

## EM-3.1 SAFETY ALERT

### HEAVY EQUIPMENT VEHICLE FIRES AND SUPPRESSION SYSTEMS

Three fire events and a TSR violation involving fire suppression systems at Environmental Management (EM) sites have occurred since 2014 associated with diesel powered heavy equipment vehicles. The events are summarized below, with generic recommendations, as a lessons-learned to help prevent similar events impacting personnel and facility safety, as well as equipment/property loss. The EM Office of Safety, Security and Quality Assurance (EM-3.1) encourages EM field sites and their contractors to review this summary, and the identified recommendations, for potential program improvements and avoidance of similar events.

#### **Savannah River Site (SRS) Fire Involving Several Pieces of Heavy Equipment**

In July 2017, the SRS Fire Department responded to extinguish flames at a heavy equipment parking area. Four pieces of heavy equipment were significantly damaged by the fire. No personnel were in the vicinity of the fire and there were no injuries (see Fig. 1).

Upon arrival to the fire, emergency response personnel observed a JLG lift fully engulfed as well as the rear of a Bobcat engine compartment parked next to the lift on fire. A small mini crane and a fork lift parked adjacent to these vehicle also sustained damage to tires and doors from the origin exposing fire.

The fire department's preliminary investigation is that no foul play was involved and the fire likely started when a battery wire on the vehicle contacted and

shorted on the vehicle frame, starting insulation on fire and spreading to the vehicles hydraulic and fuel lines (EM-SR--SRNS-CPWM-2017-0003).



Fig. 1 – SRS Fire Department response to heavy equipment fire

#### **Hanford Site (RL) Fire Involving Front End Loader**

In June 2016, a similar fire incident occurred on a caterpillar front end loader at a soil borrow pit on the Hanford site (EM-RP--BNRP-RPPWTP-2016-0013). As a result of the fire, the front end loader was a total loss (see Fig 2). The worker who was operating the loader when the fire started also exited the cab platform directly to the ground to avoid fire injury (see Fig 3). The worker received x-rays and treatment aligned with first aid due to the distance he jumped between the platform to the ground and his injury could have been more serious.

An investigation of the Hanford event concluded that the origin of the fire was under the cab of the loader and the cause of the fire was electrical in nature. It was suspected that the fire started when damaged

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loader insulation wiring came in contact with combustible materials on the loader.



Fig. 2 – Damage of the operators cab from Hanford caterpillar loader fire



Fig. 3 – Char damage under the Hanford operators cab showing platform and ladder to the ground

### **Waste Isolation Pilot Plant (WIPP) Salt-Hauler Truck Fire**

In February 2014 a 15-ton diesel powered salt-hauler vehicle also caught on fire in an underground facility at the WIPP near Carlsbad, New Mexico. In March 2014, EM

issued an Accident Investigation Report discussing the potential cause and origin of the fire concluding that the maintenance program for the vehicle was deficient, the fire protection program to prevent this event were ineffective, as well as other judgment of needs and casual factors (EM-CBFO--NWP-WIPP-2014-0001).

### **Heavy Equipment Fire Suppression Systems**

There are several reasons why specialized automatic and manual fire suppression system may be needed to be installed on heavy equipment. Many of these large vehicles may operate for long time periods and use a host of combustible liquids including lubricating oils, hydraulic fluids, greases, and diesel fuels (while some may even use propane as a fuel source which requires special attention). They generate considerable heat from engine blocks, manifolds, turbochargers, electrical components, and brake systems and when fire occurs there can be injury to operators and personnel and extensive damage can occur which takes months to replace.

Requirements specified by the National Fire Protection Association (NFPA) or controls determined by a DOE required fire hazard analysis and/or documented safety analysis may require install fixed suppression systems on heavy equipment to address fire hazards presented by the equipment and a unique environment where the equipment is being used. For example at the WIPP facility, NFPA 122, *Standard for the Fire Prevention and Control in Metal Nonmetal Mining and Metal Minerals Processing Facilities*, required by WIPP's fire protection program, specifies fixed fire suppression which should be added to heavy equipment utilized in the underground part

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of the facility. This is due to the unique nature and unique hazards associated with heavy equipment operating in an underground nonmetal facility.

Additionally, WIPP's Technical Safety Requirements (TSRs) specify underground vehicles with significant combustible liquid capacity and used near contact-handled transuranic waste to have automatic fire suppression systems to be installed in certain locations and operating modes of the underground. This requirement is to prevent radiological material release.

### **TSR Violation Involving Heavy Equipment Fire Suppression Manufacturers Design and Installation Requirements**

In July 2017, WIPP declared a TSR violation with an underground waste transporter and two fork lifts used to handle waste (EM-CBFO--NWP-WIPP-2017-0017). It was determined that some components of the fire systems were installed with deviations from the system manufacturer requirements.

While a root cause analysis is in the process of being performed, to identify causes and recommended corrective actions, the WIPP TSR specifies that the installer must certify that the installation has been made in accordance with the approved plans, the manufacturer's design, installation, and maintenance manual. Similarly, NFPA 122 specifies fire suppression systems to be in accordance with the manufacturer or designers recommendations.

### **EM-3.1 Observations/Recommendations**

Most heavy equipment fires happen when something on a machine is neglected. In addition to the specific deficiencies

associated with the individual events above, fire prevention and maintenance to keep heavy equipment, personnel, and facilities safe from fire are critical.

EM-3.1 review of the above events has resulted in the following general conclusions/recommendations, which should be considered as potential lessons-learned by EM contractors. There are two basic contributing factors to any fire, a source of ignition and a source of fuel.

### **Contributing Factor – Ignition:**

- **Turbochargers.** Turbochargers normally sit high up on the engine and is a constant source of high heat. Most heavy equipment manufacturers insulate this area from hydraulic equipment and fuel lines. However turbochargers can ignite any fuel and the most important thing is to keep the engine clean and taken out of service when any debris or leaks are found in the engine compartment.
- **Overheated components.** Other sources of high heat include overheated exhaust manifold, seized bearings and locked brakes that can ignite fuel sources on the vehicle. Regular service intervals required by the specific vehicle manufacturer by a qualified technician is the best way to prevent ignition caused by these sources.
- **Frayed electrical wiring.** Wiring added incorrectly aftermarket or wiring that is not appropriately supported can chafe against other components or the frame. Vehicle wiring should be routinely inspected against insulation rubs particularly on articulating portions of machines. Visual inspection of wiring

wraps and zip ties that could have become broken or missing during use or heat should be replaced to prevent insulation damage which could create an ignition point when in contact with metal.

- **Tires.** Tires are not a source of ignition but poor maintenance and tire changing practices sometimes leave small shards of metal inside tires. If the air inside the tire becomes overheated due to under inflation, too much load or too much speed it can cause these small bits of metal to catch fire and in turn the burning metal can start the rubber burning. And once a tire starts to burn, it is almost impossible to extinguish. It has to burn itself out and in most cases it's going to take the rest of the machine with it.
- **Batteries.** Although vehicle batteries are not often the source of point ignition in fires, they should not be ignored. A high resistance situation that causes overcurrent (e.g. electrical malfunction including loose wiring at the battery or starter causing the alternator voltage/regulator to overcharge) could cause the insulation on wires and the batteries to burn.
- **Hot work.** Grinding, welding, brazing, soldering, any work or tool that generates sparks or heat, should be kept well away from any source of fuel. EM site fire protection programs should be incorporating requirements from National Fire Protection Association Standard 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, to address hot work hazards.

### Contributing Factor – Fuel:

- **Diesel fuel.** The sources of diesel fuel leaks which can start fires includes leaky injectors, fittings, spills, and damaged fuel lines. Poor maintenance practices and chafing of hoses can contribute to leaks. Regular service intervals and inspections required by the manufacturer and caution when dispensing fuel at a designated and protected area is the best way to prevent diesel fuel fires.
- **Hydraulic fluid.** Hydraulic fluid is slightly less flammable than diesel fuel but it can contribute to a fire. The sources of hydraulic leaks are likewise poor maintenance, fittings, seals, spills and worn hydraulic lines and it is certainly no less a threat than diesel. An incorrect hoses such as a rubber fuel hose used in place of a manufacture's steel hydraulic hose could result in a leak because the rubber hose may not be rated for the constant pulsing of the hydraulic system. Regular service intervals, inspections, and replacement of hydraulic system components as recommended by the manufacture are essential.
- **Debris.** Concentration of debris on heavy equipment is often overlooked as a fire hazard source. However, depending on the application, heavy equipment can accumulate dirt, and other flammable materials in locations that may be difficult to clean. Overtime hydraulic and fuel systems, which are not properly maintained can leak and accumulate on the debris turning the equipment into a serious fire hazard. If debris caused by the working environment is a constant issue, the best practice is to clean the equipment on a

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regular basis with a steam cleaner or pressure washer to remove the debris. Additionally, the best way to get a better view of lines and cabling that are starting to rub is keep it clean from debris accumulation so inspections will catch abrasions before a serious fire occurs.

### **Neglected Heavy Equipment Maintenance**

It cannot be overstated that maintenance is a critical factor in keeping heavy equipment, personnel, facilities, and equipment safe from fire involving large machines. Contributing factors to heavy equipment fires are avoidable with adherence to routine service, inspections and maintenance recommended by the manufacturer and even more frequent when machines are operated in harsh environments. Fires are not as common on new and well-maintained machines. Therefore it's important to implement a program that addresses the most common sources of fires described in this alert for existing equipment and what can be done to prevent them being involved in fire. It's also good business practice to maintain heavy equipment in good working condition to support facility operations and mission continuity. Furthermore, these prudent practices minimize downtime and consequences associate with fire and the damaging results which can deleteriously impact employee and facility safety as well as facility pride and respect.

### **Heavy Equipment Fire Suppression System Installation & Fire System Maintenance**

In cases where fire risk is high, the addition of automatic and manual fire suppression systems may also be required by the site fire protection program, applicable NFPA

Standard, DOE fire hazard analysis or documented safety analysis to control or mitigate the consequences of vehicle fires.

However, it is important that automatic and manual fire suppression systems chosen for use on heavy equipment be installed and maintained per manufacturers or designer's recommendations as well as appropriate NFPA standard for the type of system. Because the manufacture has researched and tested their specialized suppression equipment and products under specific parameters it is extremely important to follow their installation and maintenance instructions in addition to NFPA requirements to ensure their equipment will properly function as intended under a fire event.

Questions concerning this EM Safety Alert should be directed to Jomaries Rovira (301) 903-0003 of EM-3.111. EM sites needing additional fire protection technical assistance may also contact Craig Christenson, EM-3.111 Fire Protection Engineer at (509) 376-5367.

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