



Corrective Action

1323

Carondelet Division - CA / PA / RGA Database

Corrective Action Type NCR

Date 7/27/2005 Revised 1/18/06

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.

During this investigation it was discovered that the manganese results were also flawed. We were over reporting by approximately 0.5%.

### **Root Cause**

Specification limits for phosphorus and sulfur 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 CF8MNMNMod 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.

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.

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 erroneous phosphorus and sulfur analysis. No other mechanical or software problem that would affect manganese was determined.

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 was sufficiently outside the range of Mn and inducing error. No other root cause has been determined.

#### **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 was completed on August 29, 2005.

In consideration of the erroneous Mn and other elemental readings, the following actions have been taken. Create a type standard that closely matches the Mn in CF8MNMNMOD. This type standard was implemented with A-4 coil.

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.

#### **Verification of Corrective Action**

All analysis of CF8MNMNMod will be verified by an outside laboratory. See attached reports comparing the results. Results correlate very well.

#### **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.

**Estimated Completion Date**

August 15, 2005

**Actual Completion Date**

Spectrometer preventive maintenance completed on August 29, 2005.

A new type standard has been created and put to use starting with Coil A-4.

The specification for phosphorus and sulfur were revised to 0.035% and 0.025%, respectively.



Signed: C. Ruud

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

Chemistry Check with WISCO  
A Coils

Revised 12-13-05

Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	A-3 I-1	Button #1	0.04	0.3	2.8	18.1	13.4	2.2	0.26	0.034	0.012	run after PM
CAF	A-3 I-1	Button #2	*	0.3	2.7	18.1	13.4	2.3	*	0.034	0.012	run after PM
WC	A-3 I-1	Button #2	*	0.3	2.6	17.9	13.4	2.3	*	0.035	0.016	
Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	A-3 I-3	Button #1	0.04	0.4	2.9	18.2	13.3	2.2	0.26	0.034	0.012	run after PM
CAF	A-3 I-3	Button #2	*	0.4	2.9	18.2	13.3	2.2	*	0.030	0.011	run after PM
WC	A-3 I-3	Button #2	*	0.4	2.7	18.1	13.4	2.2	*	0.032	0.016	
Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	A-3 I-6	Button #1	0.04	0.4	3	18.3	13.2	2.2	0.25	0.034	0.012	run after PM
CAF	A-3 I-6	Button #2	*	0.4	2.9	18.3	13.2	2.2	*	0.031	0.012	run after PM
WC	A-3 I-6	Button #2	*	0.4	2.7	18.2	13.4	2.2	*	0.034	0.016	
Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	A-2 I-1	Button #1	0.04	0.5	2.8	18.5	13.2	2.3	0.24	0.031	0.012	run after PM
CAF	A-2 I-3	Button #2	0.04	0.4	2.9	18.1	13.1	2.4	0.24	0.038	0.012	run after PM
CAF	A-2 I-6	Button #2	0.04	0.3	2.9	18.2	13.0	2.3	0.26	0.035	0.016	run after PM
Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	A-2 Z-1	Cast on sample	*	0.4	2.7	18.2	13.0	2.3	*	0.035	0.012	run after PM
WC	A-2 Z-1	Cast on sample	*	0.4	2.5	18.0	13.2	2.3	*	0.034	0.026	
CAF	A-2 Z-2	Cast on sample	*	0.6	2.5	18.3	13.1	2.3	*	0.032	0.012	run after PM
WC	A-2 Z-2	Cast on sample	*	0.6	2.3	18.2	13.3	2.3	*	0.030	0.024	
CAF	A-2 Z-3	Cast on sample	*	0.4	2.7	18.1	13.0	2.3	*	0.036	0.012	run after PM
WC	A-2 Z-3	Cast on sample	*	0.4	2.5	18.1	13.2	2.3	*	0.036	0.029	
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
* not analyzed by spectrometer.												

Chemistry Check with WISCO

Revised 12-13-05

B Coils			C	Si	Mn	Cr	Ni	Mo	N	P	S	
Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	B-1 I-1	Button #1	0.04	0.3	2.9	18.4	13.0	2.3	0.25	0.032	0.012	run after PM
CAF	B-1 I-1	Button #2	*	0.3	2.8	18.3	12.9	2.3	*	0.034	0.013	run after PM
WC	B-1 I-1	Button #2	*	0.3	2.6	18.2	13.0	2.3	*	0.031	0.019	
Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	B-1 I-3	Button #1	0.04	0.4	2.7	18.3	13.1	2.2	0.25	0.035	0.012	run after PM
CAF	B-1 I-3	Button #2	*	0.4	2.8	18.3	13.2	2.2	*	0.038	0.013	run after PM
WC	B-1 I-3	Button #2	*	0.4	2.7	18.2	13.3	2.2	*	0.037	0.020	
Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	B-1 I-6	Button #1	0.04	0.4	2.9	18.3	13.1	2.2	0.25	0.040	0.012	run after PM
CAF	B-1 I-6	Button #2	*	0.4	2.9	18.3	13.1	2.3	*	0.032	0.012	run after PM
WC	B-1 I-6	Button #2	*	0.4	2.7	18.1	13.2	2.3	*	0.038	0.019	

\* not analyzed by spectrometer.

Chemistry Check with WISCO  
C Coils and Shims

Revised 12-13-05

Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	C-6 I-1	Button #1	0.04	0.3	2.9	18.1	13.0	2.4	0.25	0.026	0.012	run after PM
CAF	C-6 I-1	Button #2	*	0.3	2.9	18.1	13.3	2.3	*	0.028	0.011	run after PM
WC	C-6 I-1	Button #2	*	0.3	2.8	18.1	13.4	2.3	*	0.027	0.022	
Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	C-6 I-3	Button #1	0.04	0.3	2.7	18.2	13.3	2.3	0.25	0.027	0.012	run after PM
CAF	C-6 I-3	Button #2	*	0.3	2.7	18.2	13.4	2.3	*	0.026	0.011	run after PM
WC	C-6 I-3	Button #2	*	0.3	2.6	18.1	13.4	2.3	*	0.025	0.018	
Lab	I.D.	Sample	C	Si	Mn	Cr	Ni	Mo	N	P	S	
CAF	C-6 I-6	Button #1	0.04	0.4	2.9	18.1	13.2	2.3	0.25	0.034	0.013	run after PM
CAF	C-6 I-6	Button #2	*	0.4	2.9	18.1	13.3	2.3	*	0.034	0.011	run after PM
WC	C-6 I-6	Button #2	*	0.4	2.7	18.1	13.4	2.3	*	0.030	0.024	
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	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-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
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-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
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	24424	Reported	0.054	0.4	2.8	18.1	12.94	2.21	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.