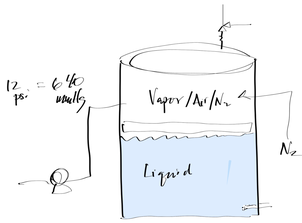
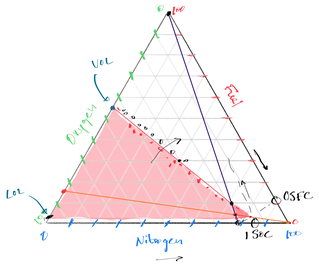
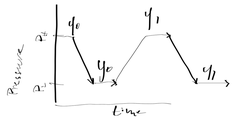
How Does This Lecture fit with PSM?
Process Safety Information (PSI)

Inerting





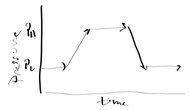
- Vacuum Purging



$y_0 = y_0 \left(\frac{P_0}{P_1}\right)^j$ Eq 7.6 CSL

$\Delta n_{N_2} = j(P_1 - P_0)\frac{V}{R_g T}$ Eq 7.7 CSL

- Pressure Purging

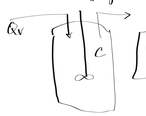


$y_0 = y_0 \left(\frac{P_L}{P_H}\right)^j$

→ more N_2 used

- Combined Pressure & Vacuum Purging
  See text

- Sweep Purging (low pressure storage vessels)



O_2 concentration of inlet

$V\frac{dC}{dt} = C_0 Q_N - C Q_N$: O_2 Balance

$Q_N t = V \ln\left[\frac{C_i - C}{C_f - C}\right]$

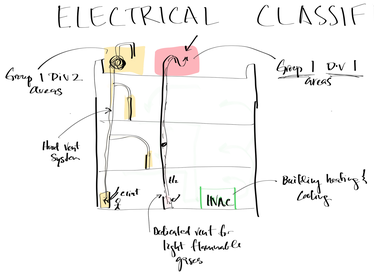
- Siphon Purging
  Fill the tank with water / other compatible chemical, then most smaller atmosphere, then drain & back fill

Taking in & out of Service

- If purging w/ air, follow air line
- Or better, purge with N_2, down to 0.5% (out of service and conc.) and then fill with air

Into Service
purge with N_2 to 1.5% then fill w/ fuel

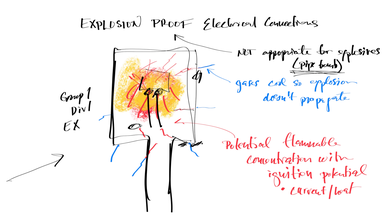
ELECTRICAL CLASSIFICATION



Group 1 Areas : Flammable Gases
" 2 " : " Dusts
" 3 " : " Fibers

DIVISION 1 – Flammable concentrations present
DIVISION 2 – " " abnormally present

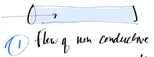
EXPLOSION PROOF Electrical Connections



CHARGING & ELECTROSTATIC DISCHARGE (ESD)

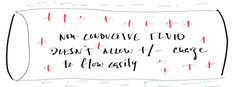
Contact & Separation yields static charging
- Fluids
- Solids
- Gases

Examples in Processing



CHARGING EVENTS

① flow of non conductive fluid
why non conductive?



- motion of fluid contacting itself & the walls results in charge separations

② Pneumatic conveying of solids

③

Lots of splashing with low conductivity fluid

④ Any time with contact & separation with itself or other items charging can occur

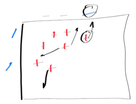
* Now, rate of charging matters.

$\frac{dcharge}{dt} = charge\ in - charge\ out$

higher charge rate
- higher flow
- higher surface area
- higher force

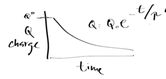
relaxation
- additive to increase conductivity

RELAXATION



Slowly over time (slower for highly insulative materials) these charges with magnitude per the driving force to be neutralized

Exponential fall-off



$Q = Q_0 e^{-t/\tau}$ ← τ can be measured

$\tau = \varepsilon\varepsilon_0/\gamma_e$ ← estimate from fluid properties & liquid

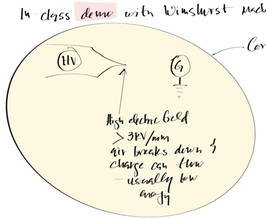
Solids can also have a τ value

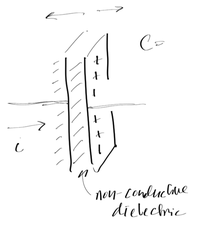
DISCHARGE

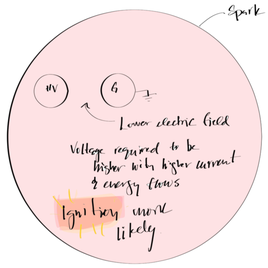
ESD Discharge Types
- Corona
- Spark
- Brush, Propagating Brush

- Additives
- Stirrers
- Mixing

In class demo with Wimshurst machine







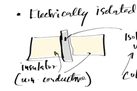
Spark Energy

(a) $E = \frac{1}{2}CV^2$
- Voltage between the two locations
- Capacitance of charge storage can be estimated

(b) $Q = CV$
- total charge

SCENARIOS TO AVOID

- Electrically isolated metal

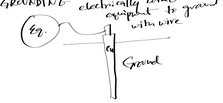


this is worse than non-conductive piece (plastic)

charge on plastic is not that mobile..
only a portion discharges @ a time

charge on metal easily ALL discharge

METAL CAN SERVE AS CHARGE COLLECTOR

CHARGE SEPARATION PREVENTION

- Reduce contact & separation
  - flow rates
  - lower surface area
  - lower force
- Allow time for charge relaxation
- Bonding & Grounding
  - BONDING
    Eq 1 — Eq 2
    electrically connect equipment together with wire
  - GROUNDING electrically connect equipment to ground with wire