Ethanol / Pipeline Technology Road Mapping Workshop

Pipeline Industry Needs and Experiences

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Colonial Pipeline Company

October 25, 2007

Pipelines & Renewable Fuels

A Complex equation

- **Technical Feasibility**
- **Logistics**
- **Economics**
- **Politics and Science**

Overcoming the technical challenges is a primary focus; however, focusing the other aspects is also needed

- **Technical Feasibility – our focus over the next day and a half**
- **Logistics – current infrastructure does not align with current production geography**
- **Economics – pipeline transportation must be competitive with existing / alternative modes (largely volume dependent)**
- **Politics and Science – Pipeline investors must be confident that ethanol is a long term component of the energy equation in the U.S. and potential changes to the renewable fuels industry (i.e. cellulosic breakthroughs, import policy changes, etc.) must be understood to make wise infrastructure decisions**

The U.S. Pipeline Industry

Approximately 100,000 miles of refined products lines

- **Primarily transport fuels from Gulf Coast to Midwest and East Coast**
- **Over 6 billion barrels transported annually**
- **Safest and most cost effective mode of onshore transportation of fuels**
- **Most pipelines are common carrier versus proprietary**
- **Primarily multi-products pipelines (batch / fungible systems)**

Today, ethanol is transported primarily via truck and rail with some barge shipment

Renewable Fuels Experiences

Ethanol

- **Limited in service experience through transmission pipelines**
  - **Producers transport via low pressure carbon steel pipelines with no reported problems**
  - **Terminal loading racks and piping have experienced problems**
- **Limited batch testing performed to understand quality issues in batch or fungible systems**
  - **Varying reports regarding product quality (discoloration, hydrocarbon pickup, etc.)**
- **Brazilian history of successfully transporting ethanol (primarily hydrous) in pipelines**
  - **500 pipeline miles, expanding to over 3,000 miles**
  - **Reported issues with valve and other elastomeric seals**
  - **Reported problems and emphasis on internal corrosion, not stress corrosion cracking (SCC)**

Biodiesel

- **Biodiesel has been tested in transmission pipeline systems**
- **No perceived material compatibility issues**
- **Concerns related to cross product contamination (jet fuel)**
- **Limited U.S. demand**

Technical Challenges

Corrosion and Stress Corrosion Cracking

- Experience shows that depending on many factors, ethanol can lead to a potent cracking environment or a potent corrosion environment
  - Stress corrosion cracking of tanks first reported in mid 90's
- Mode of damage varies based on composition and water content
  - Brazilian experience suggests: increase the water = corrosion versus cracking
  - U.S. experience suggests: reduce the water = cracking versus corrosion

Product Quality

- Ethanol absorbs foreign products typically left behind by other petroleum products (gums, inhibitors, water)
- Paradox 1
  - Increased ethanol concentration reduces quality concerns but increases corrosion / SCC concerns, while
  - Decreased ethanol concentration reduces corrosion / SCC concerns but increases product quality concerns
- Paradox 2
  - Small batch sizes increase quality issues but decrease damage potential by limiting exposure, while
  - Large batch sizes decrease quality issues but increase damage potential

Technical Challenges

Key Questions

- **What ethanol products can be shipped in existing infrastructure?**
  - Is there a blend ratio below which damage does not occur (SCC, Corrosion, Elastomeric degradation)?
  - Are there batching operations that mitigate the initiation of damage?
  - What are the QA issues at various blend ratios in various fungible systems?
- **What are mitigation strategies for ethanol products that cannot be immediately shipped in existing systems?**
  - Are there inhibitors that mitigate the potential for SCC and corrosion
  - Are there needed changes to seals or other infrastructure (similar to ULSD modifications)
- **What design considerations should be made for new pipeline systems for ethanol service?**
  - New pipeline materials / manufacturing processes
  - Changes in welding practices
  - Specifications for equipment (pumps, valves, tanks, etc.)
- **What changes must be made to fuel standards to enable transportation of ethanol products?**
- **What do we do if ethanol becomes contaminated (phase separation, water pickup, foreign product contamination, etc.)?**

Final Thoughts

- **Logistics**
  - **Origin versus destination blending (what types of products to ship)**
  - **Pipeline infrastructure investment (new, conversion, etc.)**
  - **Can existing ethanol transportation modes support the growth?**
- **Economic**
  - **At what point does pipeline transportation become most desirable and is that sustainable?**
  - **Will other forces place downward pressure on ethanol supply?**
- **Politics and Science**
  - **Will the mandates stick?**
  - **Will imports become a reality?**
  - **Will other technologies displace ethanol demand over time?**
- **Technical**
  - **Understanding the mechanisms of damage sufficiently to transport ethanol products**
  - **Quantify allowable levels of various contaminants (prevent post production changes)**
  - **Controlling oxygen has been shown as a key variable in mitigating SCC**
  - **Variability has been seen across ethanol batches**
  - **What standards and guidelines are required for ethanol shipment?**
  - **What regulatory changes are necessary for ethanol shipment?**

Ethanol in Pipelines
Roadmap meeting

Producer and End User Perspective

Dublin, OH
October 26, 2007

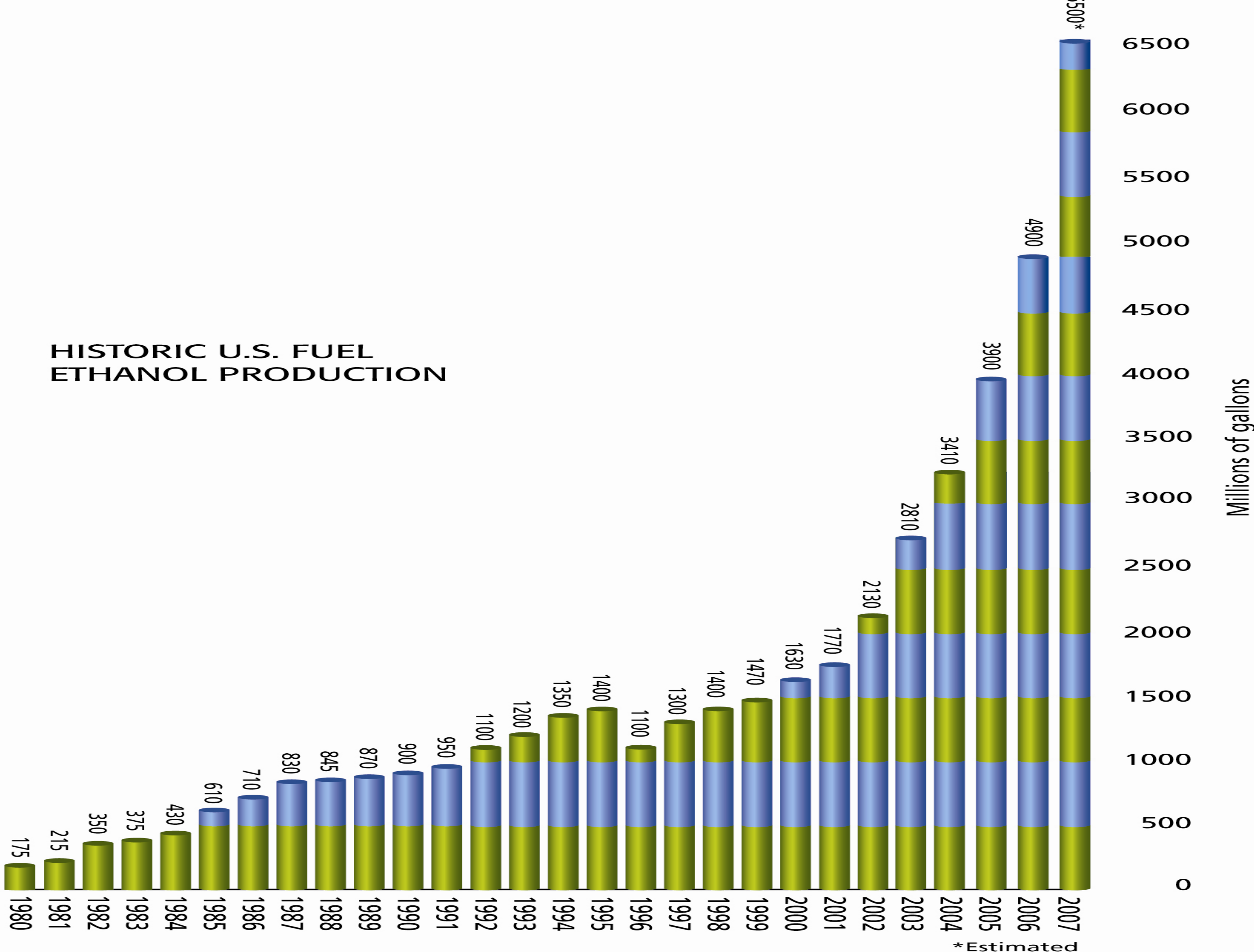
Chuck Corr
Archer Daniels Midland

Industry Objective

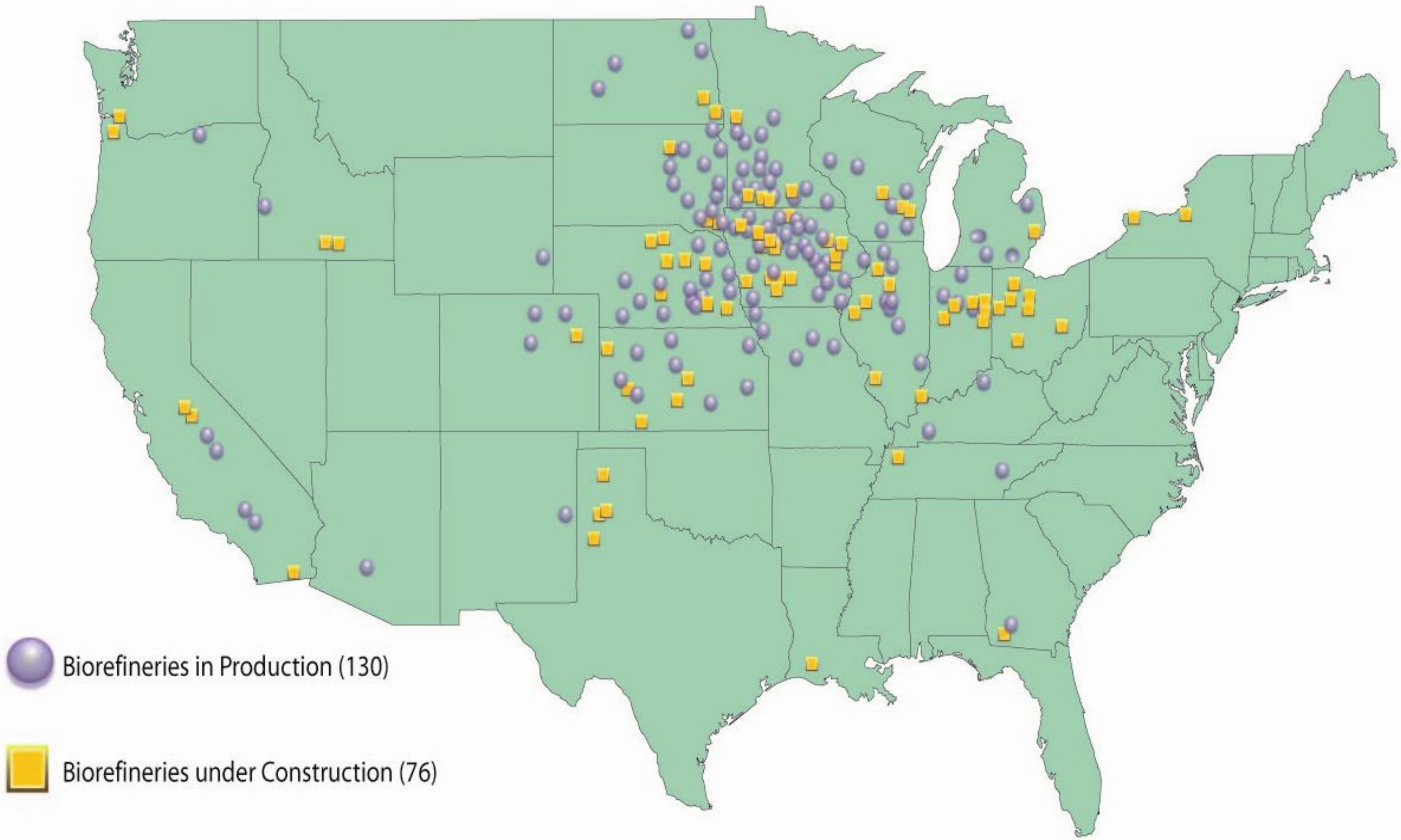
To Safely Produce & Deliver

- A liquid energy product
- Quality needed
- Volumes needed
- Where needed
- When needed
- Optimum flexibility
- Cost efficiently

HISTORIC U.S. FUEL ETHANOL PRODUCTION

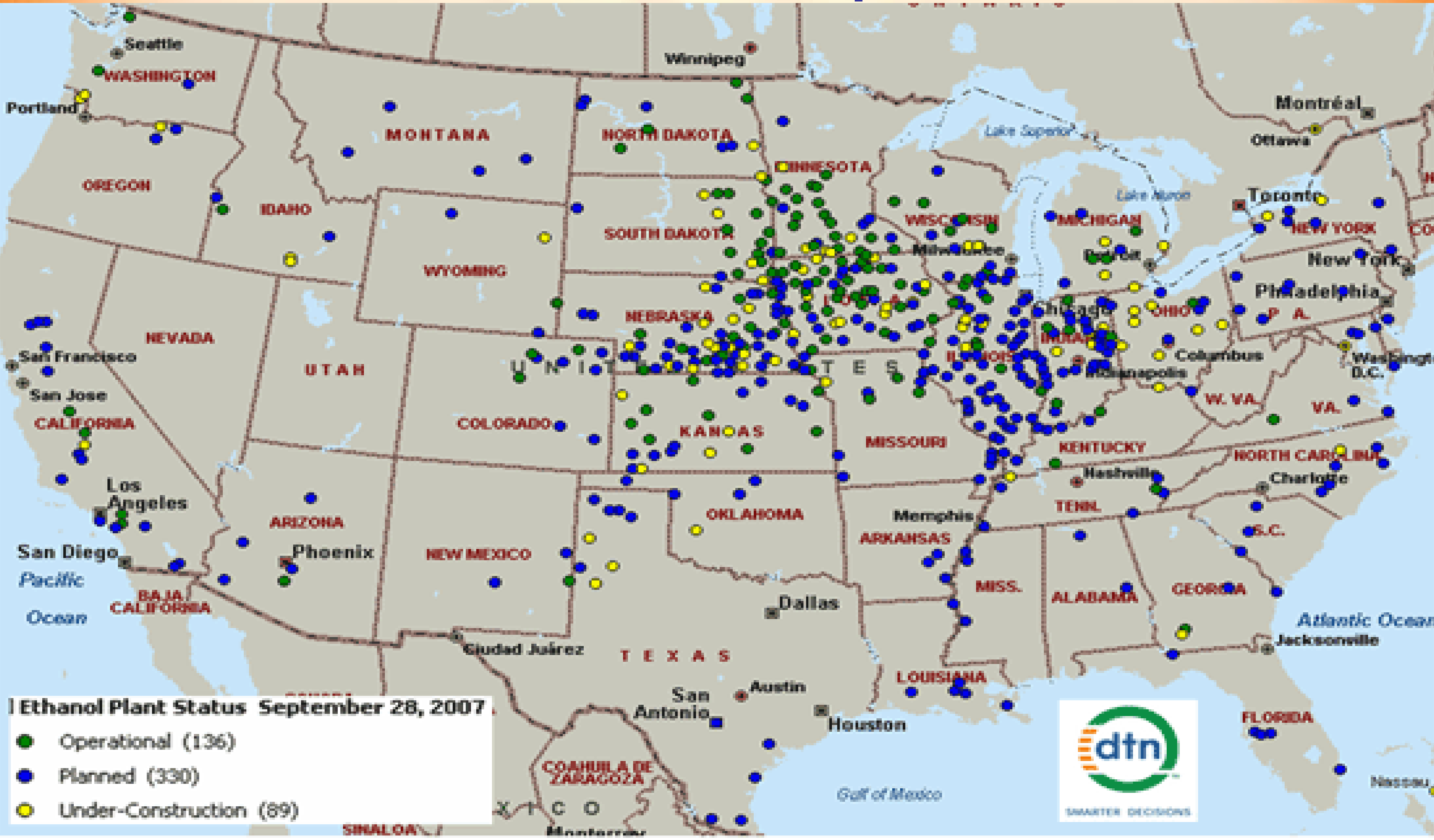


U.S. Ethanol Biorefinery Locations



Source: Renewable Fuels Association
10.4.07

US Ethanol Expansion



*Alaska has one ethanol plant in the planning stage
*Hawaii has two ethanol plants in the planning stage

Geography

- Most Ethanol produced in Midwest
- Most petroleum refined in the Gulf Coast
- Both away from major markets
- Current refined products pipelines - wrong location or flow direction

ADM

Volume Affects Mode

- **Petroleum Transportation**
  - Wooden barrels
  - Rail cars of barrels
  - ….
  - Rail Tank cars
  - Pipelines
- **Ethanol Transportation**
  - Tank trucks
  - Rail cars
  - Barges
  - Unit Trains
  - *Pipelines*

Pipeline Type

- Multiproduct Pipeline
  – Geographic issues
  – Compatibility of materials, existing products
  – Capacity for ethanol
- Dedicated Pipeline
  – New or existing pipe – From and To?
  – Materials (nonmetallic)
  – Sizing of pipeline & infrastructure
- Combination
  – Dedicated feeders to multiproduct trunk

ADM

Stress Corrosion Cracking

- Dissolved oxygen
  - May act as light switch

- Saturated with oxygen – some SCC
- Deaerated – No SCC
  - Extreme lab conditions
- **Can dissolved oxygen be controlled below the critical level?**

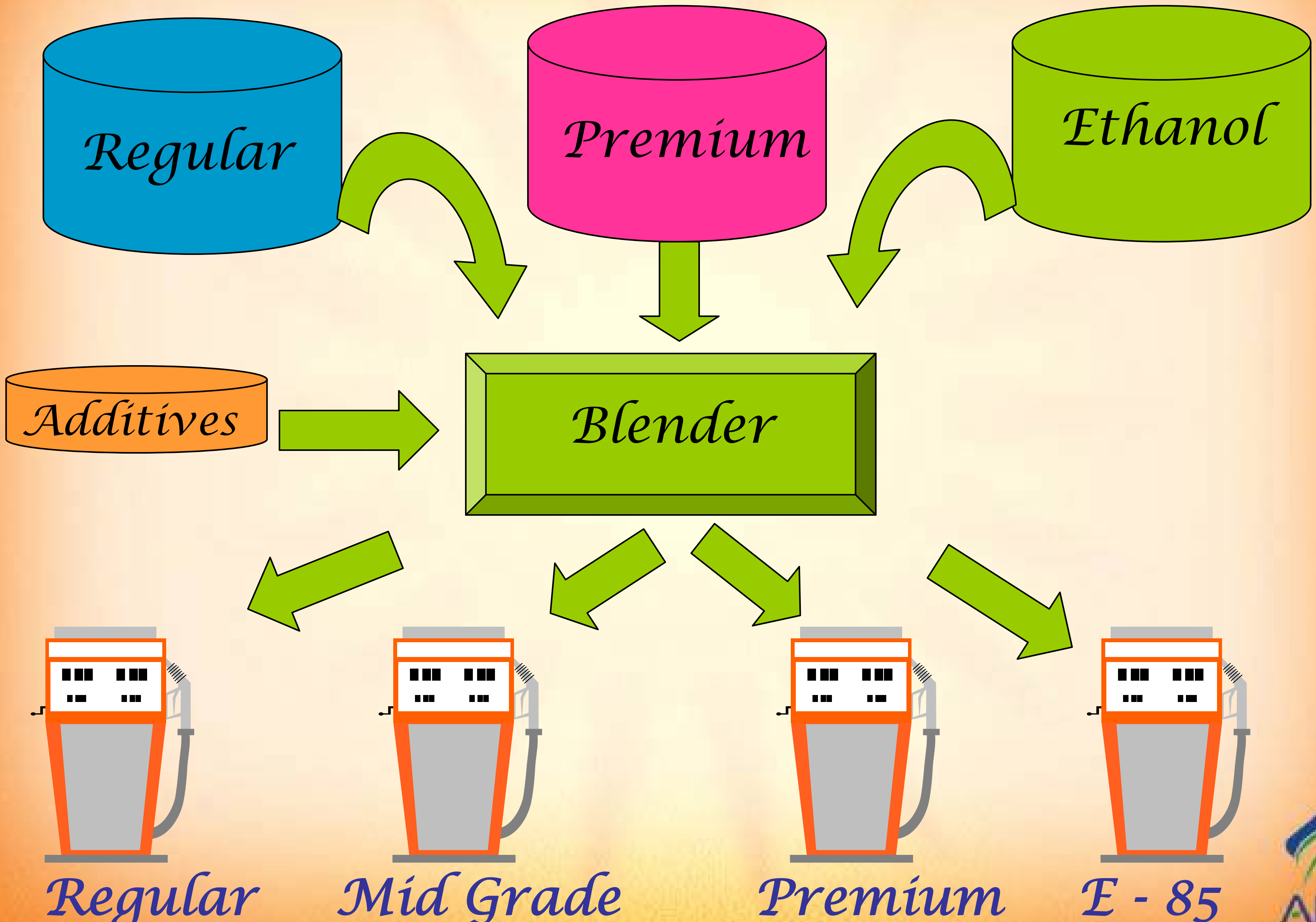
Materials Compatibility

- Ask a terminal engineer
- Many terminals currently work with high and low ethanol concentrations
- Midwest terminals have years of excellent experience

Flexibility to Blend

- The US will go beyond E10
- Terminals need the flexibility to blend beyond E10
  - E85
  - Enhanced blends (E10 to E20)?
- Must allow best economics for local markets

Terminal Blending



Ethanol in Pipelines

There are

No Technical Barriers

to moving ethanol in pipelines.

(But we do need more research

to address the operating conditions)

Ethanol in Pipelines - Economics

CC Technologies
a DNV company

MANAGING RISK DNV

Internal SCC in Ethanol Pipelines

John Beavers, Narasi Sridhar
October 2007

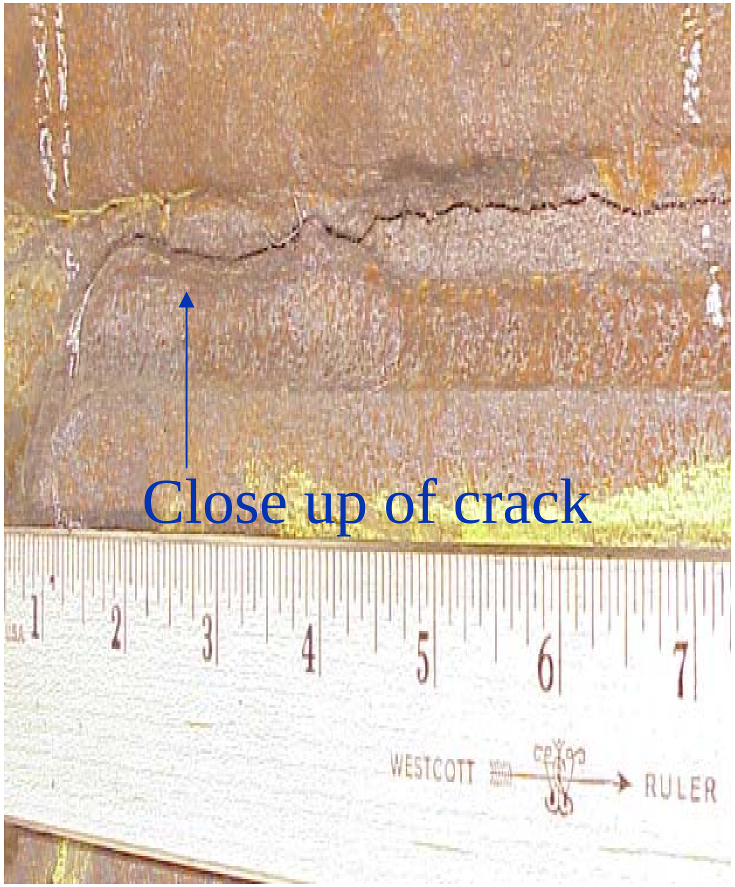
Introduction

- Significant interest within pipeline industry in transporting fuel grade ethanol
  - Oxygenating agent for gasoline
  - Alternative fuel for motor vehicles
- Ethanol now transported to blending/distribution facilities
  - Tanker trucks
  - Rail cars
  - Barges
- Increased usage of ethanol has prompted the need for alternative, economical means of transporting ethanol
- Pipeline transportation is likely candidate but there are concerns with respect to corrosion / stress corrosion cracking

Background

- Prior to shipment, ethanol is denatured & inhibited
  - Natural gasoline is most common denaturant
  - Octel DCI-11 is most common inhibitor for general corrosion
- At blending/distribution facilities, large tanks and piping facilities are used for blending operation and for storage
- SCC has been observed in carbon steels in contact with fuel grade ethanol
- Failures documented back to early 1990s
  - User terminals
  - Storage tanks
  - Loading/unloading racks
- No failures at ethanol producer sites nor after ethanol was blended with gasoline

Cracked Bottom Plate - Tank



Piping Failures in Terminals

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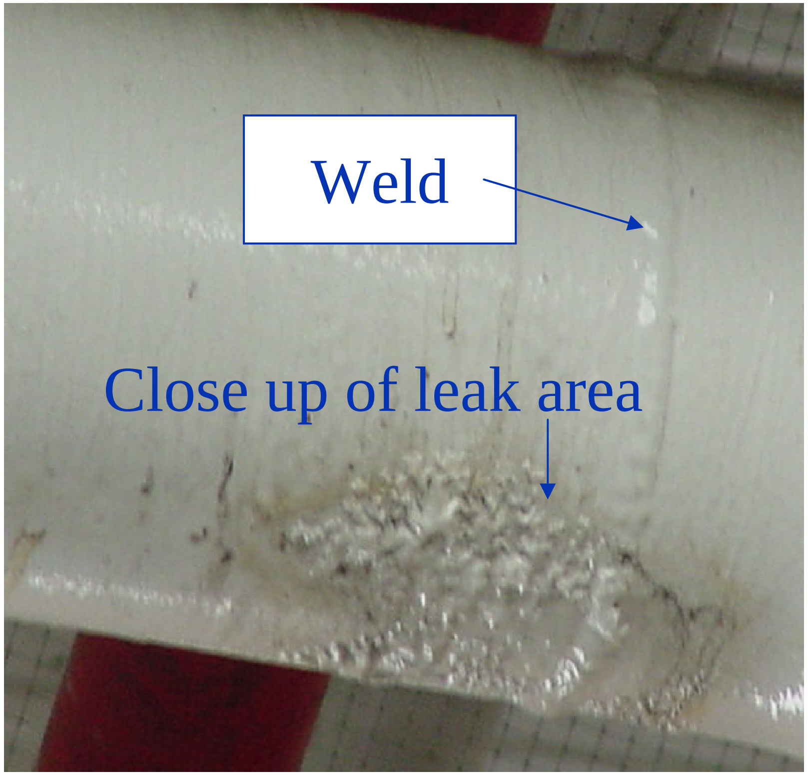
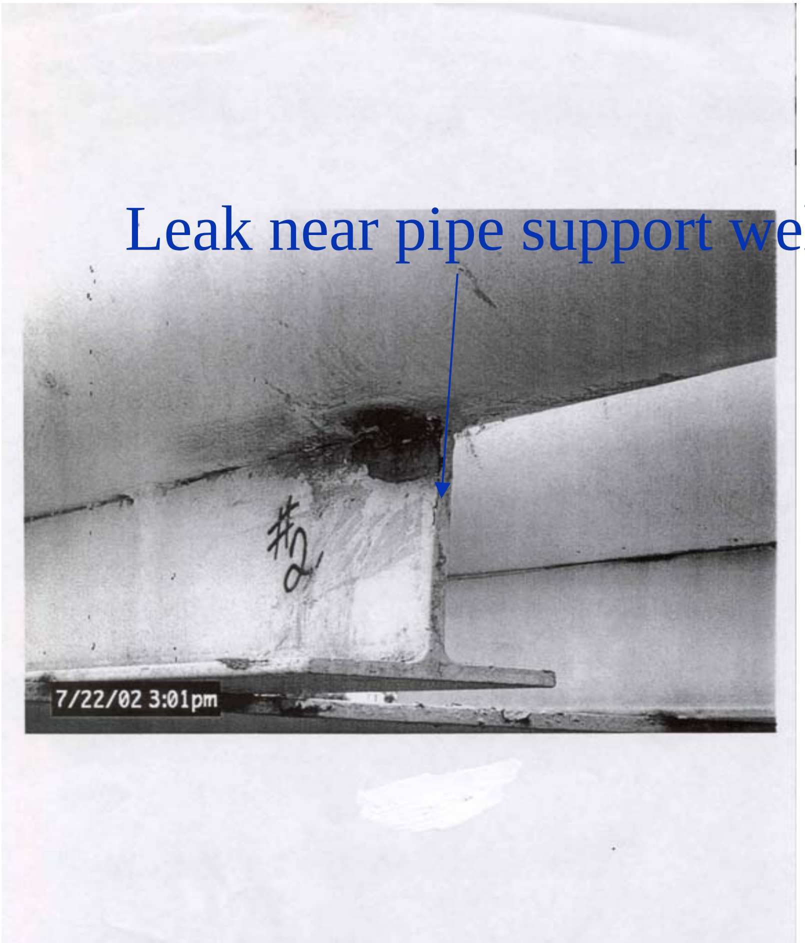
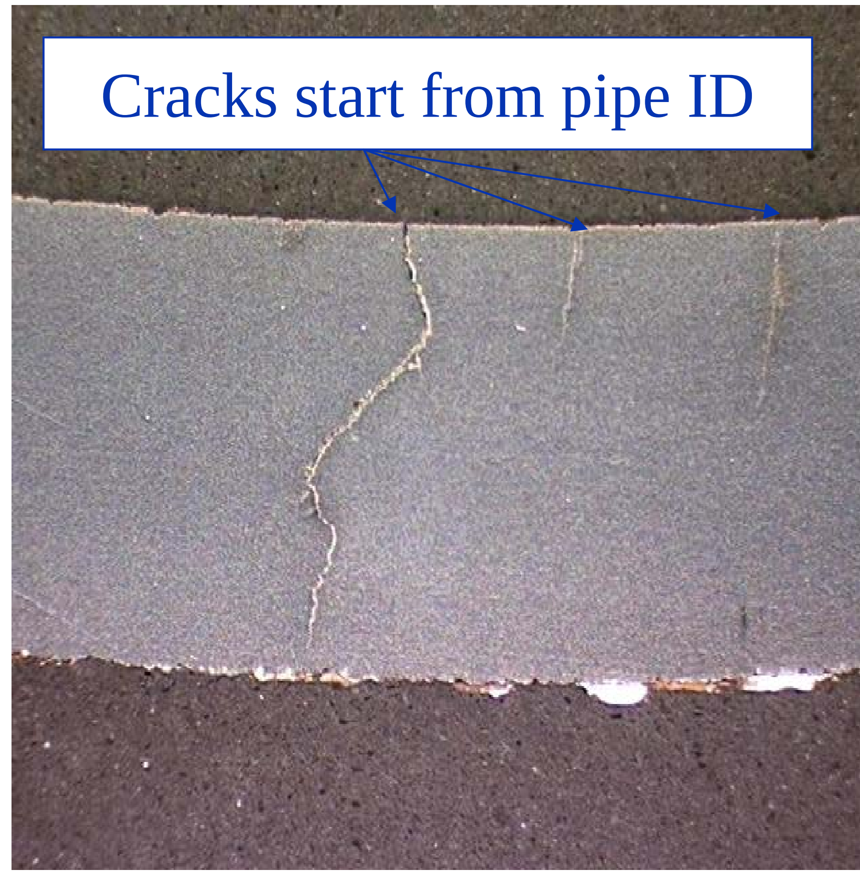


Piping Failures (Cont’d)





Background

- API Technical Report [939-D (2003)] provides a review and summary of ethanol SCC of carbon steel
  - Published literature
  - Service experience
- All occurrences of SCC were in first major hold point or downstream
  - Fuel ethanol distribution terminal
  - Subsequent gas blending or distribution terminals
- Majority of cracking found at welds
  - In base metal and HAZ of welds
  - Primary stress leading to SCC is residual welding stresses
- No cases reported in:
  - Manufacturer facilities or other transport facilities directly following blending
    - Tanker trucks
    - Railroad cars
    - Barges

Prior Research Results

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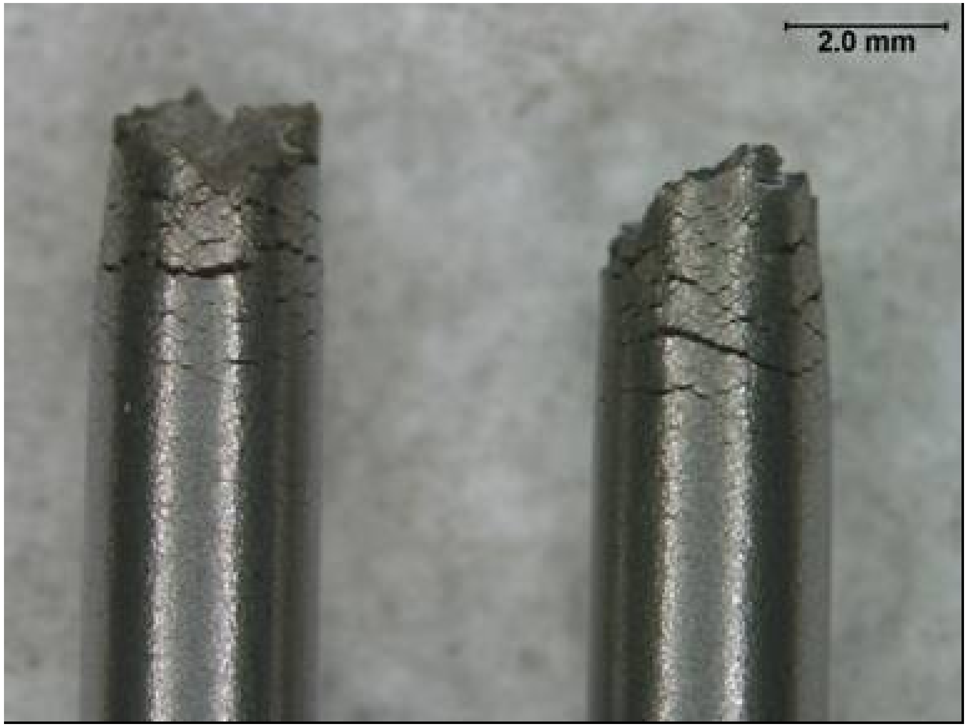
- PRCI and API funded research on the roles of chemistry and steel properties on ethanol SCC
  - Fuel grade ethanol that meets ASTM standards is a potent cracking agent
  - Dissolved oxygen concentration is a primary contributing factor in cracking
    - Reflected in potential dependence of cracking
  - Chloride was found to exacerbate cracking and affect cracking mode
    - Intergranular SCC with low Cl (<1 ppm)
    - Transgranular SCC with high Cl (>35 ppm)
  - Testing was inconclusive with respect to relative susceptibility of different line pipe steels

Prior Research Results

- Factors having some effect
  - Coupling to corroded steel
  - Presence of methanol
- Factors that had a minimal effect on SCC
  - Type of Denaturant
  - Acidity within specifications
  - Water content from 170 ppm to 2%
  - One standard inhibitor for general corrosion (Octel DCI-11)

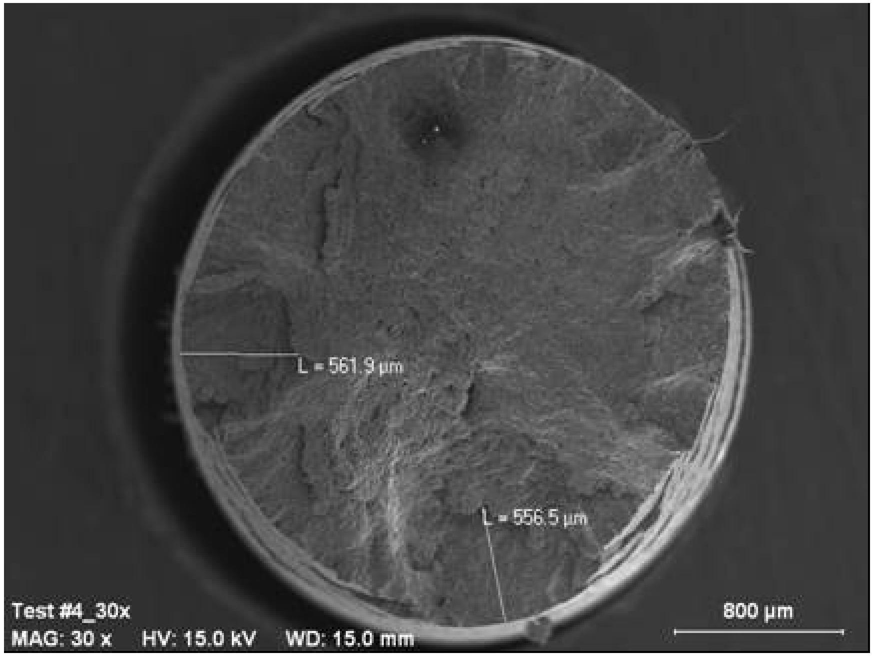
Slow Strain Rate Test Results



Severe SCC

(Aerated Simulated FGE)

Slow Strain Rate Test Results



Aerated SFGE

SCC Crack Depth Measurements

Slow Strain Rate Test Results

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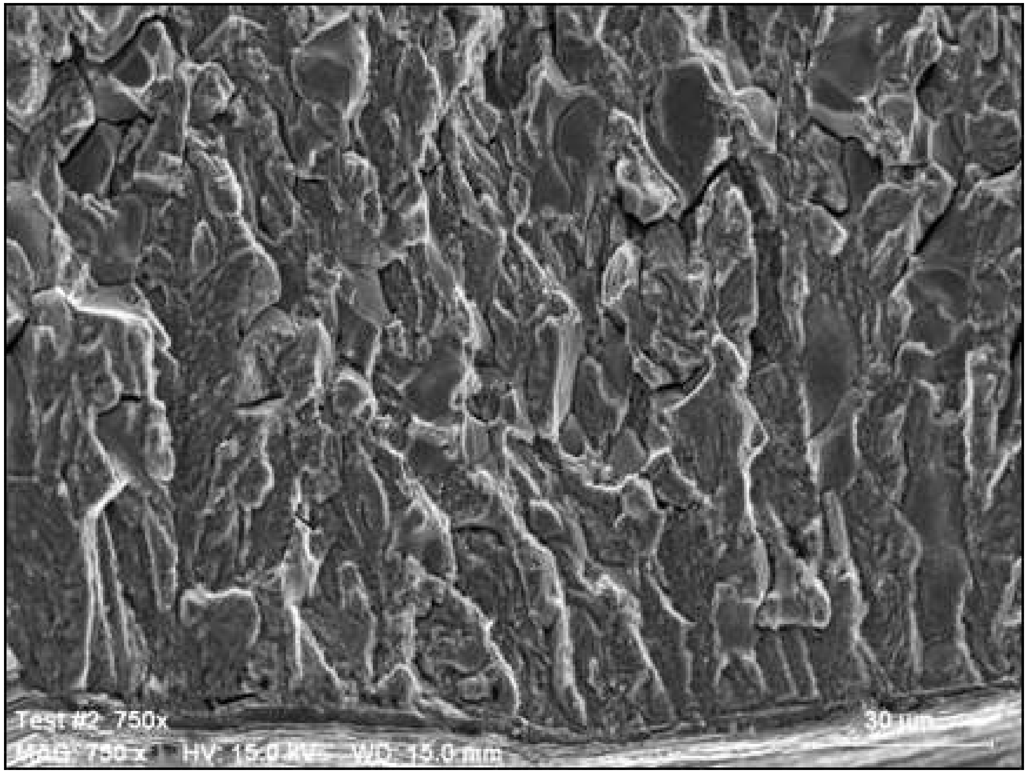

Mixed mode SCC in aerated SFGE

Recent PRCI Research Findings

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- Limited success with constant load tests in laboratory
- SSR test technique very effective for evaluating environmental effects
- Corrosion potential generally good cracking indicator
- SCC mitigation
  - One inhibitor and one oxygen scavenger identified in recent PRCI research
    - Di-ethanol amine (DEA)
    - Hydrazine
  - Three non chemical means of oxygen scavenging identified
    - Mechanical deaeration
    - Corrosion reactions (steel wool)
    - Nitrogen deaeration
- E-85 fuel potent cracking agent
- Batching with diesel fuel not shown to inhibit SCC in SSR tests

Recent PRCI Research Findings

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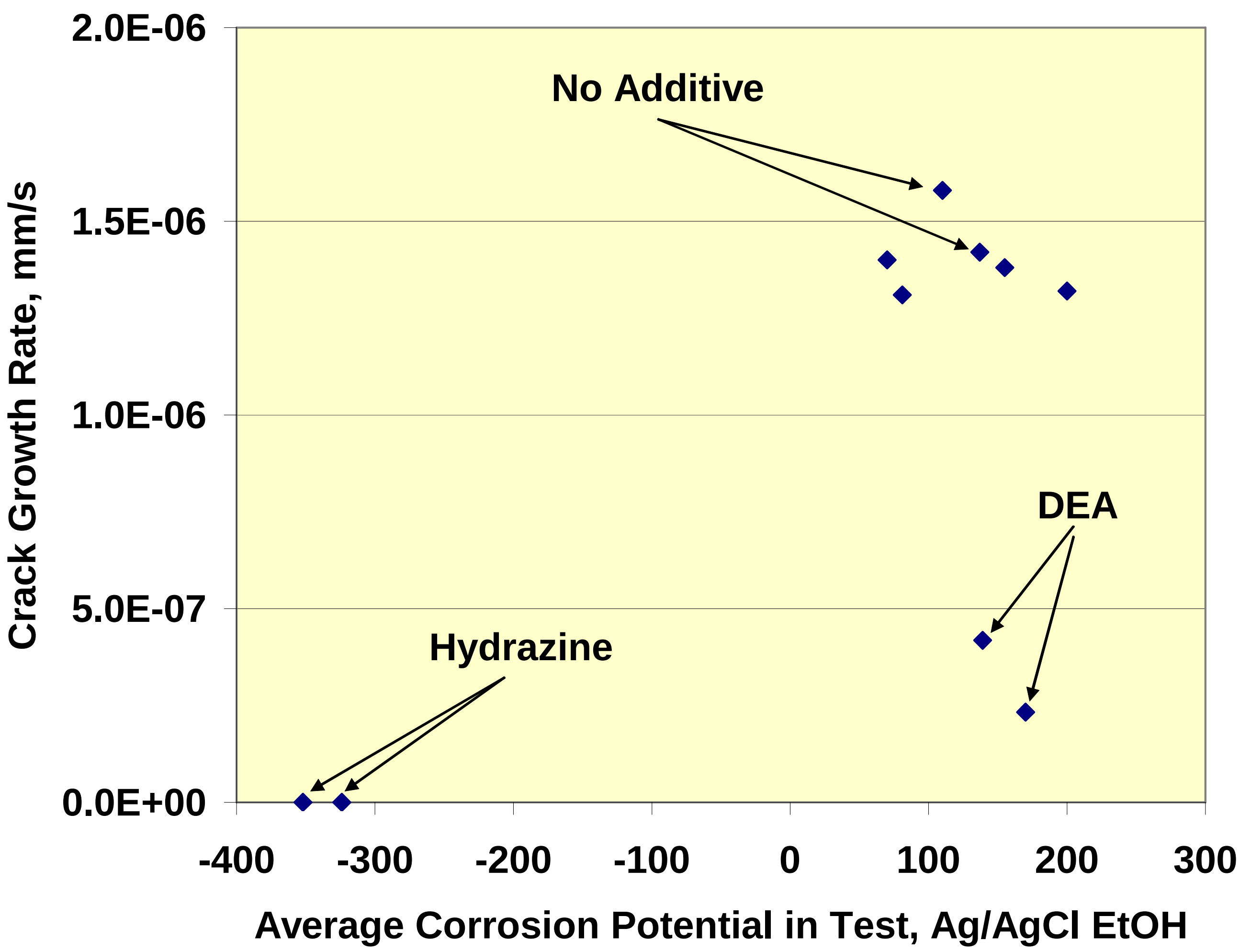

Recent PRCI Research Findings

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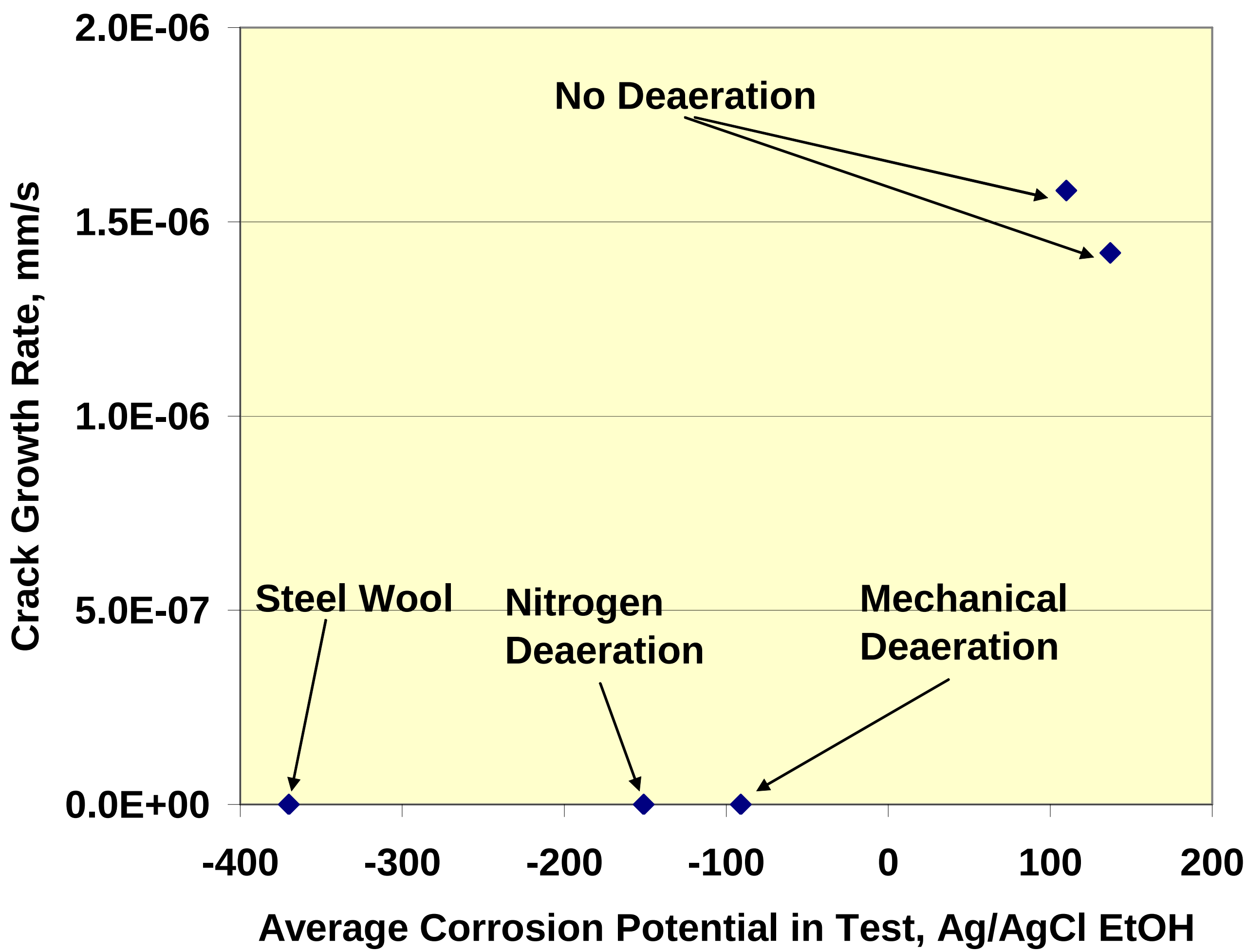

Other Recent Research Findings

- SCC potency of ethanol-gasoline blends decreases with increasing gasoline concentration
- SCC potency of FGE decreases with decreasing oxygen concentration
- Considerable variability in potency of actual FGE
- Evidence that FGE contains natural inhibitors that degrade with time

Objectives of New Research Programs

- PRCI SCC 4-4
  - Identify FGE blends that can be transported in pipelines
    - Case 1 – Blends that do not require significant modifications of systems and operations
    - Case 2 – Blends that require significant modifications but can be transported in existing systems
    - Case 3 – Blends that require specially designed systems
  - Characterize the time to initiation of SCC in a range of potent FGE environments
    - Identify operating and batching practices that prevent SCC initiation and growth

Objectives of New Research Programs

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- PRCI SCC 4-3
  - Design laboratory experimental procedures to better implement various mitigation strategies
    - Inhibitors
    - Oxygen scavengers
    - Other methods of oxygen scavenging
  - Estimate the types and concentrations of chemical treatment required for effective performance.
  - Establish protocols for non-chemical treatment methods
    - Volumes and flow rates for gaseous deaeration
    - Vacuum-time behavior for vacuum deaeration
  - Assess cost effectiveness of scale-up of mitigation methods
  - Assess end-user acceptance of mitigation methods and implications of post transportation issues
  - Develop field procedures to establish effectiveness of mitigation methods

Questions?

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CC Technologies (a DNV company)

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API Ethanol SCC in Tanks: Summary of Project Activities

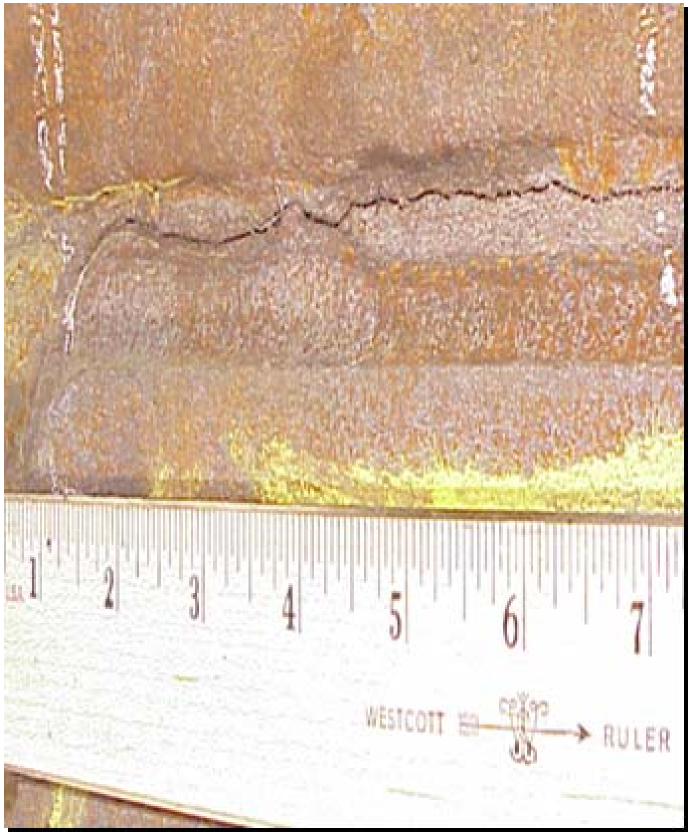
Julio G. Maldonado, Ph.D.

Materials Performance & Characterization
Mechanical and Materials Engineering Division

October 25, 2007

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**

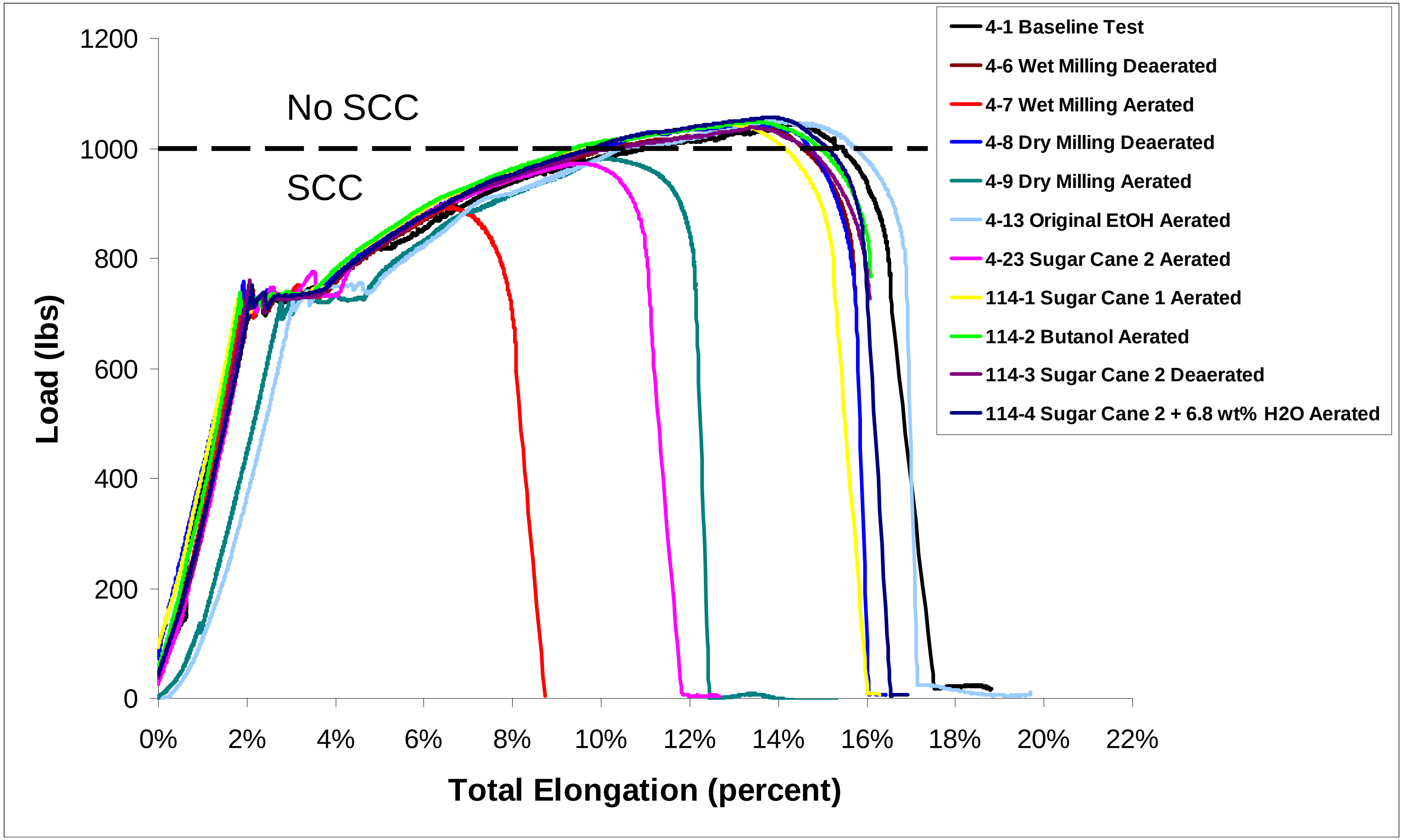
- **Recent studies have included the evaluation of additional factors including: effect of denaturant additions; effect of corrosion potential and ethanol processing source; and characterization of the SCC susceptibility of carbon steel in gasoline-ethanol blends**

Experimental Procedure

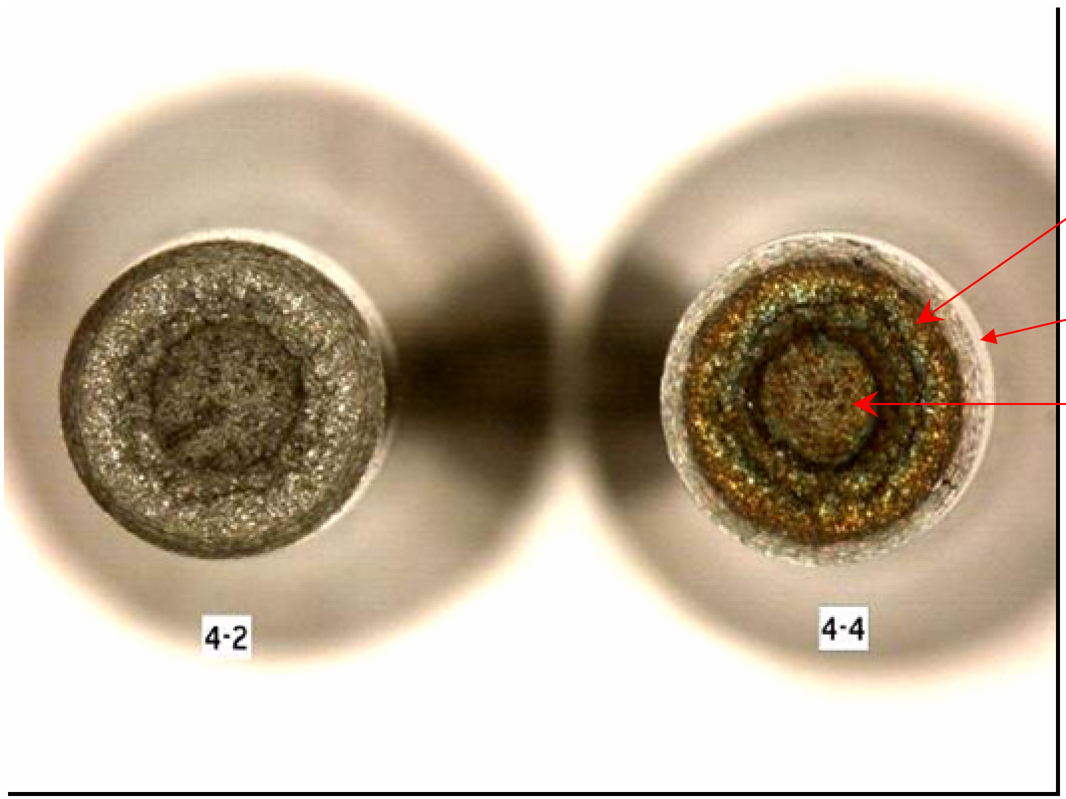
- **Notched SSRT specimens prepared from A-36 plate material**
- **Testing of actual fuel ethanol samples**
- **Chemical characterization performed on samples**
- **pH_e and water content analyses – before and after test**
- **Corrosion potential continuously monitored during SSRT**
- **Electrochemical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

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

Latest SSRT Results

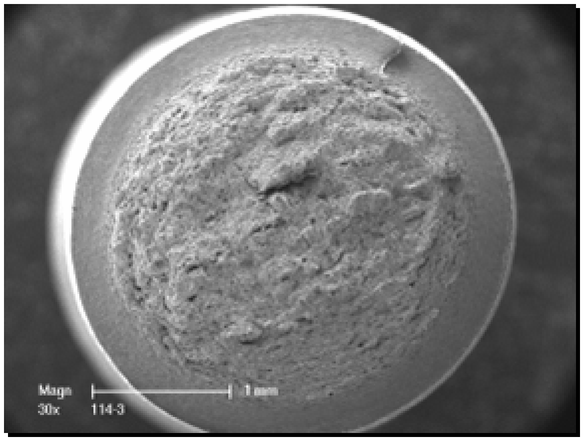


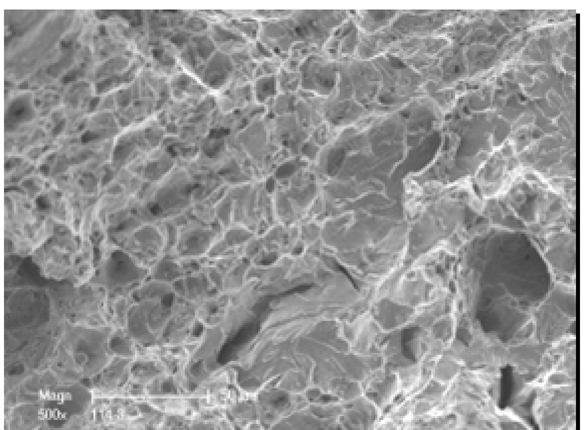
Specimen Observations



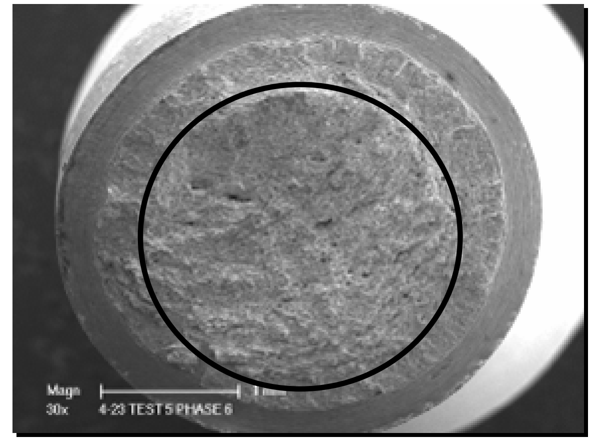
SEM Fractography

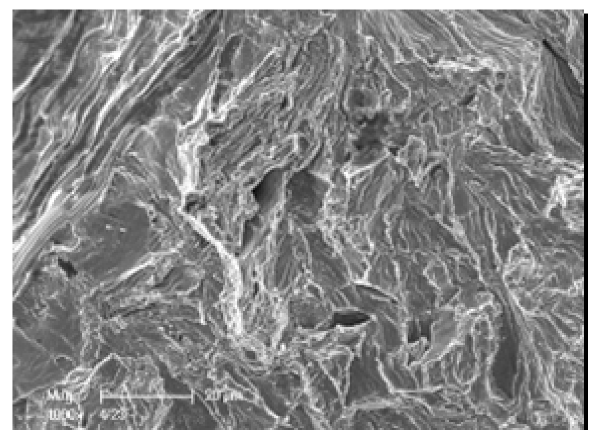
Sugar Cane Europe Sample Deaerated





Sugar Cane Europe Sample Aerated

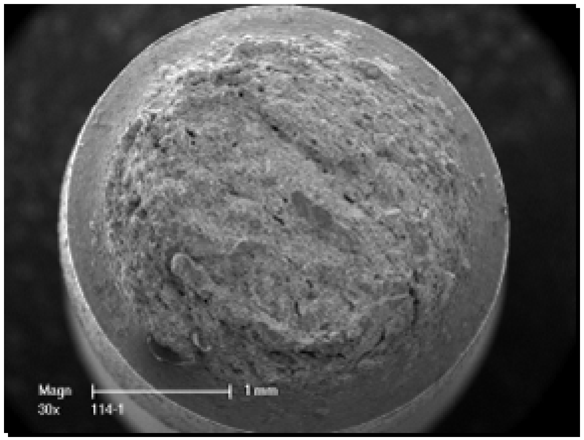


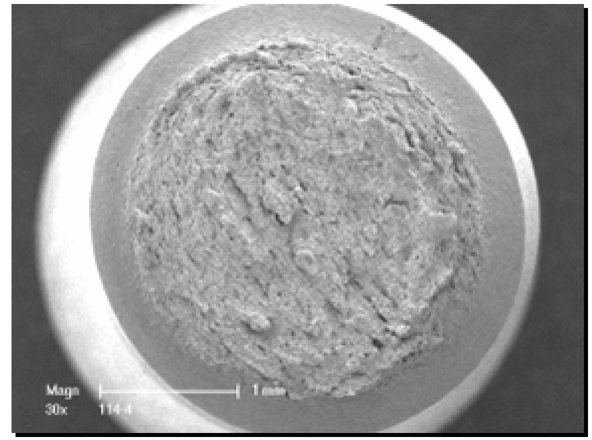


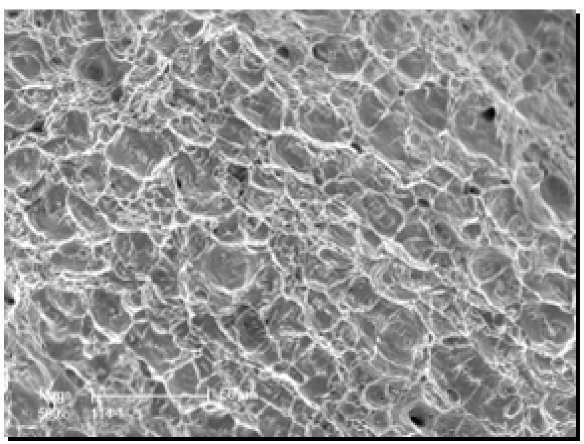
SEM Fractography (cont'd)

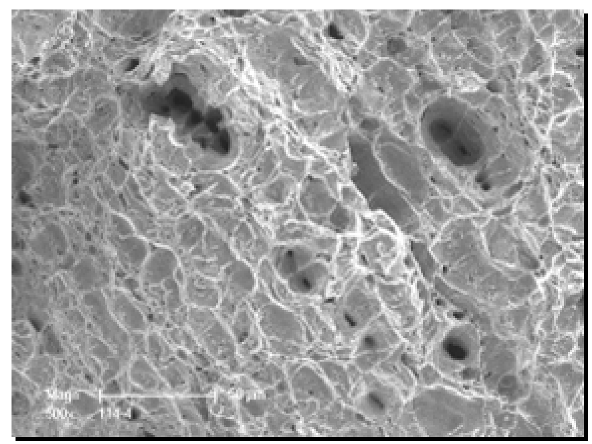
Sugar Cane Brazil Aerated

Sugar Cane Europe + Water Aerated



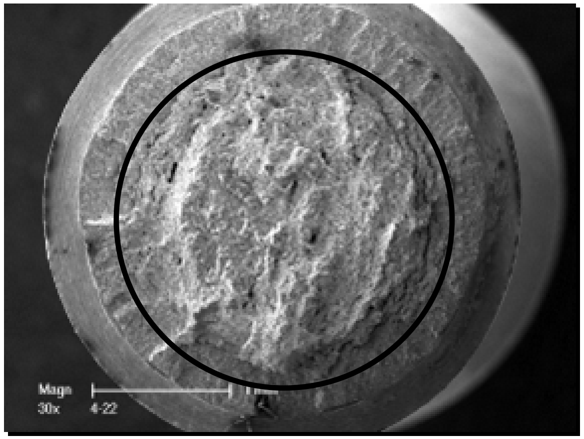




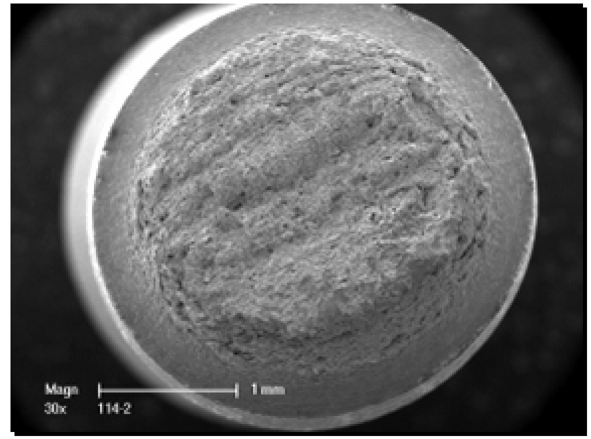


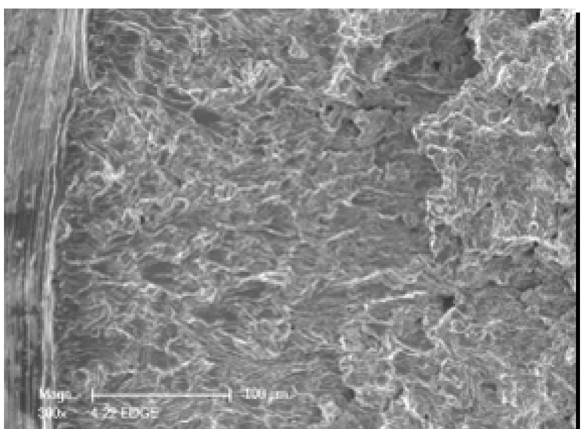
SEM Fractography (cont'd)

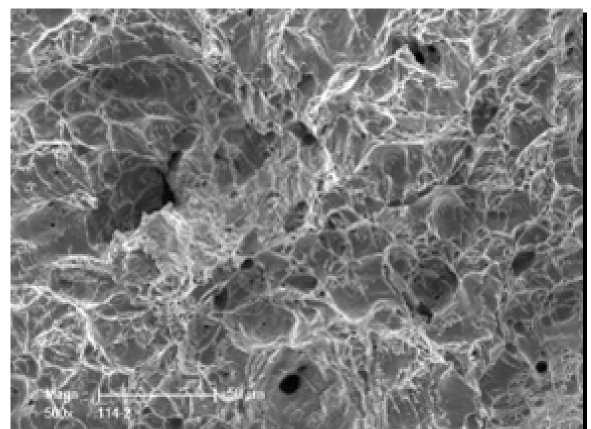
E-85 Sample 3 Aerated



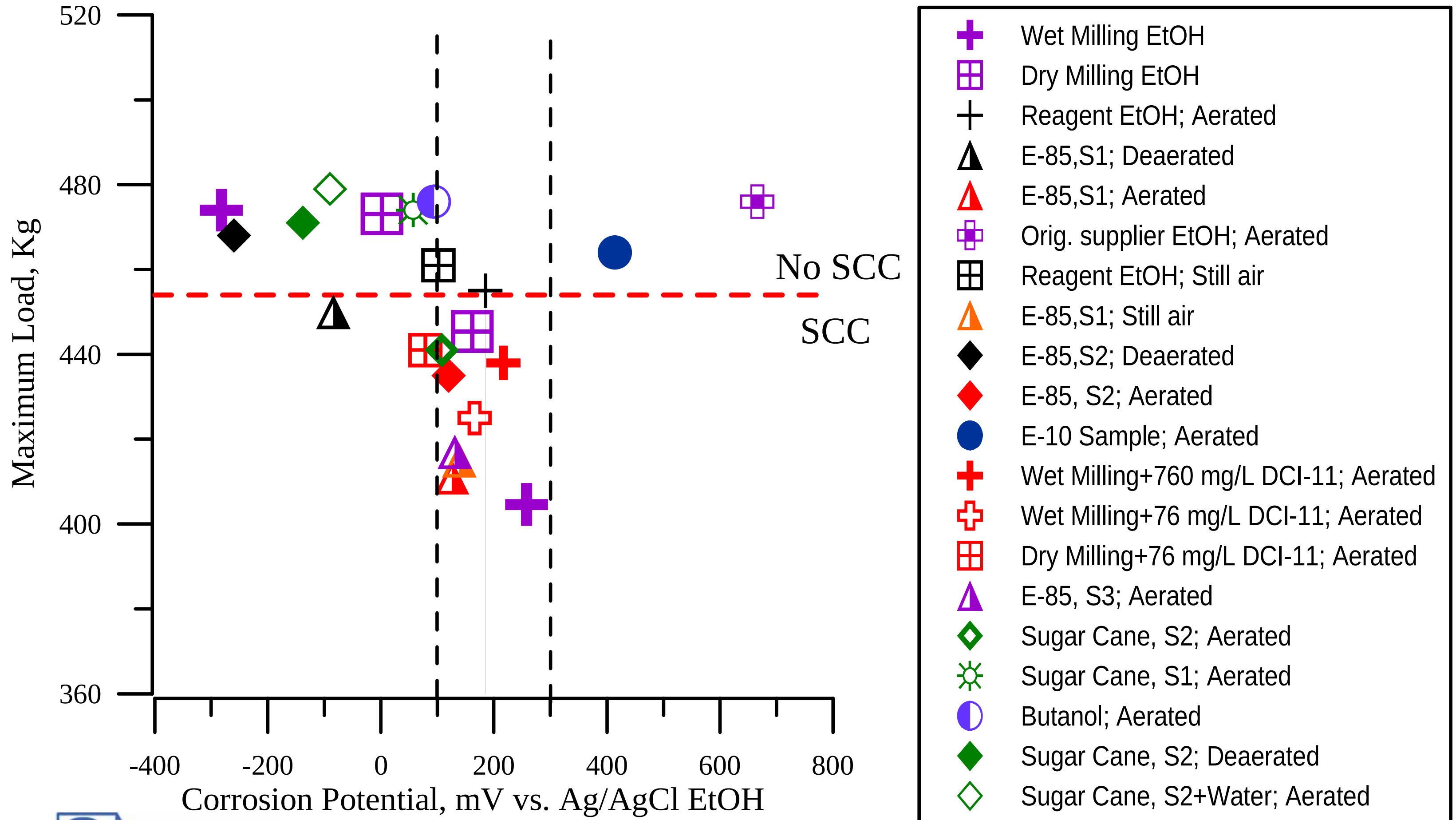
Butanol Aerated



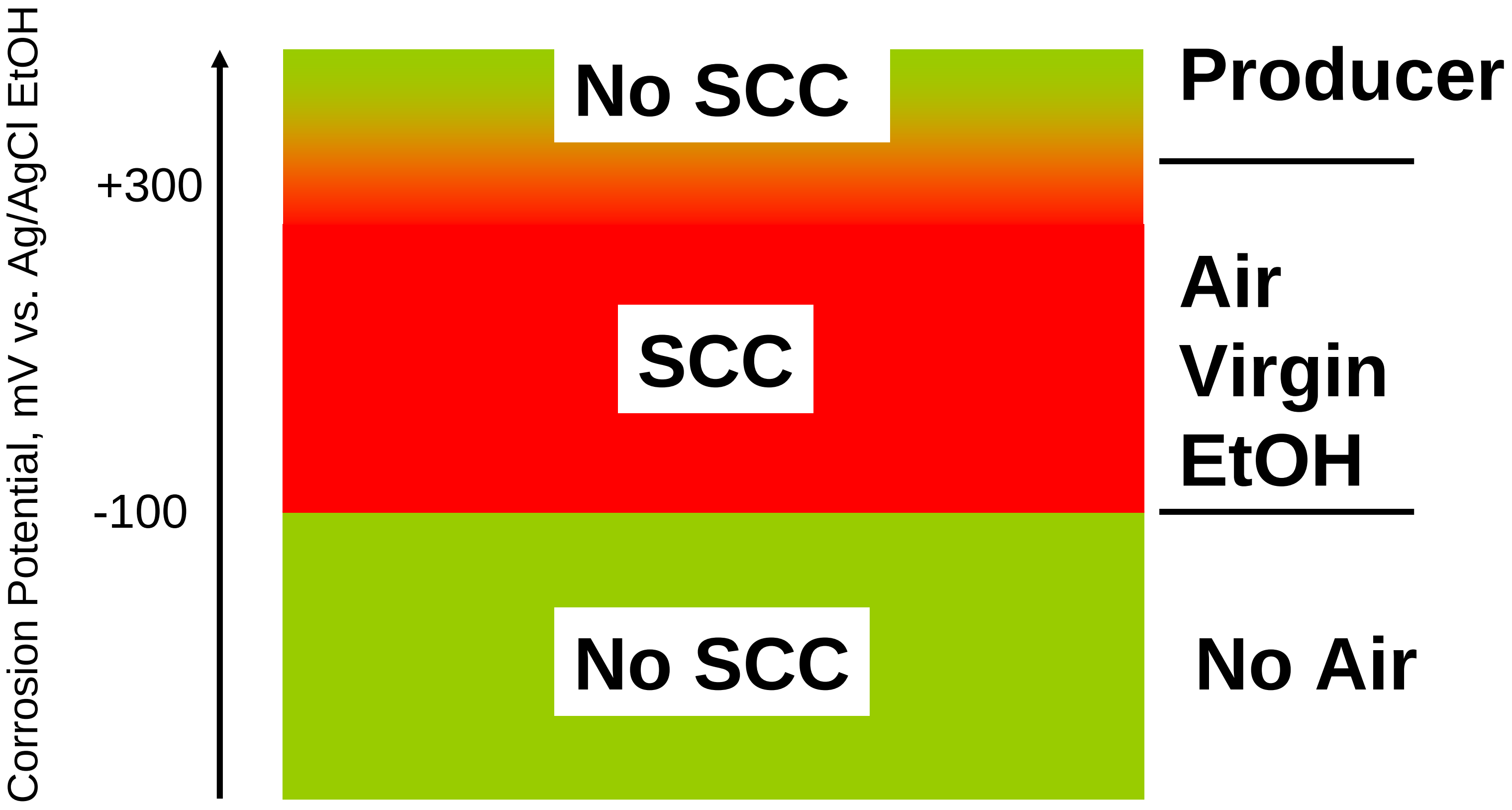




SCC vs. Potential



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**

Summary of Activities on Ethanol SCC – Tanks and Facilities

Failure Documentation, Survey Results, Guidelines Development

Presentation by:
Dr. Russell D. Kane
Director, Corrosion Services
Honeywell Process Solutions
Houston, Texas USA

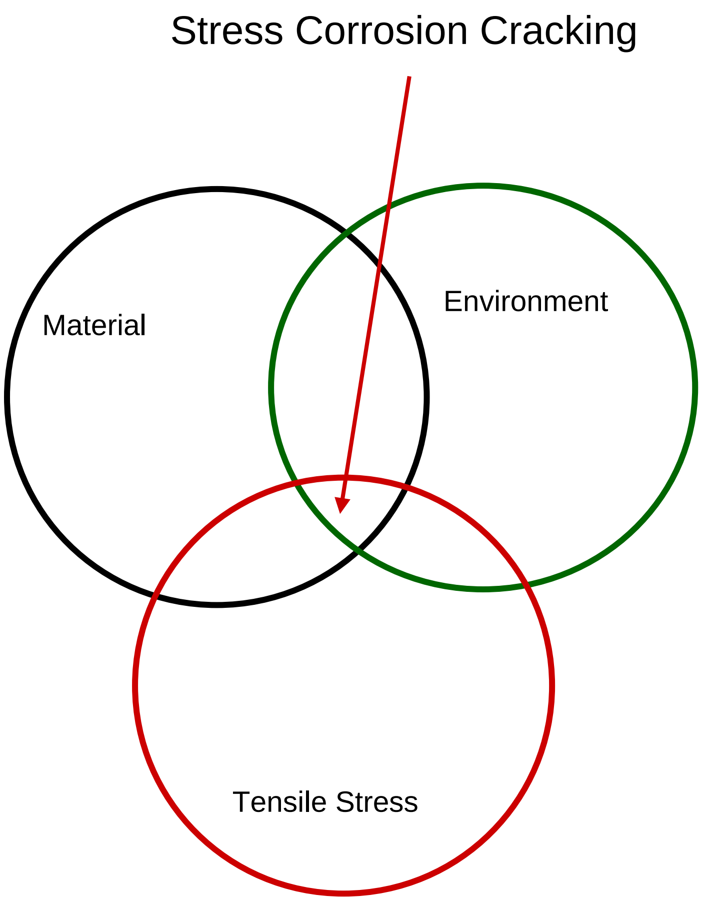
Honeywell

Organization

- API Efforts on Ethanol SCC
- Experience Documented from Survey Information
  - Example Failures
  - What crack and what does not
  - Where does cracking occur in distribution system for fuel ethanol
  - What about E10 and E85 blends?
  - How does US compare with others (Europe and Brasil)?
  - Monitoring?
- Guidelines development
  - Identification
  - Mitigation
  - Remediation
- Ethanol SCC Resources

API Approach to Investigate Ethanol SCC

- Prior to 2003, there was only minimum understanding of the extent and consequences of ethanol SCC.
- The American Petroleum Institute (Refining Committee) with assistance of the Renewable Fuels Association initiated a program to investigate this phenomenon.
- Initially, this involved the development of a white paper (survey) document (API 939D) to better understand:
  - Put ethanol SCC in context with other commonly observed SCC mechanisms in petroleum operations
  - Survey of failure experiences, handling practices; remediation methods
  - Establish a basis for a more involved research investigation; provide "linkage".



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Fuel Ethanol Survey at a Glance

- It involved a survey of companies in manufacturing, distribution and blending of fuel ethanol. Included:
  - Eight (8) ethanol processing facilities.
  - Two (2) fuel ethanol distribution terminals
  - Ten (10) end-user storage & blending facilities
  - One (1) methanol handling facility
  - Five (5) companies also provided reports and documents on SCC failures and inspections.
  - Eight (8) on-site visits were conducted
  - Review of published literature on corrosion and SCC in alcoholic environments.
  - Surveys and data gathering in EU and Brasil.
  - Survey of E85 sites
- Currently, more than 20 known cases of SCC have been documented through the survey efforts covering the period 1990-2005.
- Failures have been reported in steel – tank bottoms, wall and roofs; facilities piping, fittings and components and at least one pipeline.

Honeywell

Examples of Recent SCC Events

- End user storage and gasoline blending facilities
  - Three cases at one Great Lakes facility in loading rack piping used for blending ethanol into gasoline.
    - Cracks in sock-o-let welds, pipe butt weld, and fillet weld on pipe shoe.
  - Two cases on West Coast at two facilities
    - Cracks in roof plate welds
    - Cracks in rack piping/fittings
  - One case in Mid-Continent blending facility
    - Cracks in rack piping
- Fuel ethanol tank at liquids distribution terminal
  - Gulf Coast
    - Cracks in tank floor with subsidence – cracks at multiple ring wall locations.
  - Ethanol pipeline
    - Terminal to refinery blending facility

Example Failure Data and Format

Case No.	Location	Equipment	Service Period	Source of Ethanol	Inhibitor	Steel	Description
A1 1*	W. Coast Terminal	EU (End-User) Tank: Built in 1940; bottom replaced in 1991; 78' dia. steel pan; internal floating roof	10 yrs	During the past 4 years: •89% reported to be domestic sources •6% one source unknown •<5% from additional 10 suppliers	Dependant on source / not consistent	ASTM A36	•Double bottom tank •WMPT identified 18 cracks in or near bottom fillet welds •Plate/plate lap seams & corner welds •Floating roof springs also failed •First course butt weld seam check but no cracks found •Cracks found in one nozzle weld •Metallurgical analysis performed •Repairs: cut out cracks in bottom, corner welds ground out •Remedial: Tank bottom and lower 3 feet of shell were epoxy coated.
E 12-13	Two West Coast Locations	Two tanks – one at each location Evidence suggests SCC but no investigation documentation	Leaks reported in 5 mo. to 1 year	Not known	Not known	Not known	•Found cracking near welds of newly installed patch plates and striker plates, near the corners. •Did not find any cracking in the shell or corner welds •Remedial: Lining all tank bottoms

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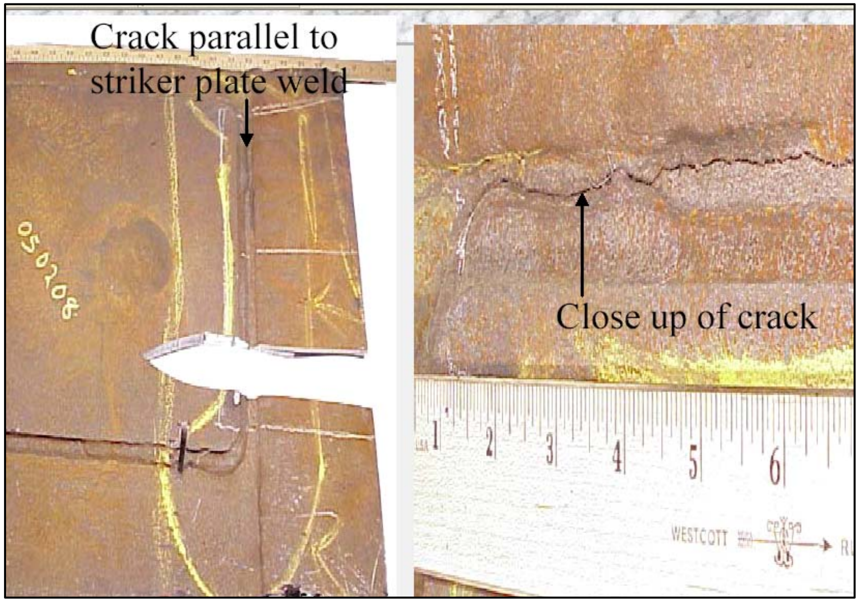
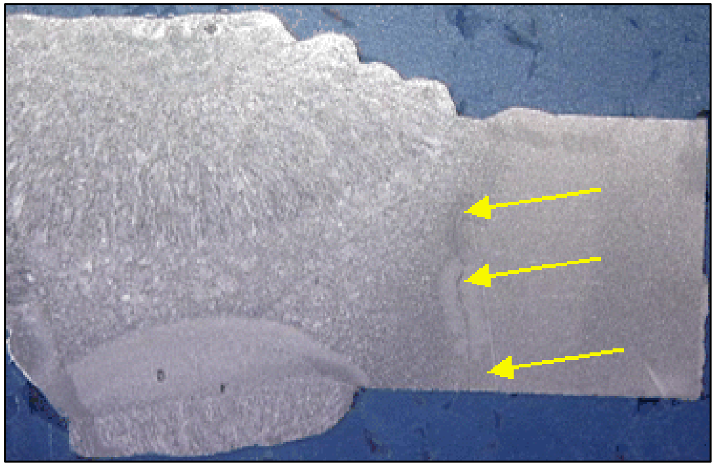
What We Know from Survey

- SCC appears to be related to conditions of:
  - Steel construction with high local tensile stresses, concentration of bending and/or hardness
  - Non-PWHT welds (basically everything), but particularly those welds where very high stress/strain concentration points are present - lap-seam welds (tank roof or bottom), low heat input (tack welds in supports)
  - Residual stresses or cold work – fabrication, forming, fit-up & subsidence
  - Flexing components (tank bottoms, roof plates & spring components)
  - More than one episode of cracking at a facility likely.
  - Experience indicates that steel grade alone is not and issue for piping and tank applications but stress, fit-up, welding and PWHT are very important.



What We Know from Survey - 2

- Based on survey results, the occurrence of SCC appears limited to only a portion of the supply chain:
  - SCC does not appear to be a problem for storage tanks and piping at the point of ethanol manufacture.
  - SCC does not appear to be a problem in the first tier distribution system (i.e. barges, tanker cars, tank trucks),
  - SCC has appeared at or after the first major hold point in the field (e.g. at either a liquids distribution terminal, storage tank, and gasoline blending facilities).
  - No reported SCC from the field:
    - after ethanol is blended with conventional gasoline (E10)
    - in E85 blends
    - outside the USA
      - including Europe - little use until recently
      - Brasil – for decades but mainly hydrated ethanol with higher water content.



What We Know from Survey - 3

- No major differences in handling and operating practices were observed between manufacturers and downstream storage/blending facilities.
- Fuel ethanol is exposed to air, moisture and other potential contaminants many times during its path through the distribution system.
- This suggests time and opportunities are available for changes to occur in the condition of the product.
- Preventative methods used to alleviate SCC problem:
  - Coating of tank bottoms and some floating roofs
  - Post weld heat treatment of piping

Honeywell

Ethanol SCC: Lab versus Field

- Fuel ethanol under aerated and still air conditions showed susceptibility to SCC. Similar to field experience.
- Fractography shows similar fracture features in laboratory tests as in field failures; but can be different (impurities).
- Effect of water content: only within 0-1 percent (no effect) in lab but hydrated ethanol low susceptibility; consistent with field experience.
- E-85 ethanol/gasoline samples demonstrated SCC susceptibility in lab. But, no field failure reported to date.

Honeywell

Current API Activities

- Starting in 2006, API has been developing a guidelines document (API 939E) to present results and experience gain thru studies on SCC.
- Focus has been SCC identification, prevention and remediation methods.
- Emphasis is on practical information for operations personnel (i.e. the corrosion non-specialists).
- This effort has produced a draft document that has been balloted within the API refining committee.
- Revised document is in progress for balloting with hopeful finalization by May 2007.
- This document focuses on:
  - Facilities piping and tanks
  - Lessons learned through survey and research effort in API
  - Ancillary information on inspection, stress relief and coating
  - Limited suggestions for monitoring (based on electrochemical methods for corrosion rate, pitting and potential monitoring).

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Available Resources on Ethanol SCC

- R.D. Kane and J.G. Maldonado, *Stress Corrosion Cracking of Carbon Steel in Fuel Grade Ethanol: Review and Survey*, Publication 939D, American Petroleum Institute, Washington, D.C., November 2003. Has 45 references and bibliography of 15 more papers.
  - API 939D has been updated to include the results of research, survey and monitoring through 2006.
- Bulletin 939E, *Identification, Repair, and Mitigation of Cracking of Steel Equipment in Fuel Ethanol Service*, API, Washington, D.C., (Contractor: R. Kane - draft ballot)
- R.D. Kane and J.G. Maldonado, “Stress Corrosion Cracking In Fuel Ethanol: A Newly Recognized Phenomenon”, Corrosion/2004, Paper No. 04543, NACE International, Houston, TX, April 2004.
- R.D. Kane, N. Sridhar, M.P. Brongers, J. A. Beavers, A.K. Agrawal, L.J. Klein, “Stress Corrosion Cracking in Fuel Ethanol: A Recently Recognized Phenomenon”, Materials Performance, NACE International, Houston, TX, December, 2005.

Available Resources on Ethanol SCC - 2

- N. Sridhar, K. Price, J. Buckingham and J. Danti, "Stress Corrosion Cracking of Steel in Ethanol", Corrosion Journal, NACE International, Houston, Texas, July, 2006, pp 687-702.
- J. Maldonado, N. Sridhar, "SCC of Carbon Steel in Fuel Ethanol Service: Effect of Corrosion Potential and Ethanol Processing Source", Paper No. 07574, Corrosion/2007, NACE International, Houston, Texas, March 2007
- R.D. Kane, Stress Corrosion Cracking in Fuel Ethanol, Paper IBP 1357 _07, RioPipeline, Rio de Janeiro, Brasil. October 2007.
- Other API Publications:
  - API Tech. Pub.1626, *Impact of Gasoline Blended with Ethanol on the Long-Term Structural Integrity of Liquid Petroleum Storage Systems and Components*, American Petroleum Institute, Washington, D.C.
  - API Tech. Pub. 4161, *Alcohols & Esters: A Technical Assessment of Their Application as Fuels and Fuel Components*, American Petroleum Institute, Washington, D.C.

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Summary

- SCC failures have been experienced in systems handling, storing and transporting fuel ethanol.
- Lab research has confirmed this phenomenon.
- Lab and field work has identified certain conditions as causal effects, i.e. aeration, chlorides (but chlorides not required).
- Failures appear to be limited to mid-stream distribution of fuel ethanol up to mixing in conventional gasoline blends (E10).
- SCC has been recently observed in lab tests of E85, but no failures reported.
- SCC mitigation methods reported are coating of tanks (novolac, epoxy phenolics) and post weld heat treatment of piping (reduce residual stress).

Honeywell

Thank You

- API has developed a data form for documentation of SCC failures.

Dr. Russell D. Kane

Honeywell Process Solutions

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DoD Corrosion Prevention and Control

Program Policy Overview and Status

Alternative Fuels Workshop

Daniel J. Dunmire
Department of Defense
Special Assistant for Corrosion Policy and Oversight

25 October 2007

Why I Am Here

- Almost all fuels require:
  - Production systems
  - Transfer systems
  - Storage systems
  - Delivery systems
- Many of these systems are vulnerable to corrosion and its effects due to:
  - Material selection
  - System design
  - Production methods
  - Inadequate treatment, detection and maintenance methods
- Corrosion prevention and control is a vital part of any new system development
- DoD leads Government agencies in corrosion prevention and control of infrastructure and warfighting equipment

Agenda

- The Law
- The Response
- DoD Corrosion Organization
- Specific Approaches
- Strategies
- Directions

Congressional Response to Corrosion Problem

Members of Congress

- Reviewed Transportation Department study
- Noted severe, pervasive corrosion during 2002 Pacific Rim tour
- Subsequently enacted corrosion control legislation because –

DOD Cost of Corrosion

- Estimated at **$10B to $20B,** and as high as **$40B per year**
- Where most dollars go toward
  - Detection and assessment of corrosion
  - Treatment to prevent or retard added effects
  - Repair of damaged equipment or facilities

The Law

***Public Law 107-314 Sec: 1067 [portions codified in 10 U.S.C. 2228]: Prevention and mitigation of corrosion of military infrastructure and equipment* requires that:**

- **DoD designate a responsible official or organization**
- **DoD develop a long-term corrosion strategy to include**
  - **Expansion of emphasis on corrosion prevention & mitigation**
  - **Uniform application of requirements and criteria for the testing and certification of new corrosion prevention technologies within common materiel, infrastructure, or operational groupings**
  - **Implementation of programs to collect and share information on corrosion within the DoD**
  - **Establishment of a coordinated R&D program with transition plans**

Strategy to include policy guidance & assessment of funding and personnel resources required

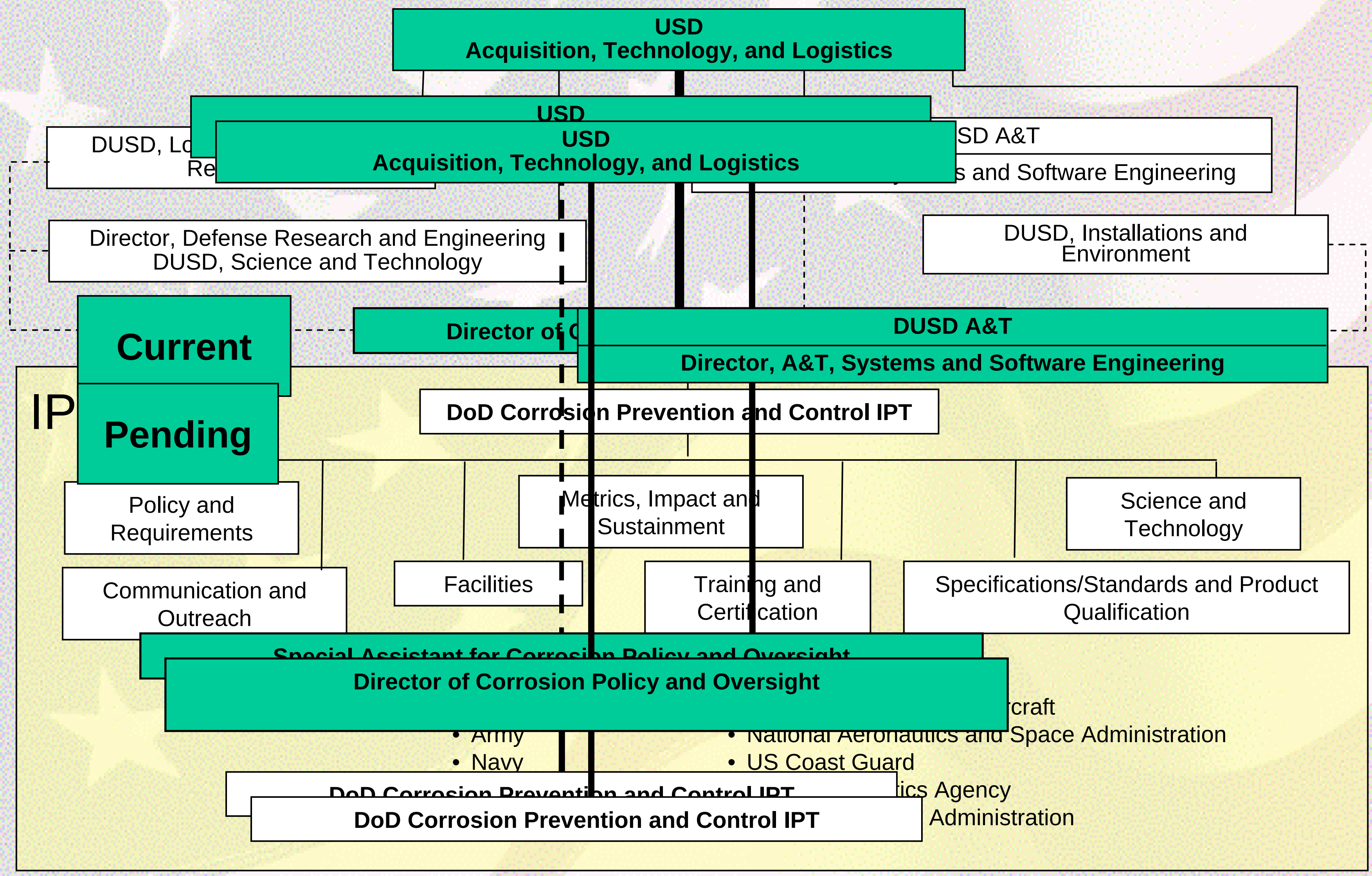
DoD Response to Congressional Mandate

- Response to the law
  - Developed organization
  - Developed strategy
  - Reported to Congress
- Assembled corrosion forum
  - Organized overarching corrosion program IPT
  - Established WIPTs (focus groups)
- Developed and published a strategic plan
- Interacted with the Government Accountability Office (GAO)

Pending Revision to Law

- Retains the requirements of the basic law
- Makes the following changes
  - Eliminates DoD Corrosion Executive
  - Elevates SA/CPO to Director CPO
  - Assigns Corrosion Executive duties to DCPO
  - DCPO becomes direct report to USD(AT&L)
  - Requires annual financial reporting
  - Codifies ongoing CPO activities

DoD Corrosion Organization



IPT Structure

- Corrosion Prevention and Control IPT (CPCIPT)
  - Provide strategic review and advice
  - Develop and recommend policy guidance
- Working IPTs (WIPTs)
  - Policy and requirements
  - Impact, metrics and sustainment
  - Science and technology
  - Communication and outreach
  - Training and Doctrine
  - Facilities
  - Specifications and standards

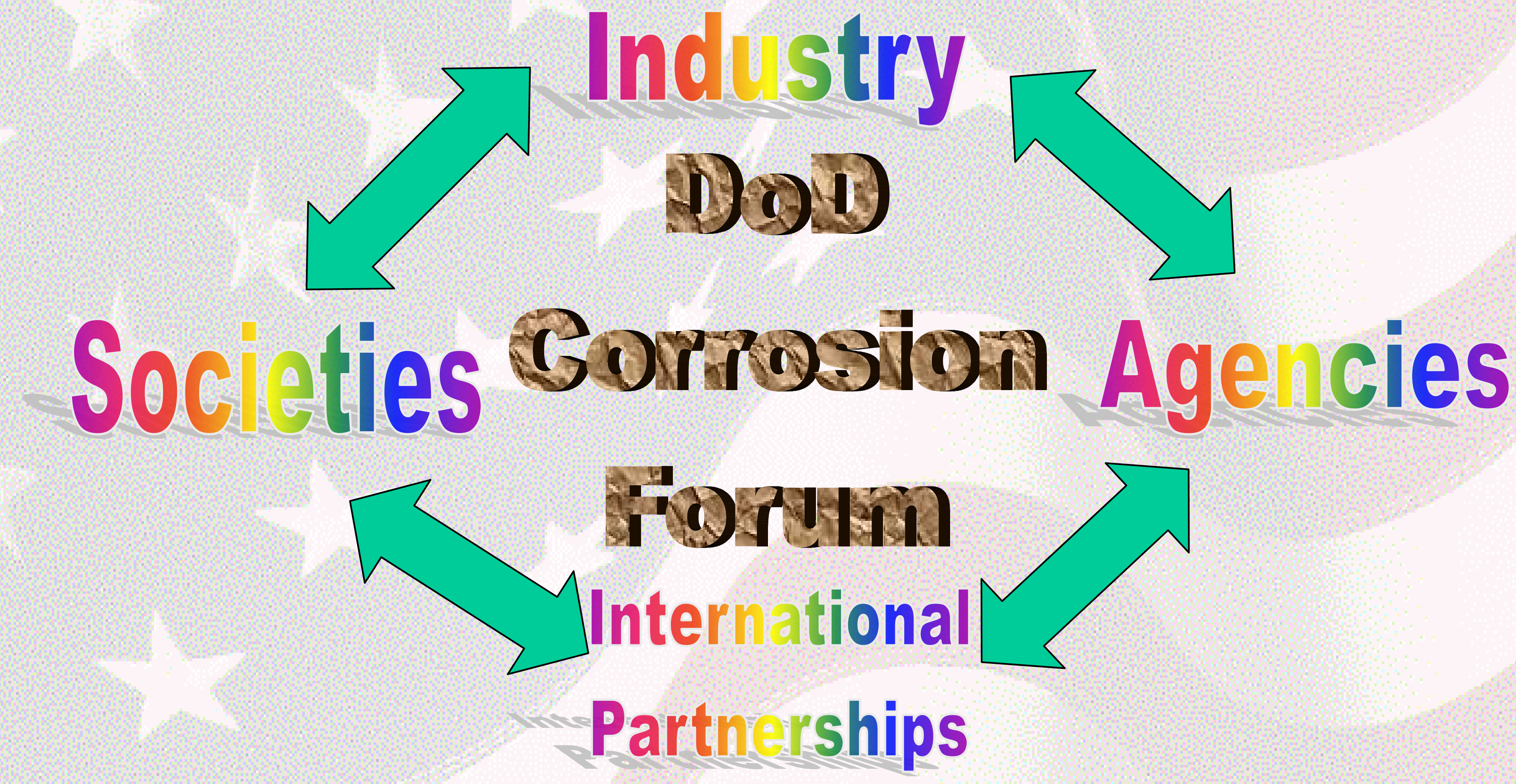
Specific Approaches to CPCP Success

- Policy changes – transcend traditional methods
- Strategic plan – develop and implement
- Specifications, standards and qualification processes – update and standardize
- Research projects – submit, select and execute
- Communication and outreach – change culture
- Training and certification – improve competence
- Infrastructure – equal emphasis as equipment
- Strategic partnerships – leverage networks
- Cost of corrosion baseline study – quantify problem

Transcending - Updated Strategies

- **Overarching strategy: transcend traditional control methods, organizations, management and funding approaches**
- **Attack corrosion early** in acquisition or construction
- **Focus** life-cycle corrosion research and development **efforts** on **four primary areas**
  - Materials and manufacturing processes that **prevent or reduce** the incidence and effects of **corrosion**
  - **Detection** of corrosion in fielded systems and facilities **and prognosis** of the expected growth, potential impact and predicted effects
  - Coatings, treatments and other **applications to prevent, arrest or retard corrosion**
  - **Repair processes** that restore materials to an acceptable level of structural integrity and functionality
- Publish **direction and guidance** regarding corrosion prevention and mitigation **policies and strategies at all** DoD and Service **levels**

Sharing Problems and Solutions



New Directions

- Education and training
  - Corrosion Engineering Degree at University of Akron
  - Advanced Corrosion Training Video and Continuous Learning Module – including 1 hour training video
  - Initiation of virtual corrosion gaming video
- Outreach and culture change
  - 2007 Tri-Service Corrosion Conference in Denver in December
  - Implement Phase 3 of supplier online product qualification process
  - Premier Outreach and Communication corrosion effort public video
  - Moved CPC Web-site to **www.CorrDefense.gov**
- International Initiatives
  - Australasia, UK, France, Germany cooperative efforts
  - Australasian Conference and World Congress on Corrosion

Summary

- Congressional interest very high – recent disasters amplifying interest
- CPC program implements modern strategies that produce
  - significant reduction in corrosion incidence and impact
  - better education and understanding
  - cultural changes
  - international interest and cooperation
- Combined efforts of industry, government, academia and user community essential to combat corrosion
- Partnership between DoT and DoD on alternative fuels corrosion prevention and control can strengthen both programs

U. S. Department of Transportation

Pipeline and Hazardous Materials Safety Administration

Ethanol Road Mapping Workshop

A Summary Presentation

www.phmsa.dot.gov

U.S. Department of Transportation

Pipeline and Hazardous Materials Safety Administration

Why a PHMSA Involvement?

- Energy Policy Act of 2005, President's 2006 State of the Union Address & Executive Order 13432 set forth strategy designed to displace use of gasoline produced from foreign oil by increasing use of renewable fuels such as ethanol and other biofuels ("20 in 10").

- PHMSA will have regulatory jurisdiction within Part 195 of its hazardous liquid pipeline regulations.

- PHMSA has research funding available to address potential threats with its stakeholder partners.

- Desire/need to remove any pipeline related barriers to an ethanol/bio-diesel economy
  - Significant investment and growth in ethanol will depend on pipelines for safe, reliable & cost-effective transportation solutions.
  - Other transportation modes (rail/barge/highway) nearing capacity with E10 economy and pose potentially more safety risks when moving higher volumes.

U.S. Department of Transportation

Pipeline and Hazardous Materials Safety Administration

What is PHMSA's Challenge with Biofuels?

- Identify and quantify any safety and reliability threats to liquid pipelines.
- Address emergency response issues unique to biofuels and ethanol.
- Remove or manage these threats through a risk-based, data driven integrity management approach.
- Address adequacy of operating procedures, set minimum standards and modify them as needed.
- Work with multiple industry and government stakeholders to address any safety, environment, and equipment impacts due to ethanol transportation.

U.S. Department of Transportation

Pipeline and Hazardous Materials Safety Administration

Policy Development & Setting Minimum Standards

- **Issued Ethanol Federal Register Notice – Aug. 10, 2007**
  - Biofuel pipelines regulatory jurisdiction - 49 CFR Part 195.
  - Outlined critical role of pipelines in biofuels transportation; requested technical papers and R&D proposals on implementation challenges; and described PHMSA's cooperative activities with emergency responders.
  - Part 195 applies to ethanol/biofuel pipelines.
  - Requested public feedback
    - *Comments received in response to the notice were generally supportive of PHMSA's overall approach.*

Policy Development & Setting Minimum Standards

U.S. Department of Transportation

Pipeline and Hazardous Materials Safety Administration

- **Participation on policy setting groups**
  - 20-in-10 Working Group
  - Biomass R&D Panel
- **Working with Emergency Responders**
  - Providing policy guidance & revise response plans
  - Setting minimum standards for response equipment/training

Research & Development and Studies

- **Pipeline R&D Forum in Feb. 2007**
  - Subject matter experts identify some ethanol challenges
- **R&D Solicitation in July 2007, Awards in January, 2008**
  - Ethanol effects on new and existing pipelines
  - Seven proposals now requested
  - Solutions in 1-3 years
- **Pipeline Industry JIP on Ethanol Blends**
  - Identifies QA/QC impacts & investigates pipe retrofitting options
  - Solutions in 9-12 months
- **Foam & Retardant Research for Ethanol**
  - Response equipment performance with blends and pure ethanol

U.S. Department of Transportation

Pipeline and Hazardous Materials Safety Administration

Stakeholder Coordination, Communication & Outreach

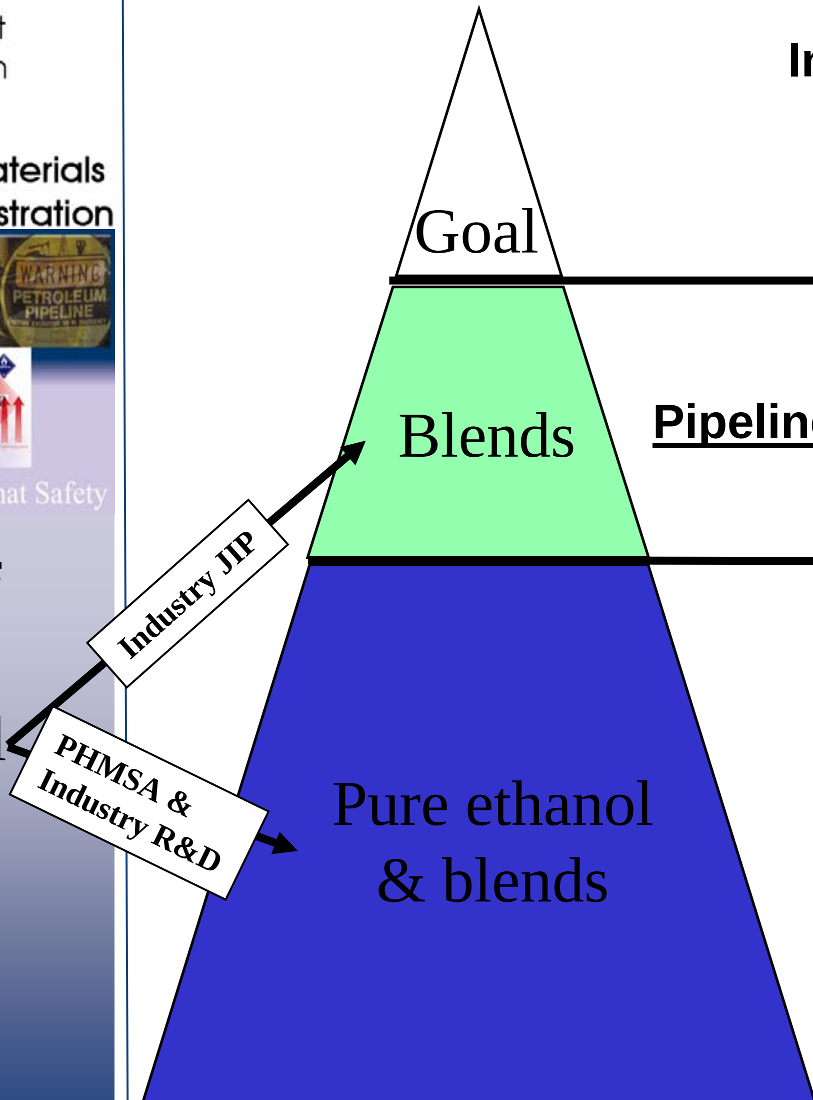
- **The Pipeline Industry**
  - American Petroleum Institute; Association of Oil Pipe Lines; American Society of Mechanical Engineers and Pipeline Research Council International
- **With Emergency Response Organizations**
  - U.S. Fire Service; National Association of State Fire Marshals; International Association of Fire Chiefs; Independent Liquid Terminal Association; and the Ethanol Emergency Response Committee
- **Federal Agencies & Others**
  - DOE, USDA, USFA & EPA
  - Hydrogen Executive Leadership Panel (HELP)

Ethanol Pipeline Research:
Basic Steps & Phases

U.S. Department of Transportation

Pipeline and Hazardous Materials Safety Administration

Status of current technical issues…



Industry Consensus Standards

PHMSA – 49 CFR Part 195

<u>Pipeline Safety/Reliability Assessments</u>

<u>Laboratory Research & Testing</u>

U.S. Department of Transportation

Pipeline and Hazardous Materials Safety Administration

Ethanol Pipelines:

What are Future Actions for PHMSA?

- Develop any required technology improvements to address threats
- Work with Standard Developing Organizations to push new knowledge into consensus standards
- Work with Emergency Response Community :
  - Revise emergency response plans & measures
    - ***Assess ethanol blend physical properties (flammability/toxicity)***
  - Investigate response equipment effectiveness with ethanol/ethanol blends
    - ***Absorption booms and foam retardants***

BRAZILIAN ETHANOL PIPELINES

Dublin - OHIO
OCTOBER / 2007

AGENDA

1. Background

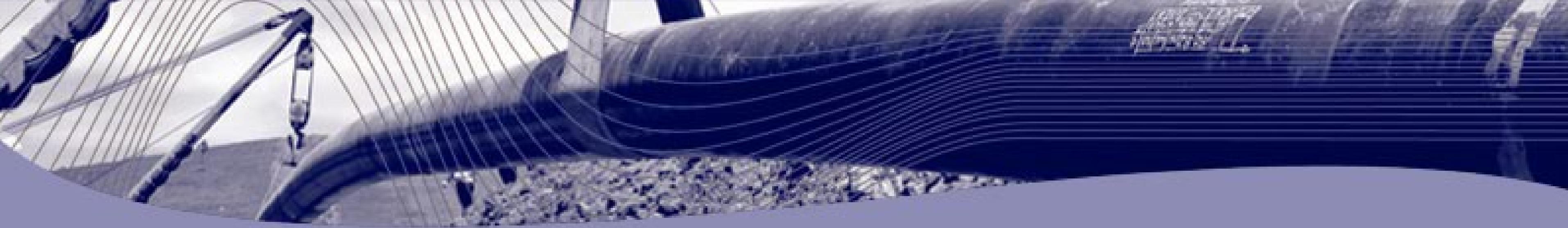
2. Ethanol Supply Chain

3. Brazilian Ethanol History

4. Petrobras Expertise

5. Ethanol Exportation Corridors

BR PETROBRAS



1. BACKGROUND

Ethanol – BRAZIL

1928

1931

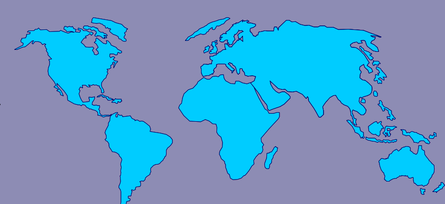
1940

1974

BR PETROBRAS

2. ETHANOL SUPPLY CHAIN

Ethanol Export Supply Chain



PETROBRAS Multimodal Leadership

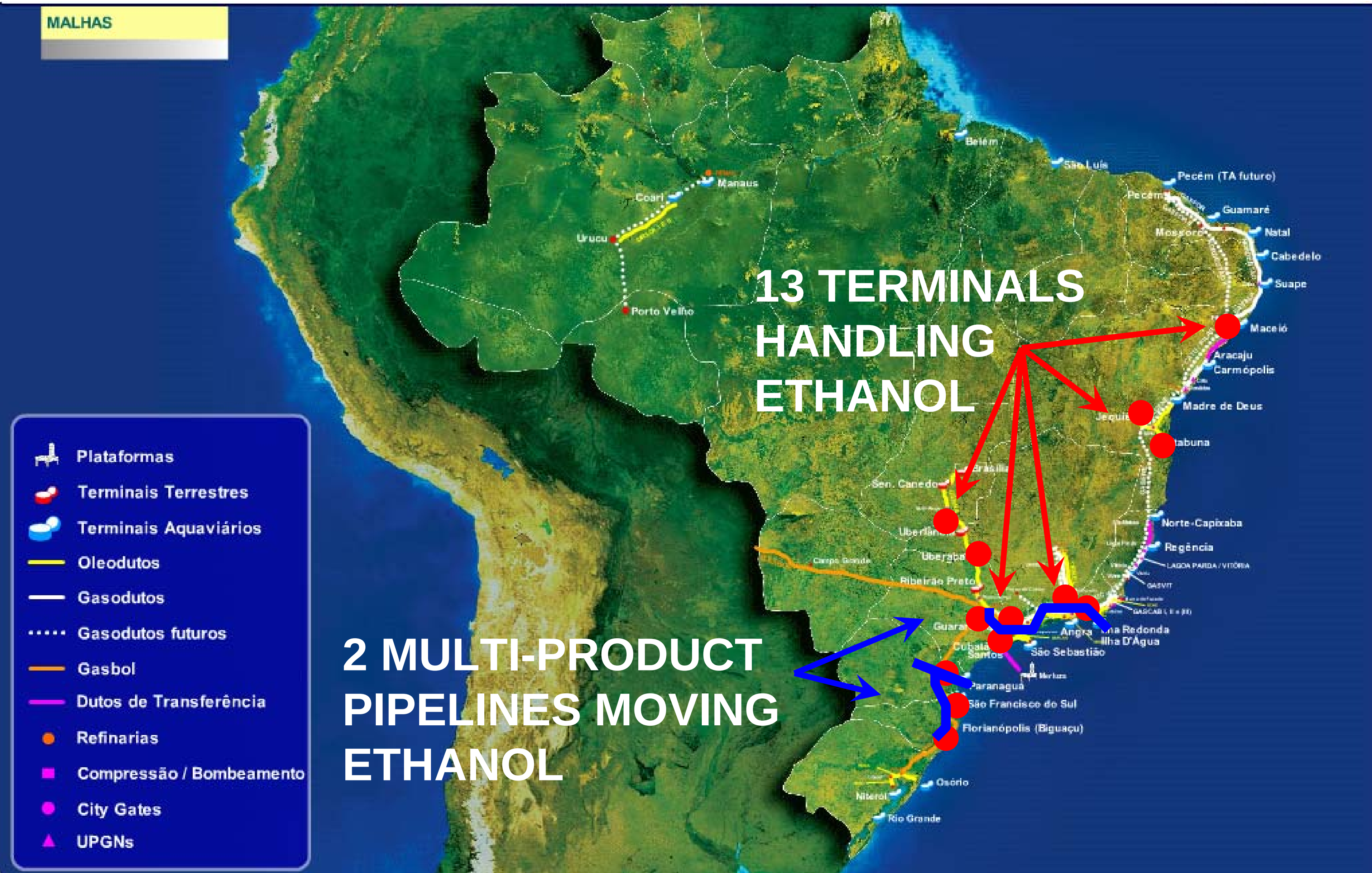
- Gathering Centers
- Pipelines
- Terminals
- Shipments

PETROBRAS

PETROBRAS LOGISTICS

PETROBRAS TRANSPORTE S.A.
TRANSPETRO

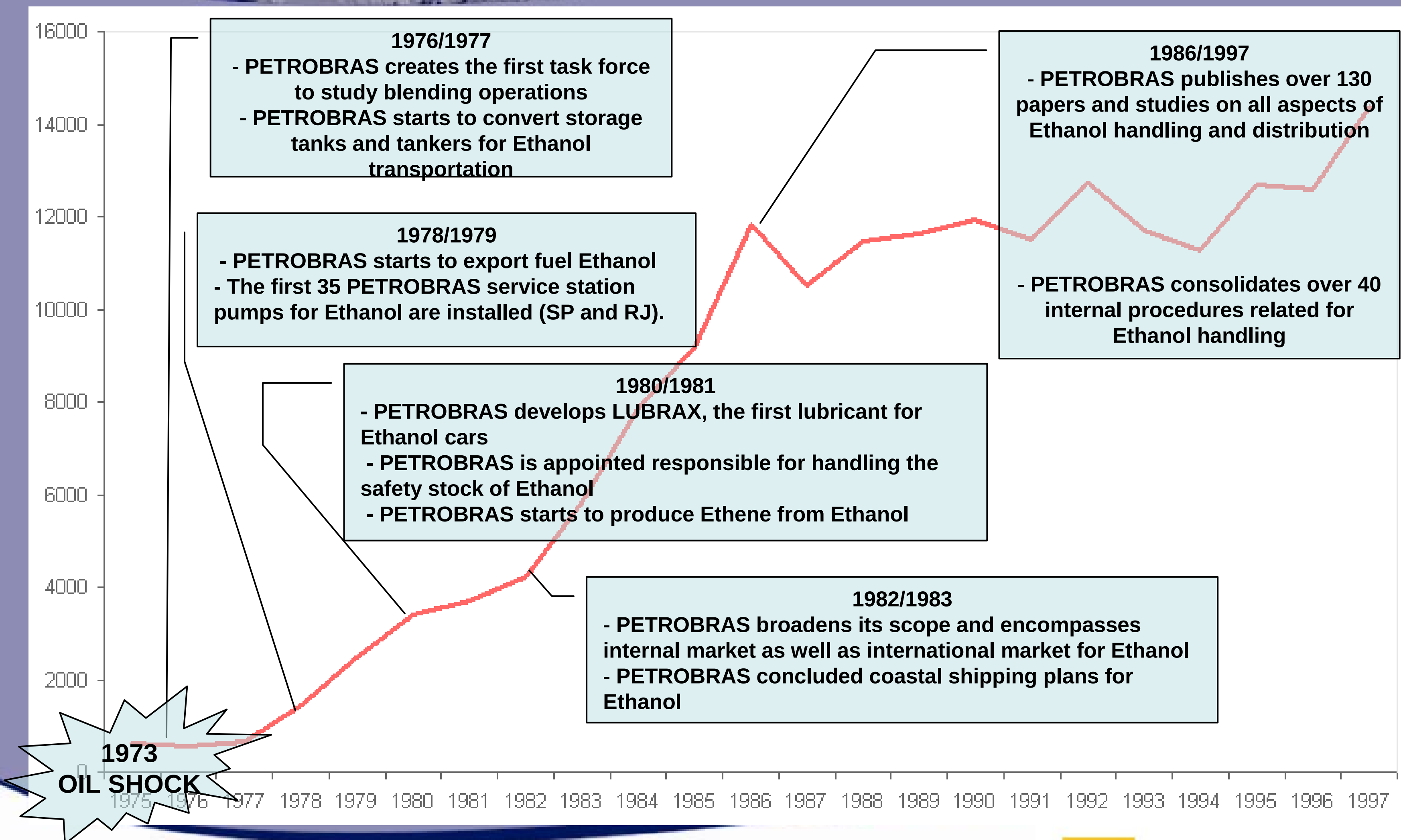
PETROBRAS LOGISTICS TODAY



3. BRAZILIAN ETHANOL HISTORY

A Brief History of Ethanol and Petrobras

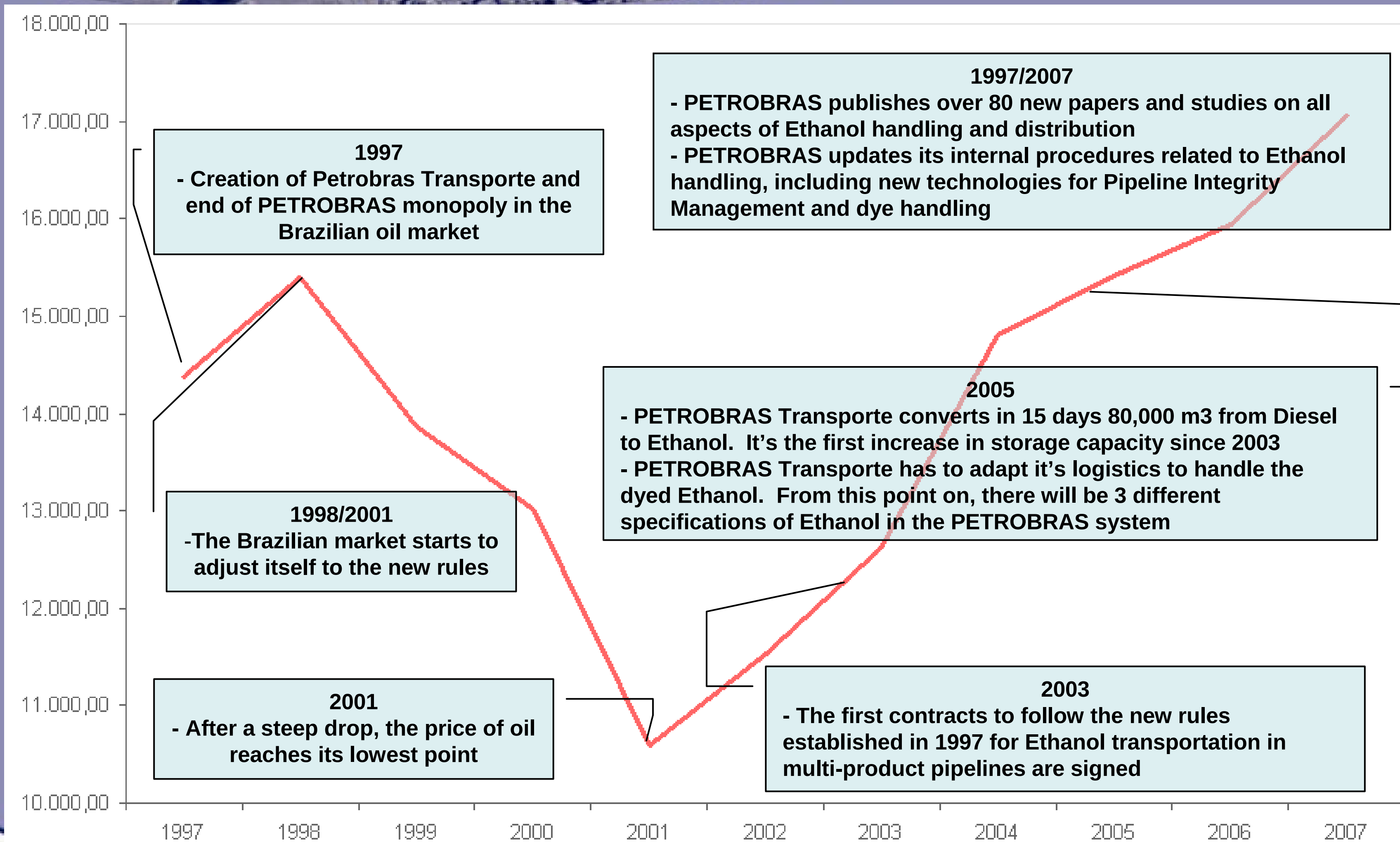
(Before the end of the oil monopoly)



Source of the Ethanol production data: UNICA
Souce of the Petrobras developments: PETROBRAS

PETROBRAS

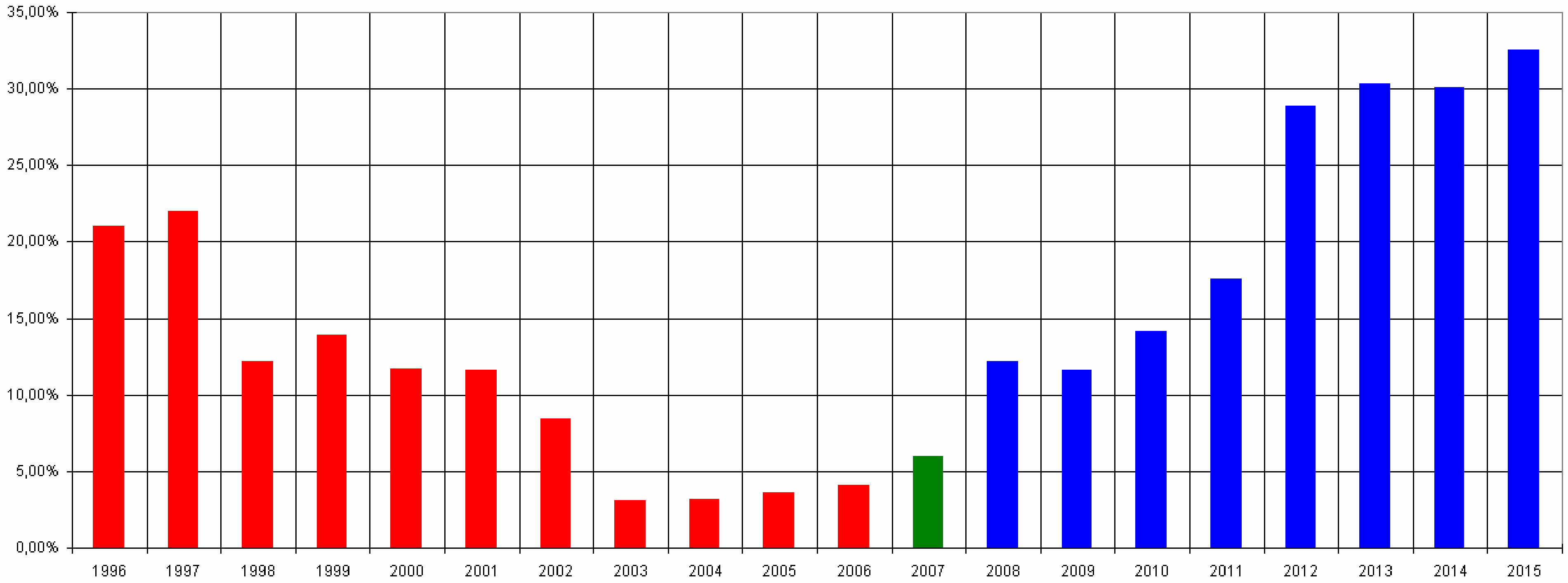
A Brief History of Ethanol and Petrobras
(After the end of the oil monopoly)



Source of the Ethanol production data: UNICA
Souce of the Petrobras developments: PETROBRAS
The Production for 2007 is an estimate

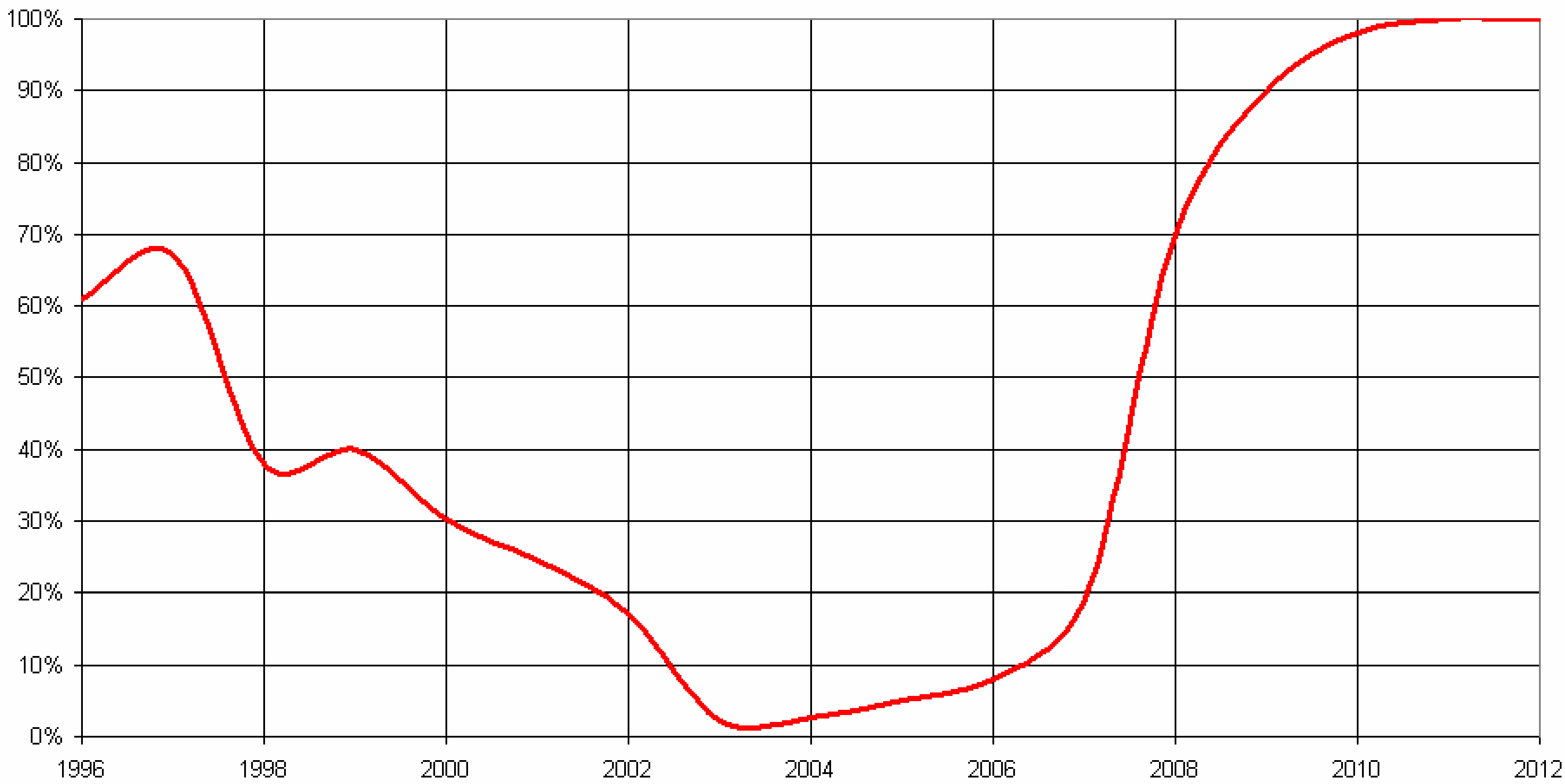
PETROBRAS

% OF BRAZIL'S ETHANOL PRODUCTION SHIPPED THROUGH MULTI-PRODUCT PIPELINE



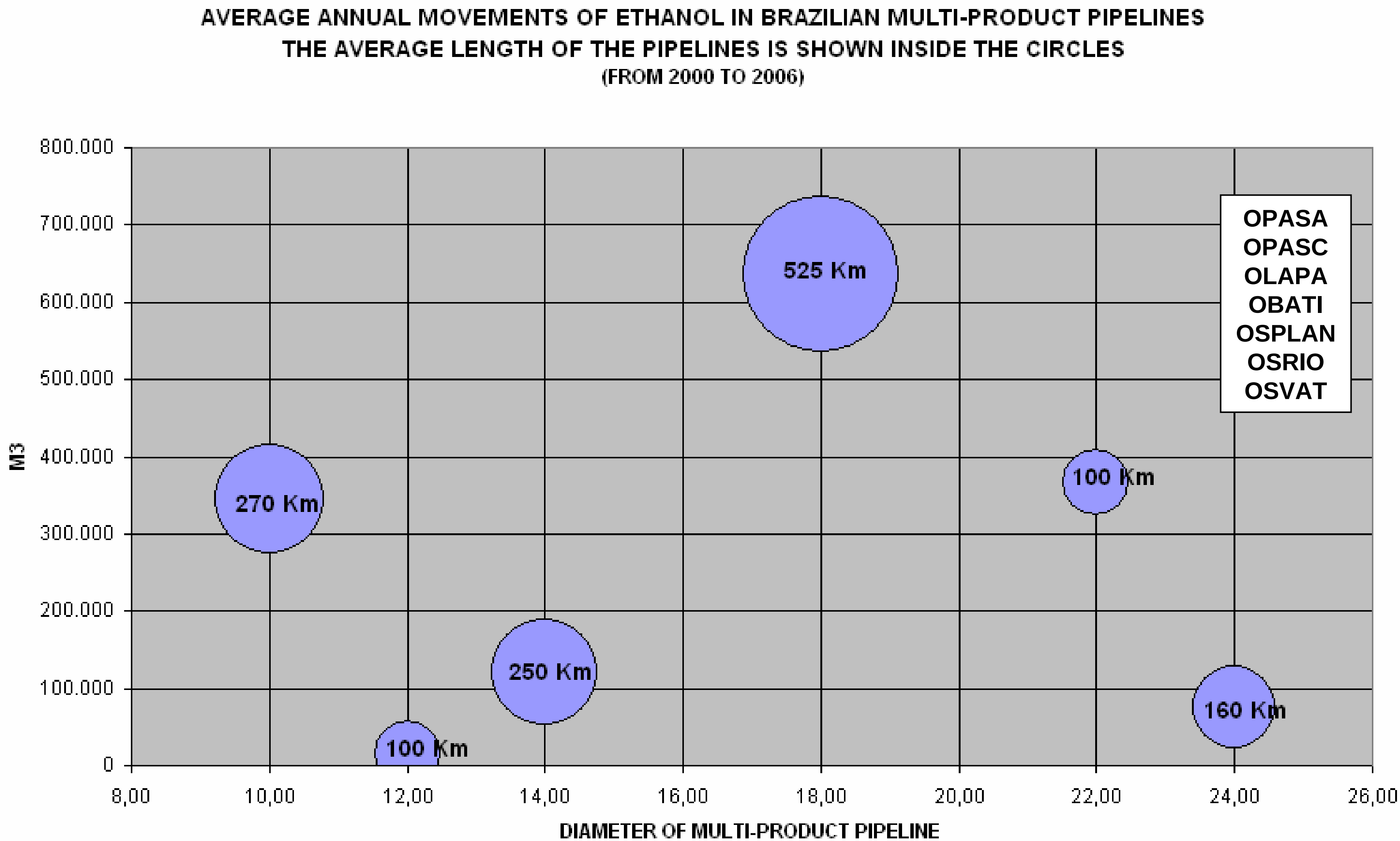
BR PETROBRAS

% OF ETHANOL SHIPPED THROUGH MULTI-PRODUCT PIPELINE
RIO DE JANEIRO CORRIDOR

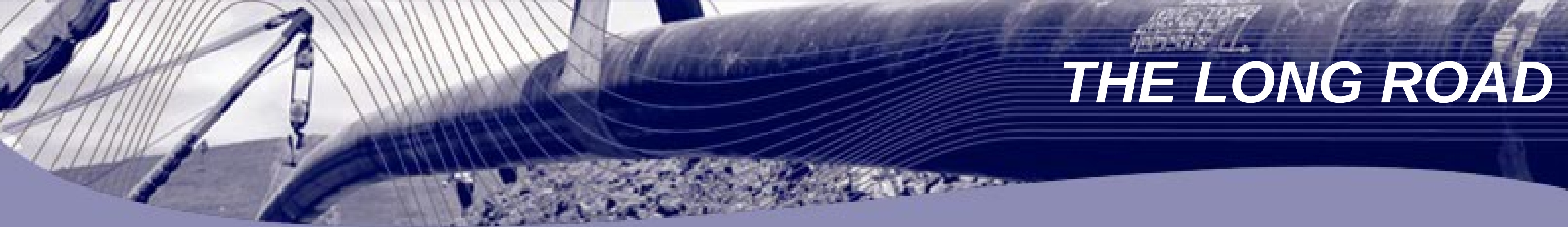


PETROBRAS

Ethanol Movements and Multi-product Pipelines



4. PETROBRAS EXPERTISE

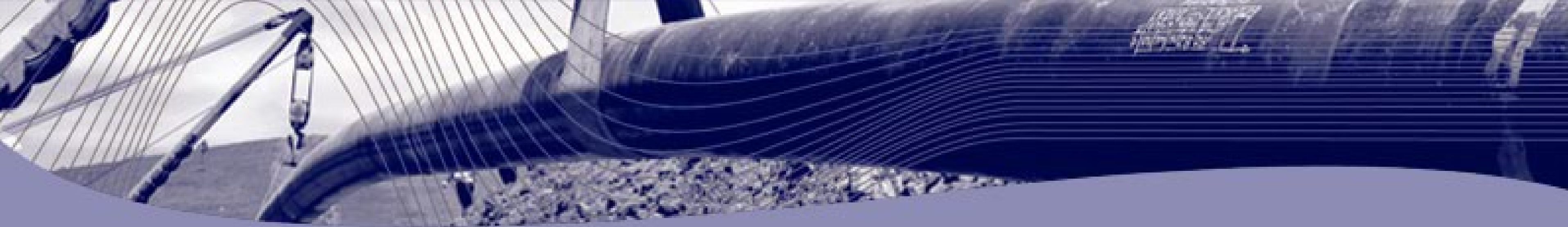


THE LONG ROAD

SINCE PETROBRAS EXPERTISE SPANS A WIDE RANGE OF VERY SPECIFIC ISSUES REGARDING ETHANOL, SOME OF THEM ARE LISTED BELOW:

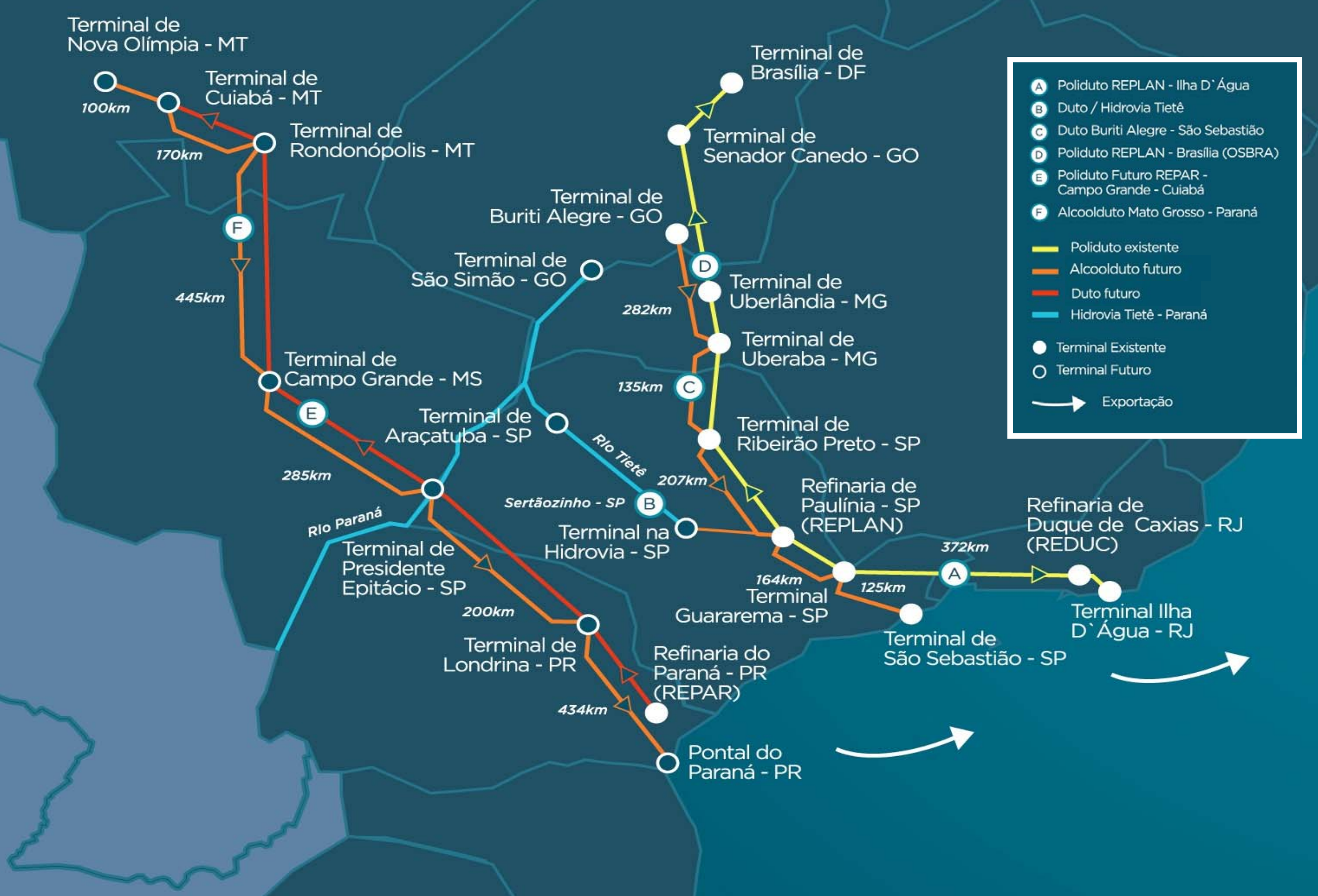
1. ***"No-Water" Contamination Procedures***
2. ***Proper Pipeline Batch Sequencing***
3. ***Ethanol Corrosion Controls (including SCC) and NACE's analysis***
4. ***Development of Tank Covers***
5. ***Coating Developments for Storage Tanks and Tankers***
6. ***Quality degradation aspects and solutions***
7. ***Inert Gas Solutions for Tankers***
8. ***Develop Blending Operations***
9. ***Interface Treatment and Handling***
10. ***Special Firefighting Needs***
11. ***Materials Compatibility***
12. ***Pipeline Integrity Program***
13. ***Corrosion Inhibitors***

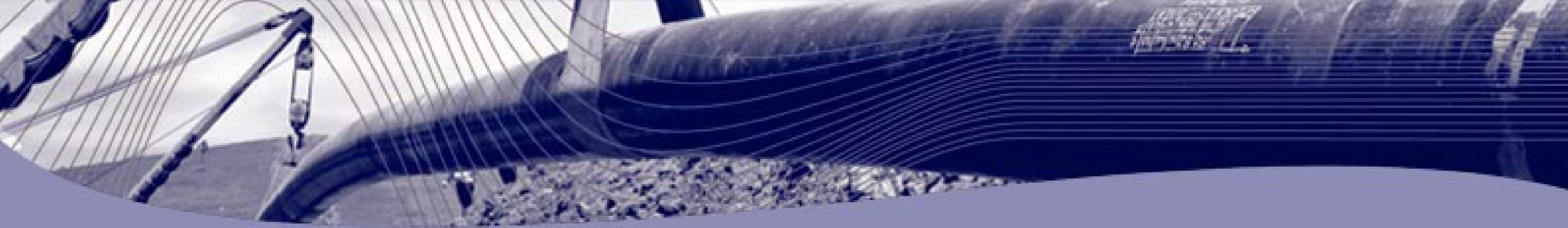
BR PETROBRAS



5. ETHANOL EXPORT CORRIDORS

Ethanol Export Corridors





THANK YOU !!!

Marcelino Guedes F. Mosqueira Gomes

Director of Terminals and Pipelines

TRANSPETRO

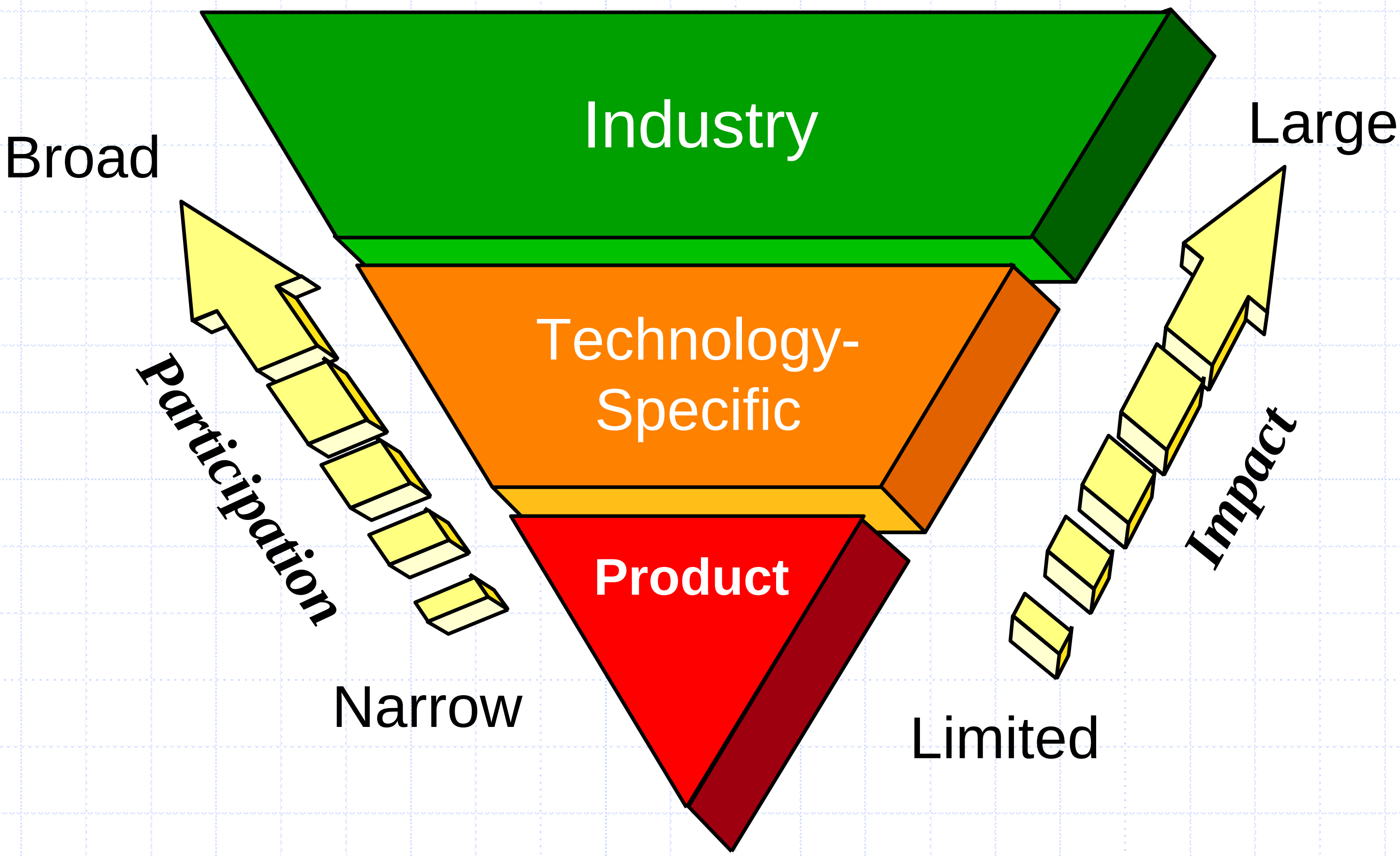
Workshop Process and Logistics

Safe and Reliable Ethanol Transportation and Storage Technology Roadmapping Workshop

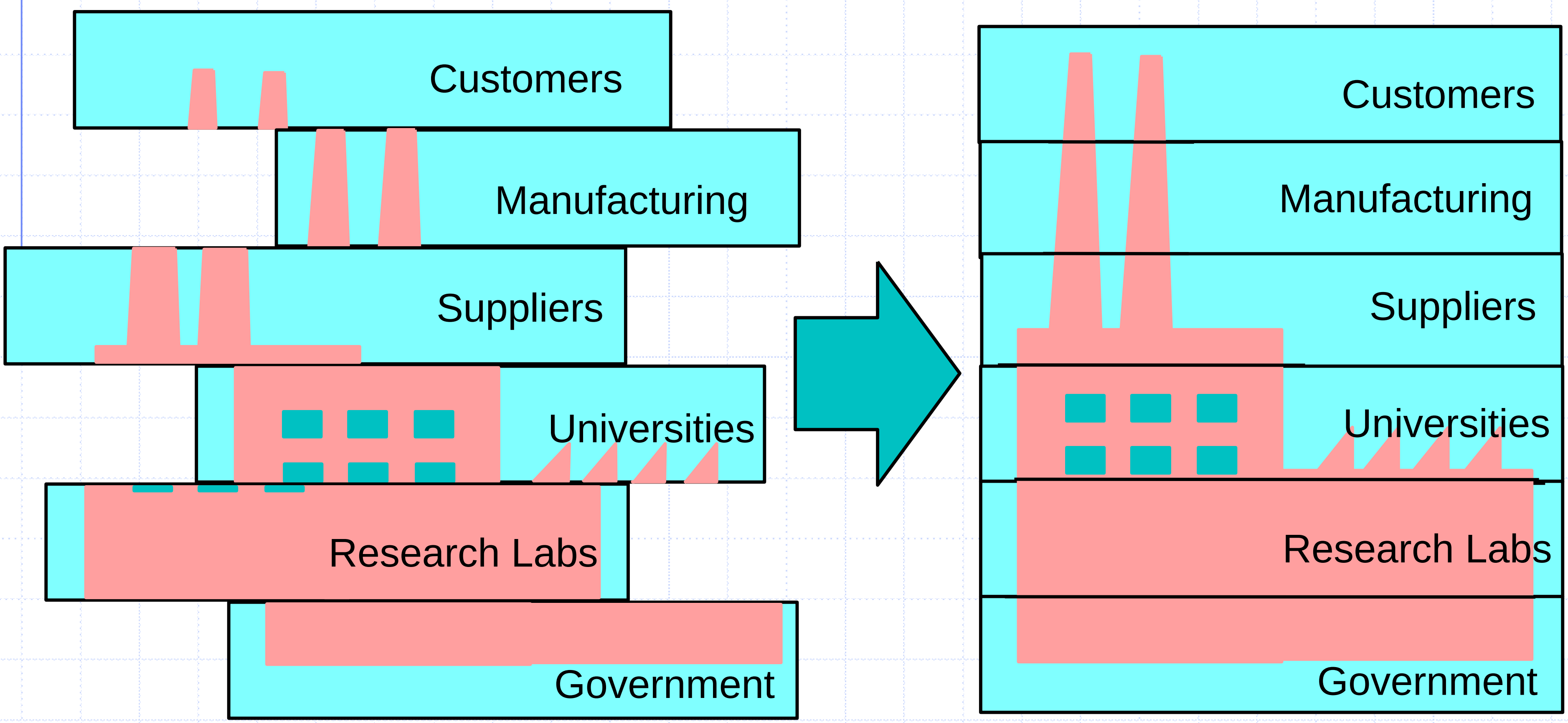
October 25-26, 2007
Dublin, Ohio

Ross Brindle
Keith Jamison
Katie Jereza
Mauricio Justiniano

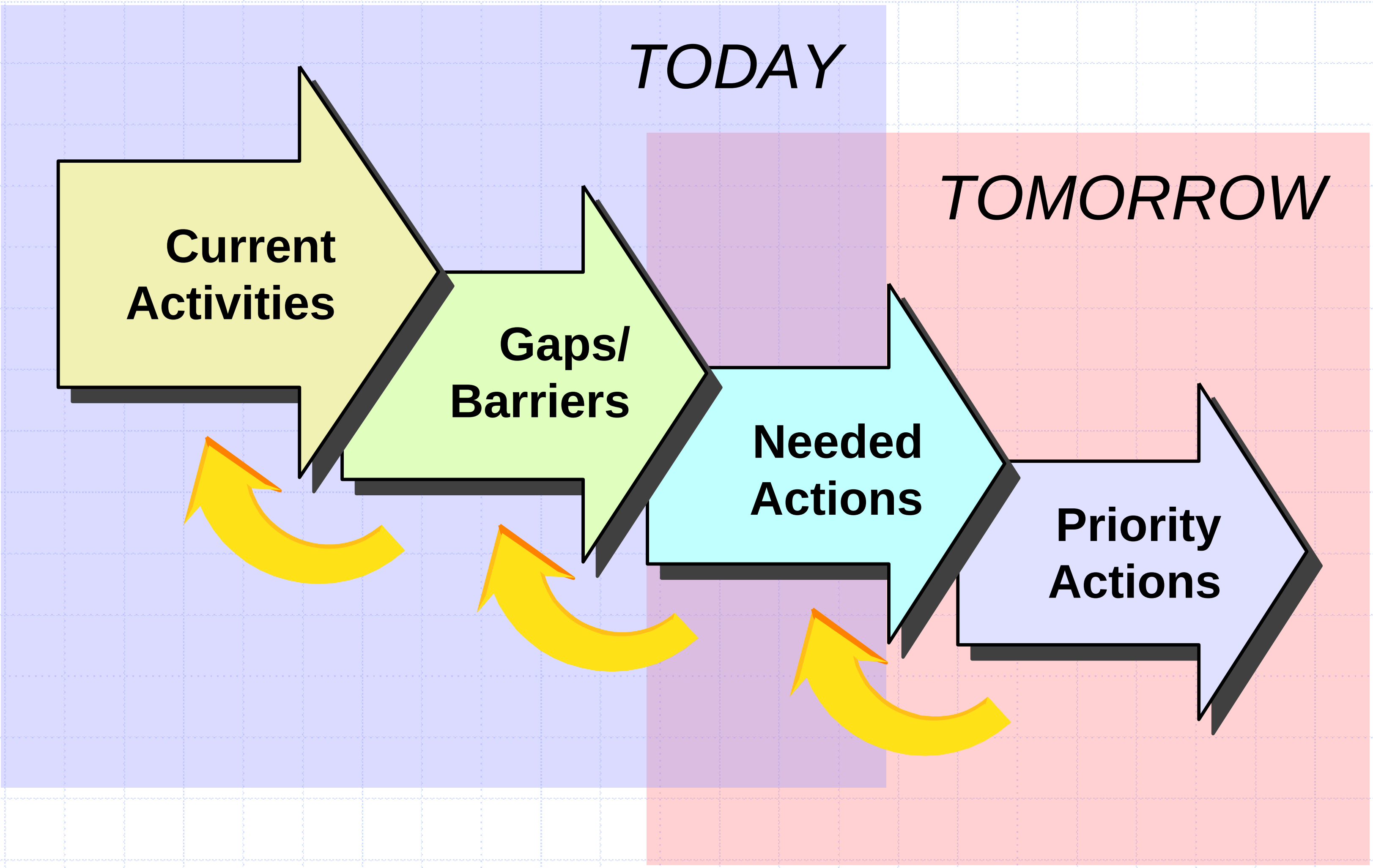
Types of Technology Roadmaps



Aligning Resources for Mutual Benefit



Technology Planning Logic



Agenda

- Characterize Current Industry Activities
- Identify Gaps and Barriers
- Brainstorm Actions Needed
- Analyze and Prioritize Actions Needed
- Summary Session

Breakout Session 1: Boardroom 1
Ethanol Sources and Quality Issues

Julio G. Maldonado	Southwest Research Institute
Feng Gui	CC Technologies, Inc.
Liu Cao	The Ohio State University
Chuck Corr	Archer Daniels Midland Company
Robert Reynolds	Downstream Alternatives, Inc.
Preet M. Singh	Georgia Institute of Technology
Jake Haase	Colonial Pipeline
Ross Brindle	Energetics
William M. Olson	Gulf Interstate Engineering
April Pulvirenti	CC Technologies, Inc.
John Beavers	CC Technologies, Inc.
Luis Garfias	CC Technologies, Inc.
Tom Siewert	NIST

Breakout Session 2: Boardroom 2

Pipeline Integrity Issues

Emerson Nunez	The Ohio State University
Frank A. Tallarida	Buckeye Partners, LP
Wayne Geyer	Steel Tank Institute
Carlos Alexandre Martins Da Silva	Petrobras Transporte S.A.
Scott Turner	Marathon Pipe Line, LLC
Craig Harris	El Paso Corporation
Patrick H. Vieth	CC Technologies, Inc.
John Farrell	BP
Robert Smith	DOT/PHMSA
Danny Aronson	Petrobras Transporte S.A.
Shuchi Khurana	EWI
Katie Jereza	Energetics
Myrriah Rowden	ConocoPhillips
Tom Bubenik	CC Technologies, Inc.

Breakout Session 3: Boardroom 3

Pipeline Operations Issues

Eric Gustafson	Buckeye Partners, LP
Richard Kinzie	PCI
Michael Pearson	Magellan Pipeline Company, LP
Jim Edmondson	Shell Global Solutions (US), Inc.
Ken Lorang	PRC International
Chad Zamarin	Colonial Pipeline
Bonita Leonard	El Paso Corporation
Dr. Russell Kane	Honeywell Process Solutions
Marcelino Guedes Ferreira Mosqueira Gomes	Petrobras Transpotre Oil Pipeline, SA
Sean Brossia	CC Technologies, Inc.
Joshua Colombo	EPCO, Inc.
Raymond Paul	Association of Oil Pipe Lines
Keith Jamison	Energetics

Breakout Session 4: Boardroom 4
Standards, Guidelines, & Training

David Robertson	LMI Government Consulting
Cliff Johnson	NACE International
Dan Dunmire	DoD
Peter Lidiak	API Energy
Donald Drake	Exxon Mobil
Neil Thompson	CC Technologies, Inc.
David Kunz Esq.	DOT/PHMSA
Leigh Klein	BP - Cherry Point Refinery
Mauricio Justiniano	Energetics
Jerry Rau	
Mark Hereth	P-PIC
David Soyster	Buckeye Partners, LP

Industry Road Mapping Workshop							
October 25 - 26, 2007							
Attendee	**Title**	**Organization**	**Street Address**	**City/State/Zip/Country**	**Telephone**	**Fax**	**E-Mail Address**
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Industry Road Mapping Workshop							
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