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BIODIESEL: Consequences for Increased Cleanup Cost Liability

Developed by Rudolph Diesel in the 1890s, the diesel compression engine was a significant leap forward from the steam engines of the 1800s. Although the original design contemplated the use of refined diesel as a fuel source, Mr. Diesel was already thinking of alternative fuels – such as vegetable or peanut oil – to be used in the combustion engine for his remote agricultural customers where conventional diesel was in short supply.

Today, scientists continue to carry the torch for Mr. Diesel with the creation of a new category of renewable fuels called "modern biofuels" – such as biodiesel. Biodiesel, derived from plant or animal fats, contains long-chain fatty acid esters mixed with conventional diesel in various blends to conform with ASTM D6751. Although the U.S. biodiesel industry relies heavily on soybean oil as the main feedstock, biodiesel can be made with other plant oils such as sunflower, palm, vegetable, and rapeseed oil, as well as animal fats.

Currently, several biodiesel blends are commercially available at many local government or independent fueling stations. Biodiesel blends are denoted with a "B" followed by a number/percent (i.e., "B5, B20, B100"), to designate the percentage of biodiesel in the mixture by volume (B20 contains up to 20% biodiesel mixed with 80% conventional diesel). Conventional diesel vehicles, although not technically alternative fuel vehicles, can run on biodiesel blends. The most common blends used in commercial fleet vehicles are B20 and B5. Biodiesel raises the octane number of the fuel and improves fuel lubricity. On average, biodiesel has 90% of the power of conventional diesel while emitting significantly lower concentrations of carbon dioxide.

Biodiesel Global Life-Cycle

The obvious benefits of using a renewable, non-toxic fuel source that reduces greenhouse gas (GHG) emissions and expands unproductive land might sound like a miracle. But biofuel feedstocks require large land, water, and air resources; increase pressure on food commodity costs; and consume other stretched resources – perhaps with unintended consequences. For example, on a net-net basis, considering the entire supply chain, some biofuels may emit more GHGs than fossil fuels on an energy-equivalent basis. In 2007, the Energy Independence and Security Act (EISA) increased mandates for the production and use of biofuels into the transportation system by key milestone dates. Concerned with what these mandates would do to resource-intensive commodity crops, water, air quality, and the environment, Congress directed the Environmental Protection Agency (EPA) to monitor and report on these potential negative impacts. In their most recent report, EPA provided feedback that was "worse" than anticipated into what they had observed since the mandates were implemented in 2007 – including the following:

- Biofuel demand is causing environmental damage to land use; cropland expansion is causing natural habitat loss (including forests) and loss of grassland, wetlands, and other ecological sensitive areas.
- Corn and soybean acreage expansion is destroying natural landscapes.
- Increased nitrogen fertilizer is contributing to additional land, water and air emissions.
- Demand for biofuel feedstocks is contributing to harmful algae blooms in western Lake Erie and the Gulf of Mexico.
- Higher amounts of nitrogen oxides (NOx) emissions are occurring due to the manufacture of biofuels including smog (ozone), acid rain, and other harmful effects.

Biodiesel Releases to the Environment

Examining the supply chains for biodiesel manufacturing offers several indicators on the most likely release points for biodiesel in the environment. At least two separate supply chains are used in biodiesel production – producing raw feedstock which is transported to bio-refineries for manufacturing, then blended and shipped to bulk depots and supply terminals for distribution to dispensing stations for end-use consumption. The second supply chain used is the transportation and delivery of various additives including acids, bases, and other ingredients used by the bio-refinery for blending. Biodiesel manufacturing primarily uses soybean feedstocks and physical processes involving mechanical steaming and separation to wash feedstocks and add chemicals (acids, bases, and reagents), along with biological fermentation to produce outputs including bulk biodiesel liquid, other byproducts (usually animal fat, glycerin) and wastes.

Several common potential release points along these supply chains include:

Biodiesel Manufacturing Facilities • Points along pipelines, manifolds, valves, fittings • Loading racks where blending and offloading occur • Catastrophic or slow leaks in bulk storage failures [aboveground storage tanks (ASTs)/ underground storage tanks (USTs)]	**Handling and Transportation (Truck, Rail, Marine)** • Roadway accidents at plant and on highways (human error) • Releases during filling, storage, blending, and handling fuels • Blended fuel releases on highways
Bulk Depot/Supply Terminal • Minor incidental or chronic releases from equipment piping manifold systems in loading and unloading process • Catastrophic storage tank failures and spills	**Dispensing Stations** • UST failures; chronic or catastrophic storage, piping, and equipment • Management practices, monitoring, and housekeeping

Cause and Origin of Biodiesel Releases

The risk and frequency of biodiesel releases along the production supply chain can be high considering the quantity of devices, mechanical mixing, transfer switches and valves used for process equipment. Typical releases may be caused by a variety of incidents including equipment failures, mixing of incompatible materials, inappropriate handling, and human error causing chronic or catastrophic accidents. However, a higher frequency of incidents is likely involved in handling, transportation and distribution of products (biodiesel and additives) during loading, unloading and in transit by truck, rail, or barge. Although considered nontoxic and biodegradable, biodiesel exhibits certain properties – including higher conductivity, increased lubricity (more slippery) and hygroscopic ability (attract more water than conventional diesel) - that tends to degrade or soften rubber hoses, gaskets, seals, and certain glues resulting in a higher risk of leaks. In addition, it can lead to phase separation, which can accelerate corrosion, pitting, and microbial induced corrosion (MIC) that can create potential structural issues, particularly in UST systems if these systems are incompatible with the blends. With its higher conductivity, biodiesel can corrode soft metals (such as zinc, brass, lead, aluminum, and copper) and lead to pitting, clogged filters, damaged pipes and potentially contaminate stored fuels.

Biodiesel Storage (UST) Compatibly

Biodiesel storage requires assurances of compatibility with the existing UST system to handle the specific blend(s) in storage, under 40 CRF 280.12 (USEPA, 1988). In 2015, EPA clarified the intent of the regulations for emerging fuels to require three general demonstration steps – including (1) Notification; (2) Demonstration of Compatibility; and (3) Recordkeeping.

Biodiesel blend storage within existing UST systems requires a complete and thorough review of each component of the UST system for compatibility with the specific blend to be stored. EPA and several states have developed resource toolboxes for owners/operators to assist with the review – including compatibility checklists, corrosion evaluation search tools, and annual walk-through inspection requirements.

The Association of State and Territorial Solid Waste Management Officials (ASTSWMO) Emerging Fuels Task Force developed a comprehensive survey (2014) and website (2017) to assist owners/operators with determining compatibility with specific fuel types. These compatibility checklists developed by ASTSWMO (www.astswmo.org/ust-compatibility-tool/) determine whether certain equipment is compatible with a fuel using their online Compatibility Evaluation Search Tool, which enables users to search for documented equipment manufacturer compatibility certifications based on fuel type or equipment components, and allows UST regulators, inspectors, contractors, and owners to report incidences or corrosion in real-time to a working database.

The ASTSWMO Corrosion Observation Tool (https://astswmo.org/astswmo-corrosion-observations-tool/) allows users to submit information on UST system corrosion during inspections and removals in field, helps to identify trends and potential problems before they become widespread, includes an interactive map to provide corrosion observation reports by state. Lastly, annual walk-through inspections require owners and operators to perform periodic inspections of UST systems by trained Class A/B UST operators.

Environmental Clean-Up and Incremental Costs

Biodiesel's behavior in the subsurface environment is not well known; and among other factors is dependent upon the site-specific geology, volume and rate of release, and fraction of biodiesel in the released product. Methane generation and off-gassing at biodiesel spill sites is common and requires attention during site investigations and cleanup due to potential explosion and fire hazards. Biodiesel groundwater plumes are more biodegradable due to the methyl esters in biodiesel and may contain more LNAPL phase separation in elongated plumes due to higher viscosity compared to conventional diesel. The longevity of methane gas generation from a biodiesel plume is not well understood and creates the potential for increased vapor intrusion risks near structures. Incremental planning, environmental investigation, and cleanup tasks needed for biodiesel spills may include:

- Emergency response extra planning and modification of response plans – including procedures for biodiesel storage, use, and spills onsite.
- Determining type and supply of environmentally friendly firefighting foam available.
- Determining compatibility of biodiesel mixtures with absorbent booms.
- Incremental explosive monitoring and sampling for gases and long-term monitoring.
- Design changes for wells to capture LNAPL from biodiesel spills.
- Increased vapor intrusion investigation and abatement costs.
- Additional human health and ecological risk assessments/studies.
- Reduction of oxygen content in subsurface (limits bio attenuation rates and requires different cleanup techniques and oxygen addition).
- Third-party claims and stakeholder concerns.

Conclusion

More than ever, the manufacture and consumption of biodiesel has been on the rise with debates on climate change, greenhouse gases, acid rain and peak oil conversations. Expanded use and handling increases the risk of environmental releases and additional cleanup costs during the production, manufacturing, transportation, storage, and distribution supply chains. Because biodiesel differs in physical, chemical, and biological properties, the introduction of biodiesel into the environment can pose unique consequences for incremental liability and cleanup costs.

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