REINHOLD ENVIRONMENTAL Ltd.

2012 NOx-Combustion Round Table & Expo Presentation

February 13-14, 2012, in Columbus, OH / Hosted by AEP

Duck Creek – Fixing the SCR Reactor

Reinhold Environmental 2012 NOx-Combustion Round Table
February 14, 2012

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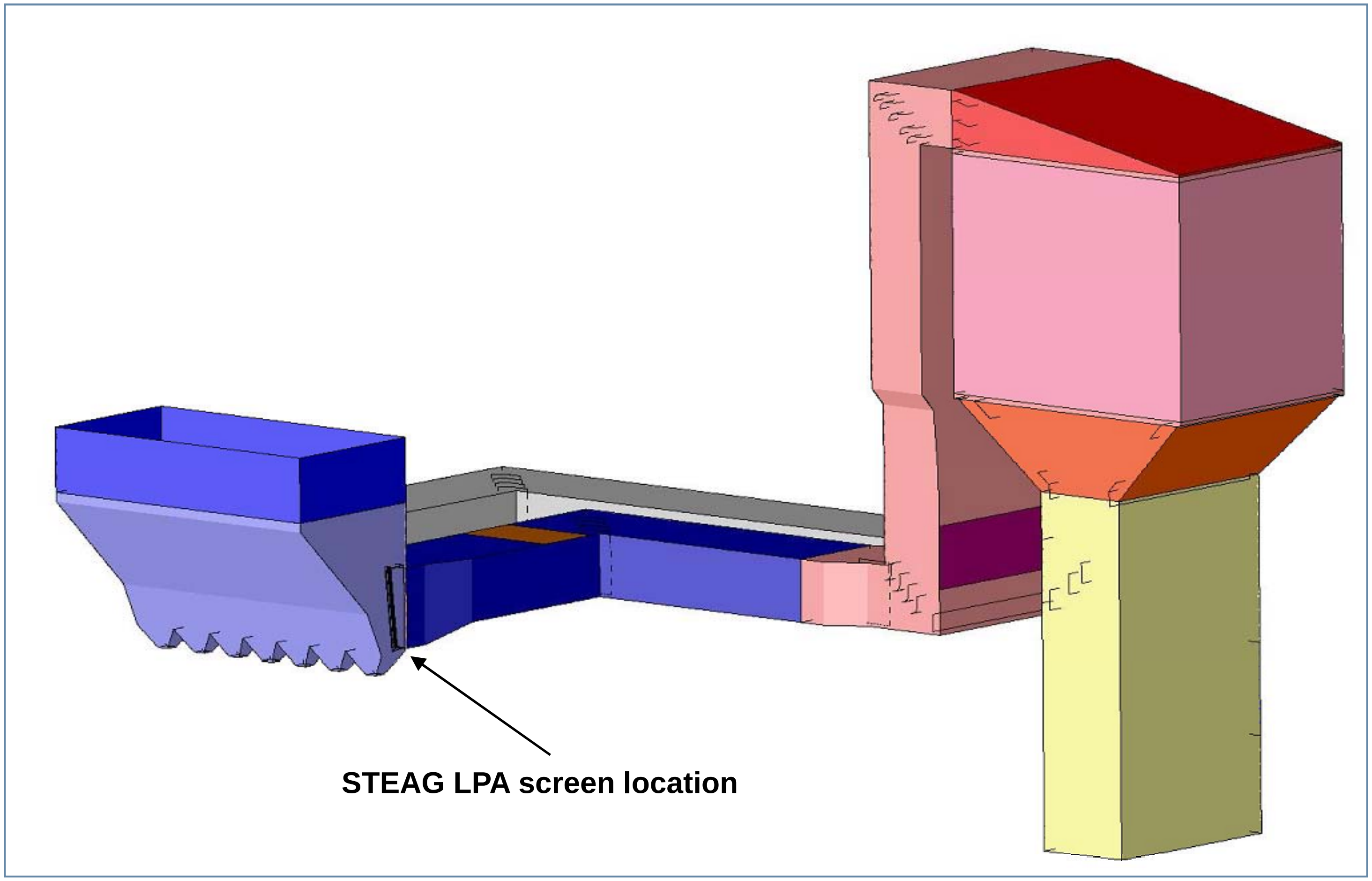
Agenda

- Duck Creek Unit 1 SCR Design
- Problems Experienced
- SCR Reactor System Evaluation
- Modifications/Improvements Implemented
- Present Results
- Potential Future Modifications

Duck Creek Unit 1

- Owned by Ameren Energy Resources Generating.
- Located near Canton, Illinois.
- Unit originally designed for Illinois Basin bituminous coal. presently firing sub-bituminous PRB coal / Illinois Basin blend.
- Retrofitted with a high-dust SCR and operation commenced in 2003. Reactor consists of 96 modules per layer. Designed for 88.5% NOx removal efficiency with a Inlet NOx of 0.7 lbs/mmBtu.
- SCR reactor experienced LPA problem from the beginning. Flat LPA screen was installed in the boiler's economizer outlet but continued to erode away quickly due to high flue gas velocities.
- Unit rating raised from 360 MW to 475 MW without touching the SCR Reactor.

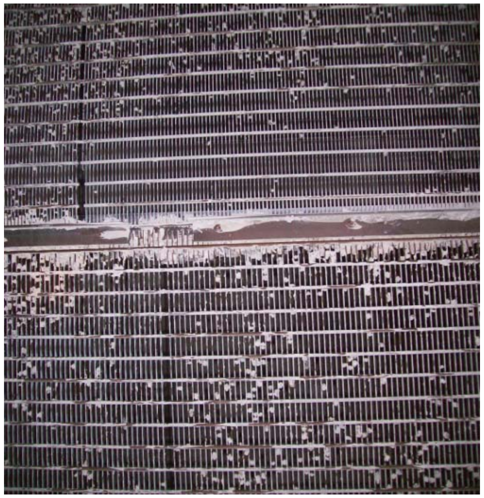
Duck Creek Unit 1



General arrangement of SCR Reactor

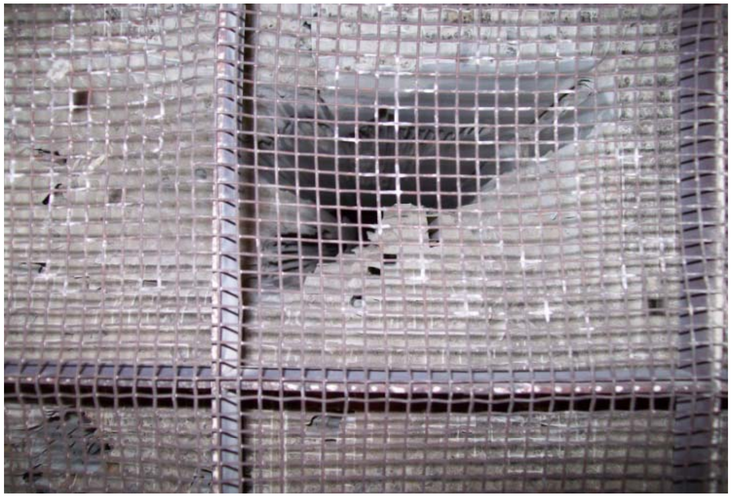
Problems Experienced

- Flat LPA screens
  - Plugged easily
  - Eroded heavily
- LPA screen pluggage shown right is for 2 months of operation
- Slagging / LPA was evident past the LPA screen
- LPA was found on and inside the catalyst



Problems Experienced

- **Extremely high velocities:**
  - **in the economizer outlet > 100 fps**
  - **through the SCR catalyst > 30 fps**
- **Excessive erosion damage of LPA screen and catalyst layers**
- **12+ inches dp across 3 honeycomb catalyst layers due to pluggage**
- **Plugged and eroded 4½ honeycomb layers in less than 2 years**
- **Catalyst pluggage mostly located along edges of reactor, erosion in the center**



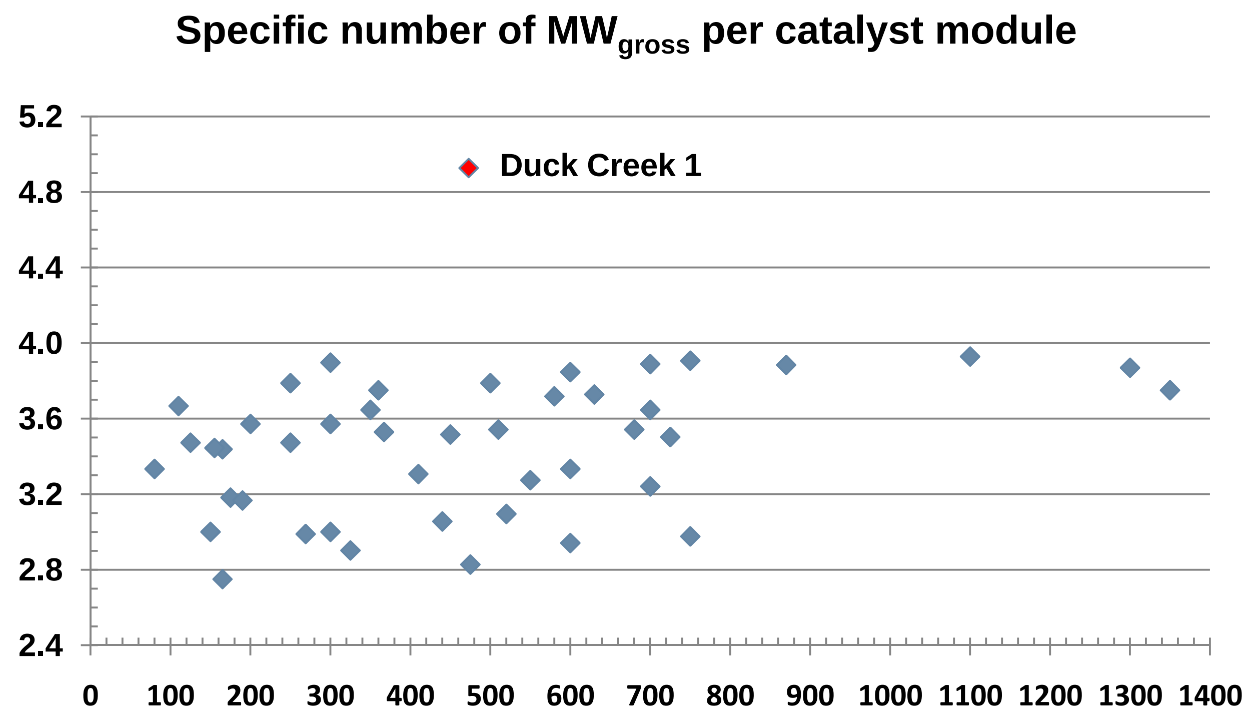
Problems Experienced

Pluggage and erosion history:

- **Startup of unit after boiler upgrade in 3/09. First time at new MCR 12/09.**
- **Honeycomb catalyst layer replacements:**
  - **1 layer in April 2010**
  - **½ layer in October 2010**
  - **2 layers in April 2011**
  - **1 layer in October 2011**

SCR Reactor System Evaluation

- **Detailed reactor inspection conducted on January 17, 2011**
- **Flow conditions were established**
  - **4,266,000 lbs/hr**
  - **761 F**
- **Simple comparison of MWs per catalyst module to other SCR units clearly indicates that the Duck Creek SCR reactor is too small for the increased boiler rating from 360 MW to 475 MW.**



Modifications / Improvements Implemented

- **Flat LPA screen replaced with STEAG's patented pleated LPA screen design**





Modifications / Improvements Implemented

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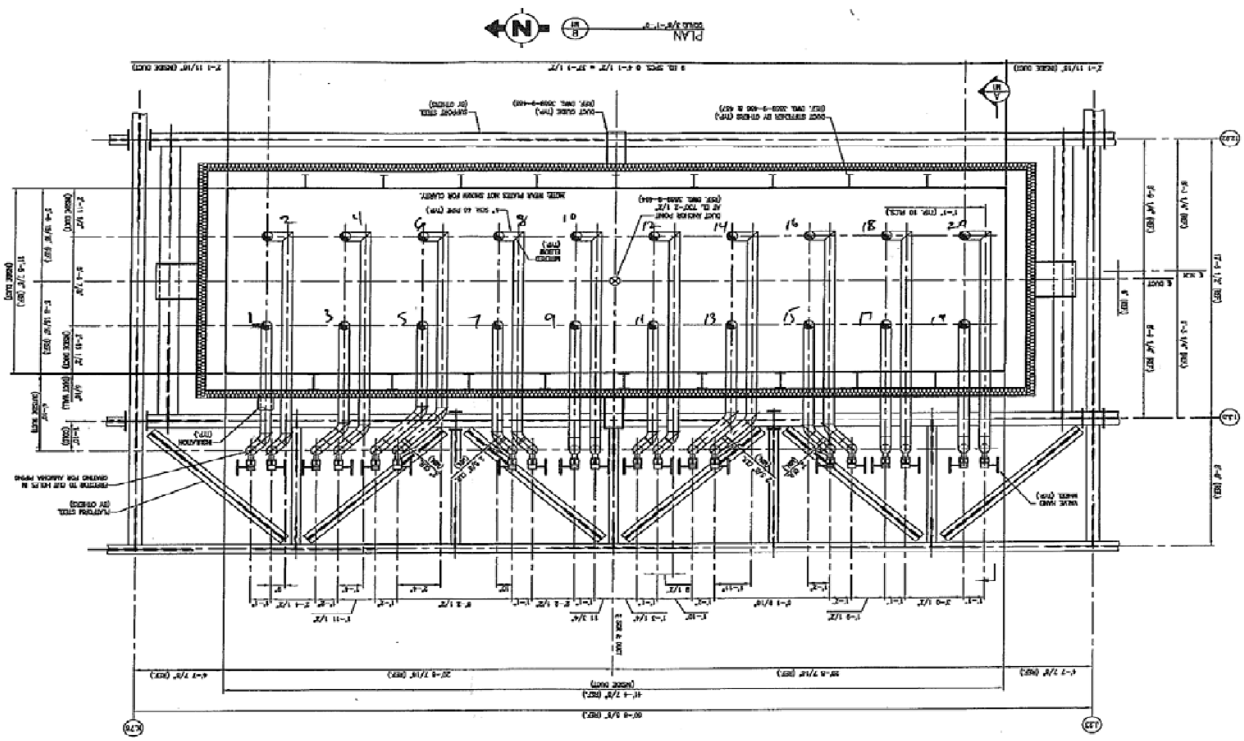
- **Initial fill of 3 honeycomb layers (6.7 mm pitch, 1,190 long), startup in May 2003.**
- **All 6.7 mm pitch honeycombs replaced by 8.2 mm pitch honeycombs in 2006 – 2009 due to pluggage problems including LPA.**
- **All honeycomb catalyst layers (8.2 mm pitch, 1,300 mm long) replaced with 3 regenerated plate catalyst layers (5.6 mm pitch, 2 x 625 mm long) in 2011.**
- **Catalyst layer seal design modified for easier installation and removal.**

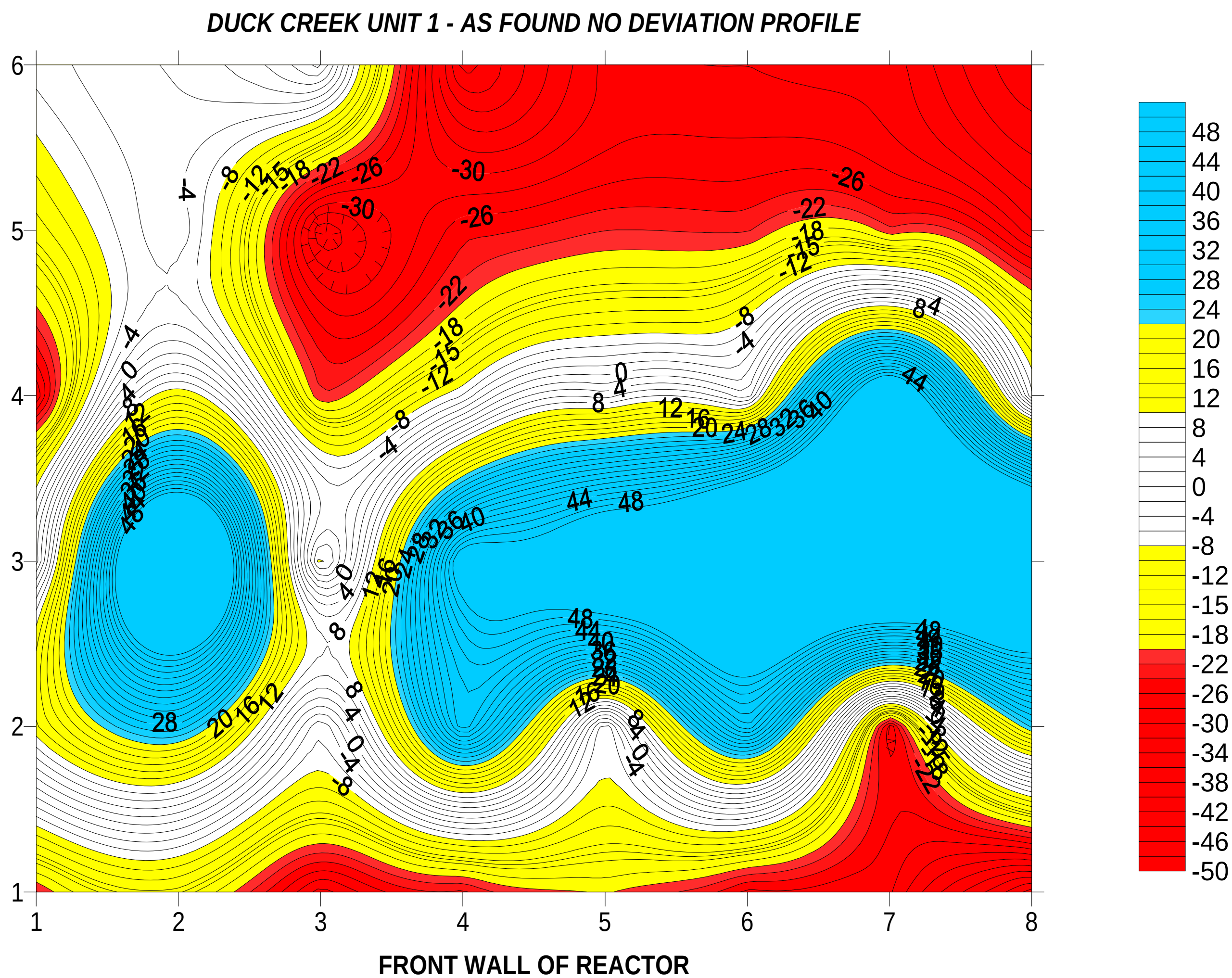
Modifications/Improvements Implemented

- **AIG tuning conducted to improve ammonia flow distribution**

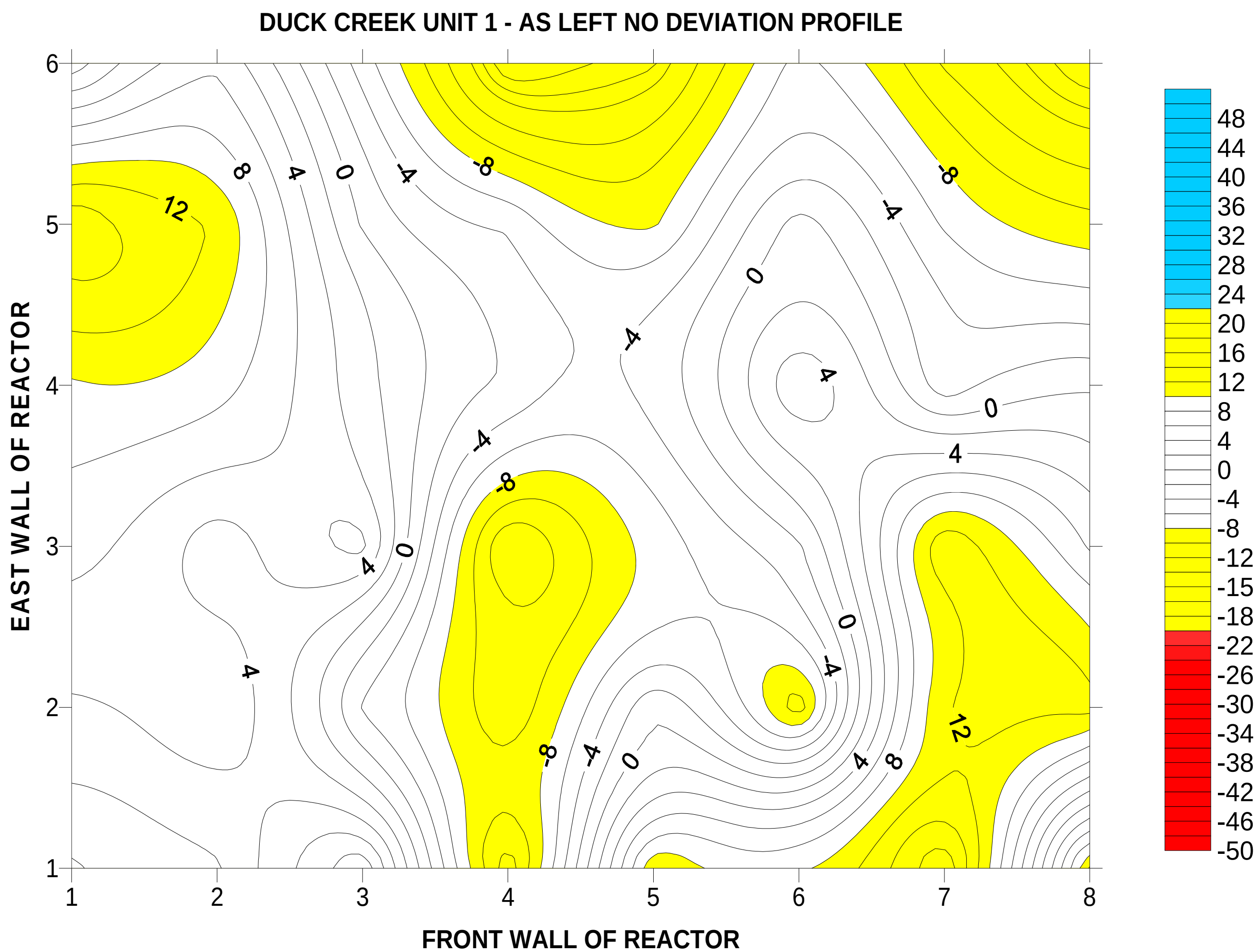
- **SCR reactor tuned to a profile within +/- 20 ppm of the average NO_x value of the entire reactor**



Modifications/Improvements Implemented



Modifications/Improvements Implemented

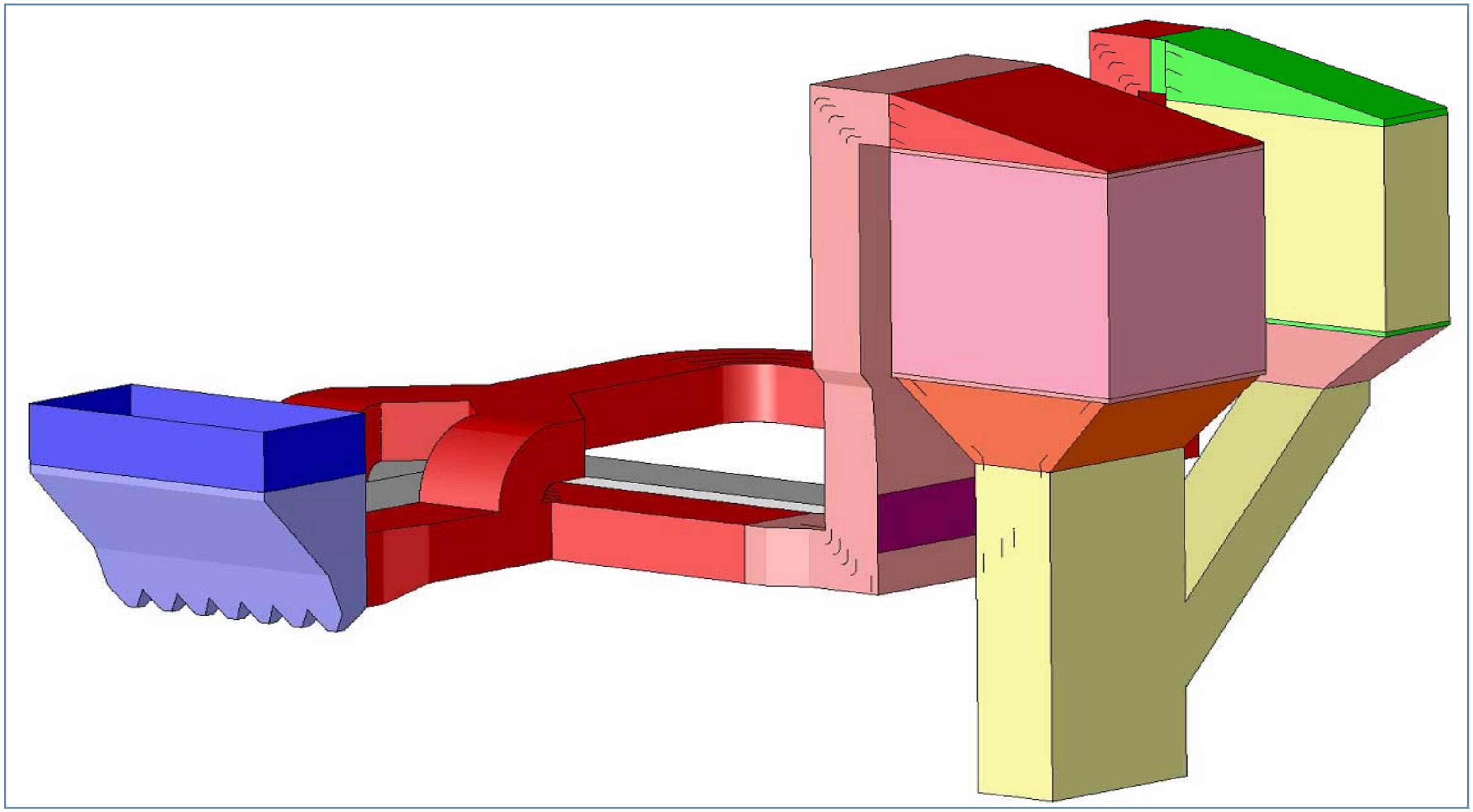


Present Results of the “Immediate Fix“

- Pleated STEAG LPA screen installed since April 2011.
- Two layers of honeycomb replaced by regenerated plate catalyst, which is in operation since April 2011.
- Third layer of honeycomb catalyst replaced by regenerated plate catalyst in October 2011.
- Since October 2011, pressure drop maintained at less than 2 inches per catalyst layer.
- No erosion seen on the STEAG pleated LPA screen or plate catalyst.
- No pluggage experienced on any of the three plate catalyst layers.

Potential Future Modifications

- **Consideration of an second SCR reactor (Backpack Reactor) adjacent to the existing reactor**

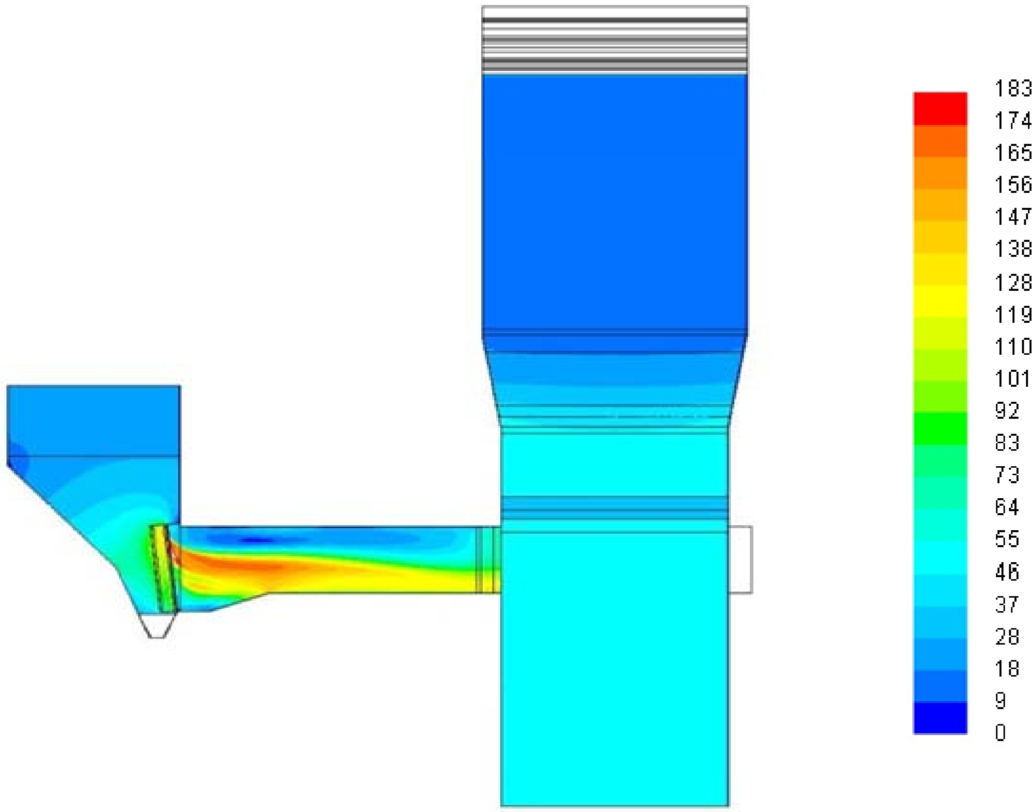


Potential Future Modifications

- **Computational Fluid Dynamic (CFD) modeling was performed:**
  - **Goal was to ensure the design layout would achieve acceptable velocity and flow profiles.**
  - **Inlet boundary condition was chosen as plug flow since no velocity data was available for the inlet plane in the boiler's economizer section.**
  - **Inlet boundary was the economizer outlet duct, immediately above the economizer outlet hopper.**
  - **Outlet boundary was the SCR reactor duct exit plane, immediately ahead of the air preheater inlet.**

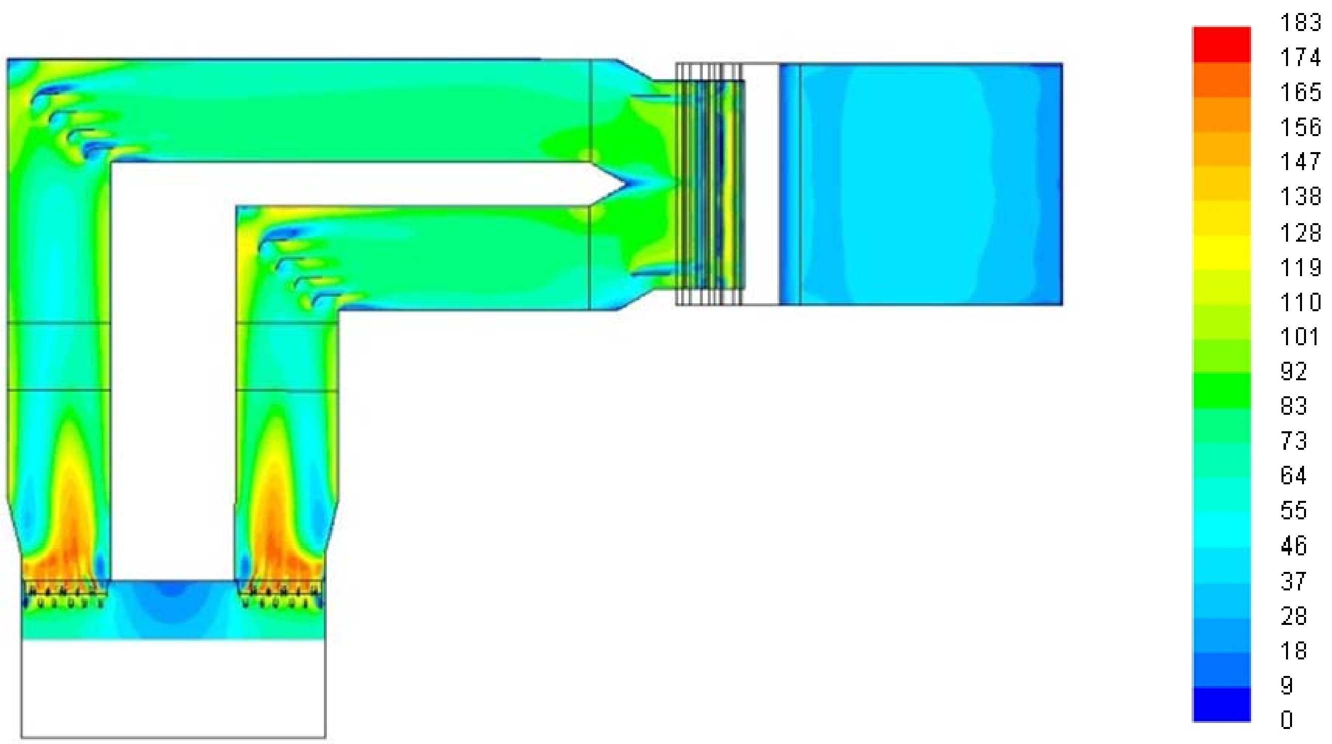
Potential Future Modifications

Gas velocity profile at duct and SCR centerline for Case 1 (fps)



Potential Future Modifications

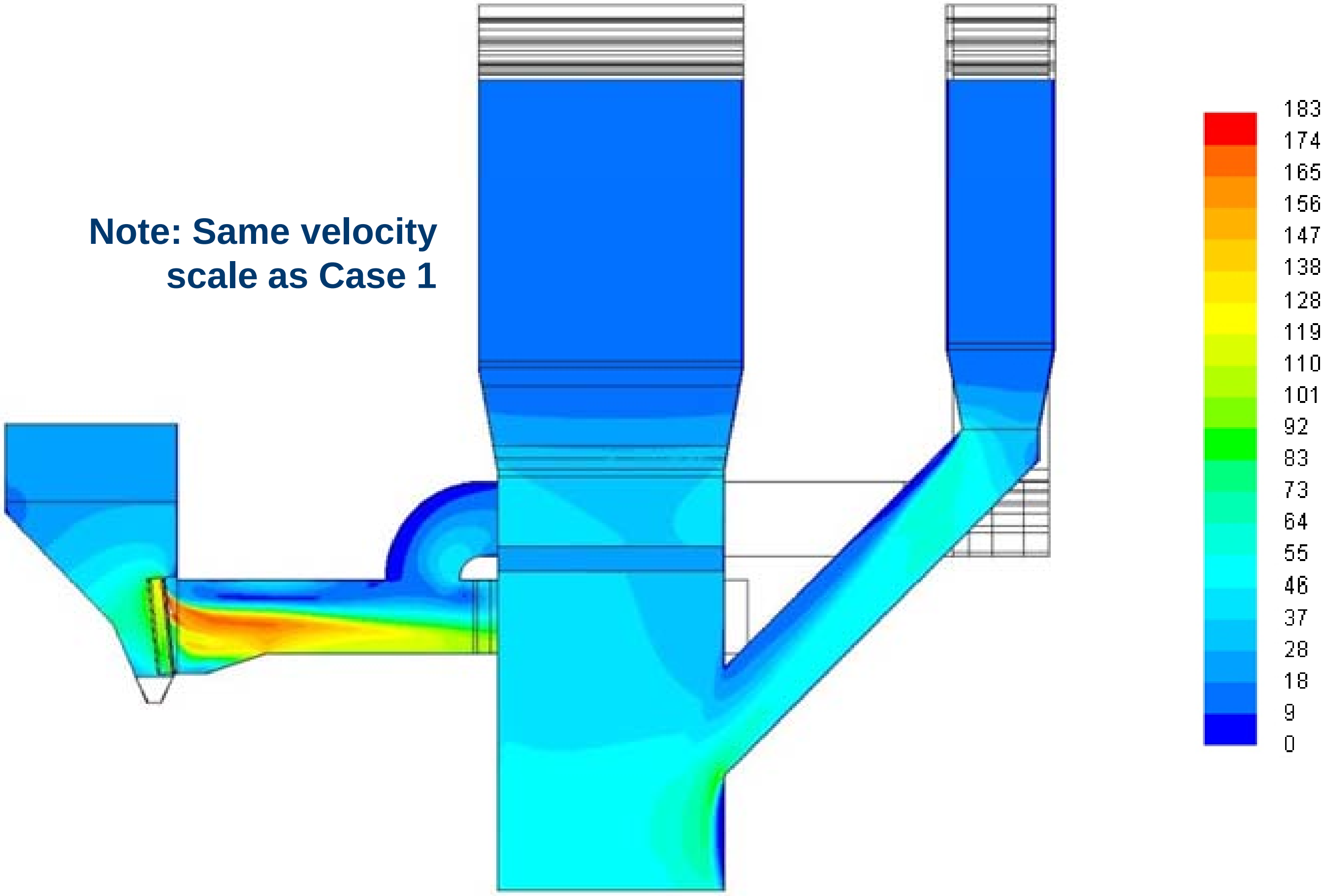
Gas velocity profile at duct and SCR centerline for Case 1 (fps)



Potential Future Modifications

Gas velocity profile at duct and SCR centerline for Case 2 (fps)

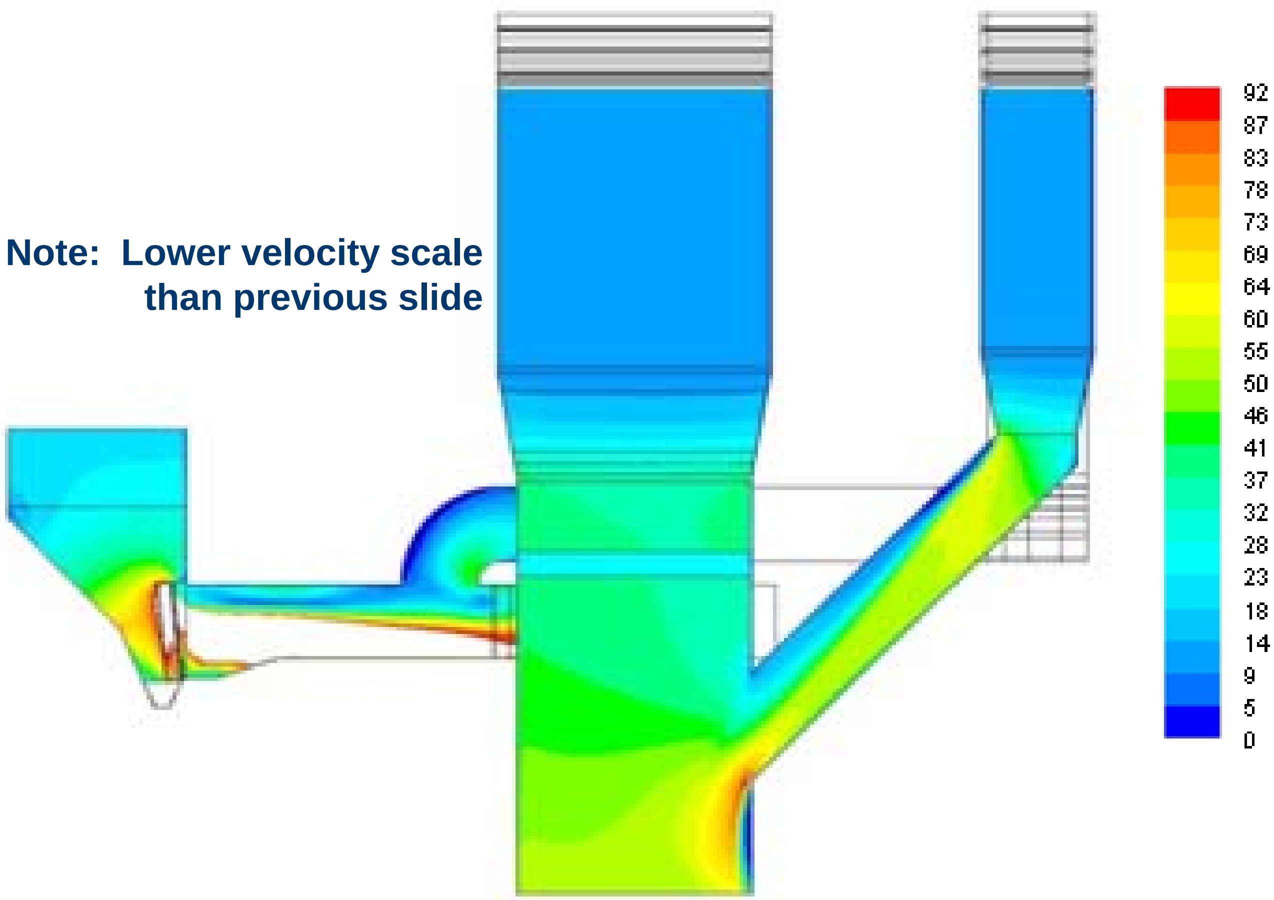
Note: Same velocity scale as Case 1



Potential Future Modifications

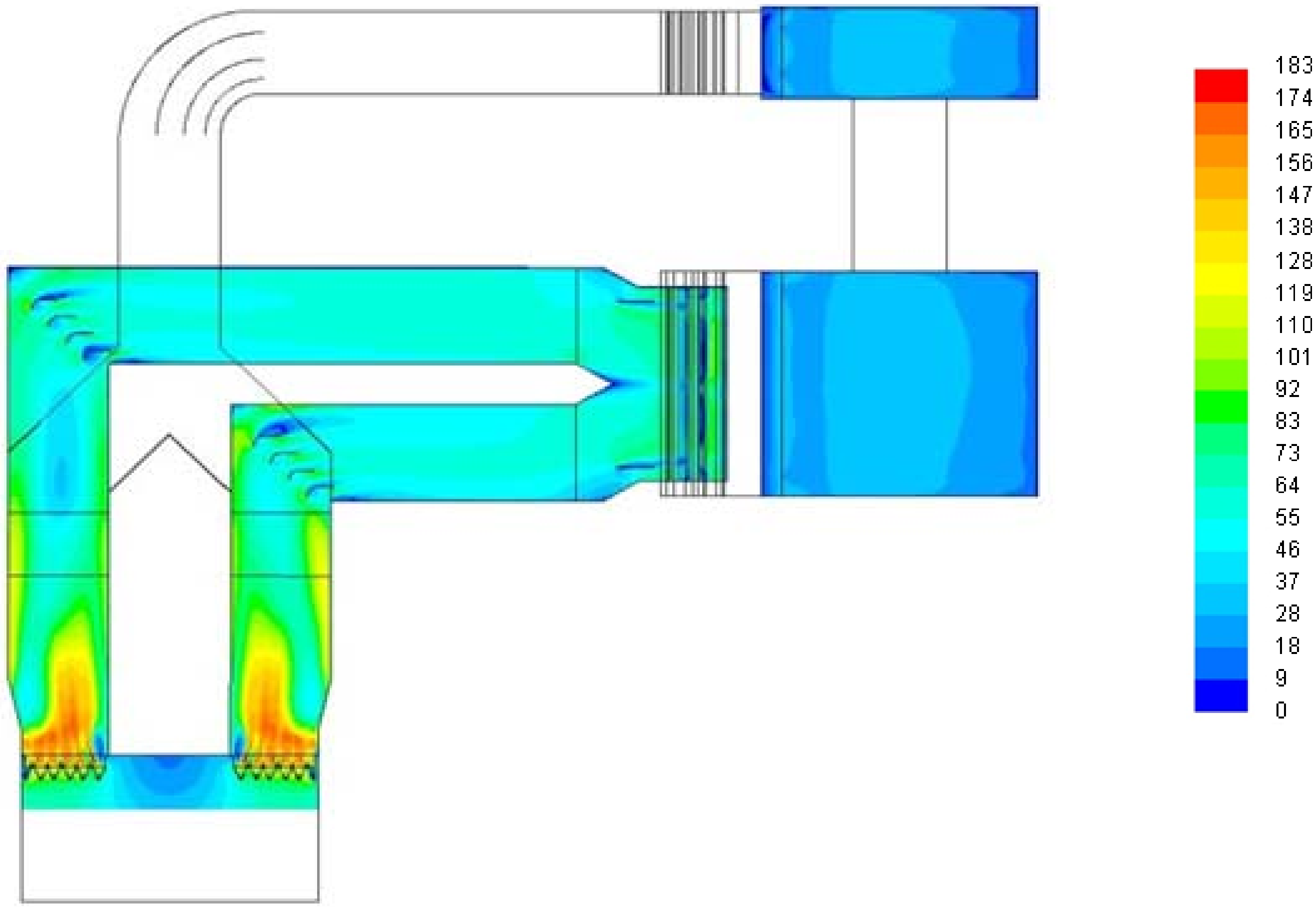
Gas velocity profile at duct and SCR centerline for Case 2 (fps)

Note: Lower velocity scale than previous slide



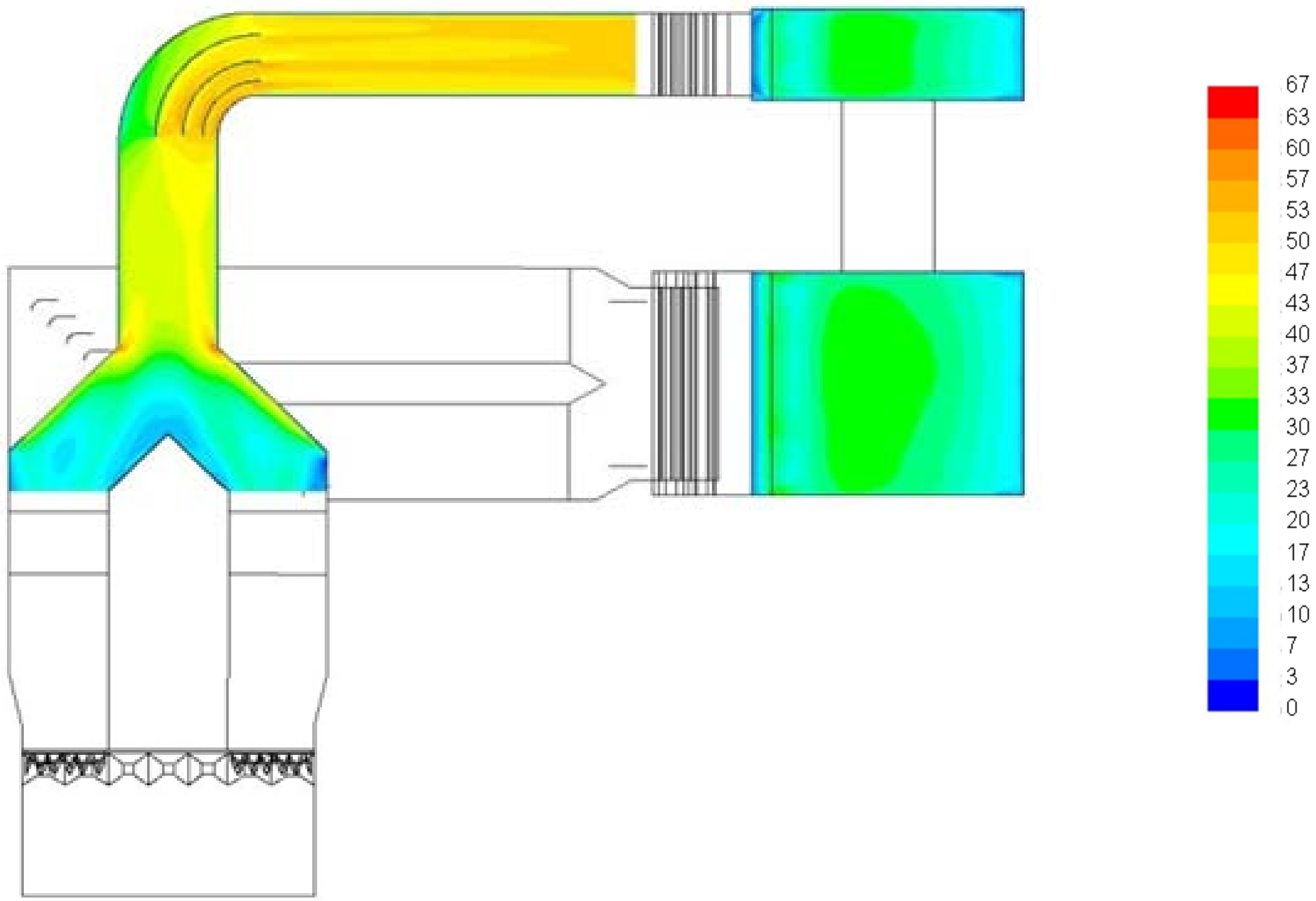
Potential Future Modifications

Gas velocity profile at duct horizontal centerline for Case 2 (fps)



Potential Future Modifications

Gas velocity profile at duct horizontal centerline for Case 2 (fps)



Potential Future Modifications

- **Preliminary results of CFD**

  - **Case 1 – Existing SCR flow system**
    - **Economizer hopper flow velocity of 60 fps**
    - **LPA screen flow velocity exceeds of 95 fps**
    - **Duct upstream of SCR flow velocity of 70 – 80 fps**
    - **SCR average flow velocity of 15.5 fps**

  - **Case 2 – Addition of backpack SCR System**
    - **Flow split is approximately 72 percent / 28 percent**
    - **Duct upstream of existing SCR flow velocity of 50 – 55 fps**
    - **Duct upstream of backpack SCR flow velocity of 45 – 55 fps**
    - **Existing SCR average flow velocity of 11.3 fps**
    - **Backpack SCR average flow velocity of 10.3 fps**

Potential Future Modifications

- **Where do we go from here?**
  - **Continue to monitor LPA screen operation.**
  - **Continue detailed inspections of the SCR Reactor.**
  - **Conduct catalyst bench scale testing and evaluation of catalyst deactivation and possible erosion regularly.**
  - **Perform annual AIG tuning for optimizing SCR reactor performance.**
  - **Continue to use of new or regenerated plate catalyst.**
  - **Complete engineering cost estimate for backpack reactor to demonstrate technical and economical feasibility if required.**

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Thank you for your attention.

Any questions?