Babcock Power Inc.

One Source *Many Solutions* *One Purpose*

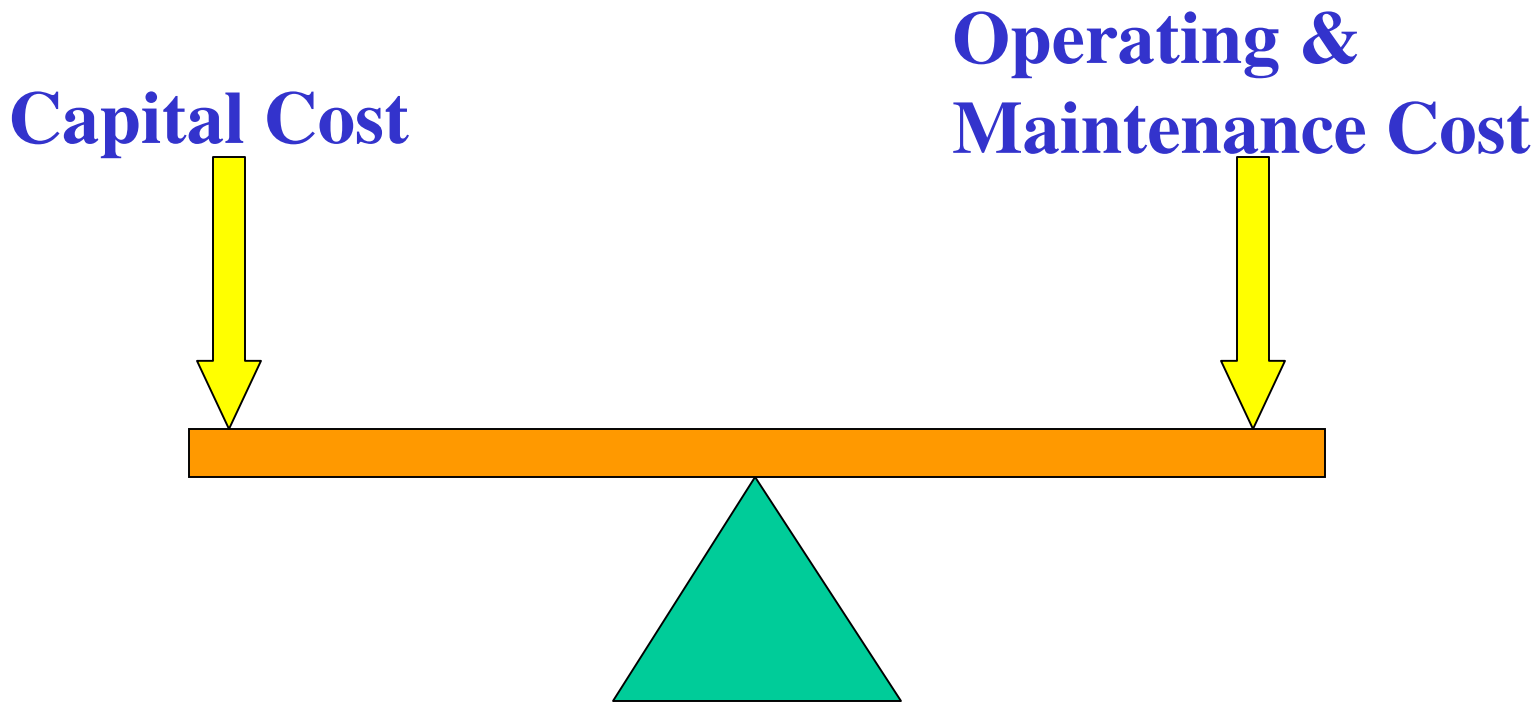
WPCA Scrubber Seminar

FGD Design and Operating Criteria

Tony Licata

Babcock Power Environmental Inc.

Total Cost



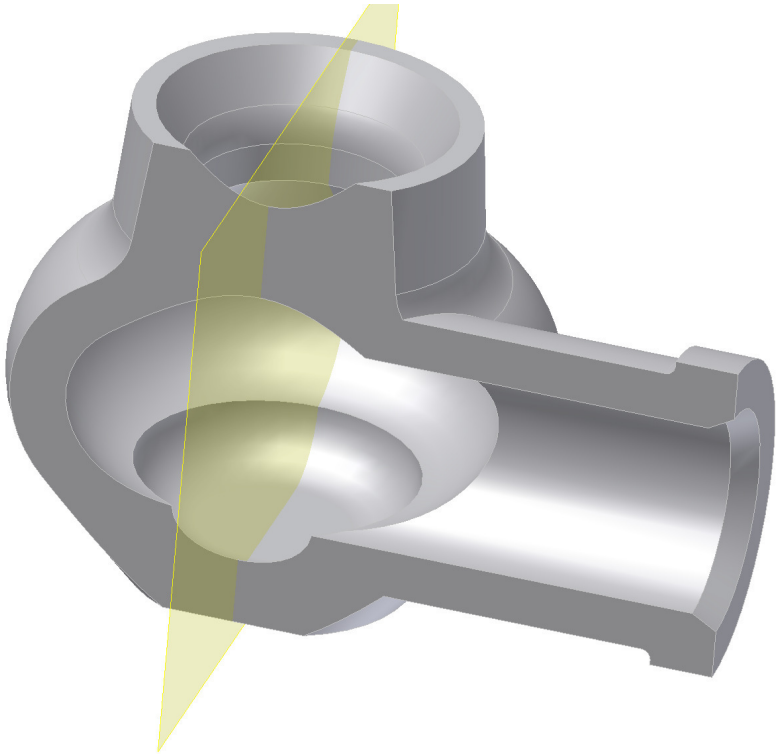
Wet Scrubbing Challenges

- Liquid to Gas Ratio
- Oxidation
- Chloride Concentration (Blowdown)
- Gypsum
- O&M
- Turndown

FGD Maintenance Challenges

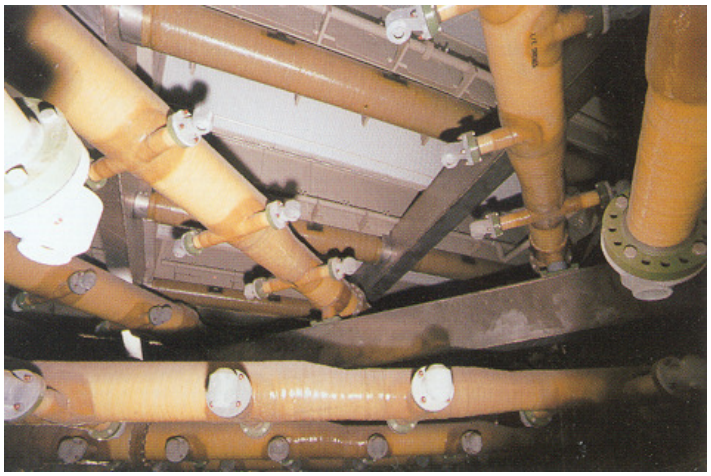
- Mist Eliminator Washing
- Plugged Nozzles/Lines
- Filtering Process
- Limestone/lime Storage-prep
- Cleaning/Safety
- Availability
  - Outage schedule
- Compliance

New nozzles tend not to plug

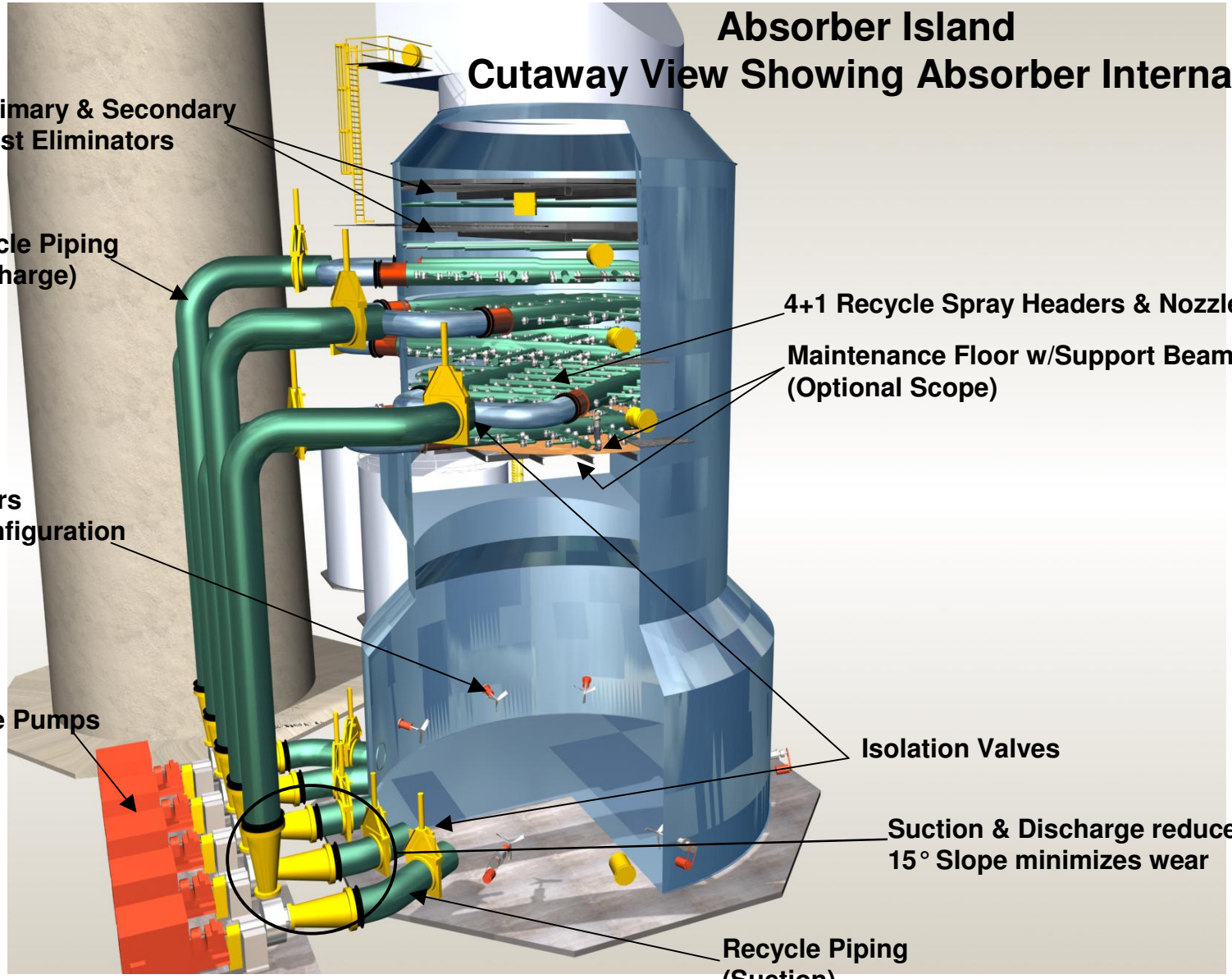


Old nozzle design – plugging problems

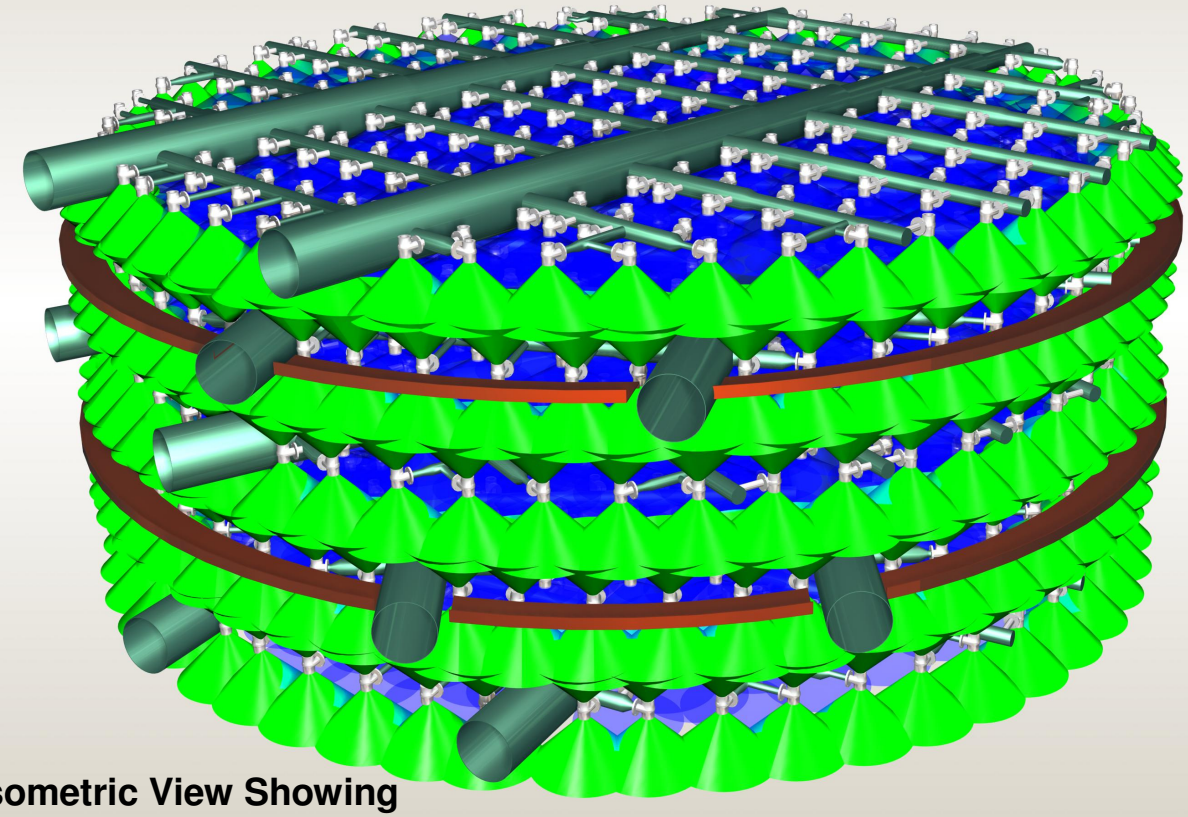
Absorber Internals



Absorber Island
Cutaway View Showing Absorber Internals

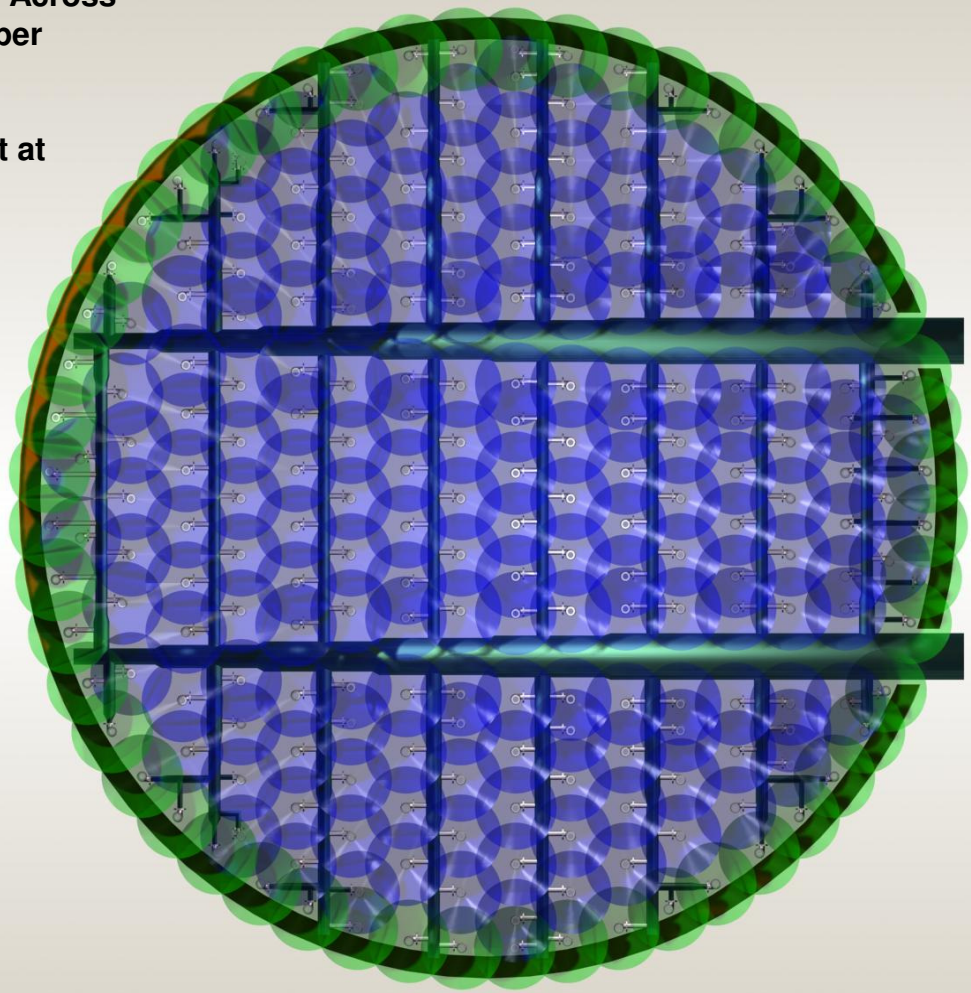


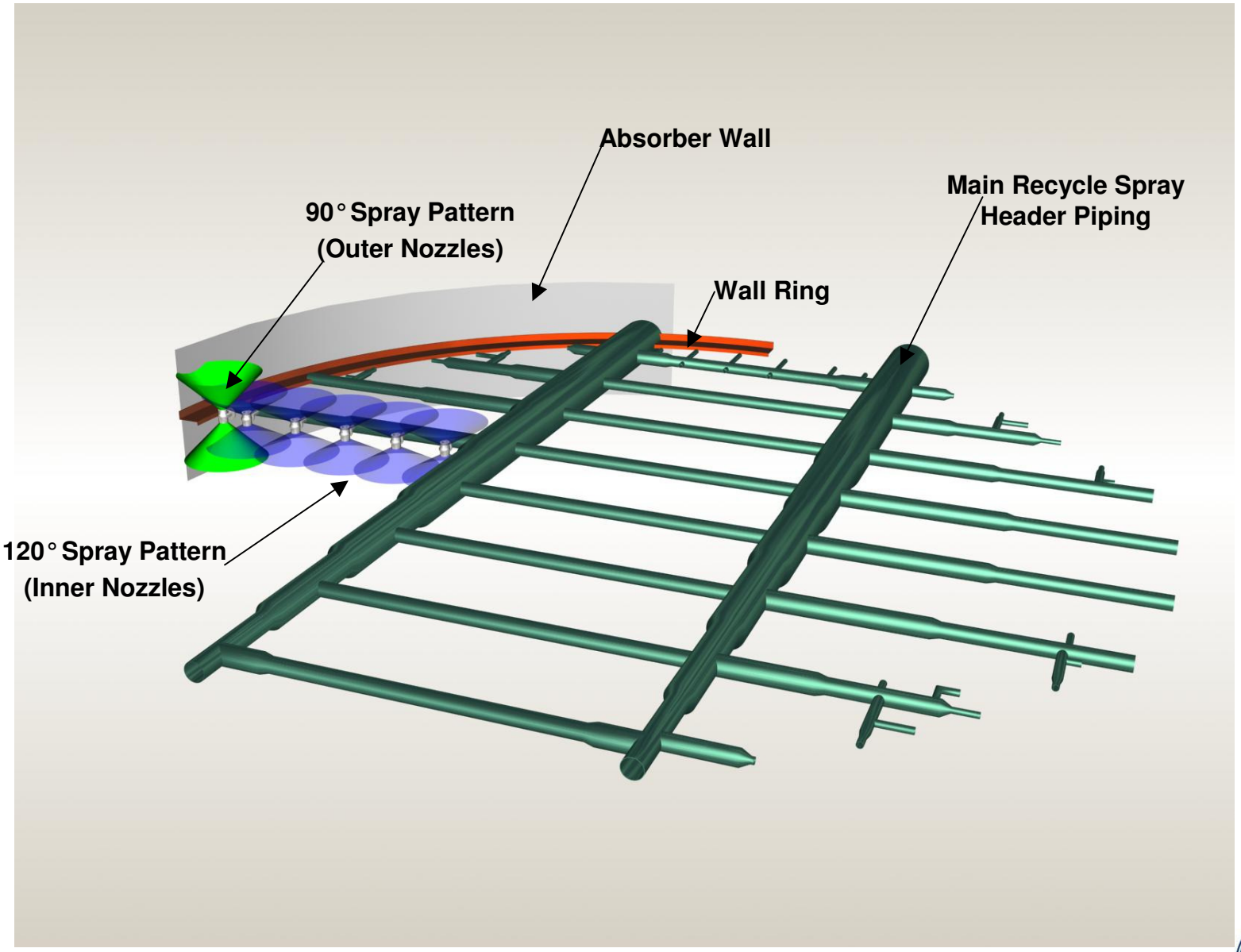
Note: All Elevations Spray In 2 Directions Except the Top Spray Level To Avoid Clogging of Mist Eliminators

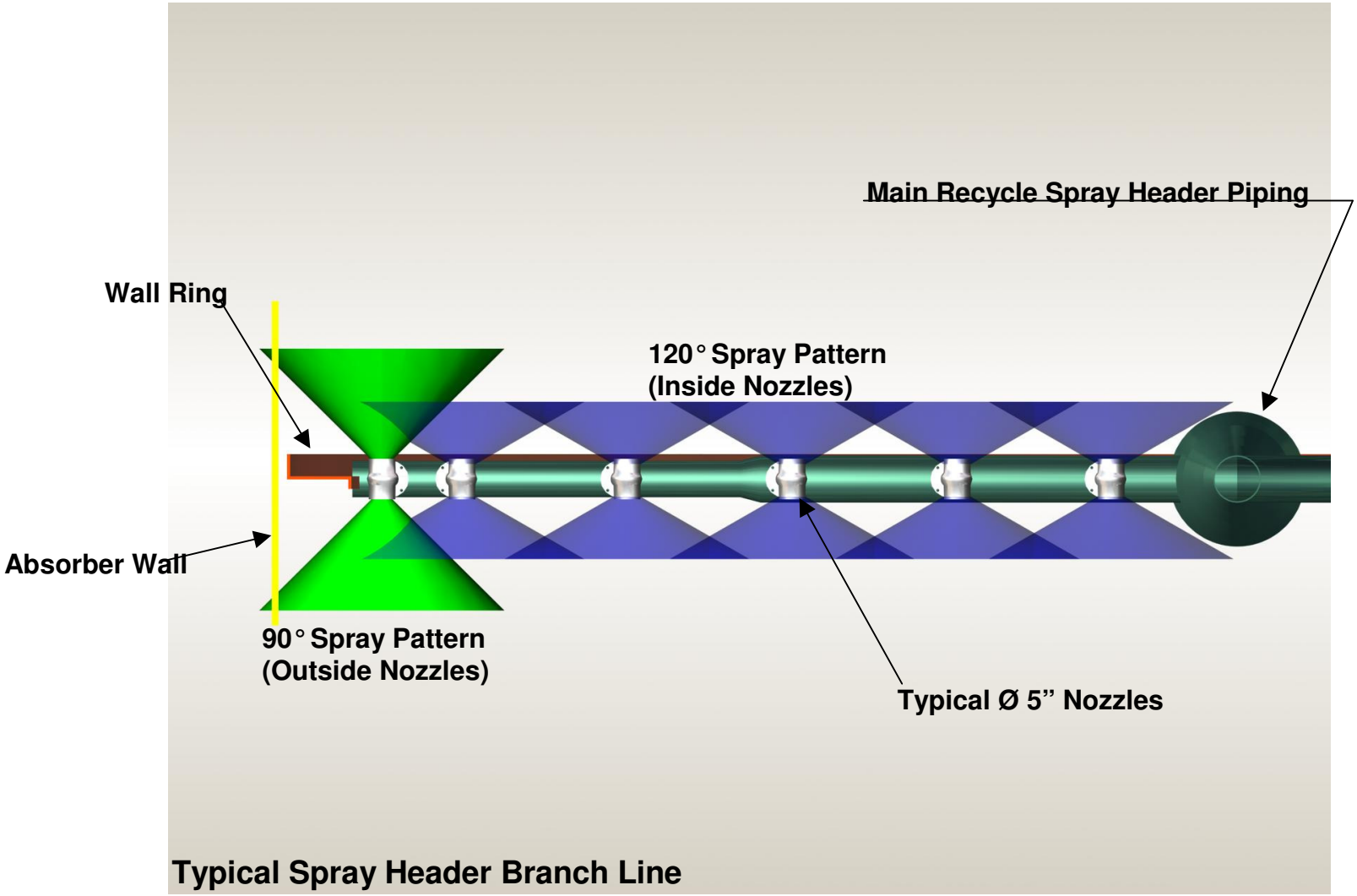


Isometric View Showing Spray Pattern Across Five Levels

- Spray Nozzles Arranged
  - To Provide Full Coverage Across The Section of the Absorber
- Outer Nozzles Arranged to Ensure Maximum Coverage And Reduce Impingement at The Absorber Wall

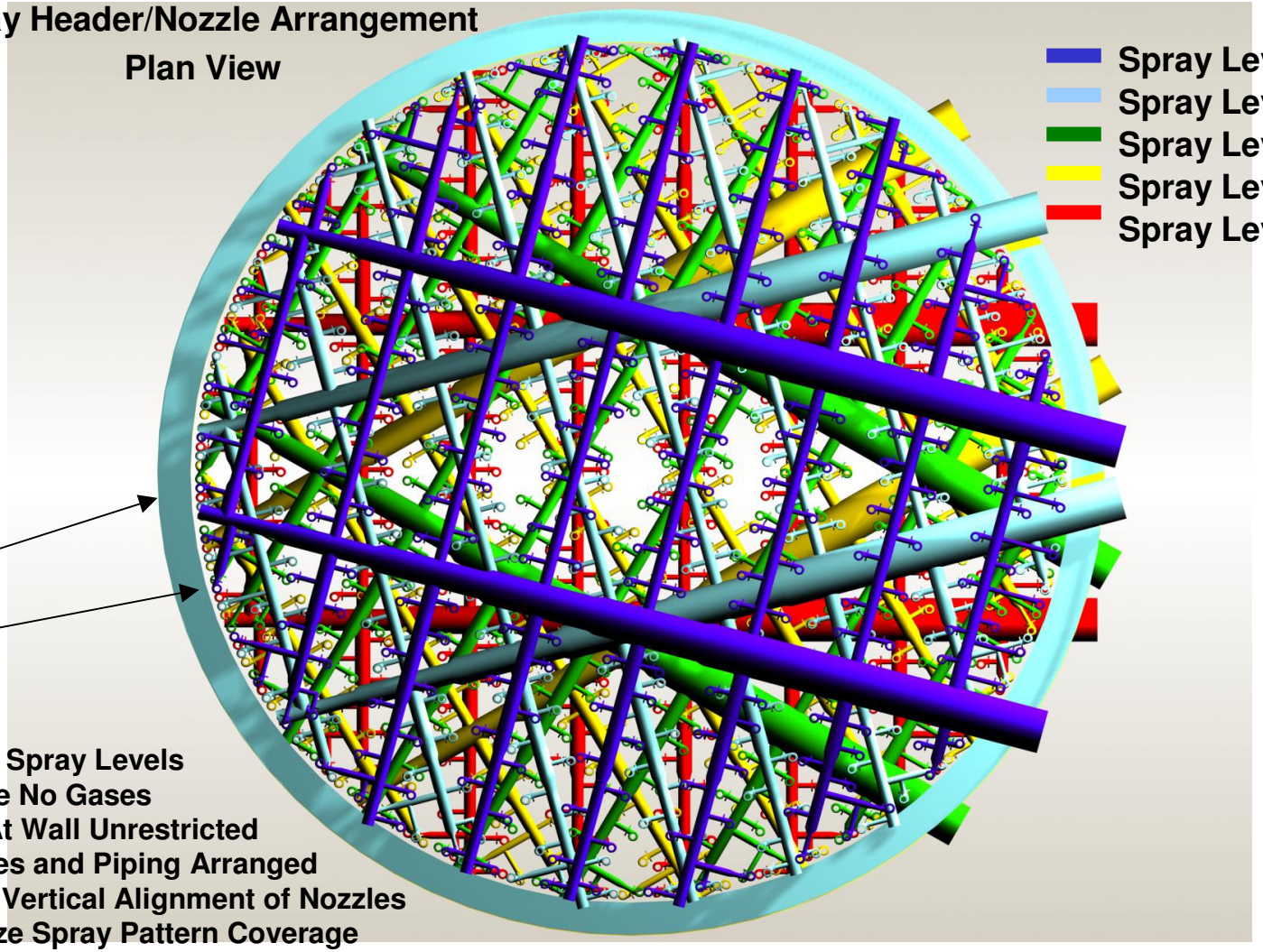






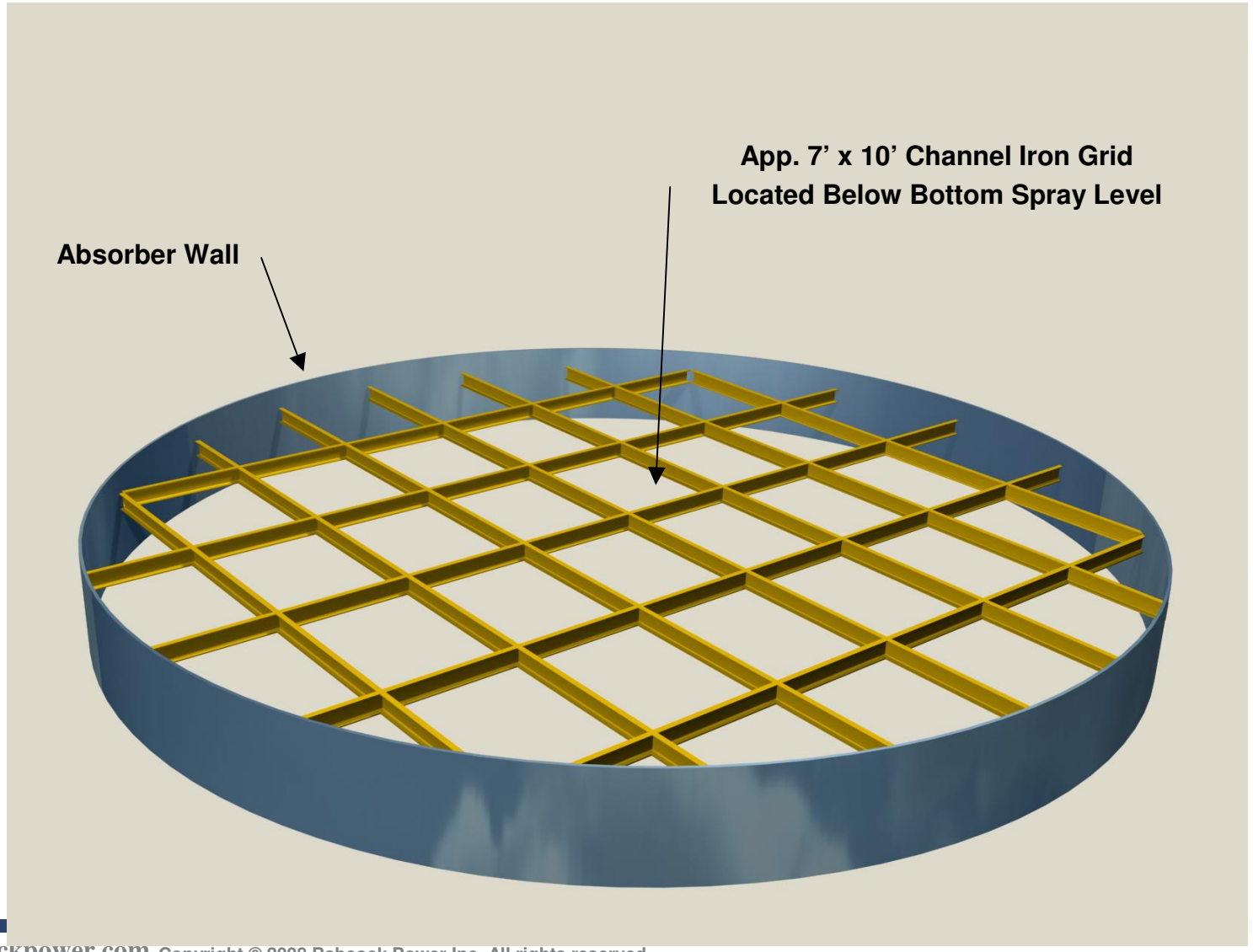
Typical Spray Header Branch Line

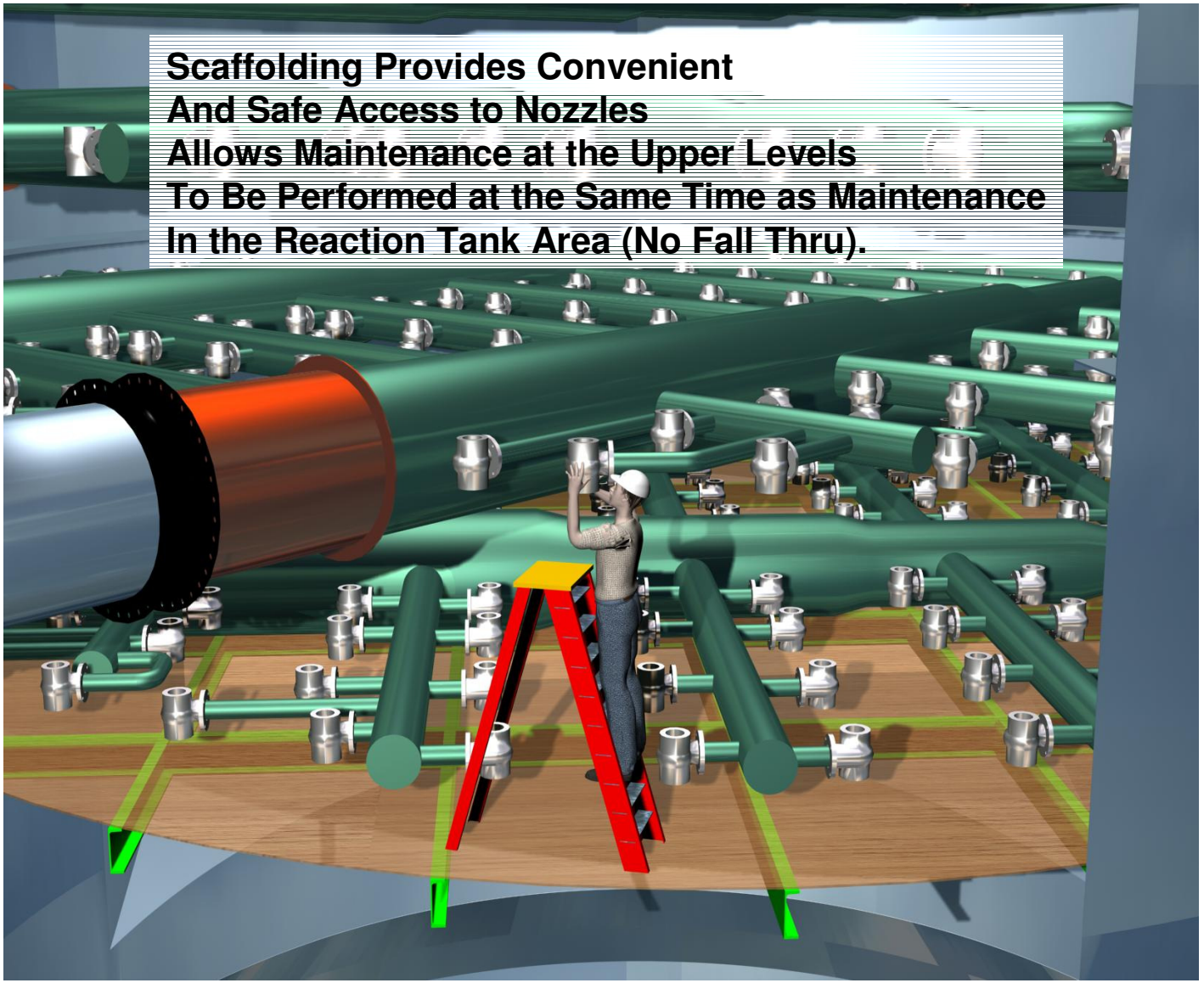
Spray Header/Nozzle Arrangement
Plan View



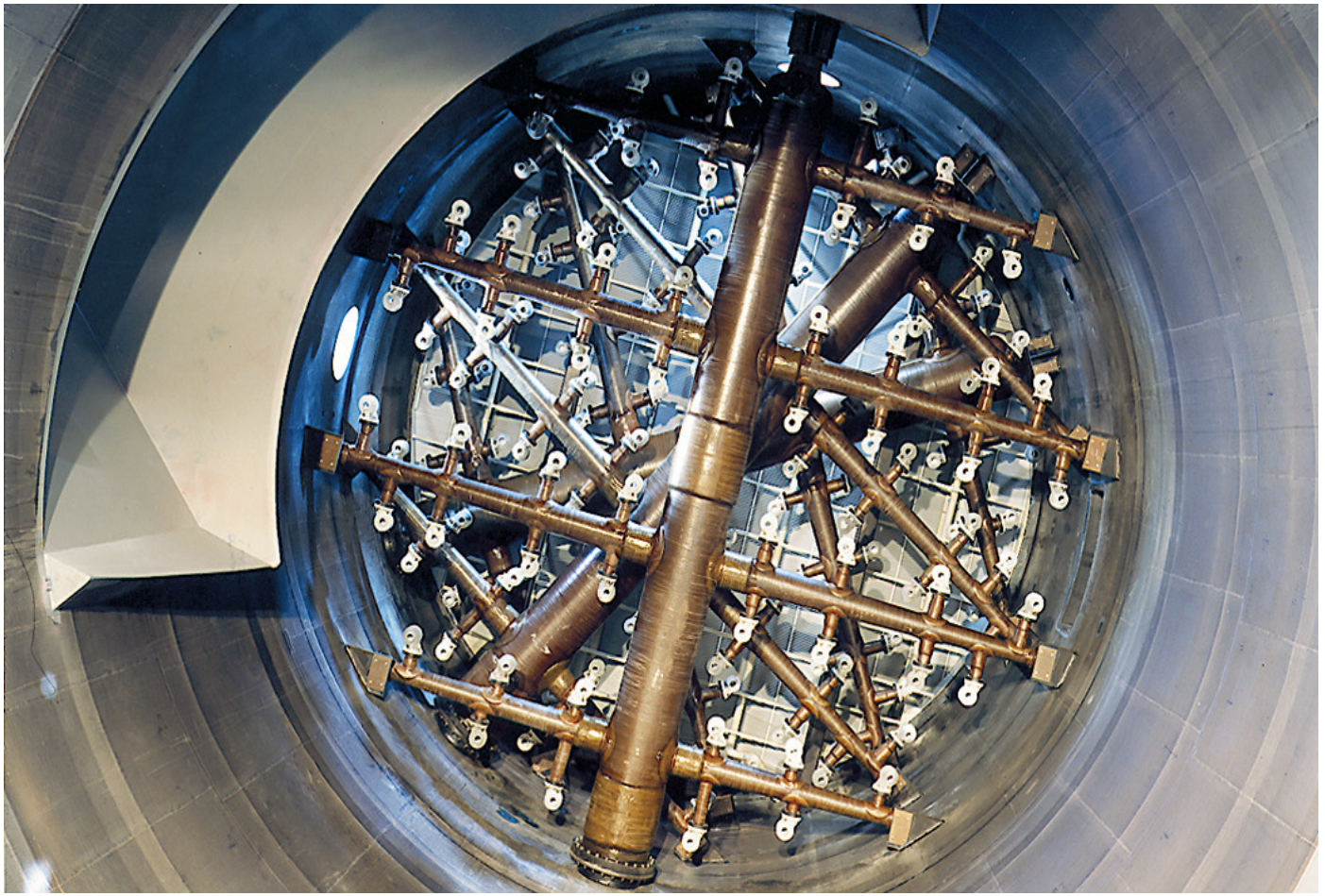
- Wall Ring @ Spray Levels 2 & 4 Ensure No Gases Flow Thru At Wall Unrestricted
- Spray Nozzles and Piping Arranged to Minimize Vertical Alignment of Nozzles and Maximize Spray Pattern Coverage

Maintenance Support Grid





FGD Absorber Internals



Weather Protected Limestone Storage and Feeding

Enclosed Ball Mill for Sound Protection and Maintenance in Cold Climate

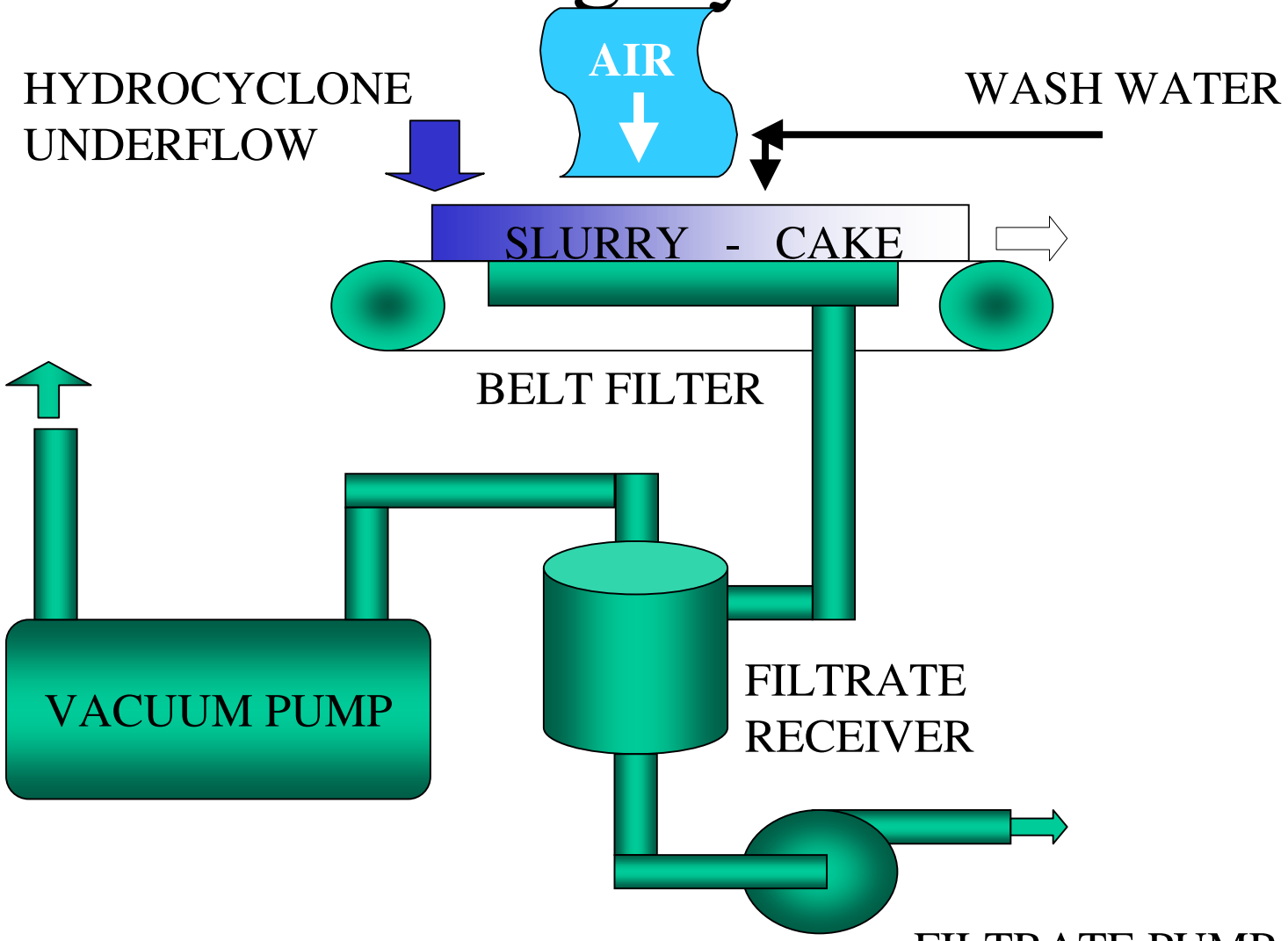
Outdoor Ball Mill

Warm Climate

Maintenance Crane

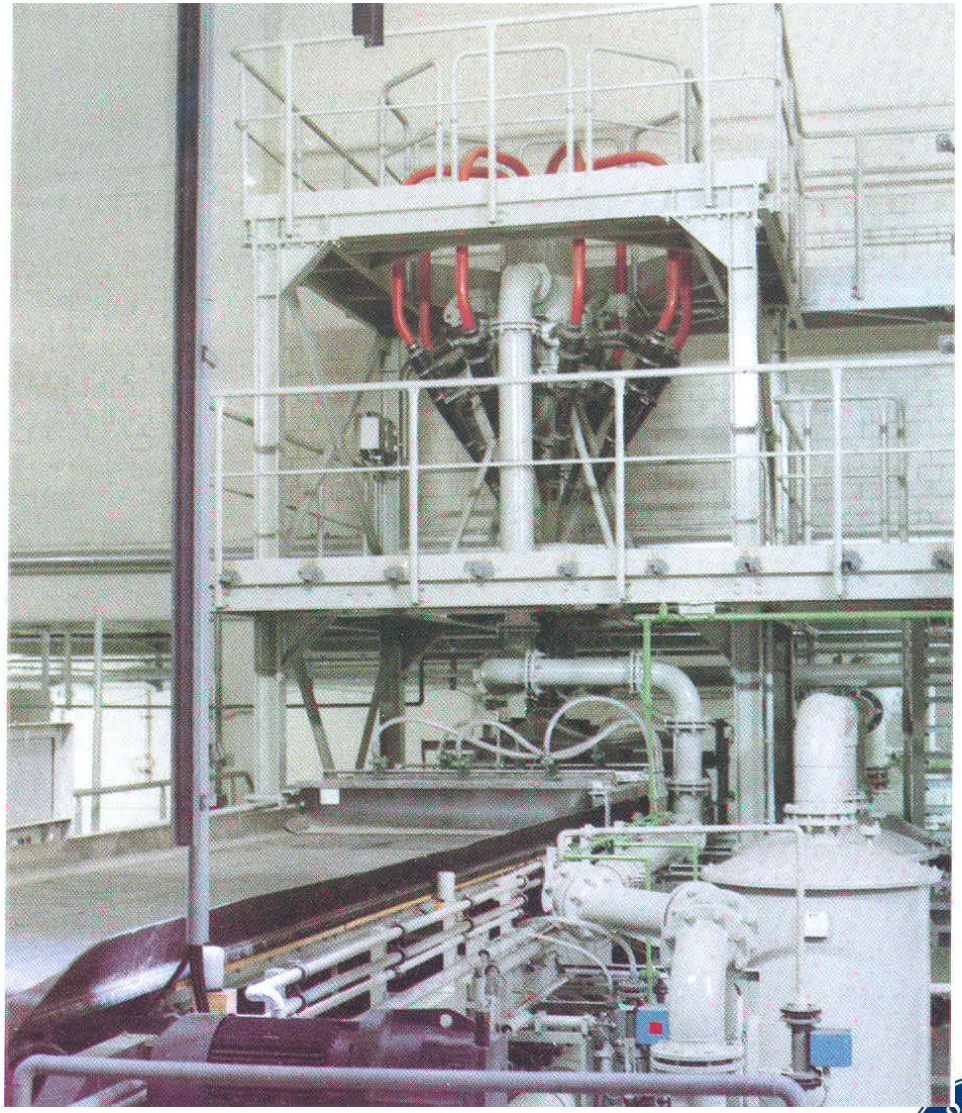
Oxidation Air Blowers in Sound Enclosure

Dewatering System



Gypsum Dewatering

Hydrocyclone & Belt Filter Arrangement



Power Optimization

Design Influence

- Recycle Pumps
- Fans – Gas Side DP
- Oxidation Air Blowers
- Limestone Grinding Mills

Operational Influence

- On-line Optimization
- Automatic and in Real Time

Power Optimization
Oxidation & Agitation

- **Tank Sizing**
  - **Limestone Dissolution**
  - **Oxidation**
    - **Mixing**
    - **Residence Time**
  - **Reaction Completion**
    - **De-supersaturation**
  - **Gypsum Crystal Growth**
    - **Size**
    - **Shape**
- **On-line Monitoring**

Power vs. SO_2 Removal

750 MW East. Bituminous Coal

Wet FGD Power Usage

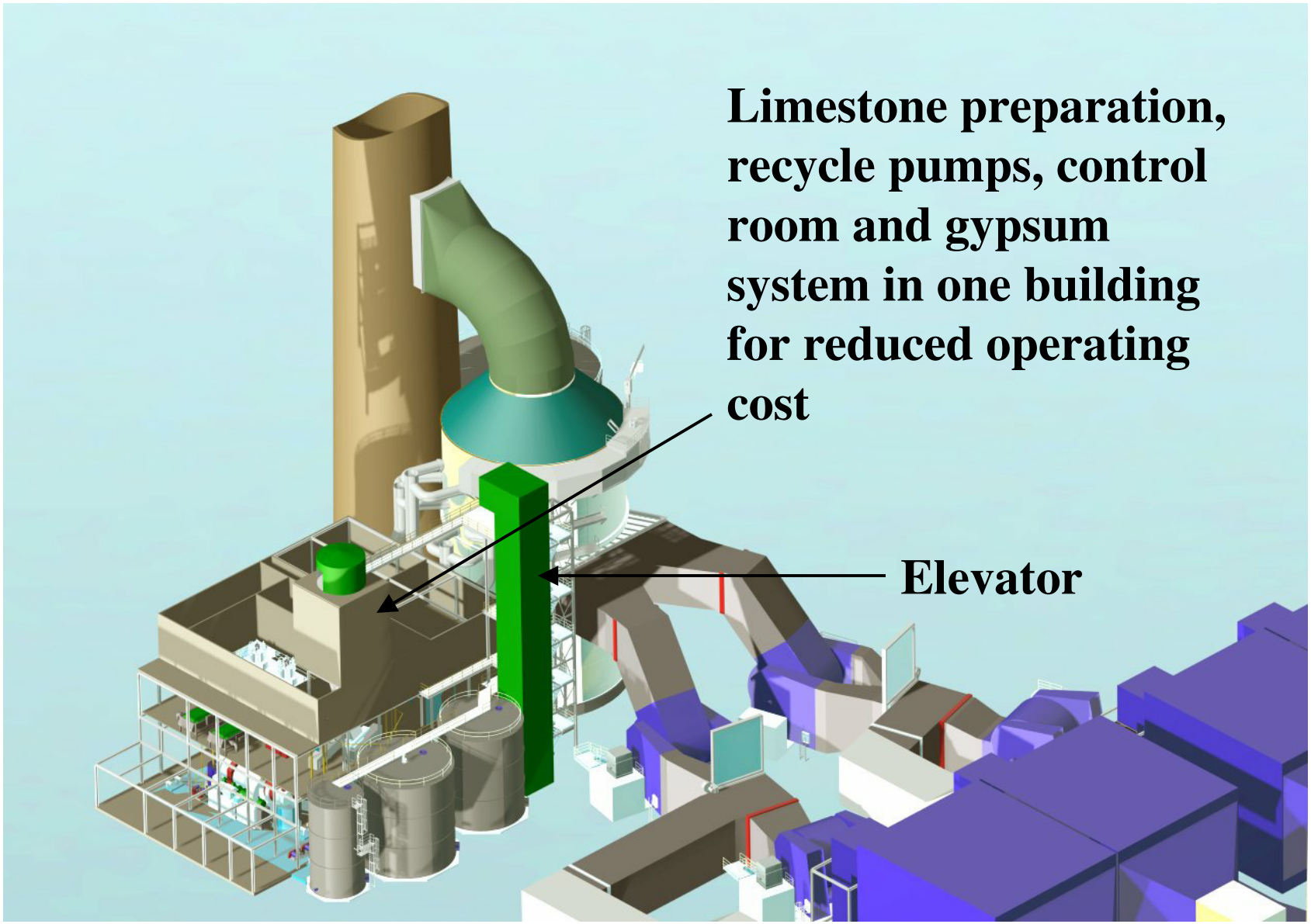
		SO_2 Removal		
		95%	97%	99%
Booster Fan	kW	4,253	4,593	5,303
Recycle Pumps	kW	4,160	4,593	6,961
Oxidation Air Blowers	kW	2,315	2,556	3,500
Ball Mills	kW	1,614	1,648	1,682
Others	kW	2,660	2,710	2,772
total	kW	14,572	16,100	20,218

Operation and Maintenance

Layout Impacts Number of Operating Personnel

O & M Criteria

- **Safety**
- Balance between initial capital cost vs. long-term operating cost
- Plant availability/redundancy
- Operating economics
  - Elevators vs. stairs
  - Weather encloses
- Wash down/Cleaning
  - Drains/pits/pumps
- All in one building



Isolation Valves for Pump Maintenance

All pumps in straight line/overhead cranes

Note wide maintenance aisles

Floor drains

Overhead crane for maintenance

Room between pumps for forklift

Overhead cranes

Recycle pump screens to prevent pump wear and nozzle plugging

Operational WFGD Testing Requirements

Test Description	Test Method
pH	EPRI – C1
Density	EPRI – D2
Wt % of Solids	EPRI – F3
Chemical Composition – Sulfate	EPRI – L2
Chemical Composition – Sulfite	EPRI – M1
Chemical Composition – Carbonate	EPRI – N3
Particle Size	EPRI – G1
Crystal Water	ASTM C471M
Residual Moisture	ASTM C471M
Chloride	EPRI– I3

Operational WFGD Testing Requirements

	Frequency of Sampling	pH	Density	Wt% of Solids	Chemical Composition of Solids SO_4 SO_3 CO_3 Inert	Particle Size Distribution	Cl- Content
Slurry Recycle	1x per day	X	X	X	X	X (2/week)	X
Gypsum Slurry	1x per week		X	X	X	X	--
Gypsum	1x per week				X	X	X
Limestone Slurry	1x per week	X	X	X	X	X	X
Limestone	Weekly composite				X		
Ball Mill Hydrocyclones						X	
Make Up Water	1x per week	X					X
Waste Water	1x per week	x		X			X

Operational WGFD Testing Manpower

- Man-hours per absorber 14.5 hours / week
- Man-hours plant common systems
  - Reagent system 15.5 hours / week
  - Water system 4.5 hours / week
  - Gypsum byproduct 4 hours / week
- Man-hour estimate 2 absorbers and common systems 53 hours
- Man-hour estimate 2 absorbers and common systems 2756 hours

Periodic Mechanical Inspection

- Pumps – Check
  - Oil level
  - Seal leakage
  - High vibration
  - Belt tension
  - Bearing temperature
  - Alignment
- Agitators – Check
  - Oil level
  - High vibration
  - Gland seal water leakage
- Strainers
  - Differential pressure each shift, clean if high

Periodic Electrical Inspection

- Motors – Check
  - Bearing temperature
  - Insulation resistance
  - Bearing vibration
  - Brush wear
  - Slip ring roughness
  - Motor heater current
  - Clean parts of carbon dust
- Electrical
  - Annual inspection or per manufactures instructions
- Relays
  - Differential pressure each shift, clean if high
- Instrumentation
  - Per manufactures instructions

Periodic Maintenance Manpower

- Man-hours per absorber 20 hours / week
- Man-hours plant common systems
  - Reagent system 20 hours / week
  - Assist with Operational Testing 20 hours / week
- Man-hour estimate 2 absorbers and common systems 80 hours
- Man-hour estimate 2 absorbers and common systems 4160 hours

Operation and Maintenance Manpower

- WFGD Operator, current control room operator from each unit will monitor and control
- Assistant WFGD Operator, one required for plant, perform WFGD operational testing
- Maintenance Mechanic, two required for plant, perform periodic maintenance and assist with testing

Scheduled Outage Inspection

- Absorber Tank
  - Inspect for corrosion, scale and deposits
  - Remove loose material
  - Map location of deposits
  - Repair lining as needed
- Spray Headers and Nozzles
  - Check spray nozzles for plugging and map
  - Clean or replace nozzles as necessary
  - Check headers for erosion
- Mist Eliminators
  - Check for damage or deposits
  - Check wash system for valve function and coverage
- Reagent Preparation
  - Inspect and repair in accordance with manufactures' instructions

Outage and Maintenance Costs

- Estimated outage (3 yr) cost $250,000 / absorber including
  - Absorber scaffolding
  - Sump cleaning
  - Absorber vessel and header repairs
- Estimated yearly maintenance cost $150,000 / absorber including
  - Agitator parts
  - Recycle pump rebuilds
  - Misc. pump rebuilds

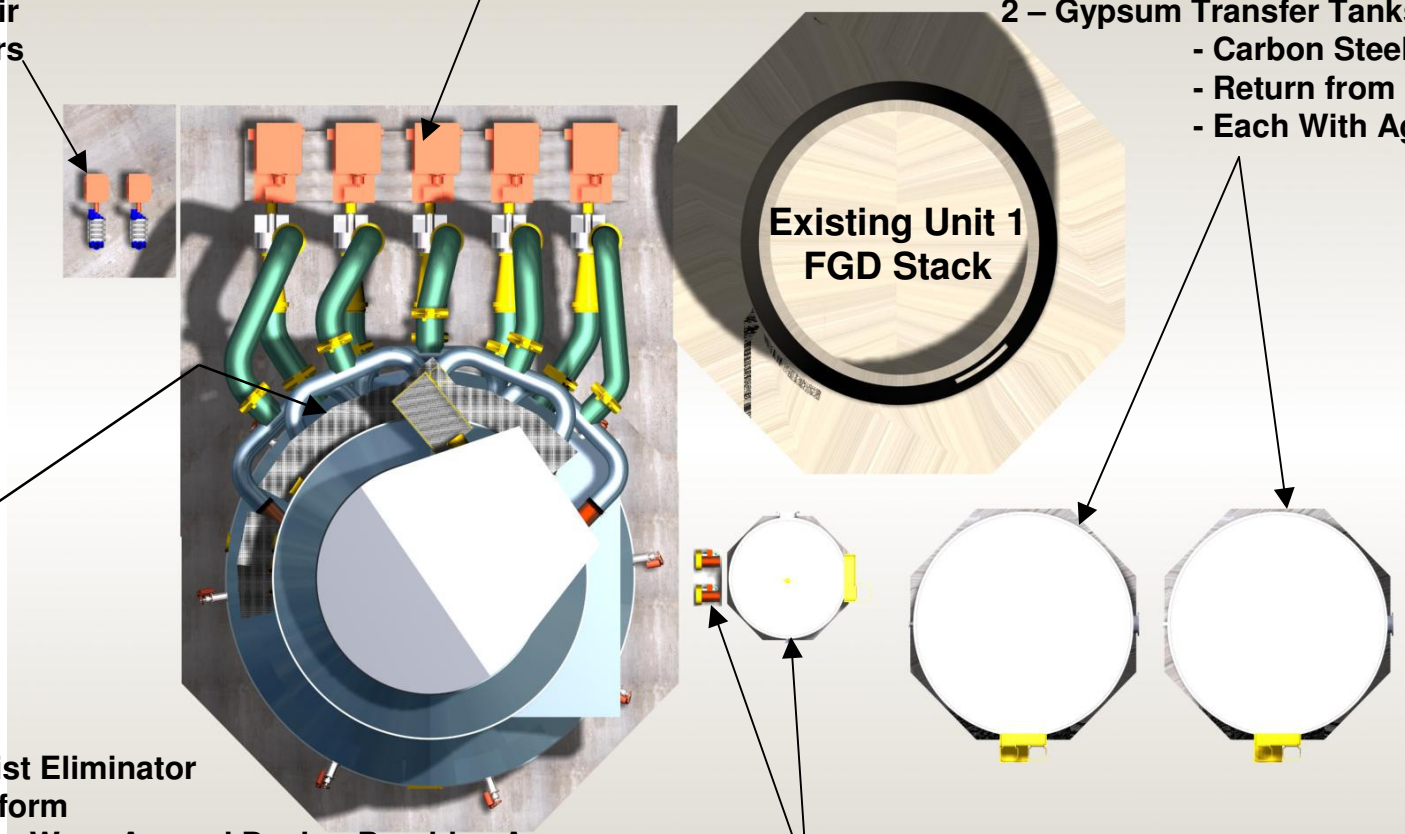
Owners Decisions

- Redundancy
  - Pumps
  - Ball Mills – 3 x 50% or 2 x 100%
  - Dewatering
  - Spares
- Organic Acids
- Waste Water
- Gypsum Markets/landfilling

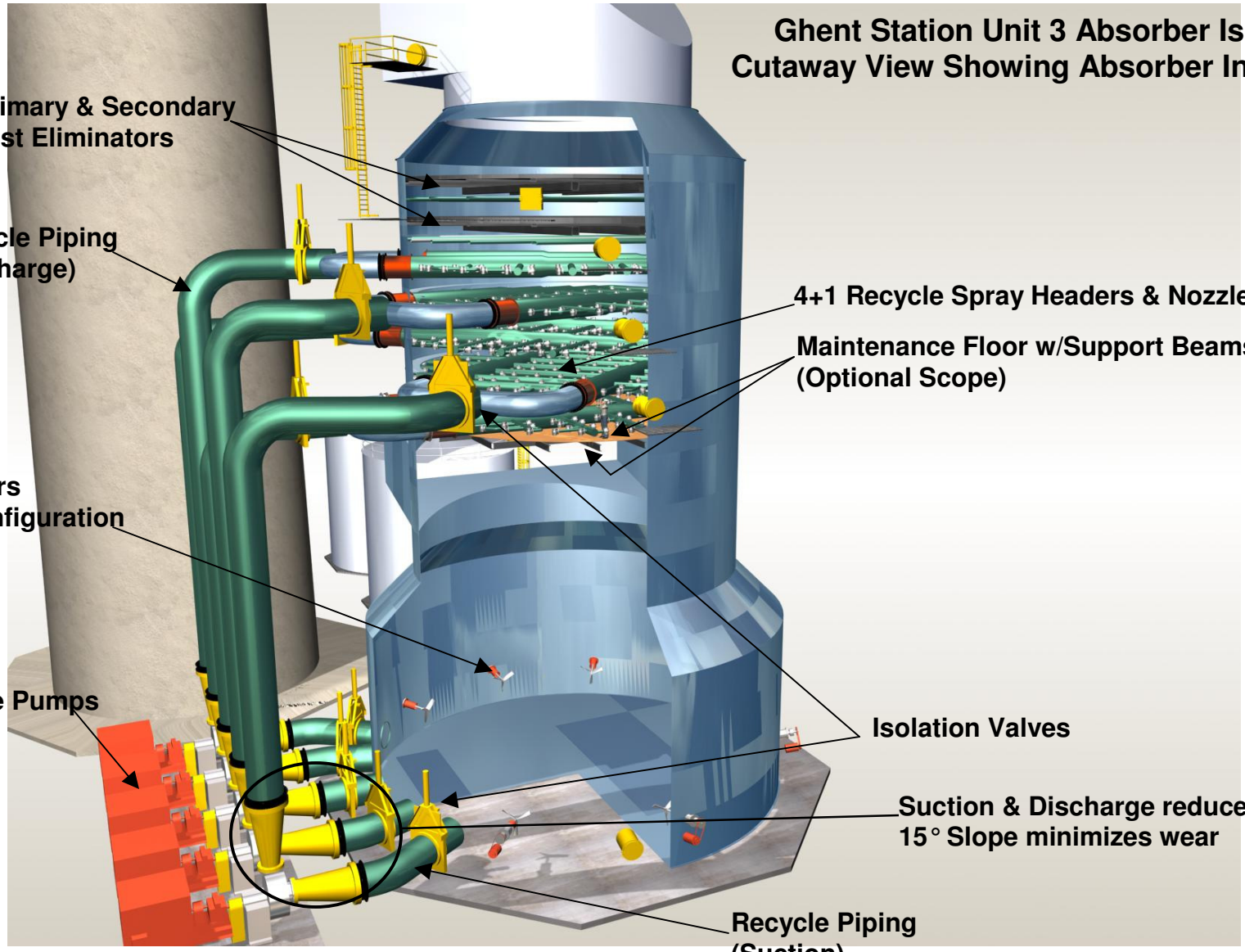
Absorber Access

- **Safety First**
  - Confined Space
  - Fall Protection
  - Personal Safety Equipment
  - Working Conditions: Lighting, GFIs, Tools, Noise, Welding. Flash Protection, etc.
- Maintenance
  - Minimize outage time
  - Simple PM programs
  - Easy access for service and cleaning

Ghent Station Unit 3 Absorber Island
Plan View



Ghent Station Unit 3 Absorber Island
Cutaway View Showing Absorber Internals



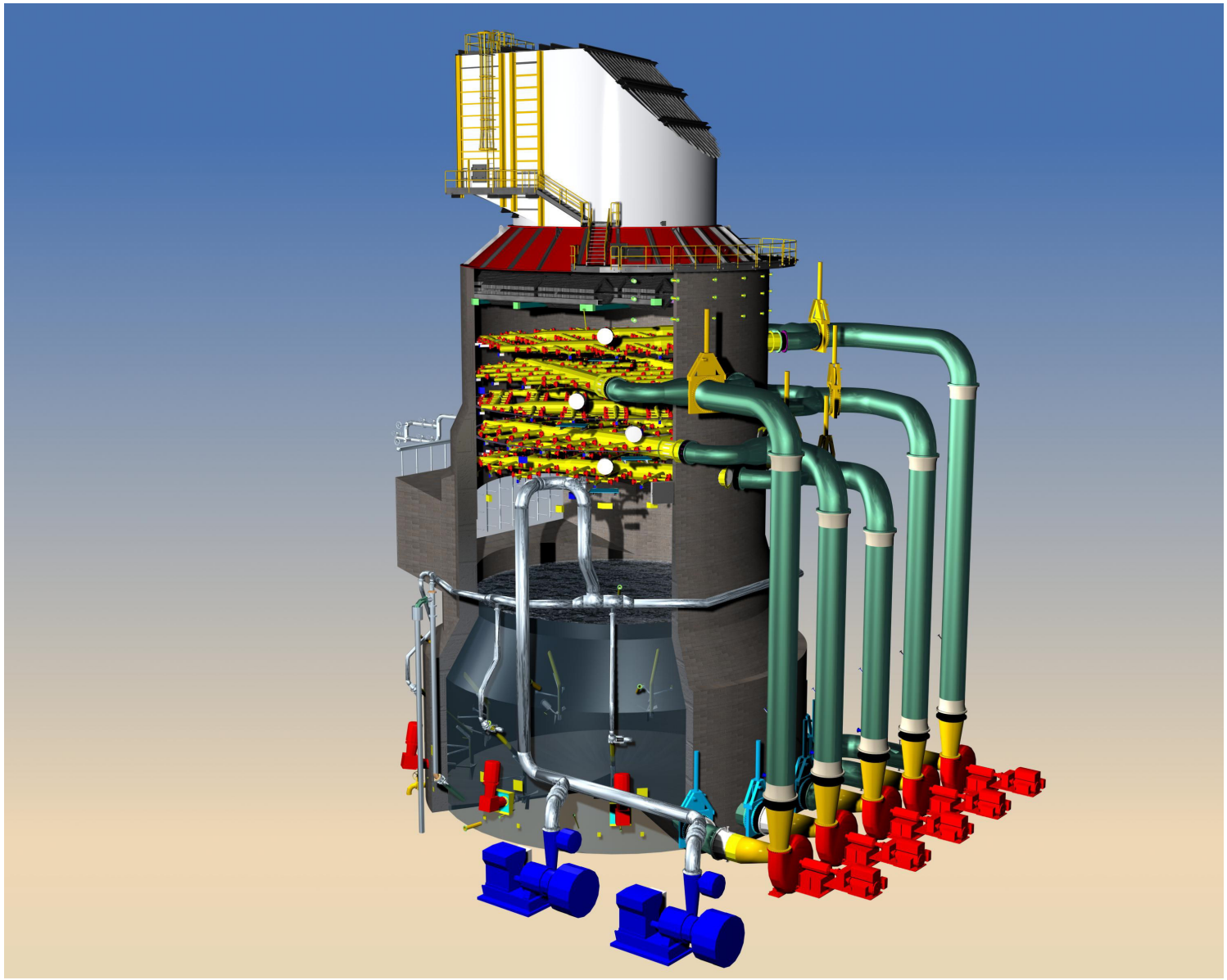
Equipment Delivery

In Weeks

Commodity	2003	2008
Structural Shapes	8-12	20-24
Recycle Pumps	26-30	56
Ball Mills	26-30	75
ID Fans	72	64
SCR Catalyst	46-48	52-54

What are can be done to shorten time line ?

- Qualifying new vendors
- Packaging components
- New construction techniques
- Standard designs
- New design tools



Thank You

Questions ??