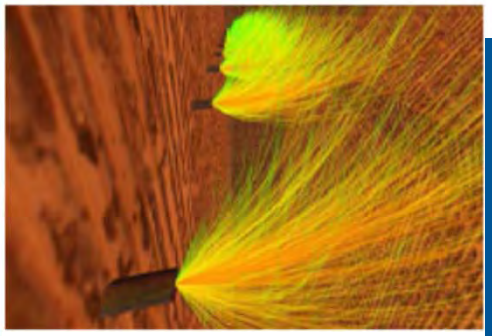
REINHOLD ENVIRONMENTAL Ltd.

2014 NOx-Combustion Round Table & Expo Presentations

February 10 & 11, 2014, in Charlotte, NC / Hosted by Duke Energy



LACYGNE UNIT 1 – CFD MODELING FOR SCR OPTIMIZATION

2014 NOx-Combustion/PCUG Round Table

Scott Hiedeman, Senior AQC Engineer, KCP&L

Reid Thomas, Senior Process Engineer, Fuel Tech

Dale Pfaff, Mountain Regional Sales Manager, Fuel Tech

Diane Fischer, Services Area Leader, AQC, Energy, Black & Veatch

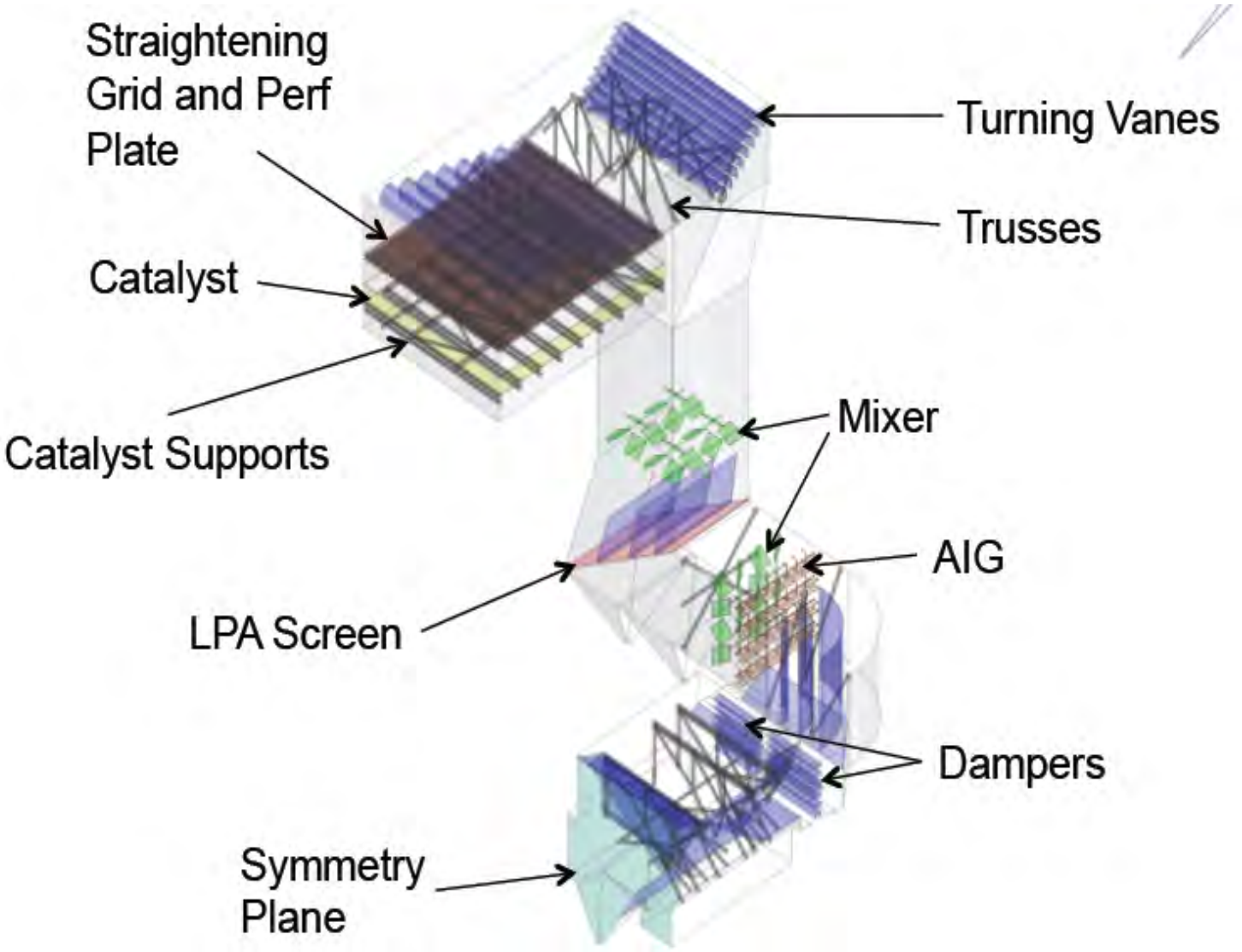
BLACK & VEATCH

PROJECT SUMMARY

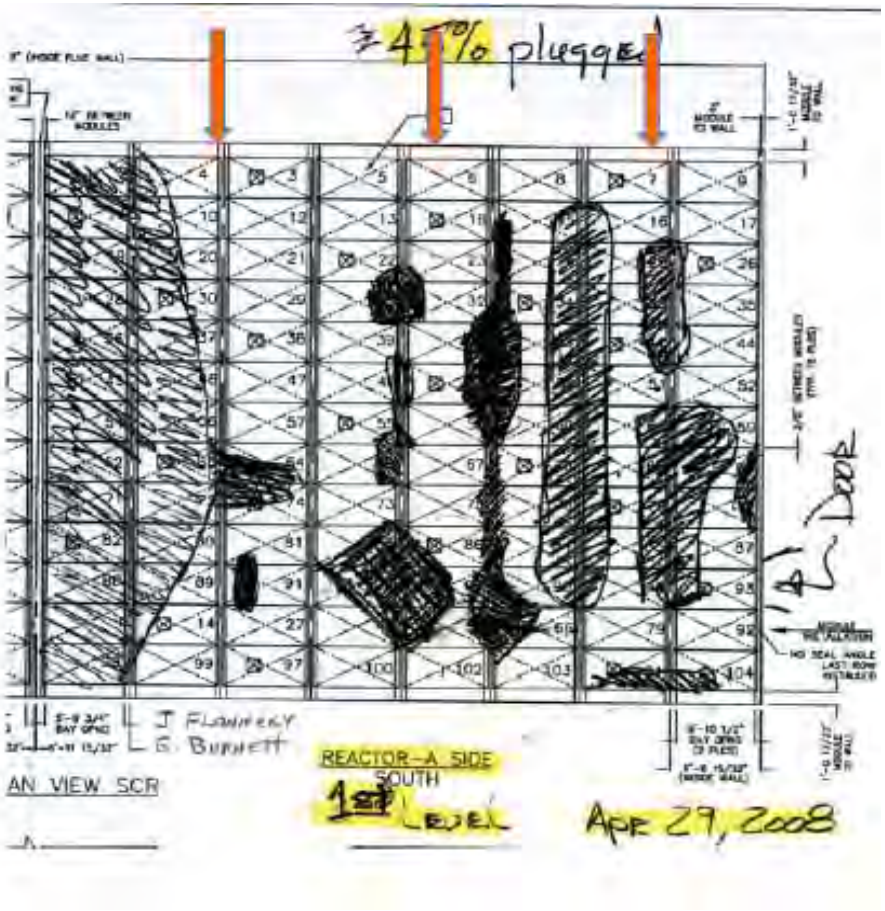
Flow Modeling and GSG technology provided significant improvements in velocity distribution and flow direction

- **KCPL experienced excess flyash pluggage in LaCygne 1 SCR**
- **CFD & Physical Flow Modeling**
- **Graduated Straightening Grid (GSG)**
- **Uniform-Vertical-Non Recirculating Flow**
- **Improvements will benefit LaCygne operation**
- **SCR Lessons Learned**

BASELINE FLOW MODEL GEOMETRY

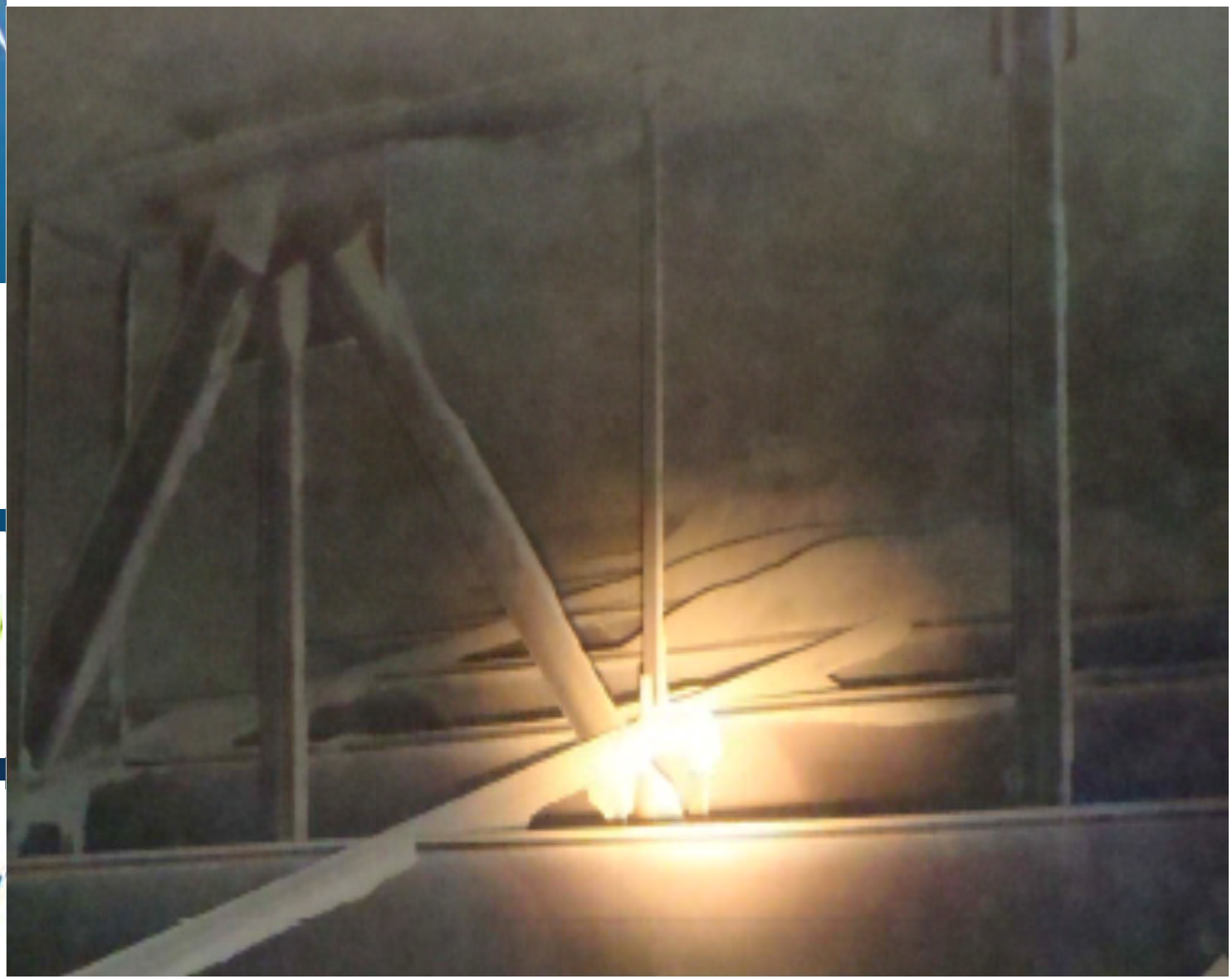


EXCESS FLYASH PLUGGAGE – LAYER 1 ASH DEPOSIT "MAP"



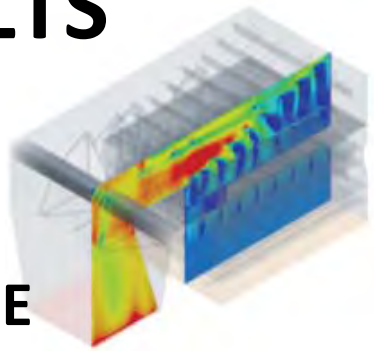
- After 1 year operation
- First layer 45% plugged
- Ash "rows" noted below structural supports

EXCESS FLYASH PLUGGAGE – TURNING VANES



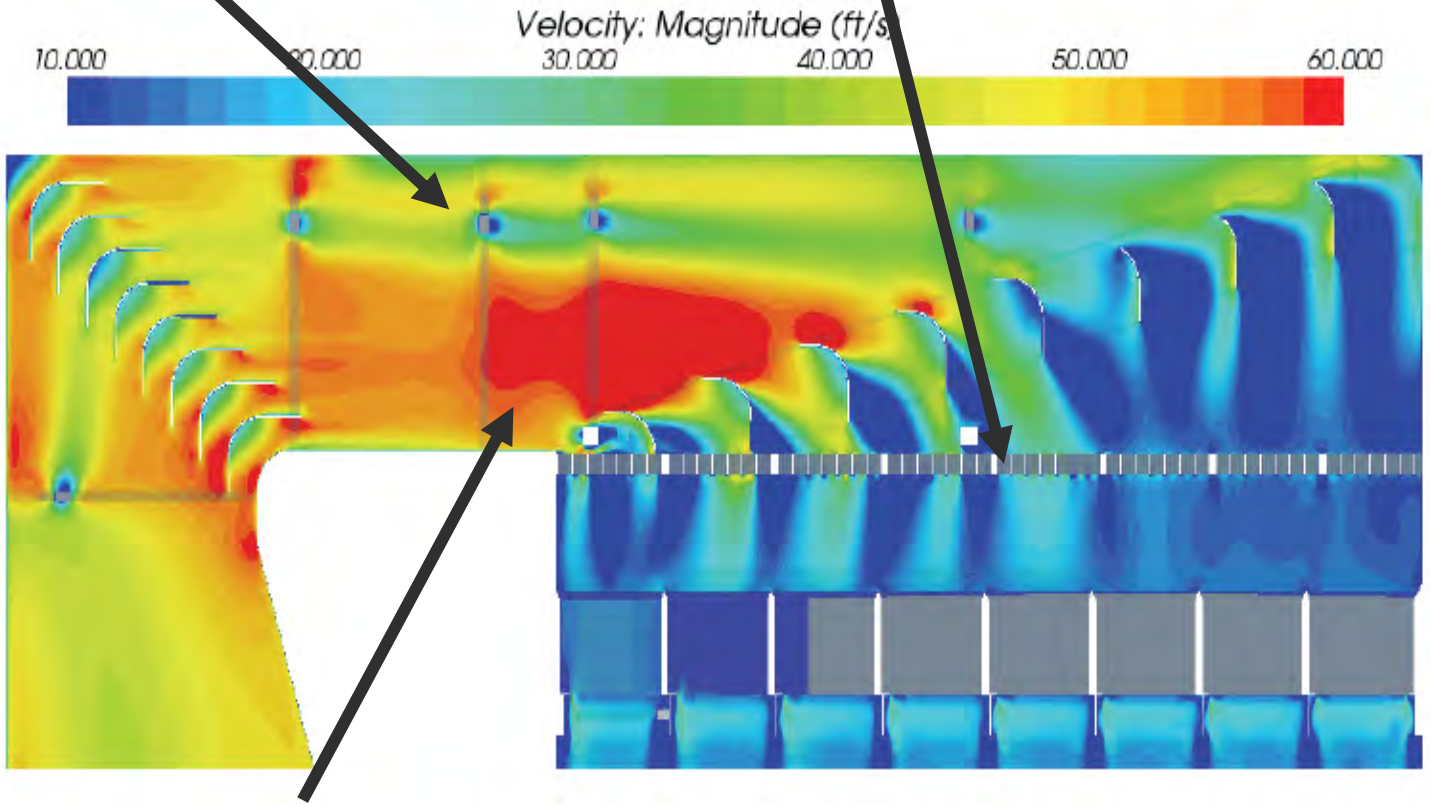
EXCESS FLYASH PLUGGAGE – A-SCR LAYER 2 2ND SEAL STRIP

BASELINE VELOCITY RESULTS



STRUCTURE:
Truss & Gussets

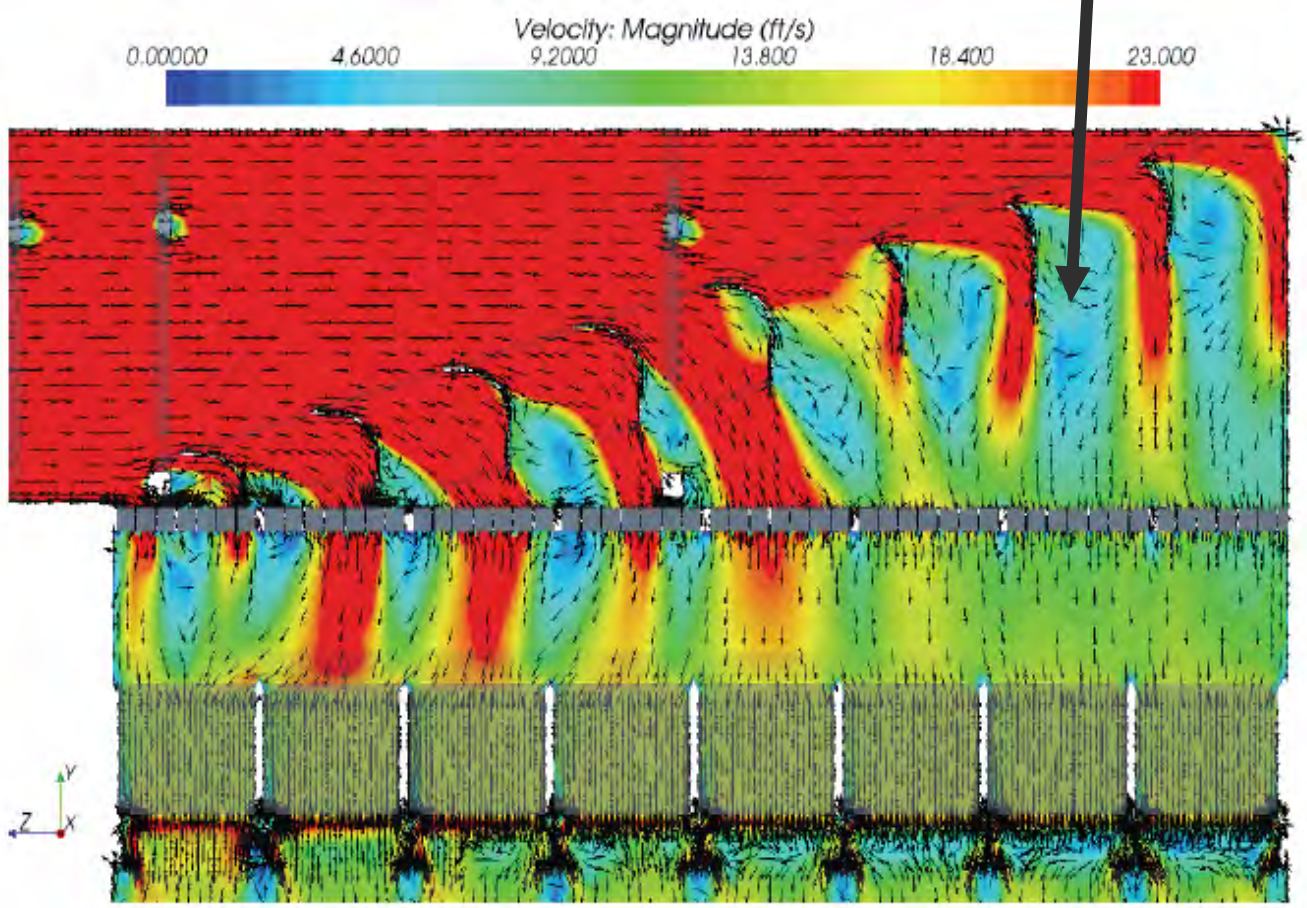
Egg Crate STRUCTURE



Inlet transition, Truss & Gussets create high flow

BASELINE RESULTS VELOCITY VECTORS

TURNING VANES & RECIRC

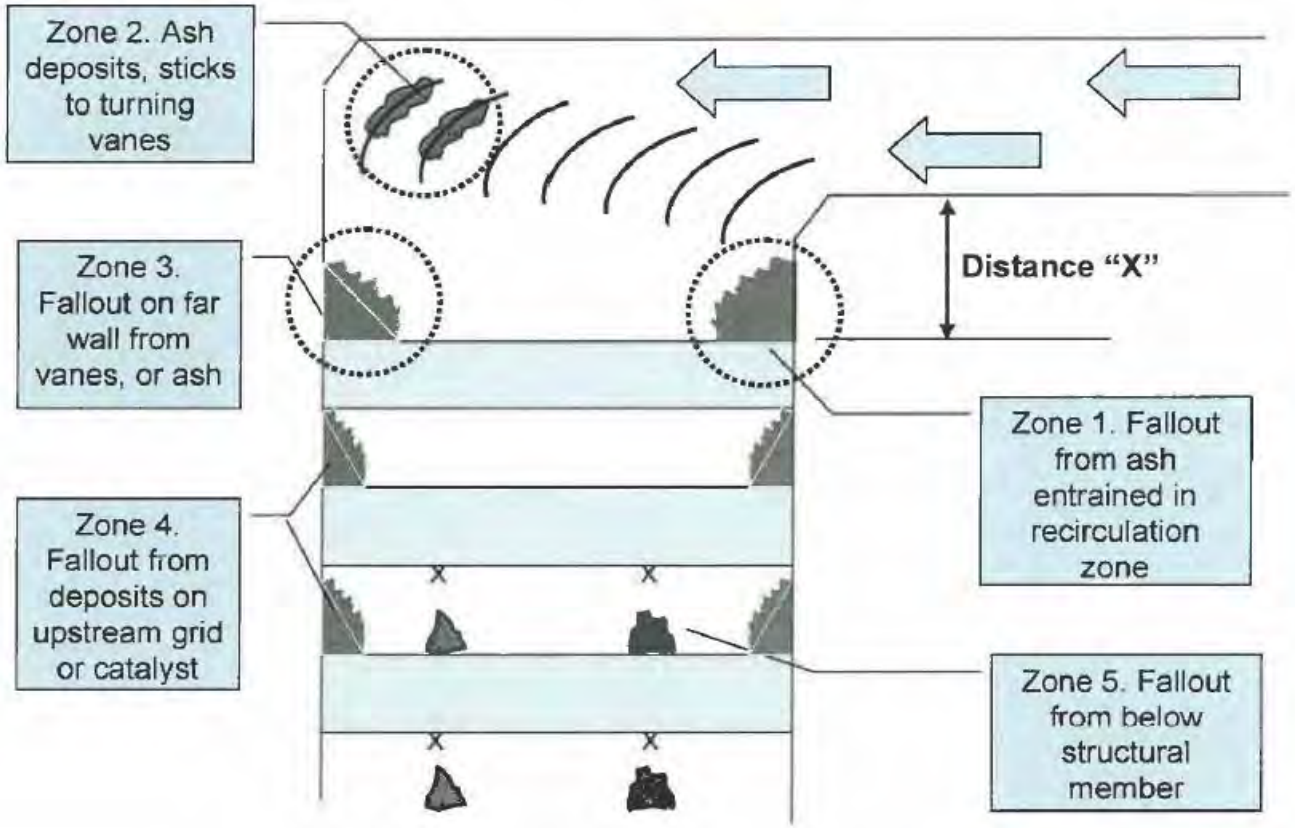


Vectors near vanes show recirculation areas where potential ash fallout can occur.

EXCESS FLYASH PLUGGAGE from TURNING VANES-FLOW RECIRC-STRUCTURE

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Guidelines for New SCR Systems



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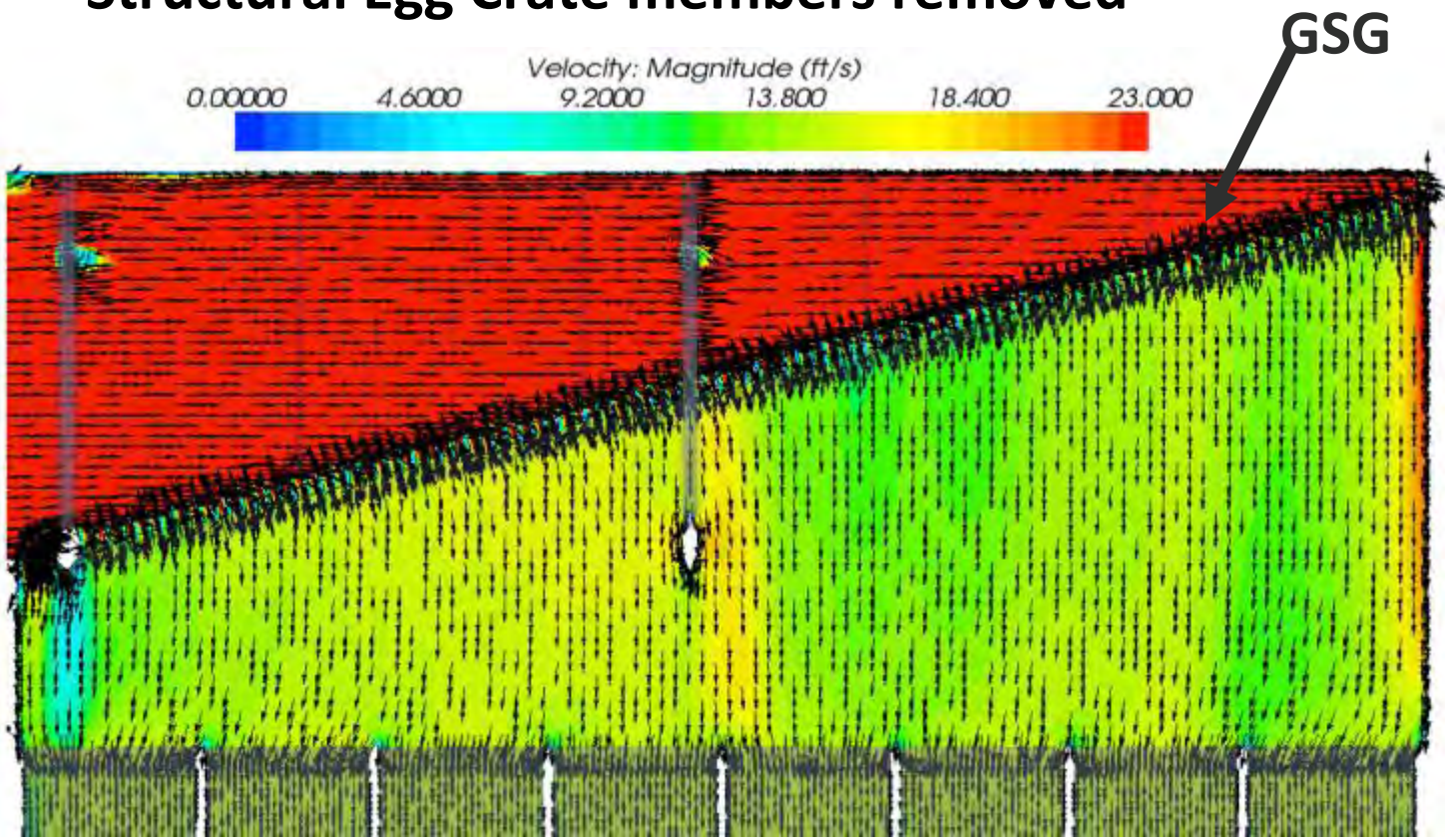
KCP&L energizing life

FUEL TECH Technologies to enable clean efficient energy

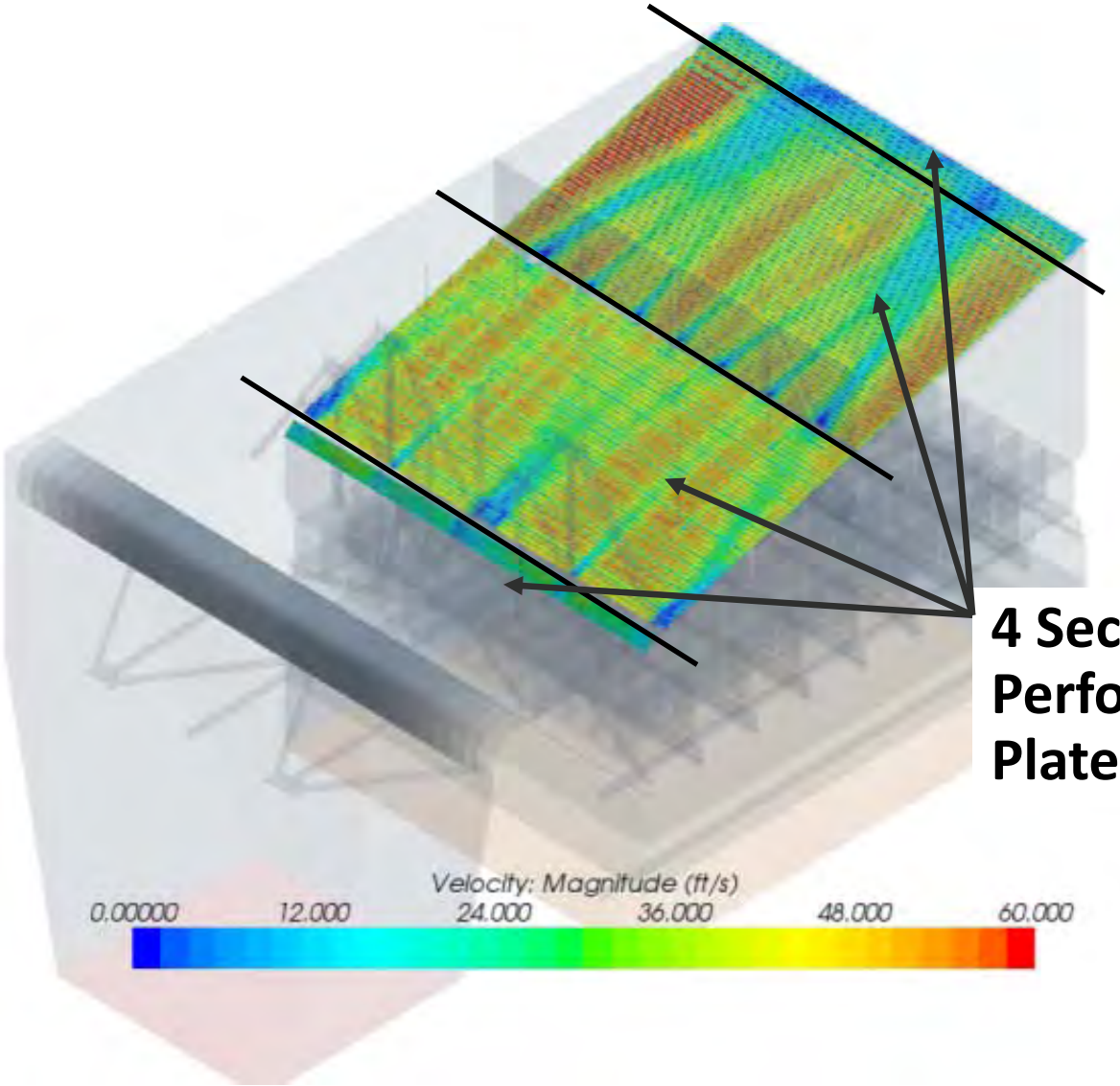
FLOW MODELING CFD SHOWS GSG BENEFITS

- Graduated Straightening Grid (GSG) with variable Perforated Plate eliminates Turning Vane Recirc
- Structural Egg Crate members removed



Vectors show very good straight flow in the hood.

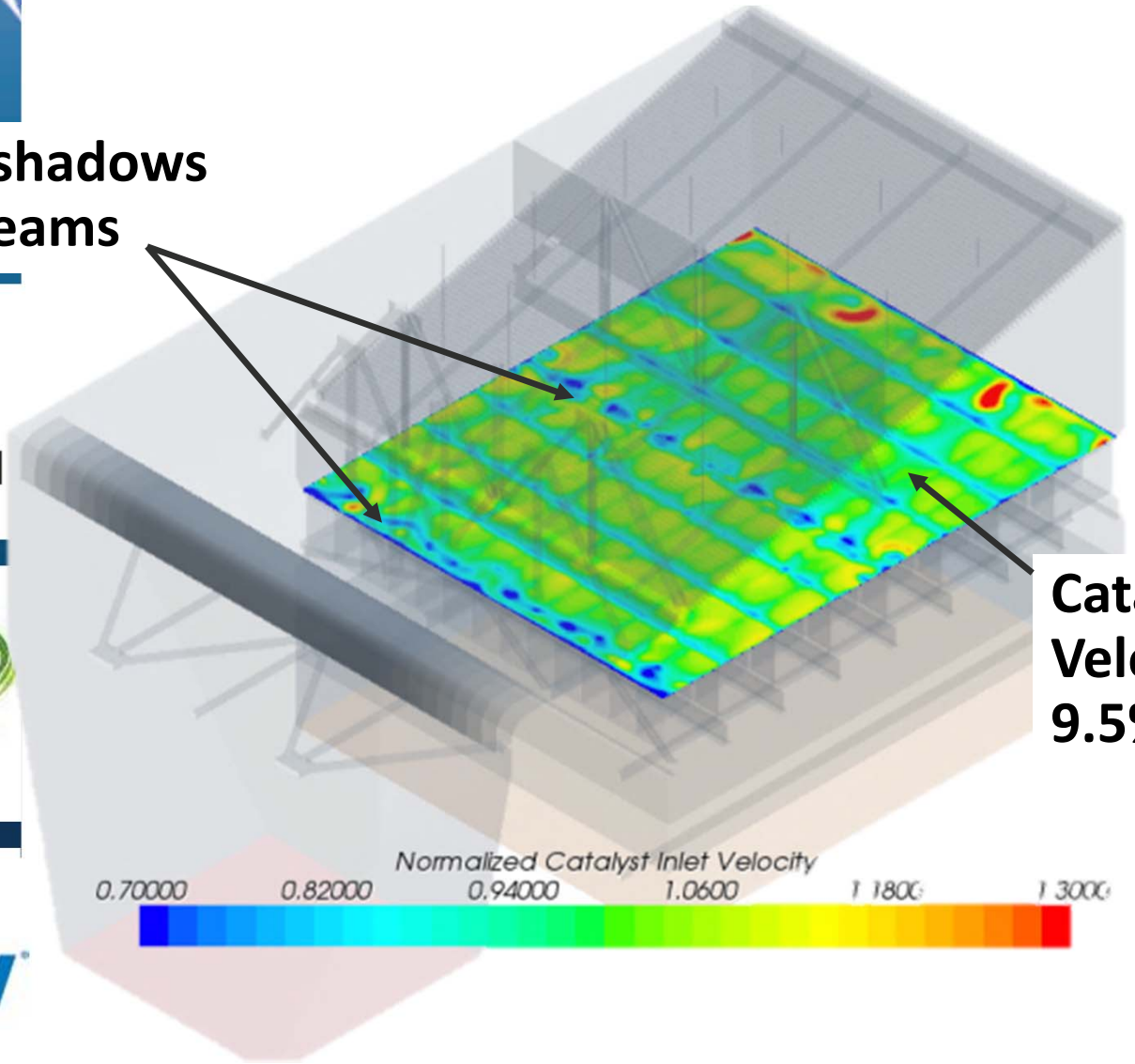
RUN 5 RESULTS (GSG) – VELOCITY



4 Sections of Perforated Plate

RUN 5 RESULTS (REACTOR) – VELOCITY

Smaller shadows below beams



Catalyst Inlet Velocity – 9.5% RMS

FLOW MODELING CFD SHOWS GSG BENEFITS

	Baseline	GSG	Desired
Flow +/- 15%	58%	91%	100%
Flow +/- 30%	94%	99%	Not Used
RMS	17.5%	9.5%	Not Used

RESULTS AT 4 MONTHS

LAYER 2 – 2ND SEAL STRIP

LAYER 2 DIVISION WALL

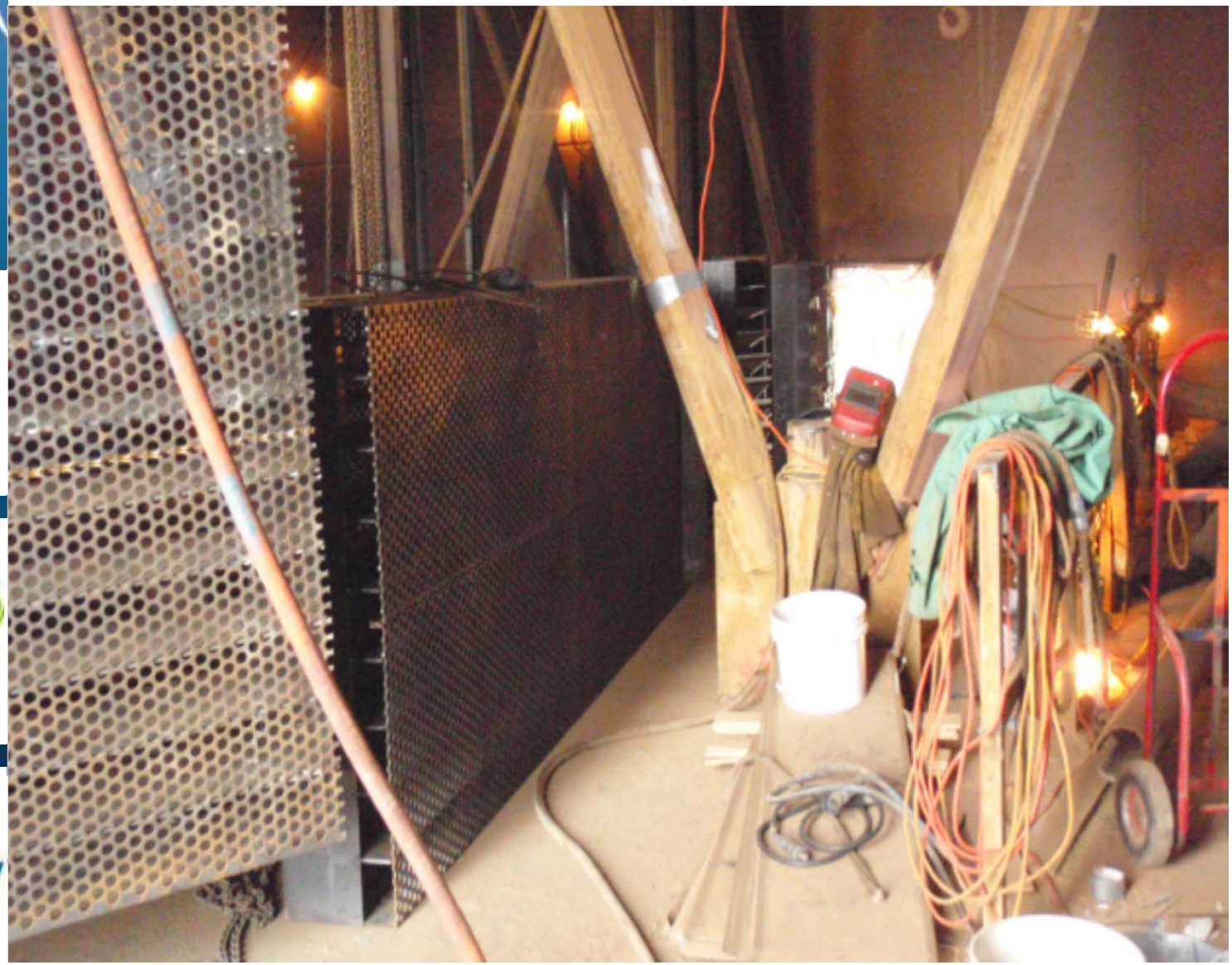
CONSTRUCTION – DEMOLITION OF TURNING VANES

CONSTRUCTION – DEMOLITION OF EGG CRATE STRAIGHTENER AND SUPPORTS

CONSTRUCTION – EXTERNAL REINFORCEMENT

CONSTRUCTION – SCR CRANE

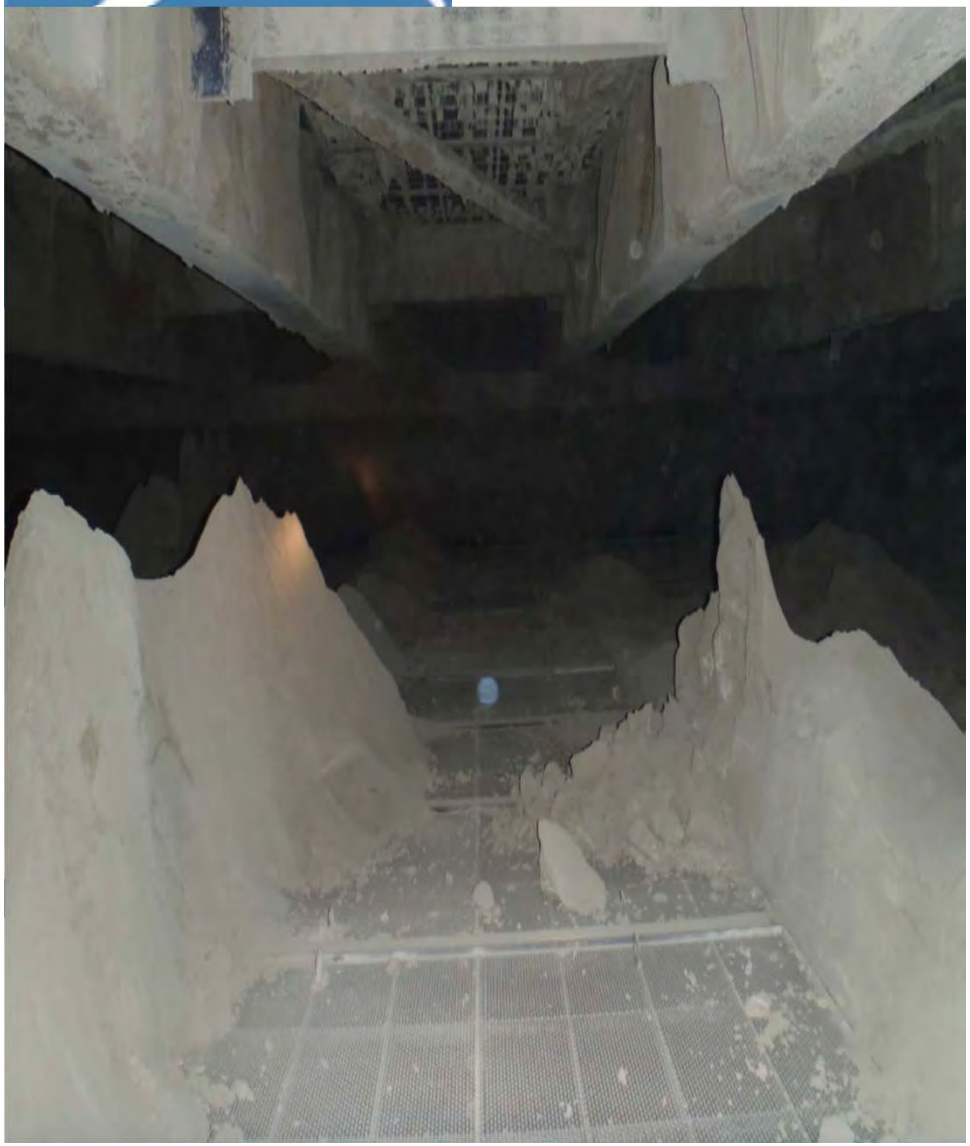
CONSTRUCTION – GSG PANEL INSTALLATION



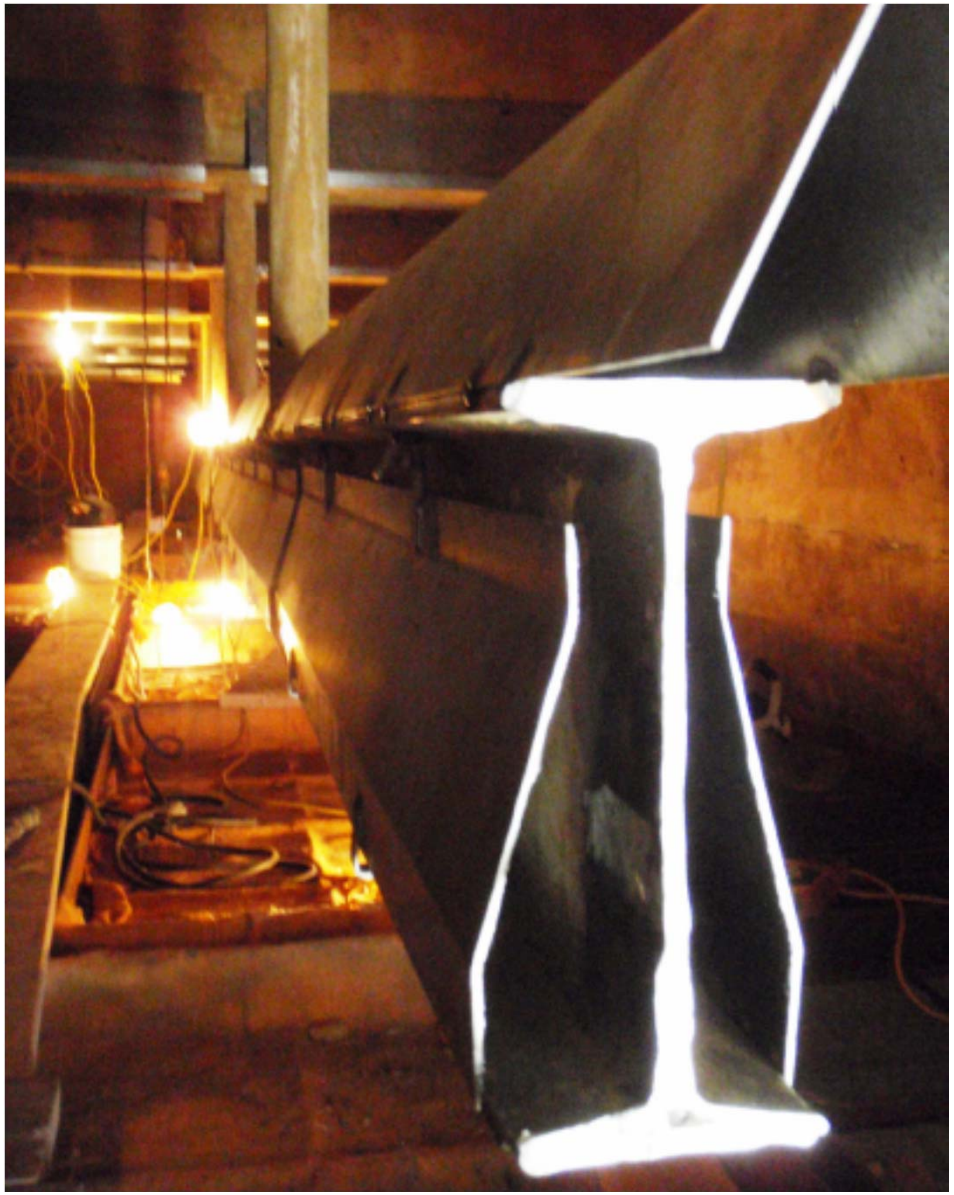
CONSTRUCTION – GSG PANEL INSTALLATION

CONSTRUCTION – GSG PANEL INSTALLATION

EXCESS FLYASH PLUGGAGE – A–SCR LAYER 2 TENT SEAL STRIPS



EXCESS FLYASH PLUGGAGE – BEAM ASH GUARDS



CONSTRUCTION – LAYER 1 FLOOR GRATE AND ASH GUARDS

RESULTS AT 4 MONTHS

LAYER 2 DIVISION WALL

GSG BENEFITS FOR LACYGNE UNIT 1 OPERATION

- **Improved flue gas flow distribution and reduced fly ash accumulation resulting in:**
  - Reduced catalyst replacement costs. The next catalyst layer replacement forecast after 2019, resulting in one layer being replaced after 7 years of operation.
  - Reduced fly ash vacuum removal costs/reduced complexity of outages
  - Reduced catalyst press drop and fan power costs eliminating de-rate of unit
  - Reduced ammonia slip and reagent costs. The lower ammonia slip also reduces FGD foaming potential that can damage ID Fans.
- **$5M in realized cost savings**

KEY SCR DESIGN REQUIREMENTS AND OPERATING LESSONS LEARNED

- Uniform, vertical, non-recirculating flow into catalyst
- Flue Gas flow design criteria – 15% from Mean vs. RMS or Cv
- CFD and Physical Modeling – Complimentary design activities. Matching results validate each model.
- Flow Modeler needs to have SCR experience & PRB coal experience
- Flow model resolution – 5-10,000,000 cells SCR Hood to Layer 1
- Equipment modeled – 6” in physical / all flow disturbances in CFD

KEY SCR DESIGN REQUIREMENTS AND OPERATING LESSONS LEARNED

- Minimal structure inside SCR and Gas Flues – flow disturbances
- Minimize horizontal surfaces – PRB ash accumulates on any surface
- Catalyst pitch – minimum 8mm Honeycomb or 5.6mm plate
- Outage layup – keep SCR hot or use heaters to prevent condensation
- Sonic horn failures – Moisture and PM
- LPA screen failures – Erosion or layout
- Outage ash cleaning method – vacuum to catalyst face
- Inspections and Monitoring – catalyst management program

LACYGNE UNIT 1 – CFD MODELING FOR SCR OPTIMIZATION

Scott Hiedeman, Senior AQC Engineer, KCP&L

Scott.Hiedeman@KCPL.com 913-632-0842

Reid Thomas, Senior Process Engineer, Fuel Tech

RThomas@FTEK.com 919-405-2299

Dale Pfaff, Mountain Regional Sales Manager, Fuel Tech

DPfaff@FTEK.com 847-504-6650

Diane Fischer, Services Area Leader, AQC, Energy, Black & Veatch

FischerDM@BV.com 913-458-7926