Reinhold Environmental Ltd.

2008 NOx-Combustion Round Table & Expo Presentation

February 4-5, 2008 in Richmond, VA

LPA Removal Alternatives

February 4, 2008

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AEP AMERICAN ELECTRIC POWER

2008 NOx-Combustion/ PCUG Conference

AEP SCR Overview

- AEP operates 13 SCR units and provides engineering and catalyst management services to all AEP SCR unit.
- AEP SCR's have been operating during ozone season only. The mandatory year round SCR operation will start on January 1, 2009. Four of SCR units start early year round operation in 2008
- All the 23 SCR units have SCR reactor bypass except for 4 SCR units of which SCR's were installed after 2004.
- AEP's Muskingum River unit 5 SCR started experiencing large particle ash (LPA) plugging the top catalyst layer from the beginning of SCR operation in April 2005.

Muskingum River Unit 5

- Unit capacity – 600 MWnet
- Pressurized, dry bottom boiler
- Low to medium sulfur coal
- SCR started operation in March 2005.
- SCR has no reactor bypass.
- Two SCR reactors which are designed to contain 4 catalyst layers with 2 layers installed initially and 2 spare layers for later catalyst addition.
- Third catalyst layer was added in spring 2007.
- Sonic horns are used for catalyst cleaning.
- LPA plugging the top catalyst layers was initially discovered during a forced outage in early June 2005, less than 3 months after initial operation.

Muskingum River Unit 5 LPA Issues

- The ash pile covered most of the first two rows of catalyst from inlet duct wall (1/4 of cross sectional area of reactor).
- The height of ash pile on the inlet duct wall is about 4 to 5 ft and is tapered off toward the center of reactor.
- At the bottom of the ash pile and the adjacent areas, significant quantity of large particle ash (LPA) laid on the catalyst protective screens.
- The quantity of LPA on the protective screens decreases considerably away from the ash pile.

Muskingum River Unit 5 LPA Issues

June 2005

Muskingum River Unit 5 LPA Issues

June 2005

Muskingum River Unit 5 LPA Issues

June 2005

Muskingum River Unit 5 LPA Issues

December 2005

Muskingum River Unit 5 LPA Issues

April 2006

Muskingum River Unit 5 LPA Issues

April 2006

Muskingum River Unit 5 LPA Issues

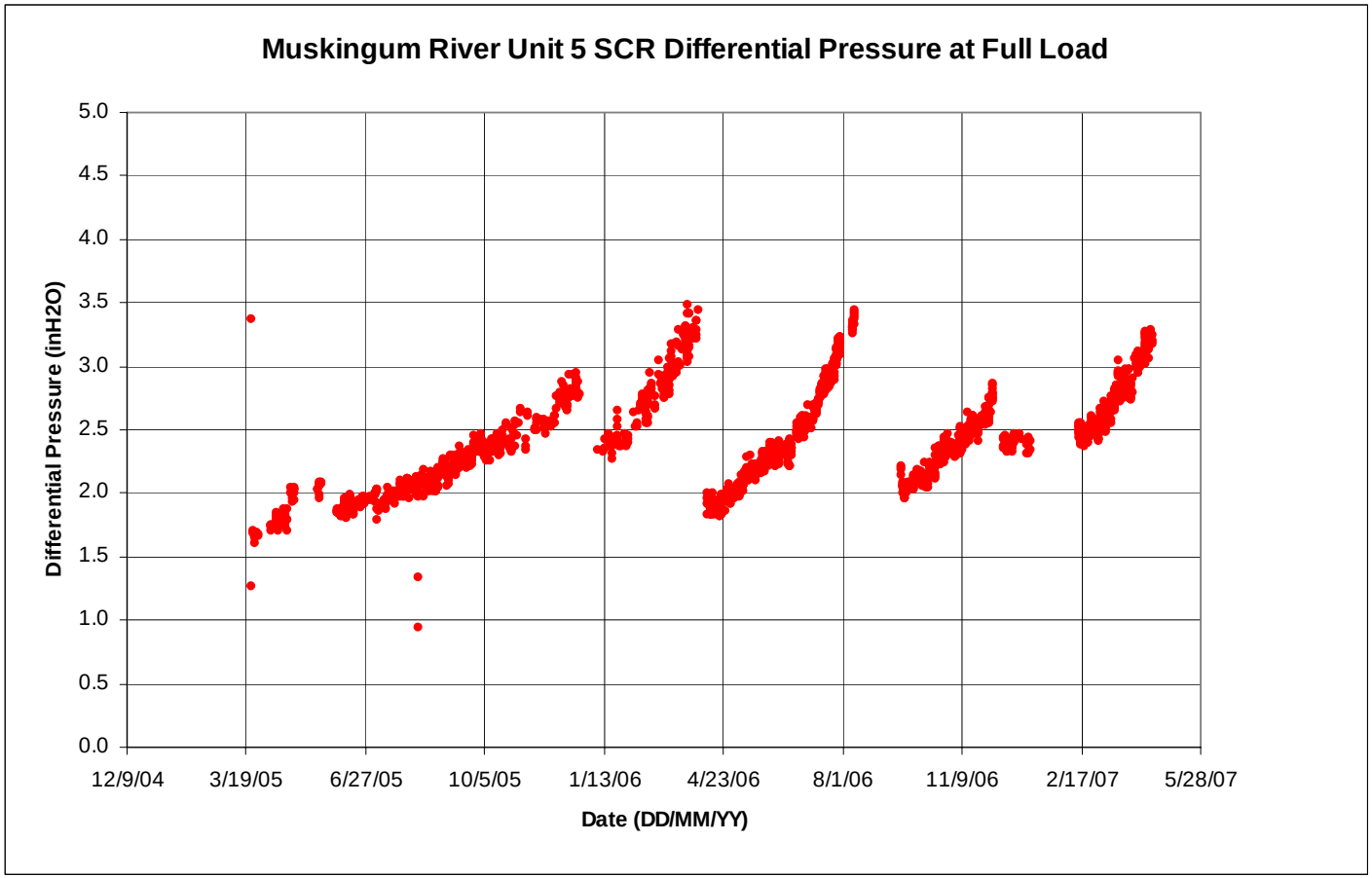
April 2006

Muskingum River Unit 5 LPA Issues

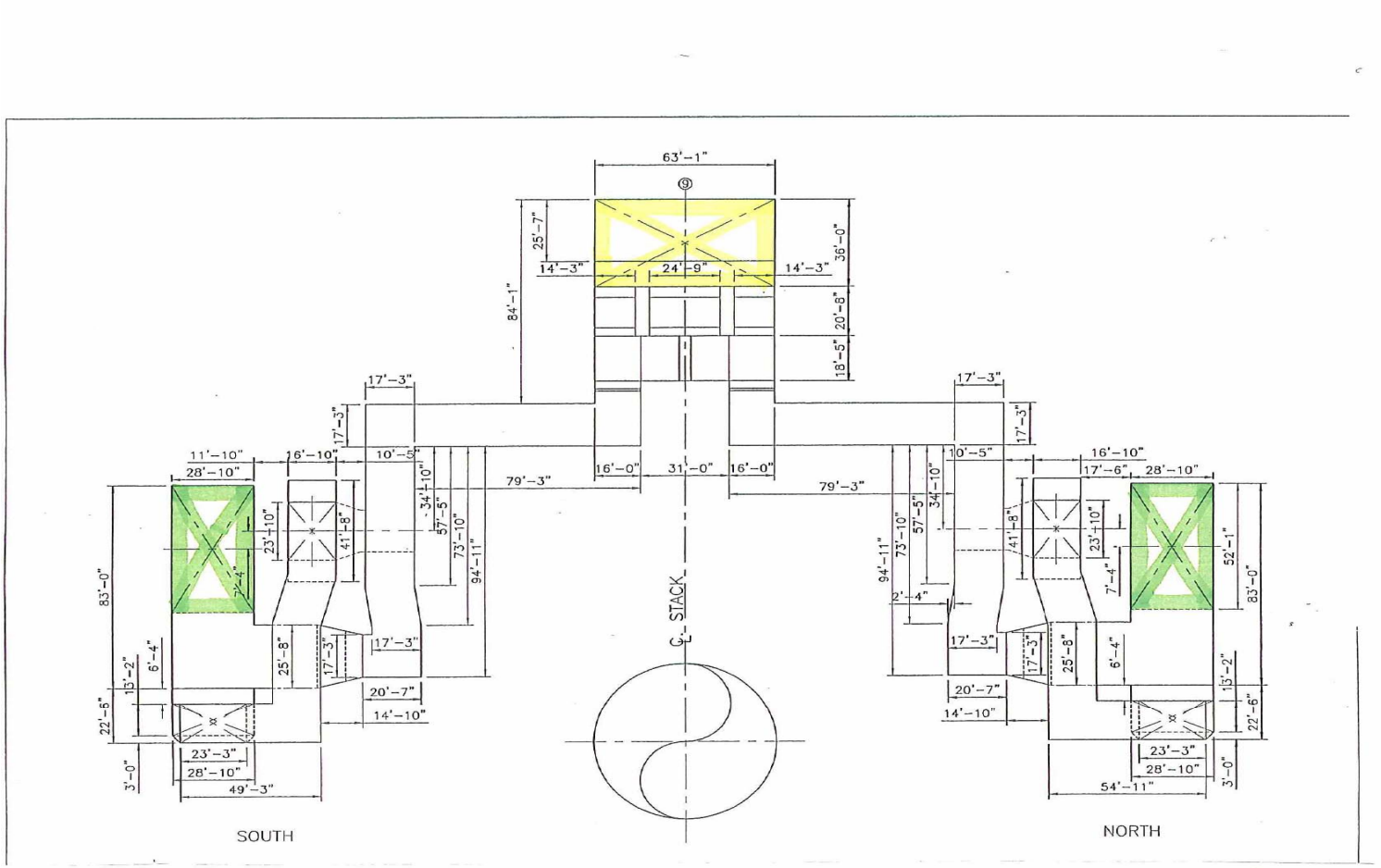
Consequences of LPA plugging catalyst

- Abnormal ash build-up
- Concern of structural integrity of catalyst support steel
- Erosion of catalyst in the areas that are not plugged by ash
- Adverse impact on SCR performance
- Increased pressure drop across SCR can result in unit operational issue such as unit load curtailment.
- Require outage for ash cleaning

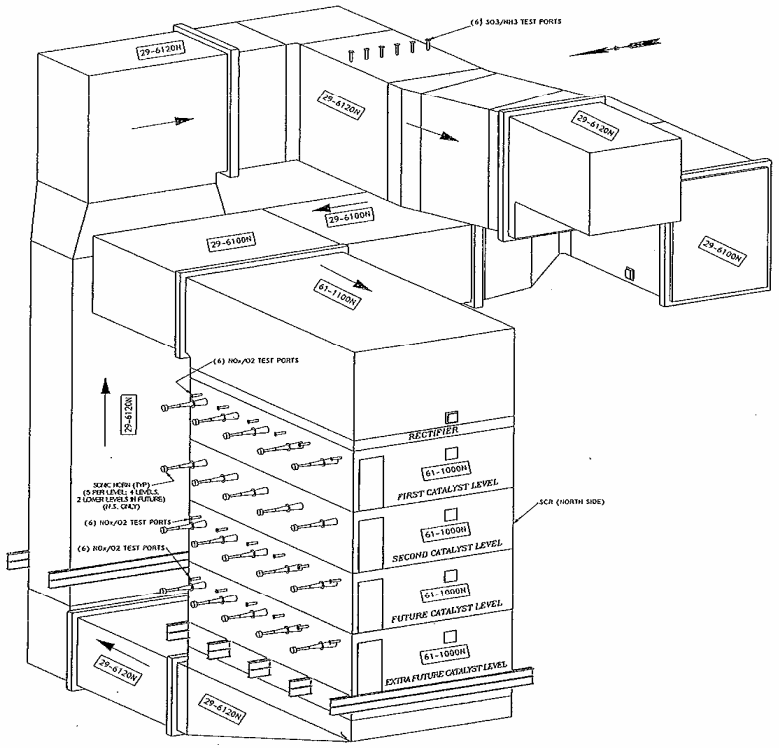
Muskingum River Unit 5 LPA Issues



Muskingum River Unit 5 SCR Layout



Muskingum River Unit 5 SCR Isometric View



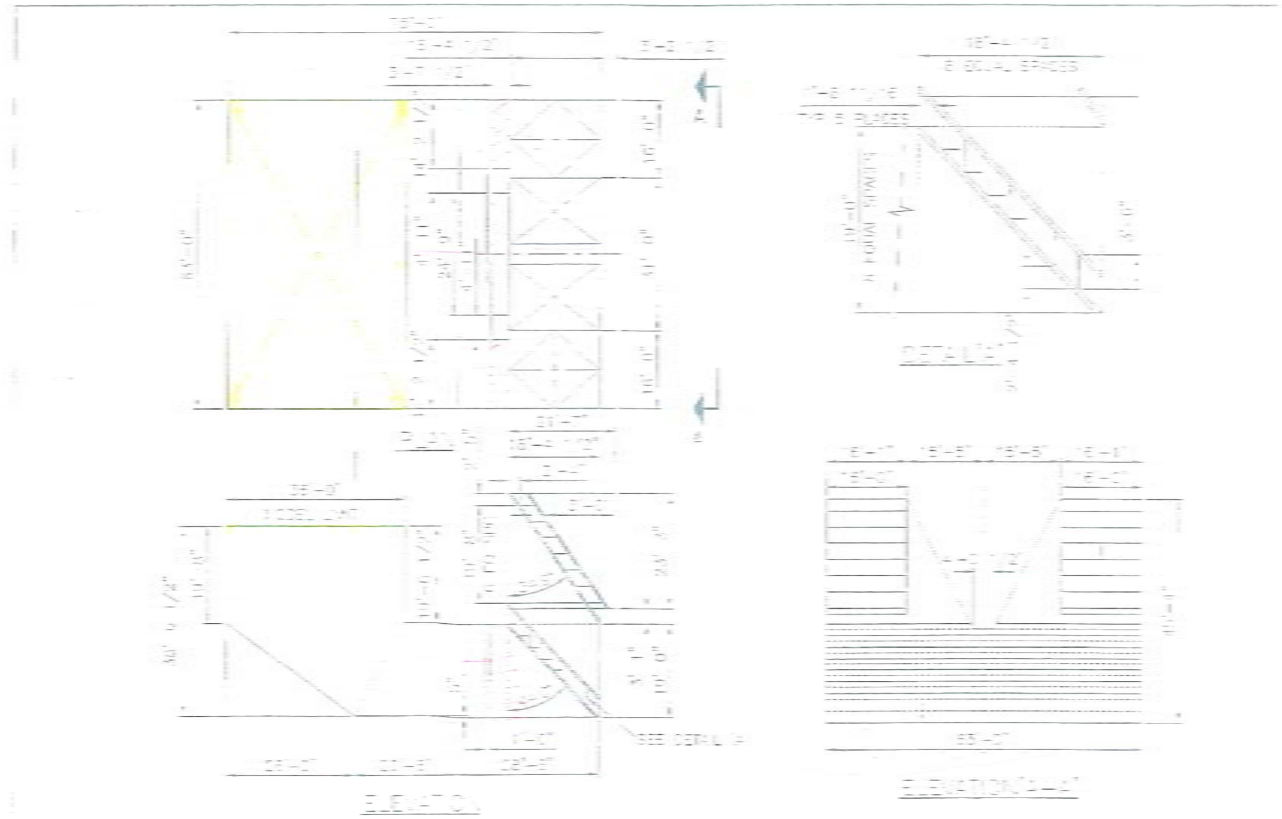
ISOMETRIC VIEW
(LOOKING EAST 30° SOUTH 18° DOWN)

Muskingum River Unit 5 LPA Solutions

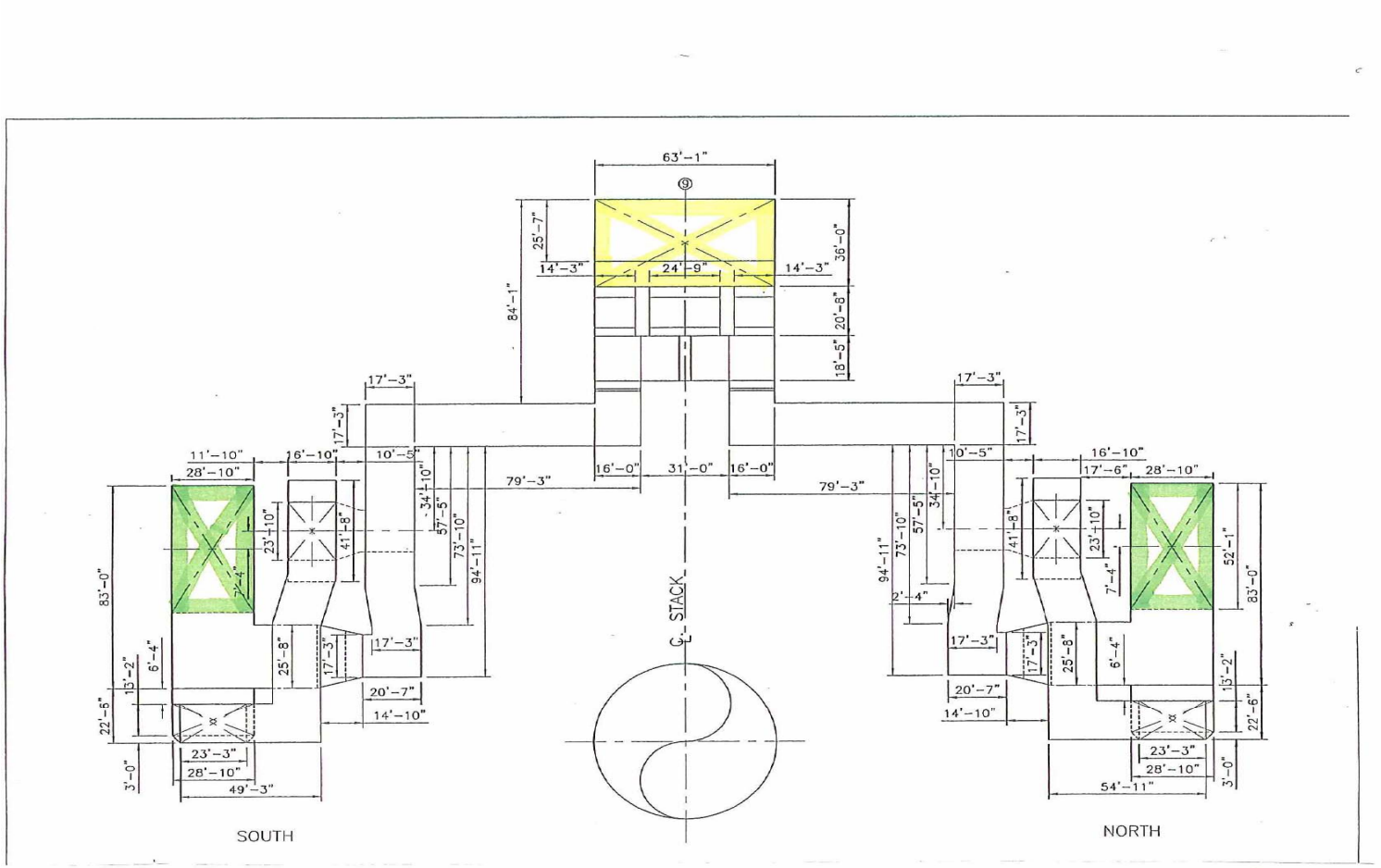
LPA Screens

- Screen location – low flue gas velocity
- Economizer outlet toggle section – 63’ x 19’
- Average flue gas velocity is approximately 40 ft/sec.
- Some areas have flue gas velocity of 50 ft/sec.
- Stainless steel 304 wedge wire screen was proposed

Muskingum River Unit 5 LPA Solutions



Muskingum River Unit 5 SCR Layout



Muskingum River Unit 5 LPA Solutions

LPA Screens

- Screen location – low flue gas velocity
- Economizer outlet toggle section – 63’ x 19’
- Average flue gas velocity is approximately 40 ft/sec.
- Some areas have velocity exceeding 50 ft/sec.
- Stainless steel 304 uncoated wedge wire screen was proposed

Disadvantages of LPA Screens

- Screen erosion and long term maintenance obligation
- Additional draft loss to flue gas system

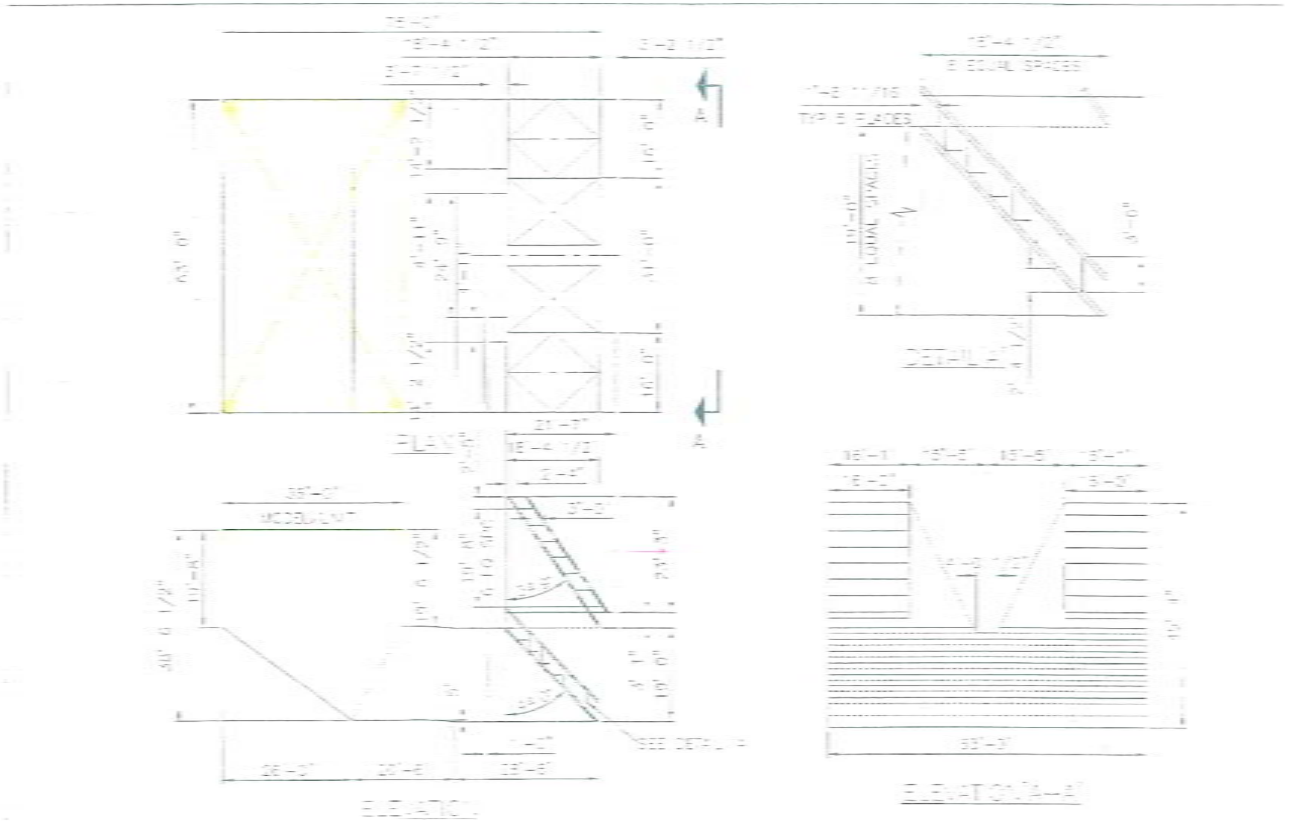
Other Alternatives ?

Muskingum River Unit 5 LPA Solutions

Economizer Outlet Duct

- Unique duct configuration
  - Three 90^{o} elbows are separated by short sections of duct work.
  - LPA's with higher momentum of inertia are expected to stay at lower part of horizontal duct.
  - Low velocity zone is formed at outside corner of second 90^{o} elbow.
- Ash accumulation history
  - Big ash pile accumulated at outside corner of the second 90^{o} elbow in 1980's caused sagging of the ductwork.
  - Guide vanes were installed to direct flue gas flow toward the outside corner of the second 90^{o} elbow to prevent ash accumulation.
  - Guide vanes installation results in approximately 2 in.W.G. draft loss
- Potential location for LPA hoppers

Muskingum River Unit 5 LPA Solutions

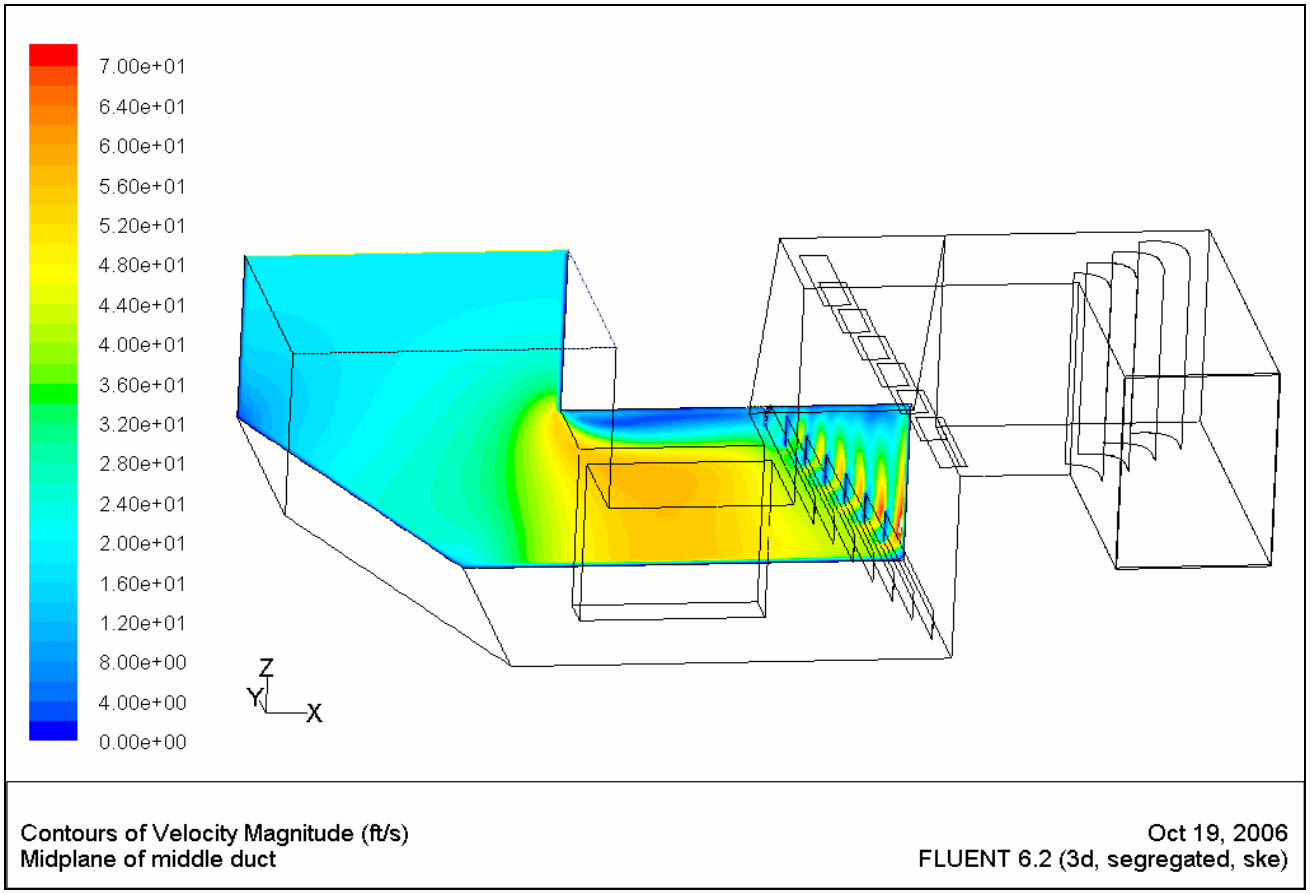


Muskingum River Unit 5 LPA Solutions

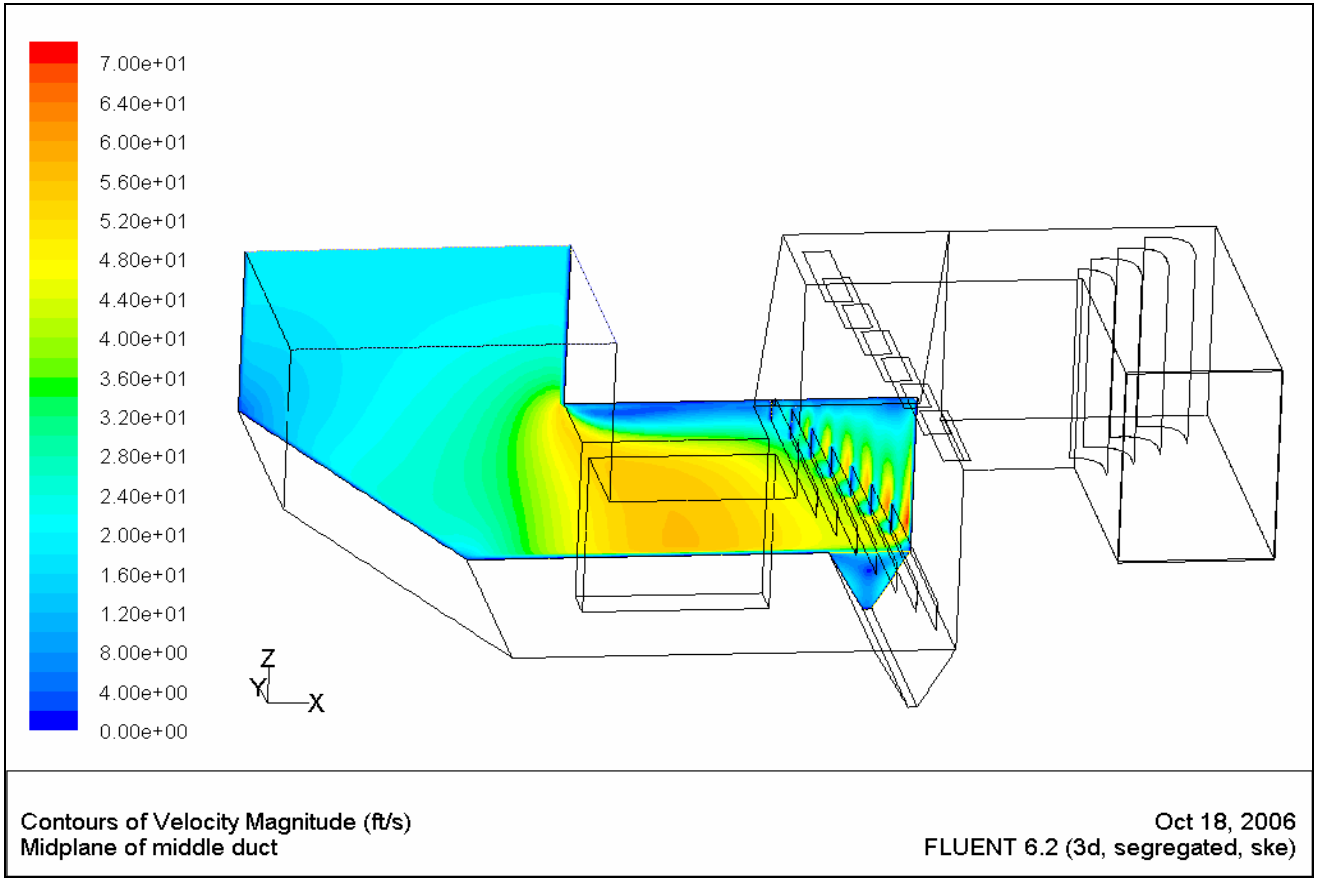
CFD Model Verification

- From economizer exit to the beginning of two separated ducts to SCR reactors
- Because of geometric symmetry, only half of the duct work was modeled.
- Assume uniform flue gas velocity distribution at economizer exit.
- LPA's were modeled using post processor particle tracking.
- Various particle sizes (1 to 13 mm) and densities (10 to 50 lbs/ft^3)
- Density of LPA at Muskingum River Unit 5 is approximately 40 lbs/ft^3.
- Reflection coefficient of 1.0 and 0.8

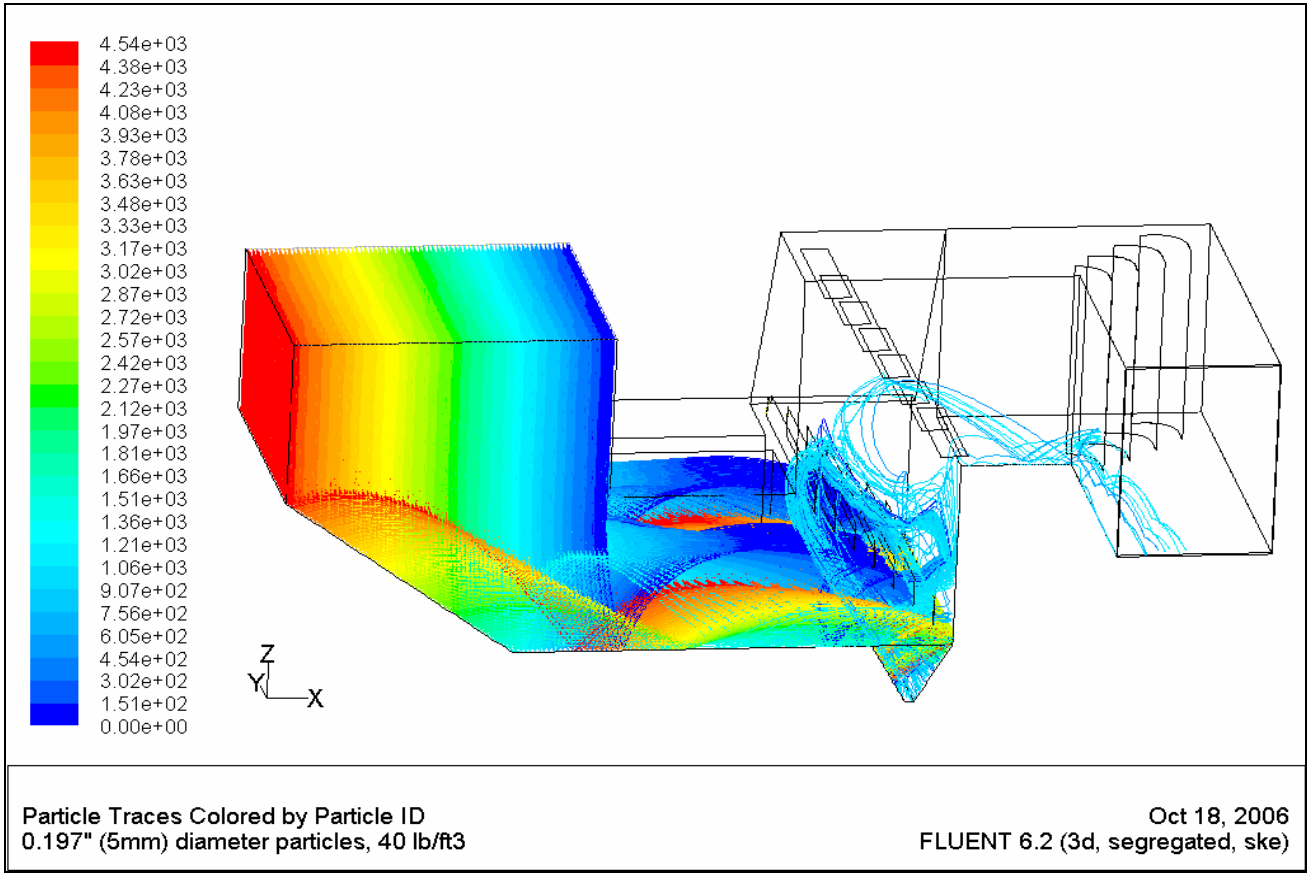
Muskingum River Unit 5 LPA Solutions



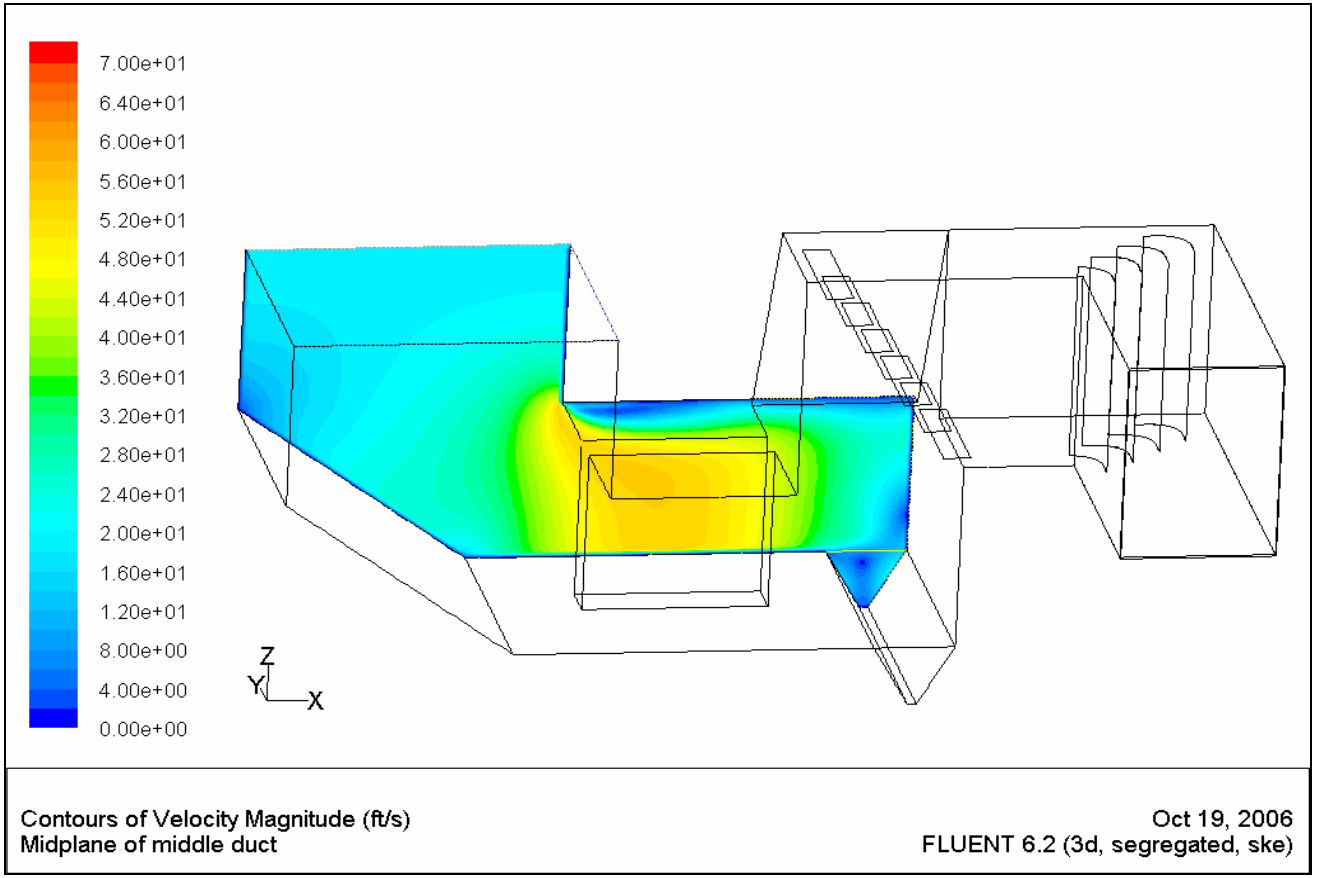
Muskingum River Unit 5 LPA Solutions



Muskingum River Unit 5 LPA Solutions



Muskingum River Unit 5 LPA Solutions



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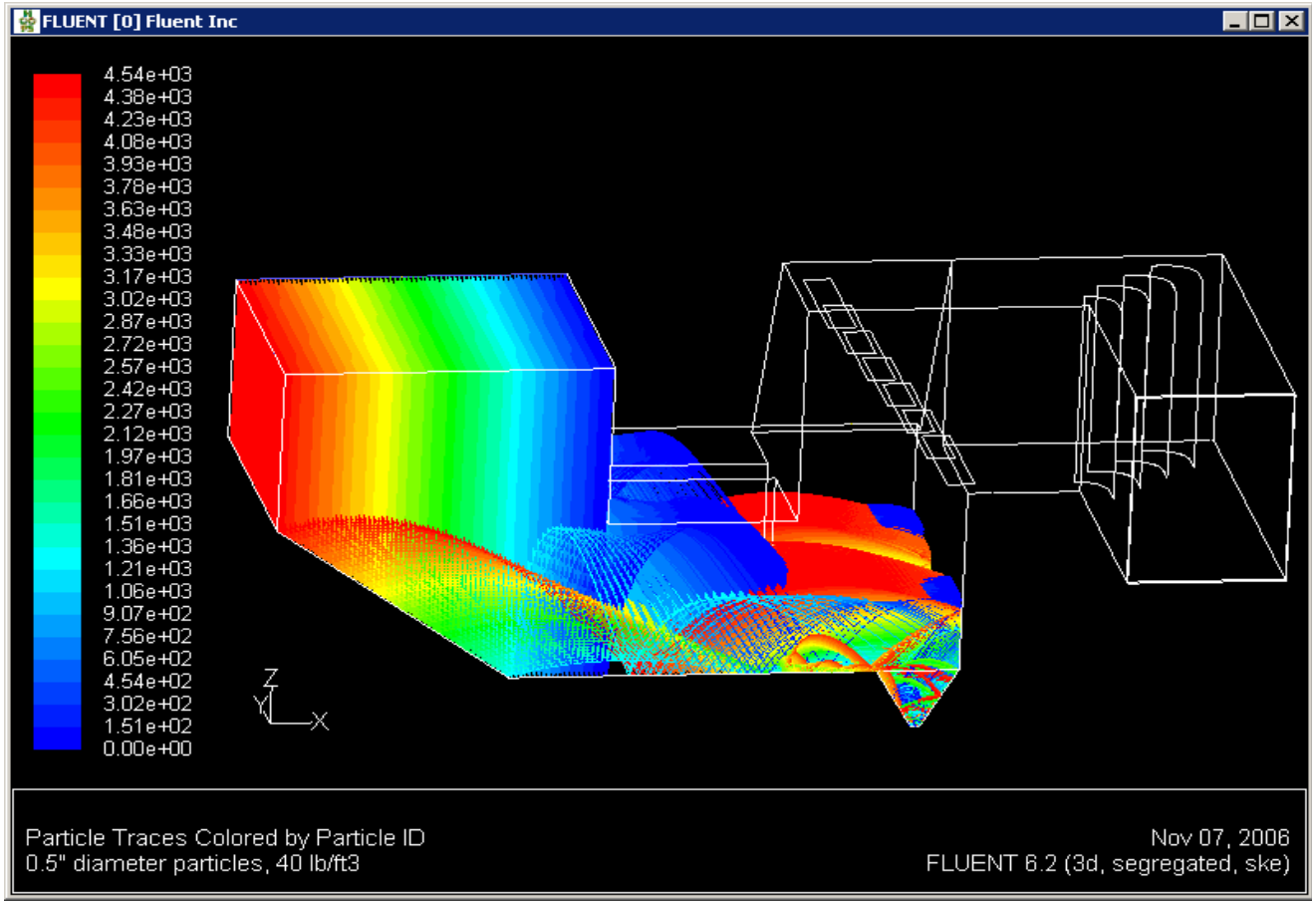

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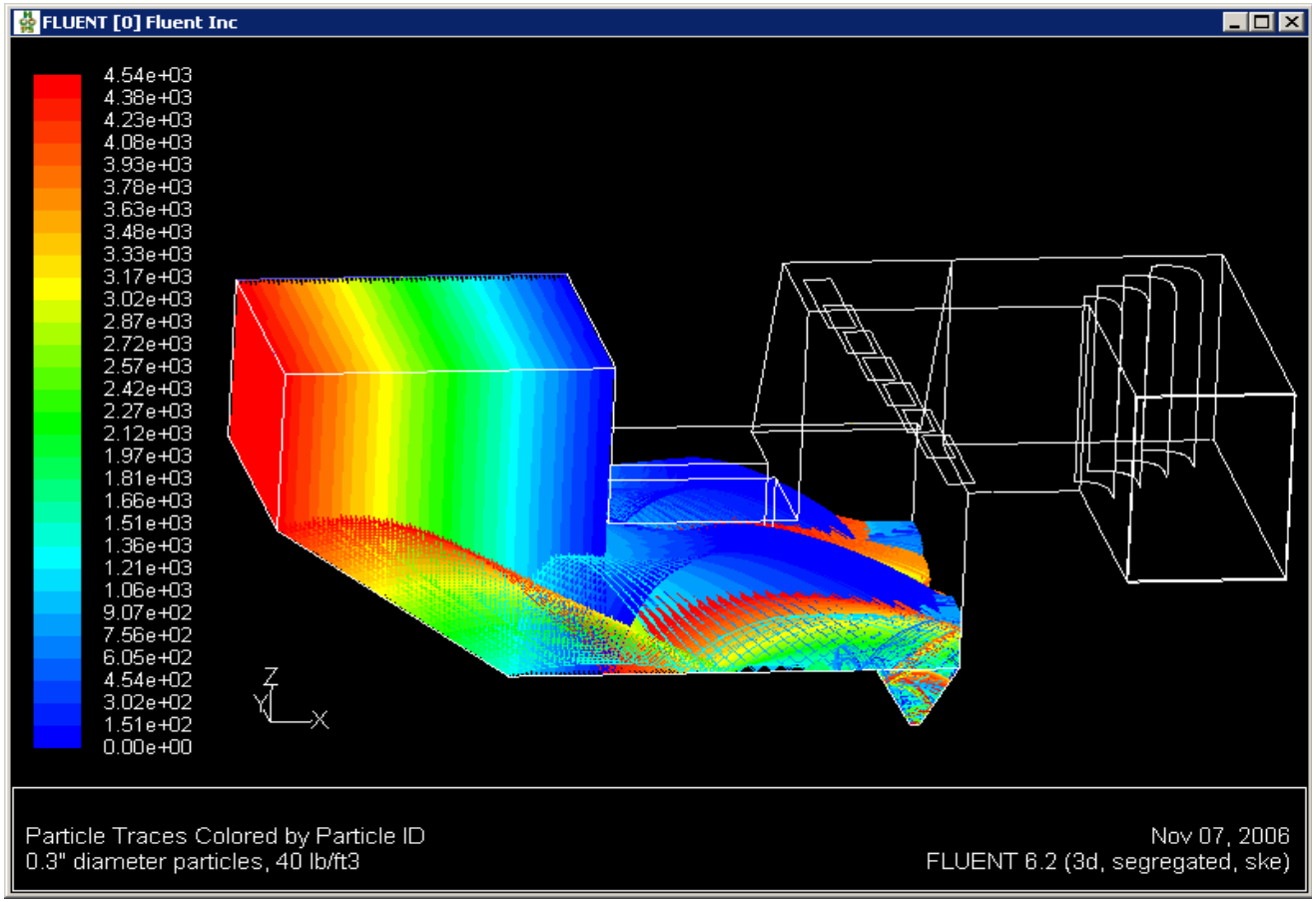

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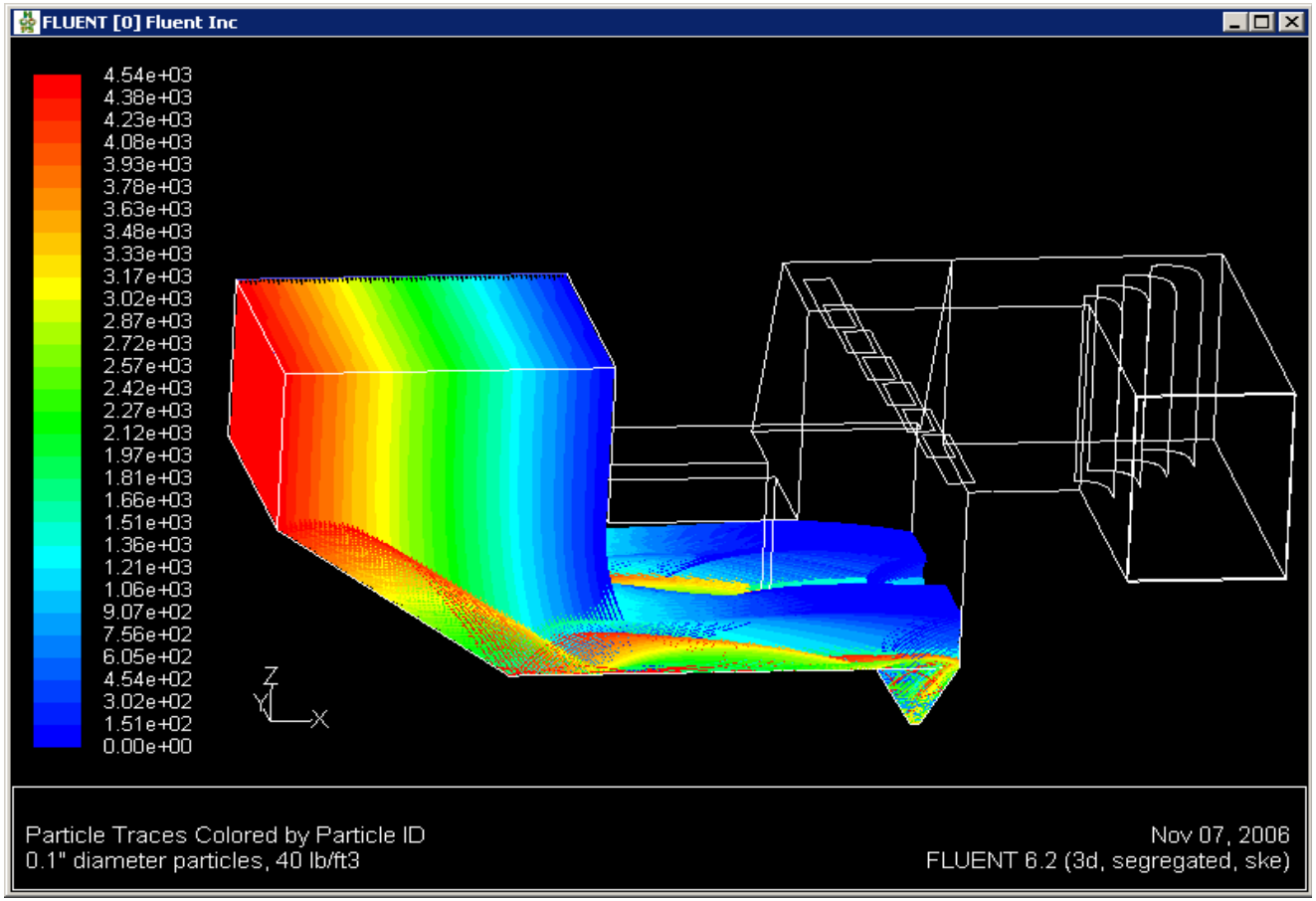


Muskingum River Unit 5 LPA Solutions

CFD Model Study Results

- LPA dropout hoppers at the second 90º elbow downstream of economizer have potential of capturing LPA's of 40 lb/ft3 with size ranging from 1 to 13 mm.

Muskingum River Unit 5 LPA Solutions

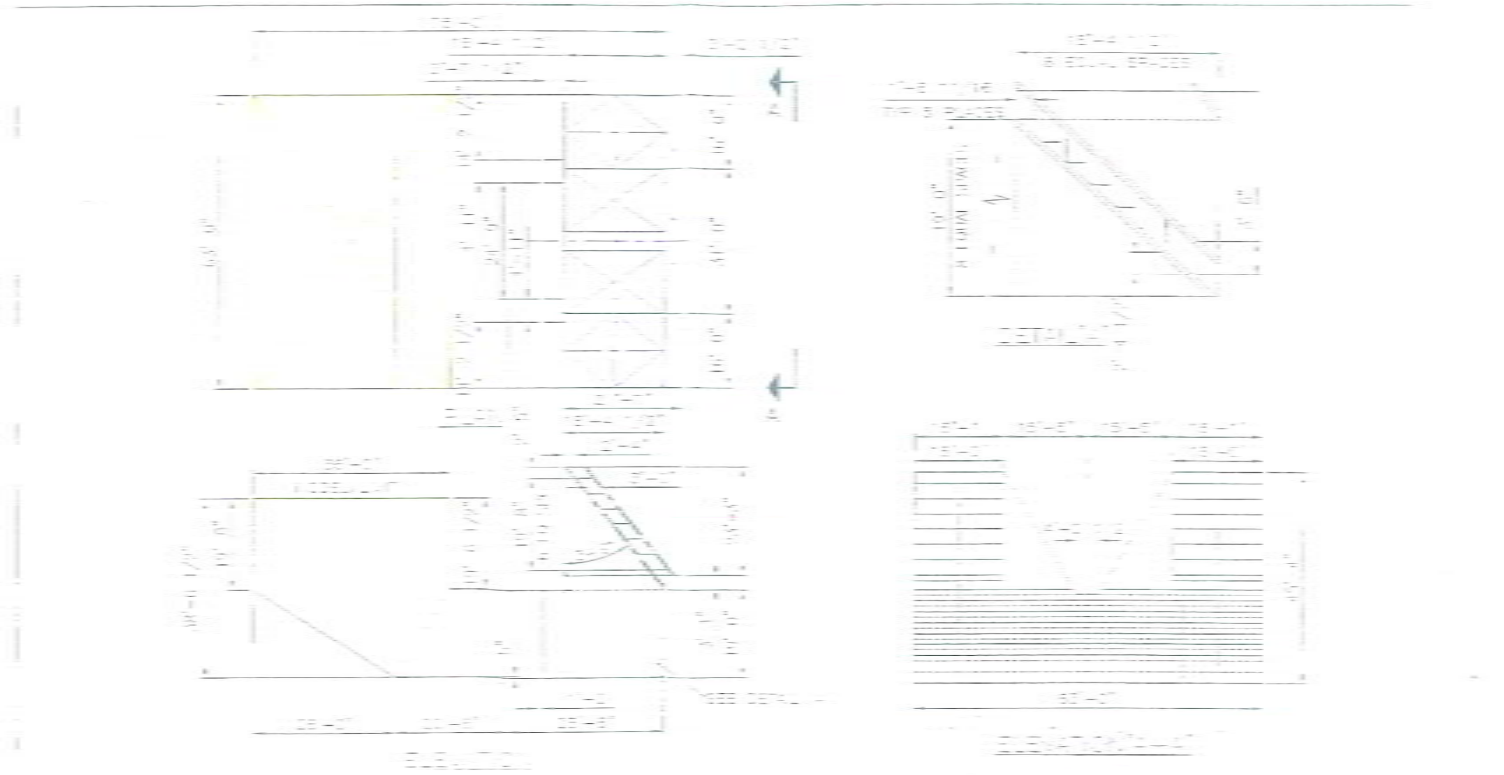
LPA Dropout Hopper Installation

- During the spring outage in April 2007

Work Scope

- Remove guide vanes at the elbow.
- Install four LPA dropout hoppers.
- Install grating at the top openings of hoppers to prevent re-entrainment of LPA's.
- Install hopper access platforms
- Install ash conveying system and integrate operation with existing ash system.

Muskingum River Unit 5 LPA Solutions



Muskingum River Unit 5 LPA Solutions

Muskingum River Unit 5 LPA Solutions

SCR & LPA dropout hopper inspection was performed in July 2007 during a unit outage

- SCR Reactors
  - The ash pile that used to cover the first two rows of catalyst next to the inlet duct wall was not found.
  - LPA's spread on the screens of the first row of catalyst covering approximately 10% of screen area in north SCR reactor and 20% screen area in south SCR reactor.
  - Only few LPA's were found in the remaining area of the top catalyst layer.
- LPA Dropout Hoppers
  - Hoppers and top gratings were clean with no ash pluggage.
  - Ash pile was formed at the front of hopper openings because of the low velocity zone at the elbow.

Muskingum River Unit 5 LPA Solutions

July 2007

Muskingum River Unit 5 LPA Solutions

June 2005

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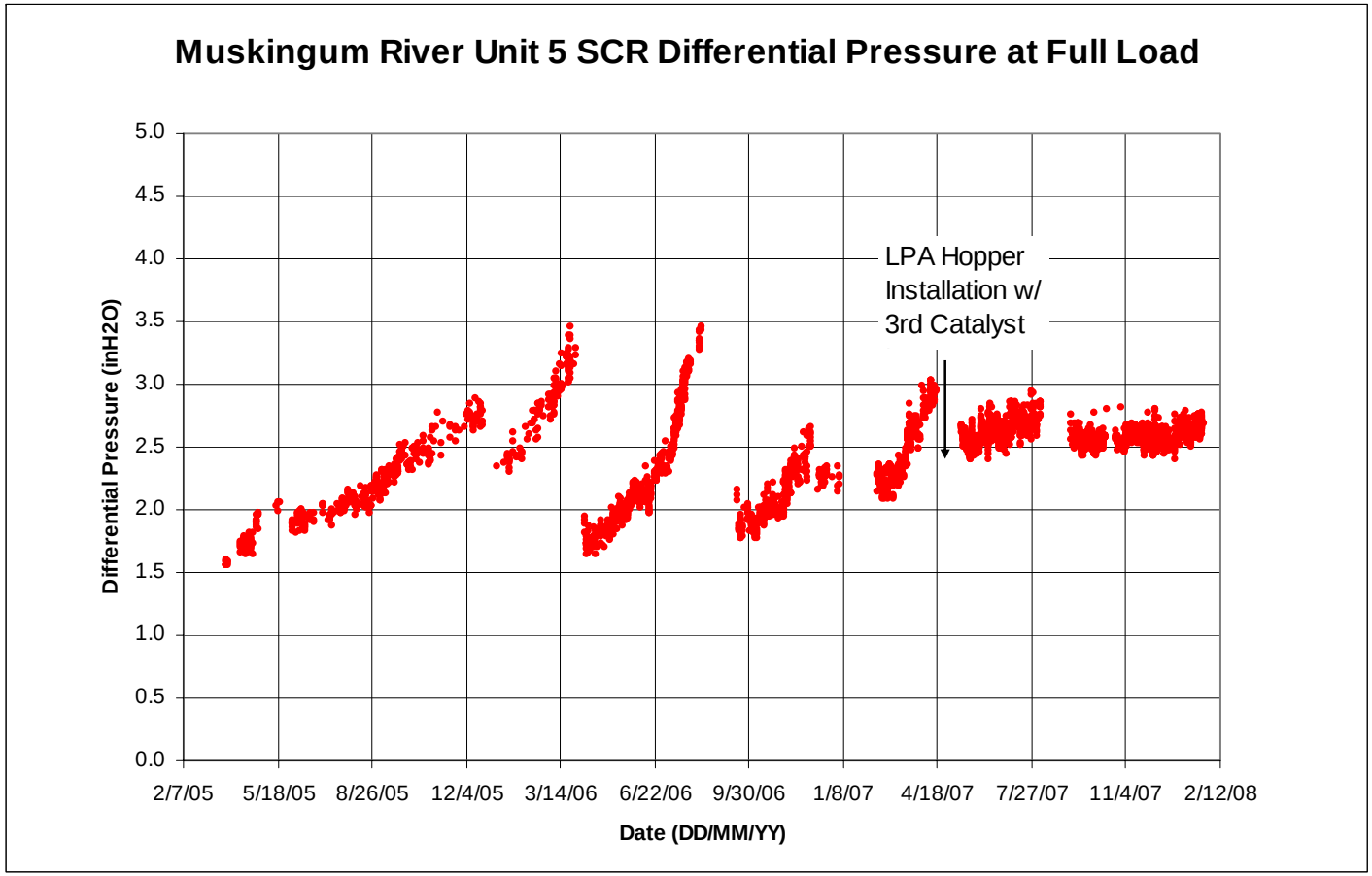

Muskingum River Unit 5 LPA Solutions

Questions ?