Safe & Reliable Ethanol Transportation & Storage Technology Roadmapping Workshop

October 25-26, 2007 • Dublin, Ohio

WORKSHOP SUMMARY RESULTS





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Organized by

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a DNV company

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FOREWORD

Biofuels, especially ethanol, are gaining attention as partial replacements of imported fuels and to offset CO_2 emissions from the burning of fossil fuels. Consequently, legislation is being proposed to mandate a significant increase in ethanol usage as a fuel over the next 20 years. The planned wide-spread usage of ethanol will require an efficient and reliable transportation and storage system that encompasses both the existing infrastructure and new construction. The fuels are currently being transported by rail, truck, and ship; however, in order to economically transport biofuels from producers to users on a large scale, safe and reliable transportation by pipeline is necessary. Prior industry experience and research has shown that stress corrosion cracking (SCC) can initiate in some fuel-grade ethanols. Detailed laboratory studies indicate that primary factors contributing to the initiation of SCC include the presence of dissolved oxygen and other contaminants, including pre-existing corrosion products, and the corrosion potential of the fuel. The source of the fuel (e.g., corn, sugar cane), the gasoline-to-ethanol blend ratio, and handling of the fuel from production to end-user delivery influences the significance of these factors as well as the operational and maintenance protocols to be applied for safe transportation of the fuel by pipeline. In addition to pipeline reliability, quality of the fuel as it travels down the pipeline to the end-user must be assured. Finally, the effect of ethanol on other metallic and non-metallic components needs to be evaluated. In an effort to solicit broad perspectives on the activities needed to enhance the safe and reliable transportation of ethanol, a Road Mapping meeting was held in Dublin, Ohio on October 25 and 26th, 2007 with the support of the Association of Oil Pipe Lines (AOPL), American Petroleum Institute (API), U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA), and Pipeline Research Council International (PRCI).

The workshop was organized to bring together experts with diverse perspectives on ethanol to identify:

- Gaps in knowledge, current industry practices, and future industry needs.
- Technical challenges related to pre-commissioning through delivery to the end user.
- Focused areas of study to support the development of solutions for knowledge gaps and technical challenges and guidelines for implementation.
- Where and how the study can be aligned with related industry and regulatory activities.

The workshop consisted of a series of plenary presentations followed by detailed breakout sessions on four topics: Ethanol Sources and Quality Issues; Pipeline Integrity; Pipeline Operations; and Standards, Guidelines, and Training. Each of the detailed breakout sessions discussed the status of knowledge today, prioritized the gaps in knowledge and barriers that must be overcome, and identified specific activities that should be undertaken to address the gaps. This document provides a summary of the workshop findings. The plenary presentations can be found separately in the AOPL web site (http://www.aopl.org).

PARTICIPANTS

ETHANOL SOURCES AND QUALITY ISSUES

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STANDARDS, GUIDELINES, AND TRAINING

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- Cliff Johnson, NACE International
- Leigh Klein, BP - Cherry Point Refinery
- David Kunz, U.S. Department of Transportation
- Peter Lidiak, API Energy
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- Mauricio Justiniano, Energetics Incorporated (facilitator)

PLENARY SESSION: KEY CHALLENGES

Policy

- Public policy vs. market forces; The overall energy and carbon balance for different sources of ethanol may dictate future policies and subsidies.
- Sustainability of future policies is important in investment decisions and risk minimization because the investment required is significant and technical issues are complex and need to be addressed
- Need to clearly define roles of stakeholders and government.

Market Forces and Risk Management

- Limited capacity in existing pipelines. Rising steel prices and limited resources (metal and expertise; limited crafts people) may constrain construction of new pipelines
- Ethanol producers are geographically distributed differently than the current liquid petroleum refineries and terminals requiring different transportation logistics
- Determining the product mix that could be moved economically and safely – blends vs. neat ethanol, multi product vs. dedicated ethanol lines, batching of different products.
- Handling the interfaces between different parts of transportation, storage, and end-use infrastructure
- Shortage of tanks; limited assets downstream; how will the different fuels affect storage needs
- Understanding the threat environment before addressing the technical issues.
- Must address the key aspects of the business and take care not to create an industry of “research"
- Comparison of different risks — e.g., internal corrosion & SCC vs. external corrosion and SCC What is the real level of risk SCC poses; how quickly does it develop?
- Managing change and abnormal operating conditions. Transfer current knowledge of managing risk
- Consumer acceptance of product will drive demand (fuel economy, cost point, etc.)
- SCC may become a bigger issue as volumes increase
- Understanding the environmental impact of ethanol leaks

Technology

- List of materials that need to be studied for both existing and new pipelines
- Developing short term solution while addressing long-term needs
- Monitoring SCC and other threats using simple solutions first (coupons) and progressing to more sophisticated solutions in the future
- Applicability of current integrity assessment methods — hydrotesting, direct assessment, inline inspection, etc.— to assessing internal cracks
- Uncertainties on the impact of different ethanol quality on pipeline integrity and end use
- Need to think way down the distribution channel (e.g., how will additives work in engines?)

Communication and Knowledge Sharing

- How do we communicate the risk with transporting ethanol in order to build new pipelines through or near communities?
- Utilizing Brazilian experience in ethanol transportation, but beware of the dangers of cut and paste technology (e.g., must understand decision making process in Brazilian pipelines)
- Challenge of coordination of all the ongoing activities; how do we communicate better?
- Need to share more information about incidents; regulations may need to change; concerns about sensitive information
- Capitalize on existing framework for handling integrity risk and transfer risk management experience

SAFE & RELIABLE ETHANOL TRANSPORTATION & STORAGE

ETHANOL SOURCES AND QUALITY ISSUES

WHAT IS HAPPENING TODAY?

GUIDELINES & STANDARDS	APPLYING LESSONS LEARNED AND BEST PRACTICES	ONGOING R&D ACTIVITIES
• ASTM specification D 4806 for fuel grade ethanol is relevant to its end-use, but not necessarily to transportation/storage • Does the quality of ethanol affect the manufacturer and design of gas engine • Creation of an international specification (IETA) • Tripartite international effort • API 939 I and E tanks perspective survey and research to identify procedures and mitigation steps	• There is information on ethanol transport in pipelines in Brazil (and some information in the US) • Utilizing and evaluating external SCC test techniques • Batch flushing - some work/tests has been done, but very controlled • API and SWRI have completed work to determine the effect of contaminants on SCC • Systems developed to fight against cheating at fuel stations in Brazil and elsewhere	• Development of O_2 sensor to monitor O_2 concentration in ethanol • R&D into ethanol from corn, switch grass, other cellulosics, and sugarcane • Role of composition on redox potential • SCC on “commercial” grade fuel ethanol • Effect of blend ratio on SCC; ongoing PRCI/CCT • Effect of batching on SCC • Accelerated international compatibility studies are being done on refueling stations • “Finger printing” protocol development • Pilot/demonstration cellulosic ethanol plants • Effect of inhibition/oxygen scavengers on SCC: PRCI/CCT completed and ongoing efforts • Brazilian fingerprinting study • Basic SCC research: a) pure ethanol, b) effect of additives • Rugged reference electrode development for potential monitoring in ethanol • Definition of actual dissolved O_2 necessary to produce/prevent SCC • Guidelines for new construction - PRCI

WHERE ARE THE GAPS IN CURRENT EFFORTS? WHAT BARRIERS MUST BE OVERCOME?

(● = Highest Priority Challenge/Need)

TOOLS & RESOURCES	SPECIFICATIONS AND REGULATIONS	CO-MINGLING	UNDERSTANDING OF CONTAMINANTS AND COMPOSITION	CROSS-CUTTING GAPS
• No practical method for routine ethanol acceptability testing ●●●●●	• Need "API" specifications (transport based) for fuel-grade ethanol ●●●	• Ensuring product quality when products get commingled ●●●●●●	• Do not know real O_2 concentrations in pipelines - no understanding of where stream is picking up O_2 ●●●●●●	• Challenges in international technology transfer - language issues (Brazil, Russia, Japan) ●●
• Defining the environment (finger printing, pH, electrodes, O_2 ,etc.) is challenging because off-the-shelf probes do not exist ●●	• Fuel regulations vary by state ●●	• Standardization of ethanol while allowing source mixtures ●●●●	• Lack of understanding of how product composition changes during aging (with time, heat, length, etc.) ●●●●	- base technology transfers from Brazil, etc., then gaps become specification issues
• A database that provides the composition of ethanol based on production routine and biomass source currently does not exist ●	• Reluctance to accept higher water content for blends ●	- Enable several producers to co-mingle product with cellulosic	• Understanding how contaminant pick up occurs in mixed-use pipeline ●	• Public and political motivations are out pacing technical development for all biofuels.
• Need confirmation of the viability of new pipeline materials and understanding of how existing materials are affected by ethanol	• Current ASTM specification is based on vehicle performance	• Uncertainty about how to process ethanol (and water) loaded transmix ●●●	• "Aging" of FGE is not well understood ●	- support for ethanol may wax and wane
		• Lack of knowledge of how ethanol transportation affects aviation kerosene filtering ●	• Lack of knowledge of what contaminants cellulosic ethanol will contain ●	- barriers and standards may change if we expand view to all biofuels
		- scheduling and trail back issues	• Lack of knowledge of cost of removing contaminants, to ensure we are cost-effective	
		• Batch sizes vs. quality vs. tank size ●	• Lack of understanding of steel microstructure-contaminant interactions during SCC	
		- Relates to gasoline quality more than ethanol		
		• Effect of ethanol (water) on corrosivity of transmix still in the pipe		

WHAT R&D, TESTING, STUDIES, OR OTHER ACTIVITIES ARE NEEDED TO FILL GAPS AND ADDRESS BARRIERS?

(● = Highest Priority Challenge/Need)

TECHNOLOGY TRANSFER

- Create body (committee at NACE, ASTM, API and/or other organizations) to manage technical transfer and coordination ●●●●●●
  - technology clearinghouse
- Create annual forum to gather researchers to stimulate technical transfer ●
- Analyze and compare Brazilian vs. US production ●
- Conduct ongoing technical transfer sessions to stimulate technical transfer
- Learn from Brazilian experience in ethanol transportation in pipelines

TOOLS

- Develop "quick field test" for FGE to test for corrosivity in day-to-day operations ●●●
- Create "Ethanol (biofuels) Handbook" with existing and future data ●
- Develop on-line tools and/or sampling methods to quickly and cost-effectively ensure quality ●
- Develop field analysis kits and procedures for ethanol ●

TESTING AND STUDIES

- Confirm key contaminants of concern ●●●●●●
  - understand which contaminants are a threat to safe/efficient operations
- Identify natural inhibitors and new inhibitors that are acceptable to everyone, including automakers ●●●●●●
  - o degradation over time is key issue
- Test FGE effect on degradation of polymers and metals ●●●●●●
- Develop new techniques for electrochemical characterization of ethanol ●●●●●
- Test FGE in flowing conditions in pipelines ●●●●
- Conduct sampling and field analysis of ethanol ●●●●
  - Sampling in real world, start to finish
  - O_2 sampling in field
- Conduct mid/long term stability studies (storage) ●●●
- Test reliability of monitoring systems for FGE (long term) ●●
- Understanding sequencing benefits of batch flushing with and without pig ●
- Confirm oxygen effect (control) on SCC ●
- Conduct paper study to identify technical issues for re-processing of transmix
  - water is one possible problem
  - this may be a "nice-to-have" issue
- Study SCC vs. pipe age, composition, etc.

SPECIFICATIONS

- Bring all information into a transportation specification for FGE ●●●●●
  - specifications allow for commingling of products
- Define the international specification
- Aviation kerosene provides good example of specifications, testing, processes - adapt to ethanol

CROSS-CUTTING

- Built a solid research program (e.g., are we sure O_2 is the villain?) ●
- Find one good ethanol product and blend to that product profile
- Conduct short term targeted research (step wise implementation)

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PIPELINE INTEGRITY ISSUES

WHAT IS HAPPENING TODAY?

R&D ACTIVITIES	GUIDELINES & STANDARDS	LESSONS LEARNED
• Understanding the effect of pipeline steel grades/alloys on Stress Corrosion Cracking (SCC) • Determining the accuracy of inspection tools for identifying problems • Building off lessons learned on external SCC to identify causes of internal SCC under existing technology applications • Collaboration among cyclic corrosion test (CCT) researchers by American Petroleum Institute (API) consensus building activities with Department of Transportation (DOT) funding resource • Evaluating the effects of O_2 concentration on SCC • Evaluating post weld heat treating to relieve residual stress • Pipeline Research Council International (PRCI) current R&D o Determining the safe blend of fuel grade ethanol that can be safely transported today (does not result in integrity threats via SCC) o Determine mitigation strategies to prevent SCC in pipeline systems • Understanding the causes of SCC	• Existing API guidelines for tanks and terminals • Early development of National Association of Corrosion Engineers (NACE) recommended practices for biofuel transport • Existing guidelines and standards for ethanol transport in Brazil • Understanding the contaminants, components, and production processes behind the specifications (fingerprinting of good and bad ethanol related to a particular bath of a production process) • Existing API 939-D and 939-E guidelines for mitigation, case histories, and research results • Existing American Society for Testing and Materials (ASTM) standards are intended for automotive applications—not relevant to pipeline operations • Existing train industry standards for transporting ethanol o Currently do not experience problems, yet conditions are harsh and high stress o Use special railcar for ethanol • Existing guidelines and soon to be released Underwriters Laboratories (UL) on E-85 dispensers	• Understanding the full scenario of the SCC failures • API & Renewable Fuels Association (RFA) testing of ethanol and ethanol production method affects on cracking potential • Understanding the difference between corn based and sugarcane based ethanol • Recovering ethanol spill from ground is difficult; understanding ground water contamination issues • Monitoring short-term versus long-term prevention • Documenting failures in an API paper • Experience where failures are not occurring • ASI inspections STI (SP001) and API (653) • Determining whether a higher water concentration in Brazilian ethanol is a factor • Experience shows SCC problems occur with denatured ethanol and not with blends

WHERE ARE THE GAPS IN CURRENT EFFORTS? WHAT BARRIERS MUST BE OVERCOME?

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SOURCE	MONITORING AND PREVENTION	PIPELINE	CONSEQUENCES	BUSINESS AND INVESTMENT
• Limited understanding of the impact of mixing of ethanol from different sources ●●●●●●● • Knowledge gap on what blends cause SCC ●●●●●● • Lack of knowledge about which constituents are driving factors for the characterization of ethanol ●●● • Uncertainties about which ethanol fuels, fuel blends, and other fuels will need to be transported in the future ● • Limited understanding of the capabilities of other fuel to be transported via pipeline without SCC concerns ● • Uncertainties about the long-term demand for ethanol • Lack of understanding the appropriate batch science • Unstable demand, fluctuates according to source (corn, sugar, cellulose)	• Avoiding O_2 contamination ●●●●●●● • How do we prevent SCC ●●●●●● • How do you monitor for SCC ● • Inspection - is it same as current methods ● • Initial pipelines are likely to be smaller, which are more difficult to inspect • Difficult to detect leaks, determine rate of propagation, especially the identification of small ones	• Limited understanding of the consequences of SCC on pipeline, environment, repair, safety ●●●●●● • Limited understanding of how fast SCC develops ●●●●● • Swelling and permeation in seals and gaskets ●●●● • Limited understanding of pressure fluctuations—can they accelerate pipeline stress? ●● • Uncertainties about the effects of ethanol on internal coatings (flow improvers, drag reducers) ● • Limited understanding of flow issues—will stagnation be a problem? ● • Difficult to control the environment inside the pipeline/tank • Multiple use lines may have complex interactions	• Impact of ancillary inhibitors on the consumer are unknown ●●●● • Uncertain probability of threats—what will be the frequency of addressing integrity issues	• Unknown economic break-even point • Approach to R&D is too focused on treating the symptom • Lack of separation of key variables from less significant ones; there are too many interesting issues

WHAT R&D, TESTING, STUDIES, OR OTHER ACTIVITIES ARE NEEDED TO FILL GAPS AND ADDRESS BARRIERS?

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CHARACTERIZATION	DETECTION	PREVENTION	RISK
• Develop a decision making tool for specific pipeline systems ●●●●●●●● • Develop a field "fingerprint" test that identifies the particular batch in which the ethanol was produced, including production process, operating variables, and raw materials; this will enable a quick and simple 'good/bad' ethanol test ●●●●●● • Measure swelling and permeation in seals and gaskets ●●●● • Develop an analytical laboratory method for identifying specific components that cause SCC; this will enable a more detailed examination of the ethanol used during SCC ●●● • Develop SCC data for various ethanol sources to determine commonalities/differences between sources that cause SCC and those that do not ●● • Research effects of ethanol manufacturing methods on SCC ● • Determine acceptable threshold of blends that cause SCC, such as the ongoing 4-4 PRCI study o Run an experimental matrix with ONLY a variation in ethanol blend and/or source	• Develop integrity assessments methods(ILI, hydro, DA) ●●●● • Early detection of SCC ●● • Develop tools to accurately predict residual stresses, e.g., database, FEA ● • Develop monitor to acceptance criteria ● • How to monitor effective treatment - determine the significance of the contact of the ethanol with the atmosphere by comparing it to tests ran in an inert environment ●	• Construction o Use alternative materials or linings or sacrificial coatings that have not experienced SCC ●●●● o Develop best practices for new construction (pipe metallurgy, post weld heat treating, etc.) ● o Develop welding technology that avoids SCC, e.g. friction stir ● • Operations o Establish operational procedures for dealing with batches/interface in a non-dedicated ethanol pipeline ●●● o Remove sources of O_2 in handling, transport and storage ●● o Develop ethanol acceptance guidelines document ●● o Develop methods to prevent SCC ●● o Determine inhibitor types ● o Transport blends where SCC is not an issue, including E100 (except in Kentucky) ● • Maintenance o Develop post weld heat treatment guidelines to avoid SCC ●●	• Understand the potential SCC failure scenarios●●●●● • Develop guidelines/practices for assessing threats (SCC, internal corrosion (IC), etc.) ●● • Study consequences of SCC in pipeline (likelihood, mode of failure, clean-up costs) ● • Develop a direct assessment approach specific to ethanol ● • Develop public communications about ethanol pipeline transportation risk; raise public awareness ● • Measure effect of SCC on pipeline integrity

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PIPELINE OPERATIONS ISSUES

WHAT IS HAPPENING TODAY?

GUIDELINES & STANDARDS	APPLYING LESSONS LEARNED AND BEST PRACTICES	ONGOING R&D ACTIVITIES
• API 935E Guidelines: identification, mitigation, re-weld & repair • Other API technical publications: e.g., alcohols and blends handling, #1626, #4161 • Guidelines: PHMSA regulations, API, PRCI projects, individual company • New NACE task group on ethanol pipeline transportation issues • MTI (materials selector series) • ASTM standards • Petrobras Standards/ANP (Brazilian Petroleum Agency) • Federal and State regulations - blending specifications	• Ad hoc experience, sometimes shared • Living with SCC • Tank coatings from API work • Review of seals/elastomers, past work • High pH and near-neutral pH SCC, assessment methods • Using results from methanol and ammonia SCC experience • Field non-destructive testing • API survey failure experience – form (producers, producers tanks, facilities) • API 939D R&D summaries and published papers • Communications essential • Applying very poorly - misinformation, innuendo, etc.	• Identify corrosion and inhibitors, identify effects of heat and various blends, methods of reduction in existing pipelines, criteria for new pipelines • Moving test batches • Developing relationships: producers, pipeline terminals, etc. • Brainstorming handling options • Trail-back, quality, seals/soft goods, storage, shipment SCC issues • Effect of O_2, H_2O, 1,1-diethoxyethane, butanol • API - crack growth rates and fracture from ethanol SCC (consequences/risk) • API - field monitoring for SCC and corrosion/pitting • Identify batching “safe harbor” • Define products ok to ship • Monitoring (e.g., monthly) vs. standards and batch trials • Inhibition: batch vs. continuous, traditional vs. O_2 scan • Minor constituents: importance, variability • Effective monitoring tools • Batching (CTDUT) Operations with ethanol - state of the art in ethanol pipelines (CTDUT) • API R&D (completed) - sources of ethanol, effect of aeration, potential range, CI, butanol • BaOH (biobutanol) SCC (alternatives) • Collaboration with Petrobras • Define allowable limits of O_2

WHERE ARE THE GAPS IN CURRENT EFFORTS? WHAT BARRIERS MUST BE OVERCOME?

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BUSINESS PRACTICES	TECHNOLOGY APPLICATION AND TRANSFER (6)	PRODUCT SPECIFICATIONS (2)	MONITORING AND QUALITY CONTROL (3)	OPERATING PROCEDURES
• Show me the money (i.e., business case sustainability) – for ethanol in pipelines – optimal delivery system – gallons? length? ●●●●●●●● • How do we convince regulators, media, public that new operation is safe ●●●●● • Uncertainty what auto manufacturers will require/do ● • Pipeline siting • End user usage/choice	• Application: lab vs. real world ●●●●●●●●●● • Timeline for research results: is current focus correct? ●●●●● • Safe stresses: levels for no-SCC • Understanding differences between lab and field SCC • PRCI R&D: safe blends (SCC), compatibility of materials, new pipeline construction standards • Gaps: understanding ethanol SCC, market stability, building infrastructure, compatibility with other products • Problems "bred" by existing scale, weld defects, etc. • Majority of SCC standards, etc. relate to facilities not pipelines	• Define safe operating limits: chemistry to prevent cracking (O_2, water), stress, etc. ●●●●●●● • Threshold level of ethanol in gasoline blend to prevent cracking ● • What is the trace compound specification for ethanol	• What needs to be monitored: why, where and when ●●●●●●●●●● • Lack appropriate commercial monitoring technologies ●●●● • How much contamination will occur and where in pipeline system (including O_2) ●●● • How will ethanol products change over time • How to baseline existing line before ethanol service • How do we know if this batch of ethanol will harm the system	• How would we blend: in pipelines or tanks (i.e., change the current model?) ● • Lack effective, practical, economical mitigation schemes

WHAT R&D, TESTING, STUDIES, OR OTHER ACTIVITIES ARE NEEDED TO FILL GAPS AND ADDRESS BARRIERS?

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TECHNOLOGY APPLICATION AND TRANSFER	OPERATING PROCEDURES	PRODUCT SPECIFICATIONS
• Fundamental understanding of ethanol SCC and driving factors (weld, stress, crack, etc.) ●●●●●●●●● • Research to transition from lab to field , including statistical/probability verification, validation ●●●●●● • Identify steps needed to reach real world applications and R&D deliverables ●●●●● • Conduct analytical survey of ethanol from various sources, including detailed comparison of actual sugar based ethanol vs. corn based ●● • Establishment of lab protocol based on actual pipeline system conditions ● • Field test mitigation strategies for O_2 control ● • Supplemental ethanol (cellulose, etc.) beyond corn-based: analyze impacts	o Emergency response procedure and public safety awareness standards ● o Drag Reducing Agent (DRA) for ethanol	• Product compatibility and mitigation means
KNOWLEDGE MANAGEMENT: COORDINATION AND COMMUNICATION	**MONITORING AND QUALITY CONTROL**	**BUSINESS PRACTICES**
• Coordination and communication among these organizations: RFA and EPI (UNICA Brazil), NACE, SAE, API, AOPL, ASME, PRCI, DOT, ASTM, CRC, DOE, USDA, DOD, EPA, Biodiesel Board, NFPA, other international organizations ●●●●●●● • Share experiences (i.e., from Brazil) ●●●●●●●●●● • Consensus re: timeline for R&D industry (published) ● • Identify all ongoing/completed research, remove duplication, catalogue • Continuing implementation dialogue • Educate public/media/government	• Better commercialization approach for monitoring ●●●●● • Develop ruggedized potential measurement system in field ●●● • Analyze ethanol as it moves through the distribution system ●●●● • Conduct joint industry effort to field test and commercialize O_2 monitors • Determine applicability of existing O_2 monitors to ethanol and ethanol/gasoline blends	• Comparison of ethanol SCC risks to other current risks - quantify ●●●●●●●●● • Government/industry policy - position study on ethanol infrastructure • Project an ethanol penetration timeline • Identify requirement to ensure need of ethanol transport via pipeline

SAFE & RELIABLE ETHANOL TRANSPORTATION & STORAGE

STANDARDS, GUIDELINES, AND TRAINING

WHAT IS HAPPENING TODAY?

GUIDELINES AND STANDARDS	LESSONS LEARNED	ONGOING R&D ACTIVITIES
• NACE biofuels pipeline transportation • Collected information about existing standards (API) • UL now accepting applications for dispenser certification for ethanol (E85) as of 16 October • ASTM re-examining specification for ethanol • EPA emission standards • API bulletin 939E identification repair - mitigation • PHMSA statement of policy - ethanol/biofuels • Standards developing organizations coordinating committee (PSDOCC) • Individual companies writing standards and specifications	• Internal SCC coordination meeting in Atlanta 10/17/07 • Multi-agency working groups, EPA, DOE, USDA, DOT, DOD, et. al. • Petrobras • Case studies API 939E appendix B • Firefighting standards • API technical bulletins 1626, 4161 • Other: - UA reaching out to industry to formulate formal education program - Pending congressional pipeline studies authorizations, energy bill, farm bill, energy water appropriations	• PRCI SCC roadmap • PRCI SCC 4 just finished • PRCI SCC 4-3 just started • PRCI SCC 4-4 just started • DNVRI reference profile co-sponsoring for ethanol TQ SCC research • Ohio State University • R&D inhibitors/O_2 Scavengers • R&D SCC susceptibility on blends • API task group on ethanol SCC (API 939D) • R&D activities, additives that meet automotive requirements • Georgia Tech. biofuels work • SWRI and Honeywell in API program • PHMSA Research, joint industry project, broad agency announcement research

WHERE ARE THE GAPS IN CURRENT EFFORTS? WHAT BARRIERS MUST BE OVERCOME?

(● = Highest Priority Challenge/Need)

THEORETICAL BASIC RESEARCH	PRACTICAL RESEARCH	TOOLS AND TRAINING STANDARDS	POLICY
• Understand mechanism of ethanol SCC ●●●●●●●	• Sharing of experience internationally ●●●●●●●●●	• Turning research into standards - influence (proactive) regulations ●●●●	• Coordination of research activities ●●●●●●●●●
• Comparison between sugar and corn ethanol ●●●●	• Does post-weld heat treatment effectively prevent ethanol SCC? ●●	• Monitoring technology, O_2 concentration, ref electrode ●●	• Conduct and validate economic impact assessment - direct/indirect costs and benefits ●●
• Gaps on understanding non-aqueous electrochemistry	• Elastomer and non-metallic compatibility with ethanol ●●	• Current ASTM standards address quality - need to address SCC potential ●	• Policymakers making uniformed decisions (Congress) ●
	• Batch tests on neat (E95) and blends ●●	• Technical transfer for training, standards, and guidelines ●	• PRCI 4-3, 4-4, 4-5 API tanks coordination of research - value in independent replication
	• SCC and pitting corrosion ●	• Developing an educated/trained workforce - associations, universities ●	• R&D focus on ethanol - not so much on biofuels
	• Any research on other pipeline components, pumps, control valves, etc. ●	• Limited ability to write guidelines and standards because of gaps in understanding	• A central alternative fuel lead in executive branch required
	• Unknown impact of additives on other parts of infrastructure (not just vehicles)	• Tools for rapid inspection and detection of SCC	• As companies and SDO's (Standards Developing Organizations) develop standards - could be harder to achieve consensus
	• Required coating tests for ethanol service		
	• DRA for gas-ethanol blends (or pure ethanol)		

RESOURCES	OPERATIONAL PROBLEMS	INTEGRITY
• Cost-benefit analysis ●●●●●●●	• Emergency response people - how to deal with ethanol ●●●	• Define threat and susceptibility ●●●●
• Scope of research efforts has been relatively small. Need much expanded R&D effort ●	• Standards for overall management of onshore pipelines do not exist. ●●●	• Understanding the impact of failure
• What is realistic limit on quantity of ethanol to be used as fuel?	• P&M strategies ●●	• What is acceptable risk (failures and consequences)
	• Maintenance of ethanol storage and transportation facilities and equipment	

WHAT R&D, TESTING, STUDIES, OR OTHER ACTIVITIES ARE NEEDED TO FILL GAPS AND ADDRESS BARRIERS?

(● = Highest Priority Challenge/Need)

OPERATIONAL INTEGRITY STANDARDS	EDUCATION AND COORDINATION EFFORTS	POLICY
• Develop integrity management plan for operation ●●●●●● • Non-destructive testing techniques for ethanol SCC ●●● • Repair & maintenance standards ●●● • Develop on-line monitors for O_2 and ref. electrode ●●● • Study to determine all the PL threats (what are we missing) ● • Test inhibitors for SCC - reducing effects ● • Study effect of water content • Study effect of aging ethanol on corrosion properties	• Involve Petrobras and other international groups●●●●● • PSDOCC standards development ●●●● • Gather R&D outputs and systematically organize into materials ● • Fast track standard development with ability to modify as data is available ● • Develop strategy plan (includes roadmap, inch stones/milestones ● • Inform Congress and Executive Branch of the risks before they create more policies and rules ● • Develop education and training programs to support future workforce • Form and cross-functional group to conduct an evaluation of threat and susceptibility of failures • Develop a realistic public relations message	• Identify the R&D roadmap owner and steering group ●●● • Conduct definitive, non-political study on viability of ethanol as a replacement for gasoline (cost/benefits) ●●● • Develop biofuels corrosion R&D board ● • Review/update PHMSA pipeline and hazmat regulations • Name lead executive agency

TESTING	FIREFIGHTING/ SAFETY STANDARDS	STANDARDS TO QUALIFY EXISTING FACILITIES	CONSTRUCTION STANDARDS	PRODUCT QUALITY STANDARDS
• Corrosion testing standards ●●●●● • SCC protocols	• Research/identify best practices in ethanol fire/spill emergency response ●●	• Research and testing on large scale to understand mechanism of SCC ●●●● • Test if some steel grades may be more/less susceptible	• PWHT testing ● • Test for effects of stress - constant, cyclic, magnitude	• Analyze effects of contaminants ●●● • Impact of blending on SCC susceptibility ●● • Test if oxygen scavengers are option for ethanol ●

PATH FORWARD

This roadmap should be considered as a "living" document that will be updated periodically as actions are taken to address the gaps identified in the four areas and as priorities change. The following overall actions are envisaged with respect to the Roadmap document:

- Follow-on meetings will be held at appropriate intervals to evaluate progress and revise the roadmap.
- Joint industry and PHMSA funding of R&D should be tracked to ensure that the gaps and barriers that are prioritized in this document are addressed adequately
- This roadmap for transportation should be aligned with any available roadmaps for biofuel production and end-use application,