Reinhold Environmental Ltd.

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ELECTROSTATIC PRECIPITATOR BASIC FUNDAMENTALS

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2007 APC/PCUG Conference

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AGENDA

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

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ELECTROSTATIC PRECIPITATOR

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

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ELECTROSTATIC FORCE
F = q x E

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

THREE PROCESSES

- **Particulate charging**
- **Particulate collection**
- **Particulate removal**

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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**

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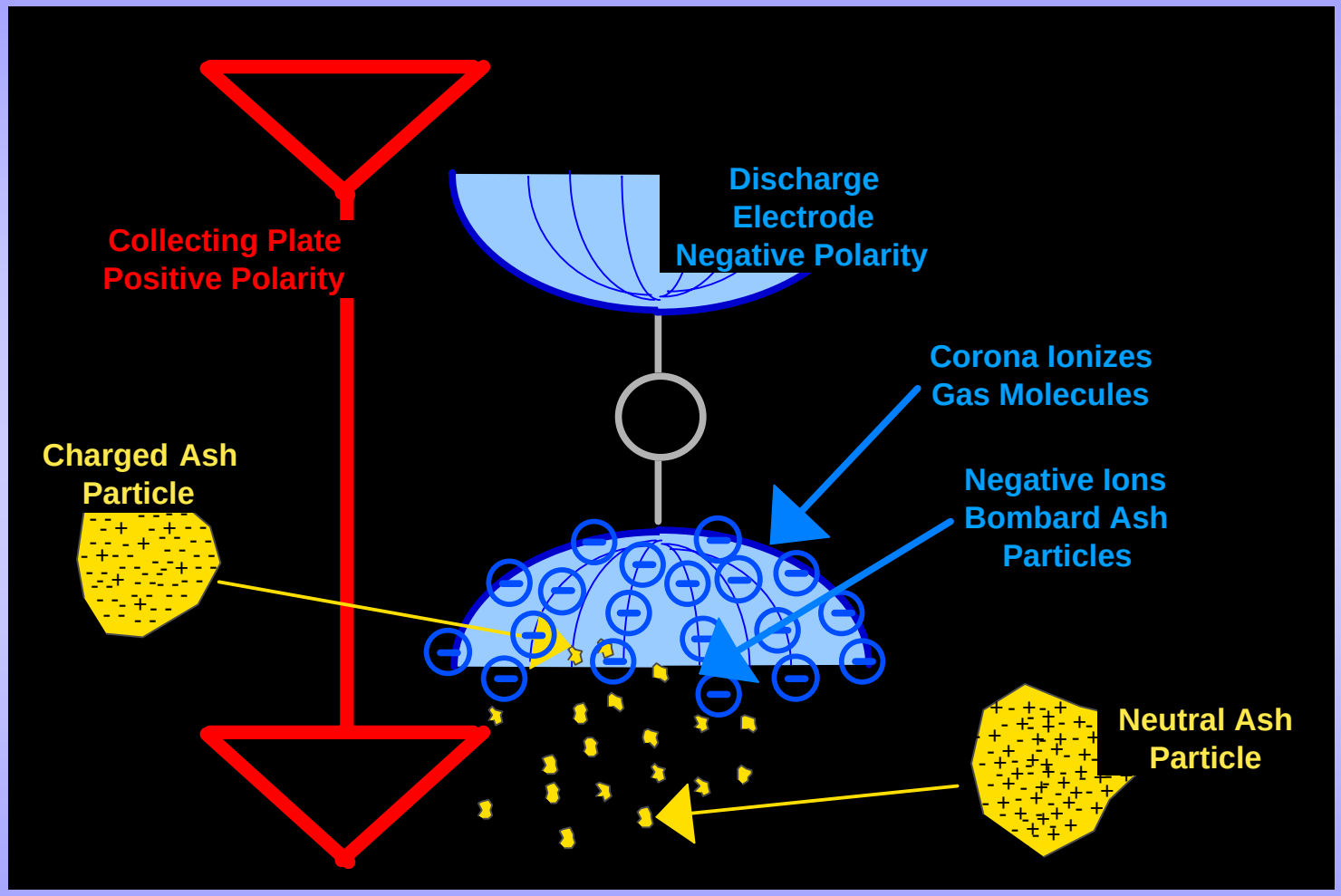
Particle Charging



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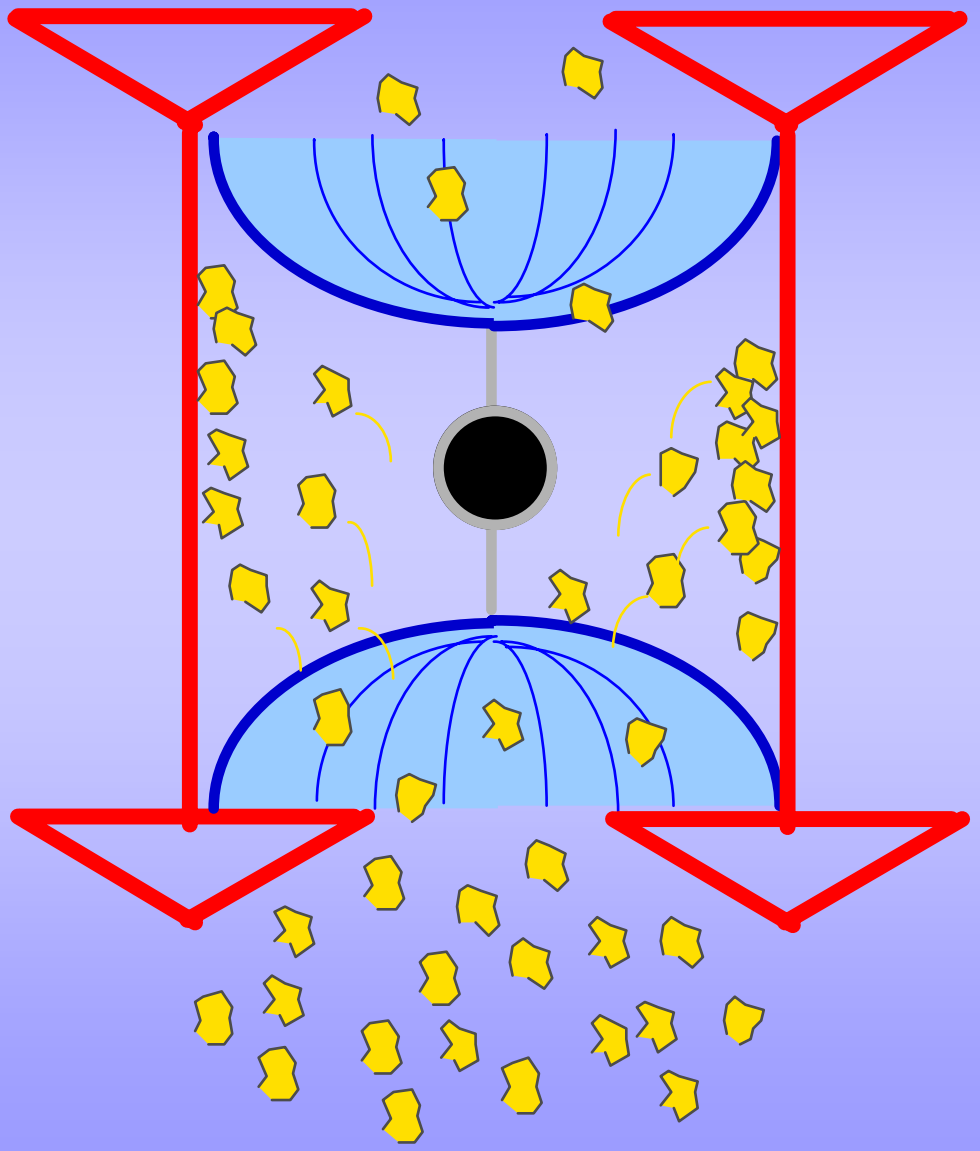
Particle Migration



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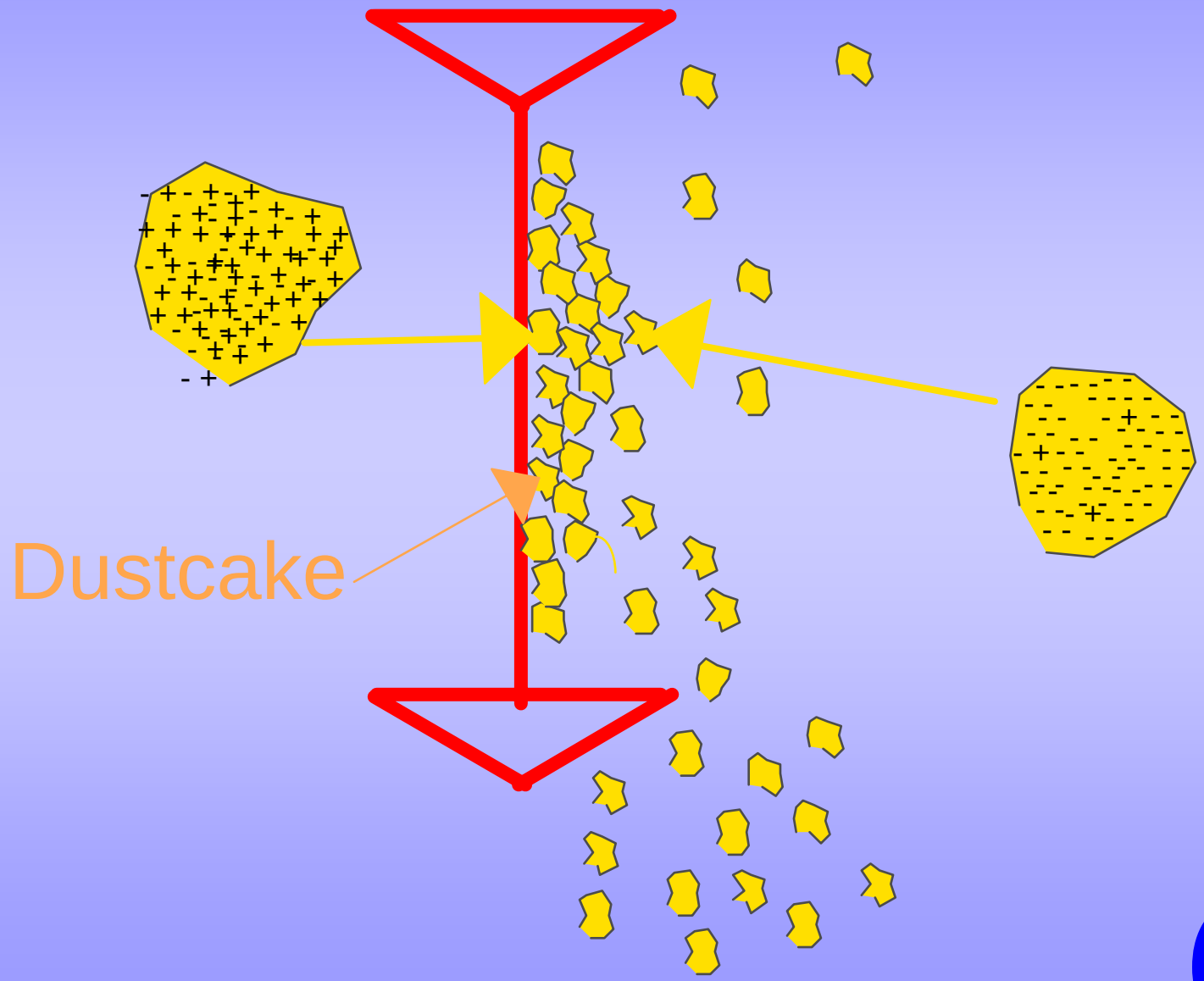
Particle Deposition



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EFFICIENCY

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

Assume: 100 in 1 out

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

Efficiency = 0.99 x 100 = 99%

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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

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EFFICIENCY

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

A = Collecting area

W = Migration velocity

Q = Gas volume

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SPECIFIC COLLECTING AREA (SCA)

$$\frac{\text{Collecting Area (Square Feet)}}{\text{Gas Volume (KACFM)}}$$

400,000 Square Feet

1,000,000 ACFM

SCA = 400

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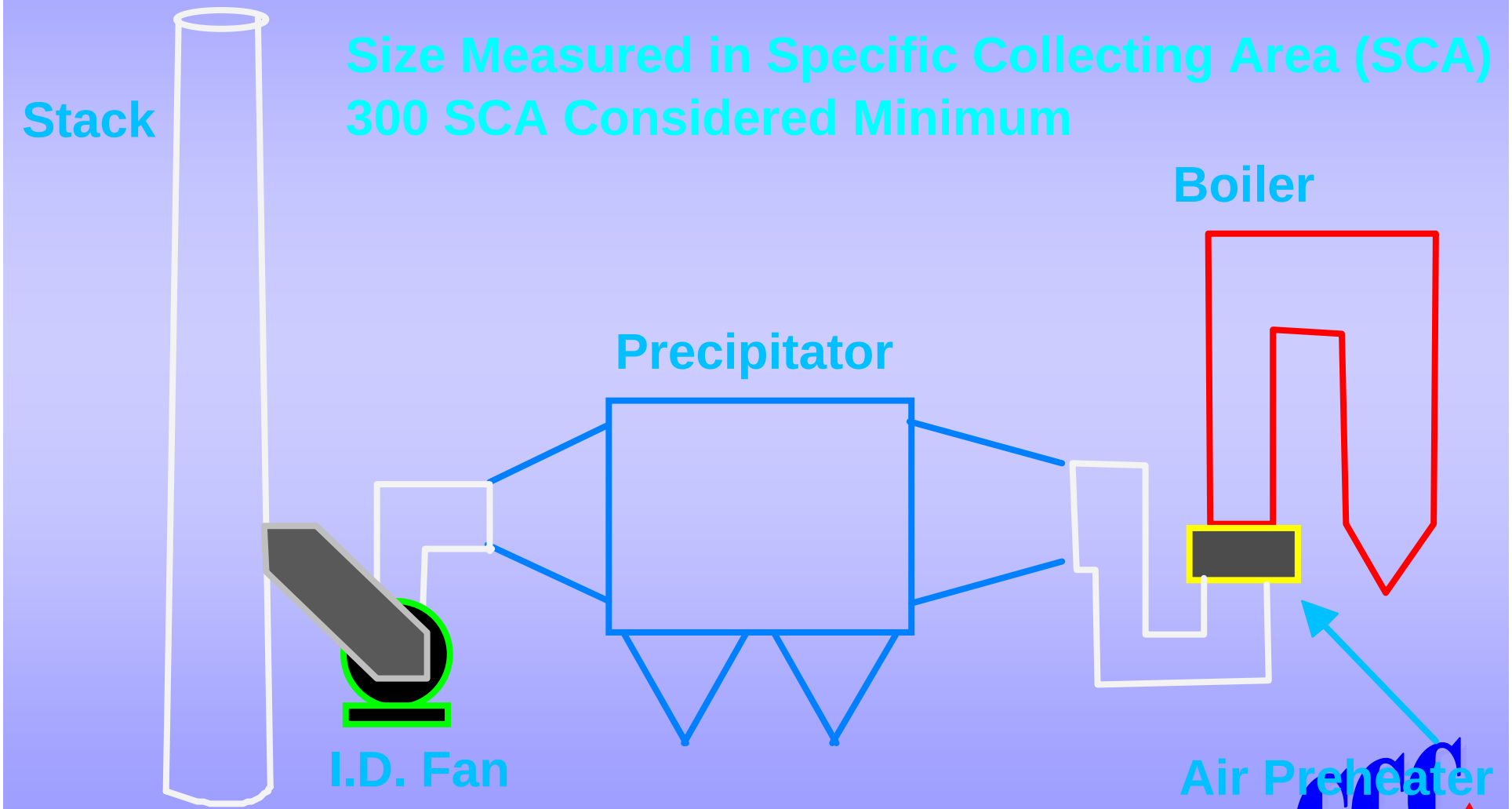
Precipitator Size - Bigger is Better

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



$$W = KE_oE_ca^2$$

K = Constant

E_o = Charging electric field

E_c = Collecting electric field

a = Particle radius

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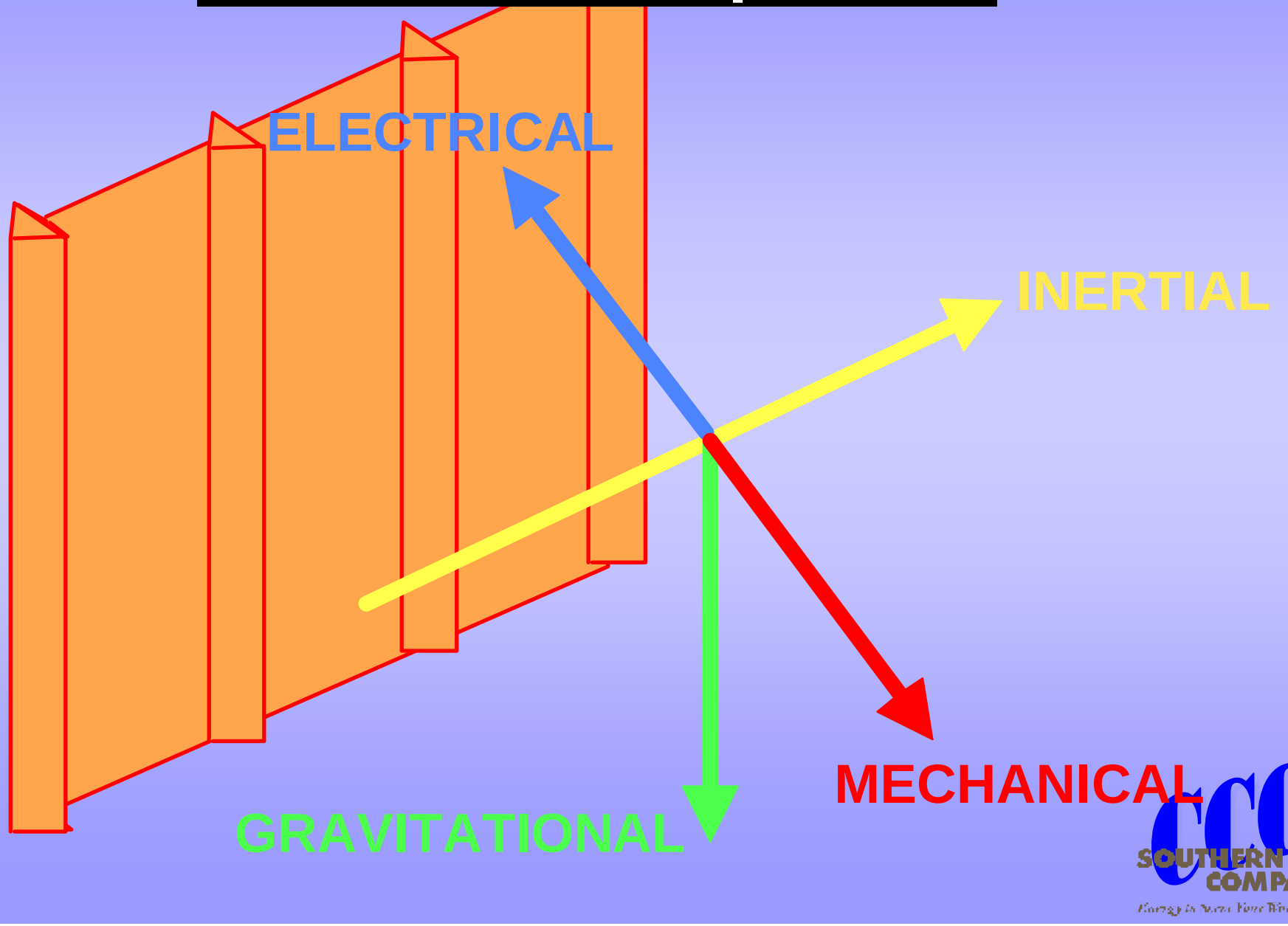
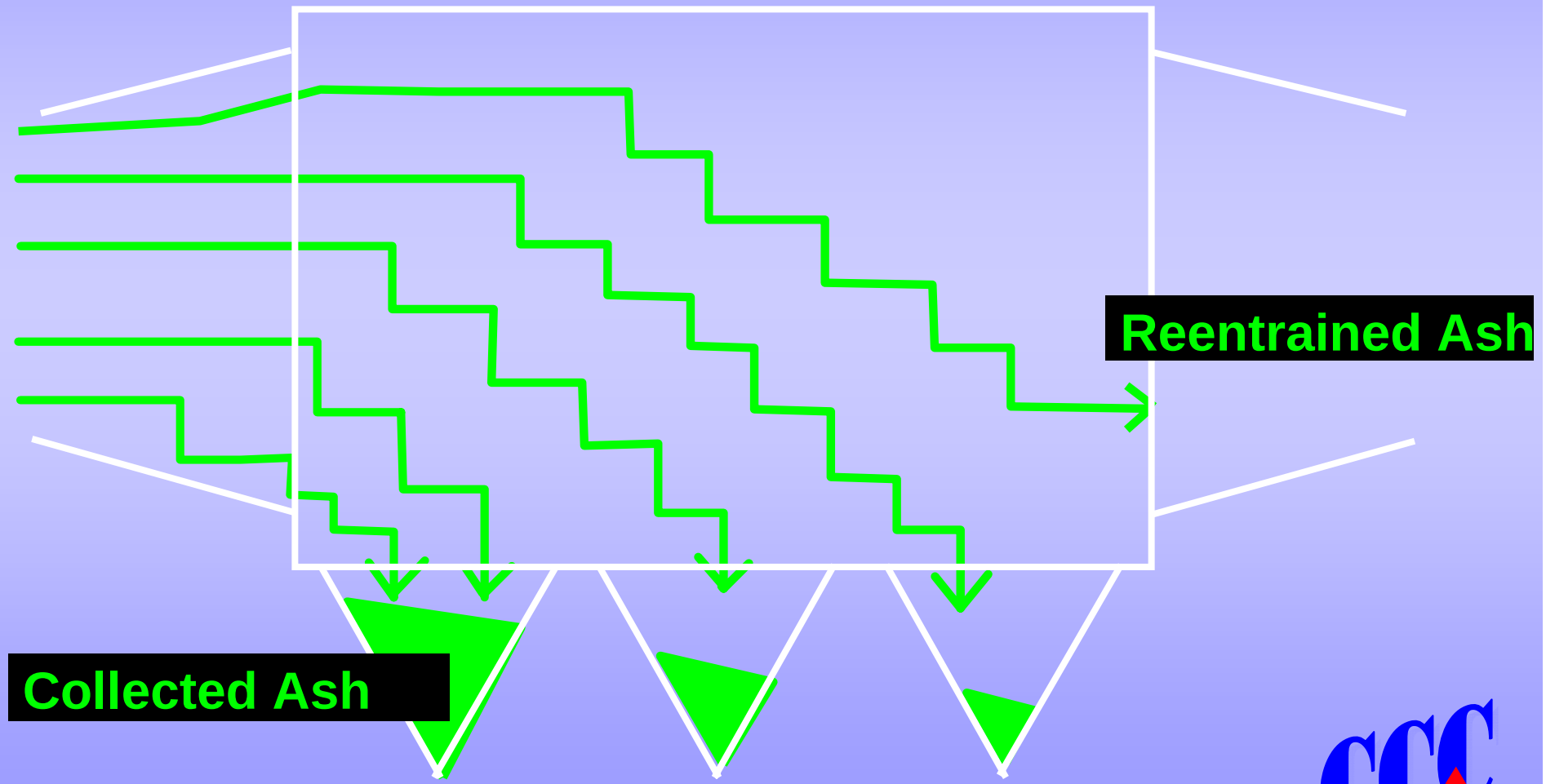
Forces of Precipitation



Particle Trajectory



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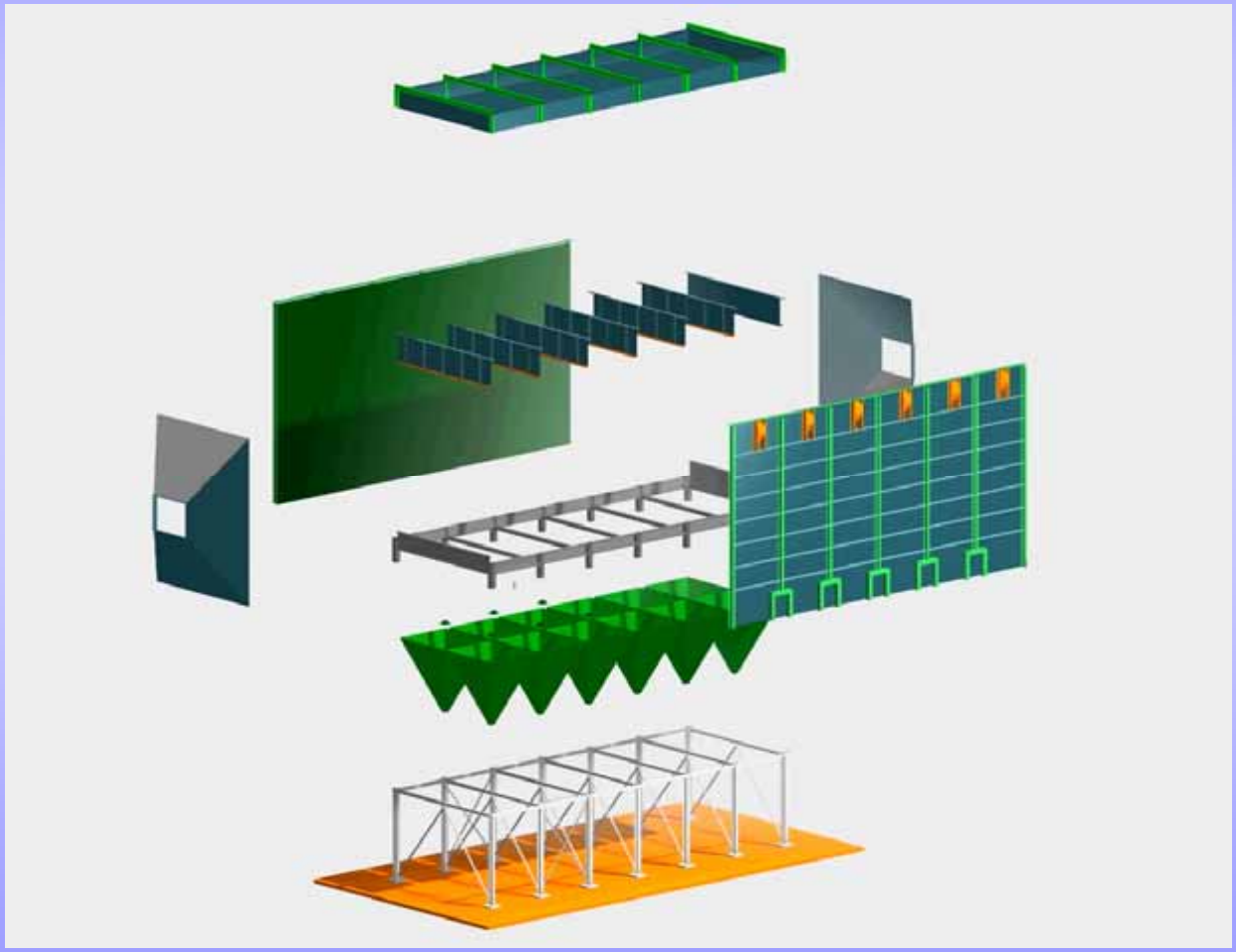
PRECIPITATOR SYSTEMS

- **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



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MECHANICAL COMPONENTS

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

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ELECTRICAL COMPONENTS

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

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ELECTRICAL COMPONENTS

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

AUXILIARIES

- Blower systems
- Ash removal systems
- Fans
- Expansion joints
- Dampers

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DISCHARGE SYSTEM

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DISCHARGE SYSTEM COMPONENTS

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

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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**

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DISCHARGE ELECTRODE DESIGN CONSIDERATIONS

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

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DISCHARGE ELECTRODES

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

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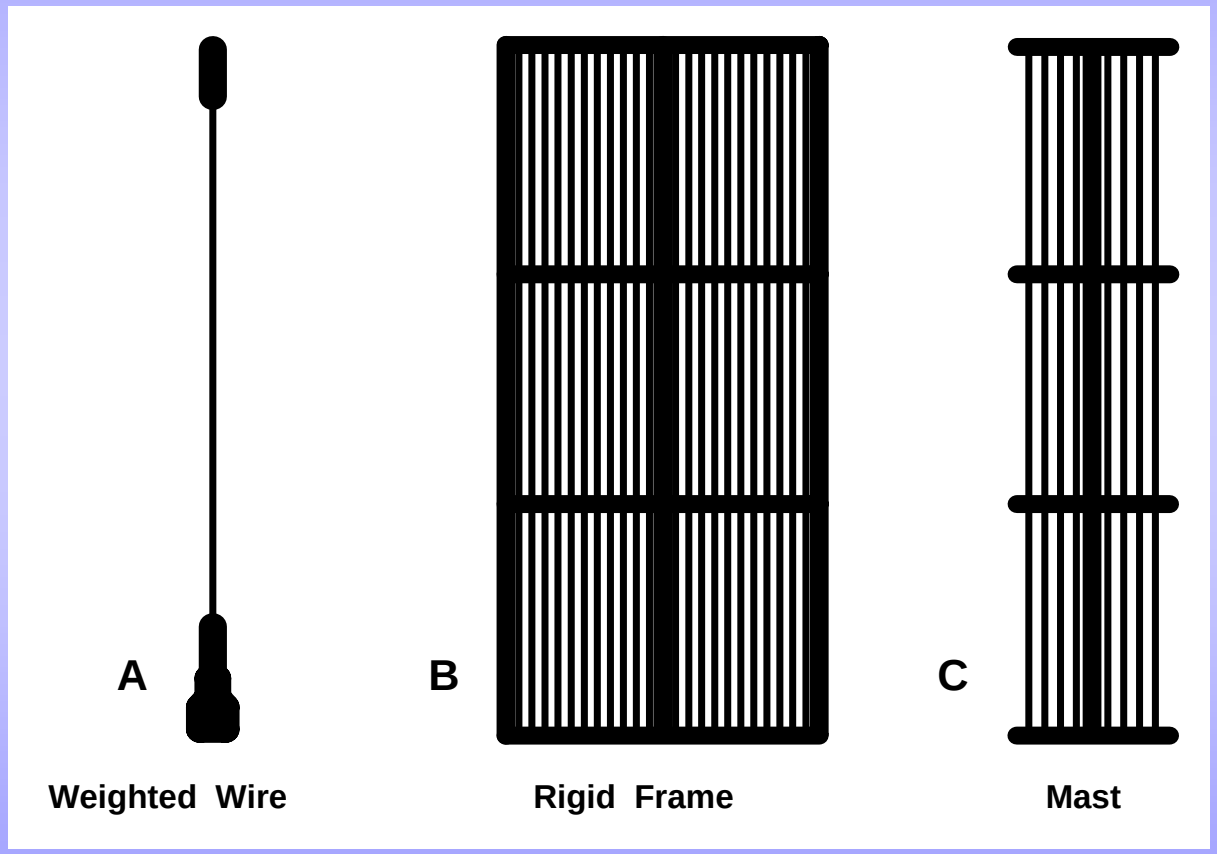
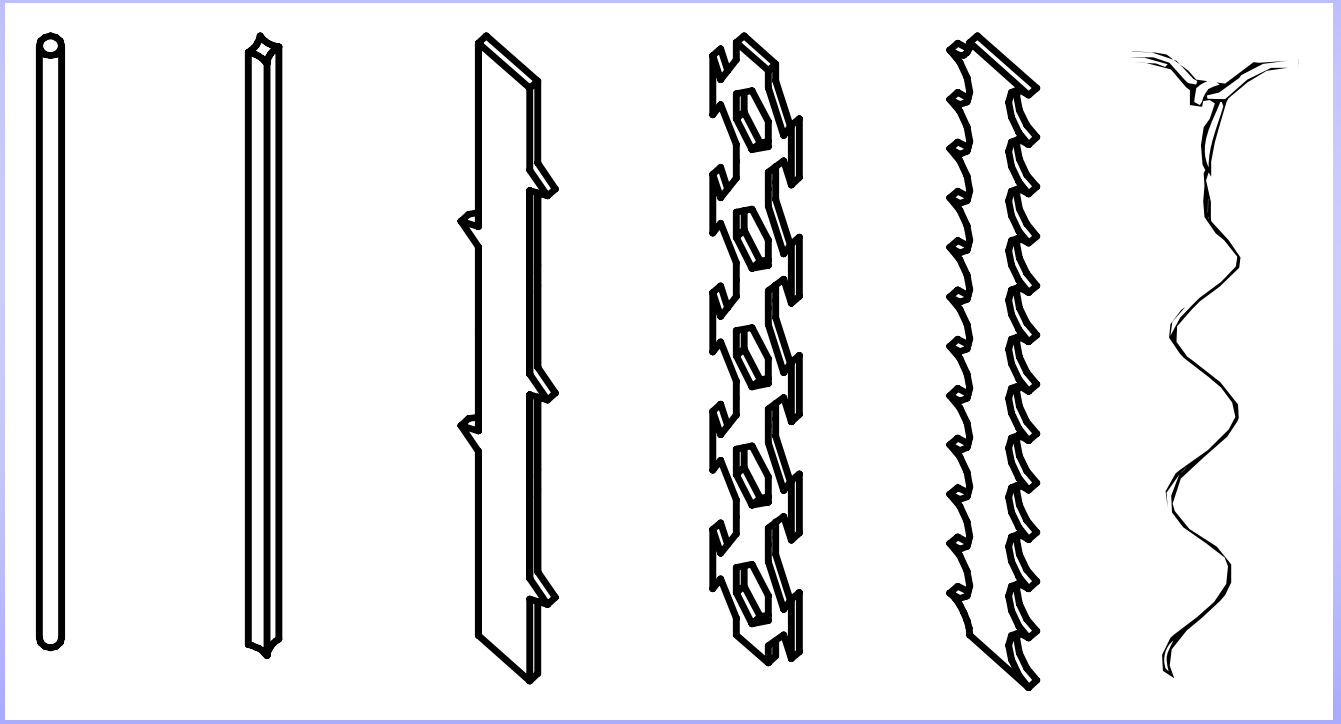
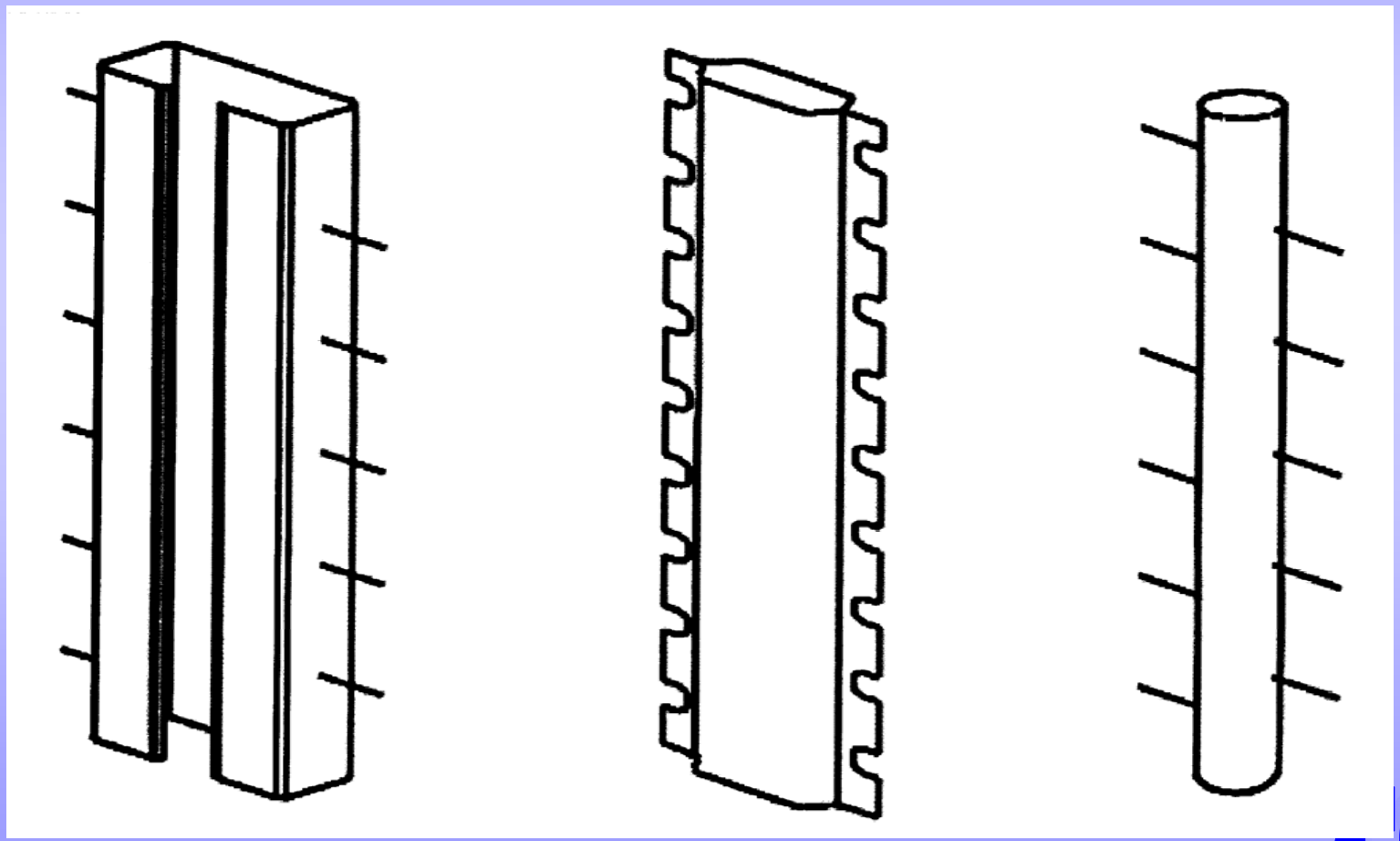
DISCHARGE ELECTRODES



DISCHARGE ELECTRODES



RIGID DISCHARGE ELECTRODES



RIGID DISCHARGE ELECTRODE RDE

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

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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**

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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

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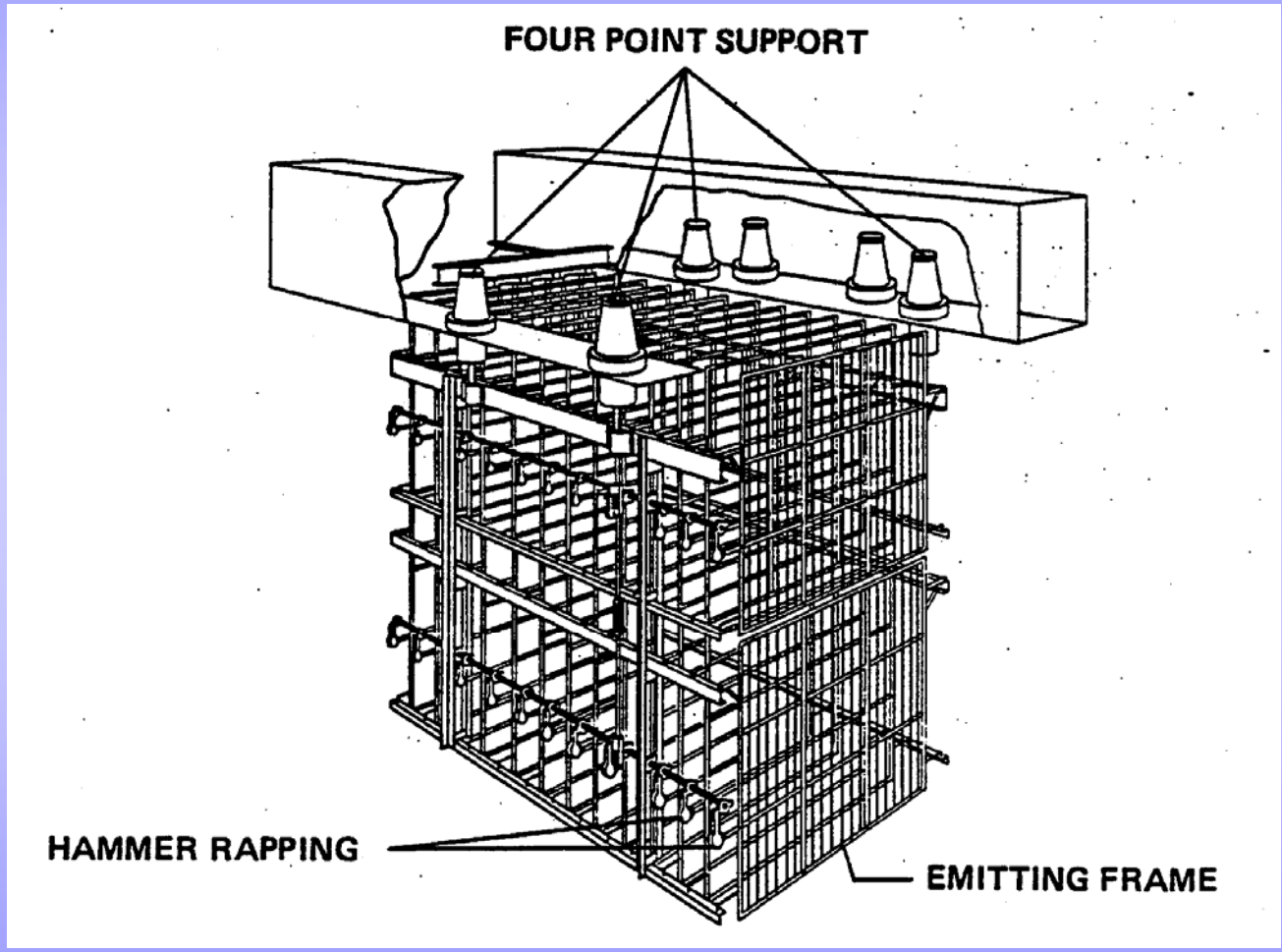
4 POINT SUSPENSION



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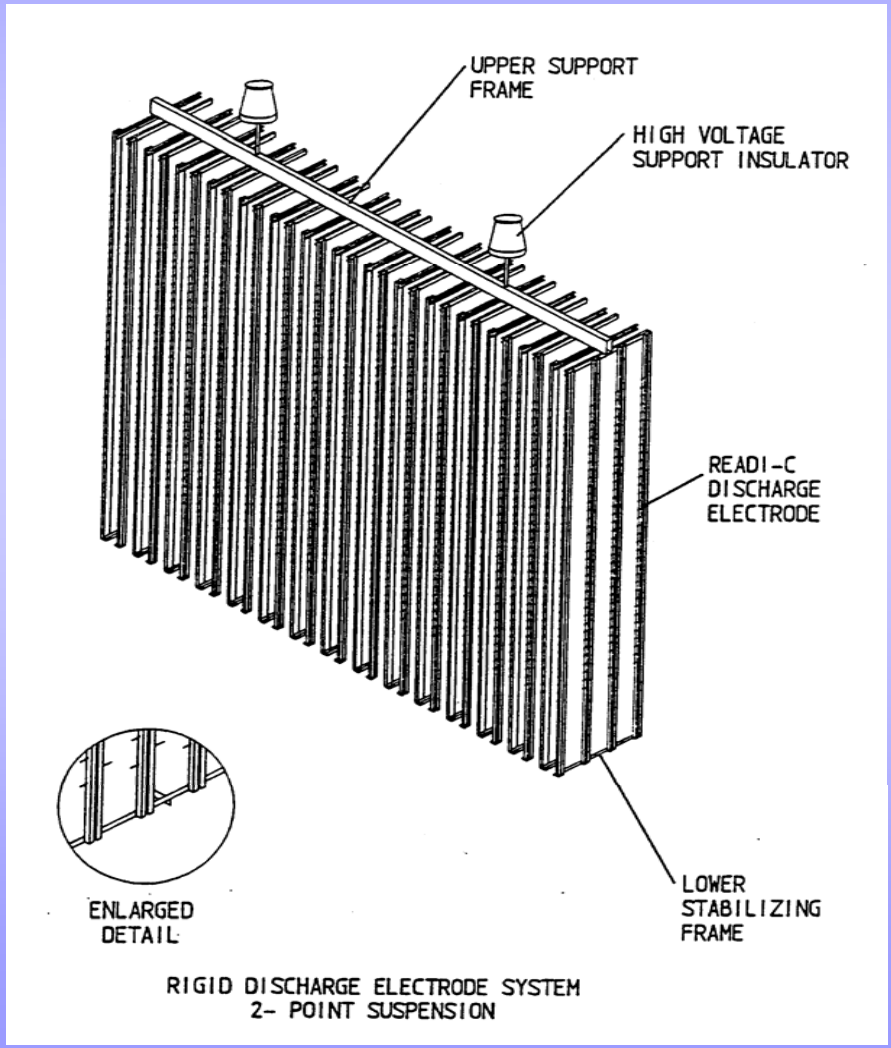
2 POINT SUSPENSION



RIGID DISCHARGE ELECTRODE SYSTEM
2- POINT SUSPENSION

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COLLECTING SYSTEM

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COLLECTING SYSTEM COMPONENTS

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

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PURPOSE OF COLLECTING ELECTRODES

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

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COLLECTING ELECTRODE DESIGN CONSIDERATIONS

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

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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?**

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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

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WIDE PLATE SPACING PERFORMANCE

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

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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

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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

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RAPPING PARAMETERS

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

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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

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SUMMARY

- Three processes: charging, collection, removal
- Terminology: Deutsch equation, SCA, migration velocity
- Plate spacing
- ESP systems: discharge electrodes, collecting electrodes, rapping systems

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