November 21, 2006

Subject: Summary of Underwriters Laboratories/US Department of Energy Technical Forum on E85 Dispenser Material Compatibility, November 1-2, 2006

The Underwriters Laboratories Inc./US Department of Energy Technical Forum on E85 Dispenser Material Compatibility was held at Underwriters Laboratories' (UL's) global headquarters in Northbrook, IL, USA on November 1 and 2, 2006. Forum attendees included national experts on ethanol fuels, with representatives from U.S. Department of Energy (DOE) national laboratories, automobile manufacturers, fuel dispensing equipment manufacturers, ethanol producers, fuel station companies, and other experts.

The goal of the Forum was to effectively gather substantive technical information related to the unique aspects of the use of high percentage ethanol fuels including conductivity of the fuel, material compatibility issues, fire suppression issues, and consumer interface issues. This information will ultimately be used to develop dispensing equipment safety requirements that may be used as a basis for certification requirements. UL will subsequently use these requirements as a basis for proposing revisions to the affected standards for safety of dispenser equipment, while coordinating a consistent approach through the system.

Standards for Dispensing Products

As a basis for focusing the Forum discussions, the major components of a fuel dispenser and the corresponding UL standards for the dispenser and its components were reviewed. These include:

- UL 87, Power-Operated Dispensing Devices for Petroleum Products
- UL 25, Meters for Flammable and Combustible Liquids and LP-Gas
- UL79, Power-Operated Pumps for Petroleum Products Dispensing Devices
- UL 330, Hose and Hose Assemblies for Dispensing Flammable Liquids
- UL 842, Valves for Flammable Liquids

The relation of the product standards to the prevailing installation Codes was also discussed.

Overview and discussion of compatibility concerns with ethanol blends

The nature of high percentage alcohol fuels, and their unique corresponding characteristics with respect to their effects on materials and properties, were reviewed as the focus of the Forum. UL standards are developed to address the safety of the dispensing equipment, including consideration of the compatibility and related concerns as they may affect safety. Research indicates that high

percentage alcohol fuels may degrade some materials in contact with the fuel. This action may have the potential effect of increasing the likelihood of leaks. It may also affecting fuel quality through the introduction of fuel contaminants and material byproducts such as suspended metal oxides and extracted polymers. UL noted that the focus of the UL requirements would specifically be the safety of the dispensing equipment, and not necessarily on the fuel quality. It is recognized that fuel quality may also be an issue that needs to be addressed; however, this is identified as out of scope for the safety requirements under development by UL. UL noted that stakeholders on fuel quality issues, including dispensing equipment and automobile manufacturers (some represented at the forum) will need to work together to establish appropriate requirements within a standard or specification designed to address these issues.

The types of ethanol/gasoline blended fuels that are in use were discussed. Low percentage ethanol/gasoline blends, comprised of less that 15% ethanol, have been in use for many years; these low percentage ethanol/gasoline blends are considered to be addressed by established requirements. While the immediate focus of the Forum was E85, nominally composed of 85% ethanol and 15% gasoline, other blends such as E20 or E60 are being used or considered. Three seasonal blends of E85 are presently defined in ASTM D5798. Possible migrations of ethanol blend percentages were also identified as a consideration with respect to the safety requirements.

The mechanics of the blending process were discussed. In many cases, the blending is done at the bulk distribution center prior to delivery at local gas stations. However, some manufacturers indicated that having the ability to blend the fuels within the dispenser was important. The possible use of a single dispenser product for dispensing traditional gasoline blends, E85, and other ethanol/gasoline blends was also reviewed. Automobile manufacturers identified that flex fuel vehicles need to accommodate all percentages (up to 90%) of ethanol/gasoline blends based on their inherent operation.

There was agreement that having the option of identifying the equipment for ethanol use was appropriate, rather than requiring all dispensing equipment to be evaluated for high percentage ethanol blend use.

Based on these factors, the objective of the requirements was defined as:

> Establish requirements that apply to dispensing equipment for use with ethanol blends. This path will be designed to cover the full range of ethanol/gasoline blends. The investigation would be applied either to support an additional rating for a dispenser product specified for use with other fuels, or to support the only rating for a particular dispenser product identified exclusively for use with ethanol blends.

Discussion regarding characteristics of commercial ethanol and the appropriate specifications for test fluids

There was a discussion about the present specifications for ethanol fuels and the practical aspects of fuel production, transport and storage.

It was noted that "E85" might include ethanol in the range of 70% to 90% based on seasonal blends and quality control factors. Existing specifications for ethanol fuels were reviewed, including ANSI/ASTM D4806, which is a fuel component specification. It was indicated that D4806 may presently be in use in some applications to cover high percentage ethanol blended fuels, although it was noted that this is an improper use of D4806. ANSI/ASTM D5798, covering finished ethanol fuels, is being revised by the responsible technical committee to address a number of issues including regional requirements and fuel conductivity specifications.

Ethanol Fuel Distribution and Specifications

Ethanol Fuel Stage	Fuel Specifications	Fuel Storage	Fuel Transport
Mass Production Stage 98%-95% Ethanol with 2%-5% ASTM D4806 or BATF CFR Title 27 Parts 19-21 denaturant Certificate of analysis Meet BATF tax regulations	ASTM D4806/ ASTM D5798 Note 1, Note 2 Internal quality control and external customer batch sampling No regulatory checks	API 650, 12D & 12F Bare steel tanks, floating roof or gas shielding Reduces H_2O Note 3 & O_2 Note 4	API 1625, USCG, DOT Rail car 80% Ship/Barge 15% Truck 5%
Bulk Distribution Stage Splash/Injection blend E10-E85 plus additives in tank or truck, per customer order Note 2	ASTM D4806/ ASTM D5798 Note 1, Note 2 Internal quality control and external customer batch sampling No regulatory checks	API 650, 12D & 12F Bare steel tanks, floating roof or closed vessel Reduces H_2O Note 3 & O_2 Note 4	US DOT Regulations Truck tanker 100% Closed vessel
Local Dispensing Stage Fuel is not changed from truck except by mixing with existing tank fuel and UST contaminants note 3	ASTM D4806/ ASTM D5798 Note 1, Note 2 Internal quality control spot check sampling No customer checks No regulatory checks	UL58, UL1316, UL1746 Bare Steel, FRP, or composite tanks No method to reduce UST contaminants note 3	UL87 et al - Dispensers Cars, ATVs, etc.

Note 1 - Gasoline/Ethanol fuel blends to either ASTM D4806 (E1-E10) or ASTM D5798 (E75-85). ASTM D4806 may be used in some applications for high alcohol fuels although at non-oxygenate levels (i.e. less than 10%).

Note 2 - Corrosion inhibitors and biocides are not required by any ASTM fuel specification. Some producers add corrosion inhibitors but not biocides.

Note 3 – Contaminants include water, salts, acids & other substances. Low contaminant potential exists at production & distribution facilities due to storage type, transfer methods and basic QC checks. High contaminant potential exists at local stations from many sources and the lack of effective fuel quality measures.

Note 4 - Oxygen (from several potential sources) absorbed in fuel may promote corrosion.

Fuel contaminants include water, salts, acids, and other substances. These contaminants may be passed along through the distribution chain, however the fuel station level appears to present the highest risk point for contamination. The hygroscopic nature of ethanol is very important with respect to absorption of water. Water may be present in storage tanks from sources such as condensation from air in atmospheric tanks, ground or surface water entering tank seals, settling out from petroleum products in previous use, and the like. Soluble road salts and acids may be present in surface water runoff and may end up in the fuel. Also, sea transport, with resulting salt air condensation, was identified as presenting a higher risk of contamination from chlorides. Consideration of the fuel conductivity with and without absorbed water and salts is a key issue.

UL reviewed previous work conducted by ASTM International, the Society of Automotive Engineers (SAE), and others dealing with ethanol fuel specifications and contaminants. UL also reviewed the findings of UL's Standard Technical Panel 971 Fuels Working Group on representative test fluid specifications for CE85a, for which the "a" suffix indicates the introduction of defined representative contaminants. There was agreement that the inclusion of contaminants including water, acids and salts in the test fluids was appropriate.

Fuel characteristics over the range of ethanol/gasoline blends were discussed. Blends with higher gasoline content tend to be more degrading on nonmetallic materials, while blends with higher ethanol content tend to be more degrading on metals. Input indicated that some elastomers react vigorously to low ethanol percentages, and some react vigorously to high ethanol percentages.
Experience from automotive applications indicated that blends having ethanol in the range or 20-25% (i.e. E20-E25) produce the most stringent degrading effects for nonmetallics. This experience also shows that properties from E85 to all ethanol (with denaturant) are about the same if there are no contaminants. There was support for plans to test with an E25 fluid and an E85 fluid to assess response of materials over the continuum of gasoline/ethanol blends.

Based on this concept, the planned test fluids were identified as CE25a and CE85a to cover the gasoline/ethanol blend continuum for which the "a" suffix indicates the introduction of defined representative contaminants. CE25a is expected to represent the worst-case condition on most nonmetallic substances; CE85a would represent the worst-case on metallic substances and some nonmetallics.

Discussion regarding the effects of ethanol on metals

The possible modes of degradation of metals that may result from exposure to ethanol were reviewed. There was agreement on possible forms of degradation of metals from exposure to ethanol blends:

- Corrosion of metals or metal plating, including pitting
- Stress cracking
- Embrittlement
- Fatigue

The focus of the safety requirements will be to assess the materials used in the dispensing equipment, and to minimize the risk of the ethanol fuels ultimately leading to leakage of the fuel, or degradation of a plating that may in turn lead to other materials degrading and leaking fuel.

There was a discussion about global harmonization of requirements to the degree possible. High percentage ethanol blends have been used in other countries such as Brazil. However, it was agreed that the defined safety requirements in those locations do not include specific assessments of degradation of materials that may lead to fuel leakage.

There was a discussion of the types of materials and processes currently in use. Plating of soft metals to avoid corrosion is common. In high volume production, there is a desire to use soft metals, but additional measures such as plating are needed to protect the soft metals from the effects of the fuels. The plating process, thickness, and material are all critical in addressing the effectiveness of this solution. Similarly, anodizing is used for some metals but its effectiveness is dependent on the process and the thickness.

The effects of galvanic interaction were discussed. Input indicates that E85 is about a million times more conductive than gasoline. Softer metals like aluminum or magnesium give up electrons, and high percentage ethanol blends can actually serve as an electrical conductor, which in some cases has caused significant corrosion. Differences between the materials in contact with each other and the fuel are critical with respect to galvanic interaction. Exposure time of the material to the high percentage ethanol fuel was identified as another important issue with respect to the corrosion.

Discussion regarding the effects of ethanol on nonmetallics

The possible modes of degradation of nonmetallics that may result from exposure to ethanol were reviewed. There was agreement on possible forms of degradation of nonmetallics from exposure to ethanol blends:

- Swelling
- Shrinkage
- Hardening
- Cracking

- Permeation
- Decomposition
- Solvation
- Extraction

Again, the focus of the safety requirements will be to assess the materials used in the dispenser, and to minimize the risk of the ethanol fuels ultimately leading to leakage of the fuel, or degradation of a material (including a plating) that may in turn lead to other materials degrading and subsequently leaking fuel.

It was noted that hydrocarbon fuels such as gasoline are non-polar molecules. In contrast, high percentage ethanol is a polar compound that can lead to extraction and other chemical reactions. More resistant elastomers are needed to deal with this effect. The use of compression set and squeeze was noted as a better assessment for elastomers than tensile strength and elongation, except for those conditions where the material will specifically be subjected to tensile forces.

It was suggested that E85 permeates slower than gasoline for some materials.

Seals may crack from peroxide contact. Automakers test for peroxide levels based on the applications. There was an indication that exposure to peroxides should not be an issue for E85 dispensers as peroxides should only be present in trace amounts and chemists have said the alcohol will buffer peroxides.

Development of testing requirements to determine acceptability of products with high percentage ethanol blends

UL reviewed the goal of developing test requirements based on the identified effects of high percentage ethanol blends, and the possible degradation modes. In developing these test protocols it is important to identify requirements that provide information that demonstrates the design has minimized the risk of degradation that could result in leakage. The test duration that is required to make this determination will be an important aspect to the protocol. Use of elevated temperature conditions may be considered as a mechanism for reducing test duration, but these specifications must be considered based on scientific information. The aggressive nature of the test fluid itself was also identified as one form of acceleration of the test conditions. Ensuring that the test may be performed safely based on the unique aspects of handling flammable fluids, and in a repeatable manner, are also practical considerations that must be addressed.

UL suggested that the performance of tests at low temperatures and high temperatures should be considered to assess the dispenser response. After some discussion, the range of $-40^{o}C$ to $60^{o}C$ was identified as the working basis for further consideration.

Performance of a leakage test at 150-200% of the rated system pressure of 50 psi, and a burst test at 500% pressure, was discussed. There was general support for this approach. The retention of key properties after exposure to test fluids was also identified as a possible test criterion.

Operation in the range of 400,000 cycles was discussed as representative of many dispensers. Some components may be rated for multi-million cycles of operation, while other components are marked with a date of 5 years of service.

Automotive test protocols range from 5000-10,000 hours at elevated temperatures of 40^{o}C or 50^{o}C.

There was an inquiry about the existence of a dispenser hardware inspection/survey of the 1000-plus E85 dispensing sites in operation, but no participants had knowledge of such information.

Aside from the information provided by the automotive representatives, little significant information about test methodologies to qualify materials for use with E85 was provided in the Forum. All Forum representatives agreed to identify and share technically substantive information that identifies criteria for determining that specific materials and constructions are suitable for use with high percentage ethanol blends. UL noted that field experience might provide useful information; however, anecdotal field information has limited relevance in developing safety requirements. Detailed information outlining the specific materials used, conditions of use and end-of-life analysis, in the proper volume, is necessary for field use information to be relevant in supporting the development of safety requirements. Participants agreed to provide the technical information available from their individual organizations, or an indication that the organization does not have information to share, to Joe Bablo by November 15, 2006. UL will also provide a questionnaire to Forum participants to facilitate transfer of this information. Information identified as proprietary will not be shared outside UL unless UL is otherwise instructed. UL will likely be setting up individual contacts after the Forum ends to conduct more detailed discussions.

Fuel conversions/switchover

UL reviewed information that had been identified regarding possible effects on the dispenser from changing from gasoline to ethanol and vice versa. There was a brief discussion on practical factors that may cause the conversion (driven by cost, regulations, availability, etc.). The possibility of a dry out condition (no fuel exposed to the products due to a shutdown etc.) and the possible effects on the dispenser was also discussed.

It was indicated that seals might dry out if they are out of service on the order of about a week, and this could lead to leaks when service is reinstated. It was indicated that 24 hours is a standard test time for dry out of elastomers.

Seals are made in many varieties, with some performing better than others. Fillers can provide dimensional stability, but if fillers are added it is also common to add plasticizers to keep the seal soft; however, plasticizers will leech and this also needs to be considered over the life of the product. Required replacement of seals on a fixed annual schedule is used to address this in some applications, but this does not seem to be a practical solution for fuel station dispensers.

Based on the discussion, use of test protocols to address performance of the dispensing equipment when switched between traditional gasoline and high percentage ethanol fuels, and when exposed to dry conditions, should be considered.

Vapor Recovery

There was a discussion about vapor recovery systems. It was indicated that at this time, the vast majority of flex fuel vehicles, but not all older vehicles, incorporate on-board vapor recovery systems. The use of seasonal blends may have an effect on vapor recovery by controlling volatility. Some jurisdictions expect that E85 systems may be treated the same as gasoline systems with respect to requiring vapor recovery, but a dedicated E85 vapor recovery line at the service station tank may be required. The details of these approaches appear to still be under development.

There was general agreement from participants that development of vapor recovery requirements may be a future initiative, but they should not be included as a part of the initial rollout of the E85 dispensing equipment requirements because of the additional time needed to deal with this issue. It was noted that if a vapor recovery feature were to be included in the dispenser, it would need to be addressed

Compatible Metals

There was a general discussion on the information included in the DOE Handbook for Handling, Storing, and Dispensing E85 (“the DOE Handbook”) regarding material recommendations. It was suggested that the DOE Handbook was more focused on documenting standard industry practice for what was currently in use, rather than a comprehensive, technically substantiated list of materials that will always perform acceptably. Some information in the DOE Handbook is similar to other documents, such as Recommended Practice 1626 issued by the American Petroleum Institute (API), but is not always the same. The recommendations in the DOE Handbook were not intended to indicate that these materials are always acceptable, or that they be used in a specific manner.

In general, there was not clear technical substantiation available at the Forum for the materials identified as recommended materials, and generic acceptance of the materials is not supported at this time.

There was general agreement that revisions to the DOE Handbook may be appropriate, and that continued communication to coordinate exchange of technical information between UL and DOE on this topic would continue.

Incompatible metals

Discussions indicated that many of the materials that are identified as those to avoid, have in fact been in use or are not in use for other reasons (e.g. environmental). There was general agreement that use of materials that are identified in the Handbook as those to avoid may actually be appropriate with respect to the safety requirements for E85 dispensing equipment. The exception to this is terne-plated steel, for which there was agreement that its use should not be permitted.

Compatible nonmetallic materials

Similar to the recommended metals, Forum participants indicated that the non-metallic materials identified in the DOE Handbook are sometimes in use. However, there was no information available to technically substantiate generic acceptance of these materials without further evaluation.

Incompatible nonmetallic materials

Discussions indicated that cork gasket material has been in use with a good history. There was general agreement that use of the other materials that are identified in the Handbook as those to avoid should also be excluded from use by the safety requirements for E85 dispensers. These include natural rubber, polyurethane, polyvinyl chloride (PVC), nylon 6/6, and methyl-methacrylate. Note that only nylon 6/6 (formed from copolymerization), rather than all polyamides, was identified for exclusion at this time.

In addition, the following materials were identified as not suitable in any case:

- EPDM – hydrocarbon based, and will swell immensely when exposed to high percentage alcohol fuels.
- Alcohol-based sealing compounds – will be dissolved by alcohol-based fuels.
- Polysulfide Rubber – conforms rapidly to the space it fits in thus producing a poor compression set for the dispensing equipment application.

Identification of E85 Dispensers

Three issues related to identification of E85 dispensers were discussed:

1) Identification of E85 dispensers/system components to facilitate proper installation and usage,
2) Identification of high percentage ethanol dispensing equipment for fire fighters, and
3) Identification of dispensers related to user notification.

Identification of E85 dispensers/system components to facilitate proper installation and usage

The need for identification of products that are suitable for ethanol blend use was discussed. The possibility of products handling multiple fuels seems reasonably foreseeable, and identification of the units for the intended application is appropriate.

The benefits of a standardized identification scheme were reviewed in comparison to schemes that permit individual manufacturers the options to identify products intended for high percentage ethanol blended fuels. There was general support for standardized markings used to identify products that are suitable for use with high percentage ethanol blends, although the markings are not yet defined.

There was a discussion related to the marking approaches for different parts and components of the dispensing system. Some internal dispenser components may have limited surface area available for markings. The use of standardized colors and the like for some components was discussed but there were concerns about addition of colorants and product aesthetics. Marking of the hydraulic tree as suitable for high percentage ethanol blends may provide a better solution for these internal parts and subassemblies. Hanging hardware that may possibly be installed or replaced by owner/operators may require more specific or expansive markings.

It was also noted that, based on earlier discussions in the Forum, all gasoline/ethanol blends will be covered by the plan of investigation rather than just E85. As a result, use of an “E85” designation may be overly restrictive and “Rated for gas/ethanol blends” or another broader designation may be more appropriate.

Based on the discussion, UL asked if industry would be interested in developing a proposal for consideration by UL on how dispenser products for high percentage ethanol blends should be identified. UL will determine if the Petroleum Equipment Industry or others are interested in developing such a proposal for UL to review. UL encouraged other participants and interested parties to provide their input on this topic.

Identification of high percentage ethanol dispensing equipment for fire service professionals

Mechanisms used for fighting ethanol fires are different than those for fighting petroleum fires. Ensuring that the fire service can properly identify the type of fire they are fighting based on the type of installation is critical for them to determine the proper method to suppress the fire.

Input from fire service professionals indicates that different foams are used to fight petroleum fires compared to high percentage ethanol fires. Fire trucks may

not be equipped with both foams. Concerns from a fire service perspective include identification of the system and resistance of the dispenser check valve from degradation. The use of placards, coordinated with first responders' guides, may be required for the facilities in some jurisdictions. Facilities may be defined as including both buildings and tanks.

There was an indication that E85 station owner/operators may initiate contact with the fire service to discuss these issues and the provision of the ethanol foams.

UL indicated that the ultimate solution for these issues might have both product standard elements and Code elements; however, UL's goal is to make sure that there is an effective, coordinated solution in place to address these issues. UL will coordinate contact with the NFPA 30A Committee Chair and will also continue communication with fire service professionals, including the International Association of Fire Chiefs, on this issue.

Identification of dispensers related to user notification

UL reviewed the Federal regulations related to user notifications for petroleum fuels, which are intended to minimize the occurrence of incidents from static discharge. The need for special consideration of these requirements as it relates to high percentage ethanol fuels was discussed.

There was an indication that the conductivity of high percentage ethanol blends helps address static discharge concerns because the ethanol conducts electricity better than petroleum. There was overall agreement that the unique aspects of high percentage ethanol blends would not present special safety considerations in this regard.

Regarding the issue of user notification about the proper use of E85 with respect to vehicle compatibility, there was an indication that some work is ongoing with respect to keying nozzles. While this presents an important use aspect for these fuels, at this time it was agreed that these issues are out of scope for the safety requirements for E85 dispensers.

Galvanic interaction

UL reviewed the concerns about galvanic interaction of materials. This presents some practical challenges that will need to be considered in the certification program. For subassemblies that are assembled together within the products submitted to UL, this can be addressed as an element of the certification program by reviewing the galvanic compatibility of the materials in contact. However, for fuel-handling parts that may be assembled or replaced in the field, additional requirements appear to be necessary in order to address this issue. Providing information on the material comprising the part, as well as the galvanically compatible materials that it may contact, would appear necessary.

Different schemes to address this, such as codes for galvanic compatibility, identification of materials, and the like were reviewed.

Closing remarks

UL has gathered some useful information through the Forum, but significant technical information is still required to define the test protocol. UL indicated that it had not received the significant technical input in the Forum that it had hoped for, and participants will need to collectively share responsibility for developing public safety requirements for these products based on technical substantiation. November 15, 2006 was established as the target date for Forum participants to share technical information on material selection protocols. The timeline for defining the requirements for E85 dispensers is highly dependent of the quantity and quality of the information that will be shared with UL. UL will provide a status report to the Forum participants approximately November 29, 2006 on the overall nature of the information it had received. UL and DOE expressed their appreciation for the attendees' participation in the Forum.

Technical Forum on E85 Dispenser Material Compatibility: Participants

Apostolou, Dennis	**PDE Manager**	**UL**
Bablo, Joe	**Principal Engineer, Automotive Equipment**	**UL**
Bolton, Patrick	**Project Manager**	**NY State Energy Research and Development Authority**
Boyce, Ken	**Principal Engineer, North America**	**UL**
Bragg, Bruce	**National Account Manager**	**Catlow**
Brummel, Brian	**Design Engineer**	**Bennett Pump Co.**
Chapin, Tom	**General Manager, North America Fire & Security Sector**	**UL**
Clark, Wendy	**Manager Fuels Performance Group**	**National Renewable Energy Laboratory – US Department of Energy**
Corr, Chuck	**Manager – Biofuels Tech Service**	**ADM Technical Services**
Davis, Kelly	**Quality Manager**	**Chippewa Valley Ethanol Co.**
Drengenberg, John	**Consumer Affairs Manager**	**UL**
English, Ed	**Vice President – Technical Director**	**Fuel Quality Services, Inc.**
Fallon, David	**Product Engineering Manager**	**ASCO Valve, Inc.**

Fennell, John		**Illinois State Fire Marshals Office**
Gallo, Mike	**General Manager, Compliance Engineering**	**CleanFuel USA**
Haigwood, Burl		**National Ethanol Vehicle Coalition**
Halla, Don	**Sensor Engineering Manager**	**Veeder-Root Co.**
Halsall, Robert	**Development Engineer, Fuel Systems**	**General Motors Research & Development**
Hanks, Gary	**Vice President, Sales & Marketing**	**Bennett Pump Co.**
Harrigan, Michael	**Fuel System Technical Specialist**	**Ford Motor Company**
Heidt, Michael	**Applications Engineering Manager**	**Parker Hannifin O-Ring Division**
Hess, Don	**Engineering Supervisor**	**Marathon Petroleum Co.**
Horne, Douglas	**President**	**Clean Vehicle Education Foundation**
Johnson, Gordon	**Manager Regulatory Engineering**	**Gilbarco Inc.**
Kammer, Claire	**Manager, Government Affairs**	**UL**
Katselnik, Phil	**Regulatory Engineer**	**Dresser Wayne**
Keller, Bob	**Director – Technology**	**Freudenberg-NOK, O-Ring Division**

Kolowich, Bruce		**US EPA National Vehicle and Fuel Emission Laboratory (NVFEL)**
McManama, Kerry	**General Manager, Global HazLoc, Gas & Oil Strategic Business Units**	**UL**
McSpadden, Steve	**New Products Engineering**	**Gilbarco Inc.**
Moses, Randy	**Director of Engineering, Fleet Fueling**	**Dresser Wayne**
Numrych, Charlene	**Manager Regulatory Affairs**	**Liquid Controls Corp.**
Pawel, Steve		**Oak Ridge National Lab - U.S. Department of Energy**
Ramirez, Al	**Manager, Regulatory Services**	**UL**
Reynolds, Robert E.	**President**	**Downstream Alternatives Inc.**
Riegel, Roland	**Principal Engineer – Flammable Liquids Containment Products**	**UL**
Ryan, Daniel P.	**Standards Technical Panel Chair**	**UL**
Santos, Alexander	**Staff Air Pollution Specialist**	**California Air Resources Board**
Schaefer, August	**Senior Vice President, Public Safety Officer**	**UL**
Schroeder, Tim	**Product Design Engineer**	**Husky Corp.**
Shelton, Art	**Project Engineer**	**Dresser Wayne**
Smith, Dennis	**Technology Development Manager, Office of FreedomCAR and Vehicle Tech.**	**U.S. Department of Energy**

Spankowski, Jesse	**Mechanical Engineer**	**Franklin Fueling Systems**
Sunderhaus, Charley	**Risk & Technical Liaison Manager**	**OPW Fueling Components**
Zeigler, Linda	**Technical Director**	**Parker Hannifin O-Ring Division**
Zeman, Bob	**Section Manager**	**UL**