UTC Spotlight

University Transportation Centers Program

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Photos by: Neeraj Mishra

This monthly report from the University Transportation Centers Program highlights some of the recent accomplishments and products from one of the University Transportation Centers (UTCs) managed by the U.S. Department of Transportation's Research and Innovative Technology Administration.

Mitigating Crash Fires with Fuel Additives

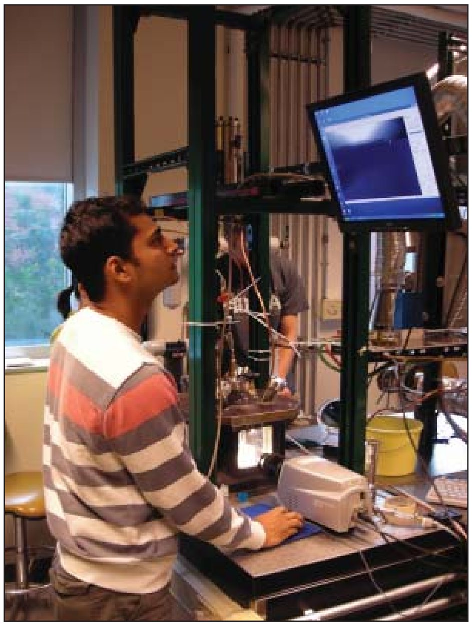
One of the most serious factors in major accidents is fuel fire, which can kill or injure those involved in an accident and prevent rescuers from getting to those in need.

This was the case on September 12, 2008, when a California Metrolink train slammed into a freight train, killing 25 and injuring 138 people. Fires, such as the one resulting from this crash, are particularly hazardous when they involve freight. Fuel fires can often trigger secondary fires as freight ignites, producing toxic smoke clouds and intense heat.

Fortunately, the approach to transportation safety has been, and continues to be, two-pronged. Both accident *prevention* and accident *mitigation* have made significant advancements as new technologies are developed and adopted. And, as the Metrolink tragedy demonstrates, when preventive measures fail, the need to mitigate the effects of that failure are paramount.

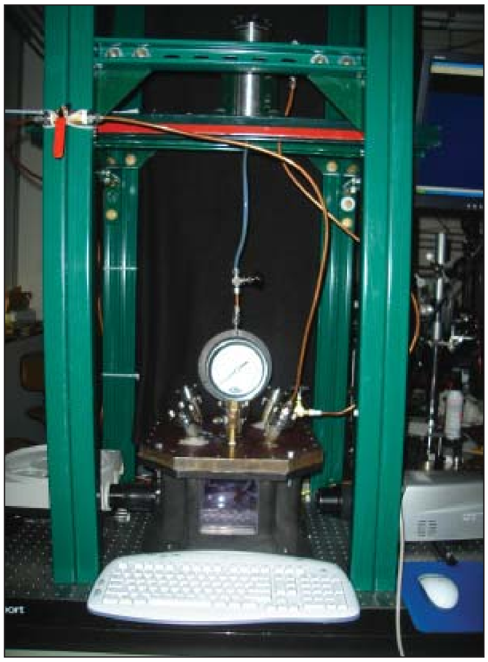
Accident mitigation uses techniques, such as improved design for better fuel tanks, along with dedicated technologies, such as seat belts and air bags, to reduce the harm caused by accidents.

For years, researchers have recognized the importance of developing fuels that resist erupting into fireballs when an accident occurs. New developments in polymer chemistry may soon make that a reality for diesel fuel. The key idea is based on the observation that diesel is hard to ignite if it simply spills and pools on the ground, whereas fuel in mist form readily ignites. Fireballs occur in crashes when the energy of the impact ruptures the fuel tanks and forces the diesel out with such force that it breaks into a fine mist. This mist is easily ignited by a sparking electrical system, hot metal, or the like. The resultant fireball releases so much heat that anything in the vicinity will ignite and burn.



Neeraj Mishra analyzing the recorded image of a drop.

The easiest link to break in this chain of events is the production of the fine fuel mist. No mist means no fireball, and a large scale fuel fire is averted. It now appears possible to develop a polymer additive that will prevent diesel fuel misting in accidents while otherwise not affecting normal truck or train engine and fuel system operation. These same polymers



Experimental setup for the diesel droplet impact test.

are known to reduce drag (and pumping cost) in oil pipelines, so there is even the possibility that the reduced energy cost for pumping the fuel will pay for this additive. These developments have kick-started new research aimed at turning the use of this polymer additive from idea into reality.

To bring this idea to fruition, it is necessary to understand the range of fuel systems involved—from truck to train—and how the additive would behave through the various pumps, fuel supply lines, and injectors. It is also necessary to link these fuel flow conditions to simple tests so that polymer chemistry can be adjusted and tested in a clear and scientific fashion before large scale (and expensive) tests are attempted. The current work at The University of Iowa is focused on these fuel behavior issues as research groups at the California Institute of Technology work on the details of the polymer chemistry. This collaboration (which has already resulted in several joint paper submissions) brings a range of expertise to the problem while keeping the focus on producing an additive that can be implemented in real systems.

RITA supported research, funded through the Mid-America Transportation Center grant to the University of Nebraska-Lincoln, has enabled significant progress in both fuel system analysis and the development of simplified tests. Fuel system analysis has validated the belief that there is a target range for fluid shear in which the polymer additive could (and should) be active. This range includes many accident conditions while avoiding fuel operating conditions. Although the edges of this range vary for different systems, analysis suggests that a viable range for all systems exists.

There has also been significant progress in research focused on developing simple tests to bridge the work from chemistry to real systems. As a first step, an experimental configuration was selected that enables high resolution measurement of how the fuel (in liquid drop form) behaves. The arrangement analyzes the impact of a single liquid drop on a smooth surface and focuses on how the liquid spreads or splashes. The particular pattern of spread or splash is inherently tied to the viscosity and other critical fluid properties. Deciphering the changes to the drop in this simple experiment leads to both understanding the polymer interaction and to predictions of how a particular polymer additive would perform in a real system.

Joseph Beitelspacher checking the level of test liquid in the reservoir.

While current and near term work is focused on quantifying these factors and enhancing polymer performance, the longer term goal of developing a fully viable polymer not only seems reasonable, but is steadily moving closer to reality. Continued support is critical to making this technology a success, and the vision of those engaged in freight safety has been a major reason for the great strides realized in this effort. The next 3 to 5 years should bring about a polymer additive that can be tested in engines and in full scale transportation systems. In 8 to 10 years, the additive should be in use with lives being saved.

About This Project

Laurence R. Rilett, Ph.D. is the Director of the Mid-America Transportation Center (MATC), located at the University of Nebraska-Lincoln. This project was conducted under the auspices of a MATC consortium member, the University of Iowa. The principal investigator on this project, and the contact for project information, is Albert Ratner, Ph.D. (aratner@engineering.uiowa.edu). For additional information about MATC, contact Laurence Rilett at: lrilett2@unl.edu.

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