LAB DATA

Keep on (safely) truckin'

UL's approach to safety of industrial trucks in hazardous (classified) locations

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Imagine operating an industrial truck in an environment where simple phenomena like electric arcs from switch contacts, high surface temperatures, static electricity discharge from exposed plastics, or percussion sparks from exposed metals could ignite an explosion. Perhaps you'd feel safer knowing that the truck met recognized safety standards specific to hazardous locations.

Photos courtesy of American Specialty Equipment, Gregory Industrial Trucks

UL can investigate and certify hazardous locations equipment, including industrial trucks, in accordance with published U.S., international and country-specific standards.

Industrial trucks, mainly powered by electric batteries or combustion engines, are workhorses essential for lifting, transporting, retrieving and positioning loads in material-handling applications. They come in various forms such as pallet, walk-along, straddle forklift, platform lift, riders and tow tractor trucks. Some are designed for low- and high-lift stacking of loads, while others are designed for use in narrow aisles.

These trucks can come with various electrical options and accessories such as light fixtures, horn and beacon light alarms, battery gauges, diagnostic equipment, radio transmitters, bar code scanners, and computer terminals and radio frequency modems for real-time data acquisition and collection.

Hazardous locations industrial trucks are used in areas such as chemical plants and warehouses, automotive manufacturing and repair facilities, government ammunition plants and arsenals, and paint manufacturing facilities.

Hazardous locations

The *National Electrical Code (NEC)*®, NFPA 70, defines hazardous (classified) locations as locations where fire or explosion hazards may exist due to the presence of flammable gases, vapors or flammable liquids (Class I), combustible dusts (Class II), or ignitable fibers or flyings (Class III).

Article 500 of the *NEC*® describes two independent classification systems. One system divides all hazardous locations into three Classes (I, II and III), in addition to two Divisions (1 and 2), and seven Groups (A, B, C, D, E, F and G). A Class I, II or III, Division 1 location encompasses locations where an explosive atmosphere is present under normal operating conditions. In Class I, II or III, Division 2 locations, an explosive atmosphere is present only under abnormal conditions.

The second independent classification system divides only Class I hazardous locations into three Zones (0, 1 and 2) and three gas Groups (IIA, IIB and IIC). In Class I, Zone 0 locations, an explosive or flammable atmosphere is present continuously or for long periods of time. Class I, Zone 1 locations are those where the explosive or flammable atmosphere is likely to occur during normal operation. In Class I, Zone 2 locations, the explosive or flammable atmosphere is not likely to occur in normal operation, and if it occurs, will only exist for a short time.

Means of protection

Mobile (non-stationary) equipment used in hazardous locations is not specifically covered by the *NEC*®. However, in order to protect against fire, shock and explosion hazards, industrial trucks intended for operation in any classified hazardous areas should be designed, tested and certified in accordance with the safety requirements for that specific location. The truck's electrical construction features still need to comply with requirements based on the protection methods accepted by the *NEC*® for hazardous (classified) locations (see table on page 13).

The concept behind the protection methods is quite simple. The specific method chosen by design must either eliminate the explosion or contain it.

A typical industrial truck for Class I, Division 1 settings may employ explosion-proof traction, steering and lifting (pump) motors, and explosion-proof enclosures for housing major electrical components such as a speed controller, contactors, circuit breaker and fuses. Many of the control functions are achieved by using intrinsic safety circuits or hydraulics (non-electrical). Conductive tires ensure that static charges cannot accumulate to an unsafe level. To avoid potential percussion sparks, exposed metal parts are made of or covered with brass, bronze or other non-sparking materials. A suitable explosion-proof battery, certified at least for the intended hazardous location, is used to power the truck.

Main U.S. standards

In the United States, powered industrial trucks are primarily covered under NFPA 505, Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance and Operation. NFPA 505 defines "approved powered industrial trucks" as those Listed by a U.S. testing laboratory for the use intended, such as UL. Therefore, if the intended use is for hazardous locations applications, whether it is for Class I, Class II or Class III; Division 1 or Division 2; or Zone 1 or Zone 2; the truck is required to be evaluated, tested, certified and marked for the intended hazardous location, protection methods and operating temperatures.

This standard from the National Fire Protection Association (NFPA) contains minimum safety requirements for various truck type designations for both electric battery-powered and fuel-powered trucks, for use in both ordinary (i.e., non-hazardous) and hazardous locations. As indicated in NFPA 505, Authorities Having Jurisdiction (AHJs) can permit ordinary locations trucks that don't meet *NEC*® Class I, Division 2 or Class II, Division 2 (flammable and combustible atmospheres under abnormal conditions) requirements to be used in such hazardous locations.

Generally, ordinary locations industrial trucks are not suitable for use in any hazardous location, unless they have been investigated, tested and marked in accordance with the safety requirements for the intended hazardous location.

UL can provide technical expertise and/or a program to investigate various NFPA 505-designated trucks for both Division- and Zone-classified hazardous locations. UL-certified hazardous locations industrial trucks are specifically marked "For Use in Hazardous Locations," along with the required Classes, Groups, Divisions and/or Zones and other applicable hazardous locations markings, such as operating temperature and protection methods.

The basic standard used to evaluate electric industrial trucks is ANSI/UL 583, UL Standard for Safety for Electric-Battery-Powered Industrial Trucks. This American National Standard is recognized and accepted by a consensus of national organizations, end-users and manufacturers.

In addition to fire and shock hazards addressed in ANSI/UL 583, hazardous locations trucks must meet the explosion hazard requirements based on their protection methods. UL requirements for some of the most common protection methods are defined in the following hazardous locations standards:

- ANSI/UL 1203, Explosion-Proof and Dust-Ignition-Proof Electrical Equipment For Use in Class I, Class II and Class III, Division 1 Hazardous (Classified) Locations;
- UL 1604, Electrical Equipment For Use in Class I, Class II and Class III, Division 2 Hazardous (Classified) Locations;
- ANSI/UL 913, Intrinsically-Safe Apparatus and Associated Equipment For Use In Hazardous (Classified) Locations; and
- ANSI/UL 2279, Electrical Equipment For Use in Class I, Zone 0, 1 and 2 Hazardous (Classified) Locations.

Currently, UL is developing a scope for a new all-inclusive standard, UL 583A, which would apply specifically to industrial trucks used in hazardous locations, with reference to ANSI/UL 583 for the applicable ordinary locations requirements.

UL investigation

UL's investigation of hazardous locations trucks consists of a detailed construction examination and testing in accordance with specific ordinary and hazardous locations standards. To fulfill the ordinary locations fire and shock hazard requirements in ANSI/UL 583, the following tests are required:

Abnormal operation — To determine the truck's ability to withstand abuse, technicians operate the truck for 25 reversals of direction with 100 percent of the maximum-rated load through a 40-foot test course. During the test, nuisance tripping of any thermostat or overcurrent-protective device connected to the traction and pump motors is not acceptable.

Temperatures — To check for a breakdown in electrical-component-insulating materials, which may result in a fire, UL staff monitor temperatures on the electrical components during normal operation of the truck with a rated load. This test requires a 200-foot test course with a ramp having a 5-percent-or-less grade based on the intended use. The ramp is not needed for trucks designed and marked for operation on level surfaces. Again, thermal protectors and thermostats are not allowed to nuisance trip. During the test, the power consumption rate of the truck (battery discharge rate) is controlled at an eight-hour discharge rate.

Brakes — The brake test is performed immediately following the temperature test. Technicians operate the truck with a rated load and apply the brakes to bring the truck to a complete stop every 50 feet (15 meters). The external brake surfaces cannot exceed 175 C (347 F).

Dielectric voltage withstand — This test immediately follows both the temperature and brake tests. For one minute without breakdown, the truck must withstand the application of a test potential of (a) 1,000 volts plus twice the rated voltage for 72-volt-or-more rated trucks, and (b) 500 volts if the truck is rated less than 72 volts. The test potential is applied between current-carrying parts and the truck frame with the battery disconnected and all switches in both the open and closed positions.

Arc-rupturing — Arc-rupturing tests are conducted on the motor controllers and switching contacts in all circuits. This test consists of 100 cycles of making and breaking the controlled circuits. There shall be no arcing to the frame or enclosure, burning or melting of lead insulation. The motor controller and switches must remain functional at the test's conclusion. The dielectric voltage withstand test is repeated immediately following this test.

Table 1: Protection Methods

Area	Protection Methods
Class I, Div. 1	▪ Explosion-proof ▪ Intrinsic safety (two faults) ▪ Purged/pressurized (Type X or Y)
Class I, Div. 2	▪ Hermetically sealed ▪ Nonincendive ▪ Non-sparking ▪ Purged/pressurized (Type Z) ▪ Any Class I, Div. 1 method ▪ Any Class I, Zone 0, 1 or 2 method
Area	**Protection Methods**
Class I, Zone 0	▪ Intrinsic safety (two faults)
Class I, Zone 1	▪ Encapsulation ▪ Flameproof ▪ Increased safety ▪ Intrinsic safety (one fault) ▪ Oil immersion ▪ Powder filling ▪ Pressurization ▪ Any Class I, Zone 0 method ▪ Any Class I, Div. 1 method
Class I, Zone 2	▪ Hermetically sealed ▪ Nonincendive ▪ Non-sparking ▪ Pressurization ▪ Restricted breathing ▪ Any Class I, Zone 0 or 1 method ▪ Any Class I, Div. 1 or 2 method
Area	**Protection Methods**
Class II, Div. 1	▪ Dust-ignition-proof ▪ Intrinsic safety ▪ Pressurized
Class II, Div. 2	▪ Dust tight ▪ Nonincendive ▪ Non-sparking ▪ Pressurized ▪ Any Class II, Div. 1 method
Area	**Protection Methods**
Class III, Div. 1	▪ Dust tight ▪ Hermetically sealed ▪ Intrinsic safety
Class III, Div. 2	▪ Nonincendive ▪ Any Class III, Div. 1 method

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Burnout test — The energized truck motor is stalled for five minutes with its controller in each position. If there is no emission of flame or molten metal from the truck enclosure and no ignition of surrounding cotton or paper test materials, the result is acceptable. The enclosure surfaces of truck components must not exceed 175 C (347 F).

Solid-state circuitry component malfunction analysis — All power and control circuits of a truck employing solid-state circuitry are subjected to a component malfunction analysis. A malfunction must not result in a risk of fire or electric shock. This is verified as part of the temperature test by opening and short-circuiting the components.

Industrial trucks intended for hazardous locations undergo additional testing. Explosion-proof enclosures of a Class I, Division 1 truck are subjected to explosion and hydrostatic pressure withstand tests. If dust-ignition-proof enclosures are used for a Class II, Division 1 truck, dust penetration and dust blanket temperature tests are also required. These Division 1 requirements are covered in ANSI/UL 1203. For a Division 2 truck, test procedures specified under UL 1604 include a spark-ignition test, nonincendive component tests, dust-tight-enclosure test, and sealed device test.

Trucks intended for Zone-classified areas in accordance with the *NEC*® are evaluated in accordance with ANSI/UL 2279. For Zone 1 applications, flameproof enclosures, motors, plugs and receptacles, boxes and fittings are used to contain possible ignition sources and high-energy components. For various operator control functions, intrinsic safety circuits and controls are utilized for low-power/energy wiring outside the flameproof enclosures. For Zone 2 trucks, restricted breathing motors, controllers and switches are common solutions.

As required by the *NEC*®, the truck's maximum operating temperature is to be marked, if it exceeds 100 C (212 F) based on a 40 C ambient. The operating temperature is based on the surface temperature outside of the explosion-proof, flameproof and dust-ignition-proof enclosures. Internal component temperature is used to determine the marking for Division 2 or Zone 2 applications, or for other methods not relying upon the enclosure for protection. Ordinary locations trucks do not have such marking requirements.

International perspective

In Europe, two major standards are used for hazardous locations (or explosive atmospheres) industrial truck certifications. They are BSI prEN1755 — Safety of Machinery-Industrial Trucks — Operating in Potentially Explosive Atmospheres, Use in Flammable Gas, Vapour, Mist and Dust (published by the British Standards Institute); and BASEEFA Certification Standard — SFA 3006 — Battery Operated Vehicles (published by the British Approvals Service for Electrical Equipment in Flammable Atmospheres).

Only the Zone classification system is used in Europe to classify hazardous locations. While the European and U.S. Class I, Zone systems share many similarities, key differences still exist including wiring and sealing, grounding, markings and the application of requirements that address the risk of fire and electrical shock associated with the trucks, in addition to requirements that address the risk of explosion.

The American Society of Mechanical Engineering (ASME) has a Technical Assistance Group (ASME B56.11) tasked with overseeing all International Organization for Standardization (ISO) safety standards relating to material-handling equipment. ISO publishes a standard entitled Powered Industrial Trucks: Safety Code, ISO 3691. Currently, ISO TC 110 SC2 Working Group 2 is rewriting the safety codes for all industrial trucks (both ordinary and hazardous locations) to be combined as a single world standard.

Several trade and standards organizations also publish industrial truck-related standards and documents. For example, the Industrial Truck Association (ITA), which represents more than 95 percent of all powered industrial truck manufacturers in North America, develops voluntary engineering practices that promote the safety of industrial trucks.

UL can investigate hazardous locations equipment in accordance with published country-specific and international standards. UL's Danish subsidiary, UL International Demko A/S, is a Notified Body under the Equipment Explosive Atmospheres (ATEX), Low Voltage and Machinery Directives, and a Competent Body under the Electromagnetic Compatibility (EMC) Directive, and can assist in certifying industrial trucks for use in Zone-classified areas.

In addition to meeting U.S. and European requirements, UL certifications to the UL, NFPA and European Committee for Electrotechnical Standardization (CENELEC) standards address most international safety certification requirements. UL staff can also research the relevant standards of specific countries and assist clients in obtaining appropriate certifications in those countries.

Conclusion

UL certified hazardous locations products bear a UL Mark. The certifications are required and accepted by inspection authorities in many countries. By demonstrating conformance with nationally and internationally recognized hazardous locations standards through independent third-party certification, manufacturers of hazardous locations trucks gain greater acceptance of their products. Users benefit through product safety and potentially lower insurance rates.

Based on existing hazardous locations requirements covered in the *NEC*®, UL Standards and standards published in other parts of the world, local authorities and manufacturers should not have extremely divergent views on certain fundamental principles of product safety relating to explosion hazards. A globally recognized safety standard for industrial trucks in hazardous locations would promote easier acceptance of these products in all markets.

For further information on hazardous locations industrial truck certifications, contact Francis Mah in UL's Northbrook office, by telephone at Int.+847-664-2842; by fax at Int.+847-272-9475; or by e-mail at Francis.Mah@us.ul.com.

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