

EXECUTIVE SUMMARY

There has been rising number of large scale fires involving high hazard flammable trains (HHFTs), some with catastrophic consequences. HHFT fires are typically complex scenarios consisting of flowing fuel, pools, and saturated substrates. HHFT events have the potential to quickly evolve into major conflagrations in which heat from initial fires can produce cascading effects due to increased thermal stress on surrounding railcars, leading to heat induced tears, pressure relief venting, and additional breaches.

Class B firefighting foams, more specifically alcohol resistant aqueous film-forming foams (AR-AFFFs), are the industry standard for mitigating and combatting flammable liquid pool fire-type hazards. First responders currently default to using an area-based method defined in NFPA 11, the Standard for Low-, Medium-, and High-Expansion Foam, for calculating foam application rates and quantities needed to fight HHFT fires. The values determined using NFPA 11 may not be accurate when considering the complex, three-dimensional, and potentially highly obstructed and limited access nature of these fires. Specifically, three-dimensional flowing fuel fires are extremely challenging to extinguish using solely Class B foams. In any case, the values determined using the “area-based” method based in NFPA 11 needed to be verified through comparison with actual incident data and applicable research.

The Fire Protection Research Foundation (FPRF) initiated this program to develop a database of HHFT derailments and the associated understanding of the foam application rates and total foam quantities needed to effectively mitigate these incidents. The information was gathered for the responder community to clarify the requirements and may ultimately be used for planning purposes and guidance for combating these fires.

HHFT incidents are a relatively new problem facing the first responder community. In addition to increased production, transporting by rail allows for greater geographic flexibility than pipelines and therefore allows the ability to quickly shift product destinations in response to market needs. Because of this factor alone, it is likely that transport of crude oil and ethanol by rail will continue to play a key role in the industry.

A literature review was conducted on foam application during HHFT events and focused on incident reports, professional articles, and academic publications. Upon completion of the literature review, it was determined that there was insufficient data regarding foam usage during HHFT events to develop guidance for first responders, and thus an alternate approach was required. Specialized Response Solutions (SRS) in Fort Worth, Texas had significant experience in combatting these incidents and was identified as a resource for data on foam usage and overall guidance in best practices for foam application in HHFT events. As a reference, SRS provides emergency response services for hazardous materials incidents and has responded to, and has a great deal of experience in extinguishing many HHFT rail cars in derailments. SRS was hired by JENSEN HUGHES to review their database and provide detailed descriptions and foam usage values for 12 representative HHFT incidents. Bobby Breed of SRS was the lead on the data preparation and has been included as a co-author to this document.

The SRS data package includes detailed information on the following twelve representative HHFT derailment incidents. The data includes incidents involving ethanol, crude oil, petroleum, denatured alcohol, and/or a combination of fuels. During these incidents, between 7 to 39 cars derailed. The incidents cover a range of weather conditions from severe cold weather to extreme heat. The foam concentrate usage ranged from 0 to 2,520 gallons. The water usage ranged from 0 to 2,200,000 gallons.

During the ten representative incidents, effective foam usage only occurred during the equilibrium phase. During 50% of these incidents, less than 100 gallons of foam concentrate was used (equates to ~3300 gallons of foam solution). During the remaining 50%, approximately 300 gallons of foam concentrate was used (equates to ~10,000 gallons of foam solution). On average, about 50% of the foam discharged during the equilibrium phase was applied directly into the burning cars (~ 14 gallons per car on average) to suppress and extinguish the fires within the car. The remainder was used to extinguish pool/spill fires and to seal fuel vapors during overhaul.

The foam use values from the incident data were then compared to the analytical values (area method) determined using NFPA 11. The analytical values were typically about five times that actually used during the event. With this said, the empirical values may be skewed toward the lower end of the range due to the extensive experience of the first responders. The data illustrated that water usage (for cooling) is equally important as foam usage when mitigating these types of incidents. The amount of water used during these scenarios was typically on the order of hundreds of thousands of gallons and approximately two orders of magnitude greater than the amount foam solution (foam concentrate/water solution) discharged during the event.

In addition to water and foam usage, information was also gathered and assessed on variables such as arrival time, fuel type, railroad substrate, weather, railcar construction (i.e., jacket tank cars) and first responder tactics. In general, arrival time, fuel type, railroad substrate, weather and railcar construction all had minimal effects on the incident. However, tactics were shown to play a major role in the outcome. Inexperienced first responders tend to use foam ineffectively and can prolong the overall duration of the incident. Resources such as the On-Scene Incident Commander Field Guide and Transport Canada's Competency Guidelines for Responders to Incidents of Flammable Liquids in Transport, High-Hazard Flammable Trains provide crucial knowledge and assist responders in making appropriate response decisions. The timeline and associated variables developed during this program provides a good high-level overview of the recommended tactics for combatting HHFT fires.

Since water usage for cooling purposes is equally as important as foam usage when mitigating these types of events, optimized cooling agents and techniques may be worth considering in areas of limited water supply/availability.

The information documented during this program helps to bracket the overall amount of foam concentrate needed to respond to an HHFT incident. During the 10 incidents documented in this report, approximately 300 gallons of foam concentrate or less was sufficient to suppress and extinguish these fires. This was the quantity used by a group of well trained, experienced firefighters and may need to be adjusted based on the expected level of training/experience of first responders. The main lesson learned from the review of data and discussions with SRS centers around using foam only after railcars have been properly cooled and after a car can be responded to with an individual tactical plan. Parallel to foam application, the use of cooling water serves as a vital preemptive step to any offensive response. Increased knowledge more than any amount of available foam concentrate will affect the overall outcome, duration, and severity of an HHFT incident. With proper knowledge of HHFT derailments and the accompanied training, first responders in areas near railroads carrying high-hazard flammable liquids will be more prepared and able to respond to an accident should it occur.