**Nonconformance Report: CA 1549 (Low Mn for C-6 Shim)**

**Project Disposition:**

The 2.0% Manganese, 0.3% under the NCSX-CSPEC-141-02 minimum of 2.3%, is accepted as is for the C-6 Shim casting. The specification chemistry will not be changed at this time.

**Approvals:**

Phil Heitzenroeder

Digitally signed by Phil Heitzenroeder
DN: CN = Phil Heitzenroeder, C = US, O = PPPL, OU = Mech. Eng. Division
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Corrective Action 1549
Carondelet Division
Corrective Action Type NCR
Date 1-27-06
CA Originator C. Ruud
Applies to: C-6 Coil Shim SN#6

**Description of Defect / Non-Conformance**
Manganese levels in material produced for C-6 coil shim casting exceed specification limits in PPPL Specification NCSX-CSPEC-141-03-07 Rev 10. Manganese is 0.3% under the minimum of 2.3%. See attached test report.

**Root Cause**
This casting was produced prior to the discovery of the spectrometer reading Mn higher than actual. Corrective action 1323 has resolved that issue.

**Corrective Action**
Use casting as is.

**Verification of Corrective Action**
See CA 1323. Spectrometer preventive maintenance completed on August 29, 2005.
A new type standard has been created and put to use starting with Coil A-4.

**Preventive Action**
The specification for manganese should be increased.

**Verification of Preventative Action**
Pending

**Estimated Completion Date**
8-15-05

**Actual Completion Date**
8-29-05

Signed: C. Ruud

CC:B. Craig, J. Edwards, E.J. Kubick, J. Markham, J. Galaske

# Material Test Report

ENERGY INDUSTRIES OF OHIO

Date: 1/27/2006

| | | | |
|---|---|---|---|
| Purchase Order Number | PPPL-FP-LTS-2 | Cert Number | S73220-1 |
| Pattern Number | SE-141-073 Coil C-6 Shim S/N 6 | Pour Date | 12/15/2004 |
| CAF Metal Designation | CF8MNMnMod | | |
| Material Spec | CF8MNMnMOD | | |
| Heat 27698 | | | |

| Element | Min | Actual | Max |
|---|---|---|---|
| C | 0.040 | 0.06 | 0.070 |
| MN | 2.300 | 2.7 | 2.800 |
| SI | 0.000 | 0.7 | 0.700 |
| CR | 18.000 | 18.1 | 18.500 |
| NI | 13.000 | 13.2 | 13.500 |
| MO | 2.100 | 2.2 | 2.500 |
| P | 0.000 | 0.020 | 0.035 |
| S | 0.000 | 0.004 | 0.025 |
| N | 0.240 | 0.28 | 0.280 |

Original analysis performed when heat was poured.

PRODUCT ANALYSIS

Results of spectrometer analysis of casting after spectrometer preventive maintenance performed.

| Element | |
|---|---|
| C | ** |
| MN* | 2 |
| SI | 0.7 |
| CR | 18.1 |
| NI | 13.1 |
| MO | 2.2 |
| P | 0.021 |
| S | 0.009 |
| N | ** |

** Not analyzed on spectrograph.

MN* See CA 1549

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 tum 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 CF8MMNMMod 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 Revised 12-13-05
A Coils

| 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 B Coils — Revised 12-13-05

| Lab | I.D. | Sample | 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 | .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-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.