REINHOLD ENVIRONMENTAL Ltd.

2012 APC Round Table
& Expo Presentation

July 16-17, 2012, in Baltimore, MD / Hosted by Duke Energy, Entergy, FirstEnergy, Southern Company & TVA

ESP Rapping Systems

APC Round Table & Expo

July 17 – Tuesday, 2012

Hilton – Baltimore, Md.

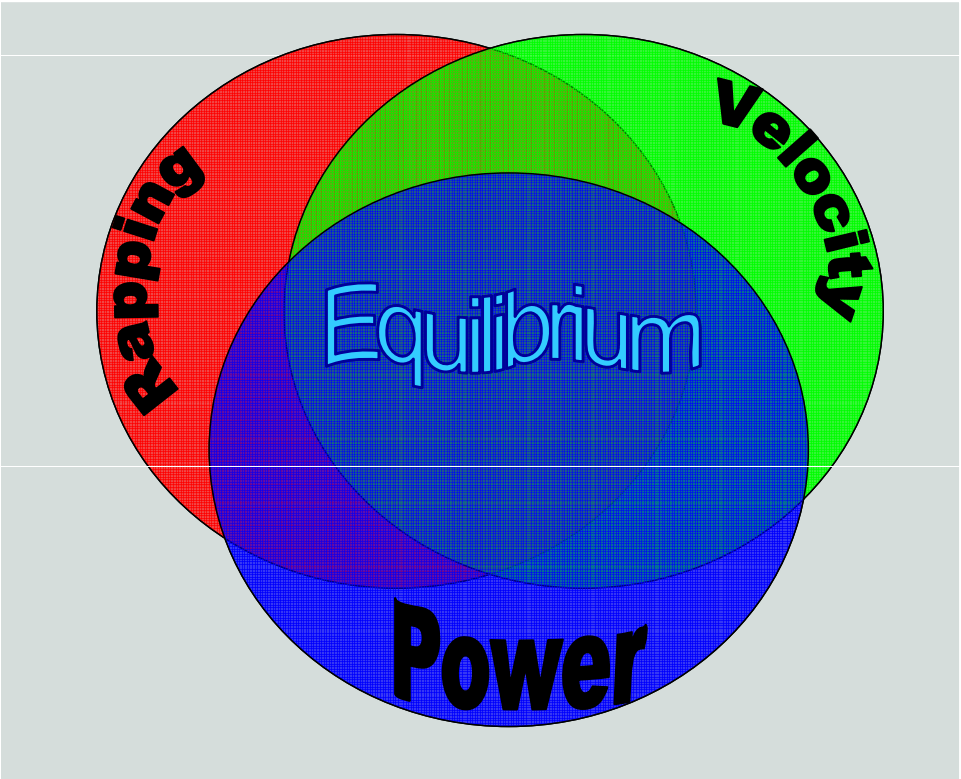
Gerry Klemm - Southern Company

2012 PCUG Round Table

The Purpose of Rapping

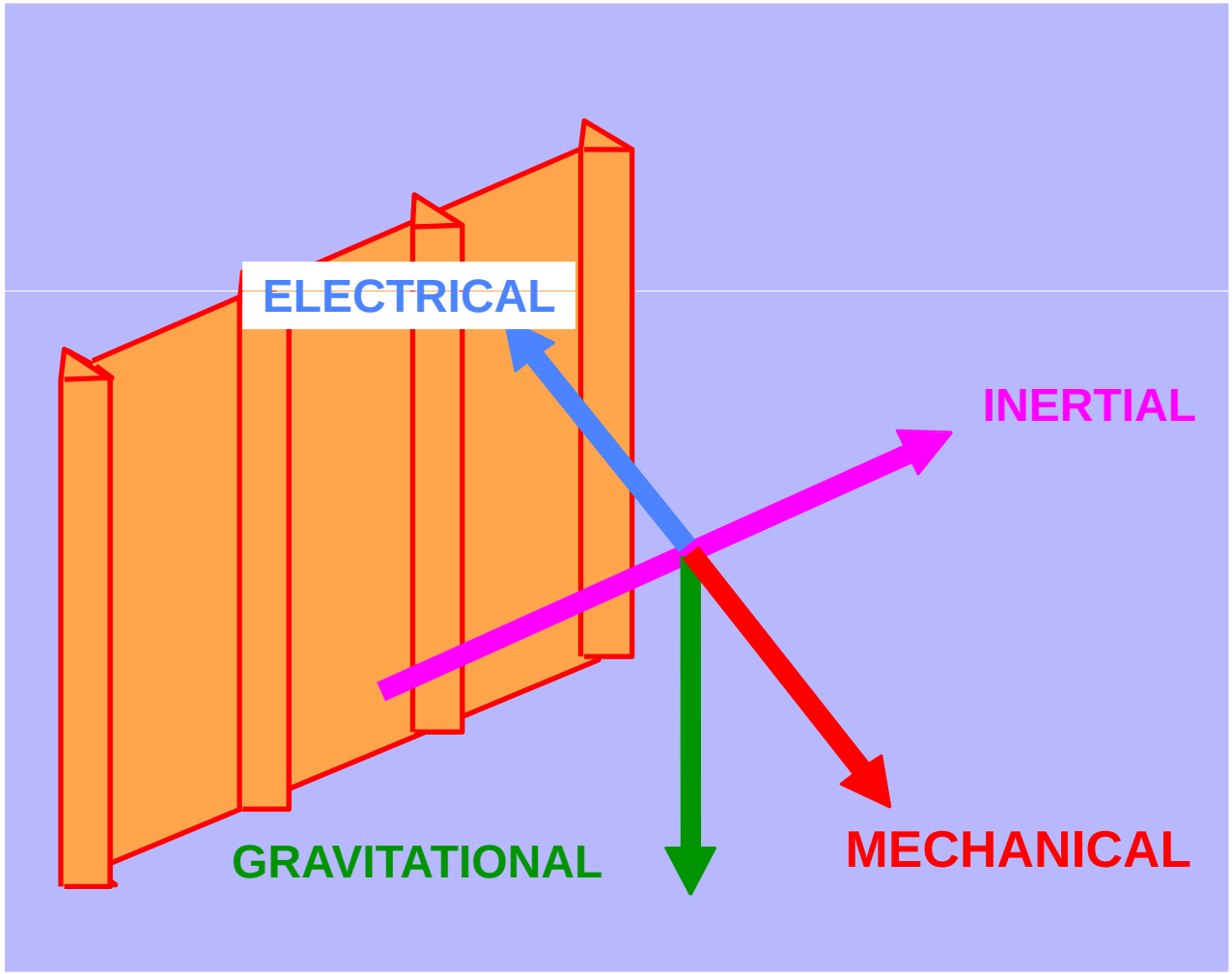
- Operate at lowest outlet emissions and opacity

- Maintain EQULIBRIUM of Collection and Removal



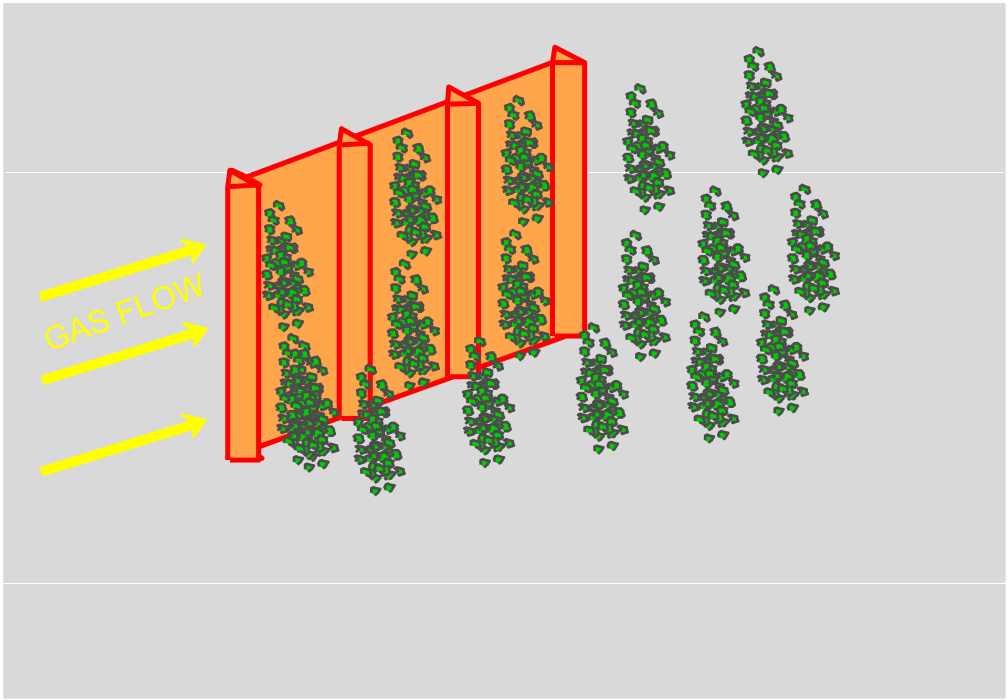
Force Interaction with Rapping

Rapping is the Mechanical Component of the 4 Branch Force Vector

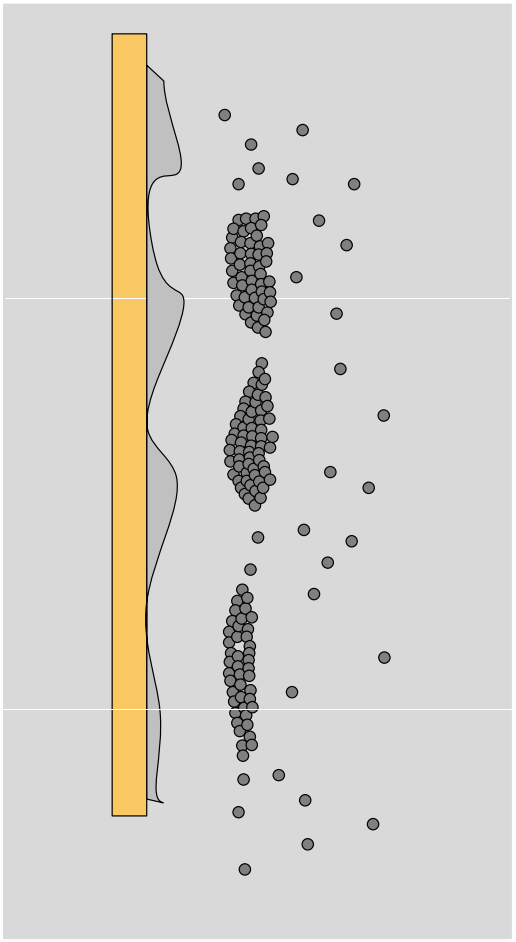


Dustcake Release

The desired method of dustcake release is cratering



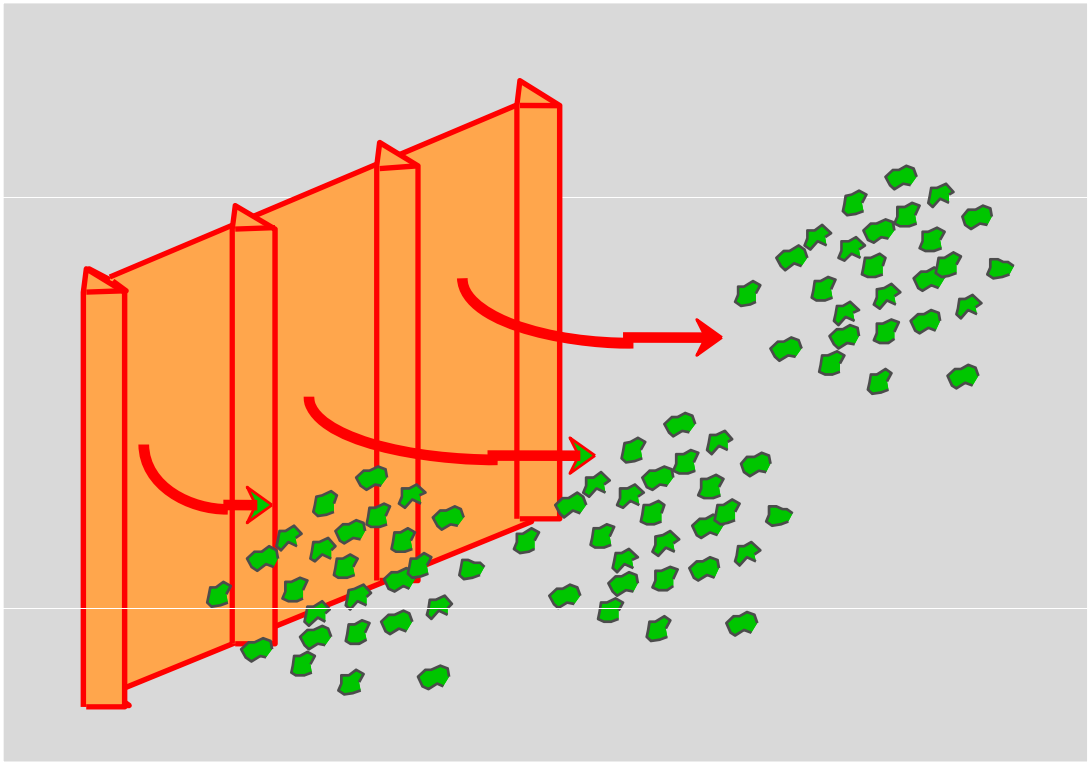
Clump Release from Collecting Surface



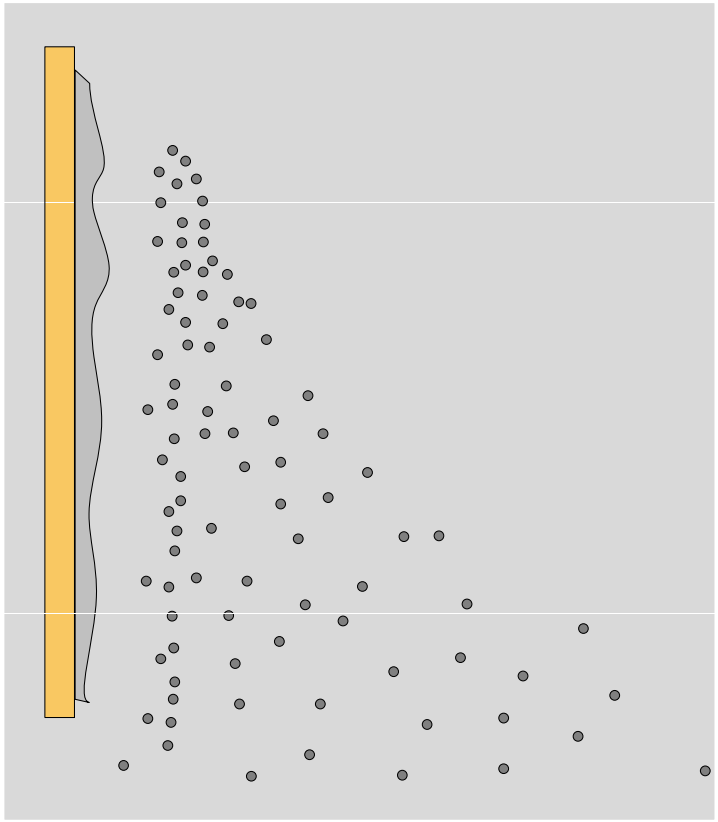
Cratered Cleaning

Dustcake Release

The undesired method of dustcake release is diffusion



Diffused Release from Collecting Surface

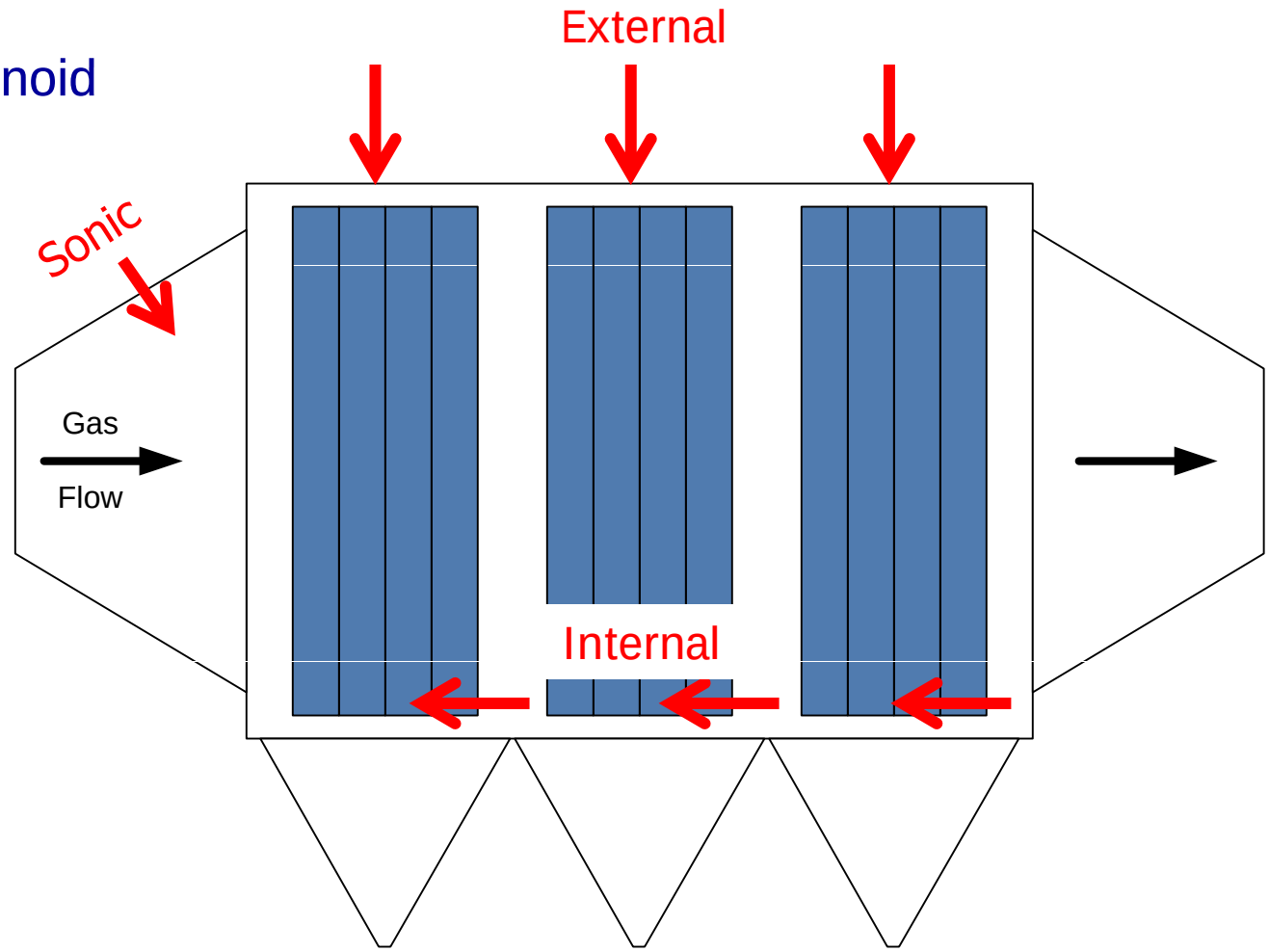


Diffused Cleaning

Rapping Approaches

Two ways:

- External
  - Electric / Solenoid
  - Mechanical
  - Vibratory
- Internal
  - Mechanical
  - Sonic



Approach Considerations

External Rapping:

- Pro's
  - All moving parts are out of gas stream
  - Equipment is consolidated to roof area
  - Solenoid rappers can be used
  - High W/GF sectionalization possible

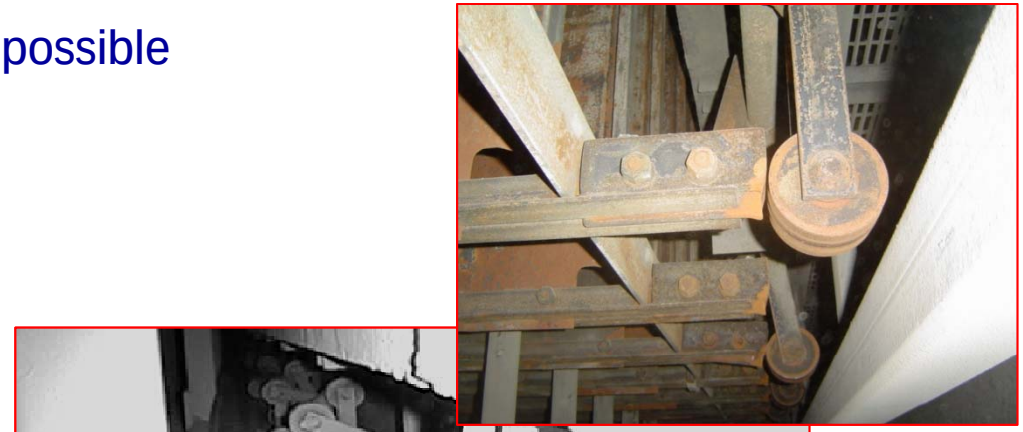
- Con's
  - Can be electrically complex
  - Many casing penetrations

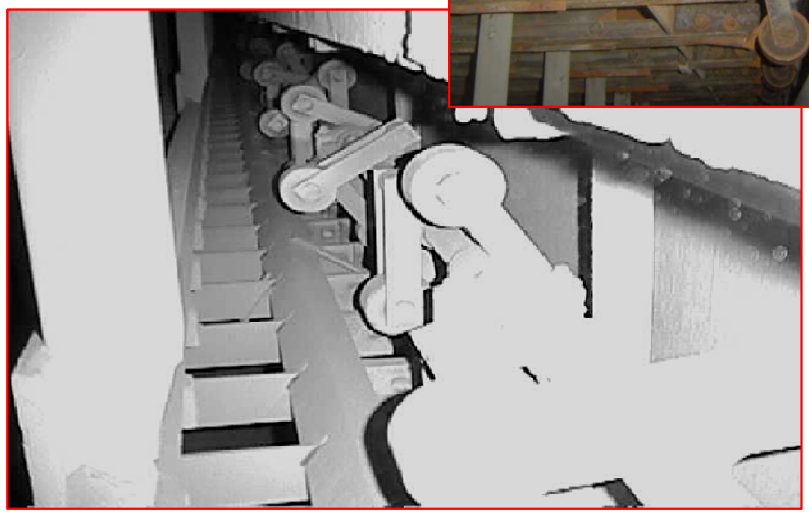
Approach Considerations

Internal Rapping:

- Pro's
  - Applies greatest force to the area with the greatest dust accumulations
  - High force concentrations possible
  - High X/GF sectionalization
  - Few casing penetrations

- Con's
  - High maintenance
  - Poor W/GF sectionalization
  - Force distribution limited on tall CPs
  - No intensity adjustment

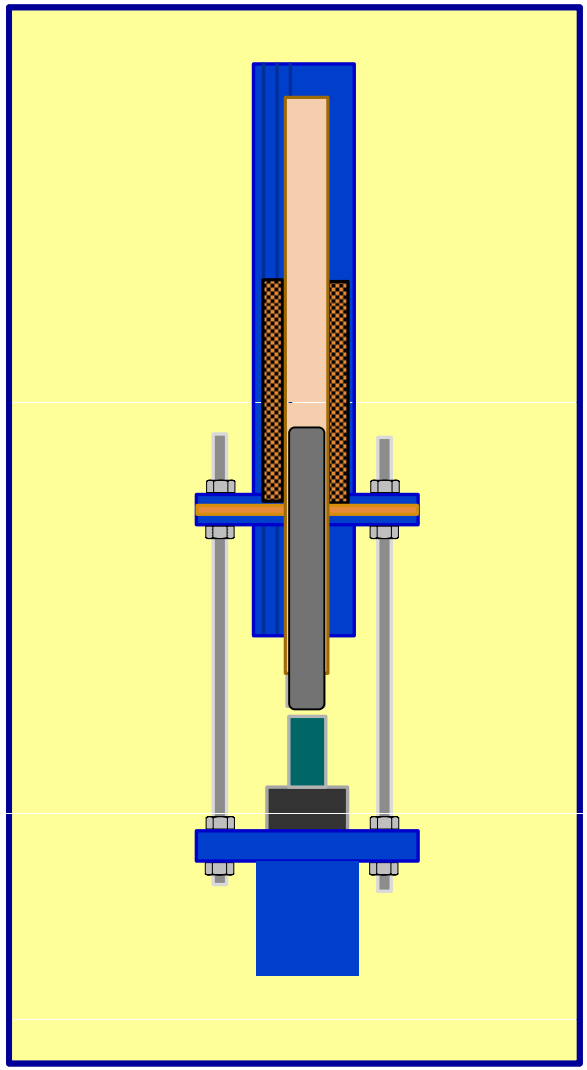




The Solenoid Rapper – Tripod Mount

Features:

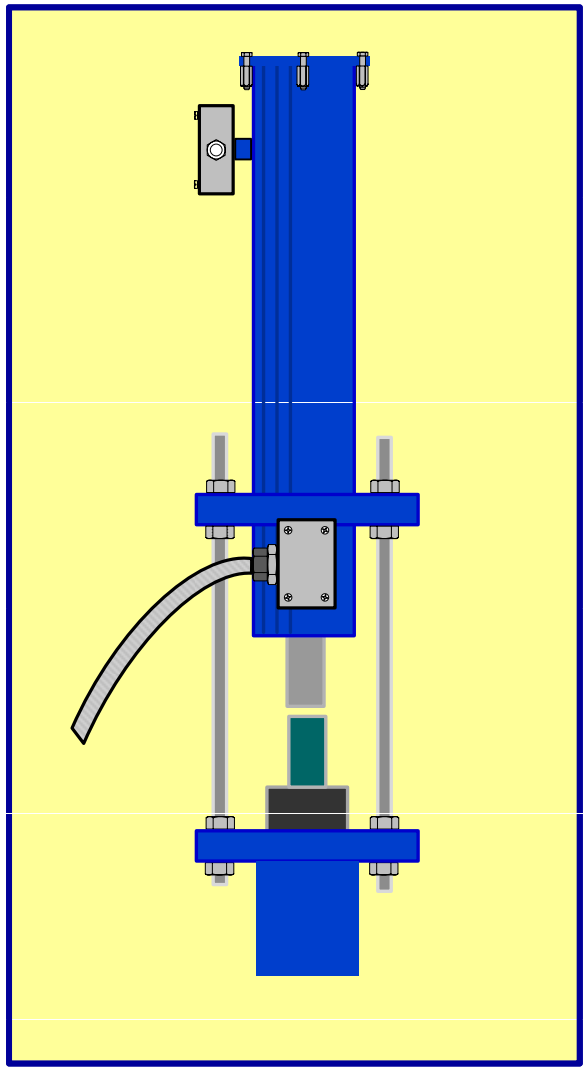
- Tri-Bolt Mount
- Electromagnetically Actuated
- Gravity Return
- Exposed Slug



The Solenoid Rapper – Tripod Mount

Considerations:

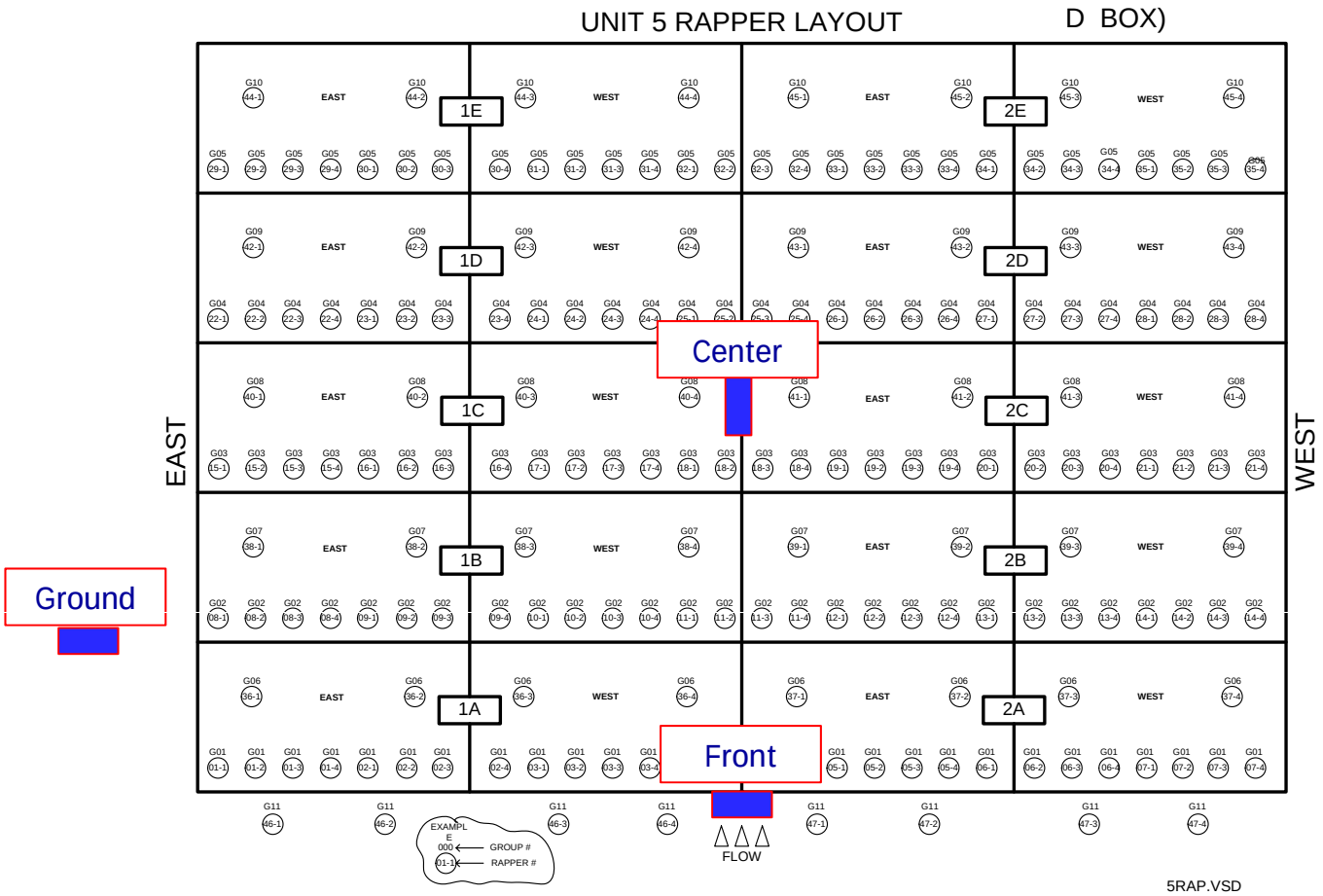
- Aluminum or Copper Coil
  - How terminations are made
- Rated Voltage
- Where controls are located
- Rebuildable?
- Duty cycle
- Rated Temp rise over Ambient
- Exposed Slug
- Access
- Interchangeable Bolt Circle



Solenoid Rapper – Control Location

Voltage Drop:

- Affects Intensity
- Where should control be located?



The Solenoid Rapper – Tripod Mount

Pro's:

- Independently Plumbed
- Visible Stroke
- Can do direct measurement of stroke from top

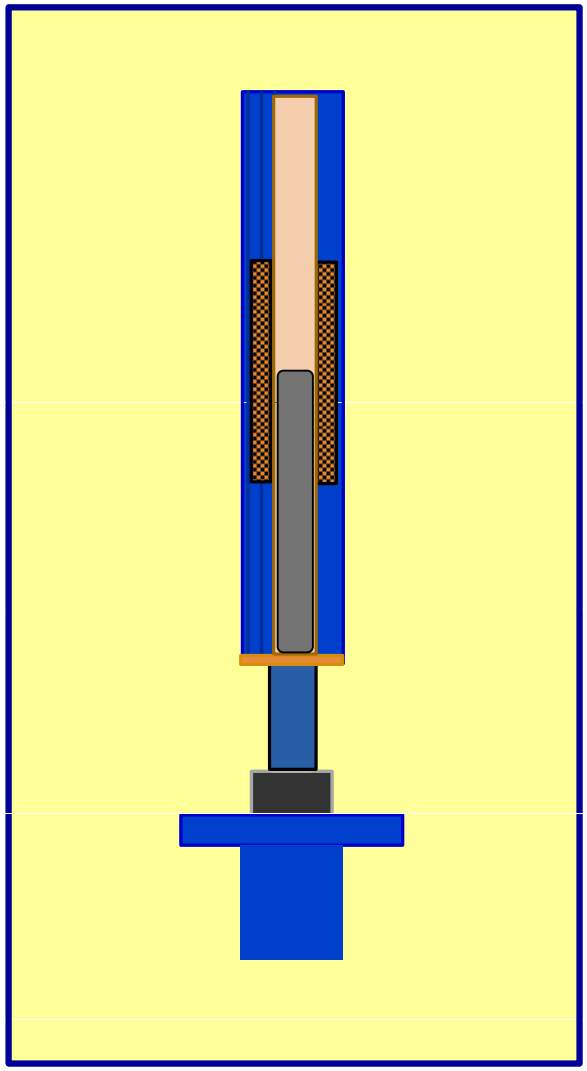
Con's:

- Can magnetize Shaft
- Highest cost among solenoids

The Solenoid Rapper – Shaft Mount

Features:

- Shaft Mounted
- Electromagnetically Actuated
- Gravity Return
- Captured Slug



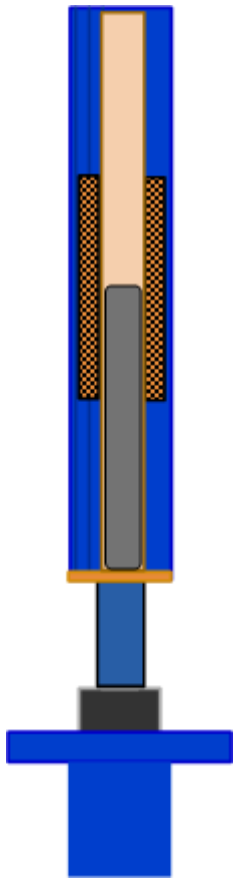
The Solenoid Rapper – Shaft Mount

Pro's:

- Low Comparative Cost
- Easy Installation

Con's:

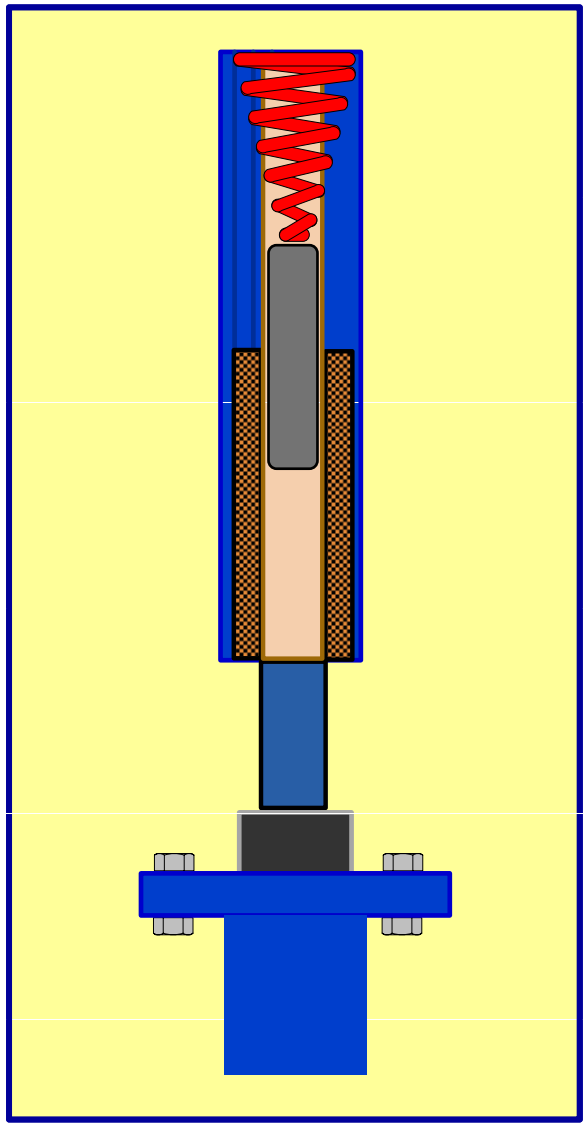
- Subject to perpendicularity of anvil shaft
- Can auto-rotate
- Wear products are captive



The Solenoid Rapper – Impulse Type

Features:

- Shaft Mounted
- Electromagnetically Actuated
- Spring Return
- Concealed Slug
- Lighter slug



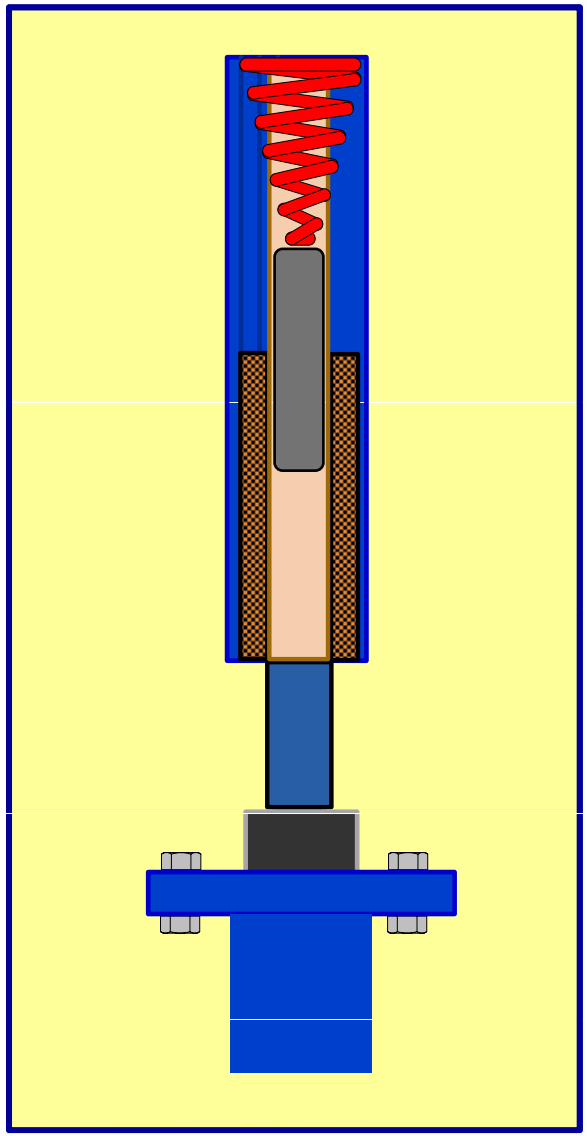
The Solenoid Rapper – Impulse Type

Pro's:

- Compact Size
- Easy Installation
- High Frequency Multi-raps possible

Con's:

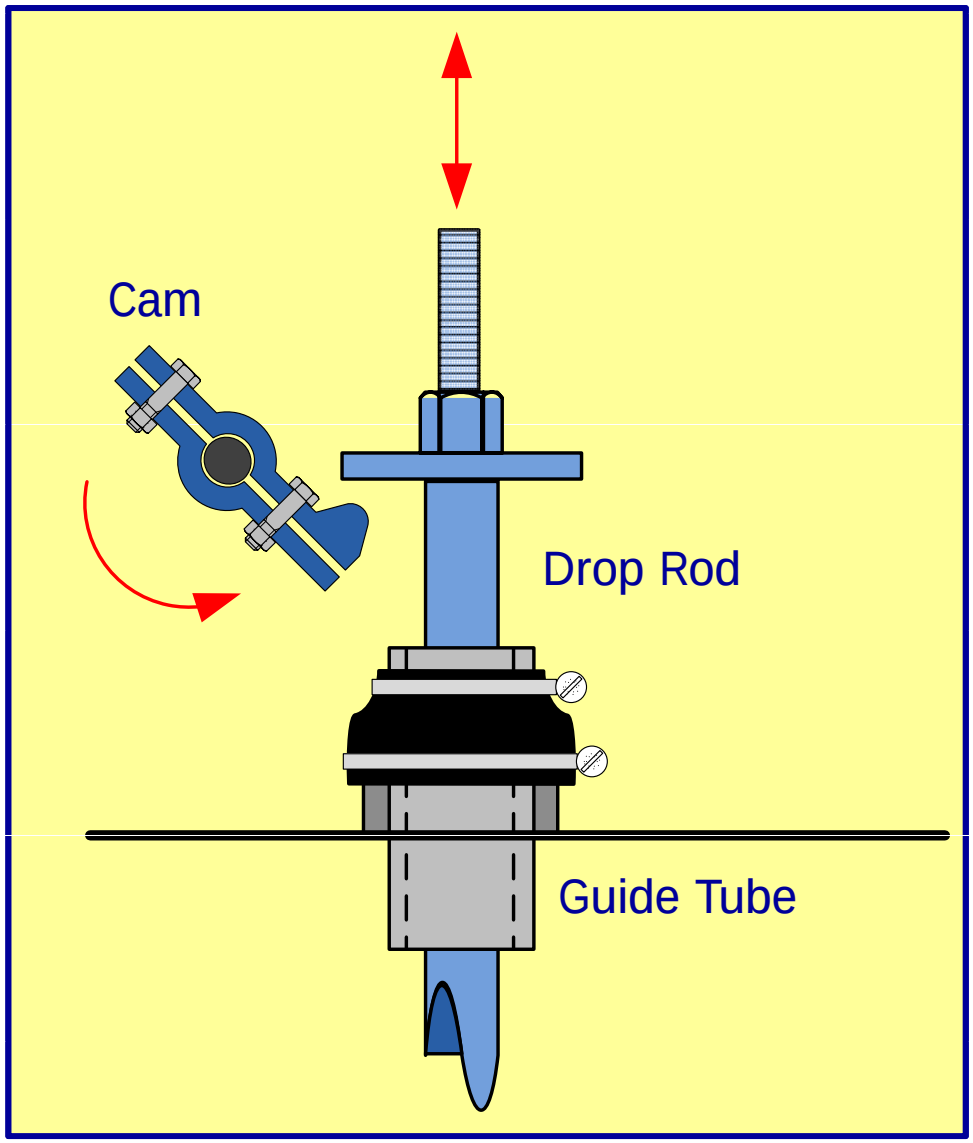
- Subject to Perpendicularity of Anvil Shaft
- Highest Maintenance
- Wear products are captive



The Drop Rod Rapper

Features:

- Headered arrangement
- Mechanically Actuated
- Gravity Return
- Short stroke, massive blow



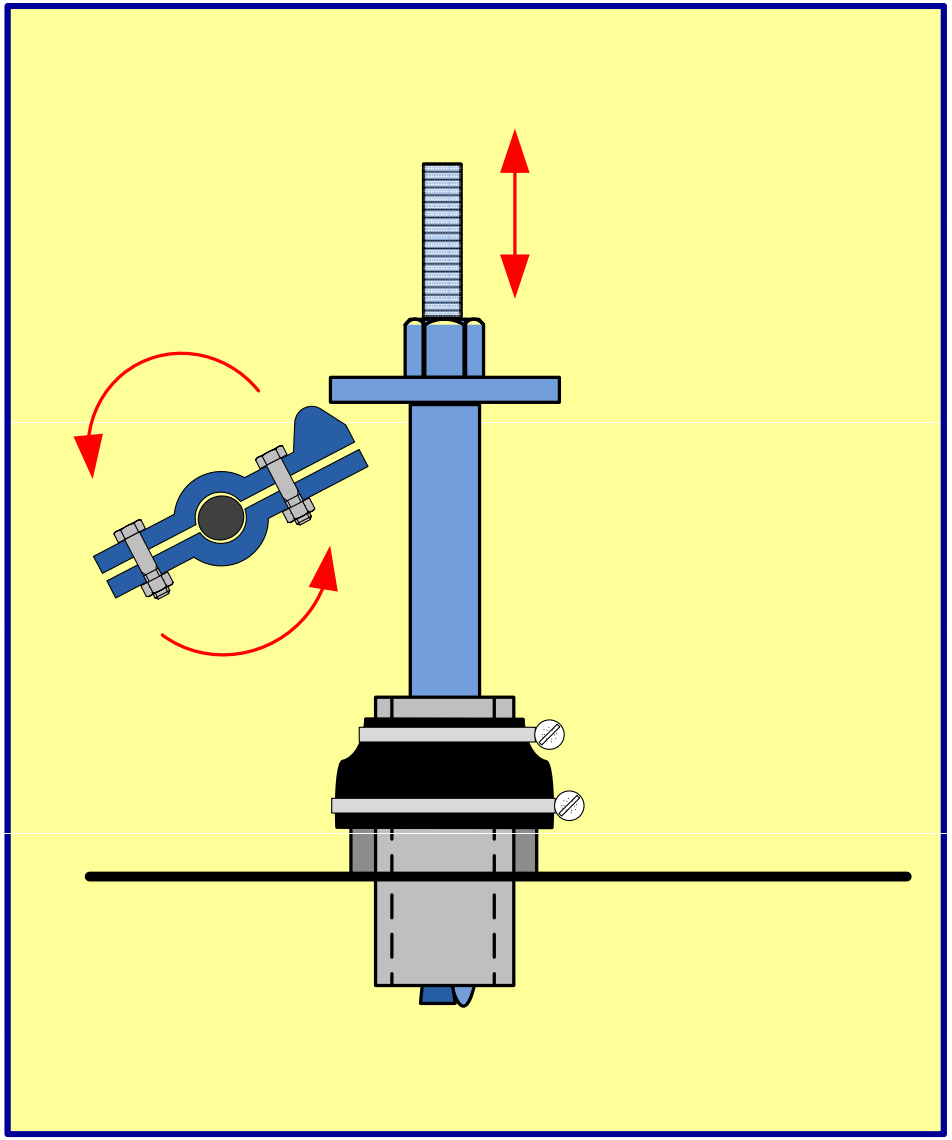
The Drop Rod Rapper

Pro's:

- Simple Electrical Requirements
- No voltage drop effect
- Heavy Dead Blow
- High Sectionalization
- Suitable for tall CP heights

Con's:

- High Force Concentrations lead to fatigue failures
- Limited Force Variation
- Large Number of Casing Penetrations



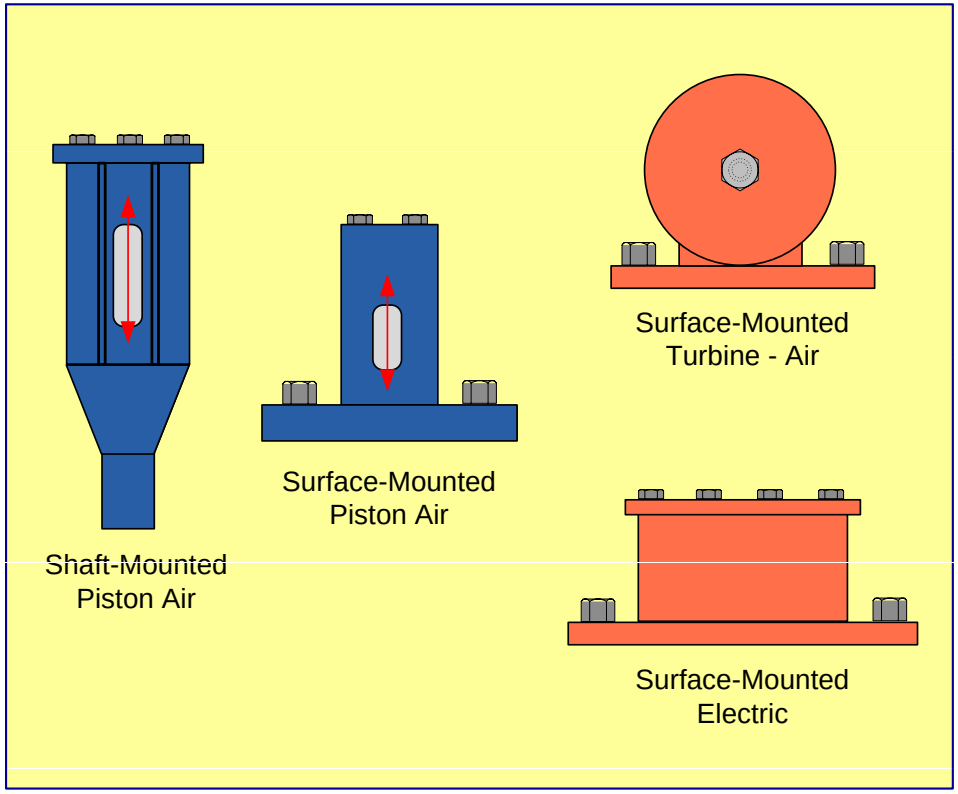
The Vibrators

Features:

- Piston Air Vibrators
  - Suitable for Hoppers Only
  - Destructive to ESP Internals

- Electric
  - -Suitable for DE's
  - Used on hoppers, but not as suitable

- Turbine
  - Suitable for Hoppers Only
  - Resembles a shaker
  - Parabolic Force Curve



The Horns

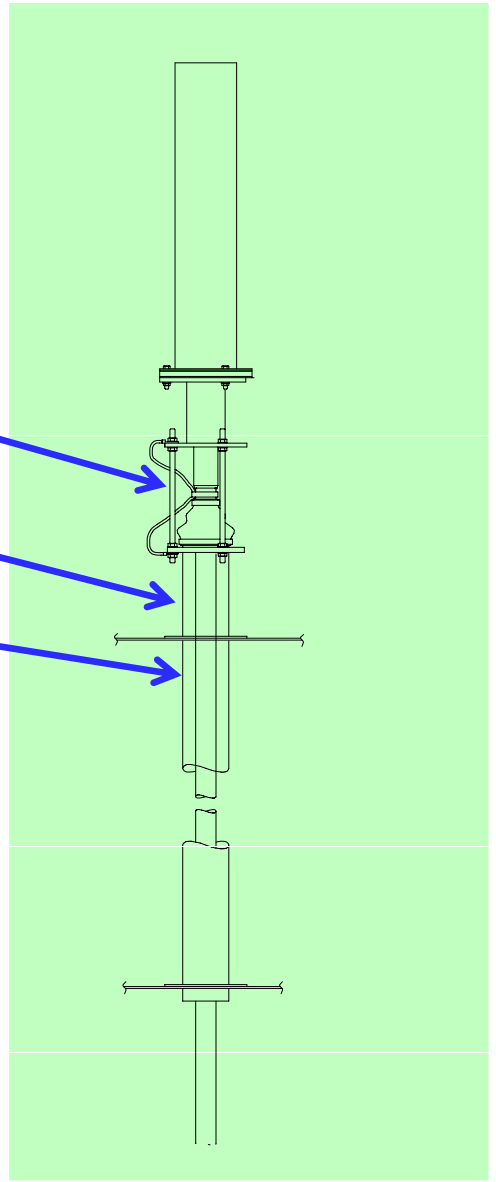
Features:

- Normally Air Powered
  - ~75hz
  - Parabolic power curve
  - Not normally recommended for electrode areas
  - Effective in areas with high loading-horizontal surfaces such as inlet plenums
  - Can be effective on tenacious dusts such as salt cake

Maintenance Experience – External Rap

Upper Train:

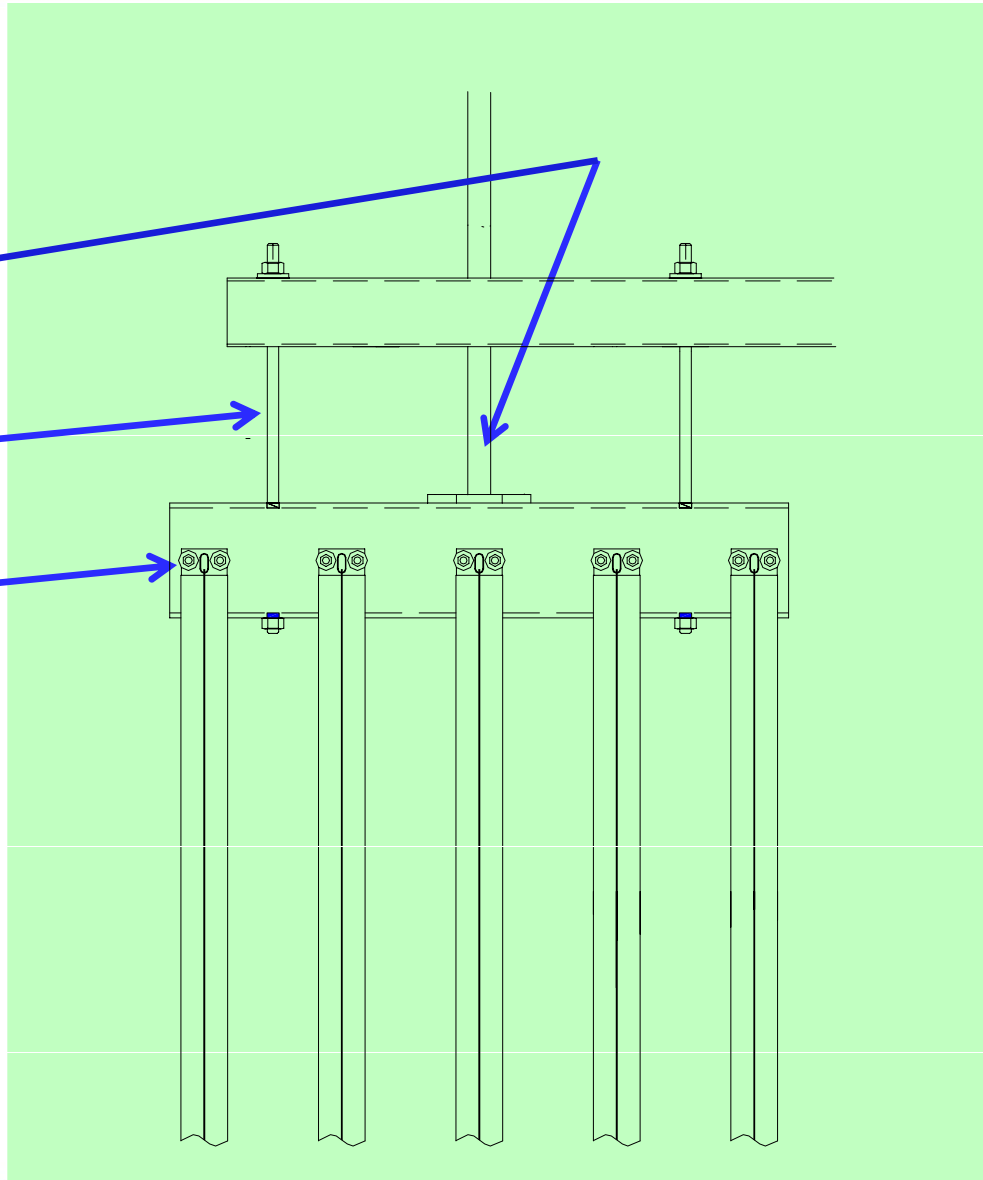
- Ground Jumpers disconnects
- Mounting Collar Corrosion
- Ash Solidification



Maintenance Experience – External Rap

Lower Train:

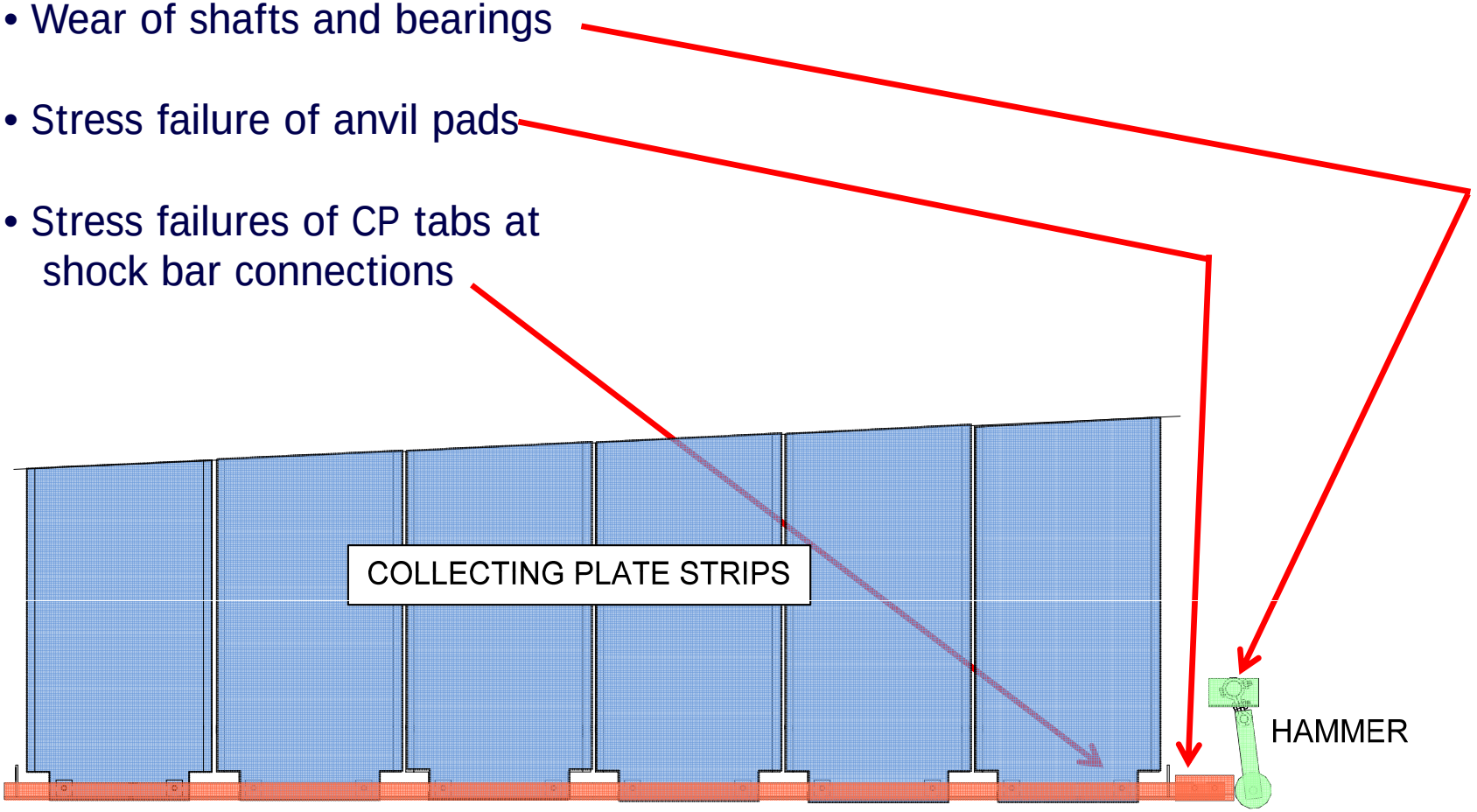
- Stress failures at shaft connection and anvil beam
- Mine Bolt failures
- Stress failures at anvil and CP connection



Maintenance Experience – Internal Rap

Collecting System:

- Wear of shafts and bearings
- Stress failure of anvil pads
- Stress failures of CP tabs at shock bar connections

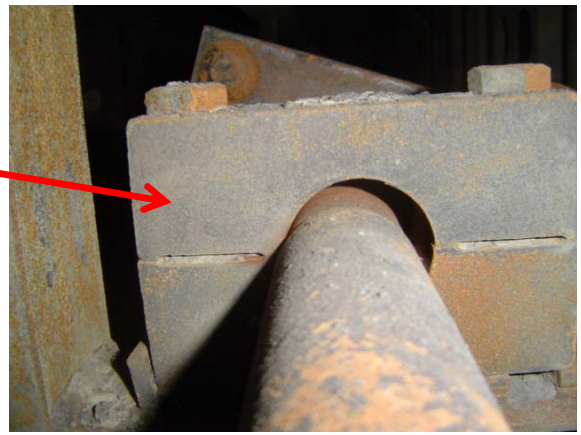


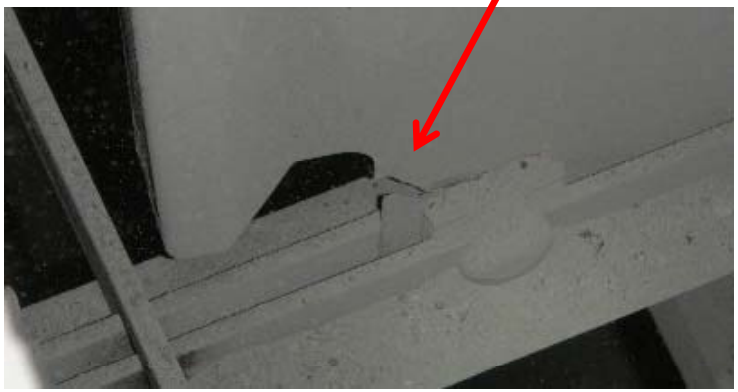
Generic CP Assy

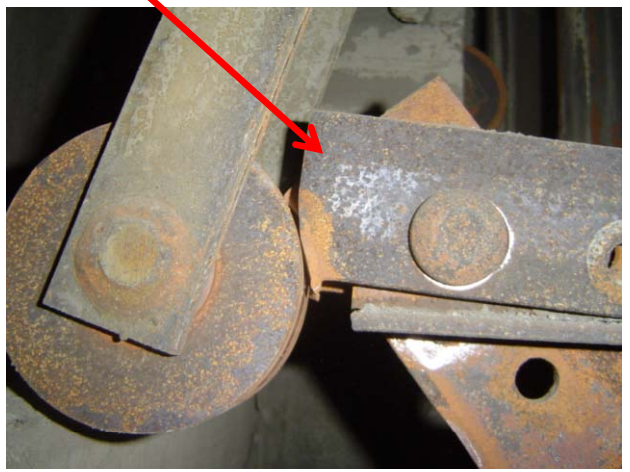
Maintenance Experience – Internal Rap

Collecting System:

- Wear of shafts and bearings
- Stress failure of anvil pads
- Stress failures of CP tabs at shock bar connections



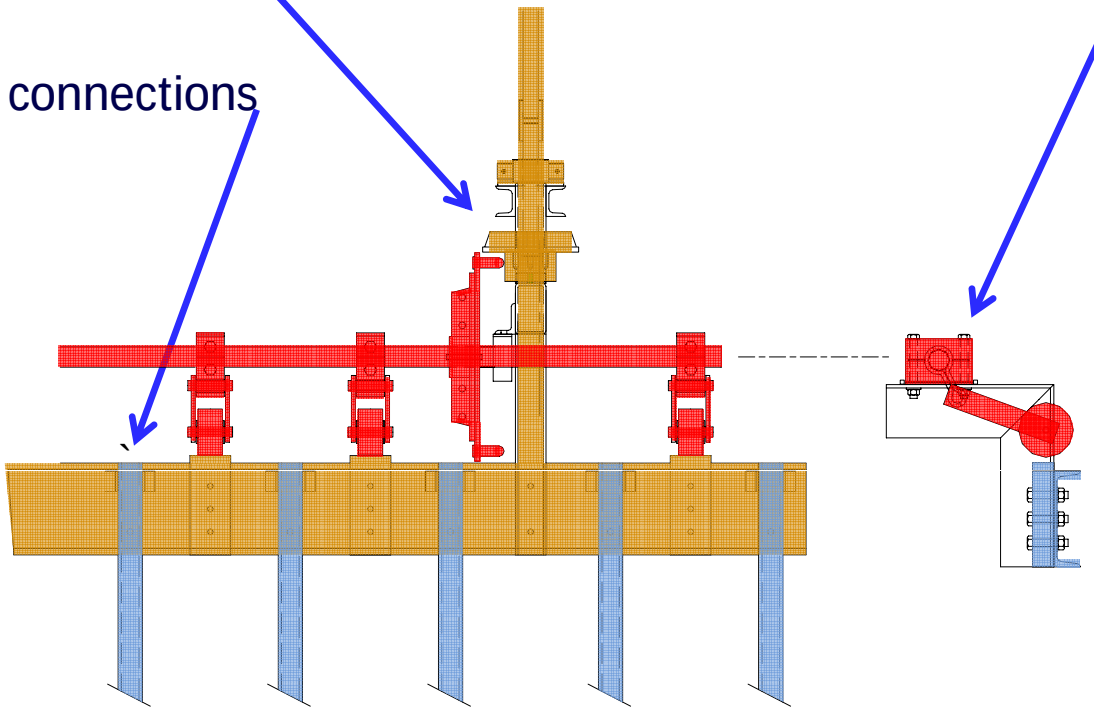




Maintenance Experience – Internal Rap

Discharge System:

- Wear of shafts and bearings
- Stress and wear at right angle drive
- Stress failures of DE connections



Generic DE Assy

Intensity, Frequency, and Force

Intensity:

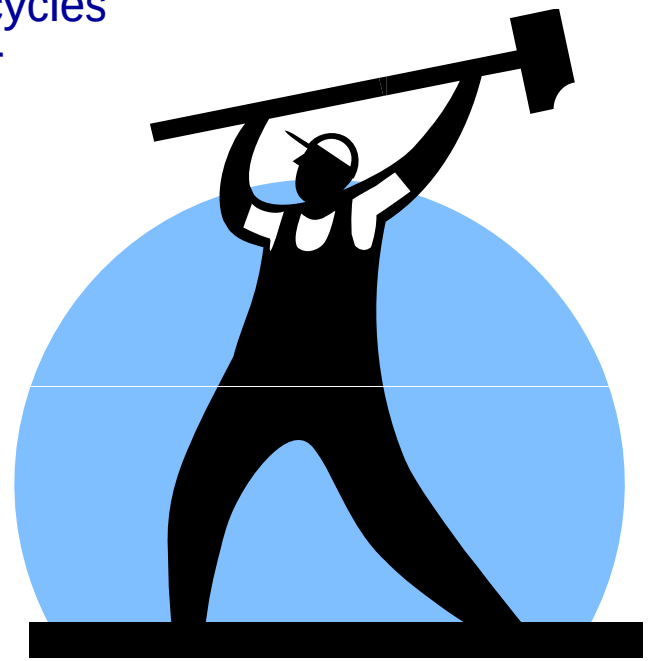
- Mass of Slug, Drop Rod or Armature **x** Velocity **x** Distance

Frequency and Repetition:

- Frequency- Interval between rapping events or cycles
- Repetition – Number of strokes or actuations per rapping event

Force:

- Product of Intensity and repetition per rapping event



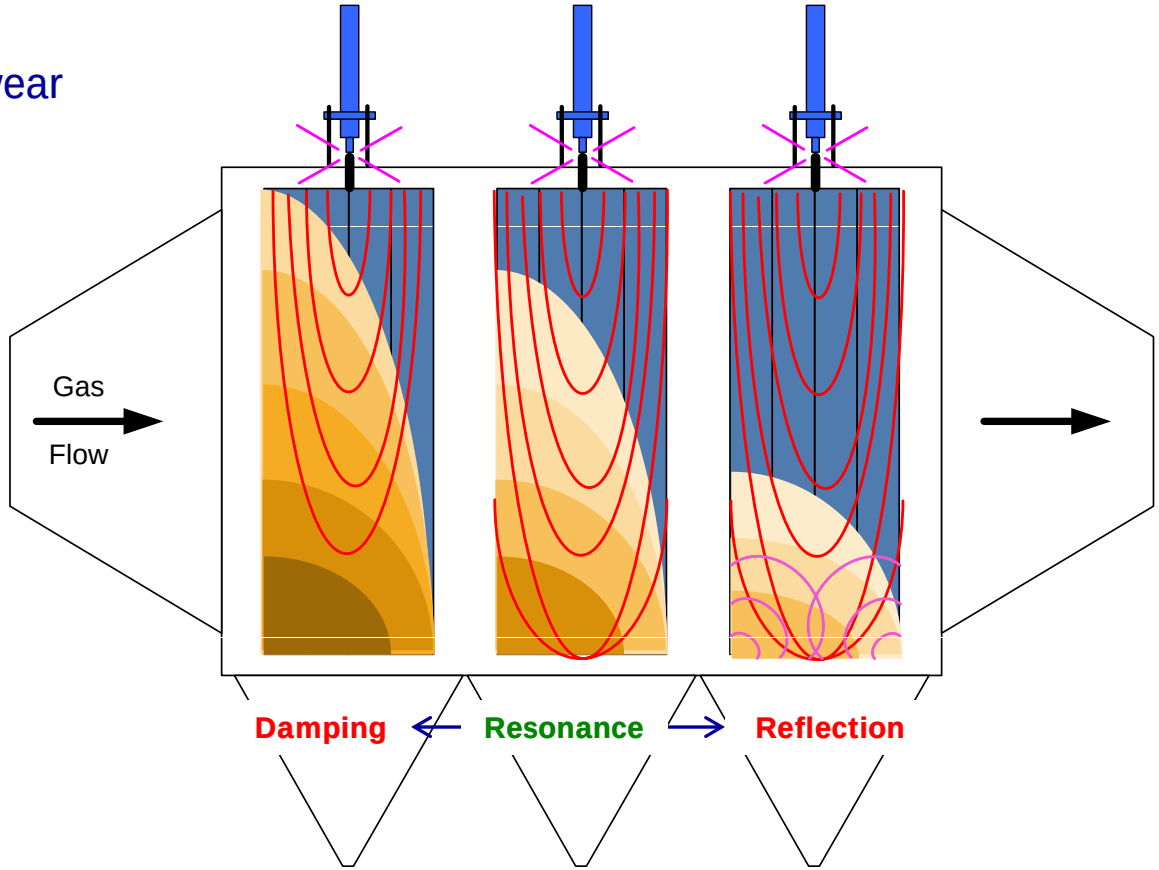
Intensity

Amplitude of intensity:

- Insufficient intensity fails to clean the extremities
- Excessive intensity produces reflected waves and undue wear
- Excessive intensity produces reintrainment
- Object is to find mechanical resonance

Propagation:

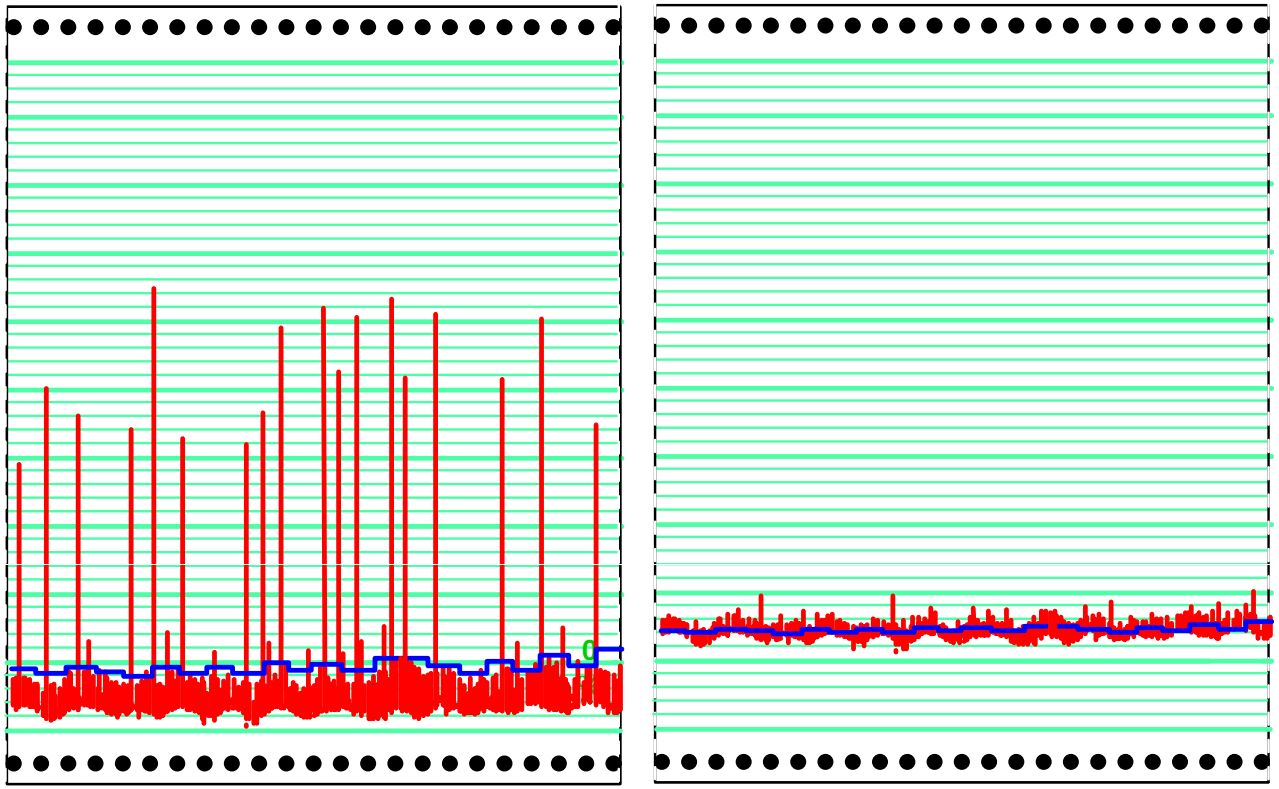
- Wave propagation is proportionate to intensity
- Waves are attenuated or damped by ash
- Waves are reflected by boundaries



Frequency

Effect on Opacity:

- Too slow produces low baseline, but high spikes
- Too fast produces low spiking, but high baseline



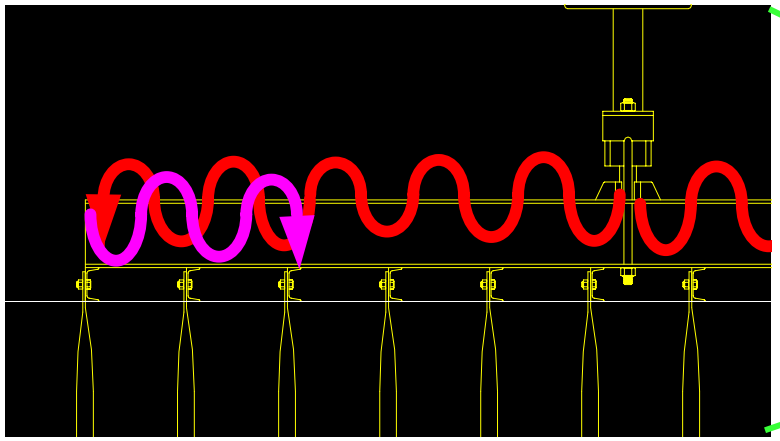
Low Frequency

High Frequency

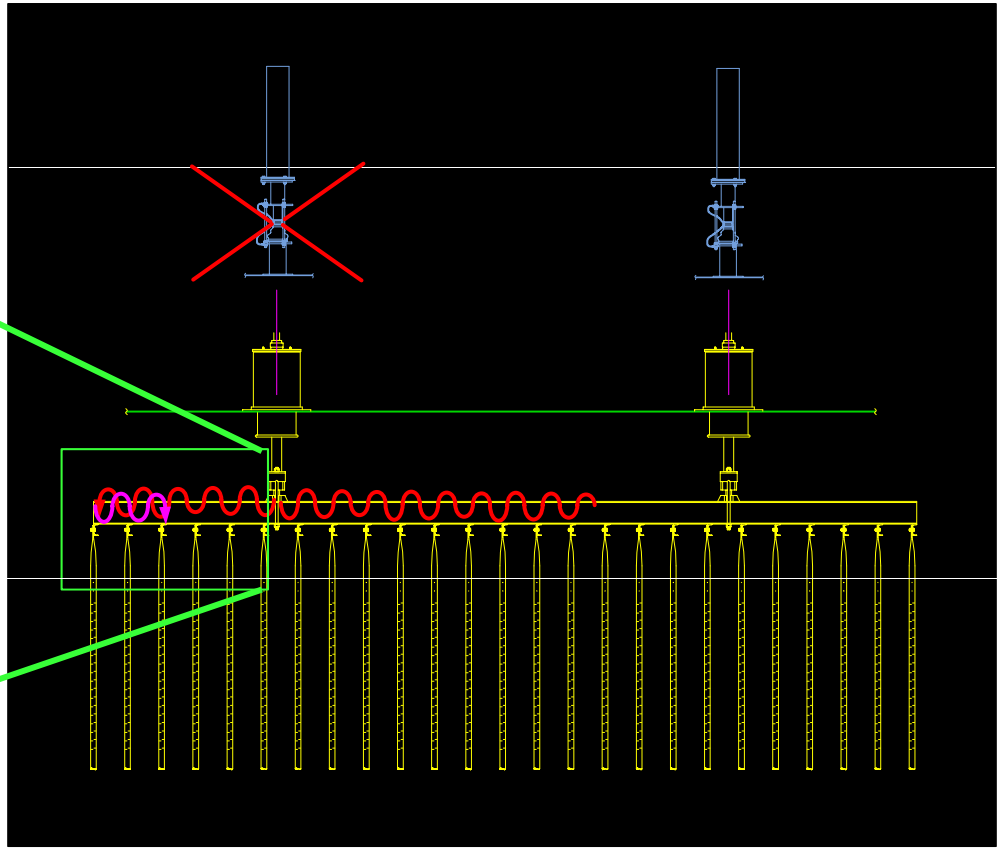
Repetition

Effects:

- Power pulse intervals must be matched with the particular rapper
- Too many repetitions per unit time can cause reflected waves and premature mechanical failures



Close-up

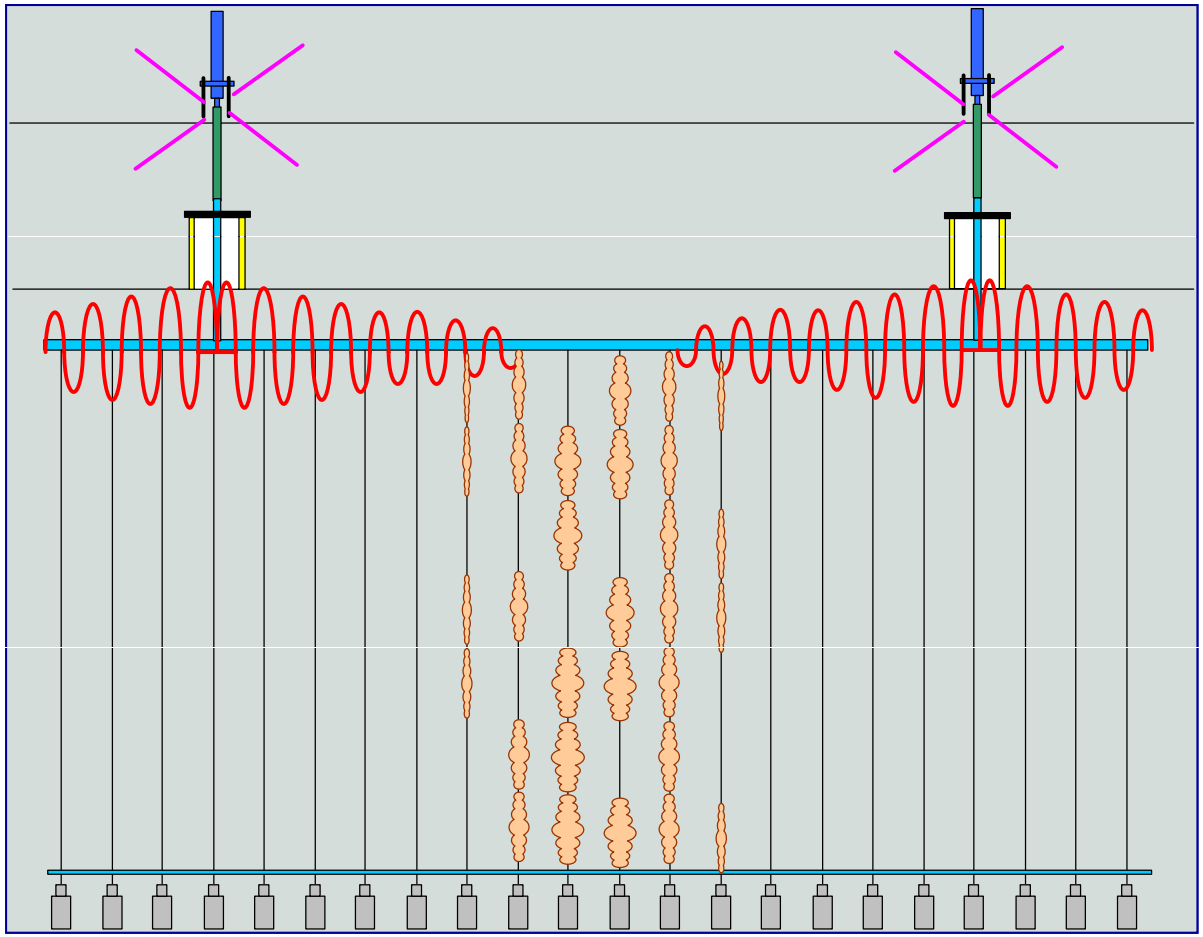


Discharge System

Wave Propagation in a Discharge System

Effects:

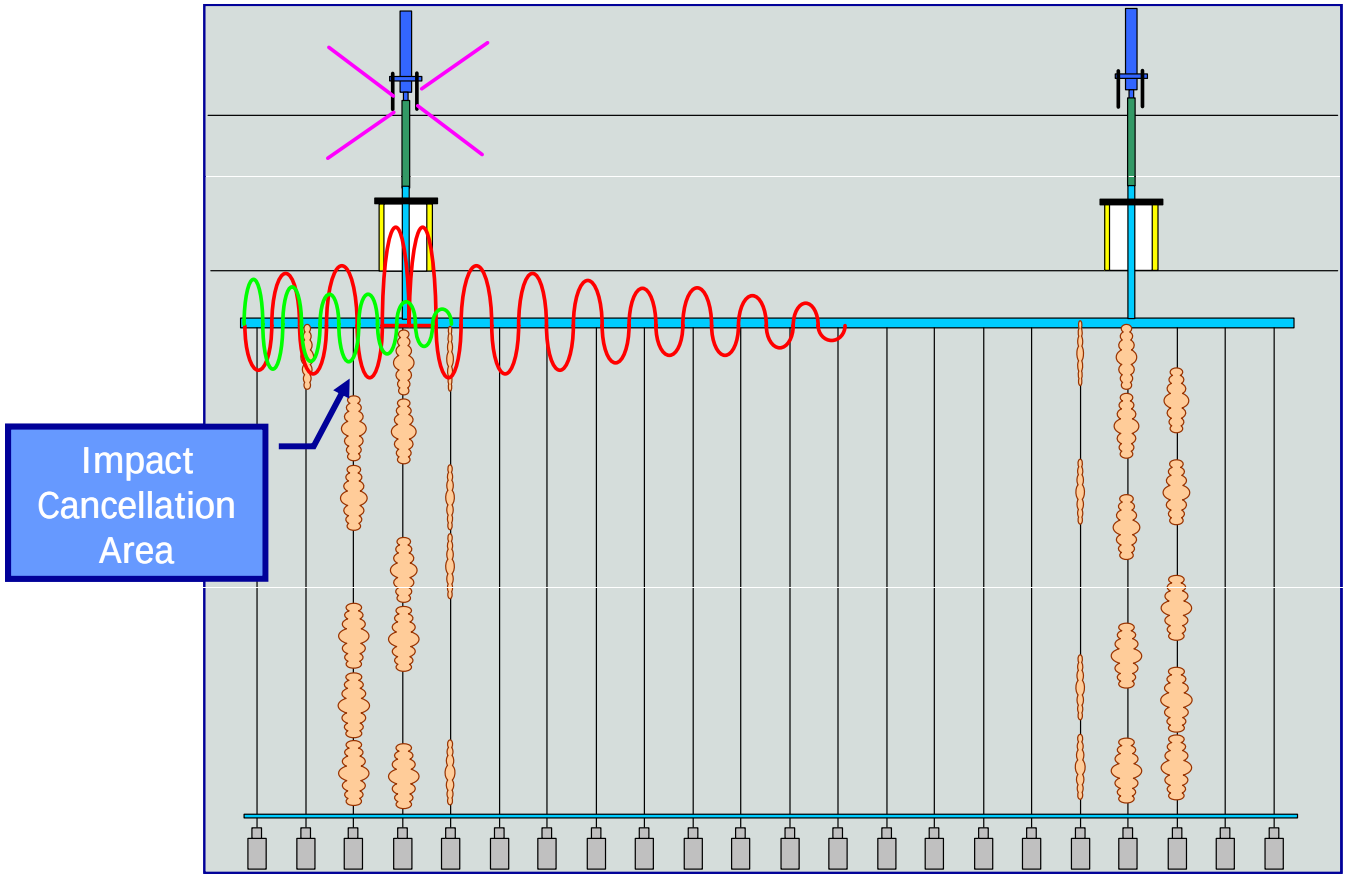
- Insufficient propagation can cause localized poor cleaning



Wave Cancellation in a Discharge system

Effects:

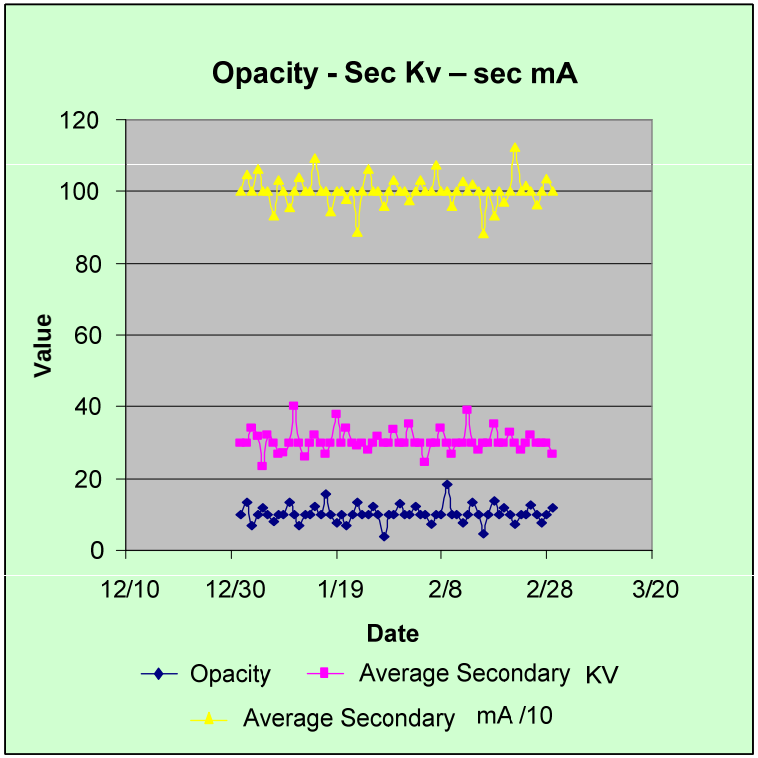
- Reflected waves can cause amplitude cancellation in localized areas within the field of propagation



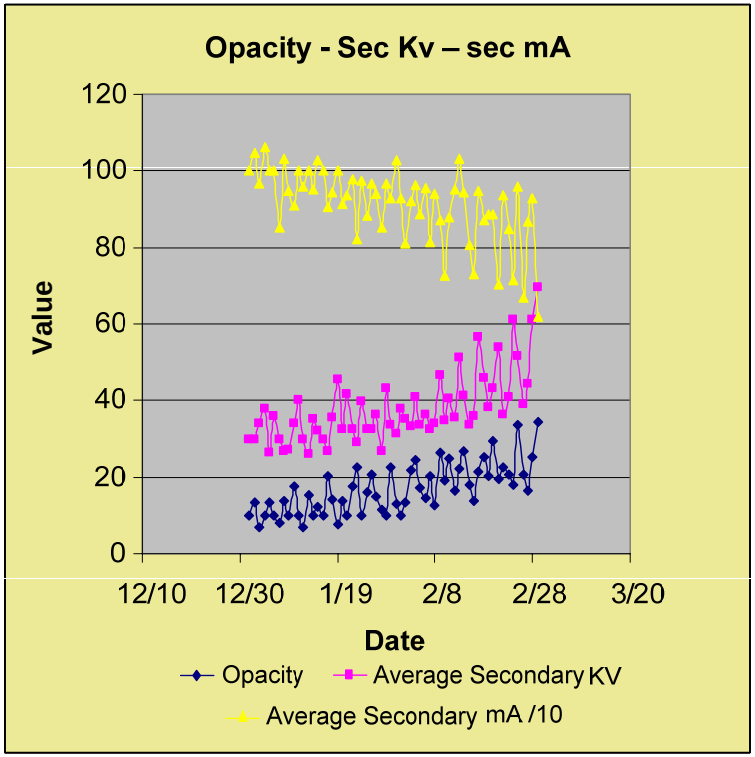
Force and Equilibrium

Force:

- Dictates the cleaning component of Opacity and Applied Power performance



ESP In “Equilibrium”

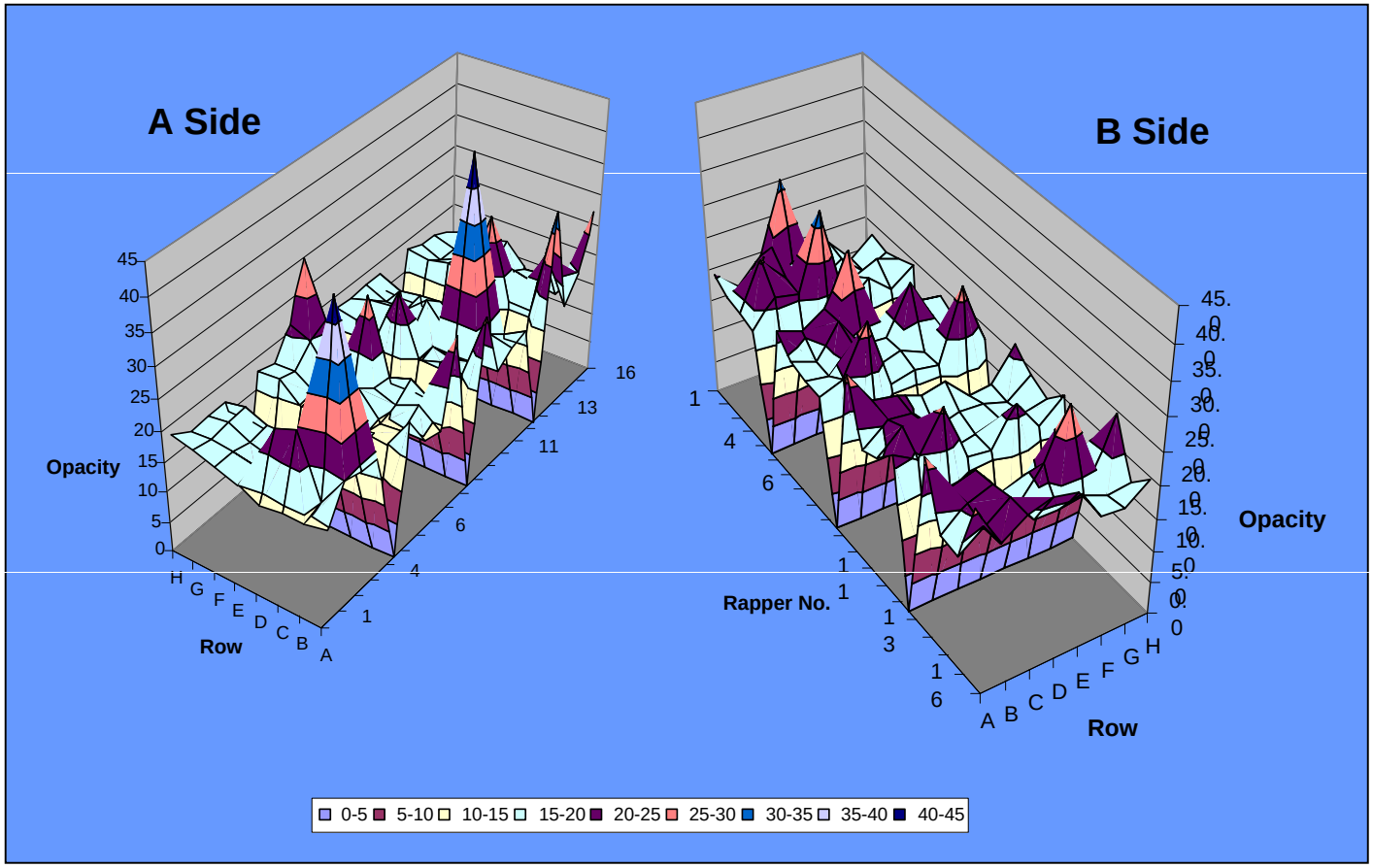


ESP Out of “Equilibrium”

Rapper Profile

Useful in:

- Finding areas of high/low velocity
- Optimizing rappers



Design Evolution

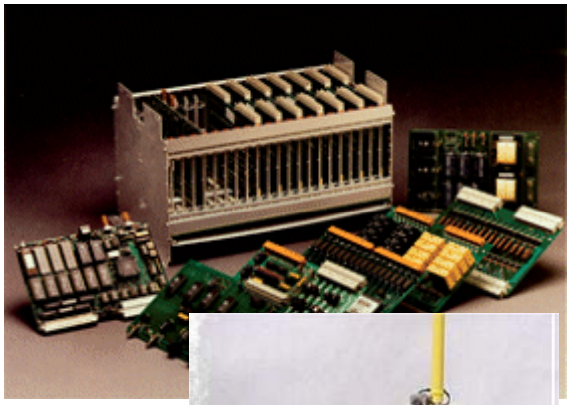
Past:

- Achievement of 16 x 16 array
- Integration of AC and DC loads
- Interconnectability to Data Management System
- Interconnectability to Distributed Control System
- Interactive displays
- Power-Off rapping

Design Evolution

Current:

- Modbus TCP/IP Connectability
- Auto demagnetization
- Improved user interfacing
- Integrated rapper w/control
- Better lift precision
- Voltage drop compensation
- Rapper vs./ opacity correlation



Design Evolution

Future (Things I'd like to see):

- Better correlation of rapping to opacity
- Automatic voltage drop compensation
- Spectral response feedback to control
- Standalone supervisory control
- Better lightening and surge protection

- Audience Forum – What would you like to see?

Thank You!