

ELECTROSTATIC PRECIPITATOR BASIC FUNDAMENTALS

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CINERGY

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AGENDA

- Theory of Operation
- Terminology
- What affects Efficiency
- Electrodes
- Rapping Systems

ELECTROSTATIC PRECIPITATOR

Electro - mechanical device that uses electrostatic forces to remove particulate from a gas stream

ELECTROSTATIC FORCE

$$F = qE$$

- q = particle charge
- E = electric field (average voltage)

THREE PROCESSES

- Particulate charging
- Particulate collection
- Particulate removal

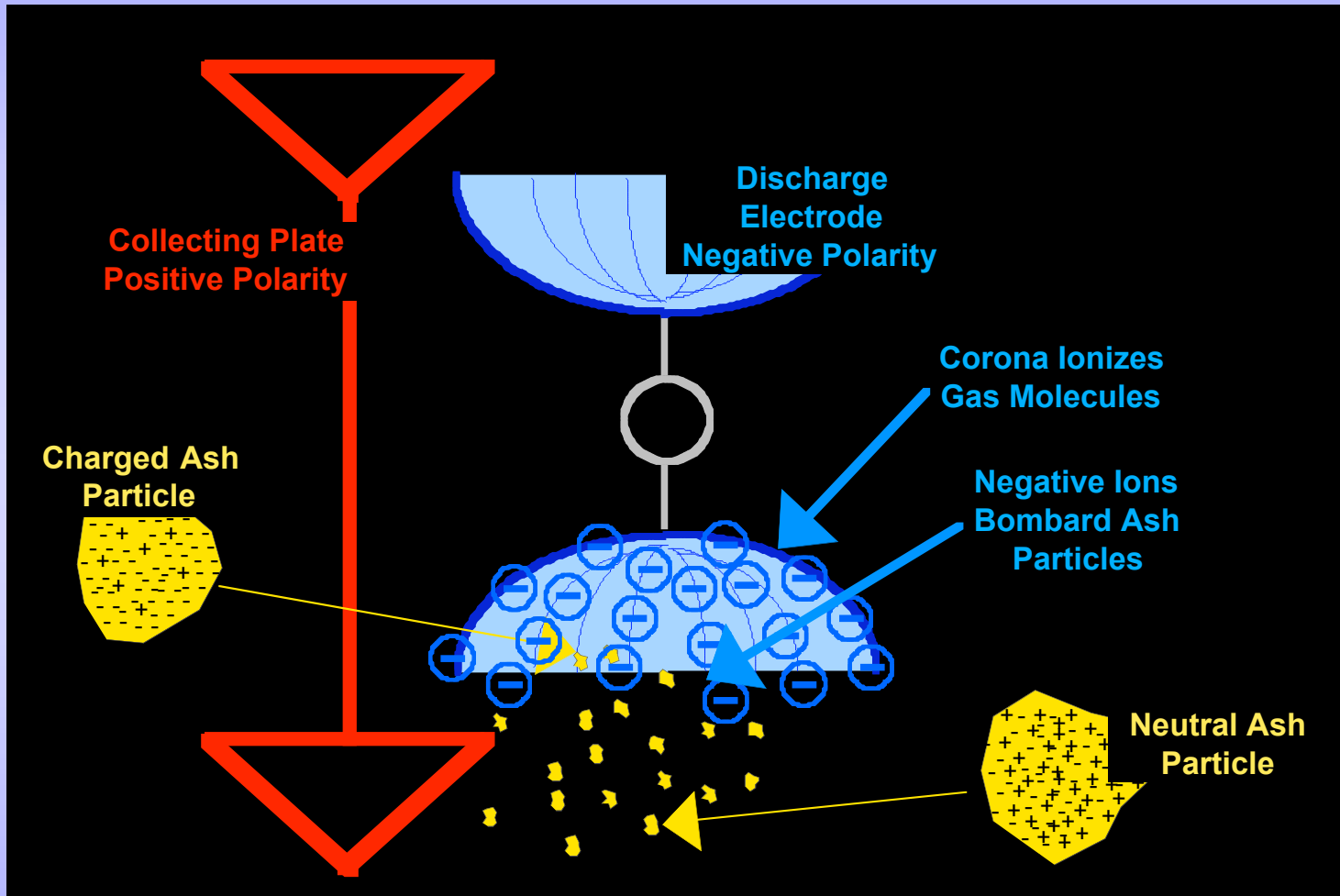
PARTICLE CHARGING

- High Voltage applied with respect to ground to generate a corona
 - Fine Wire
 - Sharp Point
 - Spike
- Corona formation generates electrons

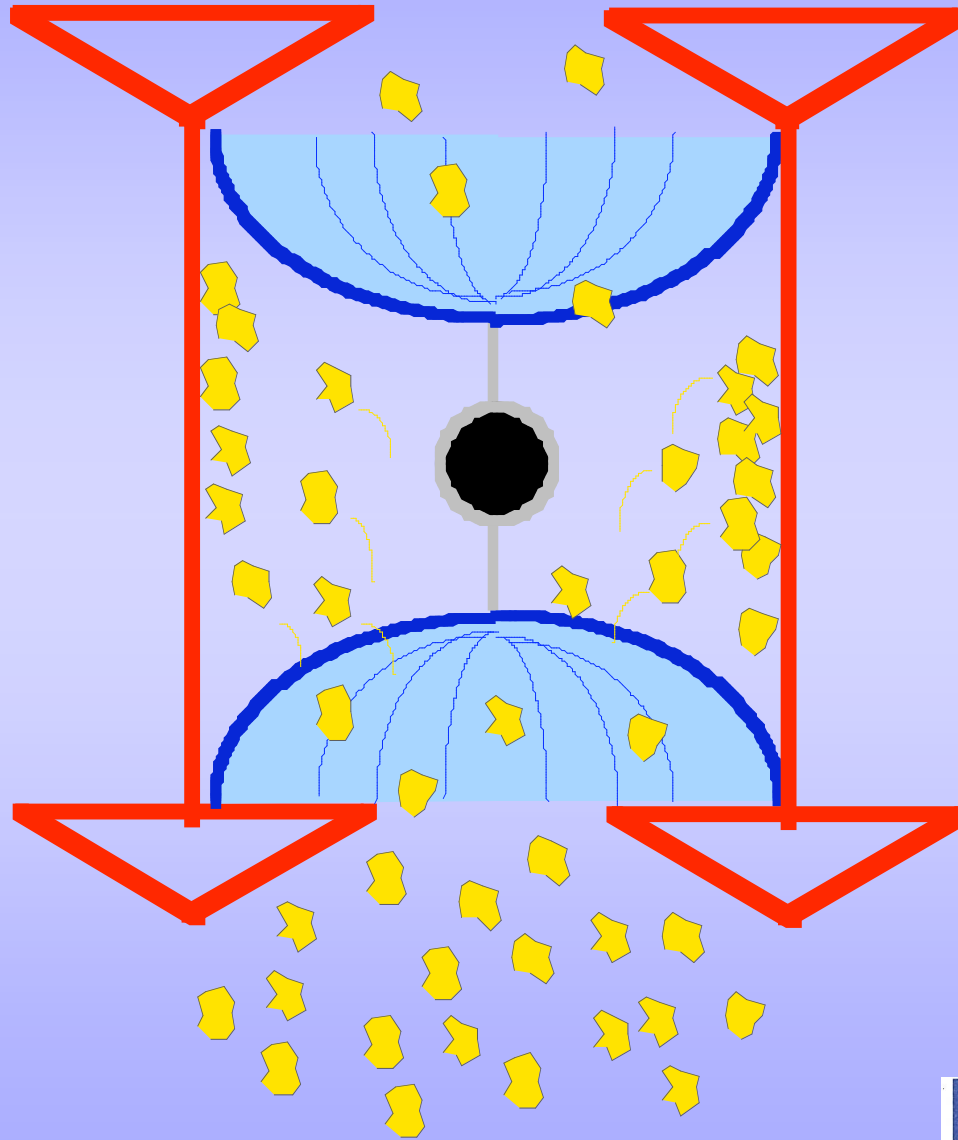
PARTICLE CHARGING

- Electrons attach to electro negative gas molecules
- Ionized gas molecules attach to particles
 - Field charging – larger particles
 - Diffusion charging – smaller particles

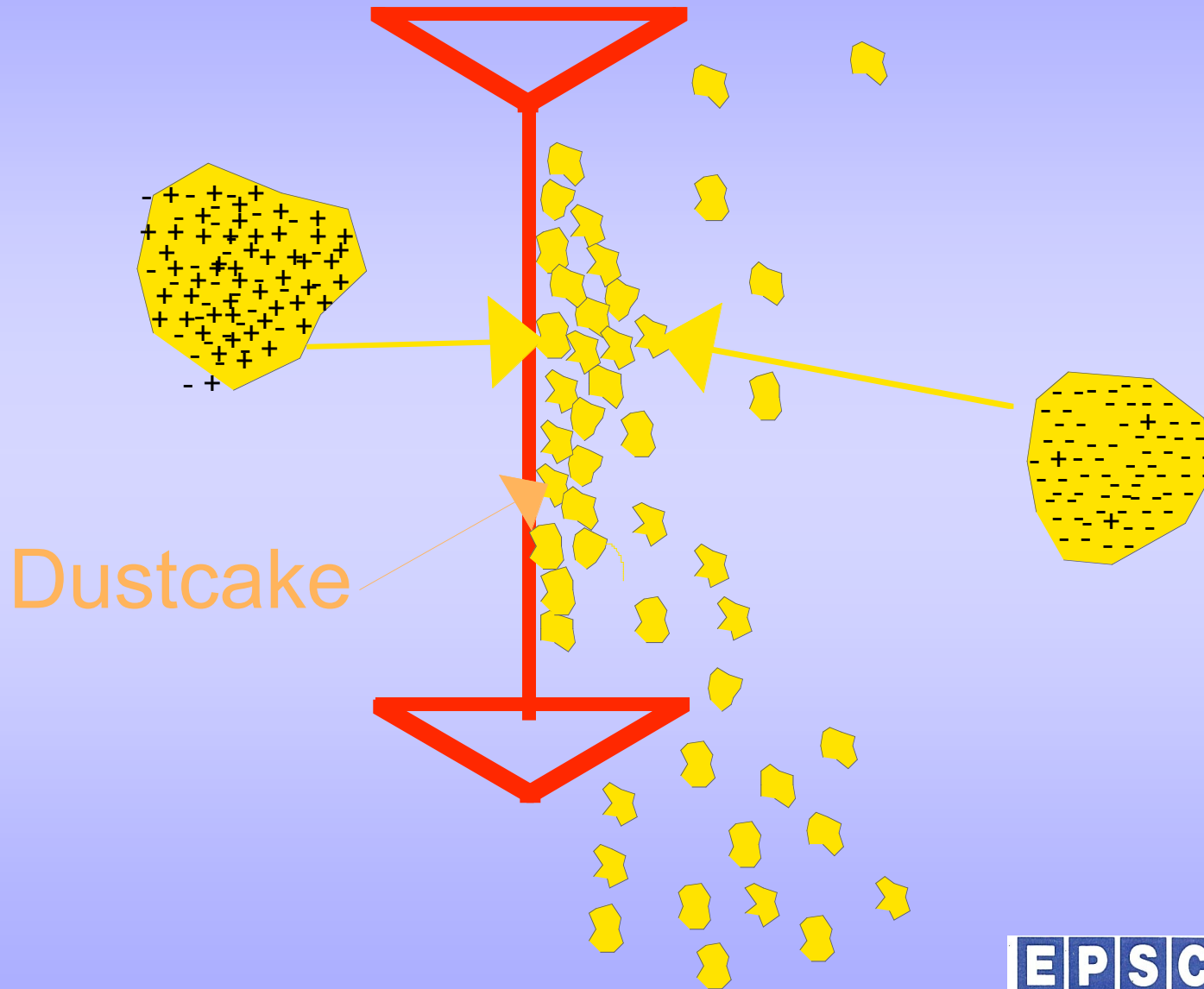
Particle Charging



Particle Migration



Particle Deposition



Dustcake

EFFICIENCY

$$\text{Efficiency (\%)} = \frac{\text{Dust in} - \text{Dust out}}{\text{Dust in}} \times 100$$

Assume: 100 in 1 out

$$\text{Efficiency} = \frac{100-1}{100} \times 100$$

$$\text{Efficiency} = 0.99 \times 100 = 99\%$$

DEUTSCH EQUATION

$$\text{Efficiency (\%)} = 100(1 - e^{-(AW/Q)})$$

$e = 2.718282$ (base of natural logarithm)

$A =$ Collecting area

$W =$ Particle migration velocity

$Q =$ Gas volume

EFFICIENCY

$$\frac{AW}{Q}$$

A = Collecting area

W = Migration velocity

Q = Gas volume

SPECIFIC COLLECTING AREA (SCA)

Collecting Area (Square Feet)

Gas Volume (KACFM)

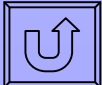
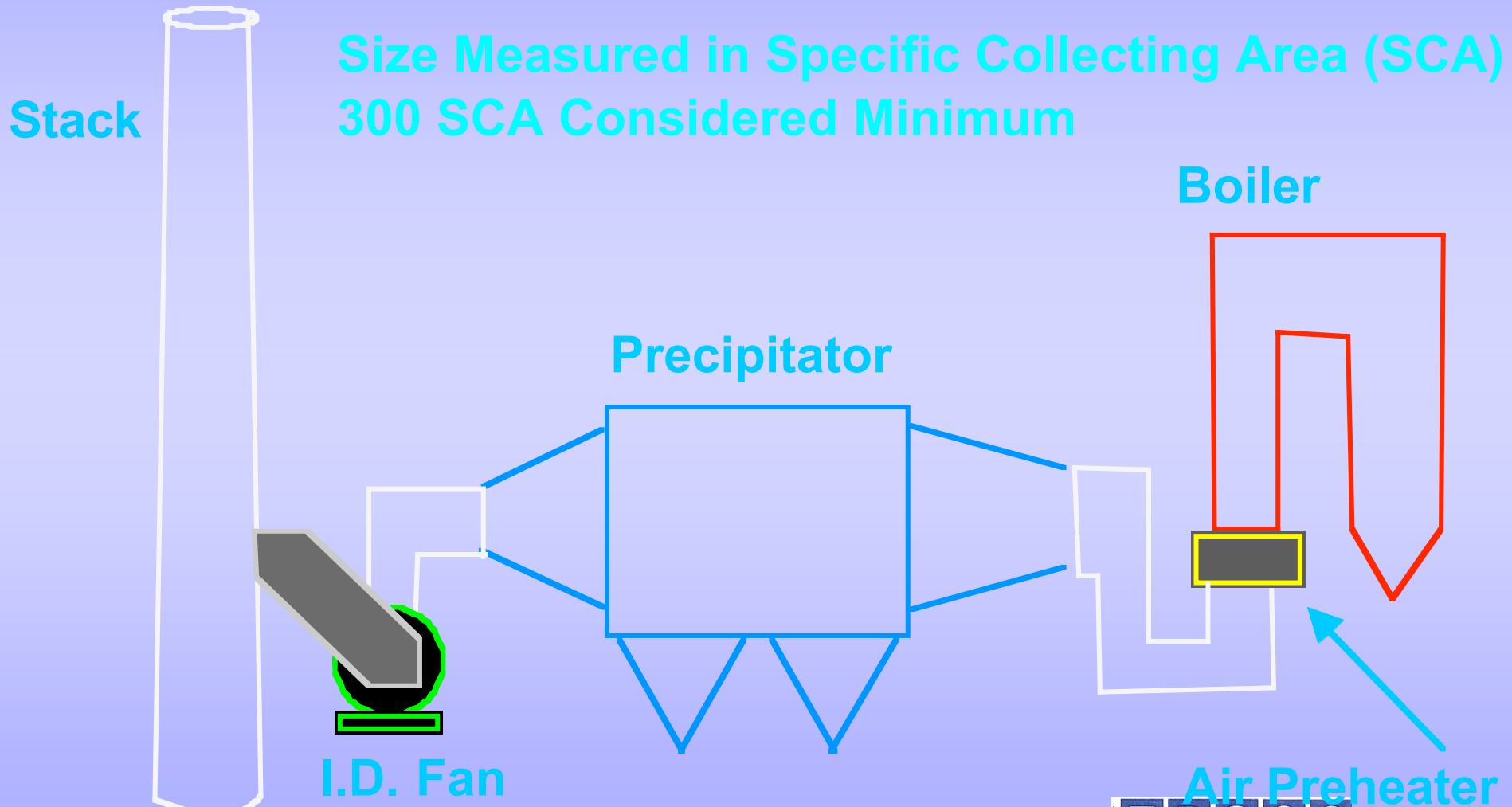
400,000 Square Feet

1,000,000 ACFM

SCA = 400

Precipitator Size - Bigger is Better

Size Measured in Specific Collecting Area (SCA)
300 SCA Considered Minimum



$$W = KE_oE_c a^2$$

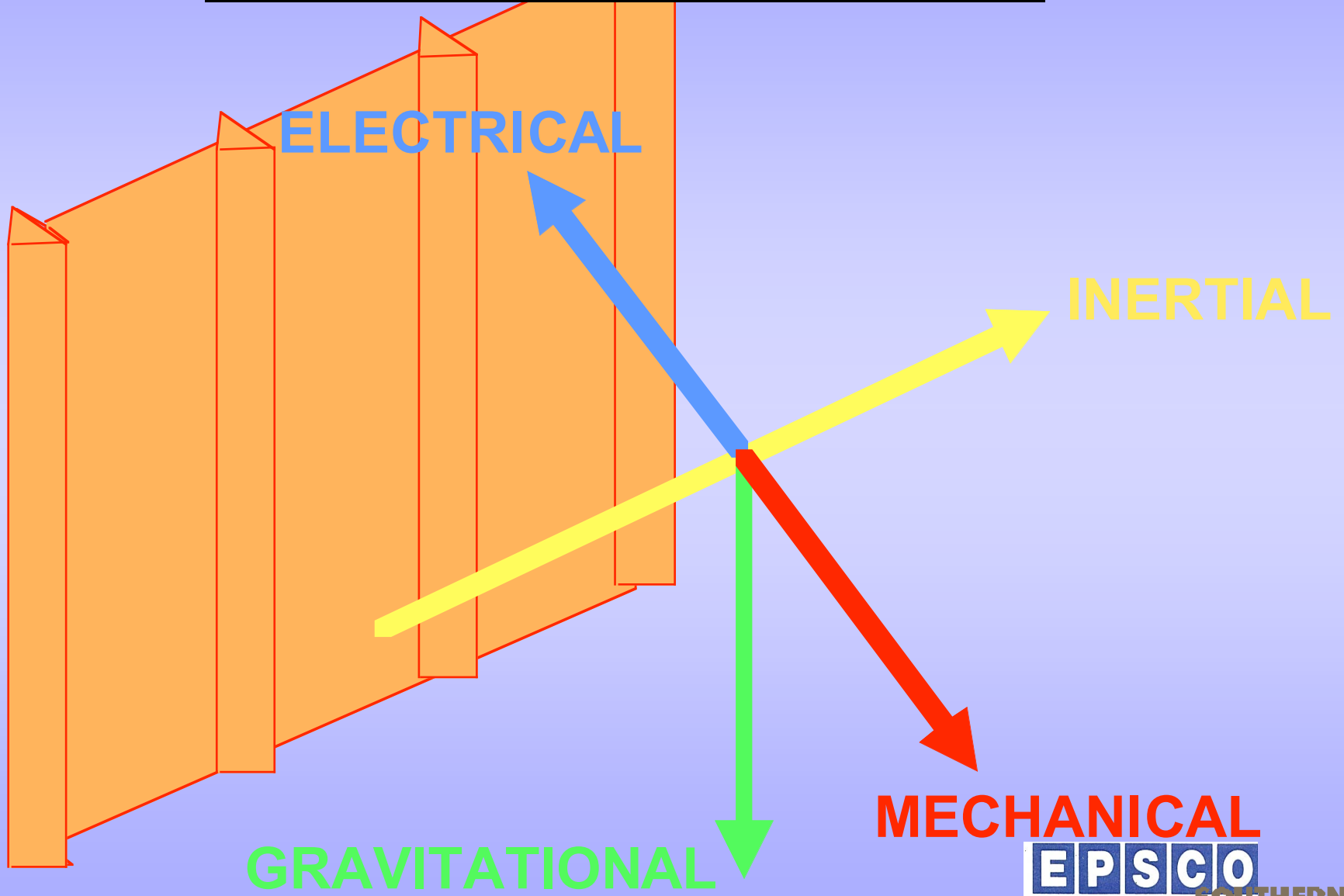
K = Constant

E_o = Charging electric field

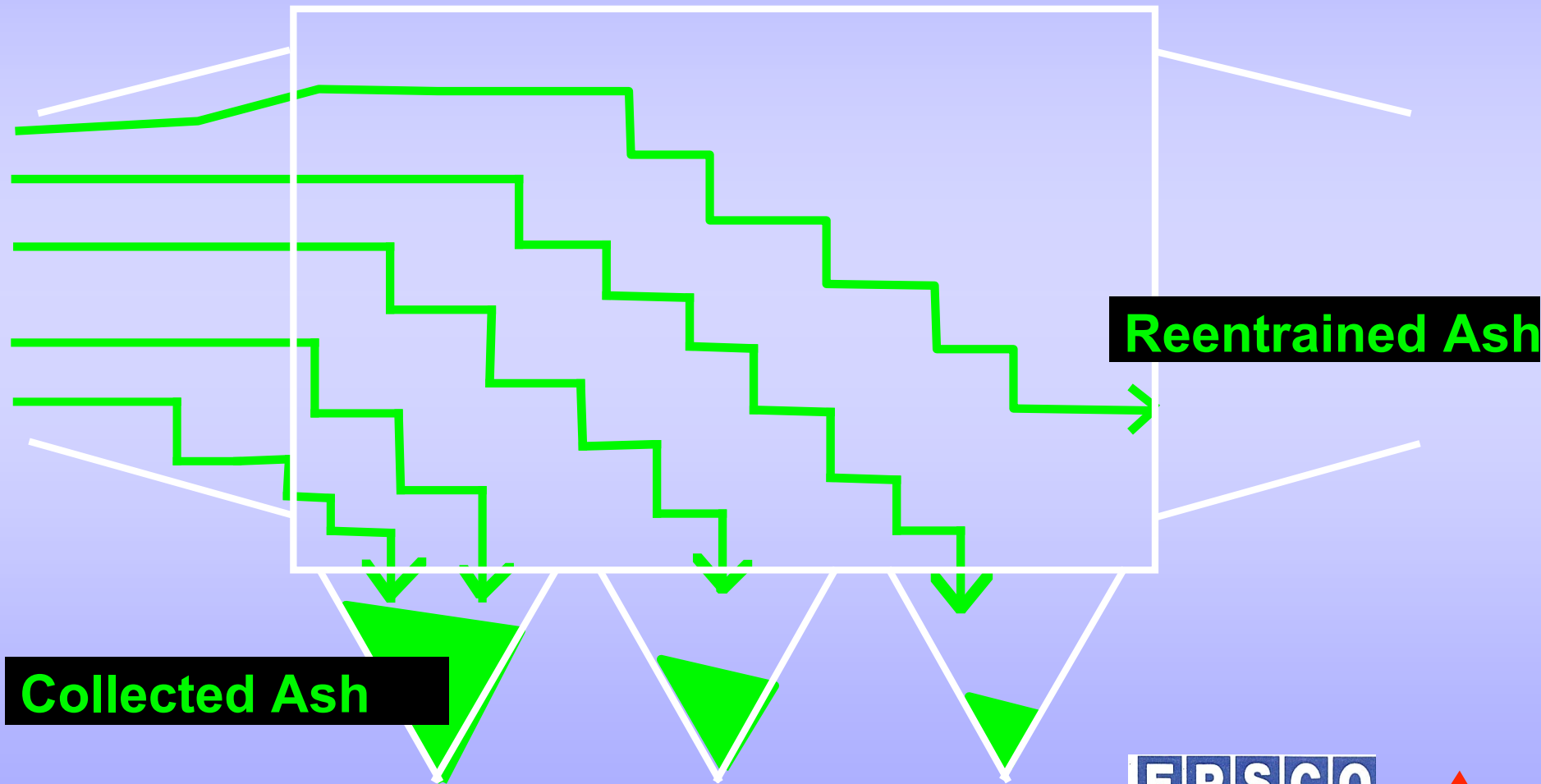
E_c = Collecting electric field

a = Particle radius

Forces of Precipitation



Particle Trajectory



Collected Ash

Reentrained Ash

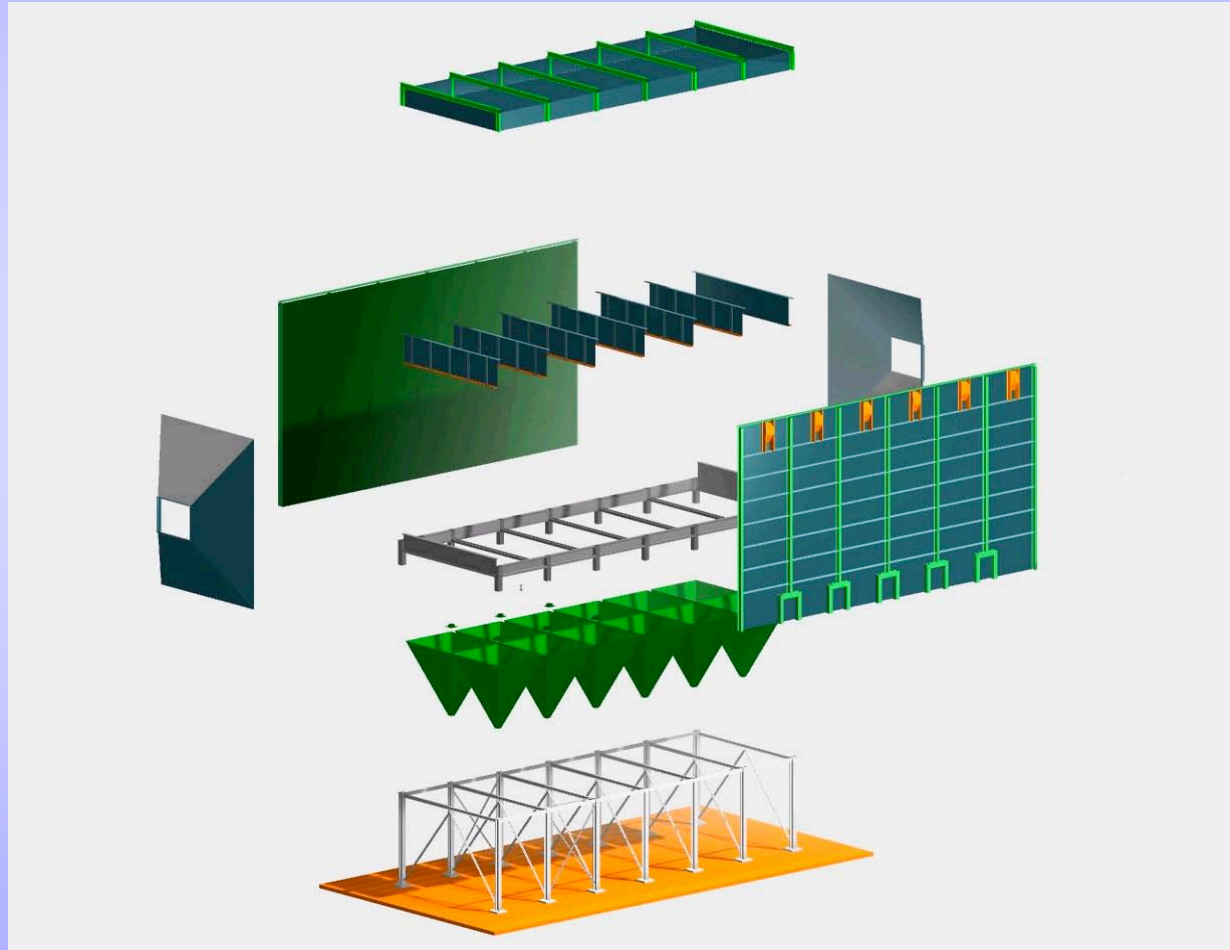
PRECIPITATOR SYSTEMS

- Structural
- Mechanical
- Electrical
- Auxiliaries

STRUCTURAL COMPONENTS

- Support Steel
- Casing
 - Side Walls
 - Dividing walls
 - Base / Roof Girders
 - Roof / Penthouse
 - Nozzles
 - Hoppers
- Weather Enclosure
- Access
 - Stairs / Ladders
 - Doors / Bolted Plates

STRUCTURAL - CASING



MECHANICAL COMPONENTS

- Discharge electrodes
- Collecting electrodes (plates)
- Rapping systems
- Gas distribution devices
- Insulators

ELECTRICAL COMPONENTS

- Energization
 - AVC panel
 - Current limiting reactor
 - Transformer / rectifier

ELECTRICAL COMPONENTS

- Auxiliaries
 - Rapper control
 - Hopper heaters
 - Insulator heaters
 - Pressurization blowers / heaters
 - Computer controls

AUXILIARIES

- Access doors / hatches
- Ash removal systems
- Fans
- Expansion joints

DISCHARGE SYSTEM

DISCHARGE SYSTEM COMPONENTS

- Top support frame
- Discharge electrodes
- Lower stabilizing frame
- Rapping system

PURPOSE OF DISCHARGE ELECTRODES

- Provide a source of ionization to charge particles
- Provide an electrostatic field to drive the charged particles to the collecting electrodes

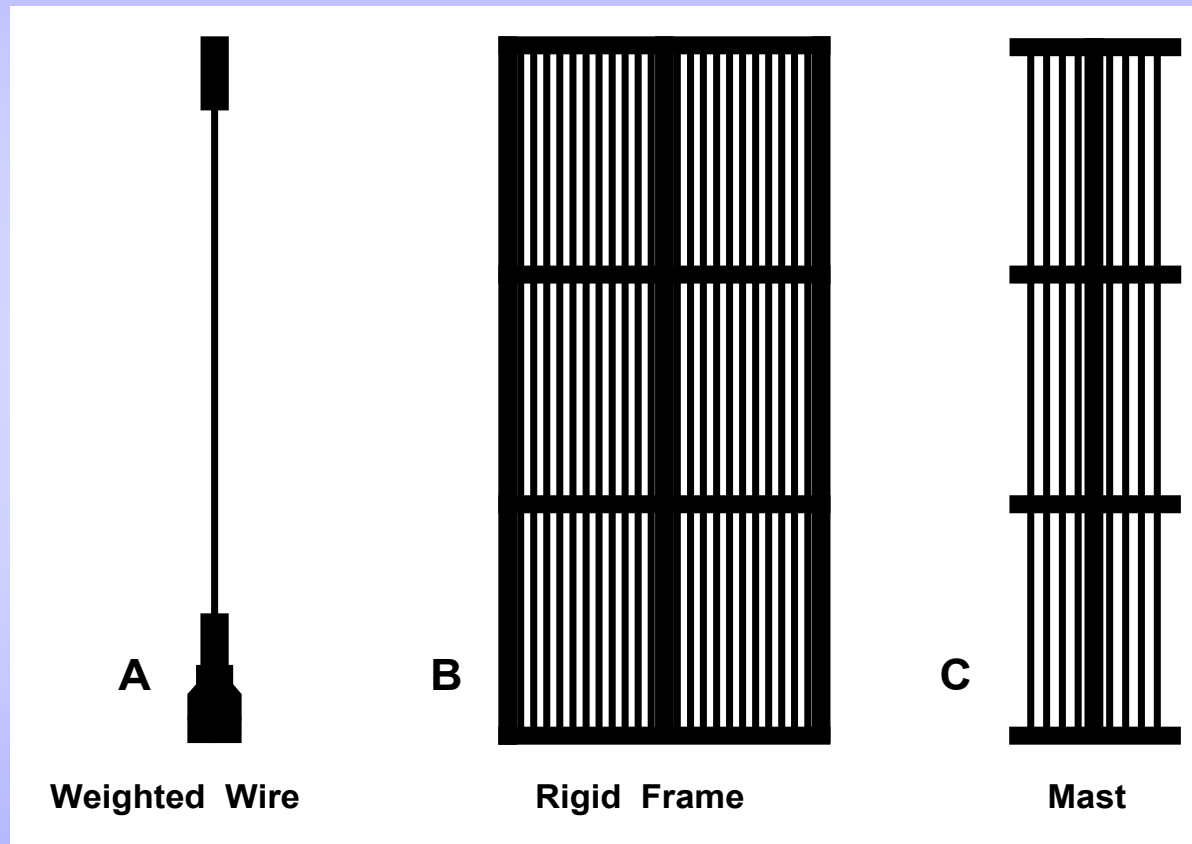
DISCHARGE ELECTRODE DESIGN CONSIDERATIONS

- Performance
- Cost effectiveness
- Ease of installation
- Alignability
- Rapability
- Reliability

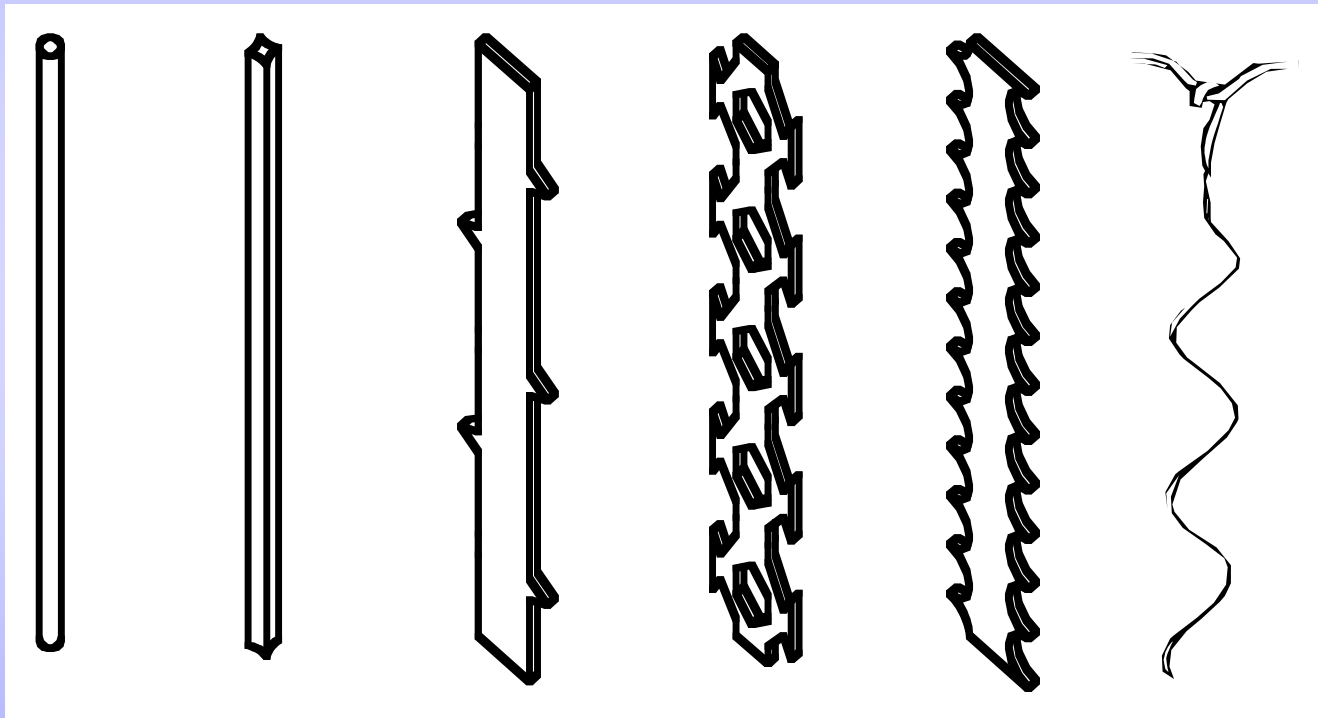
DISCHARGE ELECTRODES

- Weighted wires
- Rigid frames / masts
- Rigid discharge electrodes
(RDE)

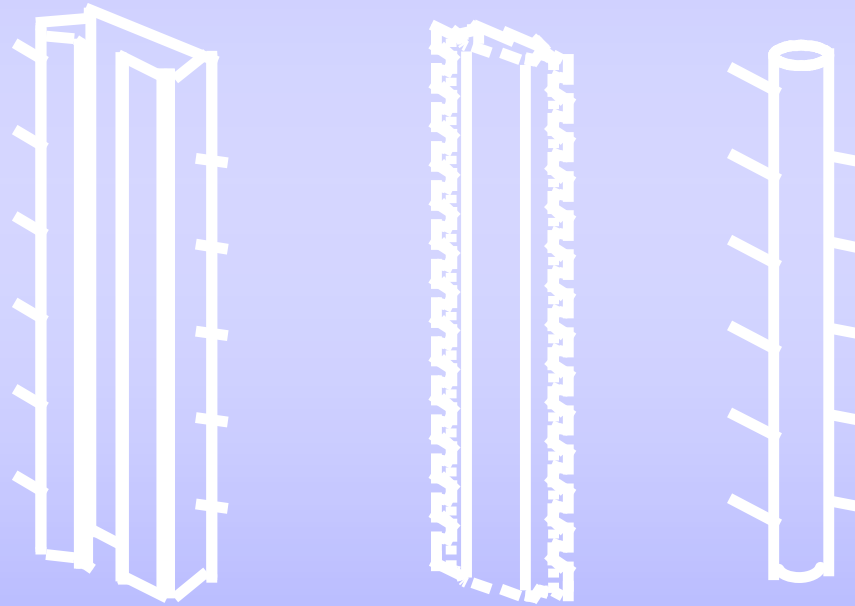
DISCHARGE ELECTRODES



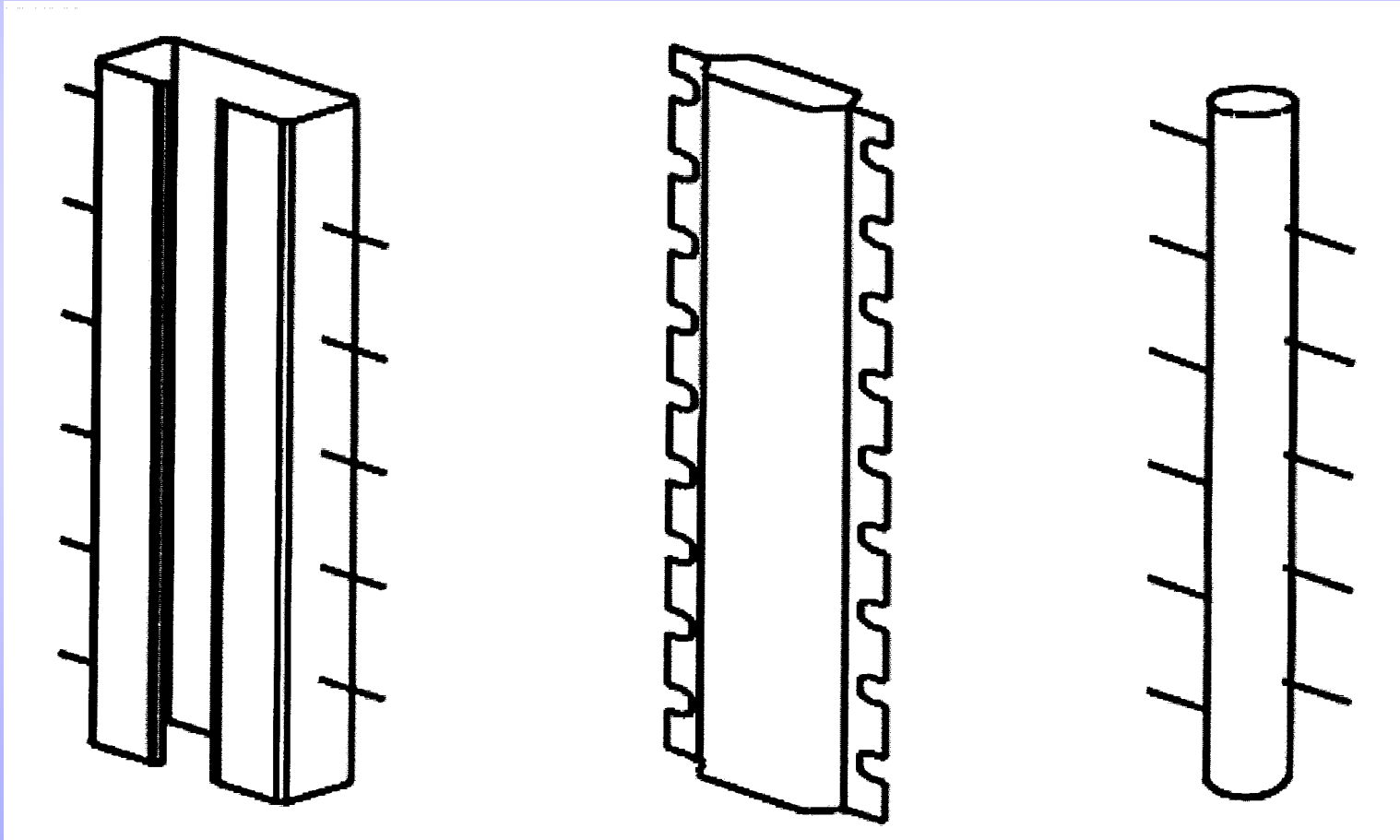
DISCHARGE ELECTRODES



RIGID DISCHARGE ELECTRODES



RIGID DISCHARGE ELECTRODES



RIGID DISCHARGE ELECTRODE RDE

- Unbreakable
- Continuous (one piece)
- Massive body
- Discharge spikes

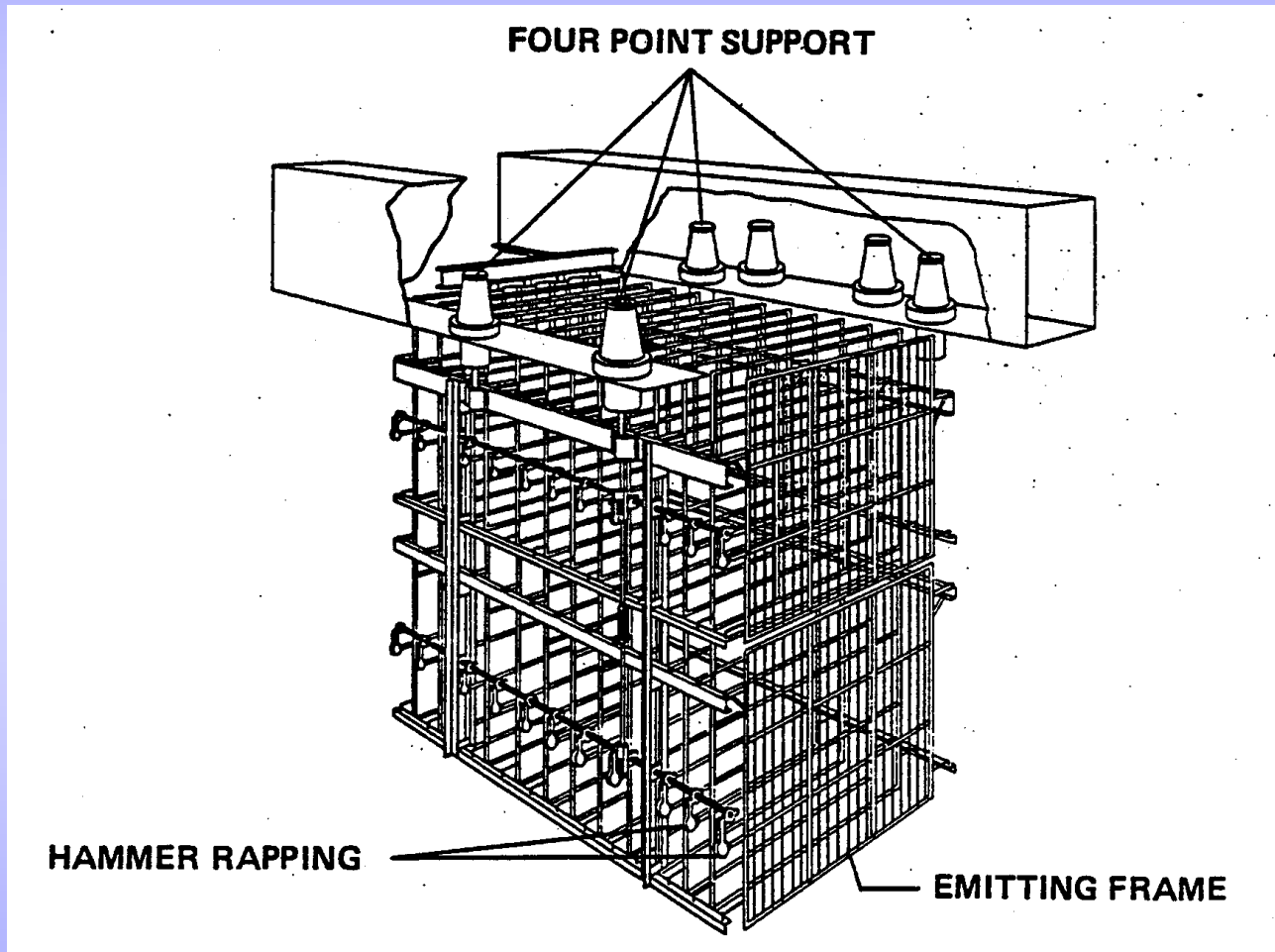
RDE ADVANTAGES

- **Reliable**
 - Durable
 - Unbreakable
 - Maintenance free
- **Better performance**
 - Higher electric fields
 - More uniform electric fields
 - Defined corona discharge points
 - More uniform current distribution
- **Customize to application**

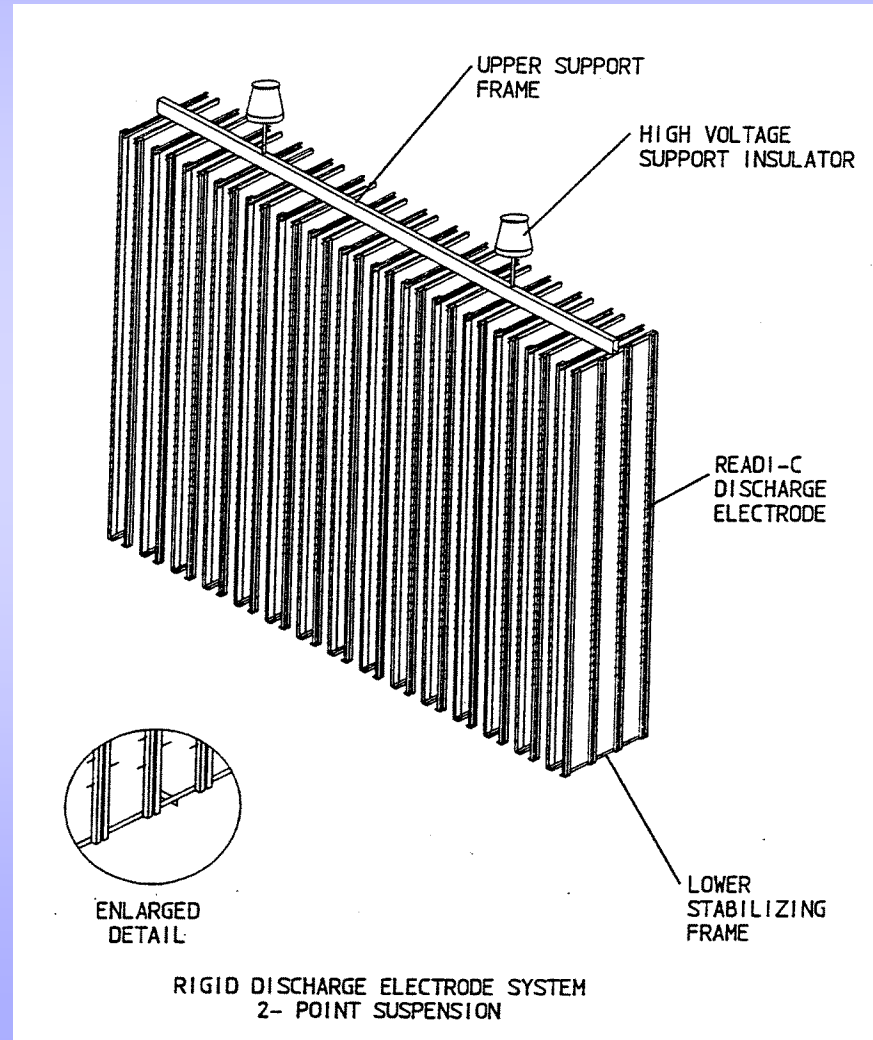
DISCHARGE ELECTRODE SUSPENSION

- Four point
 - Rigid frame and RDE
 - More stable
 - Economic for large bus sections
- Two Point
 - RDE and weighted wires
 - Requires stabilizing insulators
 - Good for short fields

4 POINT SUSPENSION



2 POINT SUSPENSION



COLLECTING SYSTEM

COLLECTING SYSTEM COMPONENTS

- Top support system
- Collecting plates
- Lower stabilizer
- Rapping system

PURPOSE OF COLLECTING ELECTRODES

- Collect particulate
- Temporarily hold it until rapped
- Carry particle charge (current) to 'ground'

COLLECTING ELECTRODE DESIGN CONSIDERATIONS

- Performance
 - Relates to discharge electrode geometry
- Cost effectiveness
- Ease of installation
- Alignability
- Rapability
- Reliability
- Re-entrainment minimization

COLLECTING ELECTRODES

- Shop assembled curtain
- Field assembled strips

ELECTRODE SPACING

- Old technology
 - Weighted wire: 9 inches
 - Rigid frame / RDE: 10-12 inches
- New technology
 - 16 inches
- WHY?

SPECIFIC COLLECTING AREA (SCA)

- Collecting area per 1000 acfm gas flow
- More SCA = higher efficiency
- Pack as much in as possible
- Suggests narrow spacing is preferred

WIDE PLATE SPACING PERFORMANCE

- Enhanced electric fields
 - Higher
 - More uniform
 - Space charge enhancement
- Alignment less critical
- At least same efficiency
- Typically better performance

WIDER PLATE SPACING ECONOMICS

- For same size box: 12 vs 16 inch spacing
 - 25% less internal parts
 - Less support required
 - Same KVA rating of T/Rs
 - 10% overall cost savings
 - Watch electrical clearances and components

PARTICULATE REMOVAL

- Rapping Systems
- Hopper Ash Removal

RAPPING SYSTEMS

- Discharge electrodes
- Collecting plates
- Gas distribution devices

TYPES OF RAPPERS

- Magnetic gravity impact
- Tumbling hammers
- Vibrators
- Dropped hammers
- Pneumatic
- Sonic horns

RAPPING PARAMETERS

- Gravity impact
 - Frequency
 - Lift height (intensity)
 - Number of impacts
- Hammer
 - Frequency
 - Lift height (intensity)
- Vibrators
 - Frequency
 - Duration

HOPPER ASH REMOVAL

- Ash must be removed on a continuous basis
- Maintenance of the system is crucial
- Operation can create high levels
- Leakage can cause opacity spikes