Nuclear Regulatory Commission (NRC), Nuclear Energy Institute, and Industry Quarterly Meeting

Office of Nuclear Reactor Regulation (NRR)

Division of License Renewal

September 10, 2015

U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

Action Items from June 11, 2015 Quarterly Meeting

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Closed Items

- Open invitation to NRC on the upcoming ORNL trip in July.
- NRC and industry will coordinate efforts to prepare a Commissioner's Assistant note on SLR in August 2015.

Action Items from June 11, 2015 Quarterly Meeting

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Open Items

- Further discussion(s) on NEI 14-13 and NEI 14-12 in future quarterly meetings.
- NRC and industry will coordinate efforts to prepare for the ACRS briefing on SLR in November 2015.
- For the NEI SLR Roadmap, NRC suggested to embed live links to connect the Roadmap to other relevant sites (e.g., DOE/EPRI SLR sites).

Action Items from June 11, 2015 Quarterly Meeting

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Open Items

- NRC will review the EPRI documents discussed in Mr. Rich Tilley's presentation.
- For future quarterly meetings, staff will upload presentation slides to the public meeting website prior to the meeting so members of the public from remote locations could better follow along with the discussions.
- NRC will schedule a presentation on the best practice from experience in reviewing earlier LRAs in a future quarterly meeting.

Action Items from June 11, 2015 Quarterly Meeting

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Open Items

- NRC will provide feedback to NEI on a future NEI 95-10 like document for the SLR.
- Once the SLR guidance documents are issued for public comment and prior to the closing of the public comment period, NRC plans to schedule two separate public meetings to further discuss the guidance documents with industry in the January and February 2016 timeframe.

Selective Leaching of Ductile Iron Components

Office of Nuclear Reactor Regulation (NRR)
Division of License Renewal
Quarterly Meeting NRC/NEI/Industry
Brian Allik
September 10, 2015

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GALL Report AMP XI.M33: Selective Leaching (or Dealloying)

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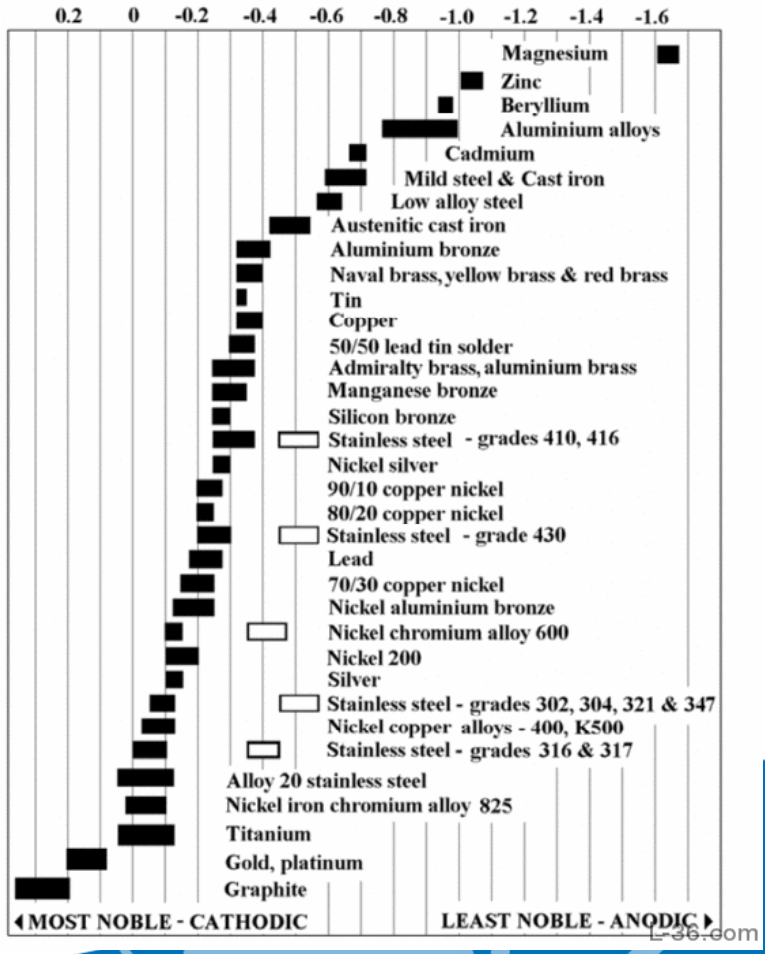
- Definition:
  - Involves selective corrosion of one or more components of an alloy – the least noble component in the alloy.
  - The part retains its shape and may appear unaffected, but it loses its strength.
- Susceptible Materials:
  - Copper alloys containing greater than 15% zinc – zinc leaching.
  - Copper alloys containing greater than 8% aluminum – aluminum leaching.
  - Gray cast iron – iron leaching.



Difference between Gray Cast Iron and Ductile Iron

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- Gray Cast Iron: ***Continuous*** network of graphite flakes surrounded by iron.

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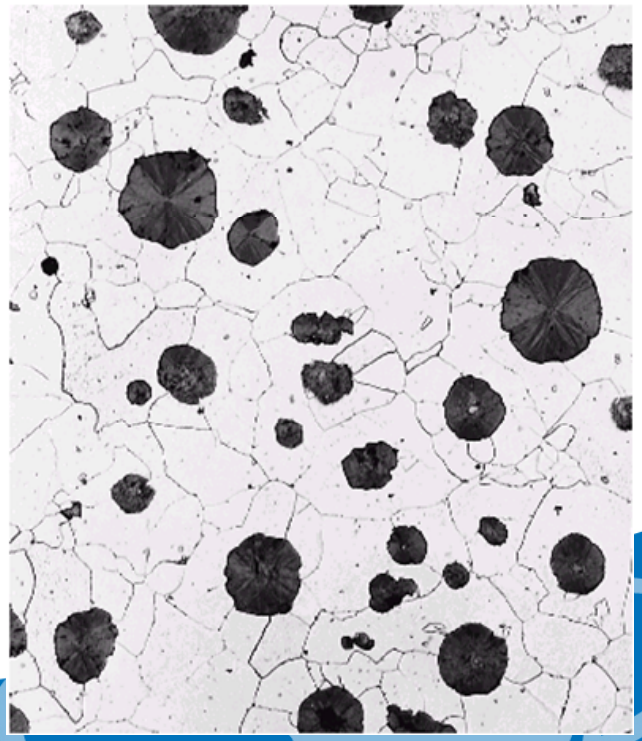
- Ductile Iron: Addition of small amounts of magnesium and/or cerium results in ***discrete*** nodules or spheres of graphite embedded in iron.



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Is Ductile Iron Susceptible to Selective Leaching?

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- Pitting most common form of corrosion in ductile iron pipe.
- Two differing opinions on susceptibility of ductile iron to selective leaching:
  - Not susceptible.
  - Less susceptible than gray cast iron.

- Both sides provide same basis for position:
  - Influence of local cathode (graphite) to anode (iron) surface area ratio.
  - Influence of continuous vs. discrete graphite phase.

Influence of Cathode/Anode Surface Area Ratio

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- Larger cathode/anode surface area = greater galvanic current
- Ductile iron would therefore be ***less susceptible, not immune***, to graphitic corrosion.

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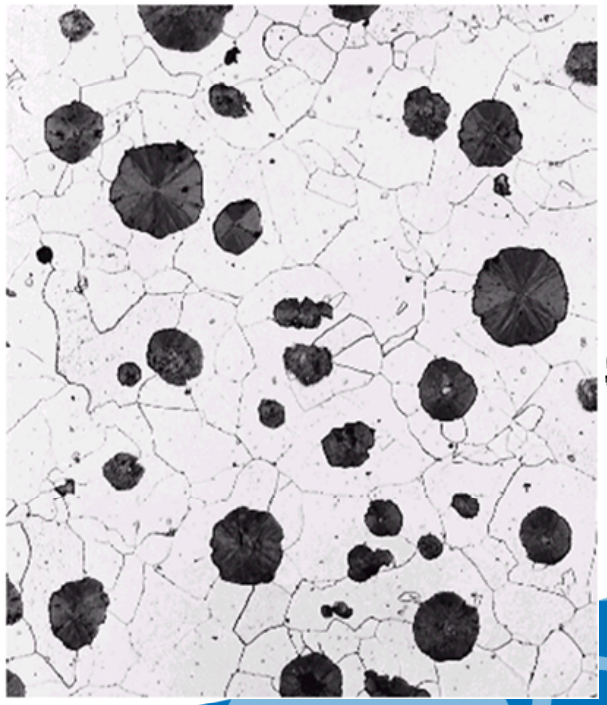

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Influence of Continuous vs. Discrete Graphite Phase

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- Selective leaching: retain shape, lose strength.
- Requires network to retain or 'hold-on' to corrosion products.
- Ductile iron consists of discrete graphite phase that cannot 'hold-on' to the corrosion products to prevent dimensional changes.

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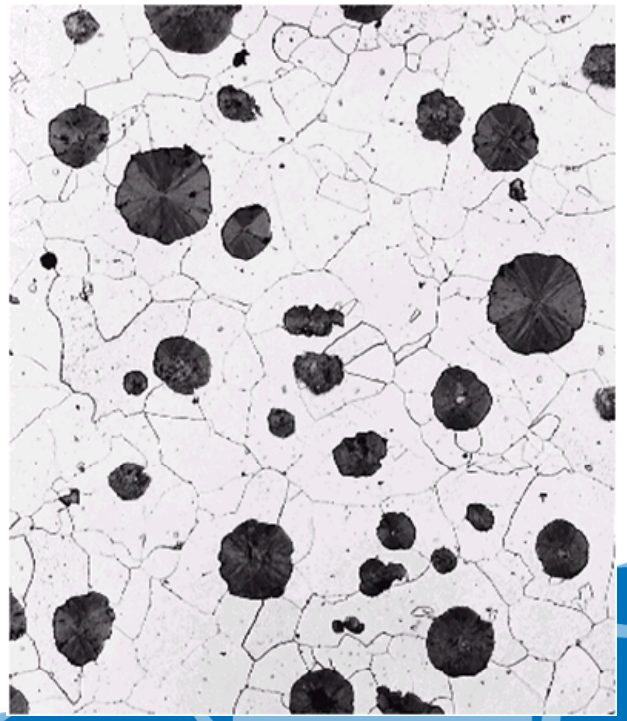

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Supporting Documentation of Ductile Iron Dealloying

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- "Buried water lines made from nodular (ductile) cast iron piping have been in use for several decades, ***and many utilities are reporting dealloying of this metal, which was once considered to be immune to dealloying***." – Uhling's Corrosion Handbook, Third Edition, page 148
- "The in-the-ditch inspections [referencing Metro Toronto gas mains] and laboratory examination of pipe samples confirmed that the cast iron corrosion products were hard and dense – often resembling the natural pipe surface and requiring chipping or sandblasting for identification. ***Our examinations of ductile iron pipe have revealed similar characteristics.***" - Effects of Soil Characteristics on Corrosion, American Society for Testing and Materials (ASTM) STP1013
- "ductile iron and gray iron not only corrode at the same rate, but that the pattern of corrosion and the ***nature of the corrosion products are also similar.***" - Performance of Ductile-Iron Pipe in Soils, American Water Works Association (AWWA)

Relative Susceptibility of Ductile Iron to Selective Leaching

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- ***"DIP typically corrodes by two mechanisms, graphitization and pitting corrosion."*** - Evaluating Ductile Iron Pipe Corrosion, American Society of Civil Engineers (ASCE)
- "Only cast irons containing graphite can corrode graphitically. Due to microstructural differences in graphite particle size, morphology, and distribution, as well as other differences in alloy composition, ***attack is usually worst in gray cast irons.***" - Nalco Guide to Boiler Failure Analysis, Second Edition
- "the smooth surface appearance of graphitized cast iron, ***and in some cases ductile iron***, may lead a casual observer to believe that the pipe has no corrosion damage and is still structurally sound." - Review of the Bureau of Reclamation's Corrosion Prevention Standards for Ductile Iron Pipe
- "This process is known as graphitic corrosion or graphitization and is a common form of corrosion on buried cast iron pipe and ***to a lesser degree on ductile iron***." - NACE International 57th Annual Appalachian Underground Corrosion Short Course, *Corrosion Control Considerations for Ductile Iron Pipe – A Consultant's Perspective*

Vancouver, British Columbia: Ductile Iron Pipe After Sandblasting

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*NACE International 57th Annual Appalachian Underground Corrosion Short Course May 15, 2012 Morgantown, West Virginia, "CORROSION CONTROL CONSIDERATIONS FOR DUCTILE IRON PIPE – A CONSULTANT'S PERSPECTIVE"

Influence of Continuous vs. Discrete Graphite Phase

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- Supporting documentation shows ductile iron can provide a network to 'hold-on' to iron oxide corrosion products.
- No consensus on the major factors influencing susceptibility.
  - Morphology
  - Graphite particle size
  - Graphite particle distribution
  - Processing conditions
  - Impurities
  - Soil resistivity
- Graphitized layer in ductile iron generally weaker and less adherent than in gray cast iron.

Conclusion/ Further Action

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- Ductile Iron is ***less susceptible, not immune,*** to selective leaching based on local cathode/anode relationship and graphite network structure.
- Given the lower susceptibility of ductile iron, a reasonable approach would be to perform inspections using one of the following approaches.
  - Use gray cast iron as a leading indicator for susceptibility to graphitic corrosion in a similar environment. Ductile iron would be inspected only if graphitic corrosion is identified for gray cast iron in a similar environment.
  - Create a separate population for ductile iron with a reduced sample size when compared to gray cast iron.

Conclusion/ Further Action

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- Considering the following.
  - Adding ductile iron as a material susceptible to selective leaching in AMP XI.M33.
  - Creating GALL-SLR line items for ductile iron.
  - Considering issuance of Information Notice.
- Submitted the following question for deep dive meetings with DOE, NEI, and EPRI.
  - What research is the industry conducting, or planning, with regard to the susceptibility of gray cast iron and ductile iron to selective leaching (graphitic corrosion)?

NEI 09-14 Reporting Scope

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All buried and underground piping and tanks outside of a building and below grade (whether or not in direct contact with soil) if they:

- are safety related,
- contain licensed material or are known to be contaminated with licensed material, or
- contain environmentally hazardous material.

In regard to reporting underground piping and tank leaks, the staff understands that the following has been added

- Leaks from piping and tanks that are within the scope of License Renewal for plants that have submitted for a renewed operating license

Requests in NEI Letter of July 7 , 2015 on Tables in GALL and SRP

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- An appendix in the SRP-SLR identifying the evolution of GALL lines from GALL Rev. 0 to GALL-SLR tables
- Same Information in the GALL-SLR and SRP-SLR Excel spreadsheet
- A new column in the GALL-SLR and SRP-SLR tables that identifies an item as new (N), modified (M), deleted (D) or blank (i.e., no change from GALL Rev 2.)
- Similar information for GALL 2 lines that have been modified by LR-ISGs
- Basis for GALL lines that have been modified, deleted, or incorporated into another GALL-SLR line (and the new number) and the reason for their applicability in the GALL-SLR Technical Basis NUREG