



Corrective Action 1323
Carondelet Division - CA / PA / RGA Database
Corrective Action Type NCR
Date 7/27/2005
CA Originator C. Ruud
Applies to: Coil castings C-1, C-2, C-3, C-4 and A-1 and C 1 shim and four C coil and six A coil shims

Description of Defect / Non-Conformance

Phosphorus levels in material produced to date exceed specification limits. Both phosphorus and sulfur readings reported erroneously in certifications.

Certification reports have shown phosphorus and sulfur levels in the <.01% range. Independent laboratory data confirmed phosphorus in the .018 to .033% range and sulfur in the .005 to .022% range. Actual levels of some tests are above those in PPPL Specification NCSX-CSPEC-141-03-07 Rev 7.

Nonconformance was first suspected as a result of analysis of zoned attached test specimens volunteered by MetalTek International as response to PPPL questions on weighted average chemical analysis and quality of blending in the gating system. Nonconformance was verified on the bars used in the study and has been extended to evaluation of previously poured products.

Root Cause

Specification limits were set below the levels achievable through use of available raw materials. Spectrometer did not properly calibrate for phosphorus and sulfur at levels of specification due to equipment malfunction.

The chemical specification of EIO heats uses alloy CF8MNMn-Mod which incorporates a type standard calibration with a certified reference material (CRM) BS180. This enables the operator of the spectrometer to match the elemental concentrations of this alloy with corrective factors. These factors are determined by analyzing the CRM and having them compared with the calibration curves for each element. The phosphorus and sulfur content have very low measured intensities due to low concentrations. Intermittent failure of the spectrometer intensity measuring card caused higher intensity readings for phosphorus and sulfur. Subsequent checks with the CRM resulted in low corrective factors that were not detected. This in turn resulted in low reported concentrations for the EIO samples. All the major elements, which are measured on other intensity cards, have been closely monitored and matched very well with the CRM and thus were reported correctly.

Corrective Action

Modification to specification for phosphorus and sulfur will be requested. Limits will be set based on process capability and consistent with other stainless steel grades. Replacement of deficient card in spectrometer will be made upon delivery.

Subsequent immediate analysis of chemistry results, obtained by wet analysis, is attached and demonstrate top of specification for sulfur and over specification for phosphorus. The spectrometer manufacturer has performed an analysis to determine the cause of the malfunction and verified that the intensity card has an intermittent fault and must be replaced. The card has been ordered and scheduled for replacement on August 15, 2005.

Until the card is replaced we will be performing additional type standardizations to ensure accurate sulfur and phosphorus analysis. Additionally, for coils made until the card is replaced, an independent laboratory will perform a verification of the chemical analysis.

Verification of Corrective Action

Will be determined at a later date.

Preventive Action

In addition to spectrometer faults, we have identified that the specification ranges for sulfur and phosphorus is unattainable. Analysis and specifications for virgin charge materials predict sulfur at 0.040% maximum and phosphorus at 0.040% maximum. We have no way to remove phosphorus from the melt and do not intentionally add phosphorus. So, the confirmed coil analyses, along with analyses of virgin material heats, demonstrate sulfur in the range of 0.010% to 0.022% and phosphorus in the range of 0.018% to 0.033%. These results are consistent with our charge material analysis. We will request a deviation for phosphorus in the subject parts and also request a permanent specification change to 0.040% maximum for both phosphorus and sulfur, to allow us to provide non-discrepant material. This change will not affect, in any way, the physical properties or material performance because all coils and test material exhibited sulfur and phosphorus within the new ranges despite inaccurate reporting. Other actions: Specifications have been added to the BS 180 standard and the type standard will be measured against the criteria.

Estimated Completion Date

August 15, 2005

Actual Completion Date TBD

Signed: C. Ruud



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

Guide to St Louis Testing Report Dated 7-26-05

Sample name	Sample origin
A1Z1	Cast on bar A-1 coil, zone 1
A1Z2	Cast on bar A-1 coil, zone 2
A1Z3	Cast on bar A-1 coil, zone 3
C1	Cast on bar C-1 coil
C2Z1	Cast on bar C-2 coil, zone 1
C2Z2	Cast on bar C-2 coil, zone 2
C2Z3	Cast on bar C-2 coil, zone 3
C3Z1	Cast on bar C-3 coil, zone 1
C3Z2	Cast on bar C-3 coil, zone 2
C3Z3	Cast on bar C-3 coil, zone 3
F1	Final analysis button from ladle for C-4 coil
F2	Final analysis button from ladle for C-4 coil
F3	Final analysis button from ladle for C-4 coil
P1	Preliminary analysis button from ladle for C-4 coil

Testing is underway of the heat used to pour the four C coil and six A coil shims.



Attachment to
CA 1323

Chemical, Metallurgical, Mechanical, Nondestructive, Environmental Testing, Analyses and Field Service.

July 26, 2005
Lab No. 05C-0608
Invoice No. 59891
P.O. No. 21324
Page 1 of 1

METALTEK INTERNATIONAL
8600 Commercial Blvd.
Pevely, MO 63070

Attention: Chuck Ruud

REPORT OF CHEMICAL ANALYSIS

SAMPLE ID: A1 Z1, A1 Z2, A1 Z3, C1, C2 Z1, C2 Z2, C2 Z3,
C3 Z1, C3 Z2, C3 Z3, F1, F2, F3, P1

RESULTS: %

ANALYTE	A1Z1	A1Z2	A1Z3
Sulfur	.013	.005	.010
Phosphorus	.025	.023	.018

ANALYTE	C1	C2Z1	C2Z2	C2Z3
Sulfur	.014	.022	.018	.015
Phosphorus	.018	.024	.021	.025

ANALYTE	C3Z1	C3Z2	C3Z3
Sulfur	.013	.014	.012
Phosphorus	.024	.025	.021

ANALYTE	F1	F2	F3	P1
Sulfur	.014	.015	.012	.010
Phosphorus	.029	.033	.028	.030

Sulfur Test Method: ASTM E1019-03

Phosphorous Test Method: Colormetric

Identification of tested specimen provided by the client.

Robin E. Sinn
Laboratory Director

RES/nmc





Carondelet Division

8600 Commercial Blvd. - Pevely, MO 63070 USA
Phone: 636-479-4499 - Fax: 636-479-3399

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

Two handwritten signatures in black ink. The first signature on the left is stylized and appears to be "JE". The second signature on the right is also stylized and appears to be "CR".



Addendum to CA1323 8-17-05

Historical:

The proto type coil was poured on February 24, 2004. The chemistry specification at that time permitted a maximum of 0.04% for sulfur and phosphorus. The reported values for these elements were 0.01 and 0.02% respectively.

Prior to pouring the C-1 coil casting the specification was revised. MT failed to incorporate the revisions into our system. The contract review procedure did not detect the changes to the specification. Therefore normal change procedures were not implemented. This was reported in corrective action 1308 on June 13, 2005. The error was recognized when the material poured to cast C and A coil shims did not meet the revised specification.

An investigation was begun immediately to determine compliance of the C-1 and C-2 coils. It was determined that both the C-1 and C-2 met the revised chemistry, except for sulfur and phosphorus. To verify the analysis MT analyzed samples from the cast on bars taken from the coils. By this time the optical card had malfunctioned. This fact, in combination with the human error (believing that the type standard was also in the 0.002% range) led MT to believe that the sulfur and phosphorus were actually in the 0.002% range. As a result MT believed the coils to be compliant and no action was taken.

Current Activities:

Samples from A-1, C-4 and C-5 have been sent to Wisconsin Centrifugal, our parent company for independent analysis of all reported elements.

Repair to the spectrometer is scheduled for this week. In the mean time we continue our surveillance of the suspect elements during melt and chemistry analysis.

C. Ruud

A handwritten signature in black ink, appearing to read "C. Ruud", written over a white background.

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



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.

A handwritten signature in black ink, appearing to read "C. Ruud".

C. Ruud

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

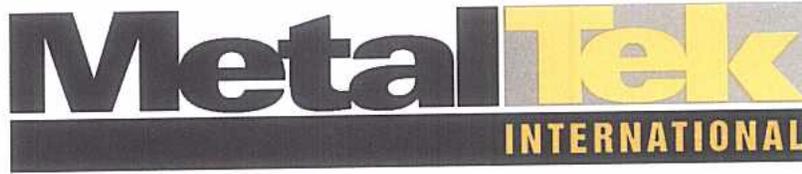
Chemistry Check with WISCO

Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S
CAF	C-5,-1	Button #1	0.05	0.3	2.6	18.1	13.4	2.4	0.26	0.023	0.011
CAF	C-5,-1	Button #2	0.05	0.4	2.6	18.0	13.4	2.6	0.26	0.026	0.013
WC	C-5,-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,-1	Button #1			2.2						
CAF	C-5,-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,-3	Button #1	0.05	0.4	2.2	17.9	13.4	2.5	0.24	0.033	0.012
CAF	C-5,-3	Button #2	0.05	0.4	2.2	17.9	13.2	2.4	0.24	0.033	0.012
WC	C-5,-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,-3	Button #1			1.8						
CAF	C-5,-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,-6	Button #1	0.05	0.3	2.4	18.1	13.2	2.4	0.25	0.030	0.012
CAF	C-5,-6	Button #2	0.05	0.3	2.4	18.1	13.2	2.4	0.25	0.029	0.011
WC	C-5,-6	Button #2	0.04	0.3	2	18.3	13.3	2.4	0.24	0.031	0.018
STL Wet	C-5,-6	Button #1			1.9						
CAF	C-5,-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	0.030**	0.014**
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	0.030**	0.014**
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.



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.

A handwritten signature in black ink, appearing to read "C. Ruud".

C. Ruud

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

Chemistry Check with WISCO			Revised 9-30-05			Information in blue added 9-30-05						
Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
Heat #29198 for 5 C and 6 A shims												
CAF	29198	Reported 9/24/05	0.07	0.7	2.97	18.1	13.12	2.45	0.255	0.013**	0.01**	
CAF	29198	Separate Test bar	*	0.8	2.7	18.2	13.2	2.4	*	0.025	0.011	re-run after PM
Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	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
CAF	C-6,I-1	Button #2	*	0.2	2.4	18.1	13.6	2.4	*	0.03	0.012	run after PM
WC	C-6,I-1	Button #2	0.03	0.2	2.4	17.9	13.7	2.5	0.26	0.028	0.010	
Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	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
CAF	C-6,I-3	Button #2	*	0.4	2.4	18.2	13.7	2.3	*	0.033	0.012	run after PM
WC	C-6,I-3	Button #2	0.03	0.4	2.2	17.9	13.6	2.4	0.25	0.028	0.013	
Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	C-6,I-6	Button #1	0.04	0.4	2.6	18.3	13.4	2.4	0.26	0.031	0.010	run after PM
CAF	C-6,I-6	Button #2	*	0.4	2.5	18.2	13.7	2.4	*	0.031	0.013	run after PM
WC	C-6,I-6	Button #2	0.04	0.4	2.4	18.2	13.7	2.4	0.26	0.030	0.014	
Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	C-6,Z-3	Cast on sample	*	0.6	1.7	18.1	13.6	2.4	*	0.031	0.012	run after PM
WC	C-6,Z-3	Cast on sample	0.04	0.6	1.7	17.8	13.8	2.4	0.26	0.025	0.011	
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	0.025	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	0.030**	0.014**	
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	0.013**	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	0.023	0.009	
CAF	C-3	Cast on sample	*	0.6	1.6	18.1	13.5	2.4	*	0.023	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	Reported	0.054	0.4	2.8	18.1	12.94	2.21	0.27	0.023	0.010	
CAF	24424	Keel bar	*	0.4	2.2	18.2	13.2	2.2	*	0.013	0.010	re-run after PM
* not analyzed by spectrometer.												
** analyzed by wet chemistry.												
For C-5 and C-6 - C and N were analyzed at CAF and at WC by Leco Analyzer, P+S analyzed on spectrometer.												