Static Electricity: Streaming Current, Voltage and Spark Energy

Streaming current in a pipe, charge and voltage built on an isolated vessel or drum, and the spark energy compared with a minimum ignition energy.

Method: Crowl and Louvar; Chemical Process Safety: Fundamentals with Applications; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Liquid velocity in the pipe	3.0000	m/s
Pipe diameter	50.000	mm
Pipe length	10.000	m
Liquid relaxation time	21.000	s
Filling time	60.000	s
Capacitance of the isolated container	100.00	pF
Minimum ignition energy of the vapour	0.10000	mJ

Calculated results

Parameter	Value	Unit
Streaming current	3.3024e-08	A
Charge accumulated	1.9814e-06	C
Container voltage	19,814	V
Spark energy available	19.631	mJ
Spark energy over minimum ignition energy	196.31	

Notes for this case

- The isolated container keeps all the charge (no leakage); bonding and grounding drains it. Low-conductivity liquids (relaxation time above about 0.1 s) are the hazard.
- A screening estimate for training and early design, not a hazard or risk study.
- The available spark energy exceeds the minimum ignition energy: bond and ground the container and slow the fill.

Formula and method

$$I_s = 10 \times 10^{-6} (ud)^2 \left[1 - \exp\left(-\frac{L}{u\tau}\right)\right], \quad Q = I_s t, \quad V = \frac{Q}{C}, \quad J = \frac{Q^2}{2C}$$

Variables

u	Liquid velocity in the pipe	m/s
d	Pipe diameter	m
L	Pipe length	m
τ	Liquid relaxation time	s
t	Filling time	s
C	Capacitance of the isolated container	F
MIE	Minimum ignition energy of the vapour	J
I_s	Streaming current	A
Q	Charge accumulated	C
V	Container voltage	V

J	Spark energy available	J
J/MIE	Spark energy over minimum ignition energy	-

Method and standards

Streaming current (u in m/s, d in m, I in A) and capacitor energy.

Assumptions and limits

- Isolated container; no charge leakage.

References

- Crowl and Louvar
- Chemical Process Safety: Fundamentals with Applications
- 2nd ed. (Prentice Hall, 2002)
- ch. 7
- eqs. 7-21 to 7-27 (streaming current, charge, capacitance, energy)

Report details

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Release checks	2 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/chemical/process-safety/static-spark-energy

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.