IMPORTANT CONSIDERATIONS FOR FIRST RESPONDERS TO LARGE VOLUME/HIGH-CONCENTRATION ETHANOL SPILLS

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In 2016, TRC Environmental Corporation (TRC) assisted the Massachusetts Emergency Management Agency (MEMA) develop the Large Volume/High Concentration Ethanol Appendix (the Appendix) to the Hazardous Material Annex of the Massachusetts Comprehensive Emergency Management Plan and the associated guidance document for first responders (the Guidance). The purpose of these documents were to promote situational awareness and outline the operational activities for the response to an emergency involving large volumes of high concentration denatured ethanol (LV/HC ethanol), such as a derailment of railroad tank cars.

The Appendix and Guidance were developed based on our review of the available literature, interviews and discussions with railroad personnel and first responders, and our experience with LV/HC ethanol spill prevention and response. From this, TRC identified important considerations for emergency personnel responding to an LV/HC ethanol incident. Specifically, ethanol is a polar solvent that readily mixes with water, so an ethanol spill may not act like a typical oil spill that the responders may be trained to handle. For incident response, this means that the equipment and tactics normally used for an oil spill may not be effective, and in some cases may make the incident worse. Therefore, it is critical that the first responders know how to identify an ethanol incident, what tactics are effective, what types of equipment may be needed, and who to call for assistance. Additionally, the responders need to understand the potential impacts from an LV/HC ethanol spill not just to people and businesses in the vicinity,

but also to the environment, surface water and groundwater sources, and wastewater treatment systems.

This paper reviews the properties and behavior of ethanol and denatured ethanol, and identifies and discusses appropriate response strategies, techniques, resources, and equipment for LV/HC ethanol spill response.

INTRODUCTION

Ethanol is the primary chemical used to oxygenate reformulated gasoline, and has been a component of blended motor vehicle fuels in the United States since the early 1970's. Since 2000, it has come into greater use as an alternative to fuel additives such as methyl tertiary butyl ether (MTBE). To meet this demand, ethanol is transported over land and water by railroad tank cars, tanker transports (i.e., tractor-trailer tank trucks), and marine vessels (i.e., barges and tank ships). Although large volume/high concentration (LV/HC) ethanol releases are rare, these low frequency incidents may have significant consequences as a result of large spills, fires, loss of life, and/or environmental impacts. TRC Environmental Corporation (TRC) with our subconsultant Hildebrand and Noll Associates, Inc. (HNA) assisted the Massachusetts Emergency Management Agency (MEMA) develop the LV/HC Ethanol Incident Response Appendix to the Hazardous Material Annex of the Commonwealth of Massachusetts Comprehensive Emergency Management Plan (the Appendix) and the associated Guidance for emergency managers/planners and first responders (Narin van Court et al., 2016a and 2016b, respectively), which were completed in July 2016. The purpose of the Appendix was to promote situational awareness and outline the operational activities for a state-wide response to a significant ethanol incident, such as an ethanol train derailment; the purpose of the Guidance was to assist local emergency managers and responders develop area-specific response plans for these types of incidents.

More importantly, the Appendix and Guidance were intended to help state agencies, emergency planners, and first responders learn from previous incidents and better prepare for their own responses to LV/HC ethanol incidents. To that end, this paper summarizes critical information and insights needed for planning responses to incidents that involve railroad tank cars transporting ethanol, and are generally applicable to LV/HC ethanol incidents involving marine vessels, tanker transports, and/or storage facilities.

Please note that in this paper the term "ethanol" will generally refer to denatured ethanol where 2% to 5%, but as much as 7%, gasoline or other denaturant added to make the ethanol unfit for drinking.

METHODOLOGY

To develop critical information and insights that may be needed for response planning, TRC and HNA reviewed the chemical and physical properties of ethanol (denatured and pure) because ethanol has different properties from standard gasoline and other petroleum products that local and state response agencies normally have experienced with. This means that ethanol spills may behave, react, and travel differently than gasoline or other hydrocarbons spills. Ethanol properties are summarized in Table 1.

In addition, TRC and HNA performed an in-depth analysis of 12 High Hazard Flammable Train (HHFT) derailments that occurred in the United States and Canada from 2006 through 2015, where an HHFT is defined in Title 49 of the Code of Federal Regulations Part 171.8 (49 CFR 171.8) as either a single train transporting 20 or more loaded tank cars of a Class 3 flammable liquid in a continuous block or a single train carrying 35 or more loaded tank cars of a Class 3 flammable liquid throughout the train consist. The HHFT derailments included 11 ethanol trains and one train with ethanol and crude oil. The details for these derailments are summarized in Table 2. Information on the derailments was generally obtained from the National Transportation Safety Board (NTSB), Federal Railroad Administration (FRA), and/or Transport Canada databases, with supplemental information from news reports, where necessary.

Our study focused on the following four key areas to guide emergency managers and planners and first responders in developing planning scenarios and response strategies and tactics:

1. Rail transportation of ethanol.
2. Potential hazards to responders from an ethanol release.
3. Potential environmental impacts from an ethanol release.
4. Behavior and response considerations for an ethanol release.

FINDINGS / OBSERVATIONS

Based on this study, we developed the findings and observations that are described in the following sections. A more complete discussion of HHFT derailment fires where the analysis covered both ethanol and crude oil HHFT – a total of 27 derailments, including the 12 ethanol HHFT derailments discussed below – is presented in a separate paper, Abstract No. 2017-145: "What Recent HHFT Derailment Fires Tell Us."

RAIL TRANSPORTATION OF ETHANOL

The tank cars transporting ethanol that derailed and breached were predominantly DOT 111 tank cars. Each tank car typically has a capacity in the range of 24,000 to 32,000 gallons, which is equivalent to three to four tractor-trailer tankers used for on-road ethanol transportation. In the first quarter of 2015 the DOT 111 was used to transport 94% of the ethanol, with the rest of the ethanol transported in CPC 1232 tank cars (Association of American Railroads [AAR], 2015). Although the newer, safer DOT 117 tank cars are being phased in for transporting ethanol, to our knowledge the DOT 117 tank cars are currently used for other Class 3 flammable liquids (e.g., Bakken crude oil), but are not yet in general use for ethanol.

In the first quarter of 2015, the ethanol block sizes (i.e., number of cars in the train) ranged from 1 to 110 cars with the greatest number of movements (about 35% of the total) in the 1 to 10 tank car block size and the next greatest number of movements in the 71 to 80 and 91 to 100 tank car block sizes, about 25% and 10% of the total, respectively (American Association of Railroad, 2015).

We examined 12 ethanol HHFT derailments, and in these incidents a total of 171 tank cars derailed and of those 112 cars breached, which represents a 65.5% failure rate. Furthermore, 10 of the 12 incidents studied (83.3%) resulted in fires that involved the contents of one or more tank car. Tank car breaches occurred due to initial head punctures, damaged fittings from the derailment impacts, and heat-induced tears (splits and tears) in the tank shell from direct flame impingement or radiant heat from the burning of released product. In addition, direct flame impingement or radiant heat may also overwhelm pressure relief valves which leads to energetic ruptures that result in dynamic failures of the tank cars and often produces a large fireball and separation of the tank car.

In the study, the average size ethanol spill was nearly 200,000 gallons, which is equivalent to about seven to eight tank cars. This means that response strategies need to address the control and containment of very large spills to minimize potential environmental damage. Since ethanol is potentially very damaging to the environment and removal is very difficult, as described later in this paper, in most cases contained burning is often considered to be the most appropriate response strategy to minimize potential environmental impacts when public safety and the risk of the fire spreading to structures is not a factor. Note that getting permission from the regulatory agencies to relight a derailment fire after it has been extinguished is exceedingly difficult, therefore, responders should let such as fire continue to burn, even after it reaches an equilibrium condition (i.e., fire is confined to the derailment area, no more pressure relief valve activations, low probability of more heat-induced tears or breaches).

In the derailments included as part of this study, derailment speeds were in the range of 10 to 48 miles per hour (mph), and the speed in one incident at the time of derailment was not provided. The average derailment speed was 32.5 mph and the median derailment speed was 36 mph. In accordance with the FRA regulations, HHFT speeds in High Threat Urban Areas (HTUA) are limited to less than 40 mph if any of the tank cars containing a Class 3 flammable liquid do not meet the DOT 117 car design specifications. Moreover, the train speeds in HTUA are typically less than 25 mph. However, even at speeds under 25 mph derailments can result in large ethanol releases. Of the 11 derailments in our study where the speed was provided, four of the incidents occurred at speeds less than 25 mph and the results were as follows:

- Derailments involved 5 to 18 tank cars with an average of about 11 tank cars derailing.
- Two to 12 tank cars breached with an average of about six tank cars breaching in each incident.
- Ethanol releases were on the order of 49,000 to 245,000 gallons with an average of about 99,000 gallons released, which is equivalent to 3 to 4 loaded tank cars.
- Three of four of the derailments (75%) resulted in fires.

As is expected, derailments at higher speeds (i.e., 25 mph and above) tended to be larger than the lower speed incidents. In seven of the 12 cases in our study where the speeds were provided, the train speed at derailment was 25 mph to 48 mph. Critical aspects of these higher speed derailments are as follow:

- Three to 31 ethanol tank cars derailed with an average of about 14 tank cars derailing in each incident.
- From two to all 31 of the derailed tank cars breached with an average of about 12 tank cars breaching in each incident.
- There were large releases of ethanol, on the order of 52,000 to 835,000 gallons with an average of about 282,000 gallons released, which is equivalent to about 9 to 12 fully loaded tank cars.
- All seven of the derailments (100%) resulted in fires.

POTENTIAL HAZARDS TO RESPONDERS FROM AN ETHANOL RELEASE

Given the potential size of an LV/HC ethanol release from an ethanol HHFT derailment and the typical rapid escalation early in the incident, first responders will need to rapidly implement the Incident Command System and establish an Incident Management Team to manage a long term incident. Emergency managers and planners should expect that the entire incident response, scene control to spill control and collection, typically requires 72 to 96 hours or more.

After understanding the potential size and consequences of an ethanol HHFT derailment, emergency managers/planners and first responders need to understand the potential hazards to the first responders from an LV/HC ethanol release. These hazards include the potential health effects from ethanol exposure and the potential effects of ethanol fires.

Potential Health Effects from Ethanol Exposure

Key health hazards are summarized below and additional information on the health hazards associated with ethanol can be found at the U.S. Occupational Safety and Health Administration chemical sampling website (OSHA 2016b) and on-line in the manufacturers' Safety Data Sheets for "denatured fuel ethanol." In addition, the OSHA chemical sampling website for ethanol (2016b) list methods that may be used for assessing the ethanol vapor concentrations in air.

- Ethanol may affect target organs (e.g., blood, kidneys, reproductive system, liver, upper respiratory tract, skin, central nervous system, and lens or cornea of the eye) and common denaturants may contain benzene or other known carcinogens.
- In the eyes, ethanol may cause severe irritation, redness, tearing, blurred vision and conjunctivitis.
- If inhaled, ethanol may cause nasal and respiratory tract irritation and loss of consciousness, coma, respiratory arrest, and/or sudden death, particularly in instances involving long term exposure and/or exposure to high concentration vapors.
- Ethanol is harmful or fatal if swallowed and aspiration into the lungs may cause severe chemical pneumonitis or pulmonary edema/hemorrhage, which can be fatal.

Although ethanol poses a number of potential health hazards, commonly used personal protection equipment (PPE), such as protective coveralls, nitrile or PVC gloves, safety goggles, etc., as well as breathing apparatus when warranted, are generally sufficient.

Potential Effects of Ethanol Fires

The other primary hazard is the intense heat from tank car fires. This is due to the large volumes of flammable liquid involved and because the incident heat flux from an ethanol fire can be two to five times greater than the incident heat flux from a gasoline fire, as demonstrated in large-scale tests. An additional concern with ethanol fires is that after the denaturant burns off ethanol has less visible smoke than petroleum fires and ethanol burns with a virtually invisible flame. This means that ethanol fires and the full extent on the fire may be less obvious to firefighters, which makes firefighting more dangerous.

Experience with actual tank car derailment fires indicates that the resulting fires grow in size and intensity very rapidly (often in two hours or less) until the fire reaches equilibrium several hours (typically 8 to 14 hours) after the start of the incident, and some fires have burned over 24 hours until the fuel is consumed. Due to the size and intensity of an ethanol HHFT fire, it would require large quantities of Alcohol Resistant Aqueous Film-Forming Foam (AR-AFFF) concentrate (i.e., thousands of gallons) and an established water supply capable of providing thousands of gallons of water per minute for an extended period. To date no ethanol HHFT fire has been successfully extinguished before reaching equilibrium. Therefore, fire suppression should only be attempted for life safety and it is generally better to control and contain an HHFT derailment fire until it reaches equilibrium or and let it burn out.

Although the available amounts of AR-AFFF concentrate and other resources may not be sufficient to extinguish an ethanol HHFT derailment fire, foam may be used in other ways to control an incident. For example, if spilled ethanol enter a storm drain or sewer, applying finished foam into the drain or sewer lines can be used to suppress vapors and minimize the ignition potential of the vapors, as well as the ignition potential of the ethanol at an outfall, and, therefore, reduces the potential for additional damage.

To suppress an ethanol fire or reduce the potential for such a fire, diluting the released ethanol is not a practical option because even diluted ethanol has a fairly low flash point: 20% ethanol in water has a flash point of 97^{o} F; 10% ethanol in water has a flash point of 120^{o} F.

Therefore, dilution will often dramatically increase the amount of ethanol that needs to be contained and collected without reducing the fire hazard. Additional details and issues concerning fighting ethanol HHFT fires are described in a separate paper, Abstract No. 2017-145: "What Recent HHFT Derailment Fires Tell Us."

As a final note about the potential hazards to responders, ethanol is a good electrical conductor. Thus, first responders need to carefully assess an incident scene for potential electrocution and ignition hazards (including static electricity) that may be present.

POTENTIAL ENVIRONMENTAL IMPACTS FROM AN ETHANOL RELEASE

The potential environmental impacts from an LV/HC ethanol release take two forms: potential impacts to the natural environment (i.e., surface water and groundwater) and potential impacts to the anthropogenic environment (water intakes and wastewater systems). In either case, every effort should be made to contain spilled ethanol as near the release site as practicable and remove spilled ethanol as soon as practicable.

With denatured ethanol, the denaturant (typically gasoline or "natural gasoline") will separate on contact with water (i.e., surface water, groundwater, or firefighting water) and the ethanol component will readily mix with water and the denaturant will typically separate and float on the water surface. Impacts from the denaturant are similar to other gasoline spills, so the rest of this section focuses on the impacts from the ethanol component (typically 95% to 97% of the released volume).

Hazards to the Natural Environment

The impacts of an ethanol release may be extensive because ethanol readily mixes with water and rapidly disperses throughout the water column. Key environmental impacts from an ethanol release are summarized below:

- Ethanol in surface water bodies (e.g., lakes, ponds, streams, rivers) is rapidly biodegraded, but the biodegradation significantly decreases dissolved oxygen levels in the receiving waters.

- Fish and other aquatic organisms may be killed by direct contact with high concentrations of ethanol or by the decreased dissolved oxygen levels in water from ethanol biodegradation.

- Ethanol released into a surface water body will impact recreational uses (e.g., fishing, swimming, boating) of the water body until the ethanol is degraded or removed.

- In groundwater ethanol may, and often does, biodegrade rapidly; however, high concentrations of ethanol inhibits biological activity and ethanol may persist in the soil and groundwater for a long time.

- Anaerobic biodegradation in the groundwater may release large quantities of methane and acetaldehyde, which may reach or exceed the lower flammable limits when mixed with air and cause a secondary hazard. Build-ups of these gases in confined spaces (e.g., cellars, basements, under concrete slabs) need to be monitored. In addition, the U.S. Environmental Protection Agency (EPA) lists acetaldehyde as a probable human carcinogen (Group B2) and people with asthma may be more susceptible to acetaldehyde-induced bronchoconstriction (OSHA 2016a).

- Long-term exposure of vegetation to ethanol that infiltrates the soils and/or enters the groundwater may cause harm, even at low concentrations (e.g., 1% to 5% ethanol); however ethanol tends to dissipate relatively quickly in the soil due to biodegradation and/or infiltration or dispersion into deeper soils and/or the groundwater.

Additional information on potential environmental impacts from an LV/HC ethanol release is presented in the reports from the Massachusetts Department of Environmental Protection (2011), ITRC Biofuels Team (2011), and Renewable Fuels Association (2013).

Hazards to the Anthropogenic Environment

As noted above, ethanol rapidly affects the entire water column of the receiving water body. Therefore, incident response needs to include notifying owners/operators of water intakes (e.g., drinking, process, aquaculture, or cooling water) that may be impacted. Ethanol cannot be easily removed from water by typical treatment systems: filtration is ineffective and activated carbon systems have limited effectiveness for removing ethanol in the water. So, downstream water users need to be notified and their intakes need to be shut down until the ethanol plume passes and concentrations decrease to an acceptable level for their treatment system.

Ethanol may also infiltrate into the groundwater and potentially impact groundwater and groundwater users. Specifically, ethanol may impact public and private groundwater sources for drinking and other uses, so users who may be impacted will need to be notified.

Another issue is that wastewater treatment plants (WWTP) may be impacted if ethanol enters them via sewers or storm drains, because ethanol may kill some or all of the microbes used in the treatment process and reduce the treatment effectiveness. Therefore, owners/operators of WWTP that potentially will receive ethanol or ethanol-impacted water need to be warned if an ethanol release threatens their systems.

Furthermore, ethanol that enters a stormwater drain system or a sewer system poses a danger from vapors in the lines, as well as the discharge of ethanol in flammable concentrations at a system outfall. Although the available amounts of AR-AFFF and other resources may not be sufficient to put out an LV/HC ethanol fire, there may be adequate resources to suppress vapors in the drain or sewer lines and minimize the potential of the vapors igniting, as well as the potential of the ethanol igniting at an outfall, and, therefore, reduce the potential for additional damage.

CONSIDERATIONS FOR ETHANOL SPILL RESPONSE

Ethanol, denatured ethanol, and high-concentration ethanol fuel blends (e.g., E85), have different properties from gasoline or other petroleum products and oils, especially with regards to the behavior in water. Therefore, first responders need to understand that spill response techniques for ethanol spills on land may be similar to the techniques for other spills; however, once an ethanol spill enters water, different spill response techniques and equipment from that used for spills of gasoline or other petroleum oils and products may be required.

The response effort for an LV/HC ethanol incident is expected to last up to 72 to 96 hours (or more) before the hazards from the incident are sufficiently reduced and the incident can enter remediation and recovery phases as noted above. Furthermore, remediation of the released ethanol will generally last for weeks or months, depending on the media impacted (e.g., soil, surface water, groundwater).

As with other flammable liquid spills the ethanol source(s) should be controlled (e.g., valves closed, leaks plugged) as soon as practicable, provided this can be done safely. On land, spilled ethanol can be contained or directed to collection points by constructing dikes and/or dams with soil or sand (with or without wrapping the soil or sand in polyethylene sheeting to form "containment logs") or by using portable containment systems. Dikes, dams, or containment systems should be used to keep the ethanol spill away from features that need to be protected, such as storm water systems, sewers, and surface water bodies, as well as basements and other confined spaces.

Released ethanol can be absorbed by or covered with dry soil, sand, or other noncombustible material and ethanol-impacted soils can be removed. Ethanol can also be absorbed with water-absorbent materials, such cat litter and pads, booms, etc. Universal absorbents may or may not be effective, so responders will need to check this with the manufacturer before using these types of absorbents. However, “oil only” absorbents, pads, and booms will only absorb the denaturant and will not absorb ethanol. Due to the potential flammability of ethanol-impacted soil, absorbents, etc., only clean, non-sparking tools should be used to collect these materials.

In addition to absorbents, vacuum trucks can be used recover ethanol, and ethanol mixtures (i.e., with water and/or foam), provided proper precautions are taken if the liquids can still be considered “flammable” (i.e., the flash points is less than 140^{o}F). If foam is collected with vacuum trucks, a dispersant may need to be added to prevent re-expansion of foam during collection. In general, skimmers are not expected to be effective for collecting ethanol because ethanol is very difficult to separate when it has mixed with water. Due to the low flash points of ethanol diluted with water, as discussed above, water for firefighting will often increase the amount of flammable liquid that need to be recovered after an LV/HC ethanol release.

To repeat, ethanol readily mixes with water and once it enters surface water (including but not limited to ditches, streams, rivers, lakes, waterways, or water in storm drains or sewers) it is not easily recoverable. It is critical to perform water quality monitoring in the surface waters that may be impacted by an ethanol release location (i.e., adjacent to and downstream) to determine ethanol concentrations and if dissolved oxygen levels are approaching anoxic or toxic levels.

If ethanol enters surface water aerating the water may be an effective way to remove the ethanol. Aeration of water bodies generally increases the dissolved oxygen in the water, which increases biodegradation of ethanol, as well as to increase evaporative removal of ethanol. However, aeration equipment needs to be kept in the ethanol plume to be effective and guidance for optimizing aeration (air volumes, bubble size, contact time) is not currently available. In ditches and small streams, riprap check dams will increase turbulence to promote evaporation and increase aeration to raise the dissolved oxygen levels and increase the biological degradation of ethanol. Alternatively, ditches and small steams can be dammed or sections can be lined (to minimize infiltration into the groundwater) and aerators can be installed for increasing the oxygen content of the water, as well as for sparging to promote evaporation.

Once ethanol enters groundwater, monitored natural attenuation is often the best remediation solution. Air sparging is not very effective for removing ethanol from groundwater, but bio-venting and other techniques may be effective, except in zones where the ethanol concentrations are high enough to kill the bacteria needed for biodegradation. Note that “pump and treat” methods are not effective for ethanol removal because activated carbon and other methods are not effective for removing ethanol from water; however, pumping can be used for hydraulic control to minimize the spread of the plume.

CONCLUSIONS

Due to the increased use of ethanol to oxygenate reformulated gasoline, transportation and storage of ethanol is becoming more common throughout the United States. As this paper demonstrates, unlike gasoline and other petroleum oils and products, ethanol is a polar solvent that readily mixes with water, so the behavior of an ethanol spill is different from the behavior of a petroleum spill. Furthermore, although the potential for an LV/HC ethanol incident, such as an ethanol HHFT derailment, is low, the consequences may be high. Therefore, emergency managers and planners and first responders need to understand the properties and behavior of ethanol and potential ethanol spills to develop area-specific response plans and identify response resources for these types of incidents. Specifically, the key points regarding ethanol properties, transportation, hazards, impacts, and spill response that were discussed in this paper, as well as the key points regarding HHFT derailment fires (including ethanol HHFT derailment fires) that are presented in a separate paper (Abstract No. 2017-145: “What Recent HHFT Derailment Fires Tell Us”) should be understood and appropriate procedures and policies should be developed and incorporated into area-specific response plans, as the Massachusetts Emergency Management Agency did with the LV/HC Ethanol Incident Response Appendix to the Hazardous Material Annex of the Commonwealth of Massachusetts Comprehensive Emergency Management Plan.

TABLE 1: CHEMICAL/PHYSICAL PROPERTIES OF ETHANOL

Formula (pure ethanol)	C2-H6-O
Molecular Weight (pure ethanol)	46.07
Color/Form (pure ethanol)	Clear, colorless, very mobile liquid
Odor (pure ethanol)	Mild, like wine or whiskey
Transported as hazardous material	DOT Class 3, Package Group II; UN 1170 – Ethyl Alcohol; UN 1987 – Denatured Fuel Ethanol (US); UN 3475 – Denatured Fuel Ethanol (Canada)
Ionization Potential	10.47 eV
Flash Point	Varies: denatured ethanol as low as -5^o F; 20% ethanol in water has a flash point of 97^o F; 10% ethanol in water has a flash point of 120^o F
Boiling Point	Initial: 165^o to 175^o F.
Reid Vapor Pressure	2.3 pounds per square inch
Viscosity	1.19 centipoise (CPS) @ ~60 ^{O}F
Specific Gravity	0.79 (lighter than water, but will mix into water column)
Vapor Density	1.59 (Heavier than Air)
Flammable Range	Flammable Limit: 3.3% to 19%
Solubility (pure ethanol)	High – readily mixes with water and organic solvents
Benzene content	Generally less than 1.0%
Evaporation Rate (temperature dependent)	>1 (High Evaporation Rate)
Sources: HSDB 2016 and Hildebrand and Noll, 2016a	

TABLE 2: SUMMARY OF ETHANOL TRAIN INCIDENTS – 2006 TO 2015
(Starting with the Most Recent Incident)

LOCATION	DATE	CARS DERAILED	CARS BREACHED	FIRE	GALLONS RELEASED	SPEED
Bon Homme, SD	9/19/2015	7	3	Yes	49,748	10
Alma, WI	7/11/2015	32	5	No	20,000	Unknown
Dubuque, IA	2/4/2015	14	8	Yes	53,000	24
Plaster Rock, NB	1/7/2014	6	2	Yes	60,759	47
Charles City, IA	5/2/2013	5	2	No	49,000	24
Plevna, MT	8/5/2012	18	12	Yes	245,335	23
Columbus, OH	7/11/2012	3	3	Yes	54,748	25
Tiskilwa, IL	10/7/2011	10	9	Yes	162,000	37
Arcadia, OH	2/6/2011	31	31	Yes	834,840	46
Cherry Valley, IL	6/19/2009	15	13	Yes	323,963	36
Painesville, OH	10/10/2007	7	4	Yes	52,200	48
New Brighton, PA	10/20/2006	23	20	Yes	485,278	37
Total – 12 Derailments		**490**	**327**		**6,618,000**	**33.5 mph (Average)**

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