

Reinhold Environmental Ltd.



***2007 APC Round Table & Expo
Presentation***

***July 8-10, 2007
Chattanooga, TN
Hosted by TVA***

Babcock Power Inc.



One Source

Many Solutions

One Purpose

WPCA Scrubber Seminar

FGD Design and Operating Criteria

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Babcock Power Environmental Inc.



Wet Scrubbing Challenges

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



Wet FGD Challenges

- Materials of Construction
 - Vessels and headers
- Plugged Nozzles/Lines
- Mist Eliminator Washing
- Filtering Process
- Limestone/lime Storage



O & M Issues

- **Safety**
- Environmental Compliance
- Plant Availability
- Operating Cost
- Cleanliness

PAY ME NOW OR PAY ME LATER

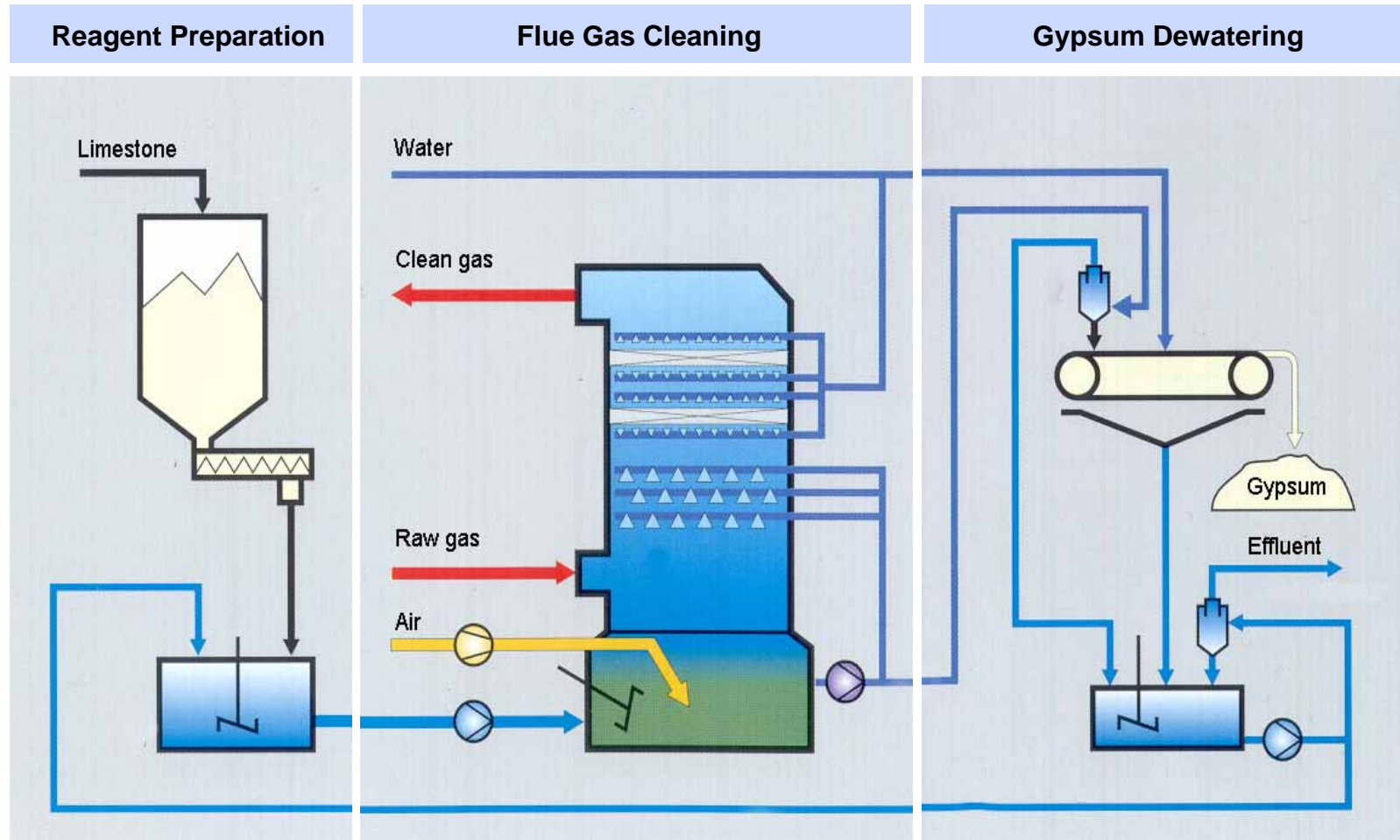


O & M Designs

- Flue gas at 300°F and hot water at 135°F
- pH environment from 1 to 12
- Noise
- High pressure air
- Slippery and slimy
- Lots of water and slurry
- Heights



WFGD Process Flow Diagram



Limestone / Gypsum will dominate utility applications





Gypsum storage silos

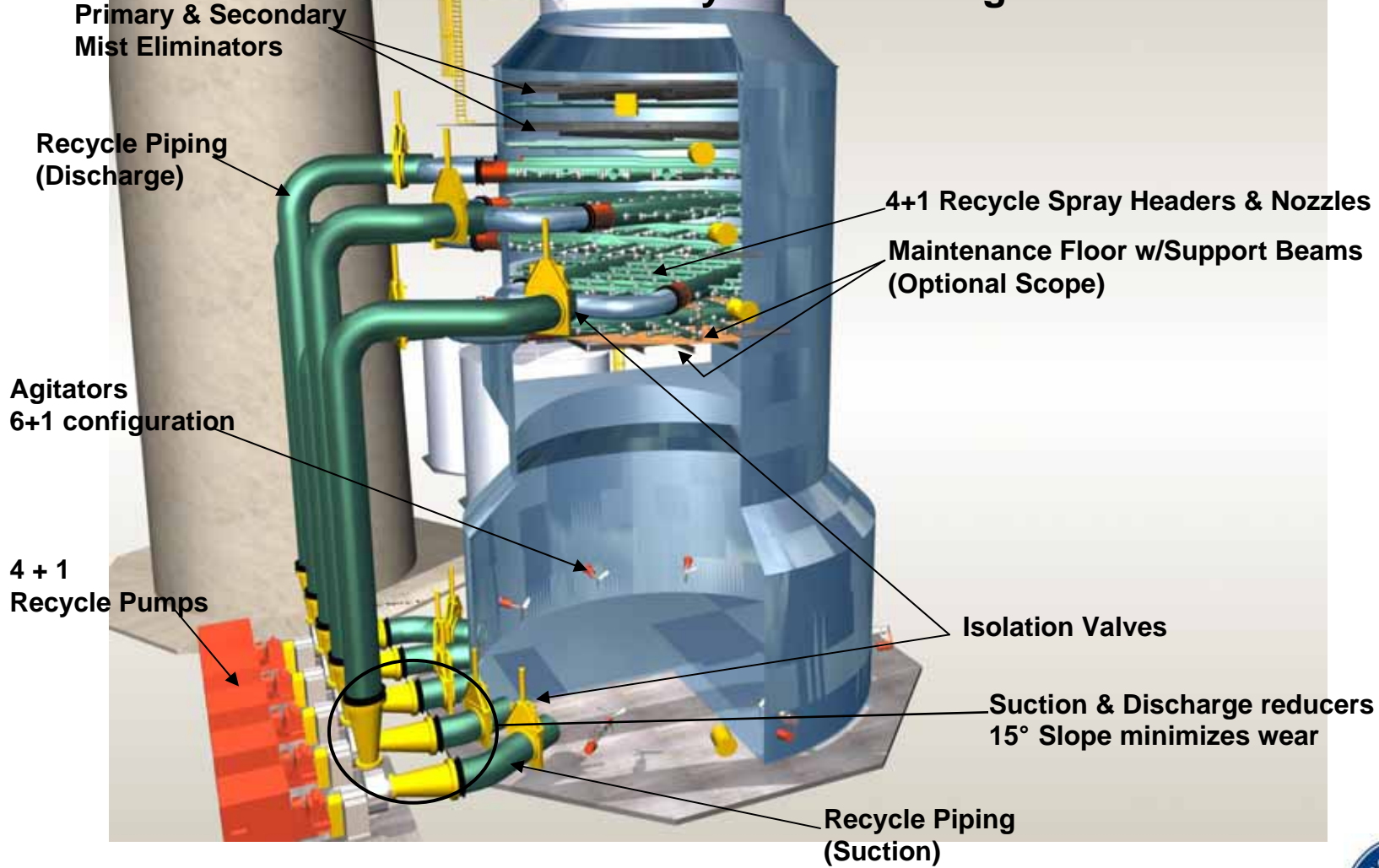
Ball mills and
recycle pumps

Limestone unloading &
Storage

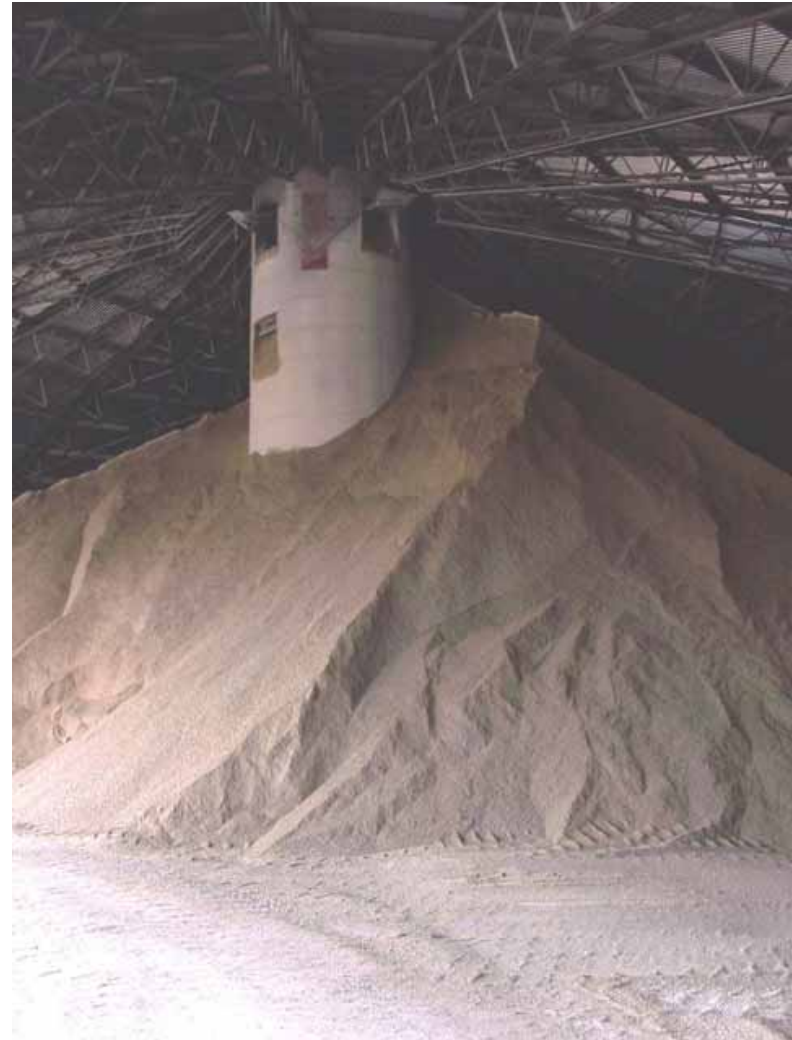
Gypsum loading barge



Absorber Island Cutaway View Showing Absorber Internals



Weather Protected Limestone Storage and Feeding



Enclosed Ball Mill for Sound Protection and Maintenance in Cold Climate



**Outdoor Ball Mill
Warm Climate**

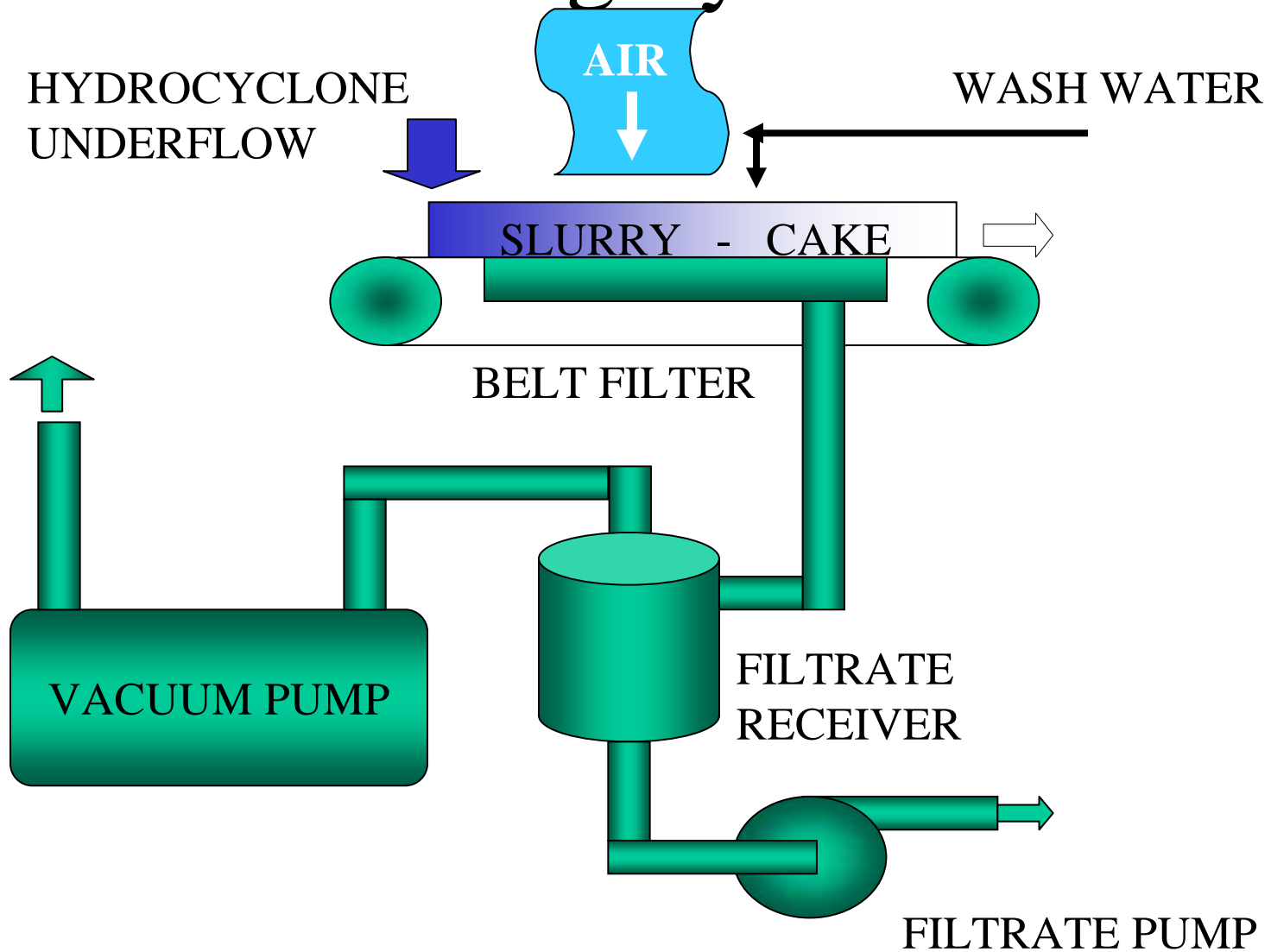
Maintenance Crane



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. SO₂ Removal

750 MW East. Bituminous Coal

Wet FGD Power Usage

		SO ₂ Removal		
		<u>95%</u>	<u>97%</u>	<u>99%</u>
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	<u>14,572</u>	<u>16,100</u>	<u>20,218</u>



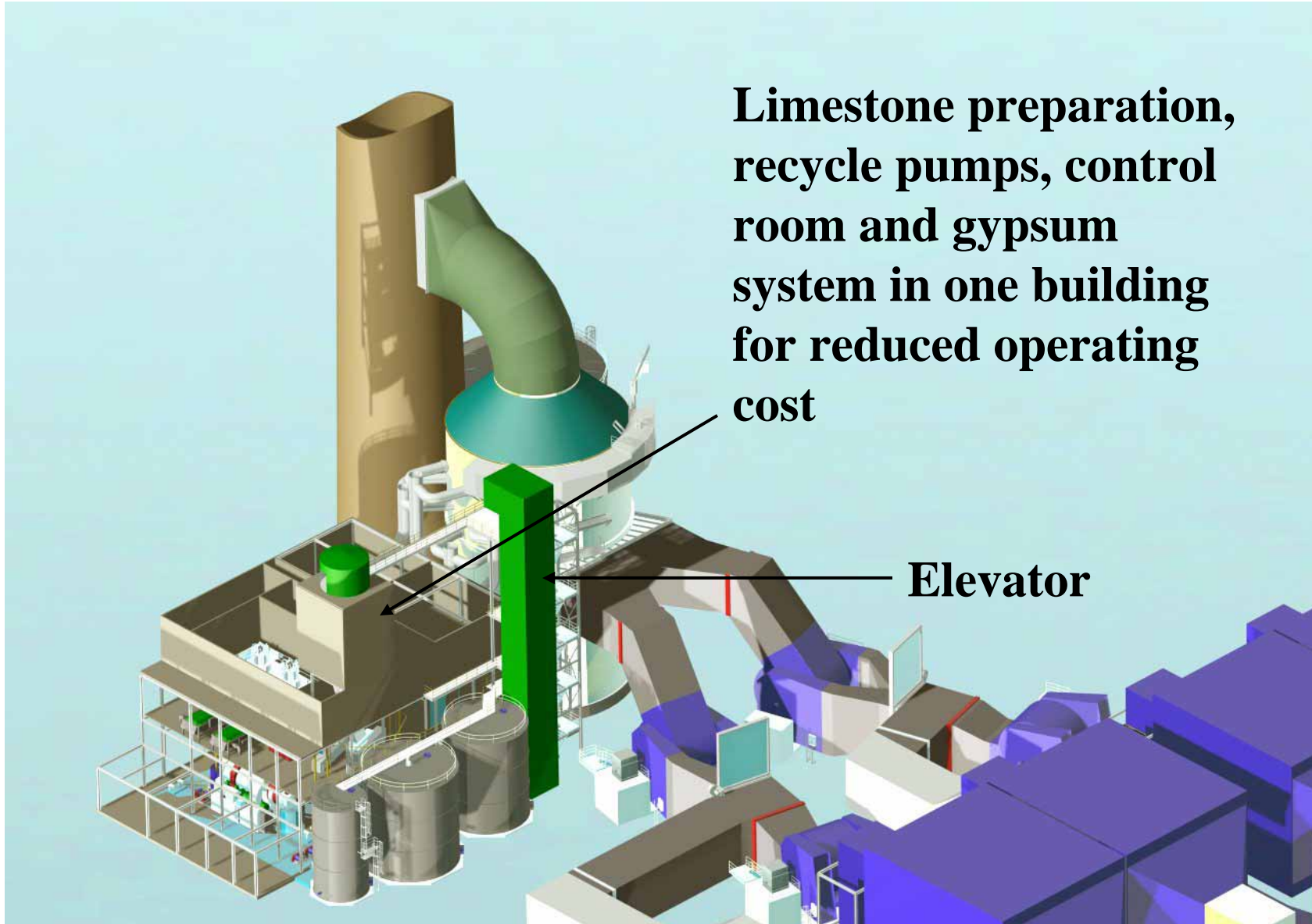
Operation and Maintenance



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





**Limestone preparation,
recycle pumps, control
room and gypsum
system in one building
for reduced operating
cost**

Elevator





Isolation Valves for Pump Maintenance



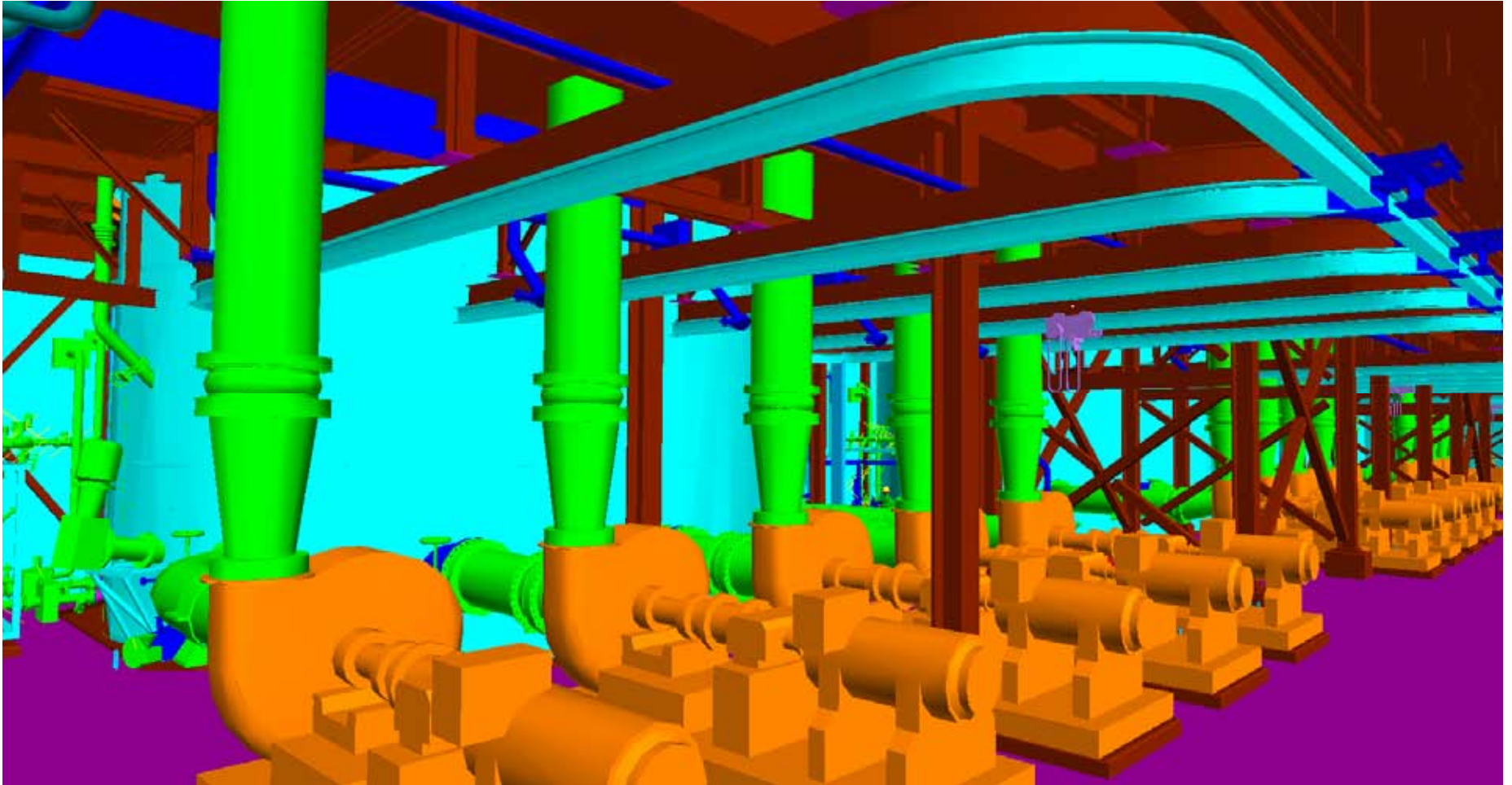
All pumps in straight line/overhead cranes



**Note wide
maintenance
aisles**

Floor drains





**Overhead crane for
maintenance**

**Room between
pumps for forklift**



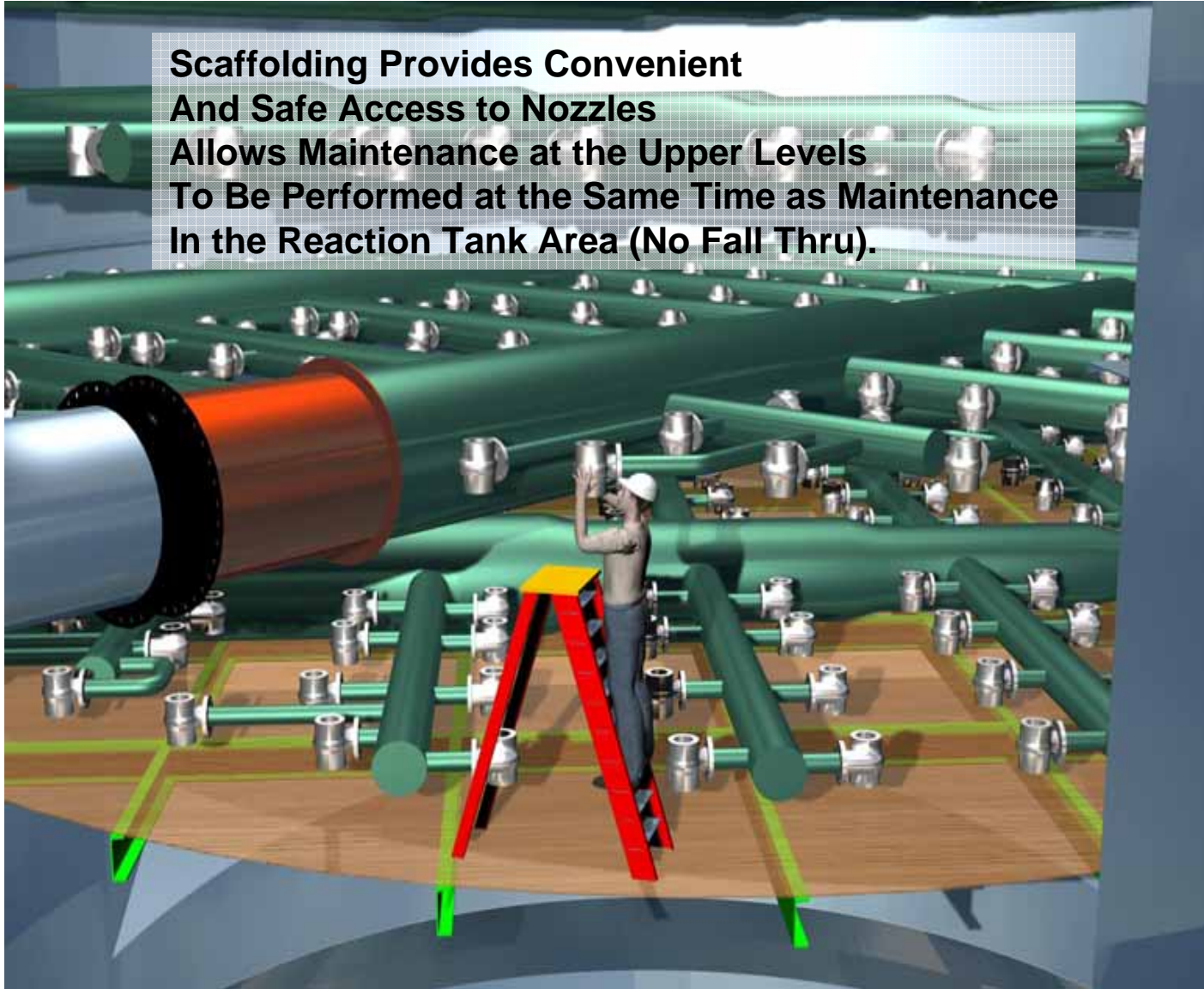
Overhead cranes



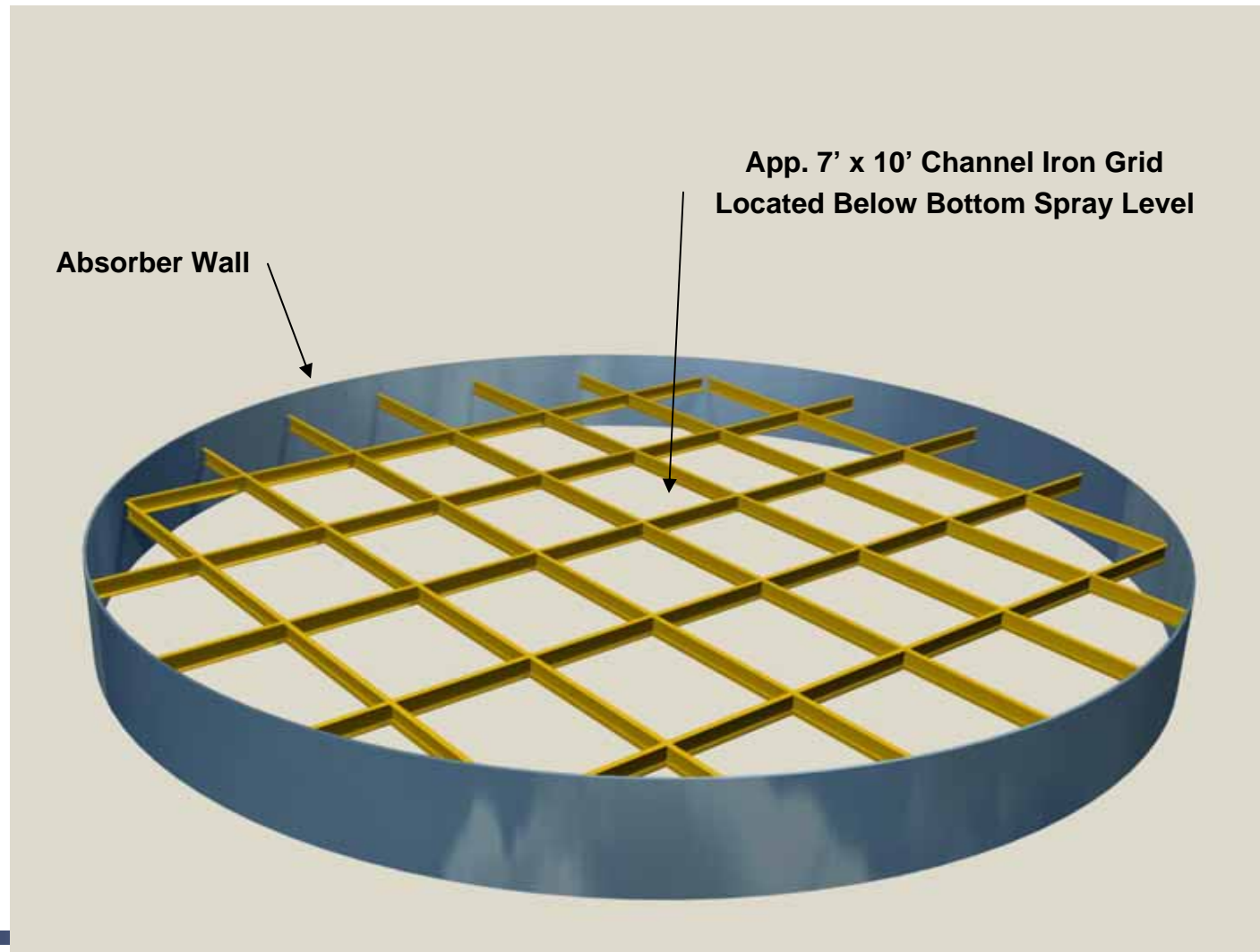
Recycle pump screens to prevent pump wear and nozzle plugging



**Scaffolding Provides Convenient
And Safe Access to Nozzles
Allows Maintenance at the Upper Levels
To Be Performed at the Same Time as Maintenance
In the Reaction Tank Area (No Fall Thru).**



Maintenance Support Grid



Operational WFGD Testing Requirements

	Frequency of sampling	pH	Density	Wt % of solids	Chemical composition of solids SO ₄ ⁻² SO ₃ ⁻² CO ₃ ⁻² Inert	Particle size Distr.	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 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	ASTMC471M
Residual Moisture	ASTMC471M
Chloride	EPRI -I3



Operational WFGD 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



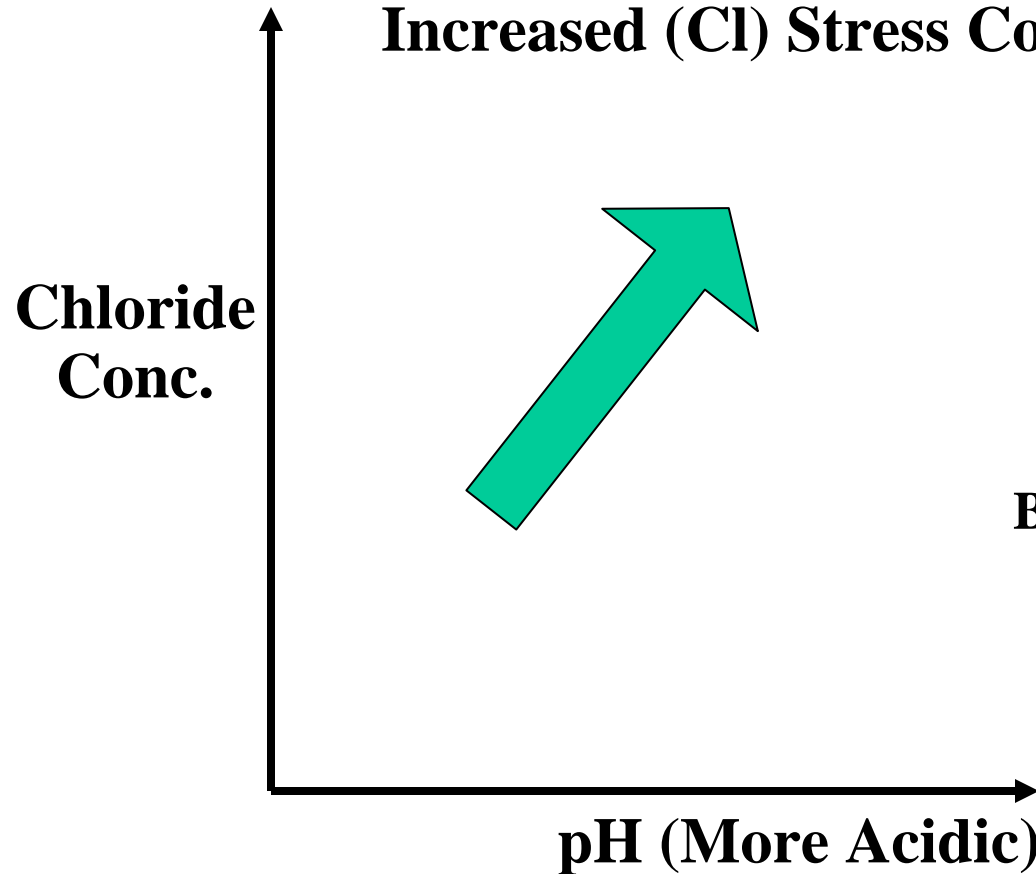
Outage and Maintenance Costs

- 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



Alloy Selection Criteria

Increased Pitting & Crevice Corrosion Potential
Increased (Cl) Stress Corrosion Cracking Potential



Need

Pitting & Crevice Corrosion Resistance

SCC Resistance

Both Shop & Field Fabricate-ability

Weld-ability

Availability

Economics



Materials of Construction	Design Chloride Limits (ppm)	GPM Wastewater
317LMN Stainless Steel (S31726)	8,000	287
Duplex 2205 Stainless Steel (S32205)	12,000	141
Super Duplex 255 Stainless Steel (S32550)	20,000	115
Super Austenitic 6% Mo Stainless Steel (N08367)	40,000	57
C-276 (N10276)	50,000	46
Carbon Steel/Glass Lined	50,000	46
Carbon Steel/Rubber Lined	50,000	46
Concrete/Tile Lined	> 50,000	46
Concrete/PP Lined	50,000	46



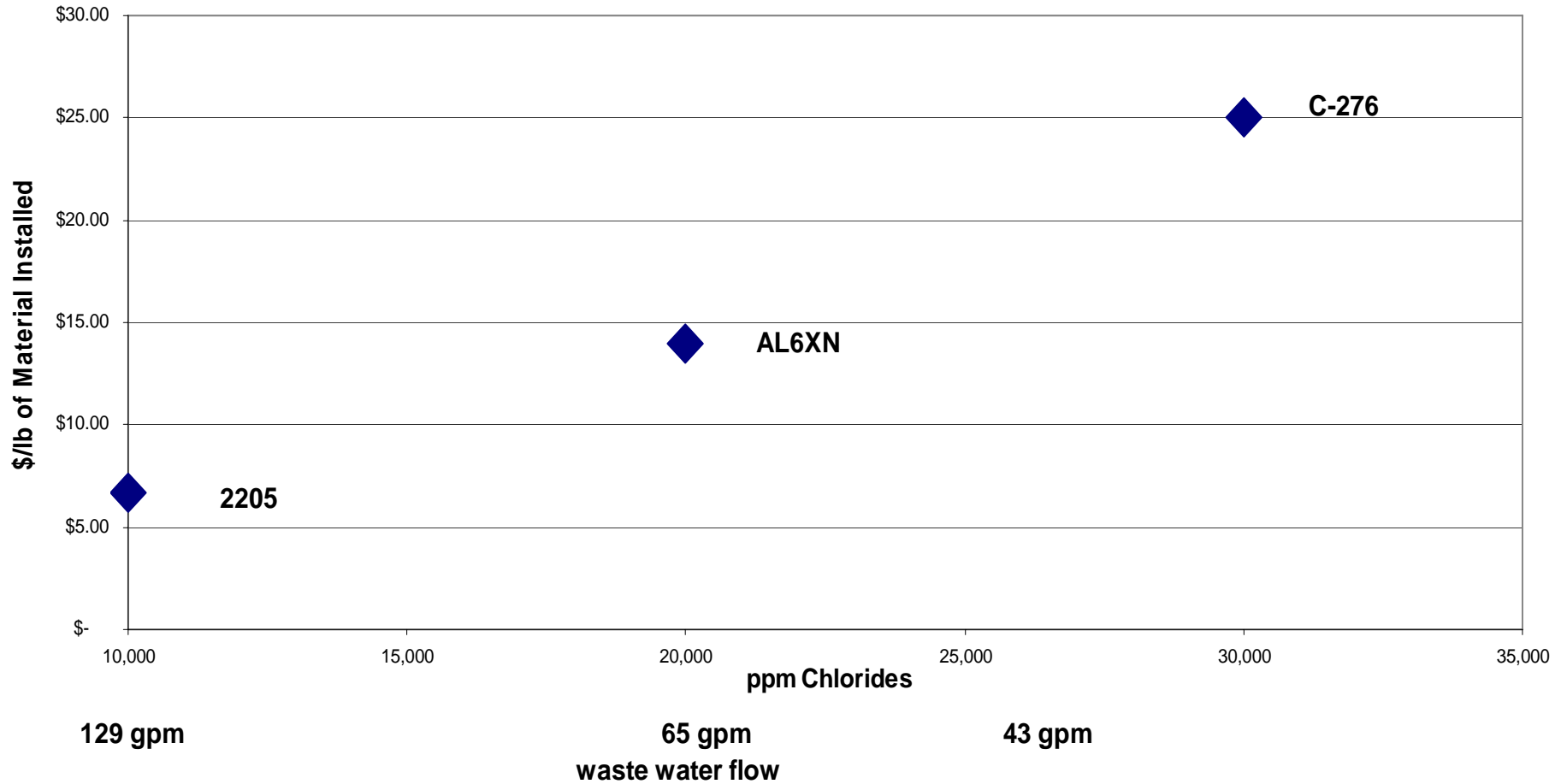
LEAD TIMES are from date BPI issues Purchase Order to its Suppliers	Sep 2003	Dec 2006	Apr 2007
Commodity Description	Total Lead Time		
Recycle Pump (Rubber Lined)	26 Wks	112 Wks	80 Wks
Booster Fans (>2,000 HP)	-	-	80 Wks
Limestone Ball Mill System	32 Wks	70 Wks	75 Wks
Recycle Pump (Metal Lined)	-	70 Wks	70 Wks
Catalyst	42 Wks	52 Wks	60 Wks
Recycle Pump (SiCast Lined)	-	56 Wks	56 Wks
C-276 Clad Outlet Cap	-	54 Wks	54 Wks
Large Recycle Isolation Valves - Knife Gate	-	52 Wks	52 Wks
Forced Oxidation	32 Wks	52 Wks	52 Wks
2205 Absorber	34 Wks	48 Wks	48 Wks
Recycle Internal Spray Headers - Metal	28 Wks	48 Wks	48 Wks
Booster Fans (<2,000 HP)	-	60 Wks	46 Wks
Gypsum Dewatering System	46 Wks	46 Wks	46 Wks
Absorber Sump Agitators	42 Wks	40 Wks	46 Wks
External Recycle Piping	-	64 Wks	45 Wks



LEAD TIMES are from date BPI issues Purchase Order to its Suppliers	Sep 2003	Dec 2006	Apr 2007
Commodity Description	Total Lead Time		
Reclaim Water System	40 Wks	44 Wks	44 Wks
Large Recycle Isolation Valves - Butterfly	-	42 Wks	42 Wks
Recycle Internal Spray Headers - FRP	-	40 Wks	40 Wks
SCR Reactor Modules/Cap and Gas Ducts	18 - 24 Wks	40 Wks	40 Wks
Structural Steel	30 Wks	34 Wks	38 Wks
Outlet Ductwork-2205	24 Wks	36 Wks	36 Wks
Maintenance Platform-2205	-	36 Wks	36 Wks
C-276 Solid Inlet to Absorber	-	34 Wks	34 Wks
Inlet Ductwork-CS	24 Wks	34 Wks	34 Wks
Recycle Internal Spray Header Supports-2205	16 Wks	34 Wks	34 Wks
Suction Line Screens-2205	-	34 Wks	34 Wks
Ammonia System	24 Wks	26 Wks	34 Wks
DBA System	-	26 Wks	34 Wks
Mist Eliminator	18 Wks	32 Wks	32 Wks
FRP Ductwork	-	32 Wks	32 Wks
Spray Nozzles	18 Wks	20 Wks	30 Wks
Mist Eliminator Support Steel-2205	-	24 Wks	24 Wks
Limestone Silo System	-	20 Wks	20 Wks
Reagent Delivery System	20 Wks	20 Wks	20 Wks
Hoists & Trolleys	20 Wks	20 Wks	20 Wks
Sonic Horns	18 Wks	18 Wks	16 Wks



Cost of FGD Vessel Materials



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**

Oxidation Air Compressors

Recycle Pumps

2 – Gypsum Transfer Tanks ea.207,000 gal.
- Carbon Steel (Rubber Lined)
- Return from 3 Recycle Pumps
- Each With Agitators

Existing Unit 1
FGD Stack

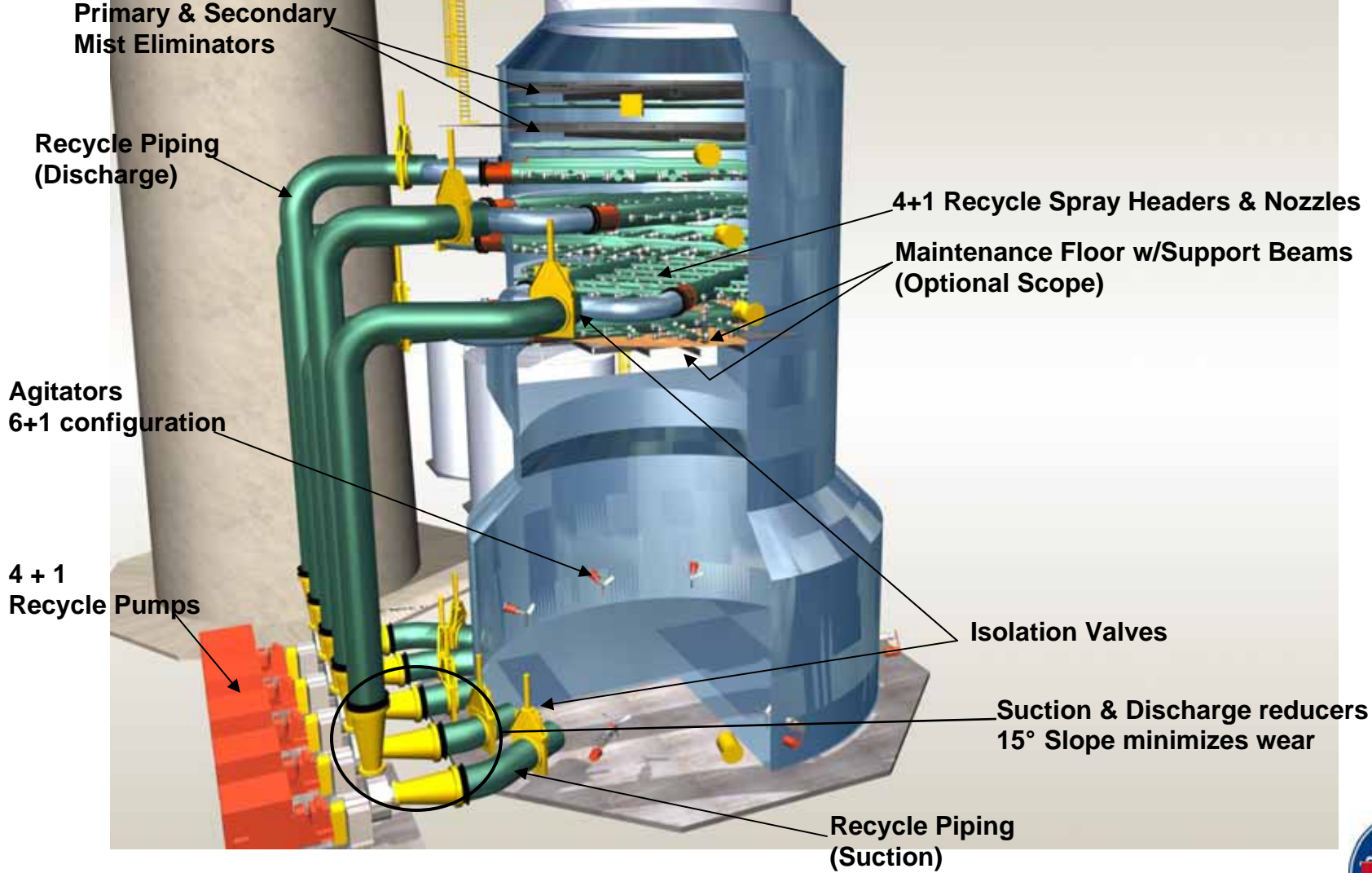
2nd Stage Mist Eliminator
Access Platform

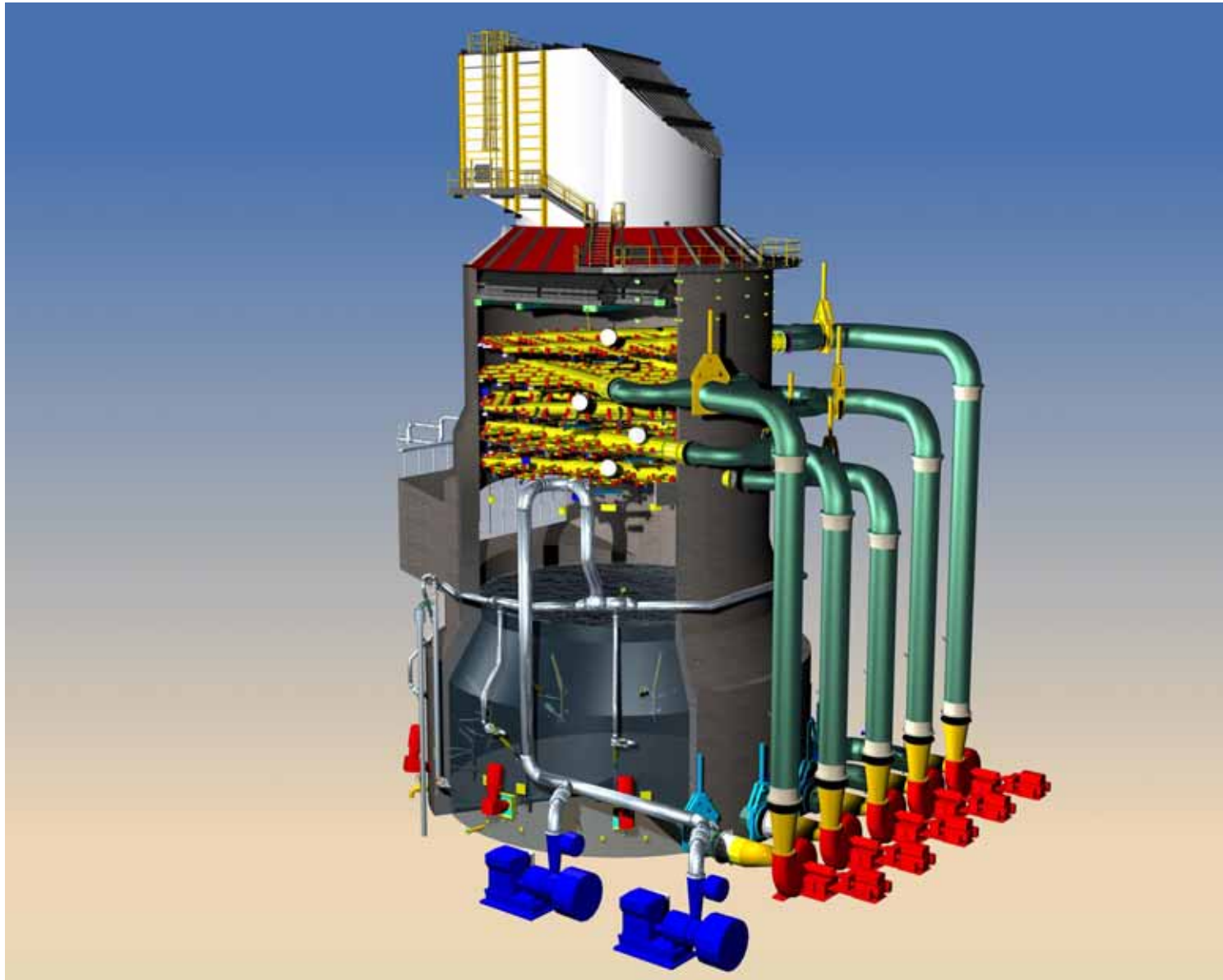
- Wrap Around Design Provides Access To Spray Header Valves
- A Lay Down Area for Demister Modules

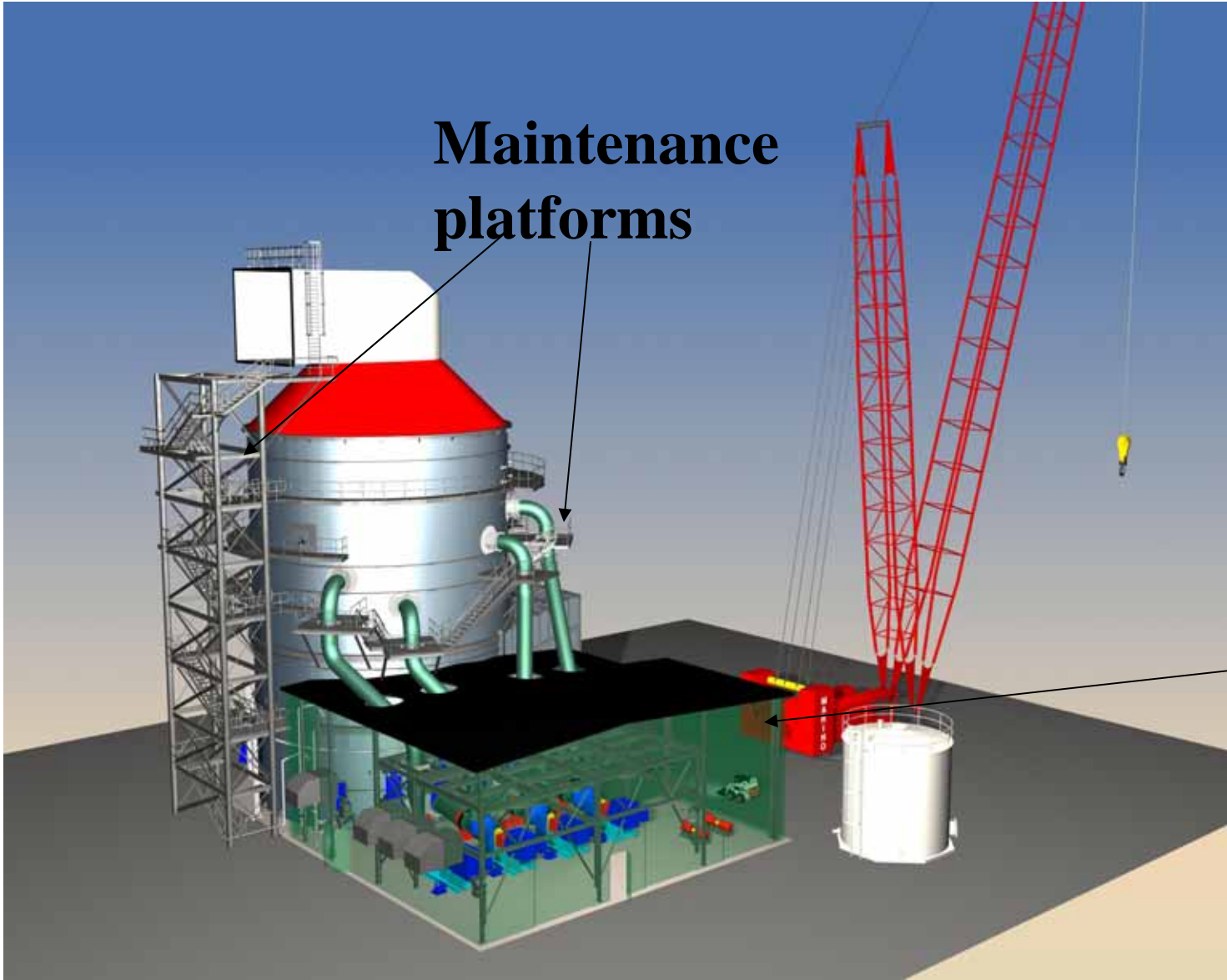
1- Process Water Tank 85,500 gal.
- Carbon Steel
- 2 Redundant Mist Eliminator Wash Pumps



Ghent Station Unit 3 Absorber Island Cutaway View Showing Absorber Internals







**Maintenance
platforms**

**Crane
rigging plan**

**Enclosed
building**



Thank You

Questions ??

