White Paper

Static Discharge
Ignition of Combustible Atmospheres

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Discharges of static electricity from hoses are known to cause the ignition of combustible atmospheres during the transfer of material to or from vacuum tankers and road tankers.

There are normally three main reasons why discharges of static electricity from hoses can occur. One reason is that non-conductive hoses are used to transfer material. Non-conductive hoses are capable of accumulating and retaining high levels of static charge which can result in incendive brush discharges from the hose itself, or the charging of isolated conductive objects attached to the hose like a nozzle or coupling that can discharge a spark themselves. It is generally accepted practice within the hazardous process industries that non-conductive hoses should not be used to transfer potentially combustible liquids and powders and numerous standards and industry association publications repeat this recommendation.

Figure 1. Four hose sections joined together in a vacuum tanker operation with an OhmGuard® hose tester testing the first hose section (blue cable).

Another common reason for static spark discharges from hoses results from connecting conductive hose, or interconnected conductive hose sections, to a vacuum tanker or road tanker that does not have a verified static ground connection. The third most common reason for static spark discharges from hoses is where the conductive components of the hose structure become isolated during normal activity.

Both the second and third modes of electrostatic discharge are the most relevant to the hazardous process industries, and are scenarios where improper use of conductive hoses can lead to the accumulation and discharging of static electricity within a combustible atmosphere.

1.1 Conductive hoses connected to ungrounded vacuum tankers and road tankers.

With no static grounding protection in place a tanker conducting a vacuuming or loading operation will become electrostatically charged as it has no means of preventing the accumulation of static electricity on its tank and chassis. Because the metal connections (couplings) of the hose should be electrically continuous with the tanker, the tanker will also transfer charges to the hose, thereby causing the accumulation of static electricity on the hose as well. The quantity of charge transferred to the hose will be high as ungrounded tankers can build up very large electrostatic voltages in a short space of time.

Charge accumulation on the conductive metal components of the hose, like couplings or nozzles, are a particular concern as these are the parts most likely to be closest to any combustible vapours or dusts during operations and may seek to nullify their electrical imbalance by sparking onto objects like operators, tank walls or pipes. If a combustible atmosphere is present in the spark discharge gap ignition of the atmosphere is highly probable.

In one reported incident a vacuum tanker was sucking off-specification toluene from a below grade sump and although the hose was conductive, the tanker to which it was attached did not have a verified static ground connection.

The hose itself consisted of a metal wire helix embedded in the hose tubing which bonded the hose couplings but given the high level of voltage induced on the hose via the ungrounded tanker, a static spark was discharged from the metal wire helix of the hose, across the hose tubing and onto the metal rim of the sump. The resulting spark ignited the toluene vapours leading to a fire [1].

1.2 Damaged conductive hoses connected to grounded vacuum tankers and road tankers.

A more insidious hazard is situations where the tanker has a static ground connection that is verified with either a tanker mounted or gantry mounted grounding system, but the hose(s) connected to the tanker has lost its electrical continuity resulting in the isolation of a metal component somewhere in its structure. A typical example of this would be when the metal wire helix of the hose becomes isolated from an end fitting like a hose coupling or a nozzle.

Metal wire helixes are commonly used to reinforce the hose structure against transfer pressures and bending kinks. Another common function of metal wire helixes is to bond end fittings to provide the necessary end-to-end electrical continuity that will prevent the accumulation of static electricity on the hose. If the metal helix, through normal industrial "wear and tear", breaks or detaches from hose couplings or nozzles, these components now have the capacity to accumulate enough charge and enough energy to ignite a combustible atmosphere. If a hose section with an isolated coupling is fitted between other hose sections, the other sections are isolated from the grounded tanker also which could lead to multiple components becoming electrostatically charged near to, or within, the potentially combustible atmosphere. In this situation the isolated hose sections will become charged due to contact with the moving liquid or powder.

Figure 2: Examples of a gantry mounted (Earth-Rite® RTR) and tanker mounted (Earth-Rite® MGV) static ground verification systems.

Another important consideration is hoses fitted with two metal wire helixes, where one helix is present on the outer surface of the hose and a second helix is present on the inner surface of the hose. In some hose designs the inner helixes are not bonded to the hose end fittings and it is important to ensure that such helixes cannot discharge sparks onto the end fittings or operator, especially when the hose is removed at the end of a transfer operation when a combustible atmosphere may be present in the hose or the area surrounding the hose. A hose fitted with an internal metal wire helix caused a fire through a discharge of static electricity, and in addition to the wire helix being broken, both end couplings were not designed to be connected to the inner metal helix. Quoting from **"Avoiding Static Ignition Hazards in Chemical Operations"**, AIChE/CCPS, Britton L.G., 1999[2]:

"A fire was reported during draining of toluene from a road tanker through such a hose and after the event it was found that the inner spiral was not only broken but was not designed to be bonded to the end connectors. Two post loading toluene fires occurred with a similar hose as the disconnected hoses were being handled by operators."

2.0 Industry standards and recommended practice.

To ensure that the hoses used on vacuum tankers and road tankers are not an electrostatic ignition source in a hazardous area there are numerous standards and recommended practices that describe the required electrical continuity of hoses. However, owing to the various hose construction types and established industry sector "norms", there are a range of electrical continuity values that preclude a "one size fits all" approach to ensuring a hose is safe to use in a potentially combustible atmosphere.

By far, the most common type of hose used on vacuum tankers and road tankers are hoses that contain metal wire helixes that may be sandwiched between layers of hose tubing or may be present on the inner or outer surface of the hose, or both.

The following table lists several standards and industry association publications that outline the conductivity requirements for hoses. The respective recommended values of hose resistance are derived for an equivalent 25 ft. length of hose.

In reality, many companies specify their own internal inspection regime that requires periodic end-to-end electrical continuity testing of their hoses. Periodic testing is normally performed every 6 to 12 weeks by a trained technician who will use a multimeter to measure and record the test results. The normally accepted end-to-end resistance "PASS" benchmark for individual hose sections with metal helixes is 10 ohms or less.

Depending on the test results the technician will either allow the hose back into service, schedule the hose for a repair or remove the hose from service altogether. Quoting from **CLCTR: 60079-32-1 (ref. Table 1)**:

Standard / Publication	Recommendation	Equivalent max. resistance per 25 ft. section of hose
ISO 8031: "Rubber and plastic hoses and hose assemblies - determination of electrical resistance and conductivity"	100 ohms per assembly (hose section) for hose with metal helix.	100 ohms
API 2219 "Safe Operation of Vacuum Trucks in Petroleum Service."	1 x 10^6 ohms per 100 ft. of hose.	250 K ohms
CLC/TR: 60079-32-1 "Explosive atmospheres - Part 32-1: Electrostatic Hazards - Guidance"	1000 ohms per metre of hose.	7600 ohms
API 2003: "Protection Against Ignitions Arising out of Static, Lightning and Stray Currents"	*For vacuum truck operations*: "use conductive hose and fittings as per API 2219"..."special considerations and controls are required to ensure bonding integrity is maintained in this difficult environment and that there are no ungrounded conductive objects connected to the hose."	As per API 2219 (see above)
NFPA 77 "Recommended Practice on Static Electricity"	Resistance to ground 10 ohms or less for continuous metal hose. Resistance to ground of not more than 1000 ohms per metre for braided hose or hose with continuous metal wire. Resistance to ground of semi-conductive hose with current limiting design 1 x 10^3 ohms to 1 x 10^5 ohms per metre.	10 ohms 7600 ohms 7600 ohms - 762 K ohms
AIChE/CCPS: "Avoiding Static Ignition Hazards in Chemical Operations	"Conductive hoses containing a continuous wire or braid bonding element should have a resistance less than ≤1000 Ohm per metre of hose length"	7600 ohms
EN 13765: 2010 "Thermoplastic multi-layer (nonvulcanized) hoses and hose assemblies for the transfer of hydrocarbons, solvents and chemicals."	"There shall be electrical continuity between both internal and external wires and the end fittings." "For hoses equal to or greater than 50 mm in diameter the resistance should be ≤1 ohm per metre."	7.6 ohms

Table 1: Standards and industry publications that address hazards related to electrostatic charging of hoses.

Figure 3 . An isolated coupling caused by a broken wire helix.

"Due to broken bonding wires or faulty construction, it is possible for one or more of the conductive components of the hose (i.e. end couplings, reinforcing helices and sheaths) to become electrically insulated. If a low conductivity liquid is then passed through the hose these components could accumulate an electrostatic charge leading to incendive sparks. Therefore, the electrical continuity of the hose should be checked regularly. Care should be taken to ensure that all internal metal helices are bonded to the end coupling."

Although periodic testing of hoses is important, from a static grounding protection viewpoint, it would be safer to test the hoses prior to every transfer operation. In the 6 to 12 week period that the hoses are in use, breaks in end-to-end continuity can, and will, occur. Normally the metal helix that bonds the couplings of the hoses together will either break or loosen from its connection to the coupling.

If hoses with breaks in continuity are kept in service there is a strong chance that they will be accumulating static electricity during loading or vacuuming operations thus increasing the probability of static spark discharges when the hose is being used in a hazardous atmosphere.

The ideal procedure for proving a secure static grounding path for all the primary components used in the transfer, i.e. the road tanker and the hose sections connected to the tanker, would be to verify a ground for the tanker via a tanker mounted grounding system (Earth-Rite® MGV), or a gantry mounted grounding system (Earth-Rite® RTR). When the ground path for the tanker is verified, the next operation would be to connect the hose(s) to the tanker and then perform an electrical continuity test through the hose sections back to the tanker. This would ensure that the hose will be capable of transferring static charges through its structure, onto the tanker and down to ground via the static grounding system.

3.0 Testing hoses used in Vacuum tanker operations.

For vacuum tanker operations the driver should perform an electrical continuity test between the end of the hose through which material will be sucked, back to the tank or chassis of the tanker. This test ensures that there is electrical continuity through the hose sections and onto the tanker itself. Any charge created on the metal components of the hose during the transfer operation will travel via the hose onto the tanker and down to earth via the tanker's Earth-Rite® MGV system.

Hose continuity tests are normally performed with a multimeter but given the circumstances in which the vacuum tankers and drivers are operating, which are typically harsh industrial environments and zoned atmospheres, the meters, at minimum, need to be robust, rugged and certified for use in zoned areas. More importantly, the technical competency and training required to operate the meters may present more problems than they would solve.

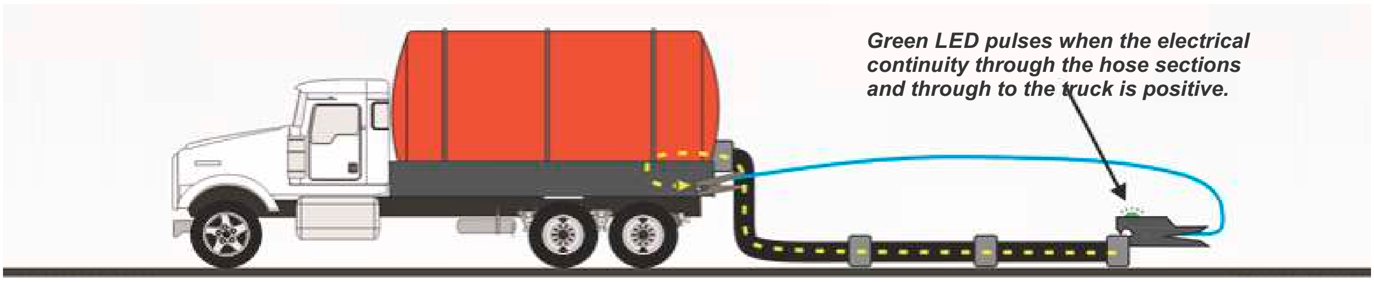

Figure 4. The OhmGuard® is a portable device that consists of 2 clamps joined by Cen-Stat cable (blue). The driver simply attaches one clamp to the tanker and the other clamp to the end of the connected hose sections. The pulsing green LED indicates good continuity through the hose and tanker. The tanker should be grounded with a truck mounted grounding system like the Earth-Rite® MGV.

An ATEX / IECEx hazardous area certified device like the OhmGuard Hose Continuity Tester enables drivers to perform a simple and quick PASS or FAIL hose continuity test prior to each transfer operation. The driver simply looks for a pulsing green LED from the OhmGuard clamp to indicate complete continuity through the interconnected hoses and, in turn, the hose's connection to the tanker. If the OhmGuard does not provide a PASS indication to the driver he can test each individual hose section to isolate the faulty hose and remove it from the transfer operation.

4.0 Testing hoses used in the loading or unloading of bulk chemical road tankers.

When chemical road tankers are bottom loading or offloading product through sealed hose connections at bulk storage chemical terminals or chemical manufacturing sites they should be grounded with a gantry mounted or tanker mounted static grounding system. In addition the hoses through which the product is transferred should be conductive.

One of the risks of using a hose with an isolated component in a closed connection transfer, e.g. the metal helix breaks contact with the hose coupling, would be at the end of a transfer operation when a vapour may be present and as the driver removes the hose from the connector could receive a static spark discharge from the wire helix or the wire helix could discharge a spark onto the site's loading connection point.

Using an OhmGuard the driver can test the conductivity of his hose prior to the transfer operation. This ensures that all the hose sections, including the couplings on both ends of the hose have proper continuity.

If the driver is transferring the contents of the tanker into an Intermediate Bulk Container (IBC) at a customer site, he should check the electrical continuity of the hose prior to transferring the product into the IBC. The tanker should be grounded and the IBC bonded to the tanker, or grounded itself.

5.0 Testing hoses when unloading road tankers at petrol service stations.

For situations where road tankers are gravity offloading or pumping petrol to underground storage tanks at petrol service stations, the road tanker is assumed to be grounded via the transfer hose connection to the service station coupling that feeds into the underground storage tanks. Despite the increased use of plastic tanks and piping the receiving tanks are assumed to be providing the connection to a true earth ground.

Although road tankers are protected from static electricity with dedicated static ground monitoring systems at the refinery or tank storage terminal, no grounding checks are performed at the service station unloading point even though the immediate area where the hose is connected to the service station filling point and to the tanker itself is defined as a Zone 1 atmosphere.

To eliminate the risk of charge accumulation on conductive hoses, after the driver completes the connection of the hose from the tanker to the filling point of the site, he can test the continuity between the tanker and the service station filling point with an OhmGuard which will verify that the hose is conductive and is securely bonding the tanker to the filling point of the service station. The OhmGuard can remain connected during the transfer with the green LED pulsing continuously to indicate a good bond between the tanker and the service station filling point. Provided the filling point at the service station has a verified true earth ground connection, static electricity will not accumulate on the hose or the road tanker. Quoting from CLCTR: 60079-32-1 (ref. Table 1) which addresses road tanker deliveries:

"Deliveries from road tankers to medium sized tanks are performed via flexible hoses using either gravity feed or pumps on the vehicle. Electrostatic ignition hazards may occur as a result of sparks from insulated conductors (e.g. hose couplings or the road tanker as a whole), brush discharges from non-conductive hoses or brush discharges within the receiving tank."

Figure 5: Road tanker loading underground tanks at a petrol service station.

The following precautions are recommended:

- >Conductive or semi-conductive hoses should be used.
- >Ensure that the tanker and all metallic couplings are bonded to the tank being filled. Separate bonding is not needed when the hoses are conductive or semi-conductive as bonding is provided by the hose.
- >When connecting the tanker to the receiving tank, first connect the hose to the tanker and then, before removing the tank fill pipe cap or making any other hose connections, equalise the potentials by touching the end coupling of the hose on the fill pipe cap or any other metallic part of the tank.
- >Providing the maximum safe filling velocities for medium sized tanks are not exceeded there is unlikely to be an ignition hazard within the tank. If the liquid contains a second phase, the filling velocity should be restricted to 1 m/s.
- >The continuity of conductive hoses should be checked regularly.

Summary

Hoses play an important role in hazardous area operations and owing to their direct interaction with moving liquids and powders are especially at risk of becoming electrostatically charged. It is important to ensure that hoses used within a hazardous area are capable of transferring electrostatic charges from their structure onto grounded equipment. At no point in its structure should such a hose be permitted to accumulate static electricity. Even so, no hose is immune to operational wear and tear and regular electrical continuity testing will enable detection of damaged hoses. Although periodic testing will identify faulty hoses, a simple test by an OhmGuard hose continuity tester, prior to each transfer operation, will ensure a faulty hose is identified and removed as soon as it becomes an ignition risk.

References:

[1]. Thomas H. Pratt, 2000, "Electrostatic Ignitions of Fires and Explosions", AIChE/CCPS.

[2] . Britton L.G., 1999 "Avoiding Static Ignition Hazards in Chemical Operations", AIChE/CCPS.

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