

Princeton University

**Plasma Physics Laboratory**  
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22 November 2005

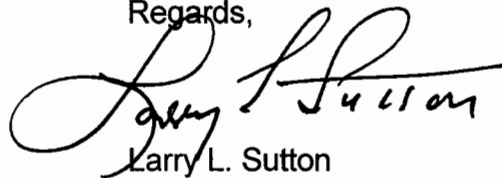
Ms. Nancy Horton  
Energy Industries of Ohio  
6100 Oak Tree Boulevard, Suite 200  
Independence, Ohio 44131

**SUBJECT:** Subcontract S005242-F  
MTK Corrective Action (CA) (NCR) 1454 Pertaining to C-5 Coil  
Casting

Dear Ms. Horton:

Attached for appropriate action is Corrective Action (CA) Non-Conformance Report (NCR) 1454, submitted by MetalTek International (MTK) 18 November 2005 and the NCSX disposition of that CA 1454 approved by the Princeton Technical Representative for Subcontract S005242-F and the NCSX Core Systems Engineering Manager on 22 November 2005.

Regards,

A handwritten signature in black ink, appearing to read "Larry L. Sutton". The signature is written in a cursive style with a large initial "L".

Larry L. Sutton  
Senior Subcontract Administrator

Attachment

cc: M. Tyrrell  
F. Malinowski  
P. Heitzenroeder



Corrective Action 1454  
Carondelet Division - CA / PA / RGA Database  
Corrective Action Type NCR  
Date 11/18/2005  
CA Originator C. Ruud  
Applies to: C-5 Coil casting

**Description of Defect / Non-Conformance**

Zone 1 Tensile test at 77K failed elongation at 31% compared to the specification minimum of 32%. A retest also failed at 29%. All other properties exceeded the specification of NCSX-CSPEC-141-03-09. See attached summary of room temperature and cryogenic test results.

**Root Cause**

Zone 1 test samples have solidified with much less superheat than the other zones as a result of their relative orientation in the mold and mold filling. Zone 1 test bars are in the bottom of the drag, zone 2 and 3 are much higher in the mold. Zone 1 test bars are getting the first cold metal poured which explains the fine grain structure versus zones 2 and 3. Photomicrographs verify that zone 1 has much finer grain structure than the other zones, see St Louis Testing lab report 05M1167. To verify our thinking the zone 1 test bar was heat treated for 7 hours at 2050 F, the same as the coil casting. Photomicrographs indicate that the grain structure did not coarsen significantly, see St Louis Testing lab report 05M1182. Therefore we conclude the fine structure caused by cold metal entering the cavity is adversely affecting ductility at cryogenic temperatures. Photomicrographs taken at Westmoreland indicate there were no defects to cause the failure, see attached photos.

**Corrective Action**

Use as is.

**Verification of Corrective Action**

TBD

**Preventive Action**

Possibly relocate the cast on bars.

**Estimated Completion Date**

TBD

**Actual Completion Date**

TBD

Signed: C. Ruud

A handwritten signature in black ink, appearing to be "C. Ruud", written over a horizontal line.

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

C-5 Coil

11/18/2005

77K (-320F)

293K (RT)

Casting	Test 1					Test 2					
	Required	C5-1Z	C5-2Z	C5-3Z	C5-1Z	C5-2Z	C5-3Z	Required	C5-1Z	C5-2Z	C5-3Z
Elastic Modulus	21 Msi (144.8 Gpa)	33	31.8	28	34.5	28.2	25.9	20 Msi (137.9 Gpa)	28.4	27.7	25.9
0.2% Yield Strength	72 ksi (496.4 Mpa)	112.6	98.3	95.5	111.2	102.5	95	30 ksi	41.5	37.7	37.1
Tensile Strength	95 ksi (655 Mpa)	182.5	166.1	163.7	177.4	172.3	163.5	78 ksi (537.8 Mpa)	92.9	84.4	83.7
Elongation II	32%	31%	52%	59%	29%	41%	64%	36%	55%	52%	67%
Charpy V - notch Energy	35 ft. lbs. (47.4 J)	81	73	87				50 ft.-lbs (67.8 J)	130	131	156

## DISPOSITION OF CA 1454 (C5 ELONGATION)

NCSX accepts the 31% elongation (vs. 32% spec. requirement) from one of the test bars from the C5 winding form. However, we request that the details of the proposed corrective action be discussed at a Quality conference call before being implemented.

**Phil  
Heitzenroeder**

Digitally signed by Phil Heitzenroeder  
DN: CN = Phil Heitzenroeder, C = US,  
O = PPPL, OU = Mech. Eng. Division  
Reason: I am the author of this  
document  
Date: 2005.11.22 17:17:09 -05'00'

Tech. Rep.

**Brad Nelson**

Digitally signed by Brad Nelson  
DN: cn=Brad Nelson, c=US,  
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Date: 2005.11.22 17:20:45 -05'00'

NCSX Core Systems Engrg. Manager