #1	0.05	0.4	2.2	17.9	13.4	2.5	0.24	0.033	0.012	
CAF	C-5,I-3	Button #2	0.05	0.4	2.2	17.9	13.2	2.4	0.24	0.033	0.012	
WC	C-5,I-3	Button #2	0.05	0.4	1.8	18.2	13.4	2.5	0.23	0.034	0.018	
STL Wet	C-5,I-3	Button #1			1.8							
CAF	C-5,I-3	Button #1	*	0.4	1.8	18.3	13.3	2.5	*	0.034	0.012	re-run after PM

Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	C-5,I-6	Button #1	0.05	0.3	2.4	18.1	13.2	2.4	0.25	0.030	0.012	
CAF	C-5,I-6	Button #2	0.05	0.3	2.4	18.1	13.2	2.4	0.25	0.029	0.011	
WC	C-5,I-6	Button #2	0.04	0.3	2	18.3	13.3	2.4	0.24	0.031	0.018	
STL Wet	C-5,I-6	Button #1			1.9							
CAF	C-5,I-6	Button #1	*	0.3	2.0	18.4	13.3	2.4	*	0.033	0.012	re-run after PM

Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	A-1	Reported	0.04	0.4	2.4	18.2	13.3	2.4	0.26	*	*	
CAF	A-1	Cast on sample	*	0.5	2.1	18.0	13.4	2.4	*	0.034	0.009	
WC	A-1	Cast on sample	0.06	0.6	1.6	18.1	13.7	2.4	0.25	0.027	0.009	
CAF	A-1	Cast on sample	*	0.6	1.6	18.2	13.5	2.4	*	0.028	0.009	re-run after PM

Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	C-4	Reported	0.04	0.4	2.5	18.2	13.2	2.2	0.26	.030**	.014**	
CAF	C-4	Cast on sample	*	0.6	1.9	17.9	13.5	2.3	*	0.037	0.013	
WC	C-4	Cast on sample	0.04	0.6	1.5	17.8	13.6	2.4	0.25	0.030	0.012	
CAF	C-4	Cast on sample	*	0.6	1.4	18.2	13.6	2.4	*	0.031	0.009	re-run after PM

Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	C-1	Reported	0.06	0.5	2.7	18.1	13.1	2.2	0.27	0.018**	0.014**	
CAF	C-1	Cast on sample	*	0.7	2.2	18.1	13.1	2.2	*	0.021	0.010	
WC	C-1	Cast on sample	0.06	0.7	1.8	18.3	13.4	2.4	0.24	0.021	0.014	
CAF	C-1	Cast on sample	*	0.7	1.9	18.3	13.2	2.4	*	0.024	0.013	re-run after PM

Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	C-2	Reported	0.06	0.5	2.8	18.0	13.2	2.3	0.26	0.023**	0.018**	
CAF	C-2	Cast on sample	*	0.8	2.2	18.1	13.4	2.2	*	0.030	0.012	
WC	C-2	Cast on sample	0.07	0.9	1.6	18.2	13.7	2.2	0.23	0.023	0.014	
CAF	C-2	Cast on sample	*	0.8	1.6	18.2	13.5	2.3	*	0.024	0.012	re-run after PM

Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	C-3	Reported	0.04	0.4	2.5	18.2	13.3	2.3	0.25	0.023**	0.013**	
CAF	C-3	Cast on sample	*	0.6	1.9	18.0	13.3	2.4	*	0.027	0.010	
WC	C-3	Cast on sample	0.06	0.6	1.6	18.3	13.7	2.4	0.24	0.029	0.009	
CAF	C-3	Cast on sample	*	0.6	1.6	18.1	13.5	2.4	*	0.028	0.011	re-run after PM

Test Heat poured 1/14/04

Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	24424	Button	0.05	0.4	2.8	18.1	12.9	2.2	0.27	0.020	0.010	
CAF	24424	Keel bar	*	0.4	2.2	18.2	13.2	2.2	*	0.018	0.010	re-run after PM

* not analyzed by spectrometer.
** analyzed by wet chemistry.
For C-5 C and N were analyzed at CAF and at WC by Leco Analyzer, P+S analyzed on spectrometer.

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August 16, 2005

Report on Alloy Specification Development of Contaminants Limits

MetalTek International was requested to comment on the limits set for the contaminants, specifically Sulfur and Phosphorus, in its specification recommendation to PPPL for the NCSX program. This is the result of that investigation.

In review of the data and efforts in the 2.1.2 Task (Alloy Selection) under the prototype contract, several items were of note relative to the alloy chemistry development:

1.) In the onset, Alloy#1, a less alloyed variant of 316ss, was considered; however, the concern within PPPL and MetalTek was the effects of water quenching on the alloy during solution anneal (e.g. dimensional control and residual stresses).
2.) The limits for P and S in the Alloy #1 were set to comply with standard CF8M (cast "316ss") limits of 0.04% maximum for both.
3.) In order to eliminate water quench, a second alloy was funded under the scope of the 2.1.2 Task. This alloy was successful and has been referred to as "Stellaloy."
4.) The limits for P and S in the Alloy #2 were set to comply with standard limits for CF8M, again 0.04% maximum.
5.) Heats were made for each alloy, with both P and S well below the 0.04% maximum limits; however, one heat showed P above the 0.015% ultimately recommended.
6.) Based on review of the testing, MetalTek International Research recommended a chemical composition range for the ultimate 2.1.2 task. This range incorporated restrictions on the P and S at 0.015% maximum limits. Insufficient review of this recommendation against historic chemical analyses and those reported in the task was performed, resulting in the recommendation to PPPL to use the lower limits.

In essence, insufficient review of available data outside the recommendation of the MetalTek International Research group resulted in the proposal of a specification beyond the limits of the planned production processes.

Joe Edwards/Chuck Ruud

Metal INTERNATIONAL

Addendum to CA1323 9-30-05

This is to supplement and report our progress on this corrective action.

We have discussed the variation in reading the Mn levels with the service technician and the spectrometer manufacturer. No new information has been obtained to explain the differences in reading Mn levels.

The chemistry for the shims poured from heat 29198 has been analyzed and is added to the spreadsheet attached. It shows similar readings for Mn.

The chemistry for the C-6 coil is also added to the spreadsheet. We aimed for higher Mn at the furnace to assure the higher Mn levels. The results indicate the effort was successful.

Update as to action steps:

Create a type standard that closely matches the Mn in CF8MNMNMOD.

Completed at WC and has been sent to another laboratory.

Request a revision to the chemistry range for Mn. (propose widening of Manganese since it has been proven to be effective at much lower concentrations than previously thought).

Pending.

Have each heat of CF8MNMNMOD verified independently for balance of program.

Complete for all coils to date.

C. Ruud

CC: Jim Galaske, Barry Craig, Joe Edwards, E.J. Kubick

emistry Check with WISCO		Revised 9-30-05				Information in blue added 9-30-05						
ɔ	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
at #29198 for 5 C and 6 A shims												
F	29198	Reported 9/24/05	0.07	0.7	2.97	18.1	13.12	2.45	0.255	0.013*	0.01**	
F	29198	Separate Test bar	*	0.8	2.7	18.2	13.2	2.4	*	0.028	0.011	re-run after PM
ɔ	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
F	C-6,I-1	Button #1	0.04	0.3	2.5	18.2	13.5	2.4	0.25	0.028	0.010	run after PM
F	C-6,I-1	Button #2	*	0.2	2.4	18.1	13.6	2.4	*	0.03	0.012	run after PM
ɔ	C-6,I-1	Button #2	0.03	0.2	2.4	17.9	13.7	2.5	0.26	0.028	0.010	
b	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
F	C-6,I-3	Button #1	0.04	0.4	2.4	18.2	13.4	2.3	0.25	0.034	0.011	run after PM
F	C-6,I-3	Button #2	*	0.4	2.4	18.2	13.7	2.3	*	0.033	0.012	run after PM
ɔ	C-6,I-3	Button #2	0.03	0.4	2.2	17.9	13.6	2.4	0.25	0.029	0.013	
b	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
F	C-6,I-5	Button #1	0.04	0.4	2.6	18.3	13.4	2.4	0.26	0.031	0.010	run after PM
F	C-6,I-5	Button #2	*	0.4	2.5	18.2	13.7	2.4	*	0.031	0.013	run after PM
ɔ	C-6,I-5	Button #2	0.04	0.4	2.4	18.2	13.7	2.4	0.26	0.030	0.014	
b	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
F	C-6,Z-3	Cast on sample	*	0.6	1.7	18.1	13.6	2.4	*	0.031	0.012	run after PM
ɔ	C-6,Z-3	Cast on sample	0.04	0.6	1.7	17.8	13.8	2.4	0.26	0.023	0.011	
ıb	**I.D.**	**Sample**	**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**P**	**S**	
AF	C-5,I-1	Button #1	0.05	0.3	2.6	18.1	13.4	2.4	0.26	0.023	0.011	
AF	C-5,I-1	Button #2	0.05	0.4	2.6	18.0	13.4	2.6	0.26	0.025	0.013	
C	C-5,I-1	Button #2	0.02	0.3	2.2	18.2	13.5	2.4	0.25	0.025	0.010	
TL Wet	C-5,I-1	Button #1			2.2							
AF	C-5,I-1	Button #1	*	0.3	2.3	18.3	13.4	2.4	*	0.029	0.012	re-run after PM
ıb	**I.D.**	**Sample**	**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**P**	**S**	
AF	C-5,I-3	Button #1	0.05	0.4	2.2	17.9	13.4	2.5	0.24	0.033	0.012	
AF	C-5,I-3	Button #2	0.05	0.4	2.2	17.9	13.2	2.4	0.24	0.033	0.012	
C	C-5,I-3	Button #2	0.05	0.4	1.8	18.2	13.4	2.5	0.23	0.034	0.018	
TL Wet	C-5,I-3	Button #1			1.8							
AF	C-5,I-3	Button #1	*	0.4	1.8	18.3	13.3	2.5	*	0.034	0.012	re-run after PM
ıb	**I.D.**	**Sample**	**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**P**	**S**	
AF	C-5,I-6	Button #1	0.05	0.3	2.4	18.1	13.2	2.4	0.25	0.030	0.012	
AF	C-5,I-6	Button #2	0.05	0.3	2.4	18.1	13.2	2.4	0.25	0.029	0.011	
C	C-5,I-6	Button #2	0.04	0.3	2	18.3	13.3	2.4	0.24	0.031	0.018	
TL Wet	C-5,I-6	Button #1			1.9							
AF	C-5,I-6	Button #1	*	0.3	2.0	18.4	13.3	2.4	*	0.033	0.012	re-run after PM
ıb	**I.D.**	**Sample**	**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**P**	**S**	
AF	A-1	Reported	0.04	0.4	2.4	18.2	13.3	2.4	0.26	*	*	
AF	A-1	Cast on sample	*	0.5	2.1	18.0	13.4	2.4	*	0.034	0.009	
C	A-1	Cast on sample	0.06	0.6	1.6	18.1	13.7	2.4	0.25	0.027	0.009	
AF	A-1	Cast on sample	*	0.6	1.6	18.2	13.5	2.4	*	0.028	0.009	re-run after PM
ıb	**I.D.**	**Sample**	**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**P**	**S**	
AF	C-4	Reported	0.04	0.4	2.5	18.2	13.2	2.2	0.26	.030**	.014**	
AF	C-4	Cast on sample	*	0.6	1.9	17.9	13.5	2.3	*	0.037	0.013	
C	C-4	Cast on sample	0.04	0.6	1.5	17.8	13.6	2.4	0.25	0.030	0.012	
AF	C-4	Cast on sample	*	0.6	1.4	18.2	13.6	2.4	*	0.031	0.009	re-run after PM
ab	**I.D.**	**Sample**	**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**P**	**S**	
AF	C-1	Reported	0.06	0.5	2.7	18.1	13.1	2.2	0.27	0.013**	0.014**	
AF	C-1	Cast on sample	*	0.7	2.2	18.1	13.1	2.2	*	0.021	0.010	
C	C-1	Cast on sample	0.06	0.7	1.8	18.3	13.4	2.4	0.24	0.021	0.014	
AF	C-1	Cast on sample	*	0.7	1.9	18.3	13.2	2.4	*	0.024	0.013	re-run after PM
ab	**I.D.**	**Sample**	**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**P**	**S**	
AF	C-2	Reported	0.06	0.5	2.8	18.0	13.2	2.3	0.26	0.023**	0.018**	
AF	C-2	Cast on sample	*	0.8	2.2	18.1	13.4	2.2	*	0.030	0.012	
C	C-2	Cast on sample	0.07	0.9	1.6	18.2	13.7	2.2	0.23	0.023	0.014	
			*	0.8	1.6	18.2	13.5	2.3	*	0.024	0.012	re-run after PM

b	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
\F	C-3	Reported	0.04	0.4	2.5	18.2	13.3	2.3	0.25	0.023**	0.013**	
\F	C-3	Cast on sample	*	0.6	1.9	18.0	13.3	2.4	*	0.027	0.010	
C	C-3	Cast on sample	0.06	0.6	1.6	18.3	13.7	2.4	0.24	0.029	0.009	
\F	C-3	Cast on sample	*	0.6	1.6	18.1	13.5	2.4	*	0.023	0.011	re-run after PM
st Heat poured 1/14/04												
b	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
\F	24424	Reported	0.054	0.4	2.8	18.1	12.94	2.21	0.27	0.029	0.010	
\F	24424	Keel bar	*	0.4	2.2	18.2	13.2	2.2	*	0.013	0.010	re-run after PM
ot analyzed by spectrometer.												
analyzed by wet chemistry.												
r C-5 and C-6 - C and N were analyzed at CAF and at WC by Leco Analyzer, P+S analyzed on spectrometer.												

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August 16, 2005

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1.) In the onset, Alloy#1, a less alloyed variant of 316ss, was considered; however, the concern within PPPL and MetalTek was the effects of water quenching on the alloy during solution anneal (e.g. dimensional control and residual stresses).
2.) The limits for P and S in the Alloy #1 were set to comply with standard CF8M (cast "316ss") limits of 0.04% maximum for both.
3.) In order to eliminate water quench, a second alloy was funded under the scope of the 2.1.2 Task. This alloy was successful and has been referred to as "Stellaloy."
4.) The limits for P and S in the Alloy #2 were set to comply with standard limits for CF8M, again 0.04% maximum.
5.) Heats were made for each alloy, with both P and S well below the 0.04% maximum limits; however, one heat showed P above the 0.015% ultimately recommended.
6.) Based on review of the testing, MetalTek International Research recommended a chemical composition range for the ultimate 2.1.2 task. This range incorporated restrictions on the P and S at 0.015% maximum limits. Insufficient review of this recommendation against historic chemical analyses and those reported in the task was performed, resulting in the recommendation to PPPL to use the lower limits.

In essence, insufficient review of available data outside the recommendation of the MetalTek International Research group resulted in the proposal of a specification beyond the limits of the planned production processes.

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