MJO:	**3726**	**Date:**	**July 13, 2012**
S.O. NO:	**3164121**	**Customer:**	**DGS/RESD/BPM**

Cast Iron Pipe Fittings Corrosion Analysis

Introduction: Two cast iron pipe fittings from the 4th floor sanitary line of 450 North St. (Suite 1200), Sacramento, CA 95814, were submitted to MTL for corrosion analysis. Sample #1 was a 1/8th Bend and Sample #2 was a Tee. Both exhibited extensive corrosion from the inside out (See Figures 1 & 2 below) however the Tee was the worse case having to be delivered in two pieces.

Figure 1 – Inside of 1/8th bend fitting (Sample 1).

Martin Testing Laboratories
A Division of Materials Technology Laboratories, Inc.
4724 Arnold Ave.
McClellan, CA 95652
Ph: (916) 920-4110; Fx: (916) 920-4390

Figure 2 – Sample 2 – Fourth floor Tee.

Findings:

Alloy Identification:

Chemical analysis of the metal from both samples was performed by Wavelength X-ray Fluorescence with Carbon and Sulfur determined by Combustion. The compositions of many of the various cast irons overlap because of the wide range of allowable content. This makes exact determination of the alloy difficult although I can say that the compositions were found to be typical of ductile gray cast irons. The exceptions here are the relatively large concentrations of phosphorous and sulfur which are typically controlled to less than 0.08%. The full analysis results are presented below:

Sample ID:	SAMPLE 1
Material:	CAST IRON

CHEMICAL ANALYSIS

Element		Result %
C	=	3.65
Mn	=	0.51
P	=	0.157
S	=	0.061
Si	=	2.52
Cr	=	0.14
Ni	=	0.09
Mo	=	0.03
Cu	=	0.32
Mg	=	0.01
Ti	=	0.03
Fe	=	Balance

Chemical Analysis performed by Wavelength X-ray Fluorescence per SOP 4.00, Revision 8
Carbon and Sulfur by Combustion per SOP 7.00, Revision 7

FOR INFORMATION ONLY

Sample ID:	SAMPLE 2
Material:	CAST IRON

CHEMICAL ANALYSIS

Element		Result %
C	=	3.56
Mn	=	0.53
P	=	0.135
S	=	0.162
Si	=	2.45
Cr	=	0.21
Ni	=	0.10
Mo	=	0.03
Cu	=	0.21
Mg	=	0.01
Ti	=	0.02
Fe	=	Balance

Chemical Analysis performed by Wavelength X-ray Fluorescence per SOP 4.00, Revision 8
Carbon and Sulfur by Combustion per SOP 7.00, Revision 7

FOR INFORMATION ONLY

This document contains technical data whose export and re-export/ retransfer is subject to control by the U.S. Department of Commerce under the Export Administration Act and the Export Administration Regulations. The Department of Commerce's prior written approval may be required for the export or re-export/retransfer of such technical data to any foreign person, foreign entity or foreign organization whether in the United States or abroad.

Metallurgical Cross-Sections:

A sample from each fitting was sectioned out and mounted in cross-section in epoxy. The cross-section was polished down to 4000 grit then etched using nital solution. Both of the samples displayed an intact layer of brittle graphite and corrosion products. This layer is indicative of graphitic corrosion in gray iron in which the iron matrix is selectively leached away, leaving a porous mass of graphite.

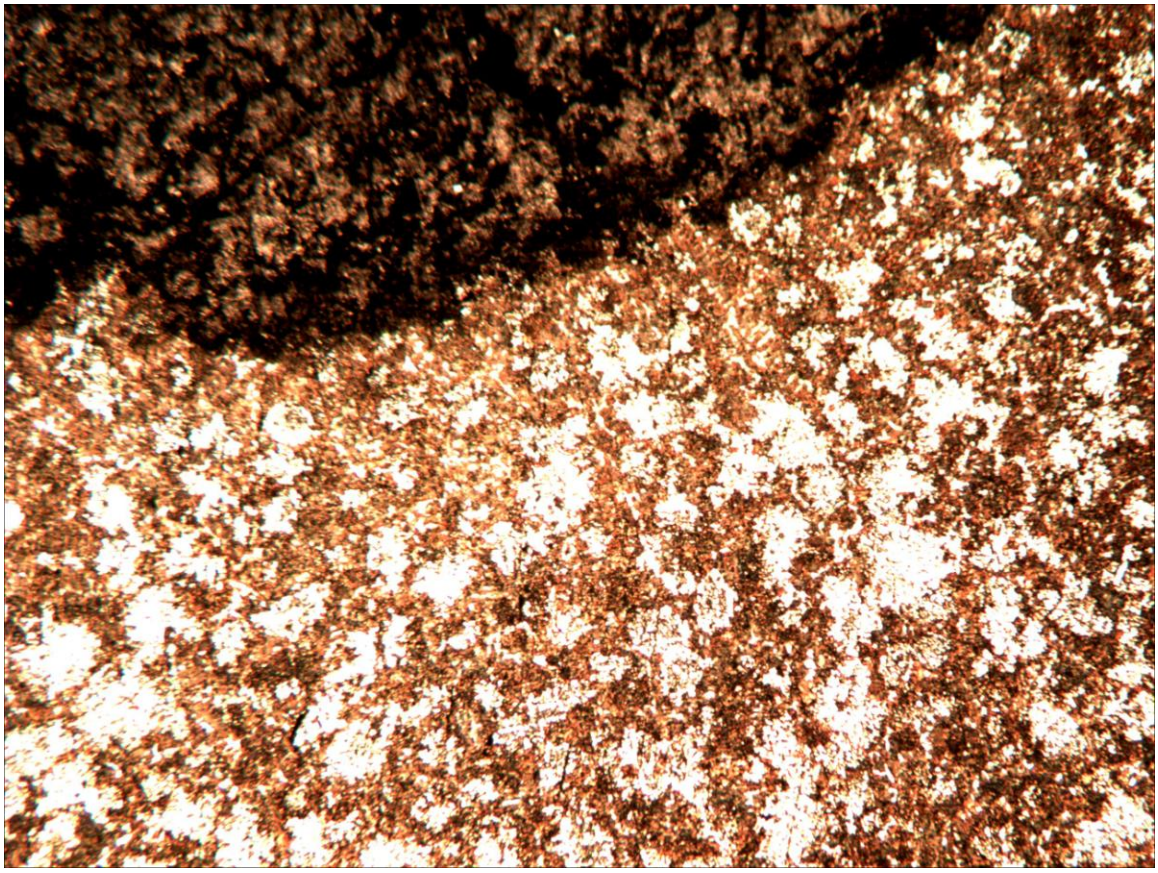

Figure 3 – Sample 1 at 100x. Black at top left is an intact porous layer of corrosion product & graphite. “Brighter” material is compromised base metal that has not yet been completely leached away.

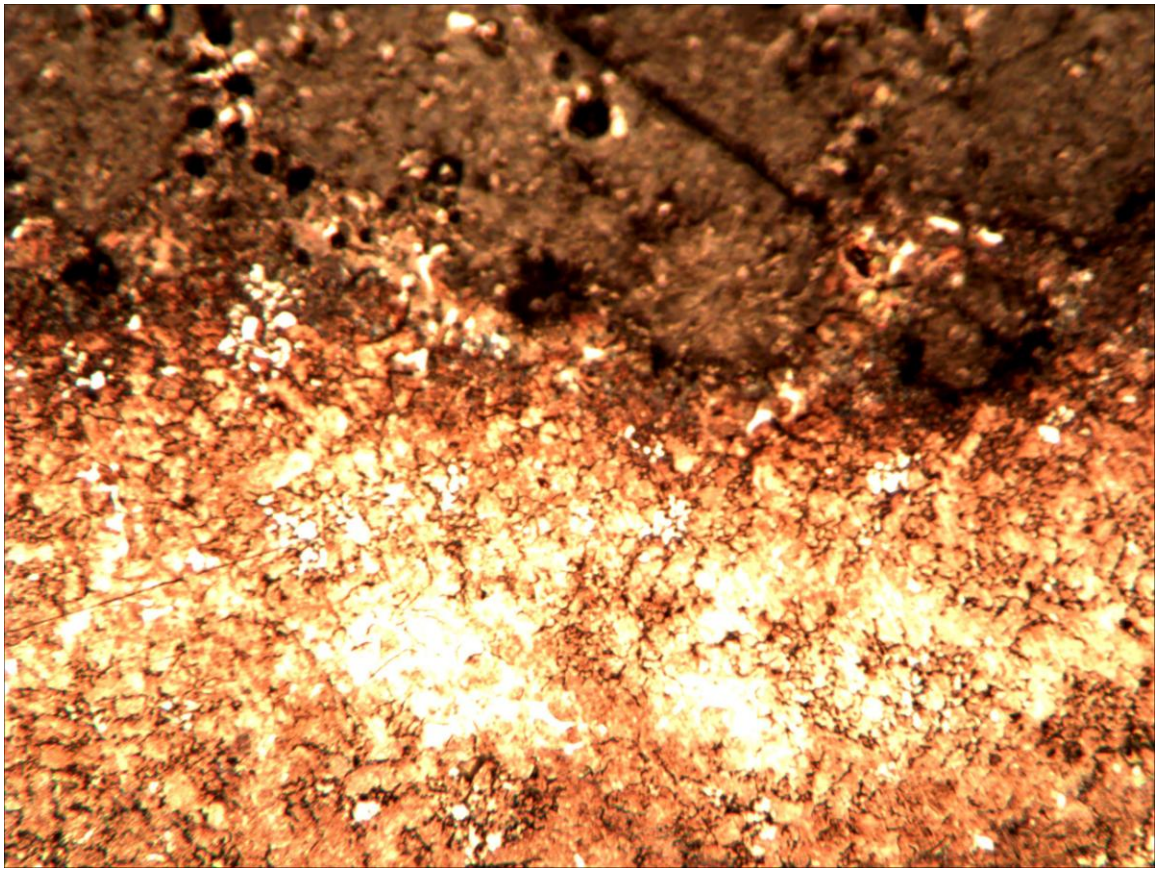

Figure 4 – Sample 2 at 200x. Close-up of the graphite (top)/ compromised metal interface.

Scanning Electron Microscope (SEM)/Energy Dispersive Spectroscopy (EDS) Analysis:

The full analysis will be available in Appendix I & II which will come as separate documents because of the size. Small amounts of sulfur were found in both samples. This may be indicative of hydrogen sulfide (sewer gas) contributing to the problem.

Conclusions:

The problem identified is Graphitic Corrosion. Graphitic corrosion is a form of dealloying unique to cast irons. It is observed in gray cast irons in relatively mild environments in which the selective leaching of iron leaves a porous graphite network. Selective leaching of the iron takes place because the graphite is cathodic to the iron making for an excellent galvanic cell. This form of corrosion generally occurs only when corrosion rates are low. If metal corrodes more rapidly, the entire surface, including the graphite is removed, and uniform corrosion occurs.

Experience has demonstrated that graphitic corrosion is favored by relatively mild environments such as soft waters, waters having a slightly acidic pH, waters having low levels (as little as 1 ppm) of hydrogen sulfide, and brackish and other high conductivity waters. A small amount of sulfur was detected in the corrosion products.

Recommendations for Prevention:

Alloy selection – White cast iron is immune to graphitic corrosion although it is susceptible to other forms.

Control of the environment – water traps could reduce or eliminate corrosion gases, raising the pH (via alkaline drain cleaners) is an inexpensive approach.

Use of sacrificial anode cathodic protection or impressed current cathodic protection.

Prepared By:

Perry L. Martin
Materials Engineer