

Internal Combustion Engines as Ignition Sources

Internal combustion engines present an ignition hazard when used in facilities processing flammable liquids and gases. If flammable vapors or gases are released in these facilities, an internal combustion engine could ignite the flammable materials with catastrophic consequences. Investigations by OSHA and the U.S. Chemical Safety Board (CSB) document a history of fires and explosions at workplaces (oilfields, refineries, chemical plants, and other facilities) where an internal combustion engine was identified as or suspected to be the source of ignition.¹

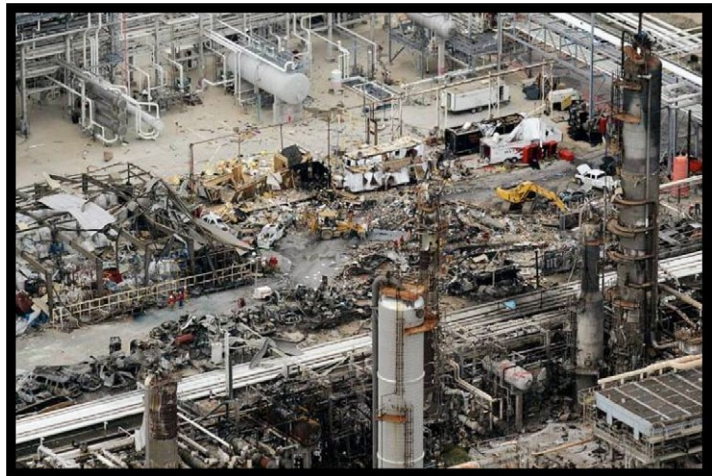
Understanding the Hazard

Internal combustion engines, whether fueled by gasoline, diesel, propane, natural gas, or other fuels, can act as ignition sources. Examples include:

- Stationary engines such as compressors, generators and pumps.
- Mobile equipment or transports such as vans, trucks, forklifts, cranes, well servicing equipment, drilling rigs, excavators, portable generators and welding trucks.
- Contractor vehicles and motorized equipment.
- Emergency response vehicles such as fire engines and ambulances.
- Vehicle-mounted engines on vacuum trucks, tanker trucks and waste haulers.
- Small portable engines such as mowers, blowers, generators, compressors, welders and pumps. This includes hand tools unrelated to a process, such as chain saws, brought in by contractors.

Internal combustion engines require a specific fuel-to-air ratio to work properly. Air enters the engine through the intake that leads to the combustion chambers (cylinders). If employers allow internal combustion engines in areas where flammable vapors or gases exist, then the vapors and gases can enter the cylinders of the engine along with the air. Additional flammable material in the cylinders provides an external fuel source and increases the fuel-to-air ratio in the engine. Changes in the fuel-to-air ratio create ignition hazards by:

- **Elevating engine operating temperatures.** Increasing the fuel-to-air ratio causes an increase in the energy output which results in increased surface and exhaust temperatures.



An explosion at a refinery site killed 15 and injured nearly 200; an idling diesel pickup truck was the most likely ignition point.

Source: U.S. Chemical Safety Board

Increasing the fuel-to-air ratio also causes pre-ignition within internal combustion engines. Pre-ignition occurs when a fuel-rich mixture in the cylinder ignites before the spark plug fires. Pre-ignition creates damaging pressure surges and higher engine surface and exhaust system temperatures.

If the temperature of the surface of the engine in contact with the fuel/air mixture reaches the autoignition temperature of that mixture, a fire or explosion will occur.²

- **Creating sparks.** Fuel-rich conditions in an engine can result in incomplete combustion.

¹ From Bureau of Labor Statistics and OSHA Integrated Management Information System (IMIS) databases, and CSB reports 2003–2010.

² The autoignition temperature of a chemical is the lowest temperature at which an air mixture of the chemical will ignite without a spark or flame.

When uncombusted fuel from the cylinders enters the exhaust system, it can ignite due to the hot surface, discharging sparks and flames (backfire). These can ignite flammable vapors and gases in the surrounding area.

- **Causing overspeed and runaway engines.** Overspeed occurs when flammable vapors and gases in the intake air cause engines to run faster than designed. This increases the wear and tear on the engine, causing overheating and risking autoignition. If allowed to continue, overspeed can result in mechanical failure causing the engine to blow apart, igniting flammable materials in the area and causing a flash fire or explosion.

Whenever possible, do not install permanently-mounted internal combustion engines in areas where flammable vapors or gases could be present.

If employers cannot remove internal combustion engines from areas processing flammable materials, then the following preventive measures should be used. These measures include administrative procedures for the safe use of portable or mobile equipment with internal combustion engines.

Control Measures to Reduce Risk

- Ensure that materials and equipment are stored and used in accord with OSHA standards such as:
 - 29 CFR 1910.106 or 29 CFR 1926.152, *Flammable liquids;*
 - 29 CFR 1910.107, *Spray finishing using flammable and combustible materials;*
 - 29 CFR 1910.119 or 29 CFR 1926.64, *Process safety management of highly hazardous chemicals;*
 - 29 CFR 1910.178, *Powered industrial trucks.*
- Ensure that worksite safety programs and safe work permit systems:
 - Address internal combustion engines as ignition sources;
 - Evaluate and establish acceptable areas, boundaries, and entry routes for mobile

The OSHA General Industry and Construction standards contained in Subparts S and K (29 CFR 1910.307 and 29 CFR 1926.407) of the Code of Federal Regulations (CFR) define hazardous (classified) locations as areas with:

- Flammable gases or vapors (Class I)
- Combustible dust (Class II)
- Easily-ignitable fibers (Class III)

In Class I locations, an installation must be classified as using the division classification system complying with paragraphs (c), (d), (e), and (f), or using the zone classification system specified in paragraph (g), of 29 CFR 1910.307 or 29 CFR 1926.407.



Three workers were killed and four injured in a fire resulting from a runaway diesel engine.

Source: U.S. Chemical Safety Board

For a gasoline engine, overspeed is stopped by turning off the ignition switch, which shuts down the ignition source (spark plugs) in the cylinders. This is not the case for diesel engines. Diesel engines do not use spark plugs; turning off the engine ignition switch does not shut down the ignition source. Stopping the fuel supply is also ineffective because the fuel is present in the intake air. The only way to prevent mechanical failure and possible explosion is to cut off the intake air supply, using systems such as automatic engine overspeed shutdown devices.

Preventing Engines from Becoming Ignition Sources

Workplace Evaluation

- Identify areas where flammable liquids or gases are used or stored.
- Evaluate where internal combustion engines are located.
- Assess contractor use of internal combustion engines in flammable material areas.



An idling diesel pickup truck believed to have ignited a vapor cloud from a nearby process area.

Source: U.S. Chemical Safety Board

internal combustion engines based on applicable standards and recognized and generally accepted good engineering practices;

- o Mark and enforce acceptable traffic routes through hazardous (classified) locations;
- o Account for special procedures, which might include the use of portable gas monitors, or emergency evacuation routes for vehicles.
- Use other preventive measures such as:
 - o Installing automatic overspeed shutdown devices on permanently-mounted engines.
 - o Installing intake flame arrestors and exhaust system spark arrest systems on permanently mounted engines.
 - o Installing flammable gas and vapor detectors in processing areas.
 - o Installing shutdown systems (positive air shut-off for diesel or ignition kill for gasoline), intake flame arrestor, exhaust system spark arrest, or other appropriate protective systems³ for mobile internal combustion engines.
 - o Using a safe work permit system to control mobile combustion engine access into areas that could contain flammable vapors and gases.
 - o Using a safe work permit system to control the use of open flames and spark-producing operations and equipment (e.g., welding, grinding, brazing, etc.)

Training

Provide training to workers and contractors on hazards in areas that contain flammable vapors and gases. The training should include instruction on:

- Hazards of internal combustion engines as ignition sources and the specific worksite areas that are subject to these hazards.



One of two vacuum truck diesel engines believed to be the ignition source for a fatal fire at an open air collection pit.

Source: U.S. Chemical Safety Board

³ Forklifts require specific unit ratings to be used. See 29 CFR 1910.178.

- Areas, boundaries and acceptable routes for mobile engines, and applicable facility safety rules. Instruct workers to avoid driving in areas where flammable vapors and gases may be present, to stay on acceptable routes, and to follow site procedures for safe access in areas where flammable materials are being processed.
- Signs and hazards of flammable vapor and gas clouds, and associated precautions.
- Signs and hazards of internal combustion engine overspeed and runaway.
- Emergency procedures for flammable materials emergencies, including response to engine overspeeds and runaways.

Standards and Resources

In addition to following applicable OSHA standards, employers should also refer to the American Petroleum Institute (API), the National Fire Protection Association (NFPA), and other applicable industry and consensus standards, which provide helpful guidance.

1. OSHA Standard 29 CFR 1910.106, *Flammable liquids: 29 CFR 1910.106(e)(6)(i), (f)(6), and (h)(7)(i)(A), Sources of Ignition.*
2. 29 CFR 1910.107, *Spray Finishing Using Flammable and Combustible Materials.*
3. 29 CFR 1910.178(c)(2)(i), (ii), "Power-operated industrial trucks shall not be used in atmospheres containing hazardous concentration of acetylene, butadiene, ethylene oxide, and hydrogen . . . metal dusts . . ." For other listed chemicals, only certain unit ratings are allowed. See the standard for more details.
4. 29 CFR 1910.119, *Process Safety Management of Highly Hazardous Chemicals.*
5. OSHA - [Petroleum Refinery Process Safety Management National Emphasis Program](#) (CPL 03-00-010, dated 8/18/2009). *Page A-55, Motorized Equipment.* "Does the employer have a safe work practice which it implements

The Process Safety Management (PSM) standard (29 CFR 1910.119) applies to processes in facilities that have flammable liquids or gases on site in one location in a quantity of 10,000 pounds or more. For covered processes, the PSM standard addresses controlling ignition sources primarily by requiring employers to:

- Compile written process safety information for working with hazardous chemicals, including identifying areas where flammable materials are or may be present, 29 CFR 1910.119(d).
- Complete a process hazard analysis that addresses the hazards of the process, including control of ignition sources such as internal combustion engines, 29 CFR 1910.119(e).
- Develop and implement safe work practices, including control of vehicle access to process areas, 29 CFR 1910.119(f)(4).
- Develop and implement written procedures (f) and training for operators (g), maintenance personnel (j), and contractors (h), 29 CFR 1910.119(f), (g), (h), and (j).
- Control hot work, 29 CFR 1910.119(k).

for motorized equipment to enter operating units and adjacent roadways?"

6. Mine Safety and Health Administration (MSHA) Standard [30 CFR 7.98](#) – *Diesel Engine Technical Requirements*. Requires explosion-proof design and a safety shutdown system, as well as intake flame arrest and an exhaust system spark arrest system. See also MSHA Standard [30 CFR 36.23](#) – *Engine Intake System*.
7. Department of Interior, Materials Management Services (MMS) 30 CFR 250.510, 250.610, and 250.803(b)(5)(ii). Requires diesel engine automatic shutdown devices/systems.
8. Coast Guard Standard 46 CFR 58.10-5. Requires gasoline engine intake system backfire flame control.
9. American Petroleum Institute (API) Recommended Practice (RP) 54, *Recommended Practice for Occupational Safety for Oil and Gas Well Drilling and Servicing Operations*.
 - o 6.1.15 "On land locations, vehicles not involved in the immediate rig operations should be located a minimum distance of 100 feet from the wellbore . . .";
 - o 9.14.2 "Rig generators on land locations should be located at least 100 ft (30.5 m) from the wellhead upwind considering the prevailing wind direction to isolate a possible source of ignition...";
 - o 9.15.3 "Spark arrestors or equivalent equipment shall be provided on all internal combustion engine exhausts located within 100 ft (30.5 m) of the wellbore...";
 - o 14.2.3 "Gasoline engines and other possible sources of ignition should be located at least 100 ft (30.5 m) from the wellbore during snubbing operations...";
 - o 15.2.2 "Any engine within 100 ft (30.5 m) of the well (within 35 ft of the well for offshore) should not be operated during the drill stem testing operations without having a heat and spark arresting system for the exhaust...";
 - o 18.3.1 "Where terrain permits, compressors should be located at least 100 ft (30.5 m) from the wellbore...".
10. API RP 7C-11F – *Recommended Practices for Installation, Maintenance and Operation of Internal Combustion Engines*.
11. API RP 505 – *Recommended Practice for Classification of Locations for Electrical Installations of Petroleum Facilities Classified as Class I, Zone 0, Zone 1 or Zone 2*.
12. API RP 2001 – *Fire Protection in Refineries*.
13. API RP 2216 – *Ignition Risk of Hydrocarbon Liquids and Vapors by Hot Surfaces in the Open Air*.
14. API RP 2219 – *Safe Operations of Vacuum Trucks in Petroleum Service*.
15. National Fire Protection Association (NFPA) 37 – *Installation and Use of Stationary Combustion Engines and Gas Turbines*.
16. NFPA 70 – *National Electrical Code*.
17. NFPA 497 – *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*.
18. NFPA 505 – *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*.
19. NFPA FPH – *Fire Protection Handbook*.
20. Diesel Engine Manufacturers Association (DEMA) – *Standard Practices for Low and Medium Speed Stationary Diesel and Gas Engines*.
21. California OSHA Standard, Subchapter 14, Article 35 – *Petroleum Safety Orders – Drilling and Production*.
22. California OSHA Standard, Subchapter 15, Article 21 – *Refining, Transportation and Handling – Gas Conveyors and Engines*.
23. Chemical Safety Board (CSB) Investigation Report – *BLSR Operating Ltd. Vapor Cloud Deflagration and Fire, 2003*. Also, see other CSB reports.
24. Center for Chemical Process Safety (CCPS) *Process Safety Beacon*, October 2009.

How Can OSHA Help?

OSHA has compliance assistance specialists throughout the nation who can provide information to employers and workers about OSHA standards, short educational programs on specific hazards or OSHA rights and responsibilities, and information on additional compliance assistance resources. Contact your [local OSHA office](#) for more information.

OSHA's On-site [Consultation Program](#) offers free and confidential advice to small and medium-sized businesses with fewer than 250 employees at a site (and no more than 500 employees nationwide) to help identify and correct hazards at your worksite. On-site consultation services are separate from enforcement and do not result in penalties or citations. To locate the On-site Consultation office nearest you, visit [OSHA's website](#) or call 1-800-321-OSHA (6742).

Worker Rights

Workers have the right to:

- Working conditions that do not pose a risk of serious harm.
- Receive information and training (in a language and vocabulary they understand) about workplace hazards, methods to prevent them, and the OSHA standards that apply to their workplace.
- Review records of work-related injuries and illnesses.
- Get copies of test results that find and measure hazards.
- File a complaint asking OSHA to inspect their workplace if they believe there is a serious hazard or that their employer is not following OSHA's rules. OSHA will keep all identities confidential.
- Exercise their rights under the law without retaliation or discrimination.

For more information, see [OSHA's web page for workers](#).

Disclaimer

This Fact Sheet is not a standard or regulation, and it creates no new legal obligations. It contains recommendations as well as descriptions of mandatory safety and health standards [and other regulatory requirements]. The recommendations are advisory in nature, informational in content, and are intended to assist employers in providing a safe and healthful workplace. The *Occupational Safety and Health Act* requires employers to comply with safety and health standards and regulations promulgated by OSHA or by a state with an OSHA-approved state plan. In addition, the Act's General Duty Clause, Section 5(a)(1), requires employers to provide their workers with a workplace free from recognized hazards likely to cause death or serious physical harm.

This is one in a series of informational fact sheets highlighting OSHA programs, policies or standards. It does not impose any new compliance requirements. For a comprehensive list of compliance requirements of OSHA standards or regulations, refer to Title 29 of the Code of Federal Regulations. This information will be made available to sensory-impaired individuals upon request. The voice phone is (202) 693-1999; teletypewriter (TTY) number: (877) 889-5627.

For assistance, contact us. We can help. It's confidential.



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www.osha.gov (800) 321-OSHA (6742)

DSG FS-3589-10 2012