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World Pollution Control Association

Wet Electrostatic Precipitation
Technology for the Utility Industry

By

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Acknowledgments

- Pilot Host Sites
  - First Energy's Bruce Mansfield Plant
  - Southern Company's Alabama Power's Plant Miller
- R&D Funding
  - DOE's NETL Office
  - Electric Power Research Institute
- Co-Authors
  - Wayne Buckley & Patrick Doonan- WAPC
  - Dr. Ralph Altman – EPRI

Outline

- Control Technologies
- WESP History
- Compare to Dry ESP
- How WESP work
- Why WESP
- What is PM2.5
- Opacity
- Applications
- Removal Performance
- Types of Wet ESPs
- Washing Options
- Design Parameters
- Materials
- Utility Installations
- Configurations
- Mercury Control
- New Developments
- Benefits

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Overview- Control Technologies

Technology	Type	NOx	PM10	SO_2	Hg	PM2.5	SO_3
Low-NOx Burners	dry	X					
SCR	dry	X					
SNCR	dry	X					
Dry ESP	dry		X			X	
Fabric Filter	dry		X			X	
SDA + FF	dry		X	X	X	X	X
Injection+FF	dry				X	X	X
FGD Scrubber	wet		X	X	X		X
Injection + FGD	wet			X	X		X
WESP	wet				X	X	X

WESP History

- First ESP was Wet , not Dry !
- Developed by Dr. Cottrell in 1907
- First dry ESP was 1922 at Detroit Edison
- Used to Control Sulfuric Acid Mist
- Numerous Industrial Applications
- Utility Installations are limited
- New PM2.5 Regulations may require WESP

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Wet ESP vs. Dry ESP

OPERATIONAL ISSUES	DRY ESP	WET ESP
BACK CORONA	YES	NO
RE-ENTRAINMENT	YES	NO
PM10 REMOVAL	YES	NO
PM2.5 REMOVAL	Limited	YES
SO3 REMOVAL	NO	YES
MERCURY REMOVAL	NO	YES
OPACITY REDUCTION	NO	YES
WASTE WATER TREATMENT	NO	YES

A WESP DOES NOT REPLACE A DRY ESP

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Wet Precipitation Process

A 3- Step Process

1. Charging – gas ions created by corona from discharge electrode charge flue gas particles.

2. Collection- the charged particles/mists are attracted to the oppositely charged collection electrode surface.

3. Cleaning – the collected particles/mists are washed away by water, preventing build-up on the collection surface.

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Why Wet ESP?

- Multi-Pollutant Control
- Opacity Reduction <10%
  - SO_3 – up to 99%
  - PM2.5 – up to 99%
- Metals – up to 99%
- Mercury – depends on species

A Final Polishing Device

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Typical Size of Various Particles

LOWER LIMIT OF VISIBILITY (NAKED EYE)… 40 MICRONS

WHITE BLOOD CELLS ……..……. 25 MICRONS

RED BLOOD CELLS ……..…… 8 MICRONS

BACTERIA (COCCI) ……..…… 2 MICRONS

SULFURIC ACID MIST…….. 0.3 MICRONS

Fine & Course Particles

- Course Particles
  - 2.5 to 50 micron in size
  - 10 micron is largest fraction
  - Mechanical, windblown & biological dust
- Fine Particles
  - 0.1 to 2.5 micron in size
  - 0.5 micron is largest fraction
  - Combustion particles
  - Most harmful due to being respirable

OPACITY

- Function of Light Extinction
- 0.5 micron particles are worst actors
- In-line opacity monitors give false reading
- Atmosphere condenses vapors into fine particles & mists
- FGD will also condense fines before stack
- Presence of SCR may also increase SO_3 concentration

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EPA Chart- Pressure Drop vs. PM Removal Efficiency In a Wet Particulate Scrubber

90% removal = 25” w.c.

95% removal = 35” w.c.

99% removal = 50” w.c.

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Industrial Applications

- Chemical
- Textile/Carpet
- Food Processing
- Mining
- Steel
- Glass
- Pharmaceutical
- Petro-Chemical
- Fiber Optics
- Hazardous Waste
- Soil Remediation
- Sulfuric Acid Production
- Arson Forensics
- Wood Products
- Medical Sterilization
- Automotive

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Removal Capability

Eastman Chemical, TN
Hazardous Waste Incineration

Pollutant	**Units**	**Test Runs**	**MACT Limits**	**%**
Particulate	gr/dscf, 7%O2	0.0024-0.0030	0.015	99.94
HCL/Cl2	ppmdv,	2.96-4.84	77	99.95
Chromium	ug/dscm	39.7-42.8	97	99.97
Lead	ug/dscm	3.59-3.85	240	99.95
Mercury	ug/dscm	1.82-1.98	130	79%
Dioxin/furan	ng TEQ/dscm	0.0131-0.0892	0.4	N/D

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Removal Capability

Kyanite Mining, Willis Mountain, VA.
Ore Roasting

Pollutant	**Units**	**Inlet**	**Outlet**	**%**
SO_2	ppm	3,580	21.4	99.4
ACID MIST (H_2SO_4)	gr /dscf	0.228	0.0159	93.0
PM2.5	gr/dscf	1.6	0.006	99.6
CONDENSED, INORGANIC	gr/dscf	0.1310	0.0143	89
CONDENSED, ORGANIC	gr/dscf	0.1415	0.0157	90
OPACITY		> 50%	<5%	

Types of Wet ESPs

- Tubular Type
  - Vertical Flow
    - Up-Flow
    - Down-flow
- Plate Type
  - Vertical Flow
  - Horizontal Flow

Washing Options

- On-line Options
  - Condensing – cooling jacket
  - Irrigated
- Off-Line Sprays
  - Intermittent Operation

Design Factors

- Particulate & Droplet Concentration and Size
- Velocity of the Gas
- Collection Surface Area
- Operating Voltage and Current
- Modular - limited by size of transformer
- Multiple Fields
  - In series- > % removal
  - In parallel > air flow

Operational Benefits

- ½” w.c. Pressure Drop
- No Additional Real Estate Possible
- Secondary Waste Treated & Concentrated
- Modular Design for Scale-Up
- Low Maintenance- No Moving Parts

Materials of Construction

- Materials can be:
  - Stainless Steel
    - 304L-316L-317LMN
  - Duplex Stainless
    - 904L, RA2205
  - Super Austenitic SS
    - Al6XN, SMO254
  - High Nickel
    - C-276, C2000
  - Non-Metallic
    - Plastic or FRP- risk of fire
    - Membrane-risk of stretching/fire/plugging
- Dependent upon
  - SO_3 in flue gas
  - Dry-wet zones
  - Chloride levels in the water

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Waste Water & Power Levels

- Water
  - If FGD present- first use
  - Service Water OK
  - If no water treatment present
    - Sluice to pond or
    - Install treatment system with recycle
    - Concentrate & remove wastes from water

- Power Requirements
  - Operating = @1kw /MW
  - Less than ½% plant power

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WESP Utility Installations

- Japan – @ 30 installations
- Europe- @ ??
- North America
  - AES Deepwater - 1977
  - Xcel Energy's Sherco Station-1995
  - Dakota Gasification Co.-2003
  - New Brunswick Power- Coleson Cove -2004

Utility Applications

- Mid-High Sulfur Coals (bituminous)
  - FGD System installed for SO_2 control
  - Saturated Flue Gas
  - Functions as a “Wet Electrostatic Mist Eliminator”

- Low Sulfur Coals (sub-bituminous & lignite)
  - No FGD installed
  - Unsaturated flue gas
  - High LOI &/or Elemental Hg
  - Last field after a dry ESP “Hybrid dry-wet ESP”

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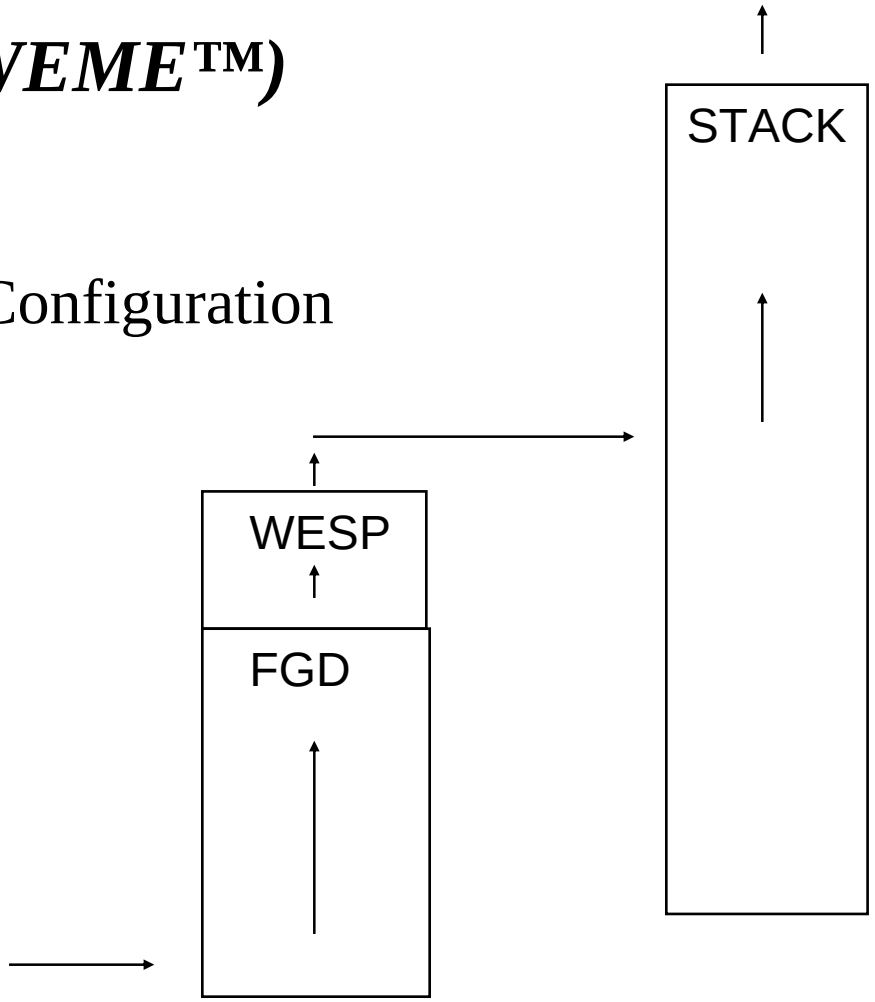
Wet Electrostatic Mist Eliminator (WEME™)

- Mounted on top of FGD
- Vertical Tubular Up-Flow Configuration
- No Additional Real Estate



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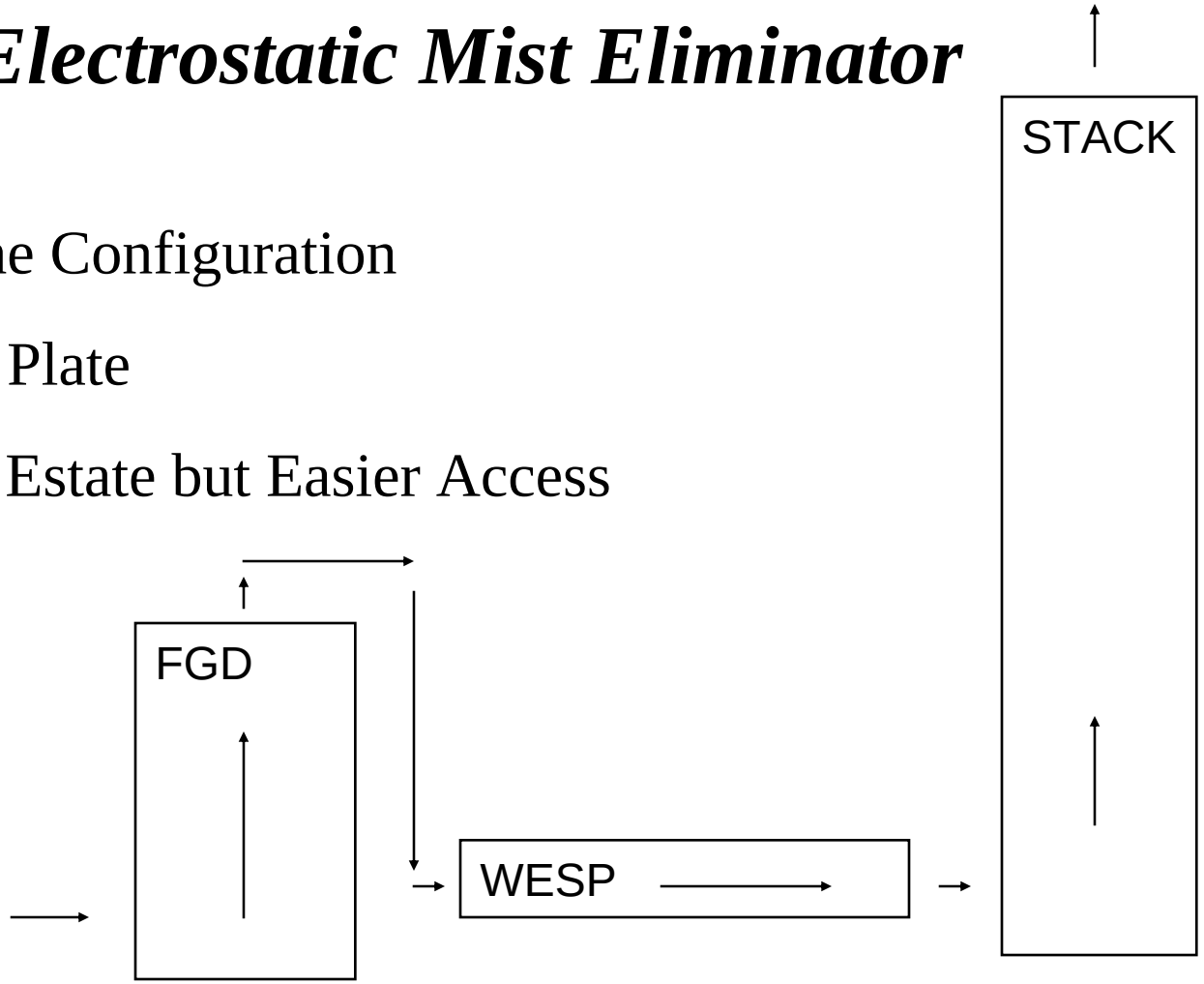
Wet Electrostatic Mist Eliminator

- Stand Alone Configuration
- Horizontal Plate
- More Real Estate but Easier Access



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Full Scale Installation

- Xcel's Sherco Station
- Units 1 & 2 750MW each
- Historic Opacity >40%
- 22 WESP Modules added
- New opacity <10%

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First Energy's Bruce Mansfield Plant

- 3 x 800 MW Coal-Fired Units
- Mid-High Sulfur Coal
- Existing Opacity >50%
- Opacity Required <20%
- Investigated Control of
  - PM2.5, SO_3, Hg
  - WESP Pilot Unit

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PM2.5 & SO_3 Test Results

	Sept/01 1 field	Nov/01 2 fields	Nov/02 2 fields	July/03 2 fields
PM2.5	79%	96%		93%
H2SO4	76%	92%	89%	88%

Note: WESP designed for 90% removal at 5,000 acfm
Testing performed at 8,000 acfm, 60% beyond design point

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Incremental Hg Removal Across FGD & WESP

	Inlet $\mu g/m^3$	FGD outlet	WESP Outlet	Total
Hg^p	4.37	80%	76%	95%
Hg^{++}	6.02	69%	86%	96%
Hg^o	2.55	-15%	18%	6%
Total Hg	12.94	62%	41%	78%

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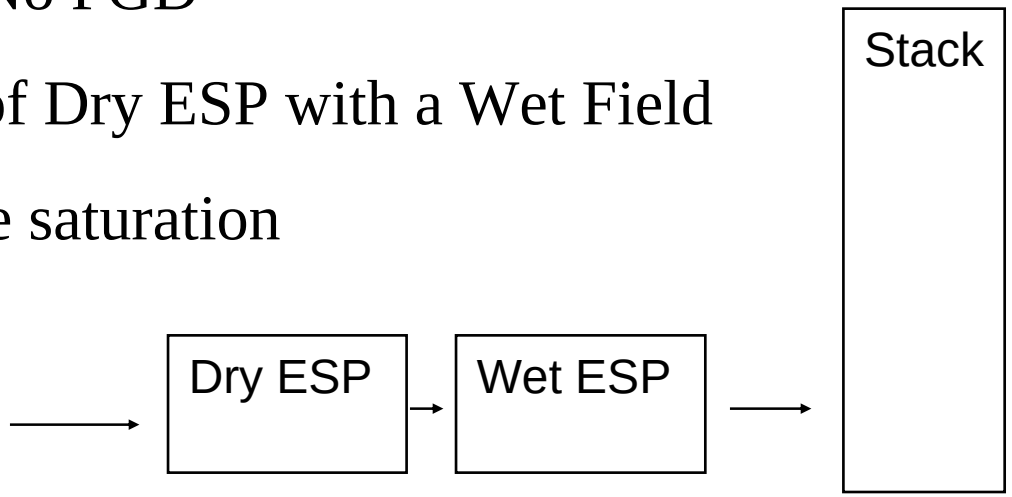
Hybrid Dry-Wet ESP™

Low Sulfur Coals-No FGD

Retro-fit last field of Dry ESP with a Wet Field

Operate 50°F above saturation



EPRI Pilot Testing-1995

Particulate matter:	95%
Sulfur dioxide:	20%
Hydrogen chloride:	35%
Hydrogen fluoride:	45%

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Hybrid Dry-Wet ESP Pilot

- Alabama Power
- Plant Miller
- PRB Coal
- SCR- Dry ESP
- 2 MW Slip-stream
- Horizontal Plate WESP

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Hybrid Wet ESP Pilot w/PEESP Hg Test Results

- Inlet Hg = 5.5 µg/m^3 – 6.3 µg/m^3
- 5 Test Runs
- Total Hg Removal = 34%-51%
- No Speciated Testing Performed
- Further Testing Nov/Dec 2005

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Comparison of Dry vs. Wet Approach

Dry Approach
Dry Scrubber/Baghouse

- Higher pressure drop-filters
- More fan capacity
- Flue gas above saturation -more volume
- Limited Coal Sulfur Content
- Dry waste by-product
- Larger volume of waste
- No water treatment required
- Higher operating cost

Wet Approach
Wet Scrubber/Wet ESP

- Lower pressure drop-open design
- Less Fan capacity
- Cools Flue gas to saturation - less volume
- Applicable for High Sulfur Coals
- Wet waste by-product
- Waste treated & concentrated
- Wastewater treated & recycled
- Lower operating cost

WESP Conclusions

- **Old, well-established technology**
- **Primarily for PM2.5 & SO_3 control**
- **High Removal Efficiencies –up to 99%+**
- **Opacity Reduction to <10%**
- **Offers Additional Hg, metal & SO_2 control**
- **Used on Mid-high sulfur coals with saturated flue gas**
- **Used on Low-sulfur coals with unsaturated flue gas**
- **Various Types & Configurations**
- **Low Pressure drop, maintenance & small footprint**
- **Improvements are reducing size, cost & Hg emissions**

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THANK YOU

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