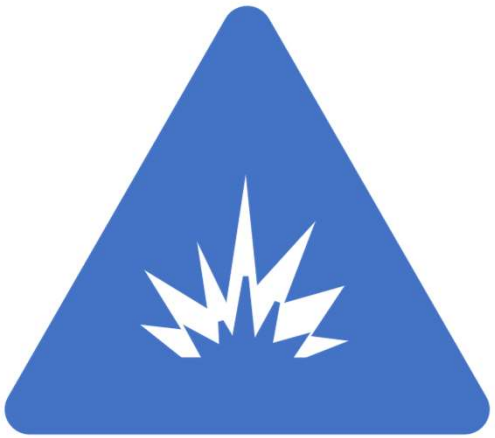
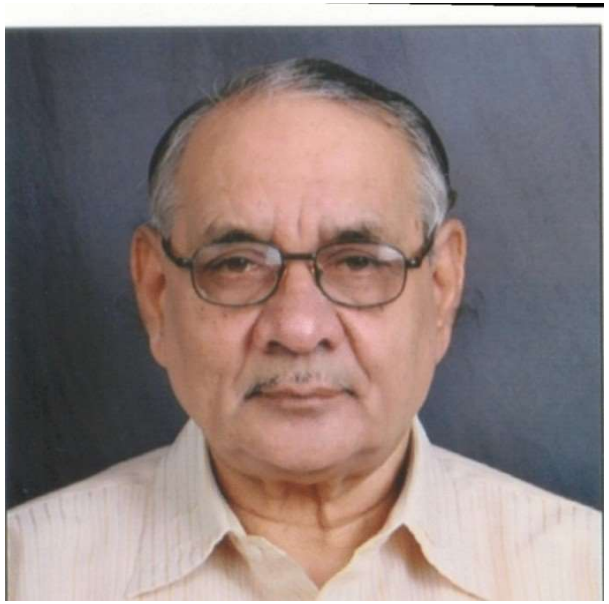
Evaluation & Prevention of Electrostatic Hazards



Electrostatic discharge risk assessment

Acknowledgement



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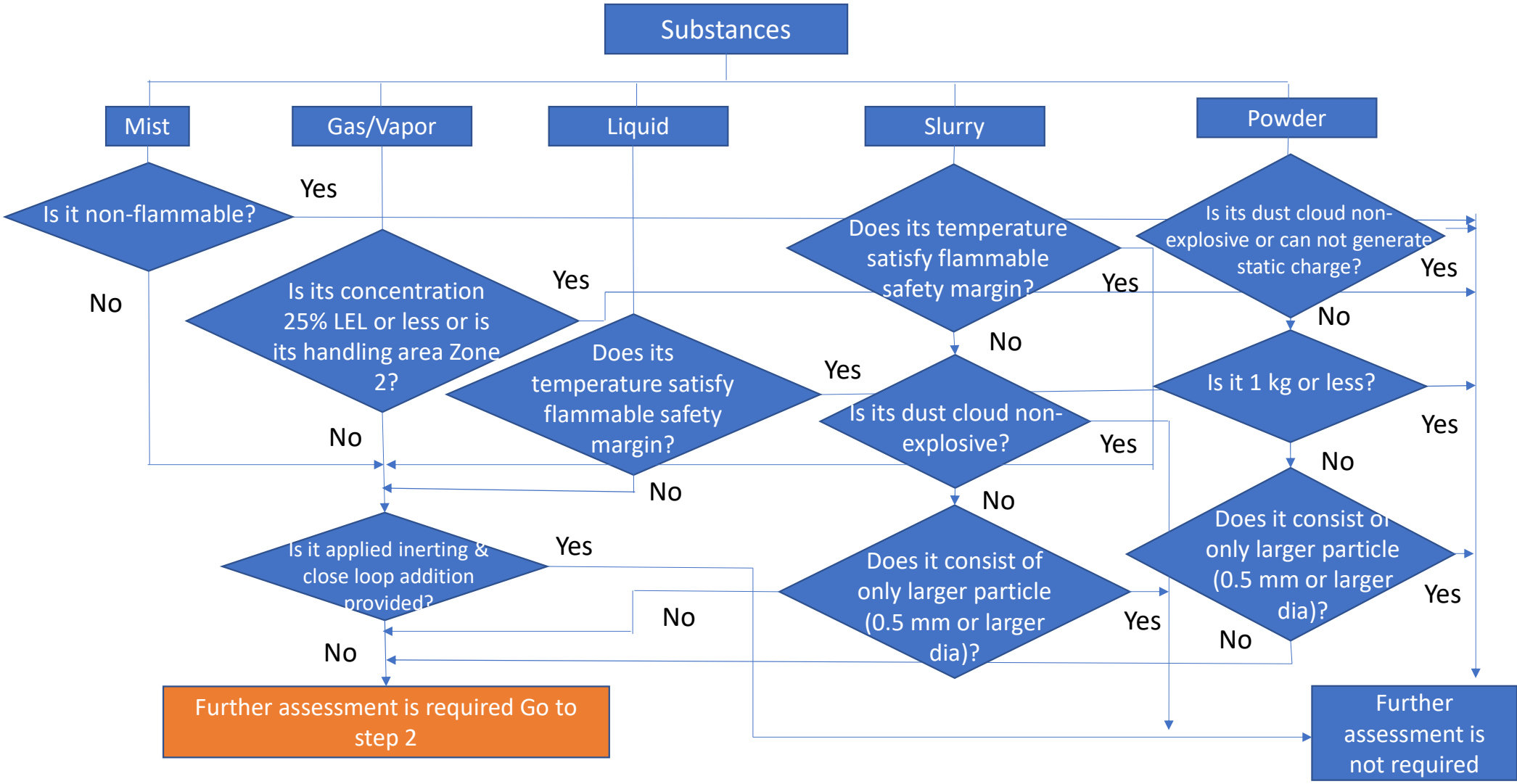
Electrostatic accident Risk assessment

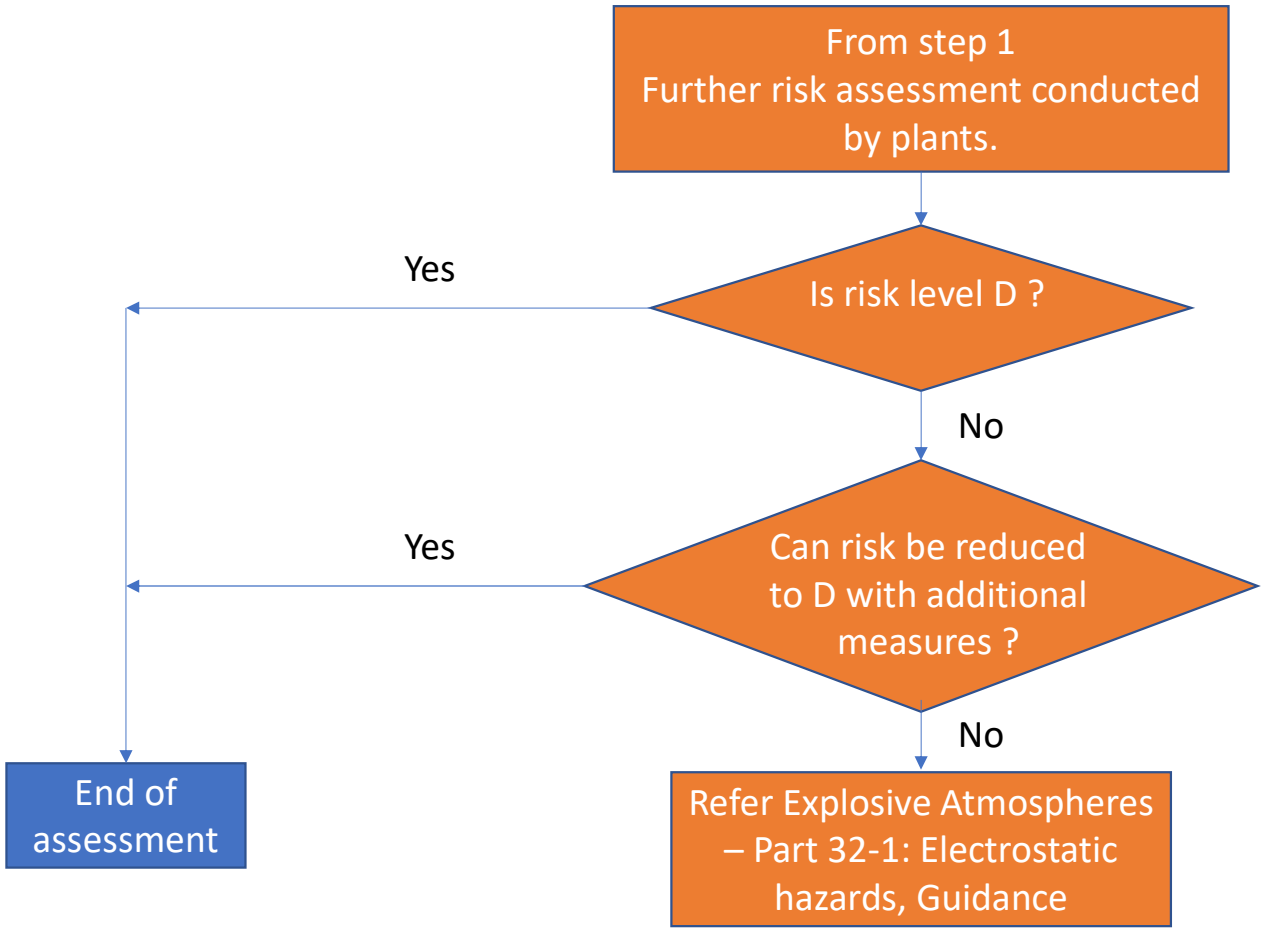
Electrostatic accident Risk assessment

- Wherever temperature does not satisfy flammable safety margin i.e. solvents are handled above flash points or insulating RM is charged in solvents above flash point.
- Wherever the exclusion of effective ignition sources is applied as a precaution, a detailed risk analysis must be carried out to compare the ignition sensitivity of the potentially explosive atmospheres that may occur with the incendivity of the possible ignition sources.
- MIE values for the Solvent RM is not required as it is available but powder RM MIE should be determined
- Systematic procedure for evaluating ignition hazards created by electrostatic charges is given below

Flow chart for electrostatic risk assessment



Flow chart for electrostatic risk assessment



Guidelines in AP context for electrostatic risk assessment

- All powder RM should be considered as Non-conductive. (Power resistive value test not required)
- MIE of mixer should same as lowest MIE of solvent in a mix.
- While deciding the type of electrostatic discharge, characteristics of ESD should be considered
- During the risk assessment present safety measures should be considered.

Electrostatic risk assessment

Table 1 Summary of electrostatic discharges and their relevance to ignition risk

Type of Discharge	Ignition energy range	Occurrence	Ignition risks
Spark	Up to several J depending on size (capacitance) of the conductor	Between conducting objects	Incendive to gas/vapour and to dust
Human body	Up to a a several mJ	Between a person and a conducting object	Incendive to gas/vapour and possibly to sensitive dust
Brush	Up to about 3.6 mJ	From surface of insulator to a conductor (including personnel)	Incendive to gas/vapour but not to dust clouds in the absence of gas or vapour
Propagating brush	Up to over 1 J	From surface of insulator 4kV that is backed by a conductor, to a conductor	Incendive to gas/vapour and to dust
Cone	Depends on silo size	Along the surface of a bulk powder cone in a silo	Incendive to gas/vapour and to dust
Corona	Not normally incendive	From sharp points or edges in high electrostatic fields	Not incendive if sparks cannot occur. Can be used to neutralise electrostatic charge buildup

Electrostatic risk assessment

Table 1 :- Likelihood of formation of explosive atmospheres (Zone classification)

Likelihood for formation of explosive atmosphere	Zone
High	Zone 0/zone 20
Medium	Zone 1/Zone 21
Low	Zone 2/Zone 22

Zone 0/ Zone 20 is a place in which an explosive atmosphere consisting of a mixture with air of combustible substances in the form of gas, vapor or mist is present continuously or for long periods or frequently. An example of Zone 0 is inside of a sealed container of flammable liquid.

Zone 1/ Zone 21 is a place in which an explosive atmosphere of a mixture with air of gas, vapor or mist is likely to occur occasionally in normal operation. An example of Zone 1 is an area near the upper opening of a container of flammable liquid that has no lid.

Zone 2/Zone 22 is a place in which an explosive atmospheric mixture with air of combustible sub- stances is not likely to occur during normal operation but, if it does occur, it will persist for a short period only. This zone includes places surrounding Zone 1.

Electrostatic risk assessment

Table 2 :- Likelihood of occurring incendive discharge (gas/vapor)

Types of electrostatic discharge (maximum energy ranges)	Likelihood of occurring incendive discharges		
	High	Medium	Low
Corona discharge (0.1mJ)	H2, C2H2	----------	General gases/Vapors
Brush discharge (4mJ)	General gases/Vapors	Some gases/vapors	Some gases/vapors
Cone discharge (up to 1000 mJ)	Almost all of gases/vapors	Some gases/vapors	Some gases/vapors
Spark discharge (up to 10000 of mJ)	Almost all of gases/vapors	----------	----------
Propagating brush discharge (up to 100000 mJ)	Almost all of gases/vapors	----------	----------

Likelihood

Low :- Not likely to occur during the life of the equipment.

Medium :- Expected to occur on an average once in five to ten years.

High :- Expected to occur on an average once a year

Electrostatic risk assessment

Table 3 Likelihood of occurring incendive discharge (dust cloud)

Types of electrostatic discharge (maximum energy ranges)	Likelihood of occurring incendive discharges		
	High	Medium	Low
Corona discharge (0.1mJ)	----------	----------	All
Brush discharge (4mJ)	MIE ≦ 3mJ	3mJ < MIE ≦ 10mJ	10mJ < MIE
Cone discharge (up to 1000 mJ)	MIE ≦ 100mJ	100mJ < MIE ≦ 1000mJ	1000mJ < MIE
Spark discharge (up to 10000 of mJ)	All	----------	----------
Propagating brush discharge (up to 100000 mJ)	All	----------	----------

Likelihood
Low :- Not likely to occur during the life of the equipment.
Medium :- Expected to occur on an average once in five to ten years.
High :- Expected to occur on an average once a year

Electrostatic risk assessment

Table 4 :- Likelihood of occurring electrostatic accident

		likelihood for formation of explosive atmosphere (obtained from Table 1)		
		High	**Medium**	**Low**
Likelihood of occurring incendive discharge (obtained from Table 2/3)	**High**	A	B	C
	Medium	B	B	C
	Low	C	C	C

Table 5 :- Severity of damages

		Criteria for judgment
Severity	**Low**	Property Damage in Rupees < 25,000 & Event causes first-aid injuries or no injuries
	Medium	Property Damage in Rupees < 5,00,000 & Event causes LTI
	High	Property Damage in Rupees ≥10,00,000 & Event causes single or multiple fatality

Electrostatic risk assessment

Table 6 :- Risk rating for occurring electrostatic accident

		Likelihood of occurring electrostatic accident (obtained from Table 4)		
		C	**B**	**A**
Severity (obtained from Table 5)	**Low**	D	E	F
	Medium	E	F	F
	High	E	F	F

Electrostatic Risk The electrostatic risk is determined in Table 6 based on the estimation results from Tables 4 and 5. If the risk ranking cannot finally be reduced to D or E, safety measures have to be determined in consultation with the safety consultant/expert of electrostatic safety & IEC60079-32-1 Explosive Atmospheres – Part 32-1: Electrostatic hazards, Guidance

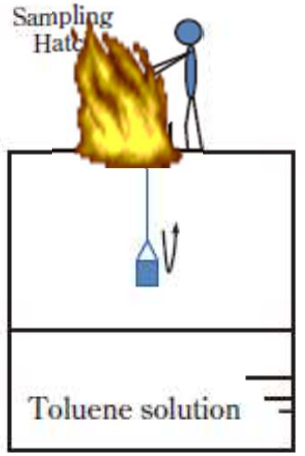
Examples of Electrostatic Risk Assessment

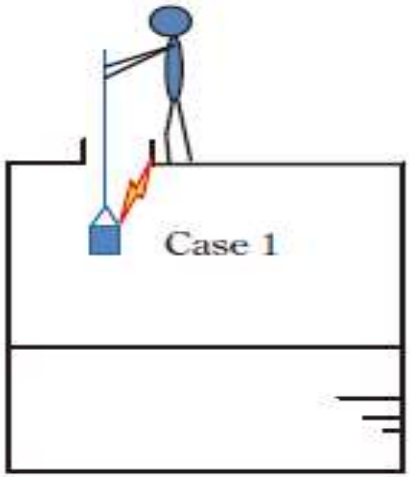
Examples of Electrostatic Risk Assessment

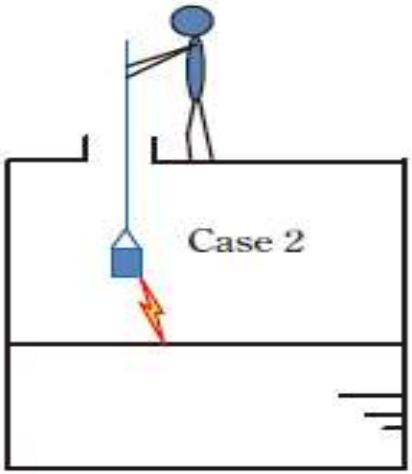
- An electrostatic risk assessment during the sampling operation.
- Toluene sampling operation from large tank, opening the tank manhole located at the top of the tank.

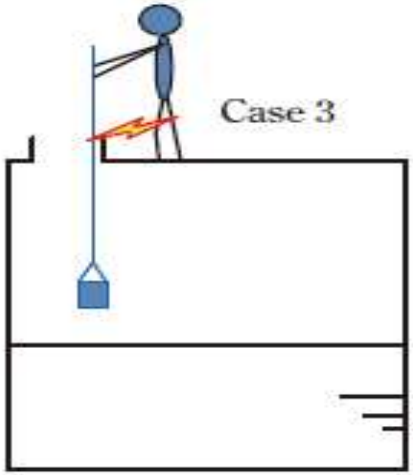
Conditions

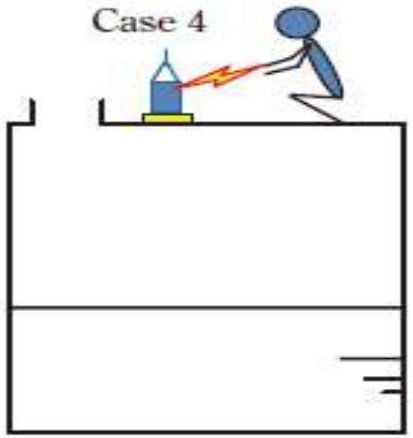
- Humidity; 25%
- Flash point (as pure toluene); 4 degree C
- Conductivity (as pure toluene) <1pS/m (Insulative)
- MIE (as pure toluene) 0.24mJ
- Inside tank atmosphere; Air
- Volume of sampling container 1L
- Material of sampling container metal
- Temp.; 10 degree C











Examples of Electrostatic Risk Assessment

Case	Hazards	Safety measures	Likelihood			Severity of damages (Table 5)	Risk rating for occurring electrostatic accident (Table 6)	Remarks
			likelihood for formation of explosive atmosphere (Table 1)	Likelihood of occurring incendive discharge (Table 2/3)	Likelihood of occurring electrostatic accident (Table 4)			
1	1-1: Electrostatic discharge is inside the tank	None	H (Zone 0)	H(Spark)	A	High	F	Need additional Measures
	1-2: Electrostatic discharge is inside the tank	Grounding (personnel/container)	H (Zone 0)	L(No discharge)	C	High	E	Effective but insufficient
	1-3: Electrostatic discharge is near the opening	Inerting with nitrogen	M(Zone 1)	H(Spark)	B	High	F	Need additional Measures
	1-4: Electrostatic discharge is inside the tank	Charge relaxation (toluene)	H(Zone 0)	H(Spark)	A	High	F	Need additional Measures

*Note :-

- 1-1 & 1-3 :- electrostatic induction from the charged toluene in the container, there is a possibility that incendive spark discharge may be generated between the sampling container and the metal part inside the tank.
- 1-4 :- toluene has not sufficiently neutralized electrically to prevent ignition from electrostatic discharge
- 1-2:- electrical potentials of the grounded sampling container and metal part inside the tank are both determined as 0[V] and thus there is no risk of discharge, the likelihood is deemed to be “low.”

Examples of Electrostatic Risk Assessment

Case	Hazards	Safety measures	Likelihood			Severity of damages (Table 5)	Risk rating for occurring electrostatic accident (Table 6)	Remarks
			likelihood for formation of explosive atmosphere (Table 1)	Likelihood of occurring incendive discharge (Table 2/3)	Likelihood of occurring electrostatic accident (Table 4)			
2	2-1: Electrostatic discharge is inside the tank	None	H (Zone 0)	H(Brush)	A	High	F	Need additional Measures
	2-2: Electrostatic discharge is inside the tank	Grounding (personnel/container)	H (Zone 0)	H(Brush)	A	High	F	Need additional Measures
	2-3: Electrostatic discharge is near the opening	Inerting with nitrogen	L(Zone 2)	H(Brush)	C	High	E	No additional Measures needed
	2-4: Electrostatic discharge is inside the tank	Charge relaxation (toluene)	H(Zone 0)	L(No incendive discharg)	C	High	E	No additional Measures needed

*Note :-

- 2-1, 2-2 & 2-3 :- the sampling container is ungrounded, there is a possibility that its electric potential may increase due to the electrostatic induction from charged toluene, thus reducing the potential difference between the container and the toluene
- 2-4 :- the static electricity has been removed from toluene to the safe level as a safety measure. Even if brush discharge occurs, it will not be incendive

Examples of Electrostatic Risk Assessment

Case	Hazards	Safety measures	Likelihood			Severity of damages (Table 5)	Risk rating for occurring electrostatic accident (Table 6)	Remarks
			likelihood for formation of explosive atmosphere (Table 1)	Likelihood of occurring incendive discharge (Table 2/3)	Likelihood of occurring electrostatic accident (Table 4)			
3	3-1: Electrostatic discharge is inside the tank	None	M (Zone 1)	H(Spark)	B	High	F	Need additional Measures
	3-2: Electrostatic discharge is inside the tank	Grounding (personnel)	M (Zone 1)	L(No discharge)	C	High	E	No additional Measures needed
	3-3: Electrostatic discharge is near the opening	Inerting with nitrogen	M (Zone 1)	H(Spark)	B	High	F	Need additional Measures
	3-4: Electrostatic discharge is inside the tank	Charge relaxation (toluene)	M (Zone 1)	H(Spark)	B	High	F	Need additional Measures

*Note :-

- 3-1,3-3 & 3-4 the electrostatic countermeasures for the human body are inadequate (e.g., not wearing antistatic shoes; inadequate leakage resistance due to the insulation paint applied on the top board of the tank, which is the foothold of the sample collection personnel). Causing incendive spark discharge between the sample collecting personnel and grounded conductor near the sampling hatch
- 3-2:- electrical potentials of the grounded sampling container and metal part inside the tank are both determined as 0[V] and thus there is no risk of discharge, the likelihood is deemed to be “low.”

Examples of Electrostatic Risk Assessment

Case	Hazards	Safety measures	Likelihood			Severity of damages (Table 5)	Risk rating for occurring electrostatic accident (Table 6)	Remarks
			likelihood for formation of explosive atmosphere (Table 1)	Likelihood of occurring incendive discharge (Table 2/3)	Likelihood of occurring electrostatic accident (Table 4)			
4	4-1: Electrostatic discharge is inside the tank	None	M (Zone 1)	H(Spark)	B	M	F	Need additional Measures
	4-2: Electrostatic discharge is inside the tank	Grounding (personnel/container)	M (Zone 1)	L(No discharge)	C	M	E	No additional Measures needed
	4-3: Electrostatic discharge is near the opening	Inerting with nitrogen	M (Zone 1)	H(Spark)	B	M	F	Need additional Measures
	4-4: Electrostatic discharge is inside the tank	Charge relaxation (toluene)	M (Zone 1)	H(Spark)	B	M	F	Need additional Measures

*Note :-

- 4-1,4-3 & 4-4 :- the electrostatic countermeasures for the human body are inadequate (e.g., not wearing antistatic shoes; inadequate leakage resistance due to the insulation paint applied on the top board of the tank, which is the foothold of the sample collection personnel). Causing incendive spark discharge between the sample collecting personnel and grounded conductor near the sampling hatch
- 4-2:- electrical potentials of the grounded sampling container and metal part inside the tank are both determined as 0[V] and thus there is no risk of discharge, the likelihood is deemed to be “low.”

Precautions Against Static Electricity

IEC60079-32-1 Explosive Atmospheres – Part 32-1: Electrostatic hazards, Guidance

Thank You

Reference:

- IS 7689 Guide for control of undesirable static electricity
- [ES][ELEC][012] - Engineering Standard For Static Electricity & Protection System
- Article on Handling dusts & Powders safety by Dekra
- Article on Evaluation & prevention of electrostatic hazards in chemical plants by Kiyoshi.
- Article on A synopsis of Explosion Hazards During the Transfer of powder into flammable solvents and Explosion Preventative Measures by Martin Glor
- Article on Safe transfer of powder into flammable liquids into flammable liquids by David E. Kaelin
- NFPA-30, *"Flammable and Combustible Liquids Code,"*
- NFPA -77, *"Recommended Practice on Static Electricity,"* 2000 edition
- Generation and Control of Static Electricity in Coatings Operations, NPCA Bulletin 803, Reppermund & Christopher, National Paint & Coatings Assn., 2002
- www.esdjornal.com
- www.chilworth.com
- www.electrostatic.com
- www.esda.org
- www.kineticpolymers.com