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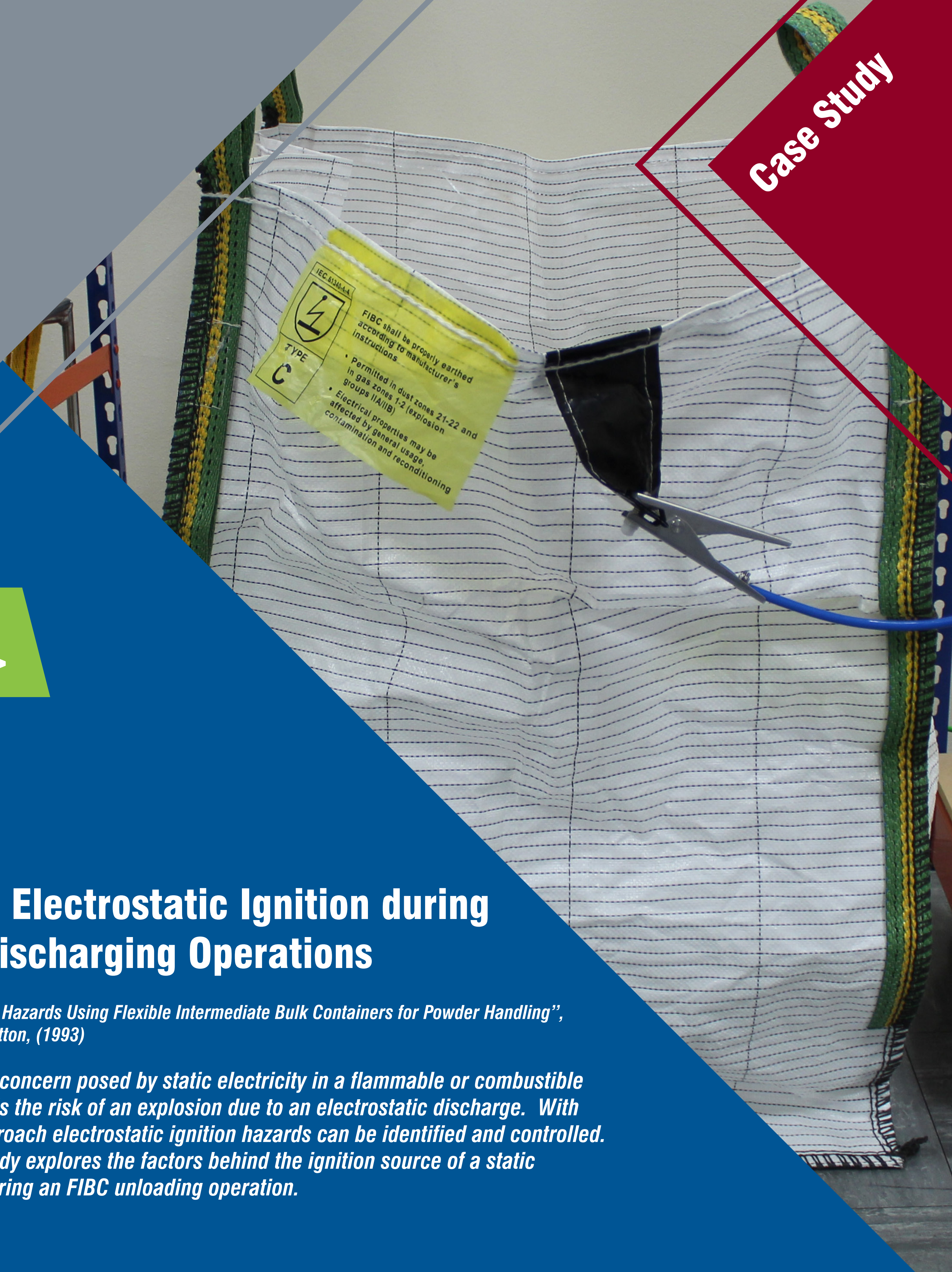
Case Study



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Risk of Electrostatic Ignition during FIBC Discharging Operations

Source: "Static Hazards Using Flexible Intermediate Bulk Containers for Powder Handling", Laurence G. Britton, (1993)

The greatest concern posed by static electricity in a flammable or combustible atmosphere is the risk of an explosion due to an electrostatic discharge. With the right approach electrostatic ignition hazards can be identified and controlled. This case study explores the factors behind the ignition source of a static discharge during an FIBC unloading operation.

Flexible Intermediate Bulk Containers (FIBCs) have long been considered a great innovation in the transportation of dry flowable material since their introduction in the sixties. Commonly referred to as a “bulk bag”, “big bag” or “tote”, FIBCs have a body made of flexible woven material, typically the high strength thermoplastic, polypropylene, along with a linear insert. FIBCs are efficient, and transportation of dry bulk goods such as sand, fertilisers, plastic granules, seeds, resin and powder coatings, to name a few, can be unloaded at a fast rate, with anywhere between 300 – 500kg typically in 30 seconds or less. Used in agricultural, chemical, food and pharmaceutical industries, FIBCs have proven to be simple to use, cost-effective and strong, and are more convenient than rigid IBCs for powder transfers because they can be collapsed after use and stored away. However, the use of FIBCs are not without their risks and when filling and emptying FIBCs in hazardous areas, electrostatic charge can accumulate on both the contents (product) and the fabric of the material itself. It is common under these circumstances for the rates at which static electricity charges are generated to exceed the rates at which the charges can relax, allowing the accumulation of a static electric charge to develop within the process.

The danger to plant personnel and the surrounding environment is if the charge is released in the presence of a flammable atmosphere, an ignition can occur. Since many products are combustible, the inherent electrostatic discharge hazard from the material cannot be overlooked. Mitigating the potential risk of an electrostatic ignition is of paramount importance.

In the first of two incidents, an operator suffered a singed head, a burn to the back of their neck and a second-degree burn on their right arm. The second incident led to second and third-degree burns to their stomach and face too. As a result of the second static incident, the employee made the decision to leave his role, citing his apprehensive nature towards the job.

Incident A

In the first incident an FIBC Type C bag was used to transfer resin to a 6,000 gallon mixing tank. This operation involved making lacquer for can coatings. The mixing tank was equipped with thin conductive wires running lengthwise through the spout and connected to a bare stranded aluminium wire and alligator clip. The FIBC was hoisted above the tank using a fork lift and the resin was dumped through a circular port on a hinged tank cover. There was no independent venting of displaced vapor and the tank lid was not gas tight. Despite the operator reporting that the ground wire was missing from the FIBC, it did not stop him proceeding to unload the container regardless.

The tank lid was open allowing solvent vapor to readily escape into the operating area. Although it was not categorically determined whether the fire occurred immediately or after the FIBC was nearly completely empty, as the operator was standing within the vicinity of the tanker during the operation, he turned away when he observed the flash. An operator typically stands within close proximity of the FIBC during emptying, first to untie the strings and later to shake out residual powder. In this scenario an ignition occurred and the operator was caught in the flash-fire zone and severely burned in the process.

Conclusion

The investigation into the incident made the assessment that a spark discharge had occurred from the ungrounded FIBC during emptying. The lack of continuity to ground meant that charge could not be dissipated. Charge on an insulated object is retained because of the resistance of the material itself. For a conductor, such as the FIBC to remain charged, it has to be isolated from earth. As it was known that the resin had low minimum ignition energy (MIE), it was assumed that flammable vapor was a significant factor in the ignition process reaching well in excess of an acceptable level. Materials with low MIE will regularly reach the minimum explosive concentration (MEC) in an FIBC emptying operation such as the one described due to the flow-rate and ability to charge, and may be at risk of combustion by several sources of ignition. In this incident electrostatic discharge was the ignition source.

Although the operator himself was not grounded, the nature of the operation involved making a lacquer, meaning that static dissipative footwear would probably have been ineffective as there was possibility of a film of lacquer on the floor around the tank. Common in processes where coatings are prevalent, a build-up on the sole of the shoe regularly occurs. A cleaner sole will typically give off a lower resistance. Despite this, he was not considered a likely source of ignition.

Minimum Ignition Energies (MIE) of regularly transported gases, vapours and dusts in milli-joules (mJ)

	Material	MIE (mJ)
Liquid Vapour Gas	Gasoline	0.80
	Ethanol	0.65
	Propanol	0.65
	Ethyl acetate	0.46
	Methane	0.28
	Propane	0.25
	Ethane	0.24
	Hexane	0.24
	Methanol	0.14
	Acetylene	0.017
	Hydrogen	0.011
	Carbon disulphide	0.009
Powder	Zinc	200
	Wheat Flour	50
	Polyethylene	30
	Sugar	30
	Magnesium	20
	Sulphur	15
	Aluminium	10
	Epoxy resin	9
	Zirconium	5

Minimum Ignition Energy of explosive / flammable materials (Source: IChemE)

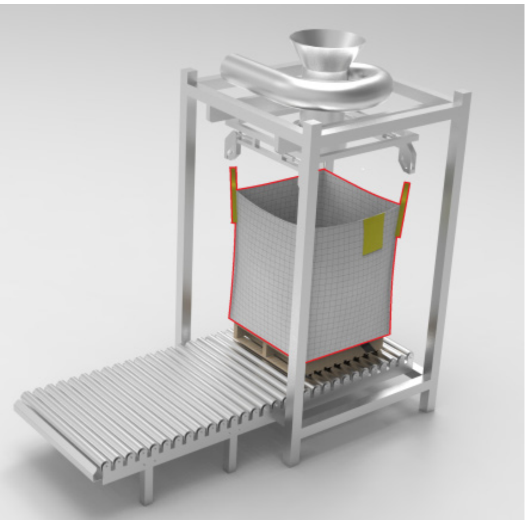
Use of different types of FIBC's

Bulk Product	Surroundings		
MIE of Dust	Non Flammable Atmosphere	Explosive Dust Atmosphere	Explosive Gas and Vapour Atmosphere (Group IIA or IIB)
MIE $>$ 1000 mJ	A, B, C, D	B, C, D	C, D
1000 mJ $\geq$ MIE $>$ 3 mJ	B, C, D	B, C, D	C, D
MIE $\leq$ 3 mJ	C, D	C, D	C, D

Incident B

Unfortunately, this incident involved the same operator and was not dissimilar to the first. The main difference being the FIBC was designed with an internal conductive aluminium liner bonded to the polypropylene in the spout. This was connected to an external grounding tab to which a grounding clamp was to be connected by the operator. The FIBC was suspended over the tank as before, and after applying the grounding clamp the discharge spout was pushed through the port in the tank manway so that it is extended 10-12 inches inside the tank. The draw cord was then cut to open the spout and release resin into the tank. The FIBC was not opened at the top to vent the contents and mitigate drawing vapor into the FIBC. On this occasion flow was delayed and the operator “puffed” the FIBC to free the flow. Within 10 seconds of flow a flash occurred. Failure to vent the FIBC was not believed to be a contributing factor as there was no fire or explosion inside it.

In the event of an ignition during an FIBC operation, plant personnel that are usually within close proximity are likely to be caught in the flames. The operator once again was in the vicinity of the FIBC but not touching it. As a result he received second and third degree burns to his stomach and face.



The sprinkler system installed above the tank did not emit water; however, pallets of resin bags were singed at a distance of 20 – 30ft from the tank. A major hazard in any explosion is when material is dispersed into the general plant area and a secondary ignition occurs. Although the hinged lid was closed there was again no provision for venting either the purge gas or the air entrained into the tank by the powder flow. A significant displacement of flammable vapor therefore took place into the operating area.

Conclusion

Unlike the first incident, in Incident B it was reported – but not conclusively determined, that a grounding connection had been properly made ensuring continuity to earth to dissipate static charge. However, it was not possible to completely ascertain whether this was the case as the grounding clamp was unavailable for examination. As a result, an FIBC operational error causing loss of continuity could not be ruled out since the FIBC involved was destroyed in the fire. Although polypropylene has a unique blend of qualities and characteristics that make it an ideal material for the construction of FIBCs; it is also highly flammable and susceptible to ignition via a spark discharge. If we are to generalise failures for FIBC operations, these typically occur due to manufacturing defects, operator error or disabling continuity to a verified earth via a grounding clamp.

What actions could have been taken to mitigate these incidents?

With any incident the first place to start is to determine why electrostatic charge was “permitted” to accumulate. Charge generation normally occurs due to the process of contact and separation of the material which takes place between particles and the equipment, known as triboelectrification. Any material will naturally become charged by triboelectric action. Particle separation within FIBC processes occurs between conveying equipment and the bulk bag during filling and emptying. The nature of FIBC operations means that they are particularly susceptible to charge accumulation.

Helpful Tips for correctly grounding Type C FIBC bags:

>Ensure that the grounding system selected can check and continuously monitor the full range of resistance through the bag.
> Ensure the grounding system not only check the condition of the bag’s static dissipative threads, but also ensure that the ground circuit includes a direct and monitored connection to a verified True Earth grounding point.
> Ensure the grounding system does not monitor a limited percentage of the permitted range of resistance as they may pass faulty bags and reject acceptable bags.
> Ensure Type C bags are manufactured in accordance with the electrostatic recommendations of IEC 61340-4-4 or NFPA 77.

IEC 61340-4-4 "Electrostatics – Part 4-4: Standard test methods for specific applications – Electrostatic classification of flexible intermediate bulk containers (FIBC)" states:

7.3.1. Type C FIBC

A Type C FIBC intended for use in the presence of flammable vapours or gases, or combustible dusts with ignition energies of 3 mJ or less shall have a resistance to groundable point of less than 1×10^8 Ohms when tested according to 9.3. Additionally, the FIBC shall be constructed entirely from conductive material or at least shall contain fully inter-connected conductive threads or tapes with a maximum spacing of 20 mm if the threads or tapes are in a stripe pattern, or 50 mm if they are in a grid pattern.

NFPA 77, 16.6.6.3, "Type C FIBC" states:

The recommendations for conductive IBCs given in 10.1.4 also apply to conductive FIBCs. A grounding tab that is electrically connected to the conductive material or threads is provided and is intended to be connected to a ground point when the FIBC is filled or emptied. The resistance between the conductive elements in the FIBC and the grounding tabs should be less than 1.0×10^7 Ohms.

* Always check for and read the latest version of the International Standards, Guidance and/or Recommended Practices.

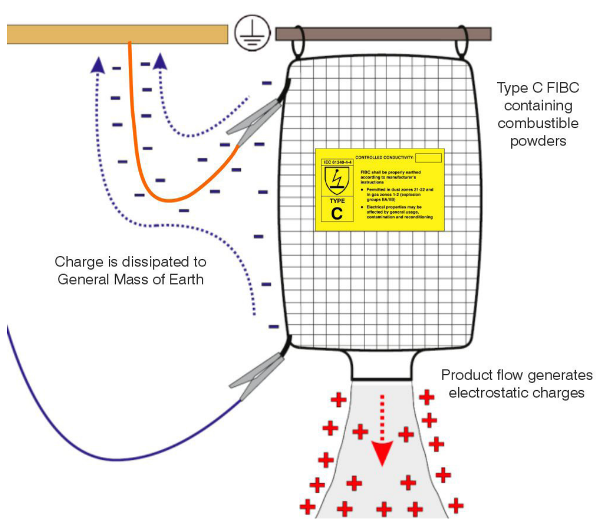
In these incidents electrostatic charge had been allowed to accumulate because the FIBC was isolated from ground, whether this was through the negligent actions of the plant operator or inconclusive grounding methods. As grounding wasn't achieved, charge was allowed to accumulate. Had grounding been accomplished via a Type C bag with either passive (single pole clamp and cable) or through active means (monitoring systems), connection to a true earth ground would have been verified and charge subsequently dissipated. In accordance with industry guidelines such as NFPA 77 "Recommended Practice on Static Electricity" and IEC 61340-4-4, "Electrostatics – Part 4-4: Standard test methods for specific applications – Electrostatic classification of flexible intermediate bulk containers (FIBC)" the resistance through the bag should be less than 10^7 Ohms (10 meg-ohm) for NFPA 77 and 1×10^8 Ohms (100 meg-ohm) for IEC 61340-4-4.

Given the magnitude of charge that can build up on bags, an active grounding system is the recommended – and safer choice. This is because the system can determine whether or not the bag's construction complies with the relevant standards and will also ensure the bag is grounded for the duration of the filling/emptying operation.

The primary benefit of checking the resistance through the bag is to ensure that after many cycles of repeated use, the static dissipative threads are functioning correctly, and more importantly, to ensure that bags not of Type C construction are not permitted to be used in hazardous areas.

Newson Gale's Earth-Rite® FIBC system validates and monitors the resistance of Type C bags ensuring that conductive elements of the bag are capable of dissipating charges in compliance with the necessary guidelines. Type C bags are designed to dissipate static electricity through static dissipative threads that are interwoven through the bags material. Grounding tabs located on the bags are points where grounding systems can be connected to ensure static electricity does not accumulate on the bag. Once the connection of two grounding clamps has been made onto the grounding tabs, the FIBC system will identify if the bag is operating in accordance with the relevant standard. This is achieved by sending an intrinsically safe signal through the bag. The system verifies the grounding of the bag by ensuring the signal returns via a verified true earth ground (static ground NOT verified by the FIBC). Should any charge have accumulated on the bag, it will leave via the static dissipative threads to the verified ground.

The static dissipative loop system check continuously monitors the resistance of the bag so that if it rises above NFPA 77 - 1×10^7 Ohms or IEC 61340-4-4 - 1×10^8 Ohms, a red LED on the remote indicator station illuminates to tell the operator the system has gone non permissive.



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Additional benefits of grounding systems over introductory level clamps and cables is that the movement of product can be controlled through output contacts interlocked with the process; material cannot flow without the permission of the operator.

Simply put, a Newson Gale Earth-Rite FIBC system will have a red LED when:

1. **The system is not in use**
2. **The grounding is compromised (exceeds 1 x 10^7 Ohms or 1 x 10^8 Ohms)**
3. **The Type C bag's construction does not comply with the relevant standards**

Summary

Of course, recognition of the hazard is only the first step. It is easy to assume that the use of simple clamps will automatically mitigate the risk posed by static electricity. However, the complexity of dissipating static effectively requires careful planning and a sound approach to risk management. The correct bag and grounding system can always be negated by plant personnel that purposely or inadvertently circumvent safety procedure; however, as documented in Incident A, the effects far outweigh the time it takes to perform the necessary checks and conclusively confirm visually that (a) the operator has clamped on, and (b) the system has confirmed a resistance to ground of 1 x 10^7 Ohms / 1 x 10^8 Ohms or less.

Regular static hazard awareness training combined with grounding equipment that displays compliance with industry guidelines will go a long way to mitigating fires or explosions caused by static electricity.

If you have any questions on this case study e-mail [Newson Gale].
If you would like to learn more about the Earth-Rite® FIBC follow this link to the [product webpage].

Please note this case study is referenced from a third party source and is not in any way linked to the operations of Newson Gale customers.

United Kingdom
Newson Gale Ltd
Omega House
Private Road 8
Colwick, Nottingham
NG4 2JX, UK
+44 (0)115 940 7500
groundit@newson-gale.co.uk

United States
IEP Technologies LLC
417-1 South Street
Marlborough, MA 01752
USA

+1 732 961 7610
groundit@newson-gale.com

Deutschland
IEP Technologies GmbH
Kaiserswerther Str. 85C
40878 Ratingen
Germany

+49 (0)2102 58890
erdung@newson-gale.de