API Ethanol SCC in Tanks: Summary of Project Activities

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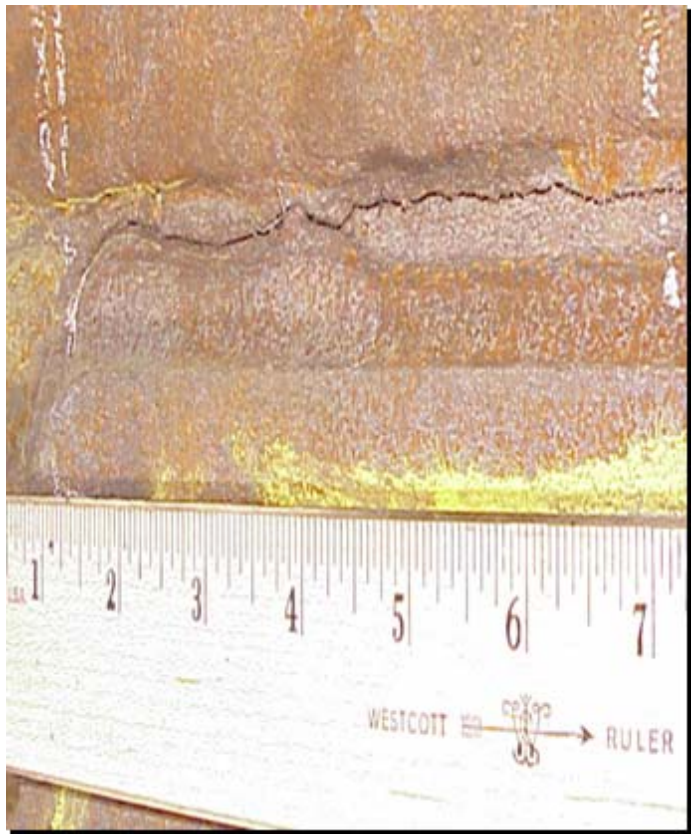
Background Information

- **Research supported by the American Petroleum Institute (API) through its Subcommittee on Corrosion and Materials**
- **SCC appears to be related to conditions of:**
  - Non-PWHT welds particularly those welds with very high stress/strain concentration
  - Residual stresses or cold work
- **SCC observed in wide geographical areas within U.S.**
  - West coast, Great Lakes, Gulf Coast
- **SCC reported at user facilities (e.g. at distribution terminals or storage and blending facilities)**
- **No SCC reported by ethanol producers**
- **No reported SCC after ethanol is blended with gasoline**



Example of Tank Bottom Failure

Program Objectives

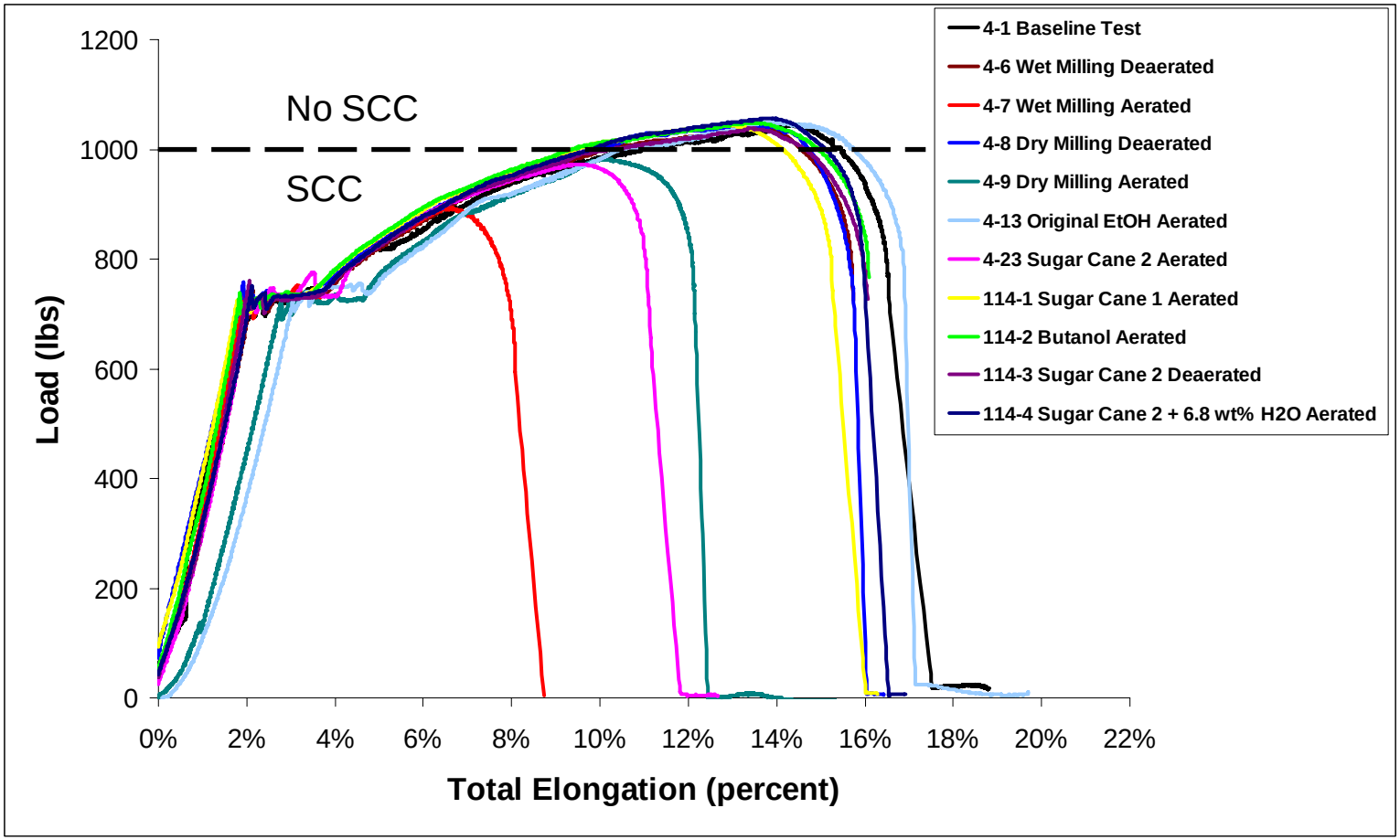
- **Initial phase was performed to determine the primary factors, within the ASTM D 4806 standard constituents, responsible for SCC of carbon steel**
- **Parametric study was conducted to evaluate the effect of water content, acetic acid, inhibitor, chloride, methanol, oxygen, denaturant and galvanic coupling on corroded steel**
- **Results showed that SCC can occur within current ASTM specifications with oxygen being the most important factor in causing SCC**
- **Recent studies have included the evaluation of additional factors including: effect of denaturant additions; effect of corrosion potential and ethanol processing source; and characterization of the SCC susceptibility of carbon steel in gasoline-ethanol blends**

Experimental Procedure

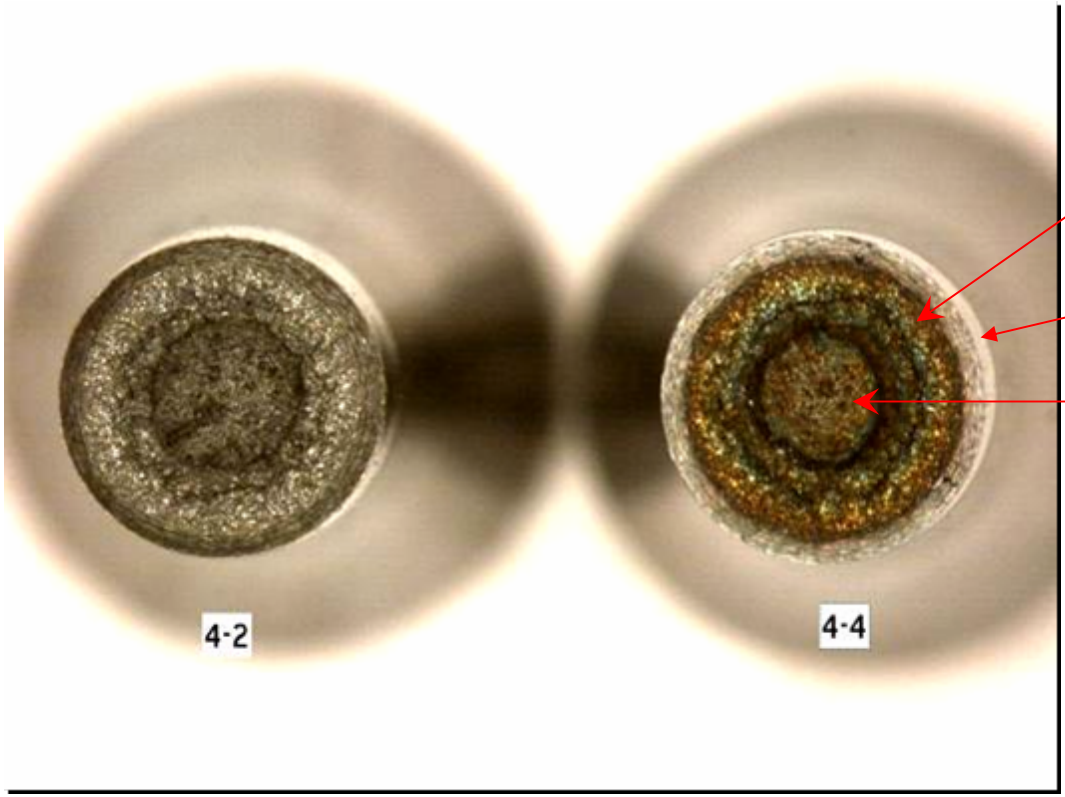
- **Notched SSRT specimens prepared from A-36 plate material**
- **Testing of actual fuel ethanol samples**
- **Chemical characterization performed on samples**
- **pH_e and water content analyses – before and after test**
- **Corrosion potential continuously monitored during SSRT**
- **Electrochemical testing performed on selected EtOH samples**

Strain rate = $4x10^{-7}$ per sec

Latest SSRT Results



Specimen Observations



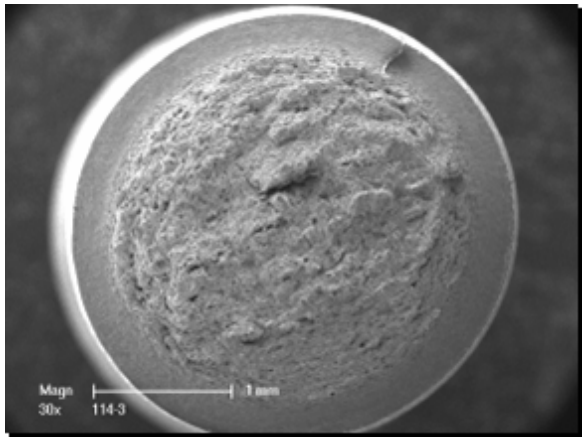
Rim of discoloration

Machine Notch

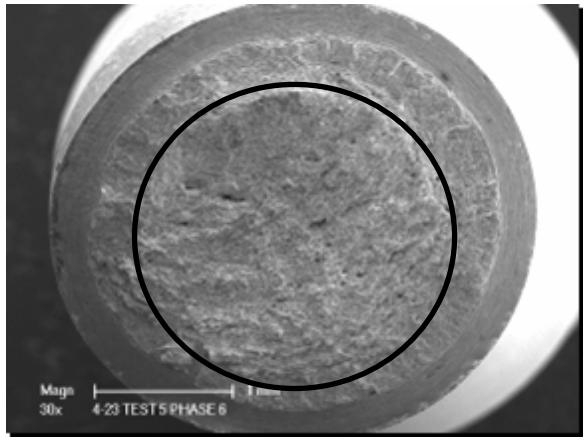
Ductile fracture

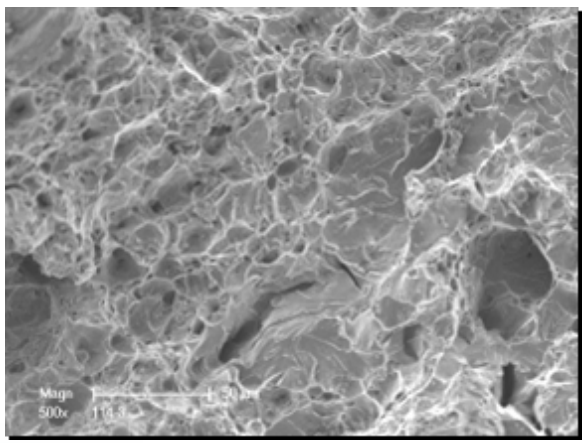
SEM Fractography

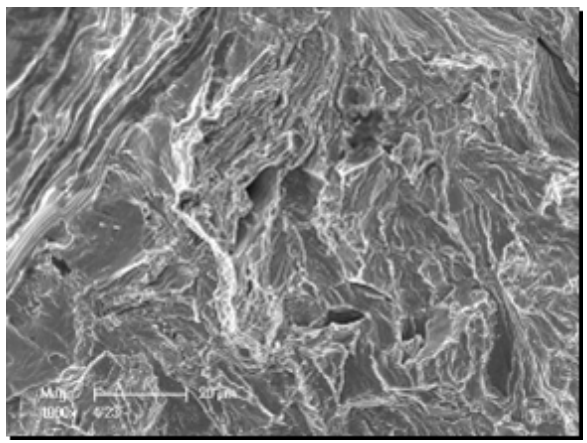
Sugar Cane Europe Sample Deaerated



Sugar Cane Europe Sample Aerated

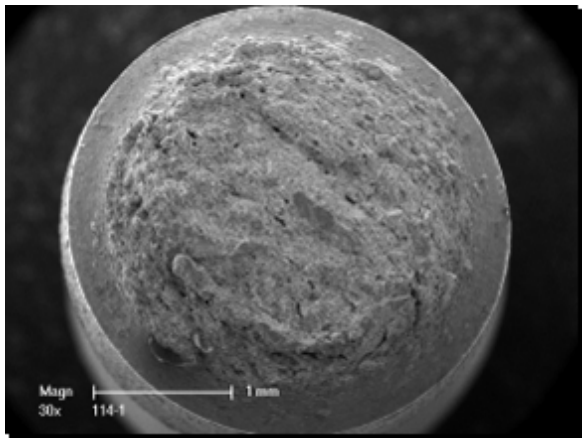


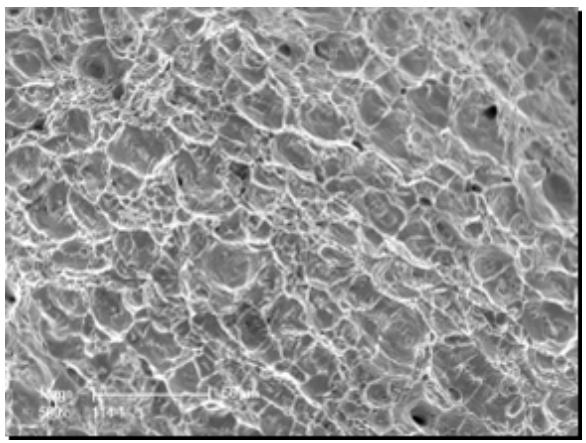




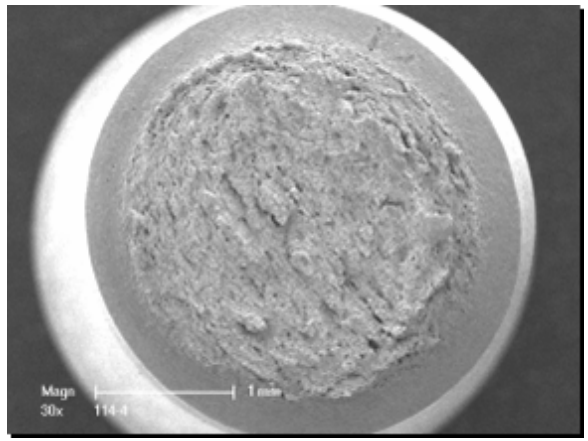
SEM Fractography (cont'd)

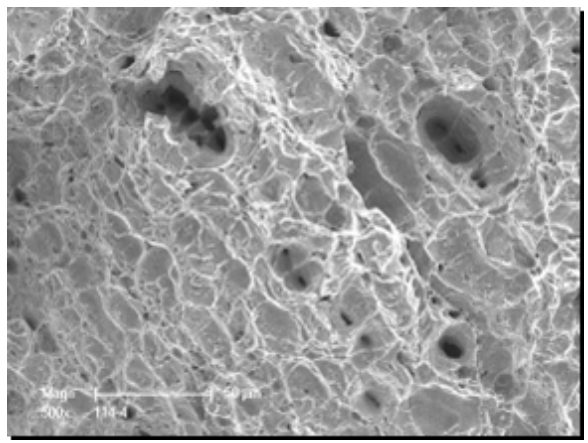
Sugar Cane Brazil Aerated





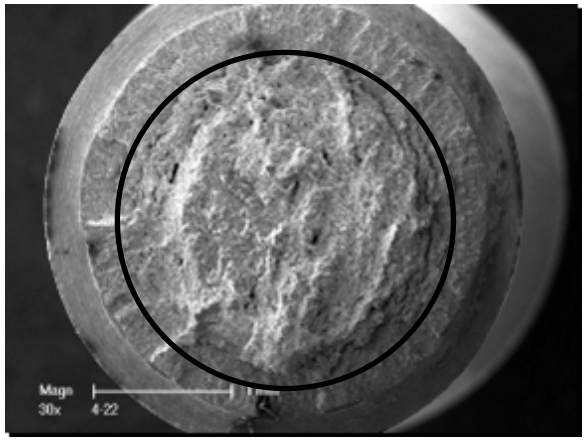
Sugar Cane Europe + Water Aerated

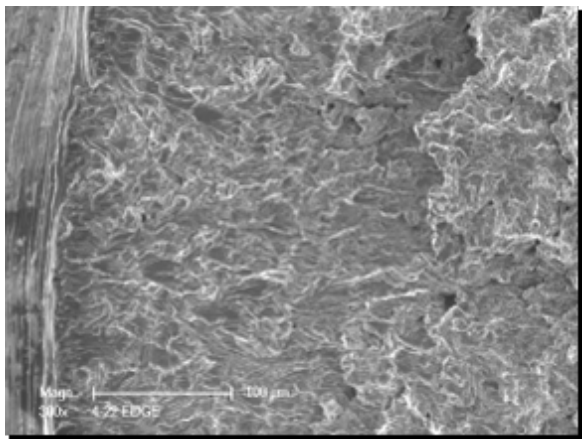




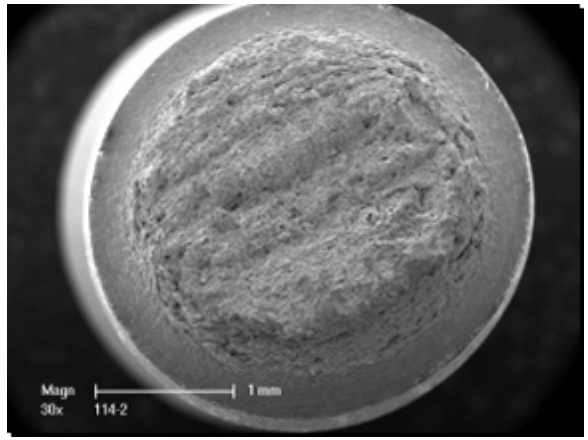
SEM Fractography (cont'd)

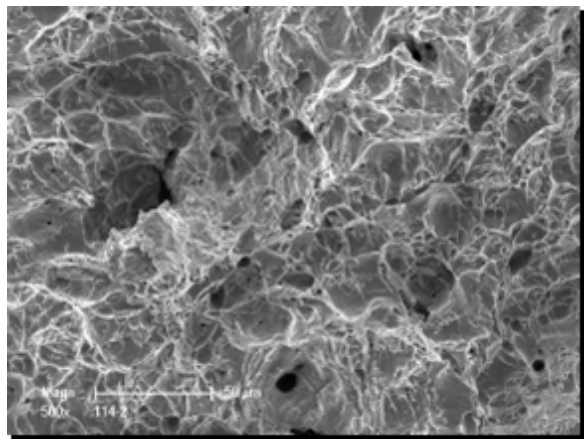
E-85 Sample 3 Aerated



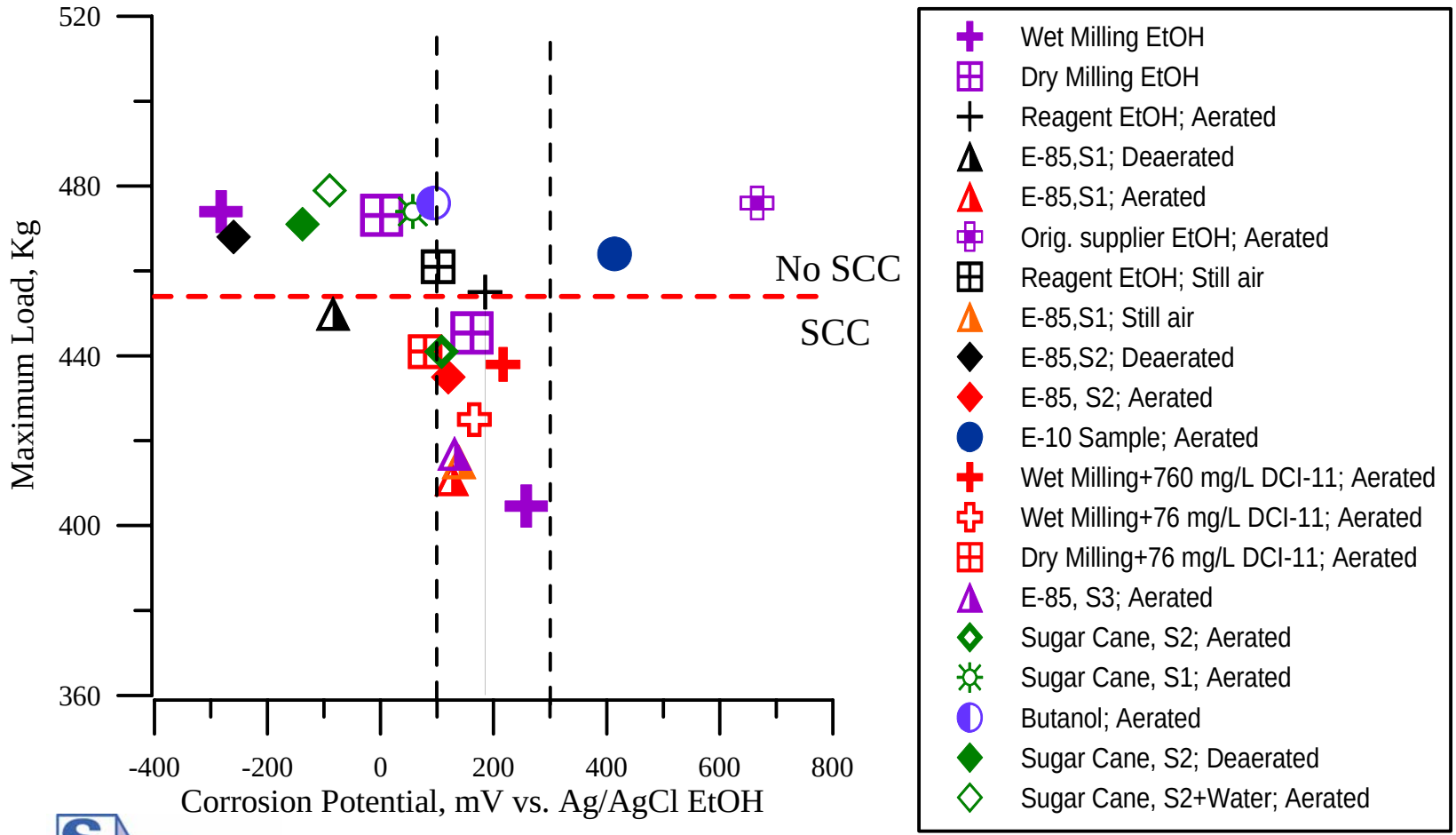


Butanol Aerated

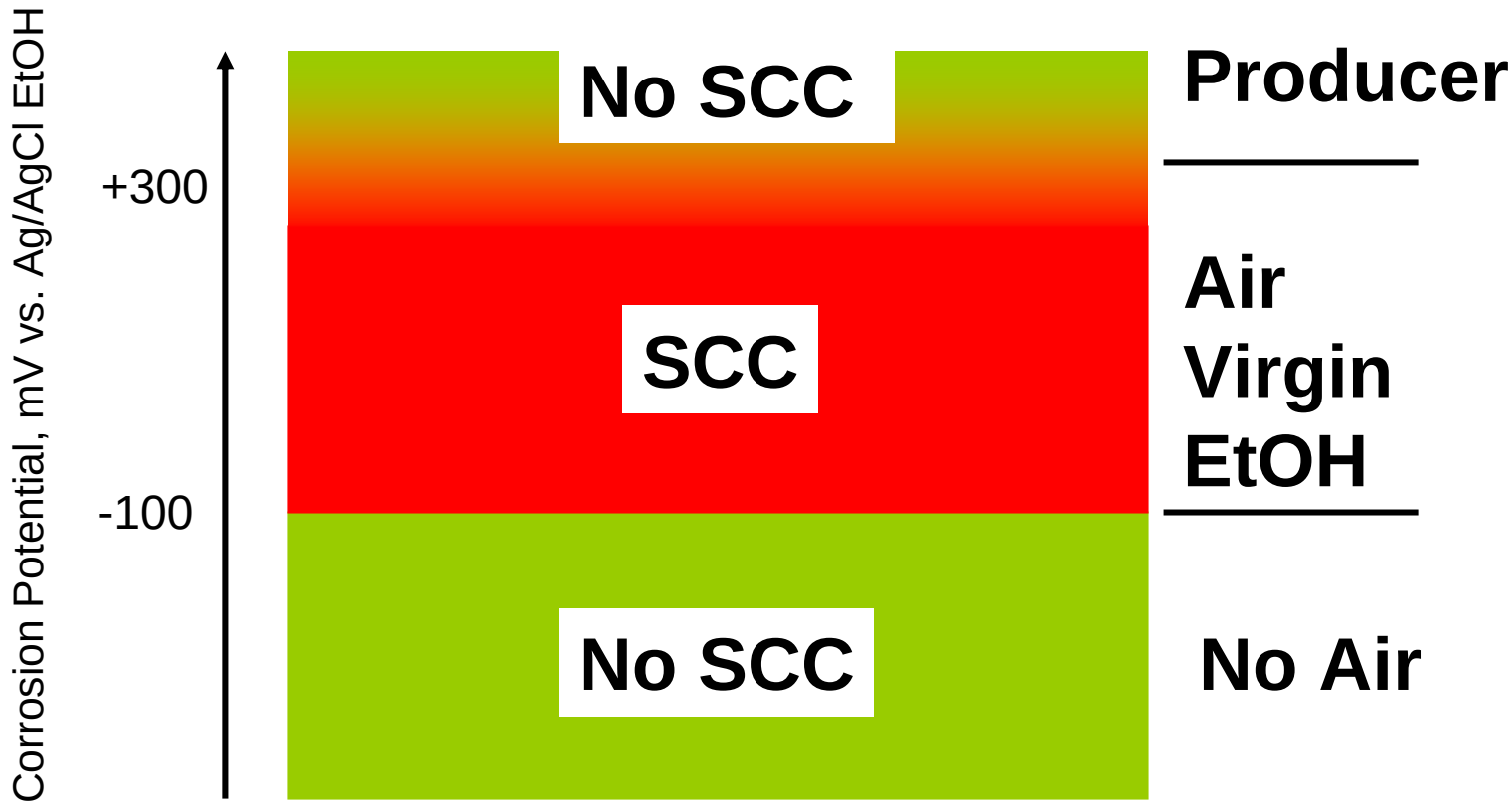




SCC vs. Potential



SCC Potential Range?



Summary of Recent Findings

- **SCC not observed in the absence of oxygen**
- **Ethanol processing source seems to have an influence on SCC**
- **E-85 fuel ethanol samples presented evidence of SCC under aerated conditions. No failures reported in the field with the use of E-85 and more testing is necessary for verification.**
- **Corrosion potential of virgin EtOH samples that produced SCC were in the range of potentials where SCC was previously documented**
- **New proposed work – Parametric study to investigate the following parameters: oxygen content; water content; Ethane, 1-1 diethoxy ; and butanol blending to inhibit cracking**