Reinhold Environmental Ltd.

2008 NOx-Combustion Round Table & Expo Presentation

February 4-5, 2008 in Richmond, VA

Evonik Energy

– formerly Steag

EVONIK INDUSTRIES

Evonik's SCR Management System consists of the following components:

Equipment optimization through e.g.:

- SCR inspection, root cause analysis
- Perfection of flow distribution
- Elimination of LPA intrusion
- NH_3 system inspection
- AIG inspection and tuning

Catalyst management including e.g.:

- Asset management
- Catalyst baseline testing
- DeNOx potential & forecasting
- Catalyst regeneration

Equipment Optimization

➲SCR Inspection, root cause analysis

Visual SCR inspections have revealed:

Overheated seal air expansion joint

Fly ash accumulation on catalyst layer and pluggage

SCR reactor inlet expansion joint rupture

Misalignment of damper louvers

Evonik‘s SCR management: ~2.5 million hours of SCR operating experience

Severe LPA screen erosion

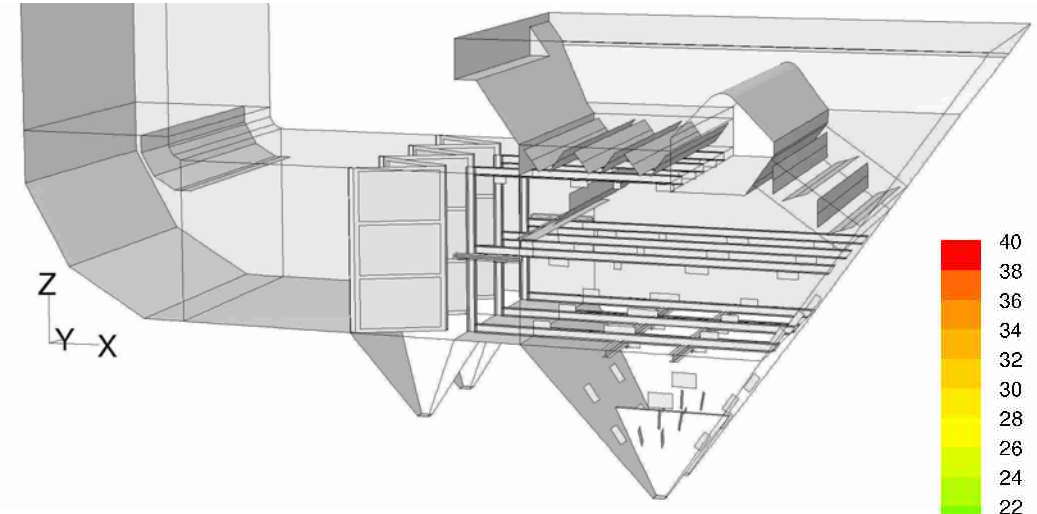
AIG nozzle pluggage

Guide vane damage to SCR outlet ductwork

Equipment Optimization

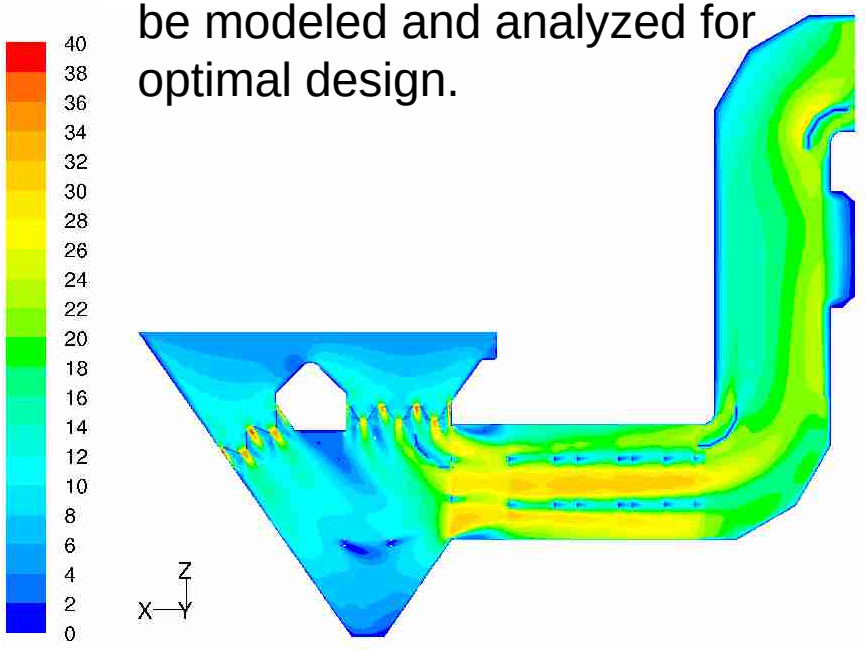
➲Perfection of flow distribution

CFD modeling enhances flue gas flow data and can be a useful tool for evaluation of system performance.



CFD modeling may identify other flow issues such as pressure losses or ash maldistribution.

Duct internals such as baffle plates, flue gas guide, turning vanes, LPA screens, etc. can be modeled and analyzed for optimal design.



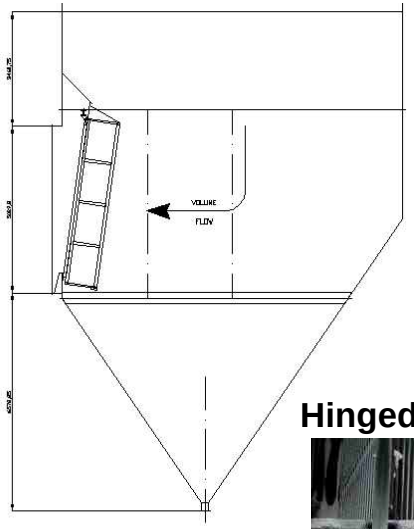
Equipment Optimization

➲Elimination of LPA intrusion

Evonik‘s proven patented LPA screen design:

Key features:

- **Pleated screen < 60°**
- **Hinged and free swinging**
- **Filtering screen separate from structural support**
- **Well proven since 1996**



Separate filtering and structural support screens

Hinged, free swinging design

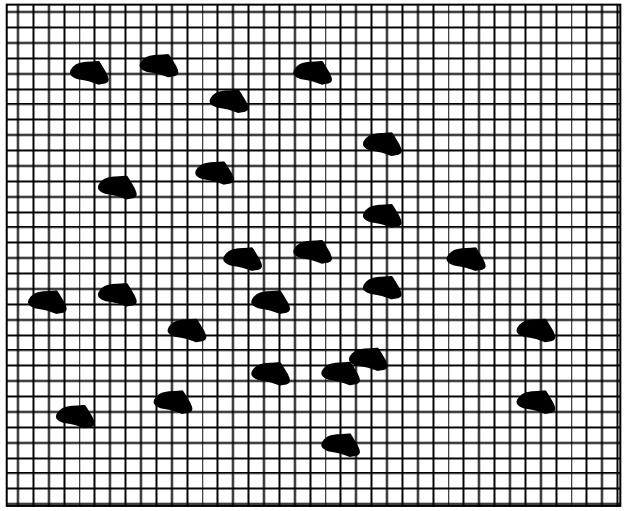
Evonik‘s SCR management: ~2.5 million hours of SCR operating experience

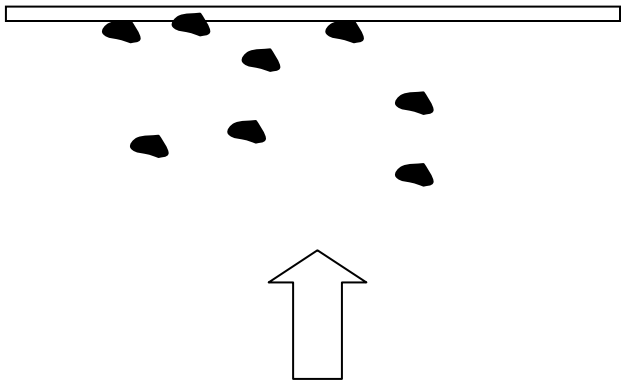
Design allows for full interchangability of various screen inlay materials including wire mesh, perforated plate & wedge wire

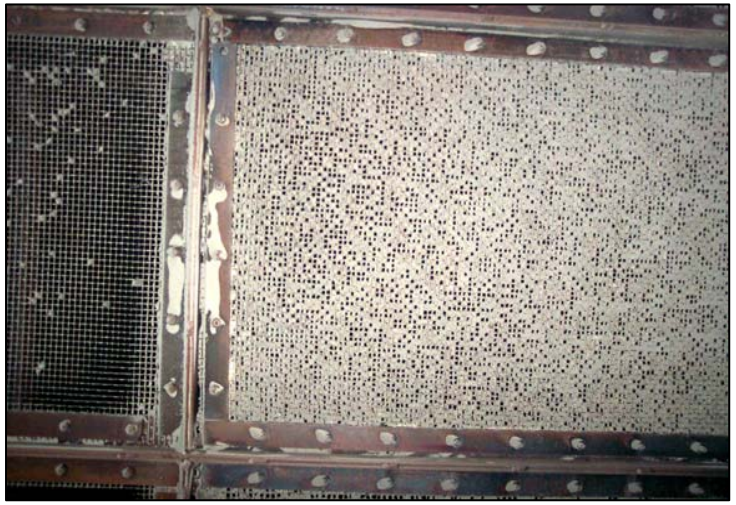
Equipment Optimization

➲Elimination of LPA intrusion

Typical Flat LPA Screen



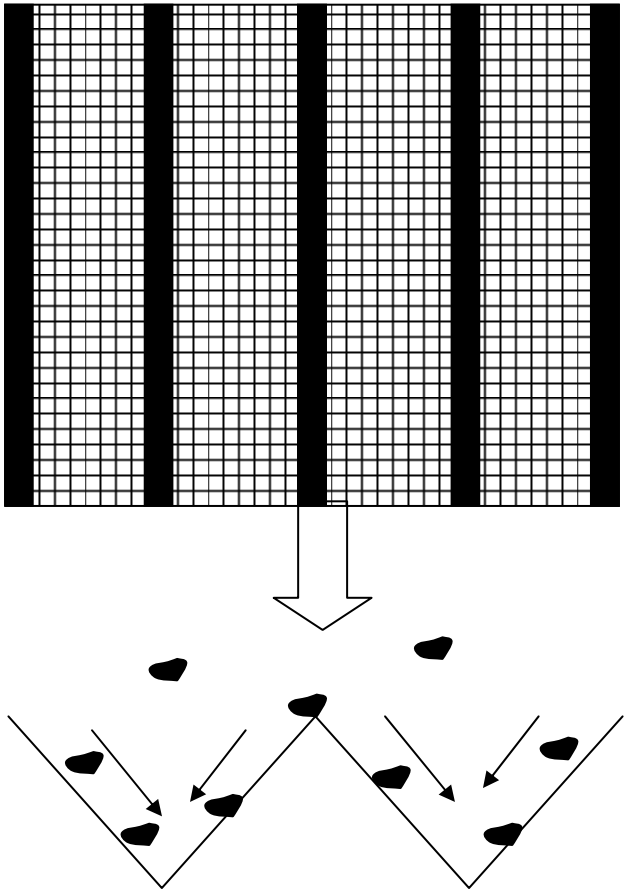


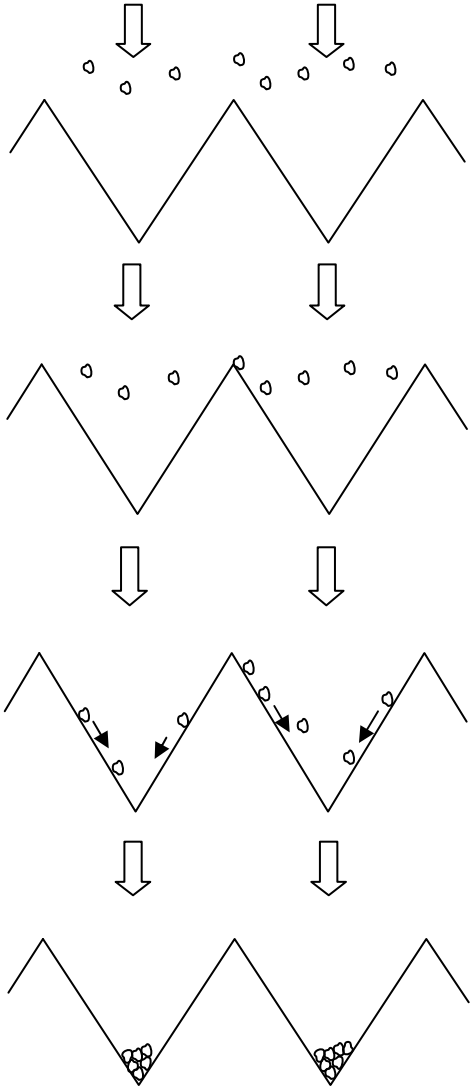


Equipment Optimization

➲Elimination of LPA intrusion

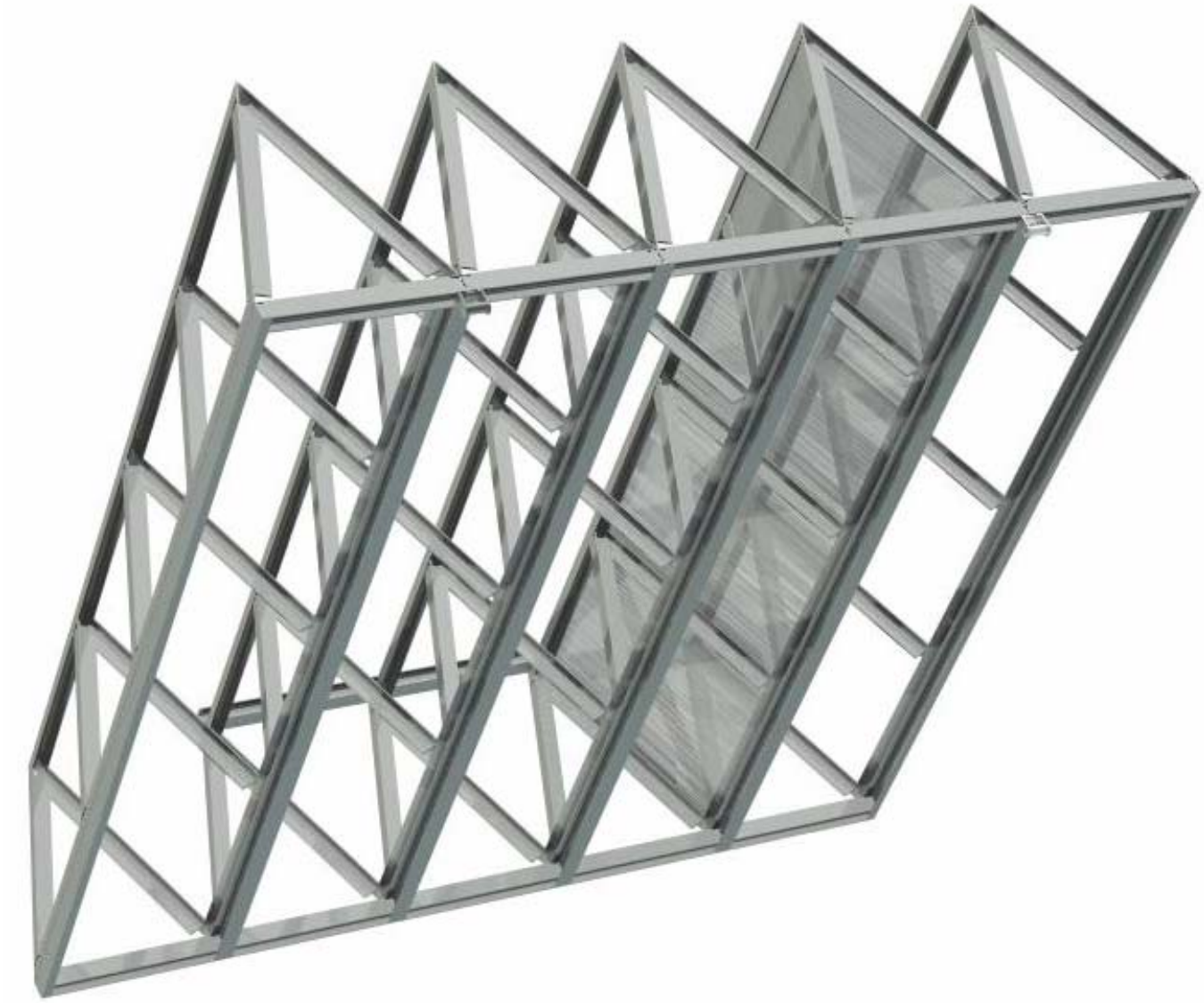
Evonik's Pleated LPA Screen Design





Equipment Optimization

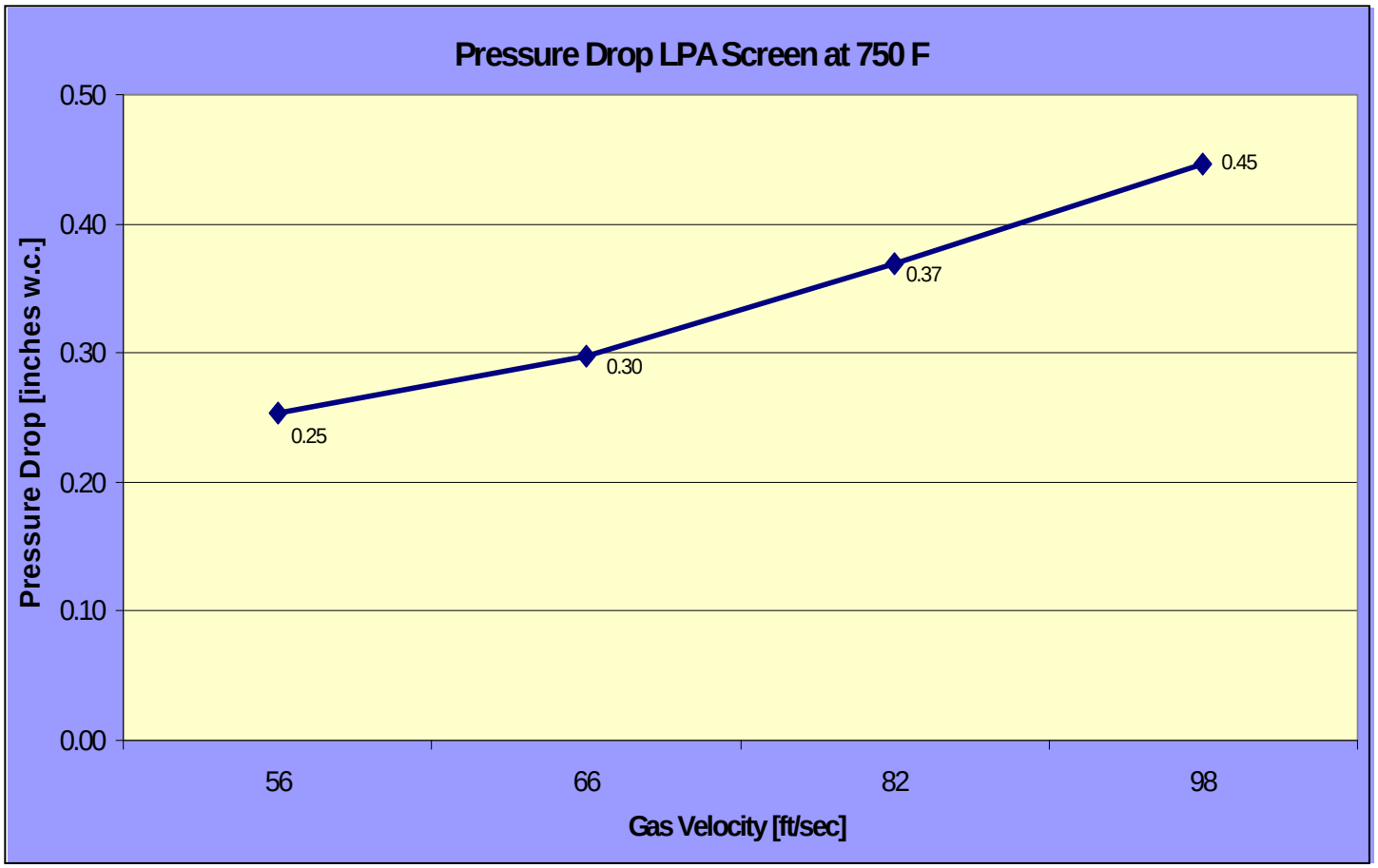
➲Elimination of LPA intrusion



Equipment Optimization

➲Elimination of LPA intrusion

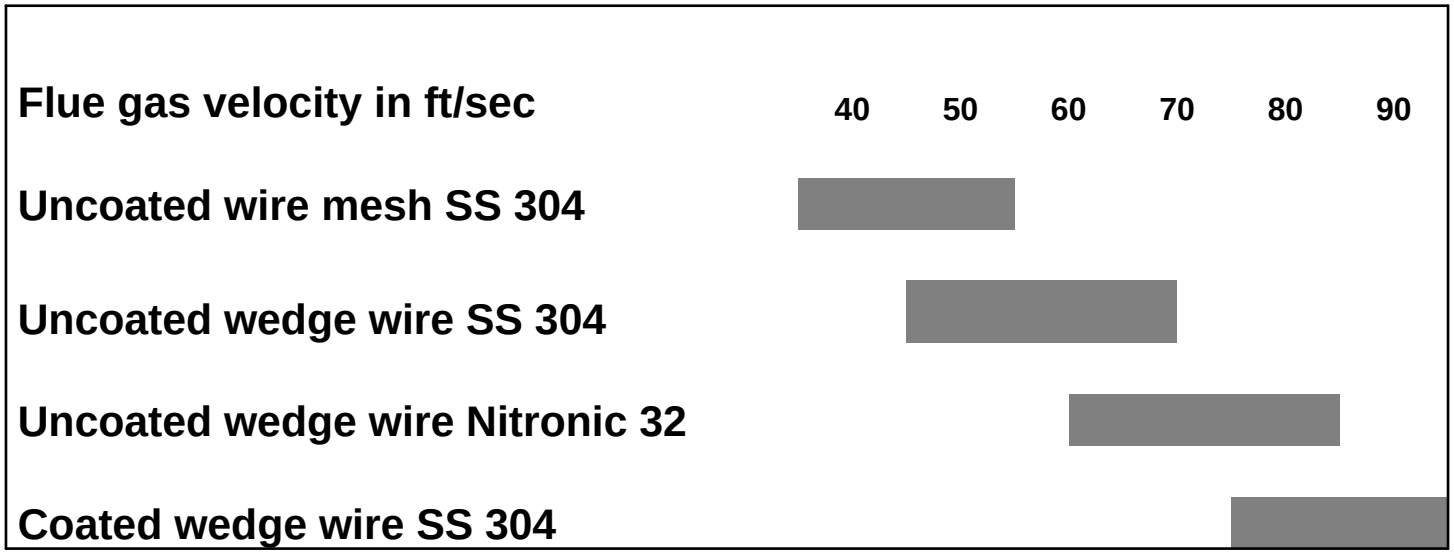
Large open surface area and slow flue gas velocity through the LPA screen inlays ensure a low pressure drop across the LPA screens:



Equipment Optimization

➲Elimination of LPA intrusion

Suitability of various screen inlay materials depending on the average flue gas velocity in the economizer outlet duct:



Note: The suitability of the various screen inlay materials for the respective velocity ranges is based on their installation in Evonik's patented self-cleaning pleated and hinged LPA screen design only.

Equipment Optimization

➲NH3 system inspection

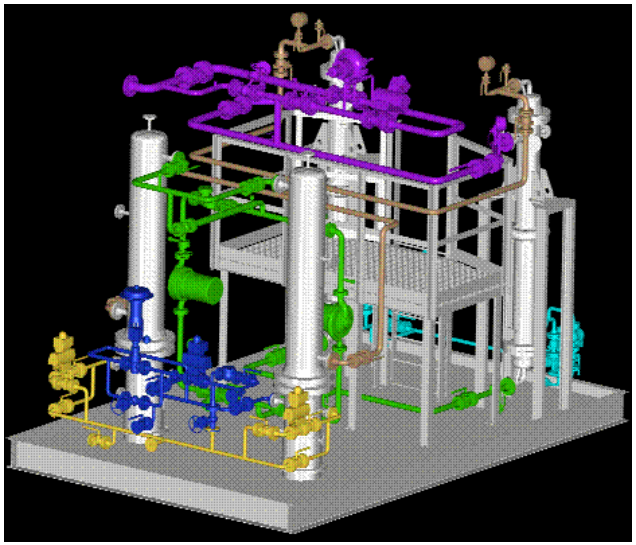
•Periodic inspections of all ammonia system components associated with the off loading, storage, vaporization and supply of ammonia to the AIG.

- Inspection of ammonia tanks, vent/purge, LEL
- Inspection of safety systems (sprinkler, fogging, etc.)

•Independent site audits, regulatory compliance

•Established maintenance plan

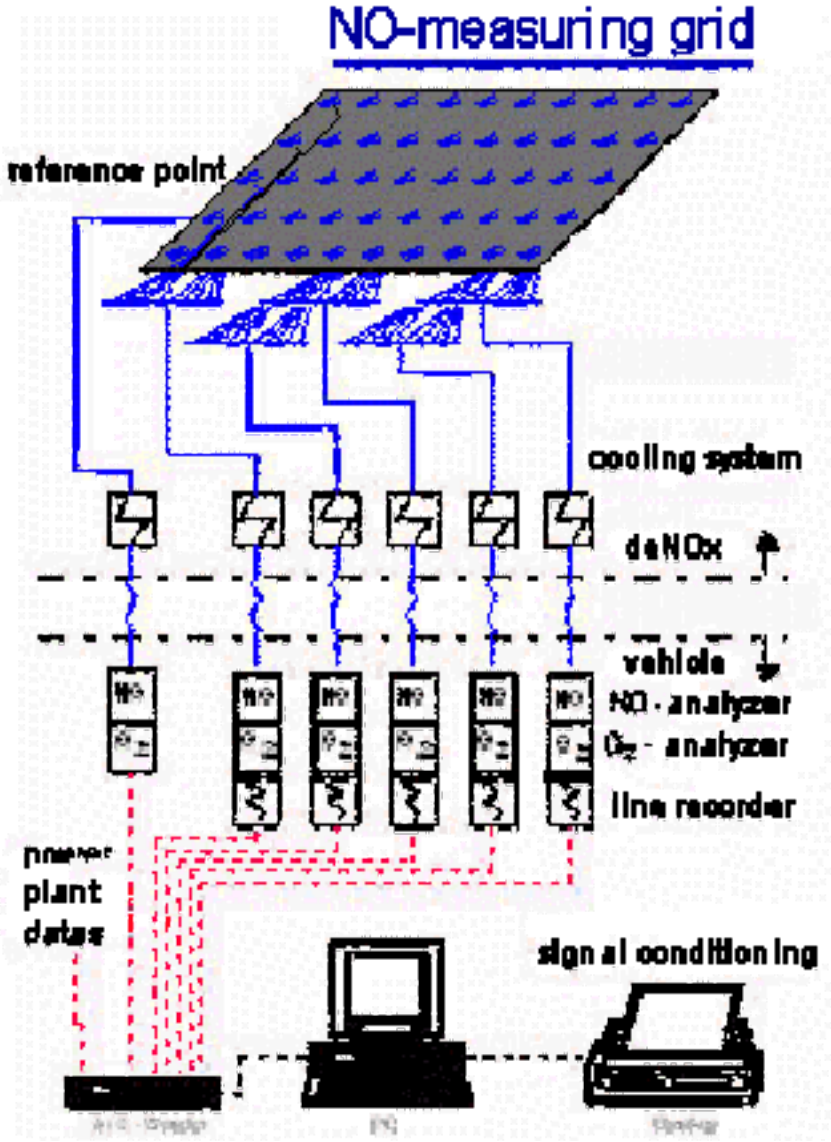
•Documentation review



Equipment Optimization

➲AIG inspection and tuning

Evonik‘s SCR management: ~2.5 million hours of SCR operating experience

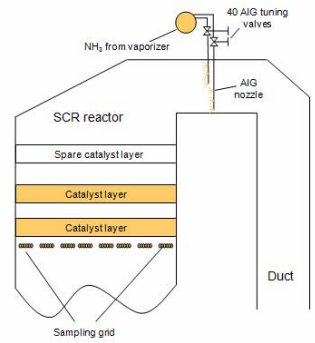


AIG tuning with Evonik‘s ECOS (Emissions Control and Optimization System) allows for:

- **Using up to 7 NO/O_2 analyzers in parallel.**
- **Building a fully O_2-corrected 3D NO-profile after the last catalyst layer for up to 100 points in about 30 minutes.**
- **Tuning quality within about +/- 10 ppm NO.**

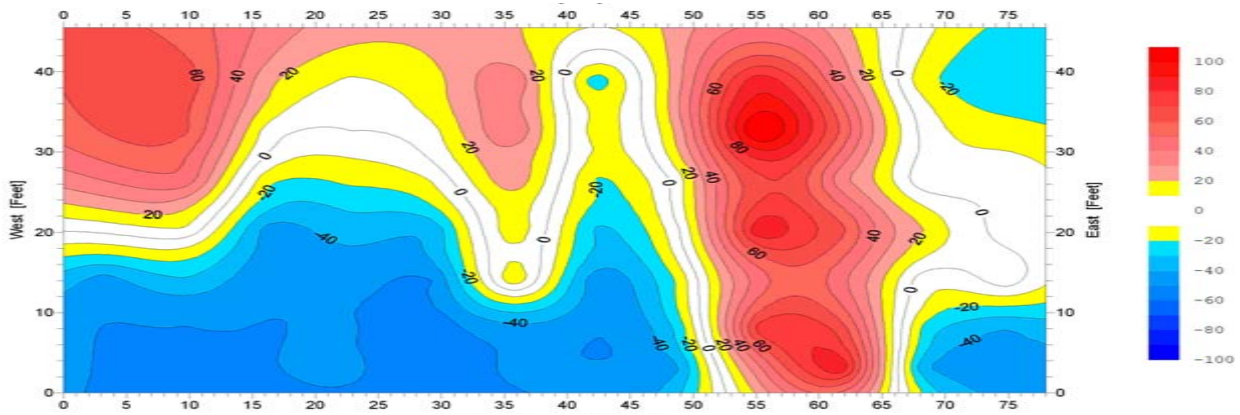
Equipment Optimization

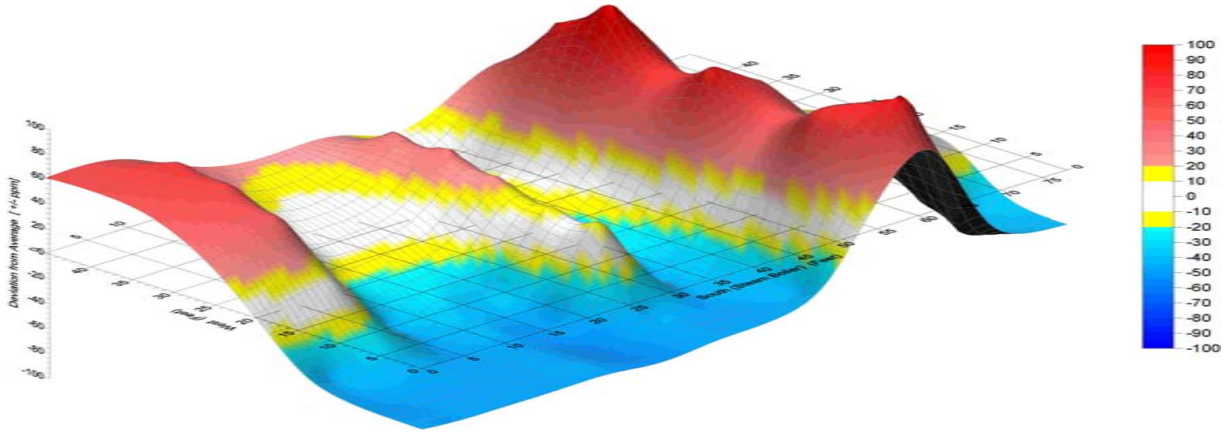
➲AIG inspection and tuning



AIG Tuning:

SCR performance monitoring before AIG tuning

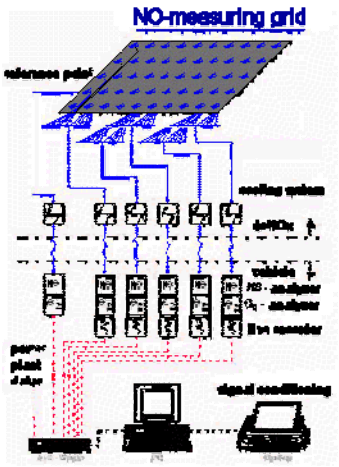




Evonik‘s SCR management: ~2.5 million hours of SCR operating experience

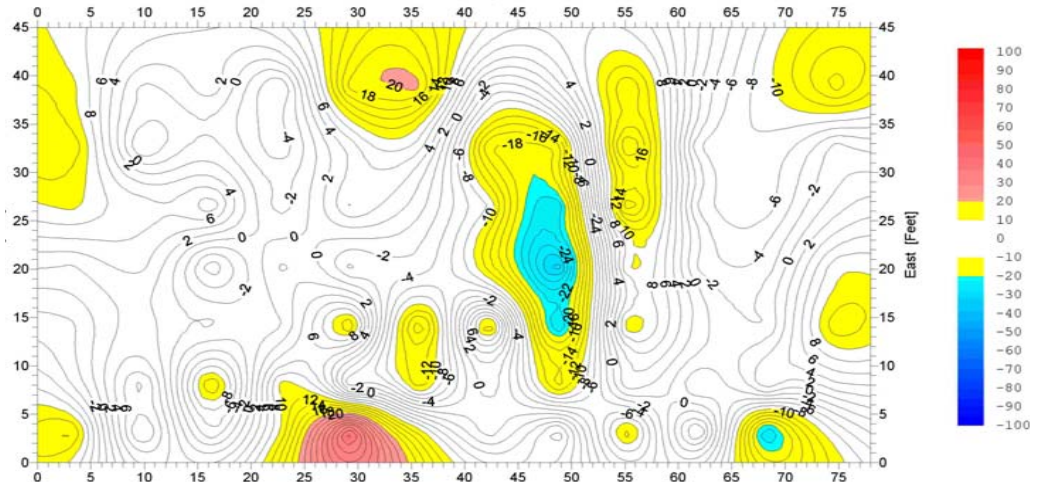
Equipment Optimization

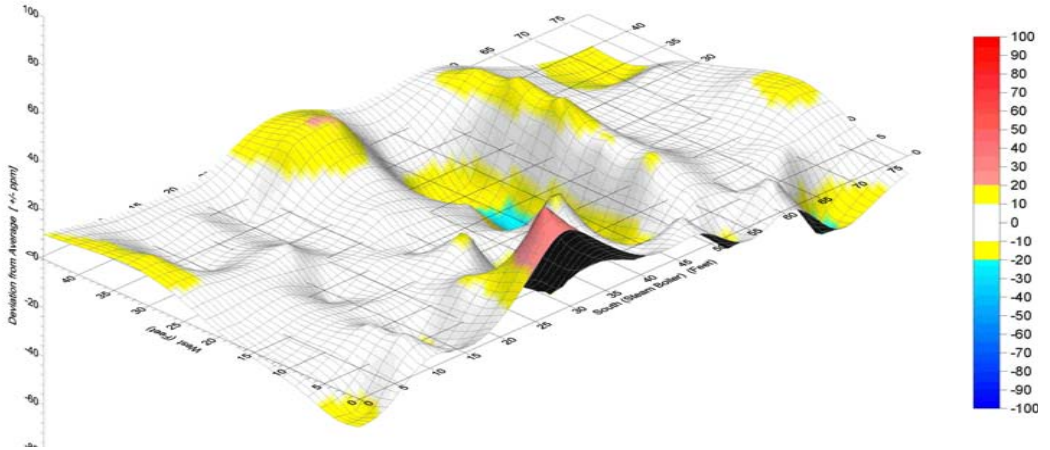
➲AIG inspection and tuning



AIG Tuning:

SCR performance monitoring after AIG tuning





Evonik‘s SCR management: ~2.5 million hours of SCR operating experience

Evonik‘s SCR Management System consists of the following components:

Equipment optimization through e.g.:

- ➲SCR inspection, root cause analysis
- ➲Perfection of flow distribution
- ➲Elimination of LPA intrusion
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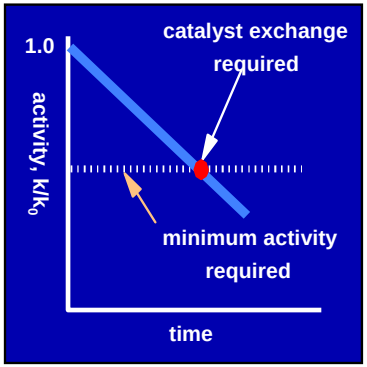
- ➲AIG inspection and tuning

Catalyst management including e.g.:

- ➲Asset management
- ➲Catalyst baseline testing
- ➲DeNOx potential & forecasting
- ➲Catalyst regeneration

Catalyst Management

➲Asset management



SCR catalyst must be prudently managed as an asset:

Periodic catalyst exchanges will be necessary.

Catalyst exchanges are largest O&M expense for SCRs.

Catalyst deactivation is caused by:

- **Chemical deactivation by trace elements (As, Ca, K, Na, P).**
- **Blinding of catalyst micropores by ABS, $CaSO_4$ etc..**
- **Physical plugging by e.g. popcorn ash, bad flow distribution, fly ash overload, wrong pitch selection etc.**
- **Erosion through too high dust loading and/or too high flue gas velocities.**

An effective SCR management and O&M plan can greatly reduce catalyst replacement and thus SCR operating costs.

Evonik‘s SCR management: ~2.5 million hours of SCR operating experience

Catalyst Management

➲Asset management

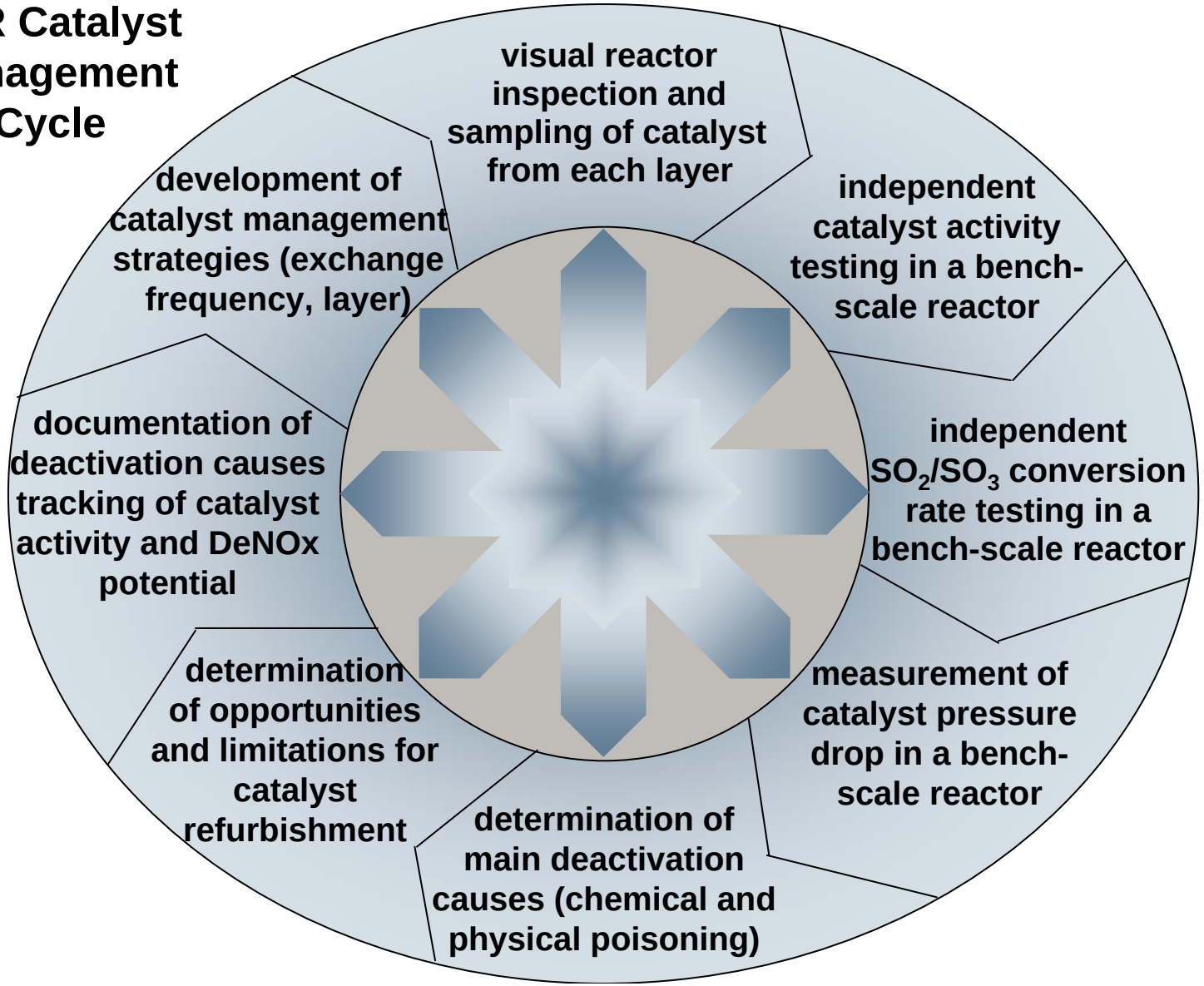
O&M Costs

- **Catalyst Replacements**
- **Ammonia/Reagent**
- **Power (Differential ID Fan Power)**
- **Steam/Vaporization Medium**
- **General Maintenance (Sootblowers, Ammonia System, Dampers, Monitors)**
- **Ammonia Injection Tuning**
- **Diagnostic Testing**

Catalyst Management

➲Asset management

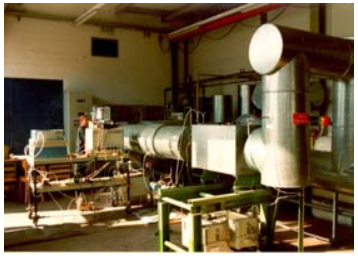
SCR Catalyst Management Cycle



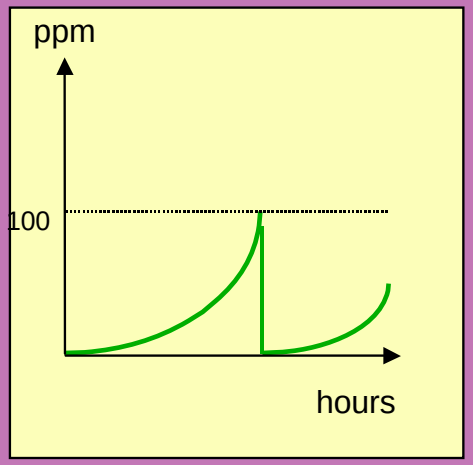
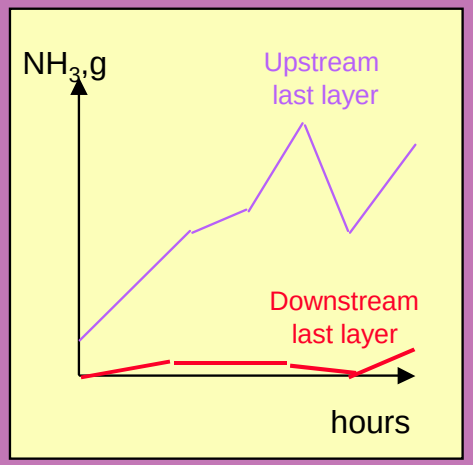
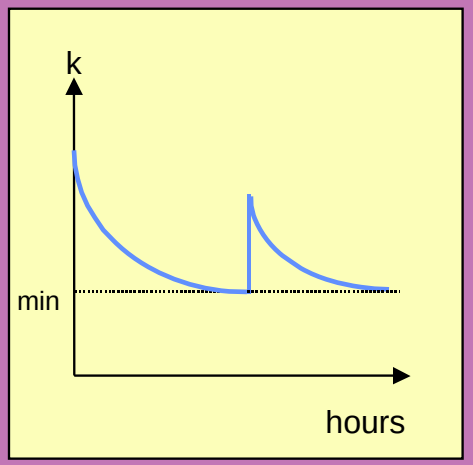
Evonik‘s SCR management: ~2.5 million hours of SCR operating experience

Catalyst Management

➲Catalyst baseline testing



Periodic Operational SCR Performance Monitoring:

NH_3 concentration in the fly ash	NOx distribution and NH_3 measurements	Catalyst activity testing
		
Operator	**Evonik**	**Evonik**
Measurements: daily / weekly	Measurements: once or twice a year	Measurements: once a year

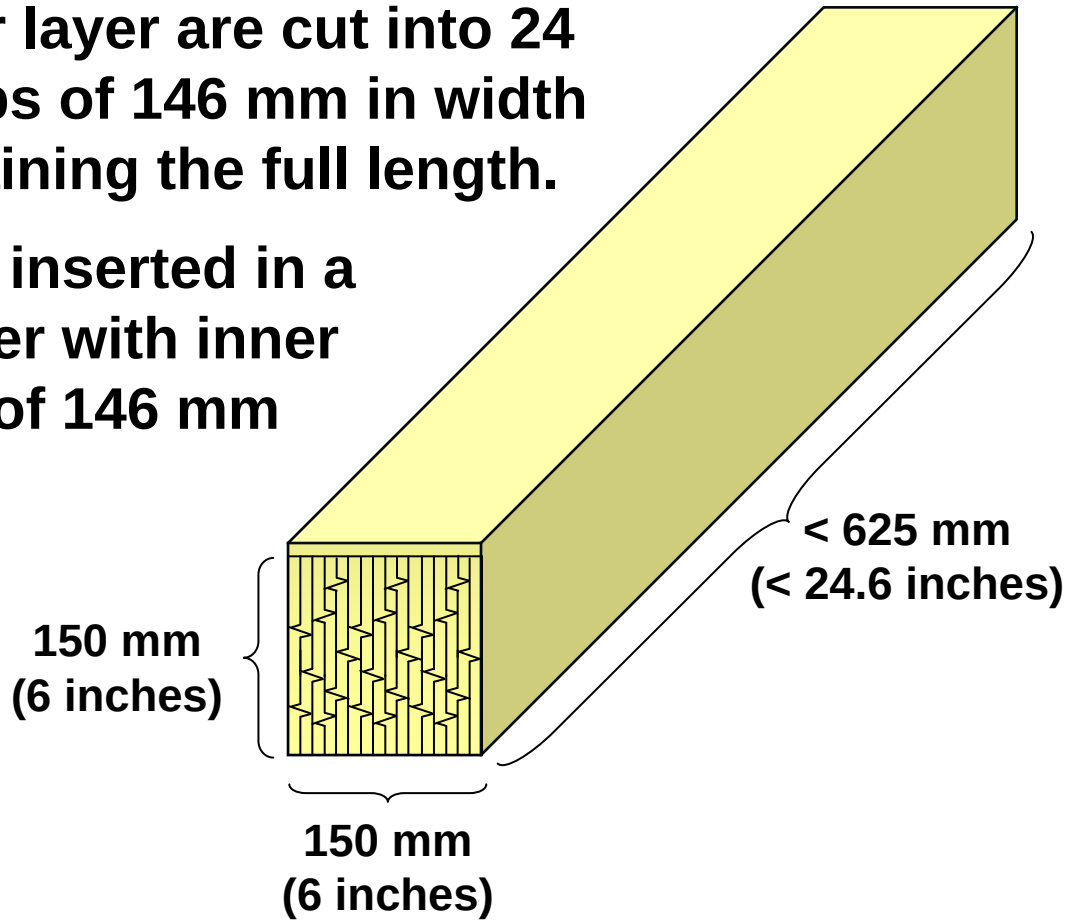
Evonik‘s SCR management: ~2.5 million hours of SCR operating experience

Catalyst Management

➲Catalyst baseline testing

Plate-type catalyst sample test element preparation:

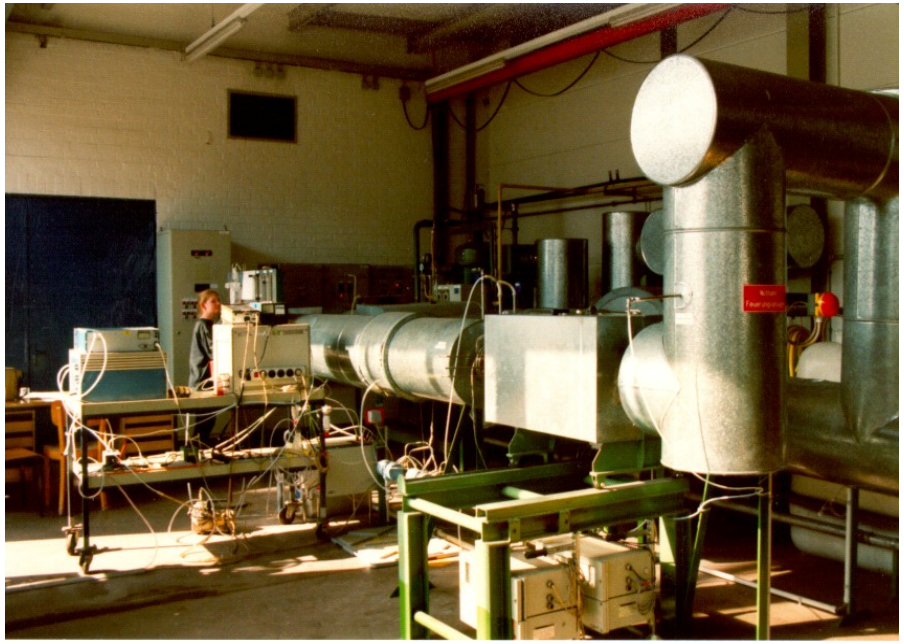
- **12 plates per layer are cut into 24 catalyst strips of 146 mm in width while maintaining the full length.**
- **24 strips are inserted in a sample holder with inner dimensions of 146 mm x 146 mm.**



Catalyst Management

➲Catalyst baseline testing

Evonik‘s Catalyst Testing Lab:



Evonik‘s lab services:

- **Bench-scale reactor testing (K, $K_{SO2/SO3}$, Δp)**
- **Micro-scale reactor testing (e.g. coupons)**
- **XRF analysis**
- **XRD analysis**
- **SEM analysis**
- **Proximate and ultimate coal analysis**
- **Ash fusion analysis**

Evonik‘s SCR management: ~2.5 million hours of SCR operating experience

Evonik was one of two SCR operators representing the users during developing the catalyst testing protocol VGB-R302He.

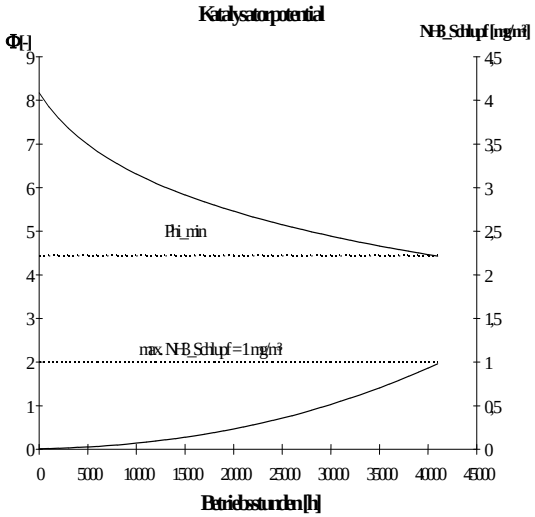
Evonik has always successful passed the VGB Round Robin tests to certify our bench-scale reactor testing results.

Evonik is one of only three firms who provides truly independent catalyst testing services and one of two that are certified.

Catalyst Management

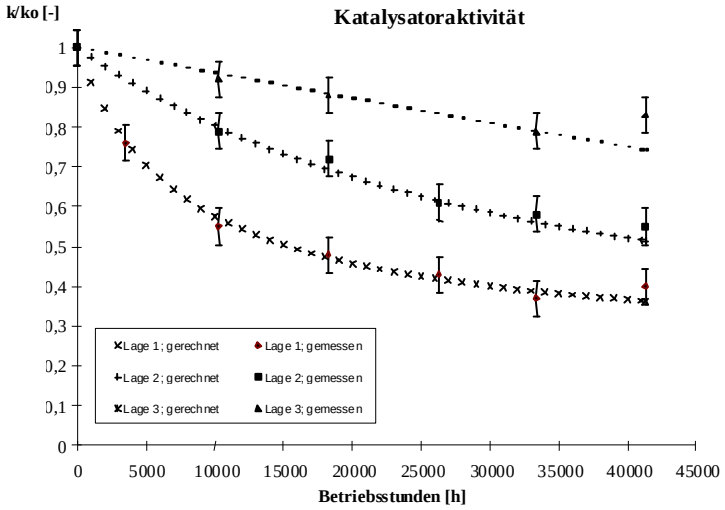
➲Catalyst baseline testing

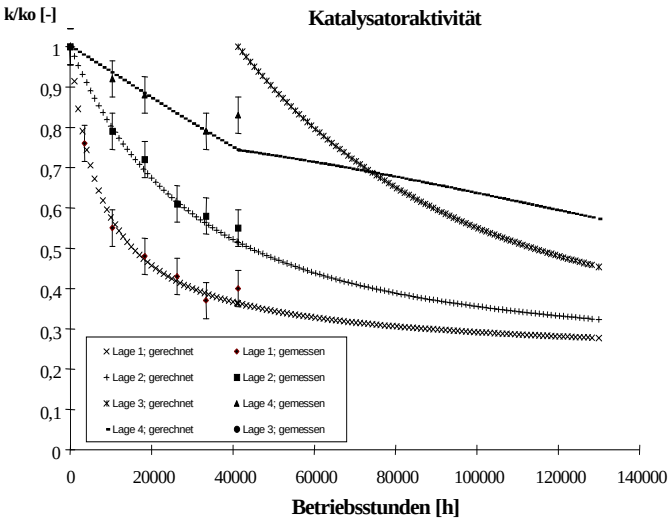
Catalyst Testing Data Interpretation:



Results and data from catalyst bench-scale testing results and chemical catalyst analysis need to be correctly interpreted and prepared for further use.

Evonik‘s SCR management: ~2.5 million hours of SCR operating experience

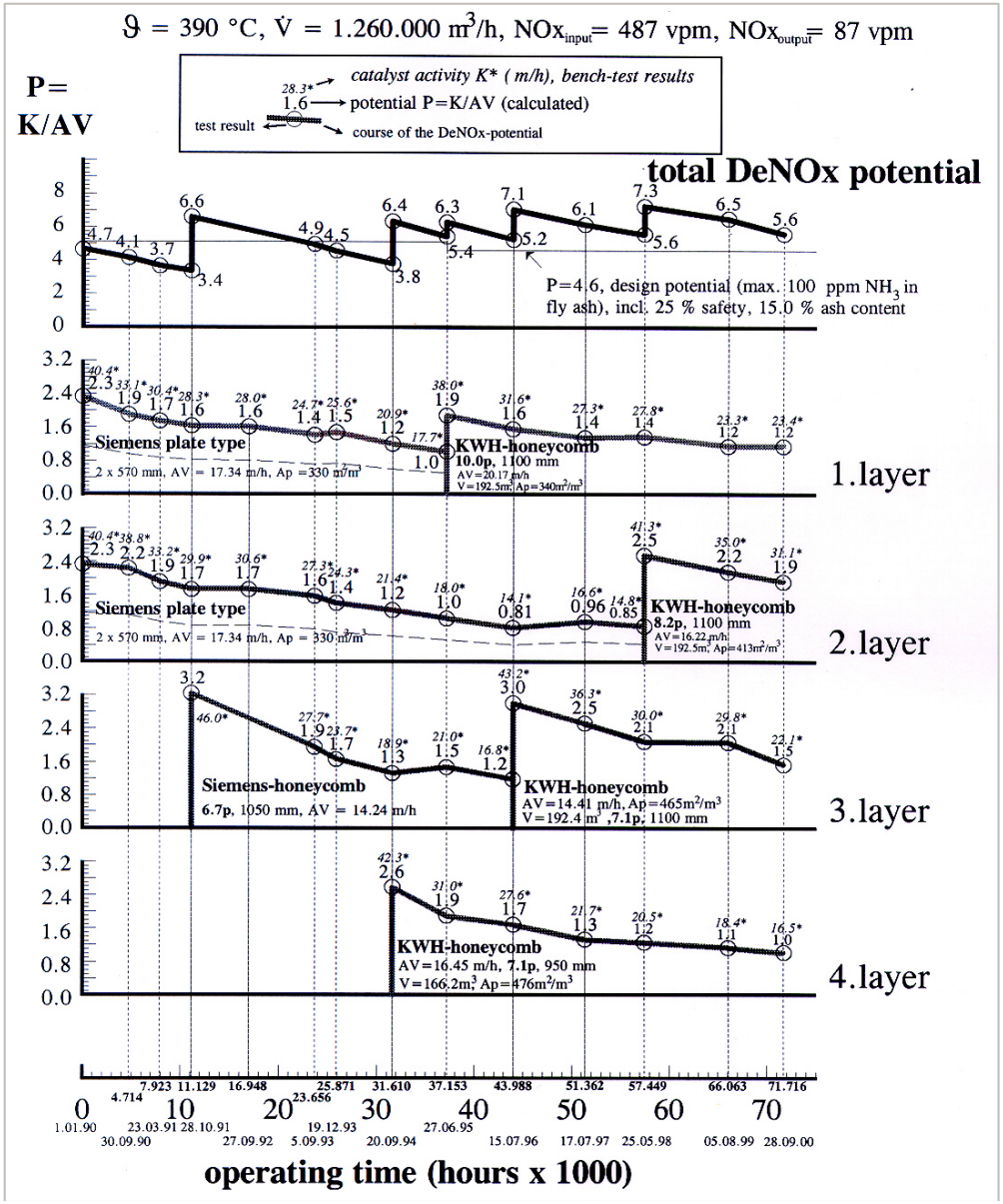




Catalyst Management

➲DeNOx potential & forecasting

Evonik's SCR management: ~2.5 million hours of SCR operating experience

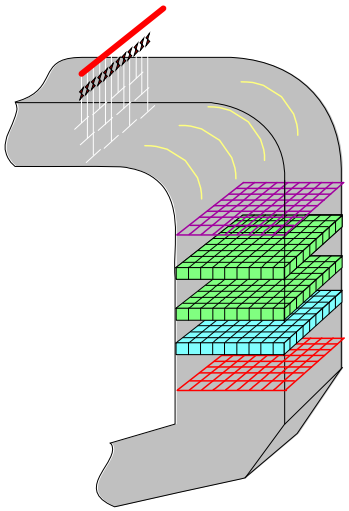


DeNOx potential tracking and forecasting:

- **Determining theoretical required potential P_{theo}.**
- **Calculating minimum needed and initially installed potentials P_{min} and $P_{initial}$ from catalyst baseline test data.**
- **Determining initial catalyst design margin.**
- **Determining residual DeNOx potential from actual catalyst activity.**
- **Accurately forecast SCR catalyst performance.**

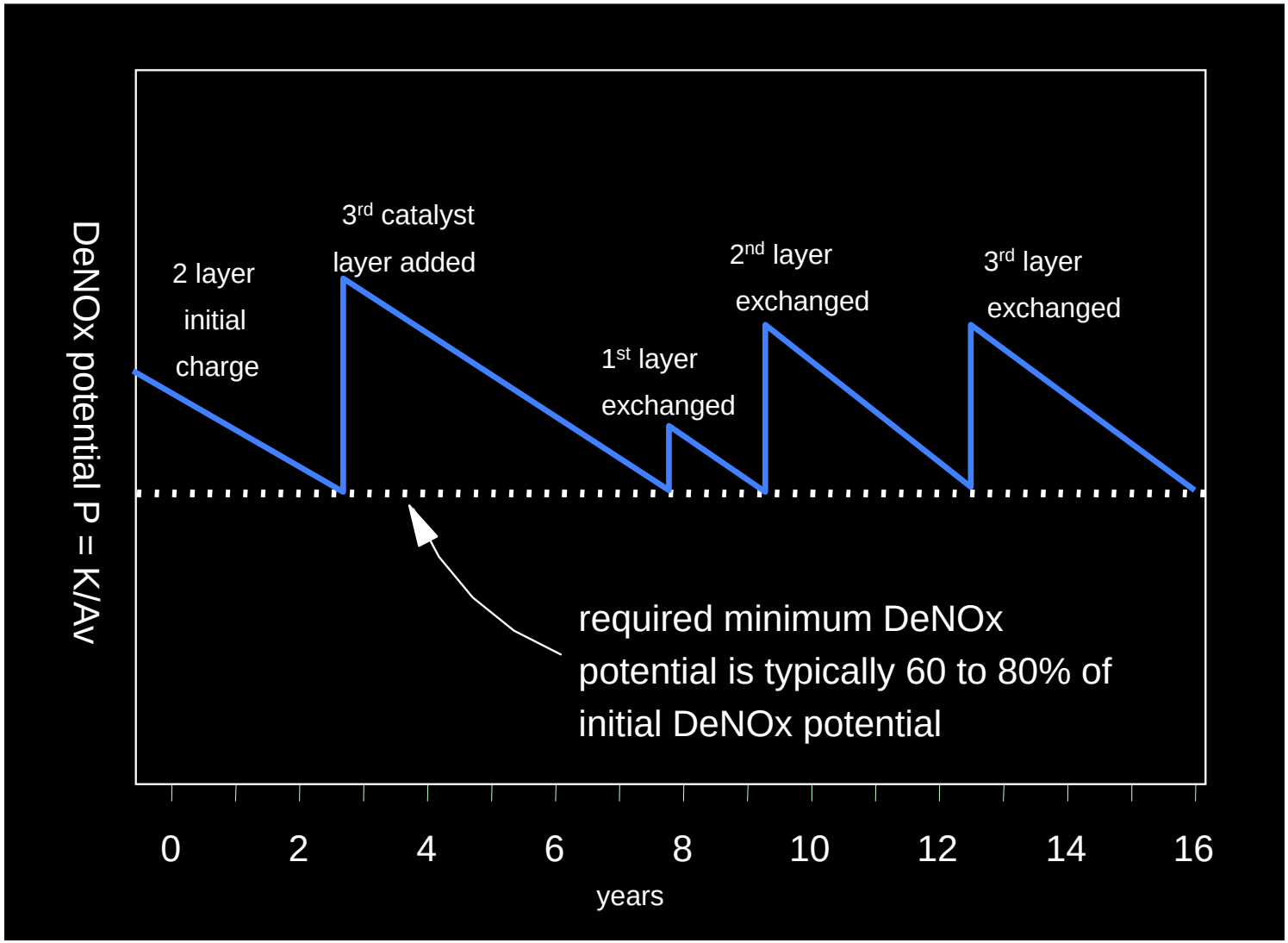
Catalyst Management

➲DeNOx potential & forecasting



Evonik‘s SCR management: ~2.5 million hours of SCR operating experience

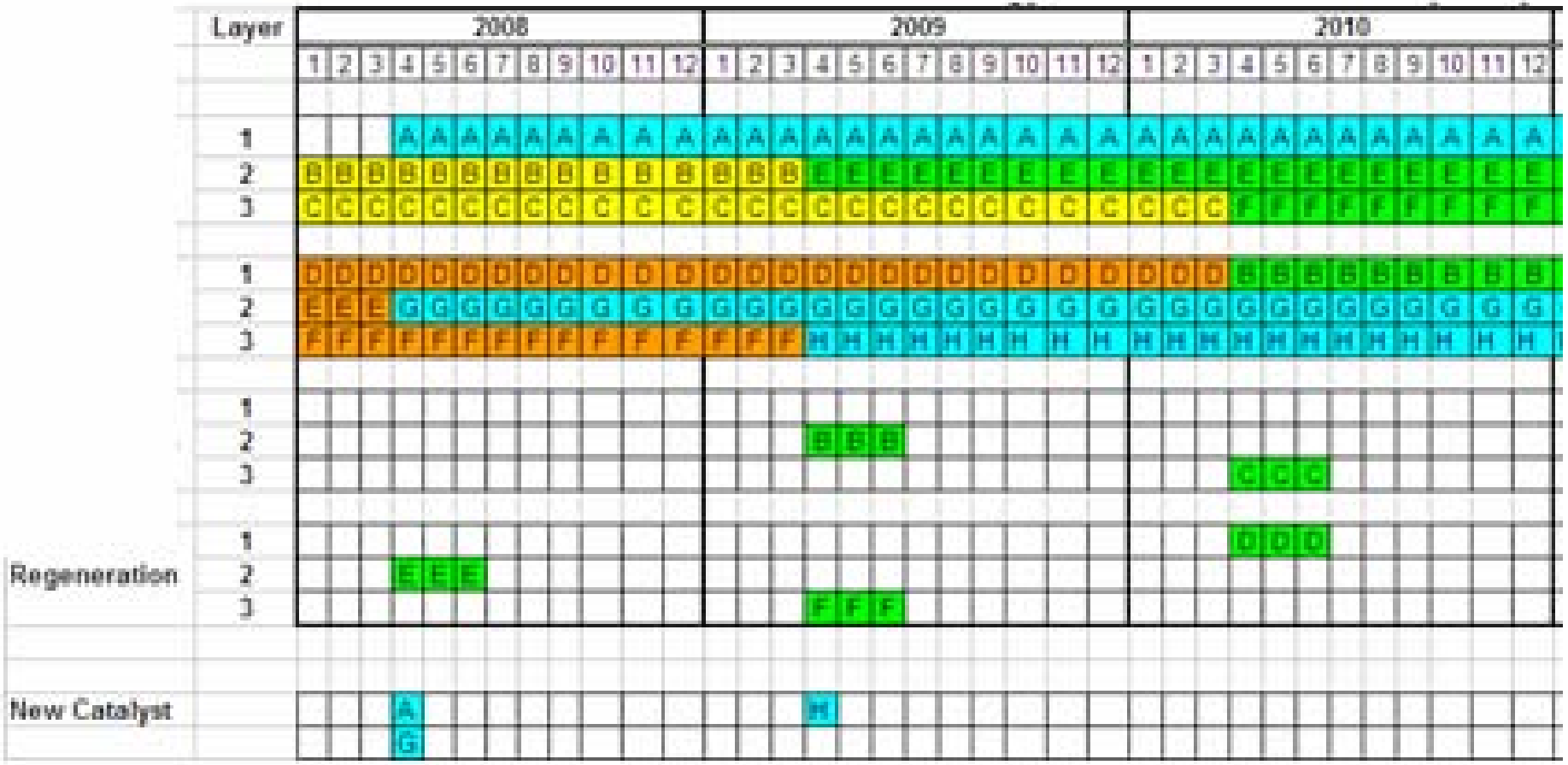
Typical Catalyst Exchange Plan:



Catalyst Management

➲DeNOx potential & forecasting

Typical Catalyst Occupancy Plan:



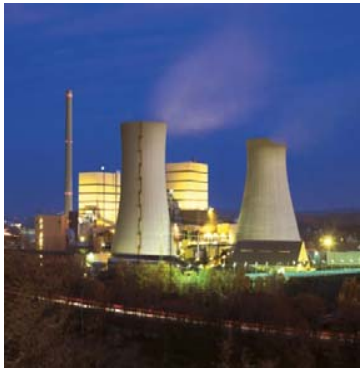
Catalyst Management

➲Catalyst regeneration

Evonik‘s Bergkamen Power Station

SCR Catalyst Regeneration Nomenclature

- **Cleaning = Removal of physical restrictions such as blinding layers and large particle ash – can be done on-site as well as off-site.**
- **Rejuvenation = Removal of catalyst poisons without the need for replenishing catalytically active compounds – can sometimes be done in-situ, but is most commonly done either on-site or off-site.**
- **Regeneration = Removal of catalyst poisons plus restoration of catalytic activity by addition of catalytically active ingredients – can typically not be done in-situ or on-site, but should be done off-site to ensure required close process control.**



Evonik‘s Fenne Cogeneration Plant

Catalyst Management

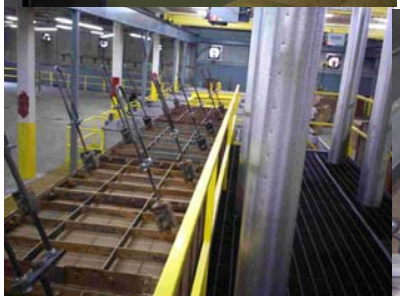
➲Catalyst regeneration

Evonik's Catalyst Regeneration Process

•**Evonik's regeneration technology is based on effective:**

•**Removal of physical restrictions (fly ash, LPA, blinding layers, etc.).**

- **Removal of chemical catalyst poisons (As, P, Na, K, etc.).**
- **Prevention of unintended removal of components essential for maintaining the catalyst's structural integrity and mechanical strength (i.e. WO_3).**
- **Full activity restoration through locally selective replenishment of the catalyst's active components (V_2O_5, MoO_3, WO_3).**
- **Recalcination for best impregnation success and mechanical strength protection / restoration.**



Questions?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