

Innovative Research, Inc.
A Computational Fluid Dynamics Company

Data Center Airflow: A Predictive Model

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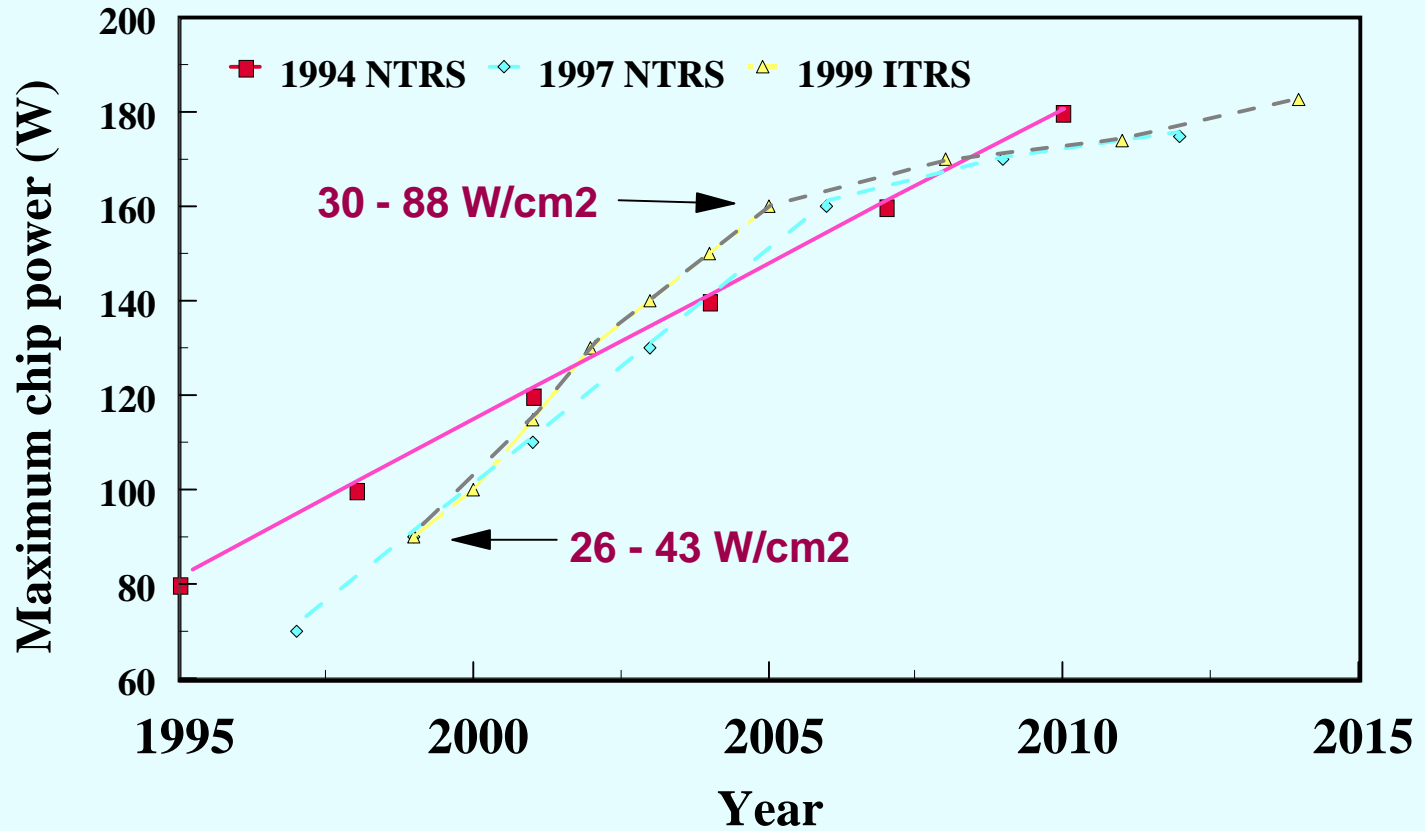
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President, Innovative Research, Inc.

Agenda

- Product Heat Load Trends
- Data Center/Equipment Cooling
- Data Center Flow Measurements
- Data Center Predictive Model/
Comparison with Measurements

Microprocessor Power Trends



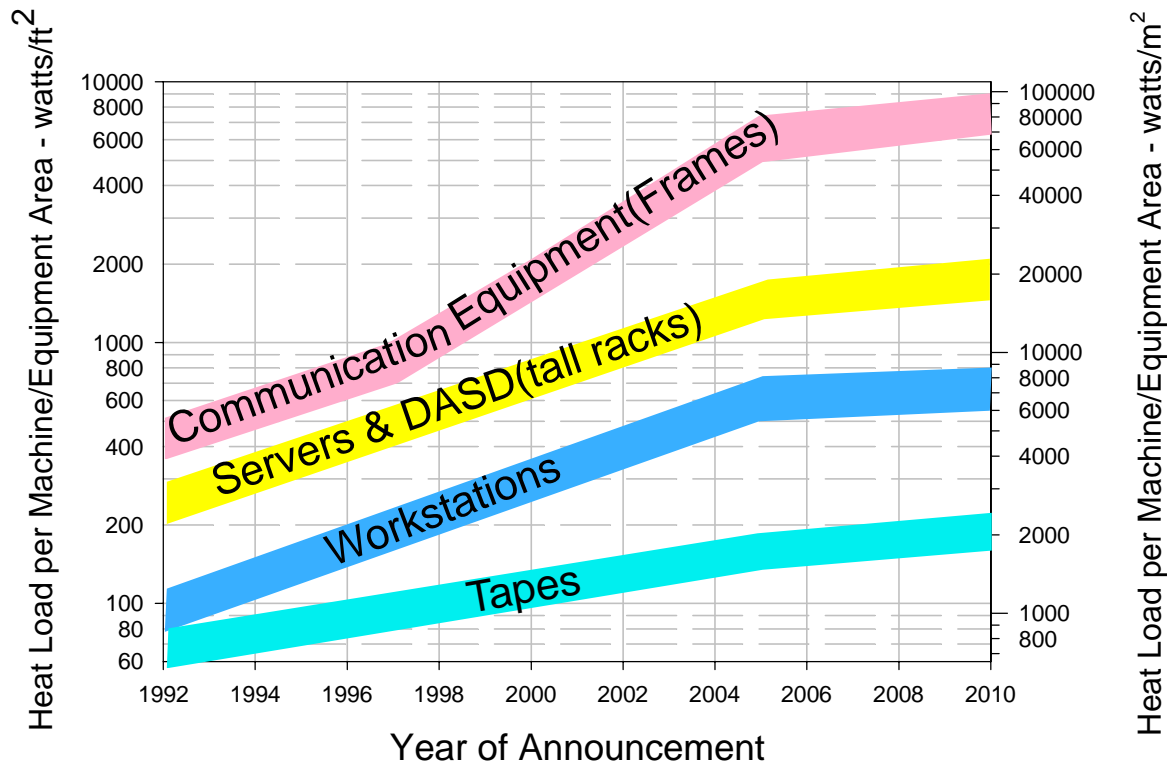
Heat Load Trends

**Consortium of Computer and Telecom Manufacturers
Will be published by Site Uptime Group**

- Amdahl
- Compaq
- Cisco
- Cray
- Dell
- HP
- IBM
- Lucent
- Nortel
- Sun
- Unisys

Projections for Heat Loads

Data Processing/Telecom Equipment Heat Load Trends



The Site Uptime Group

IBM's xSeries Servers



Environmental Facts

- 1 frame
- 7.7 sq. ft.
- 7.6 kW max
- Max 982 watts/ft₂
- 1800 lbs(133 lbs/sq.ft.)



New IBM xSeries server

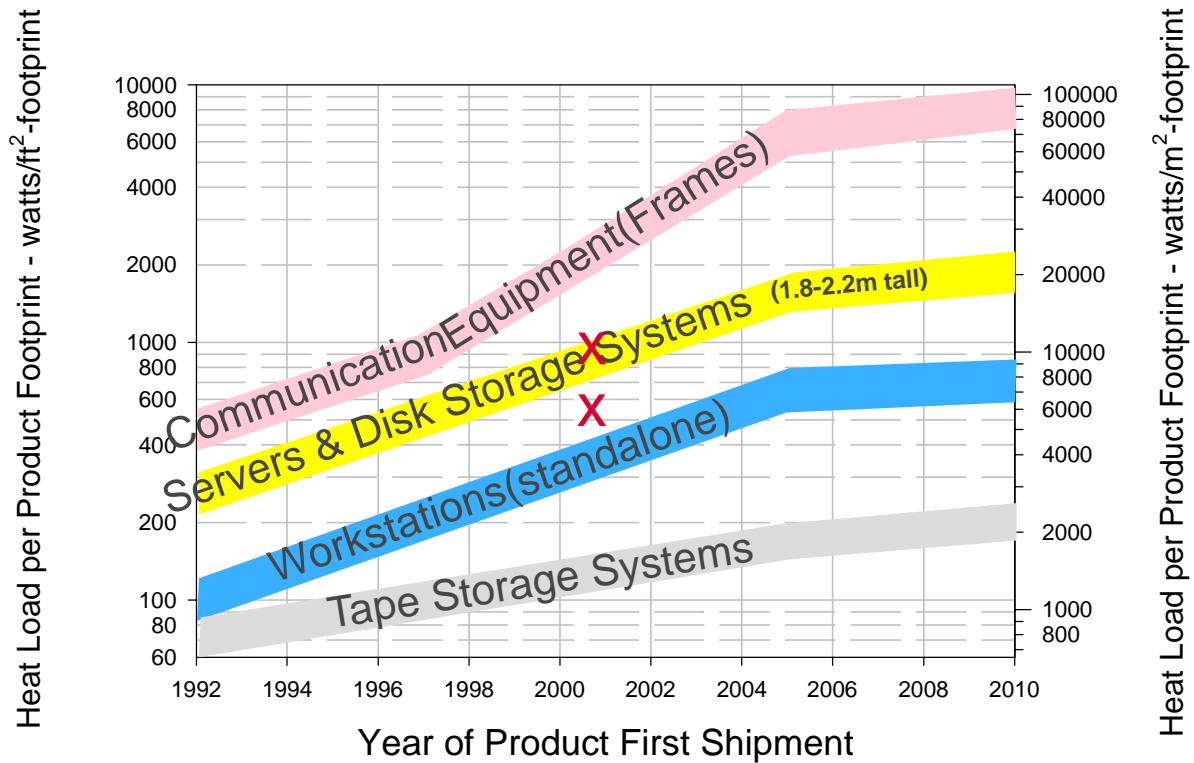
IBM's zSeries Servers



Environmental Facts

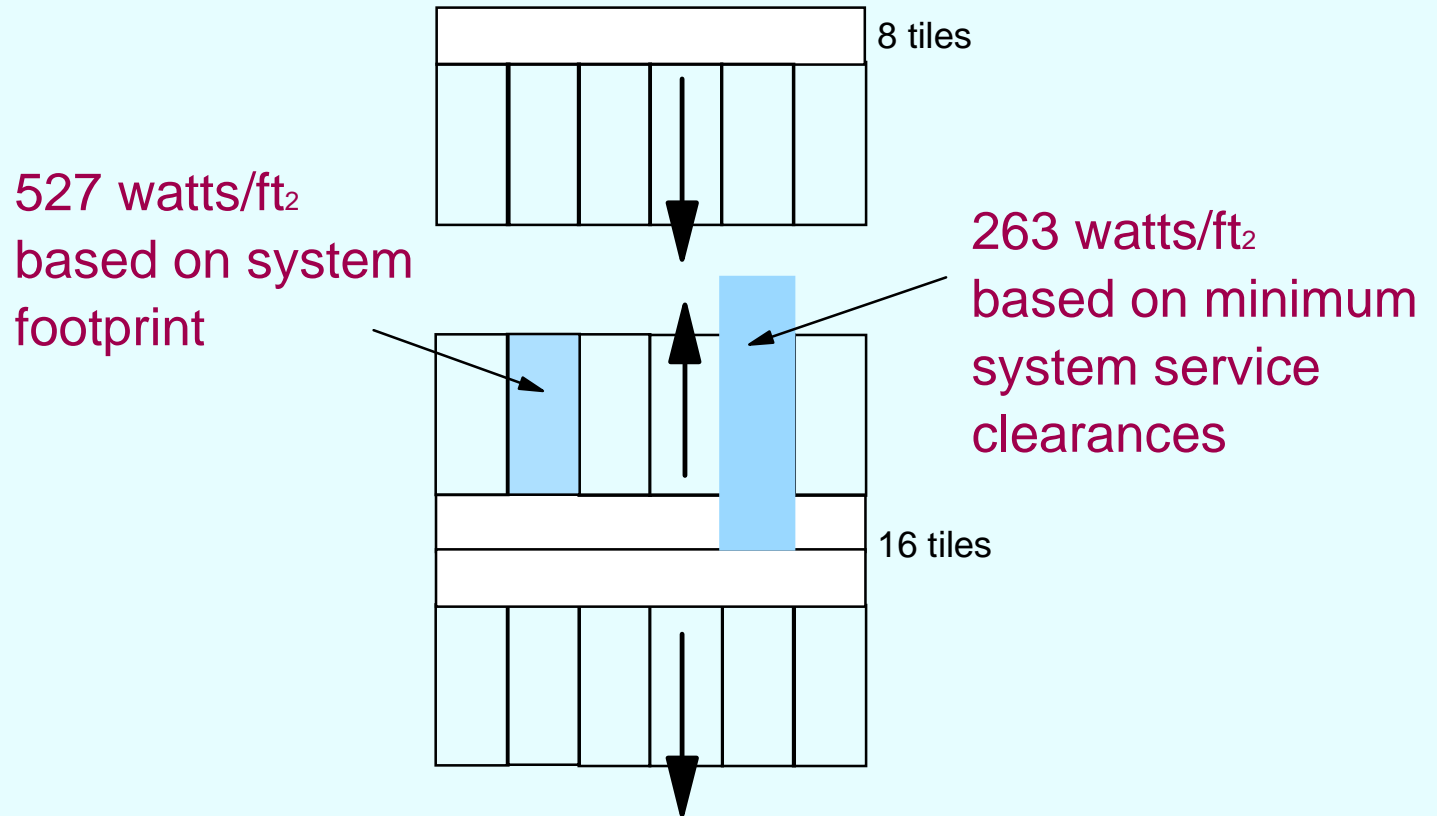
- 1 or 2 frames
- 14.4 sq. ft. for 1 fr.
- 7.6 kW max for 1 fr.
- Max 527 watts/ft₂
- 60 Amp dual power plugs
- 2621 lbs(121 lbs/ft₂)

Product Family Heat Density Trend Chart



The Site Uptime Group

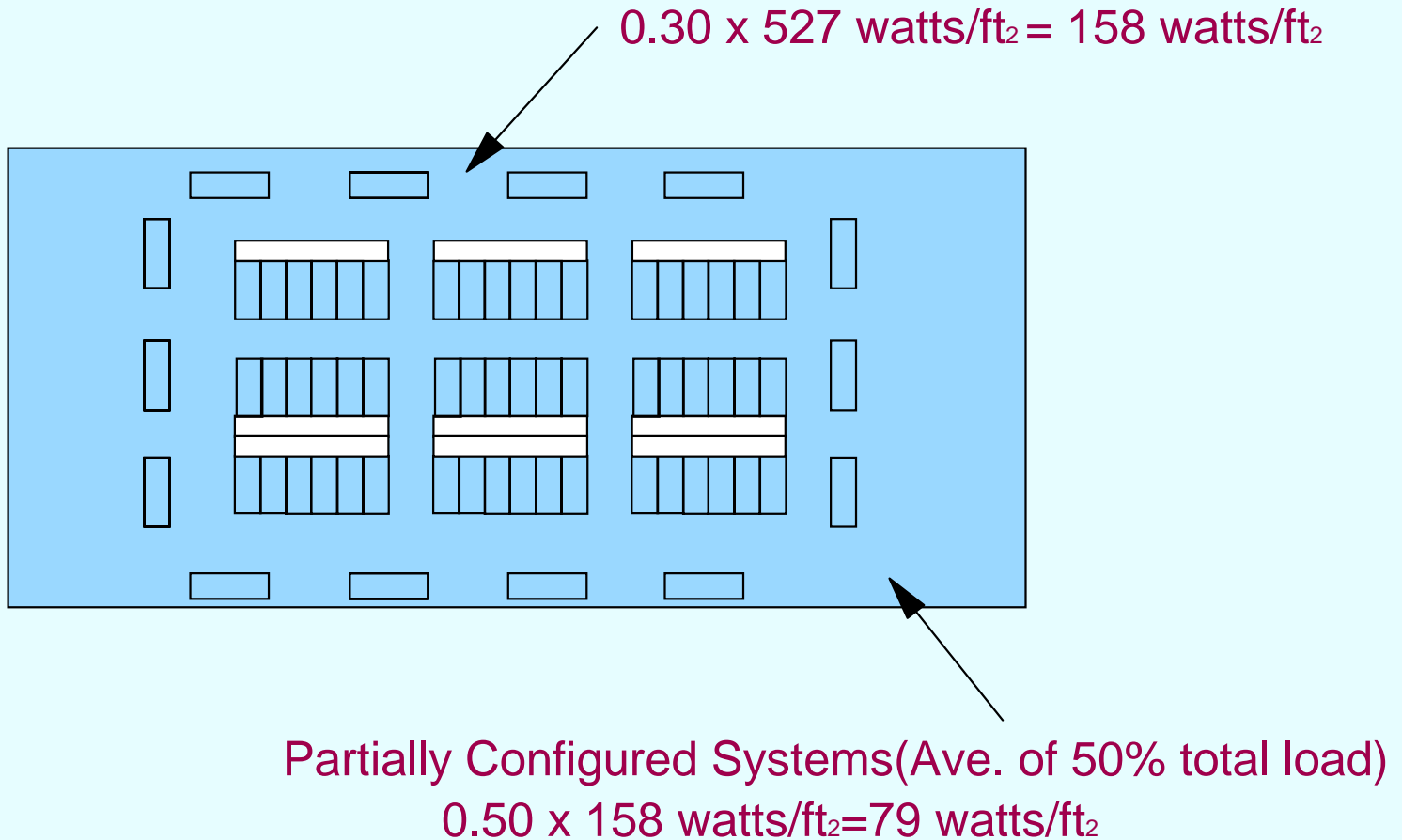
zSeries Cluster



Typical Functional Allocation within Data Center

- Electrically active IT hardware - 30%
- Service Clearances around products - 30%
- Site infrastructure support equipment - 20%
- Main aisles and other inactive areas - 20%

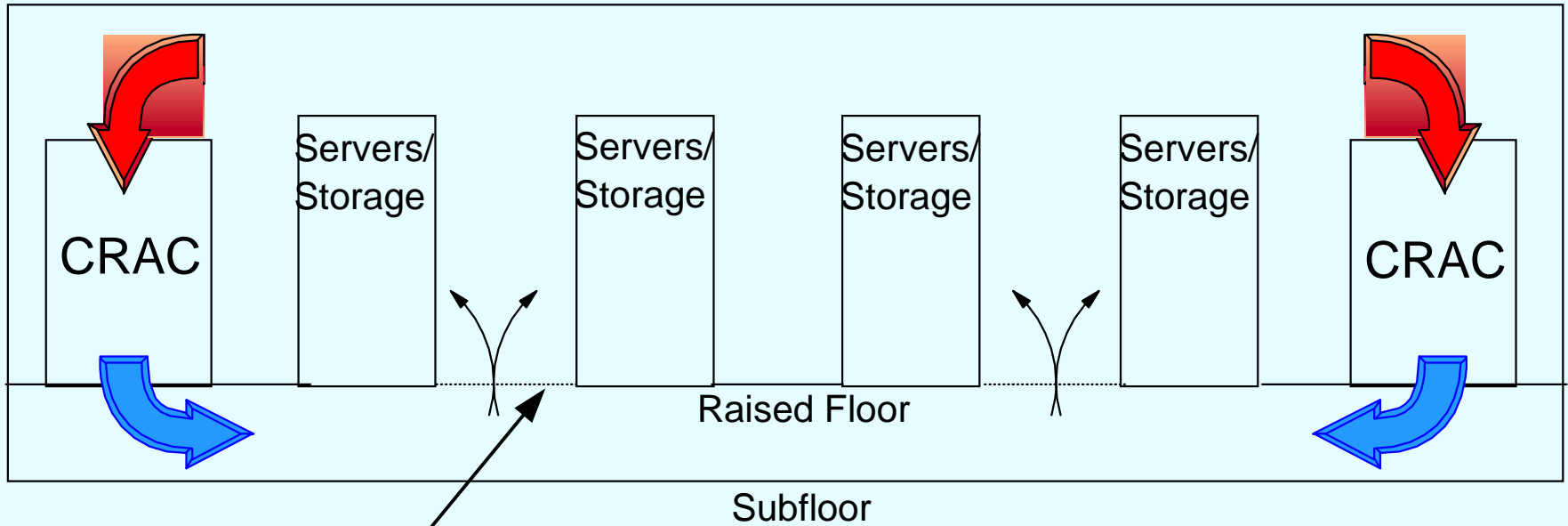
Complete Data Center



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Computer Data Center Cooling

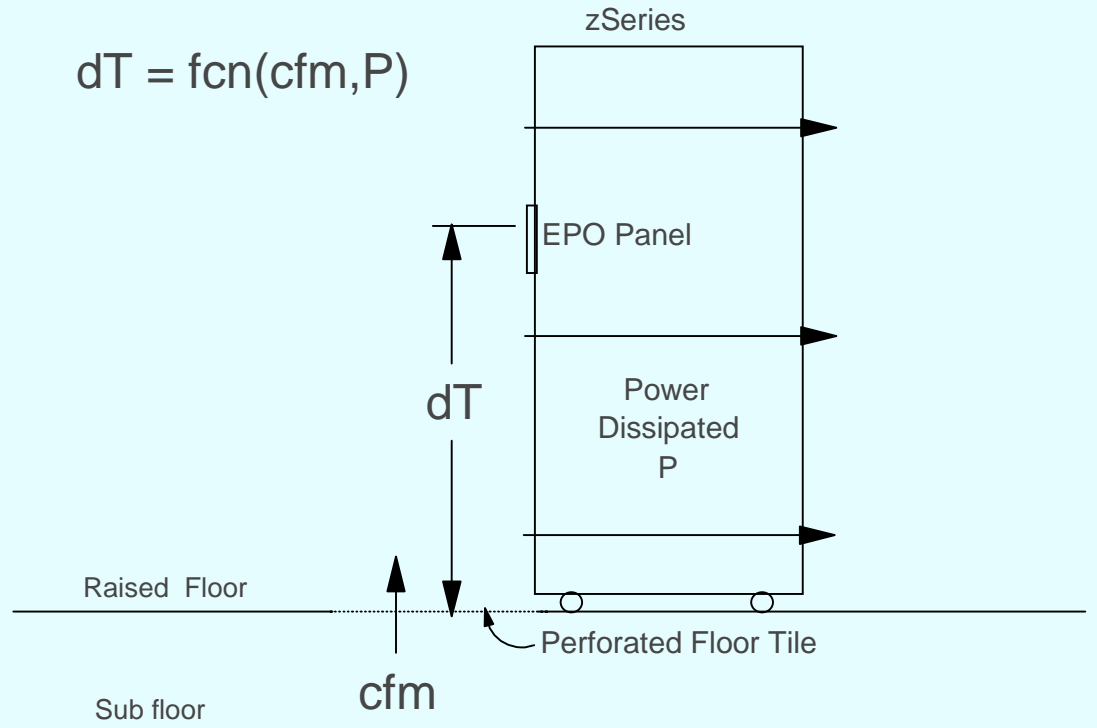


Perforated Floor Tiles (6, 11, 25, 40, 60% open)

Data Center Cooling



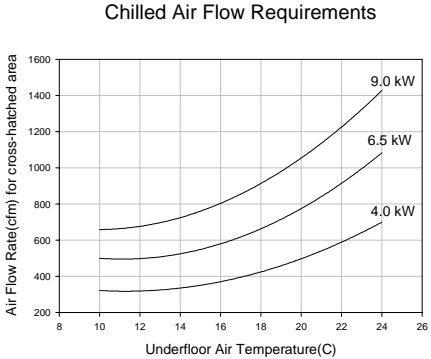
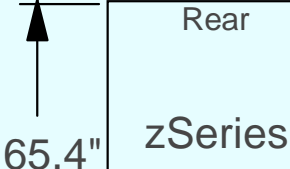
Data Center Characteristics



Objective: Maintain EPO panel thermistors below 35C

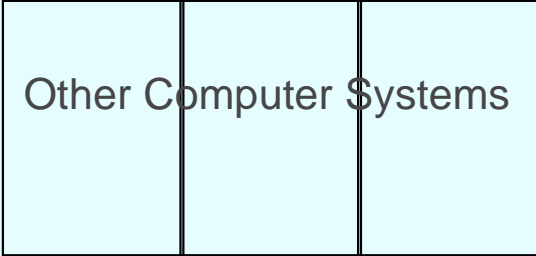
Chiller Air Flowrate Required for zSeries

29.5" to 32.6"
(depends on whether side covers are installed)



Area of Floor Tiles to Supply Chilled Air to Freeway System

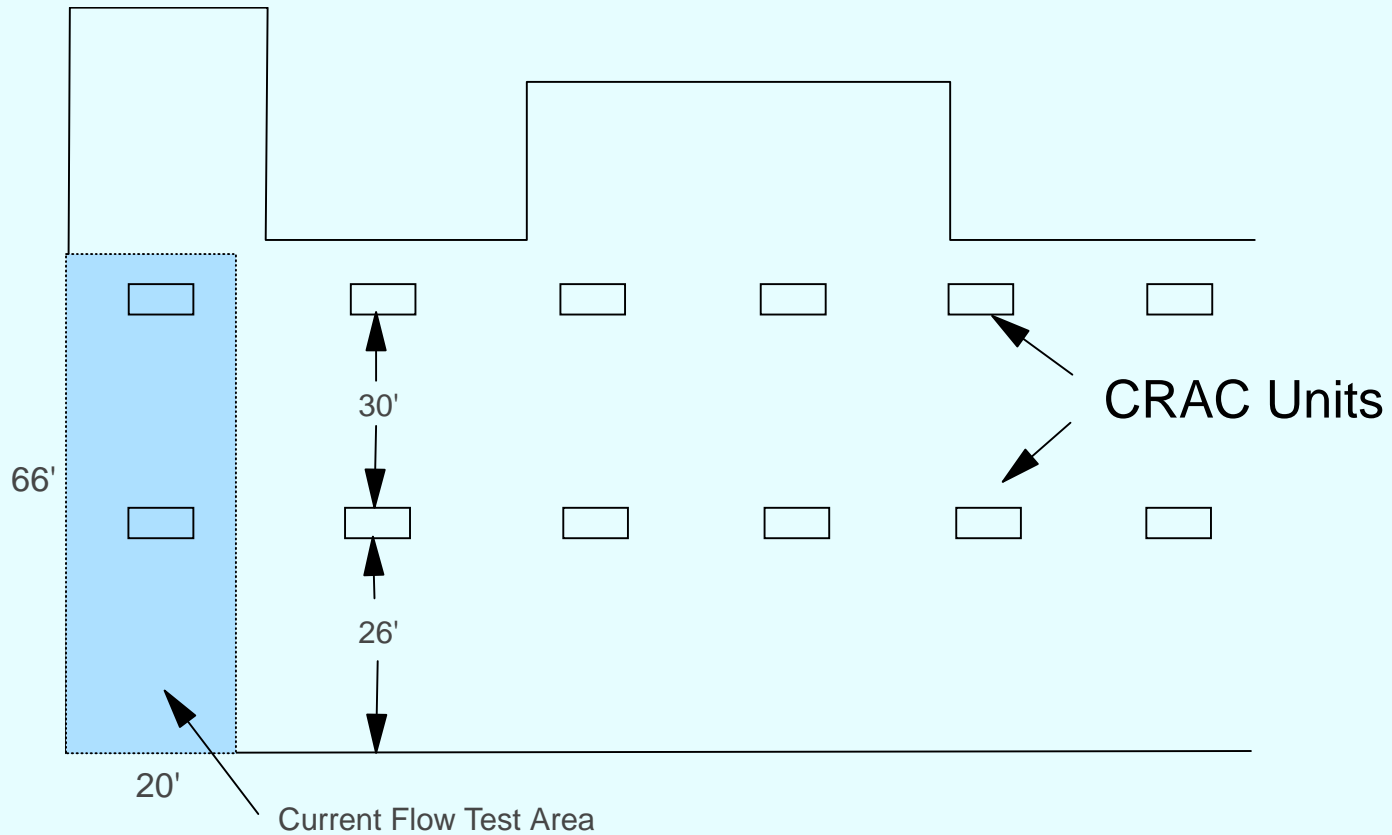
Centerline of Aisle Walkway



Agenda

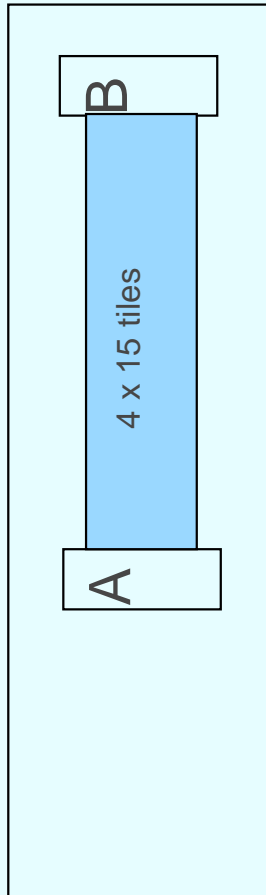
- Product Heat Load Trends
- Data Center/Equipment Cooling
- **Data Center Flow Measurements**
- Data Center Predictive Model/
Comparison with Measurements

Data Center Floor Plan - Test Area

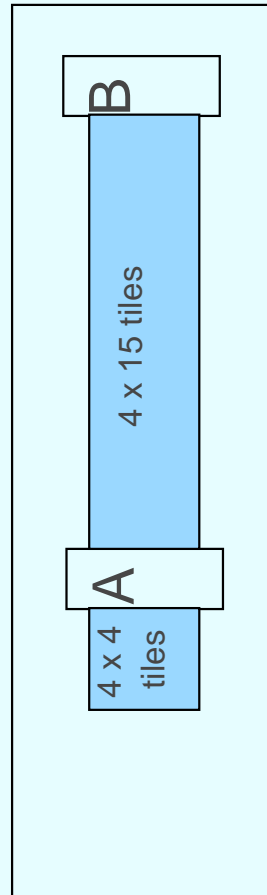


Test Area Perforated Tile Test Cases

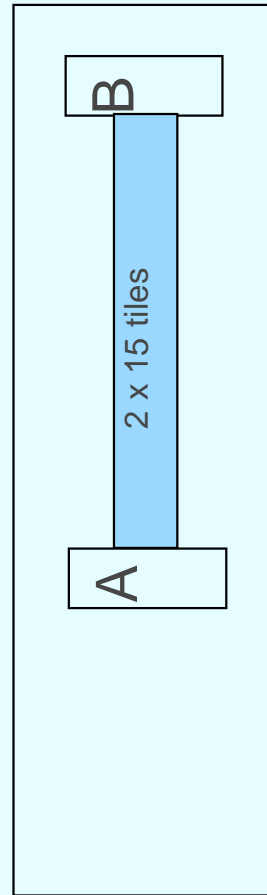
Case 1



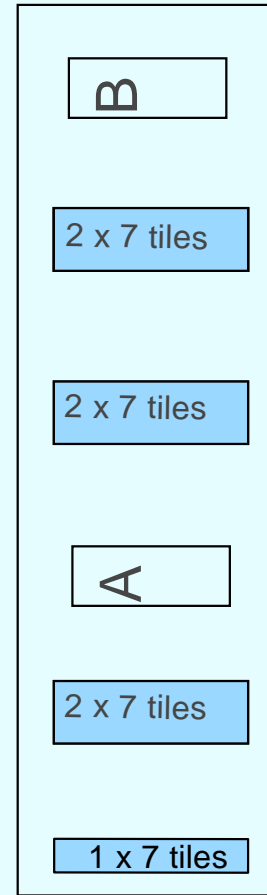
Case 2



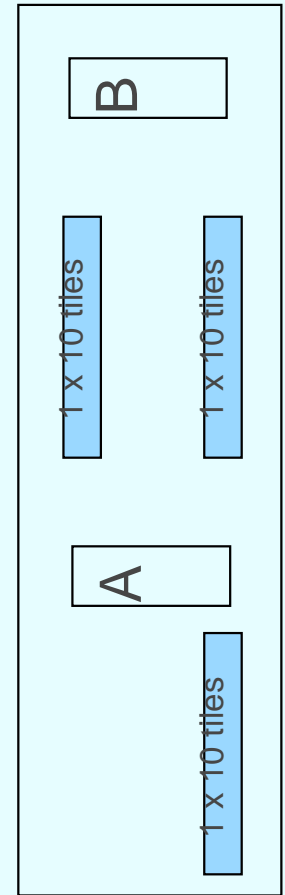
Case 3



Case 4



Case 5



Calibrated Flow Tool



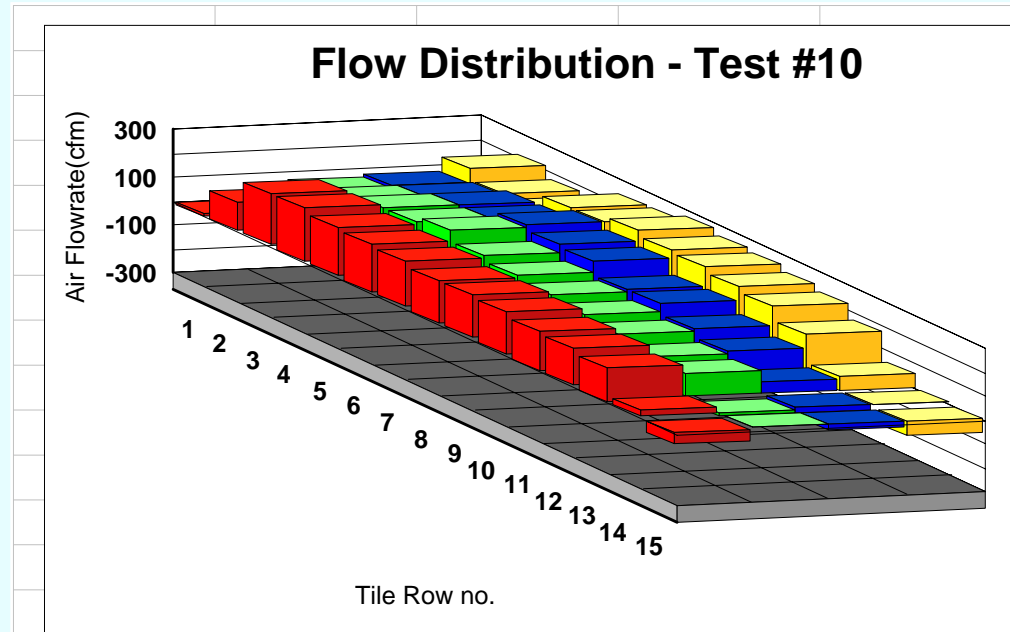
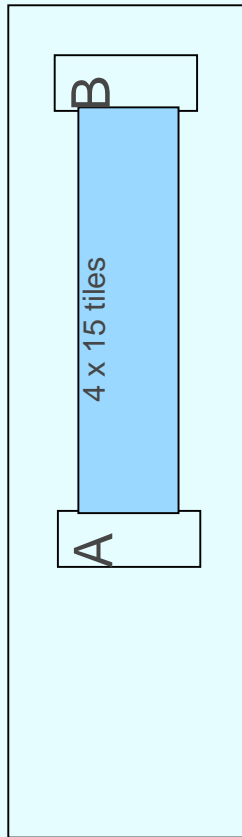
Boxed-In Test Area



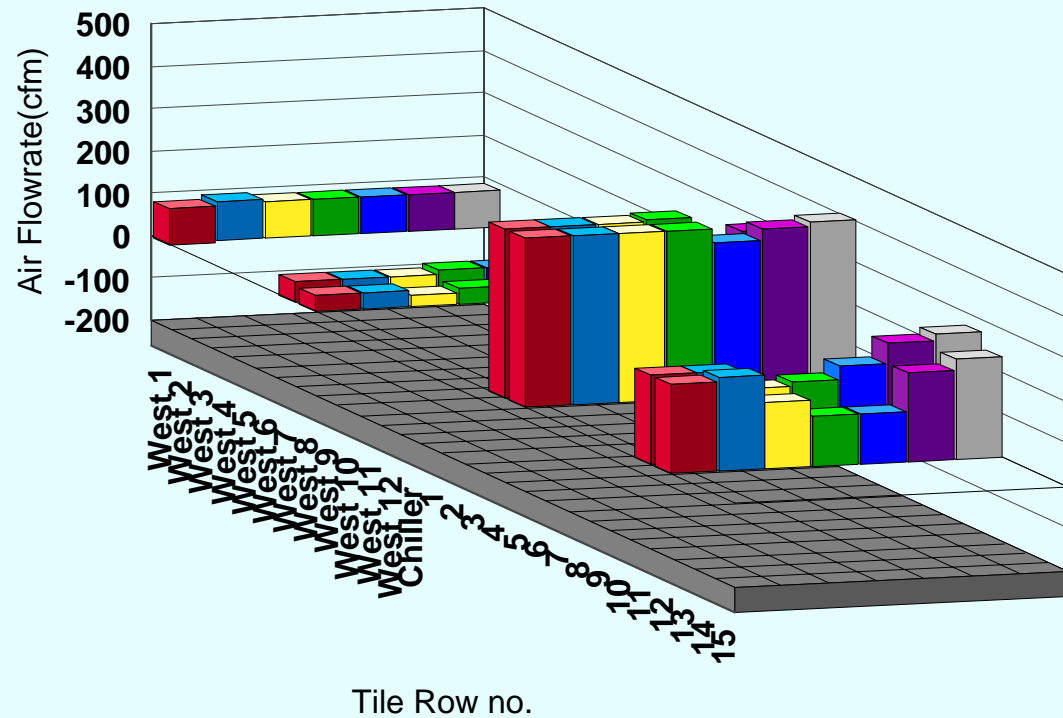
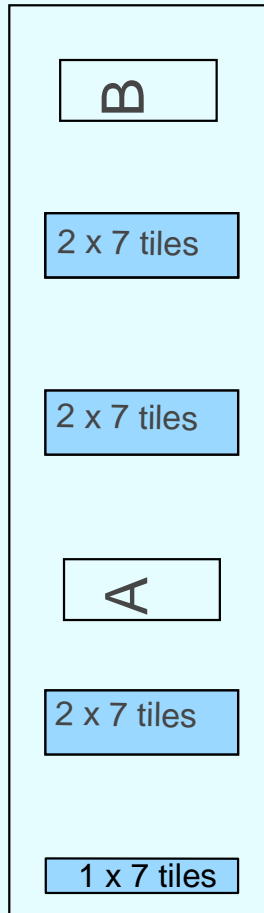
“25%” Open Floor Tile



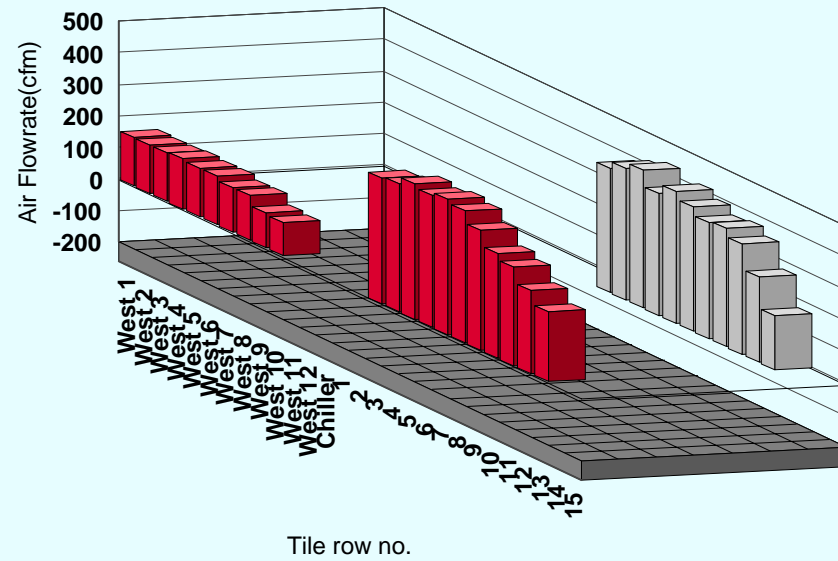
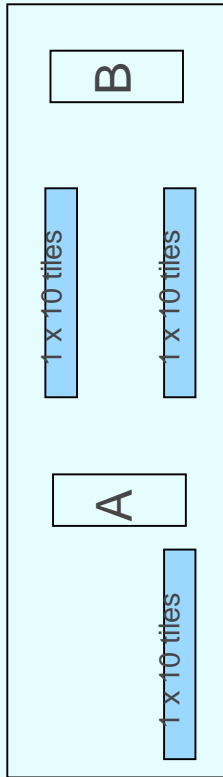
Data Center Test - Case 1



Data Center Test - Case 4



Data Center Test - Case 5



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Objectives of the Model

- Calculation of airflow distribution through the floor tiles for the whole data center
- Ability to vary chiller flow, tile perforations, and raised-floor height
- Easy-to-use, fast, flexible
- Intended for routine use by data-center designers and operators

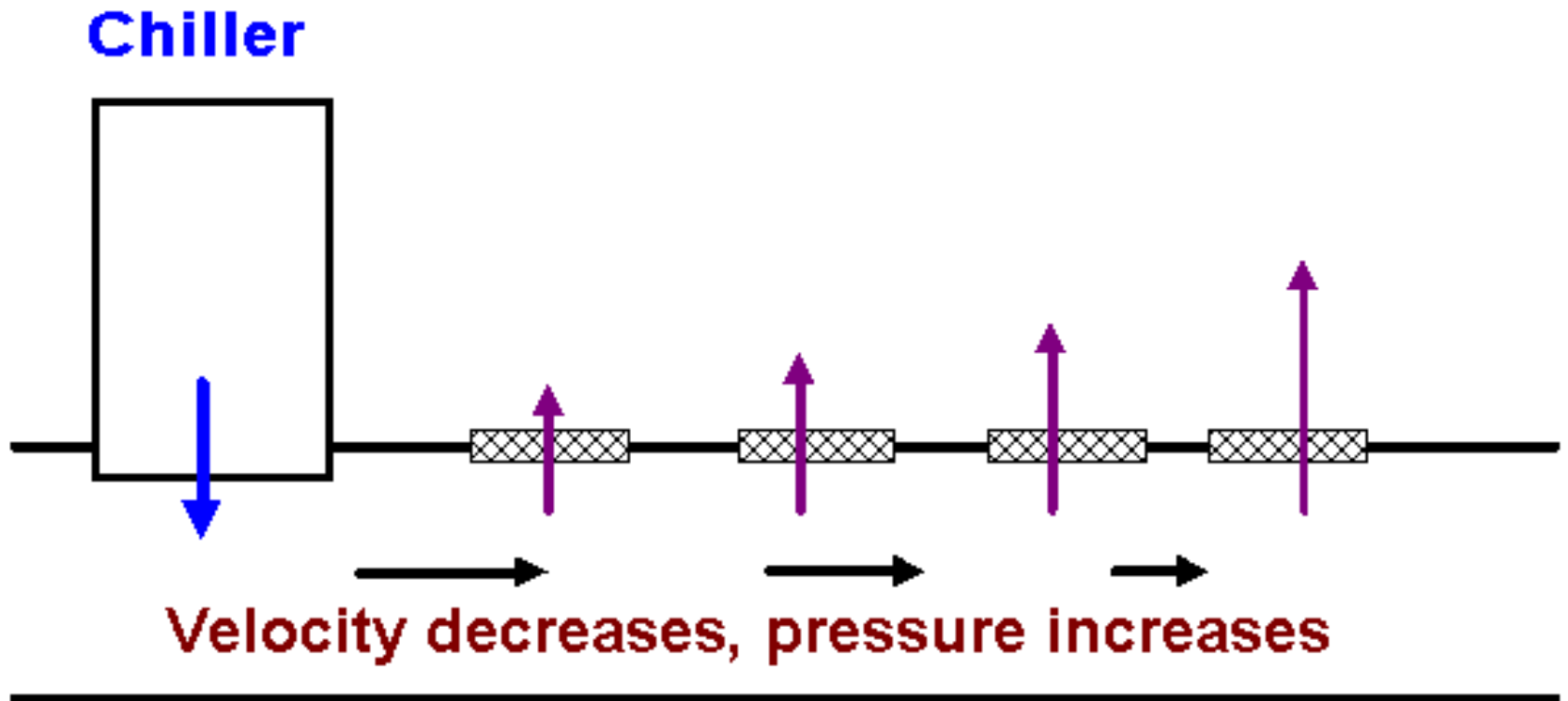
Basis of the Model

- A two-dimensional (depth-averaged) calculation of the velocity and pressure fields under the raised floor is performed.
- The chiller flow is specified as inflow.
- The outflow through the perforated tiles is calculated from:

$$\Delta p = A Q^2$$

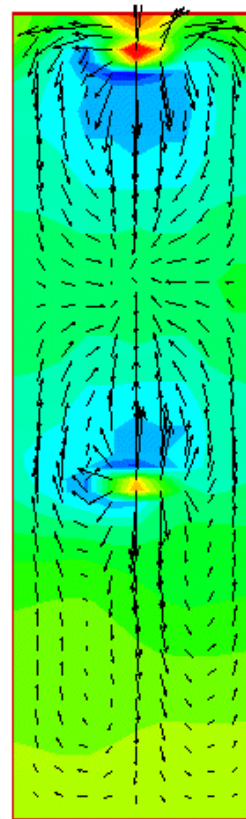
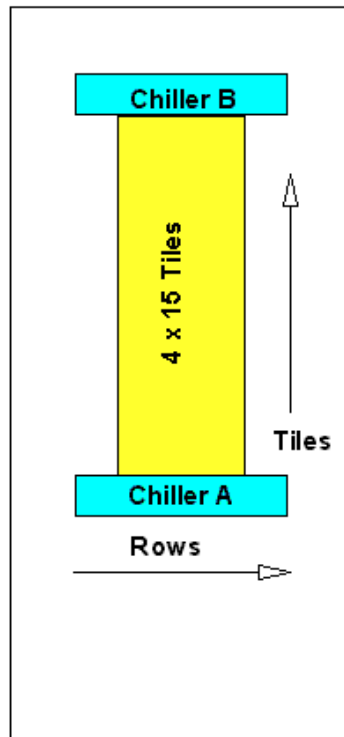
where Δp is the pressure drop and
 Q is the volumetric flow rate

The Cause of Flow Maldistribution

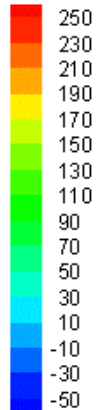
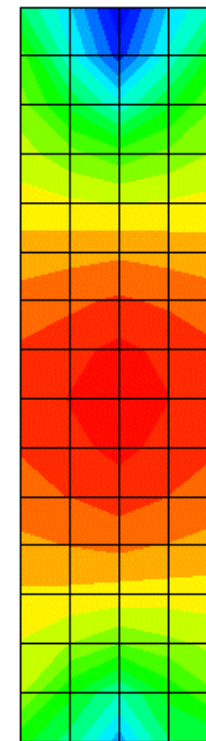


Results of the Model

Both Chillers On



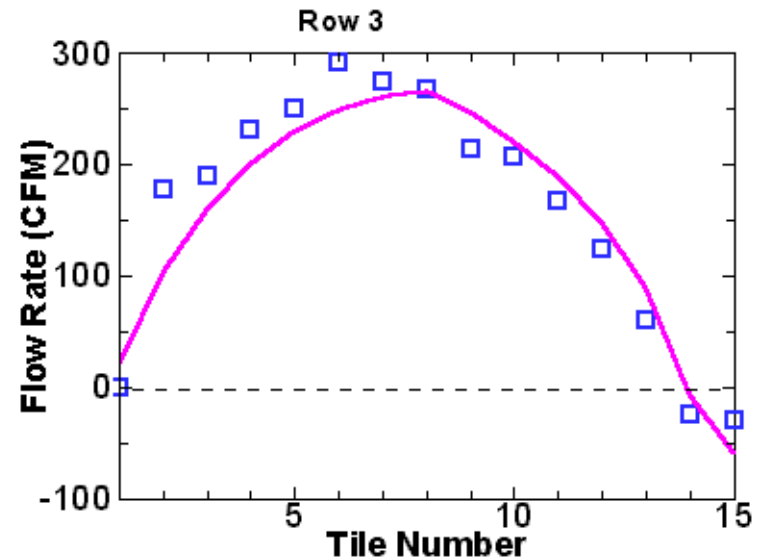
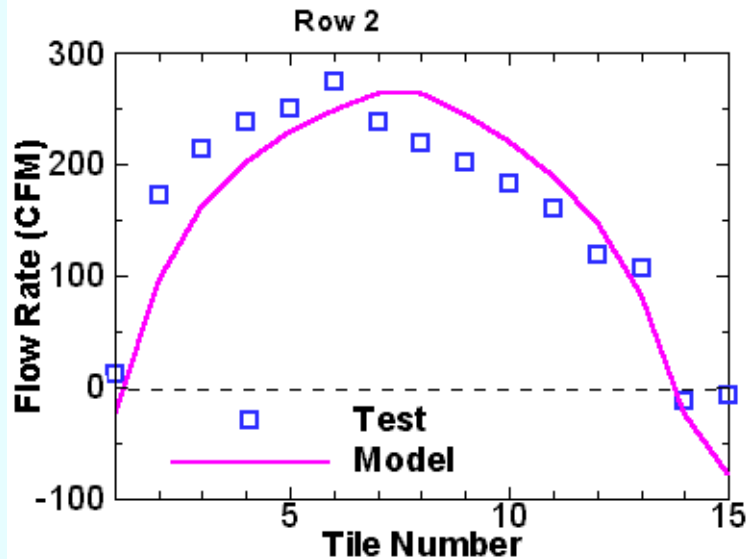
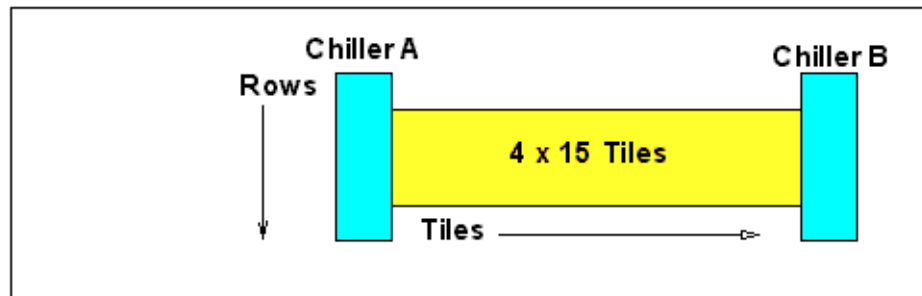
Pressure



Tile Region
Volumetric Flow Rate

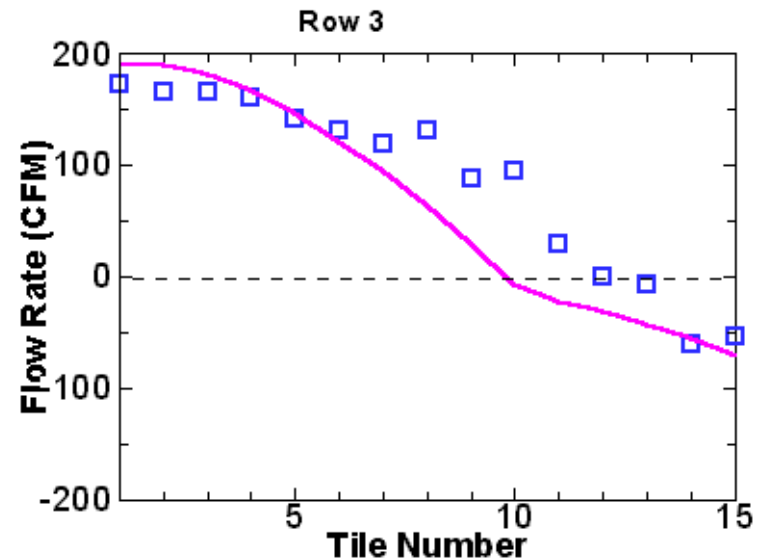
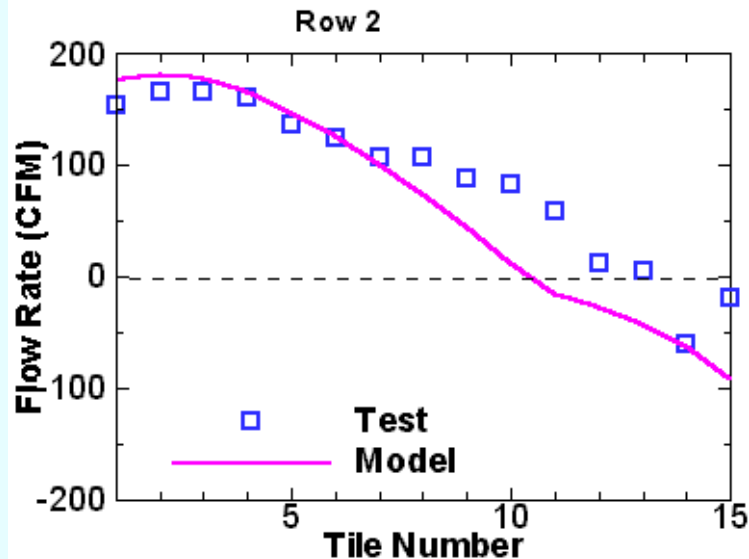
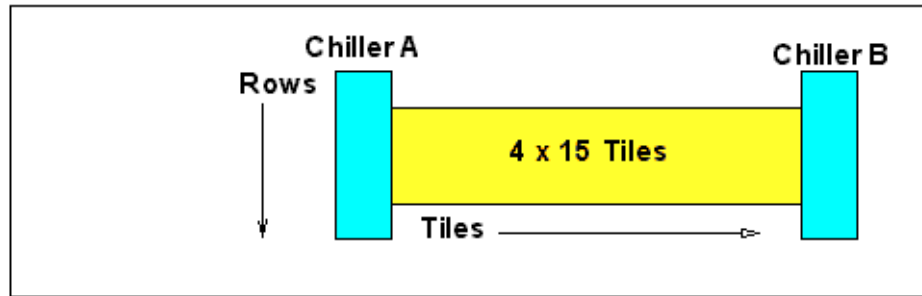
Comparison With Measurements

Test 10 (Both Chillers On)



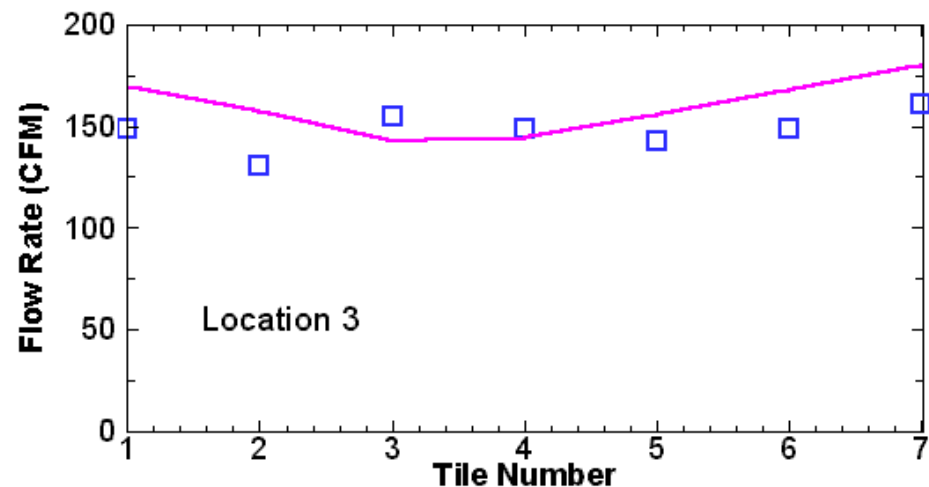
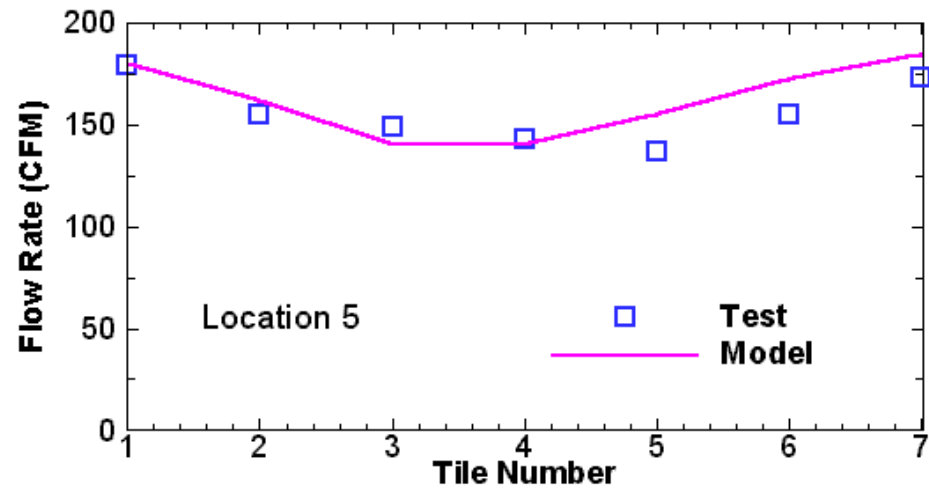
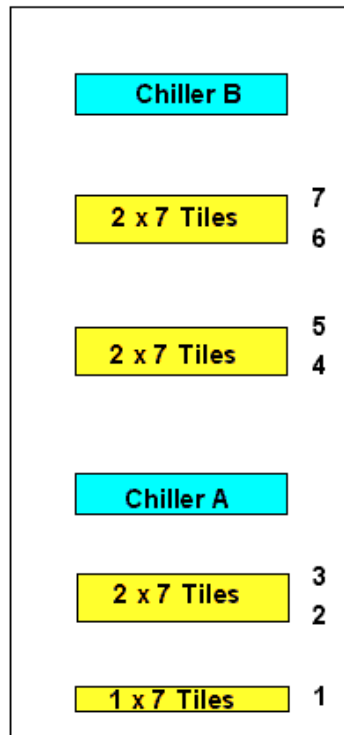
Comparison With Measurements

Test 12 (Chiller A Off)



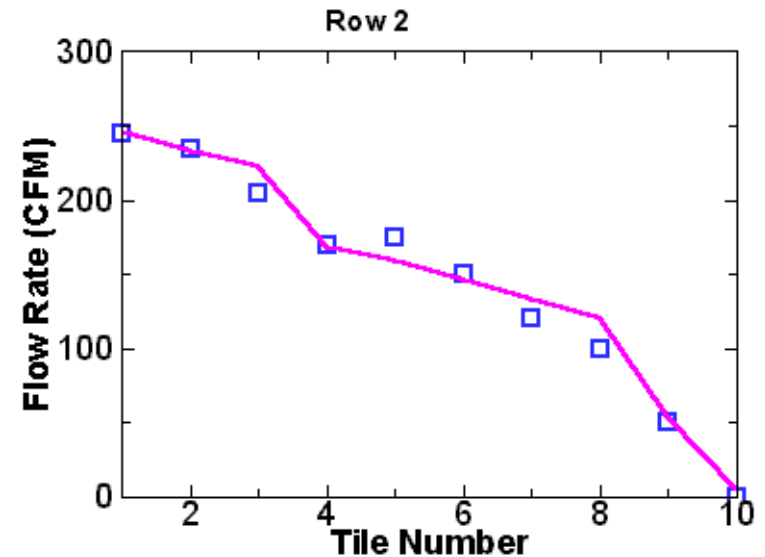
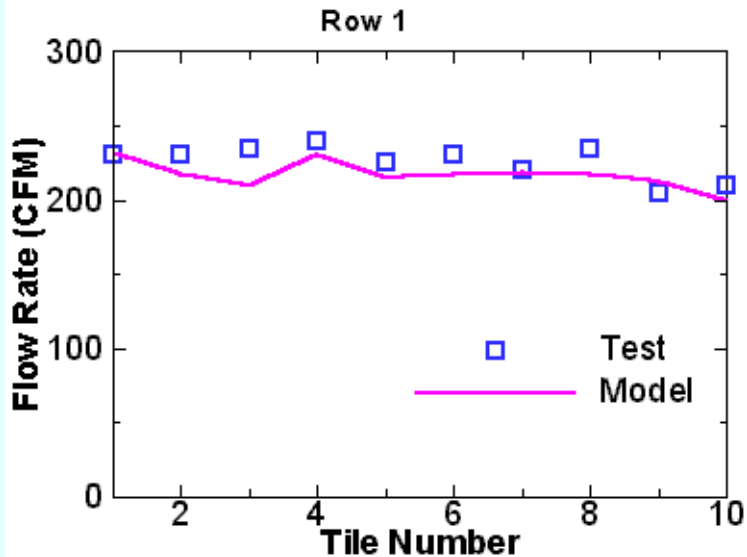
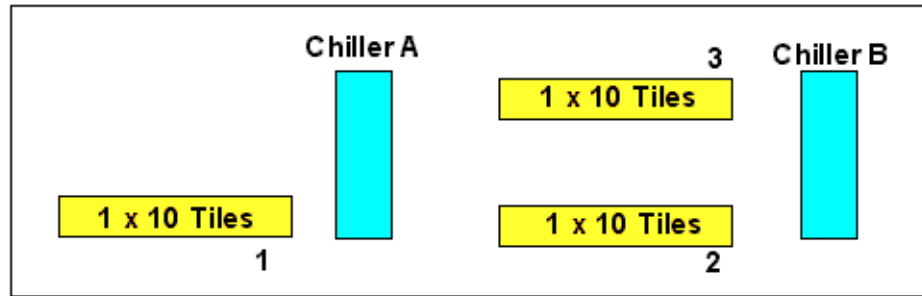
Comparison With Measurements

Test 19 (Chiller A Off)

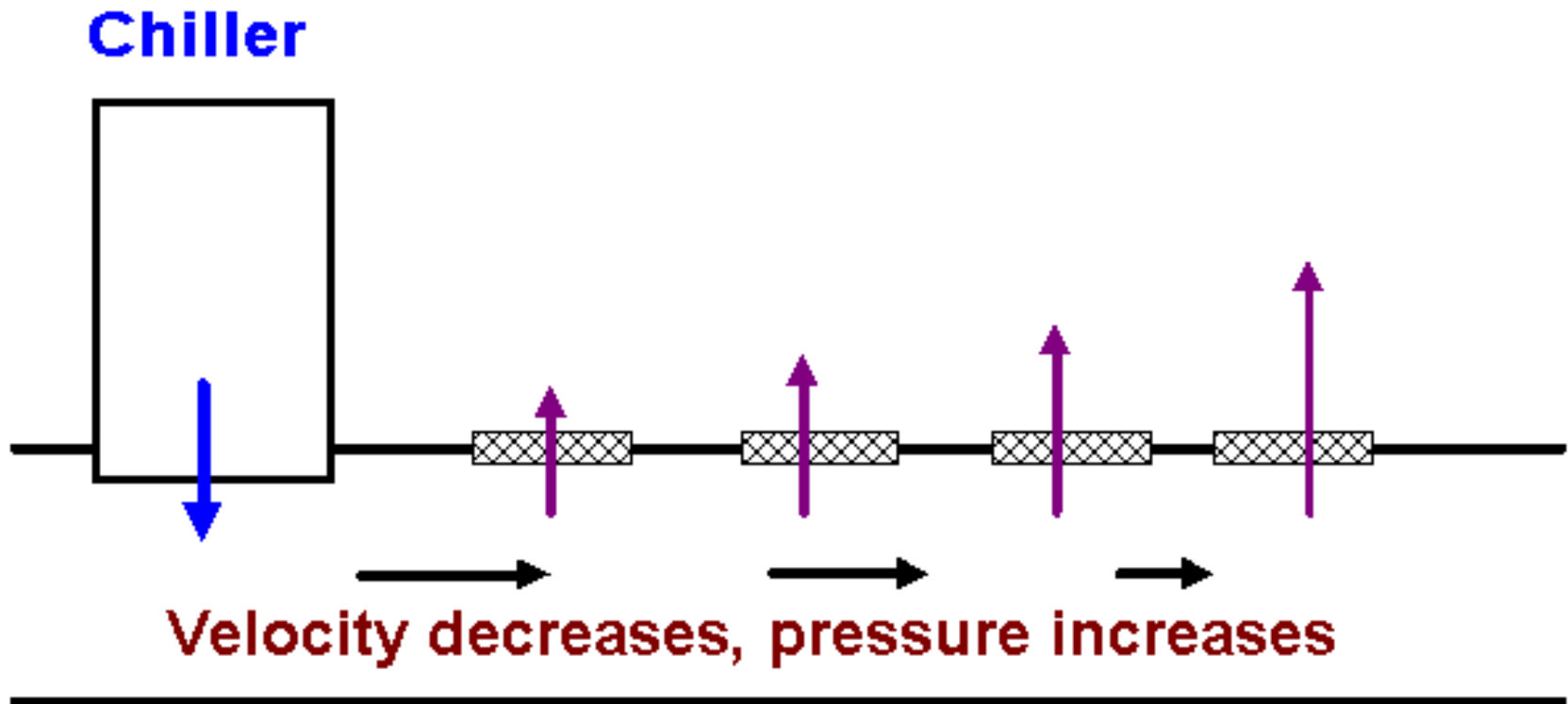


Comparison With Measurements

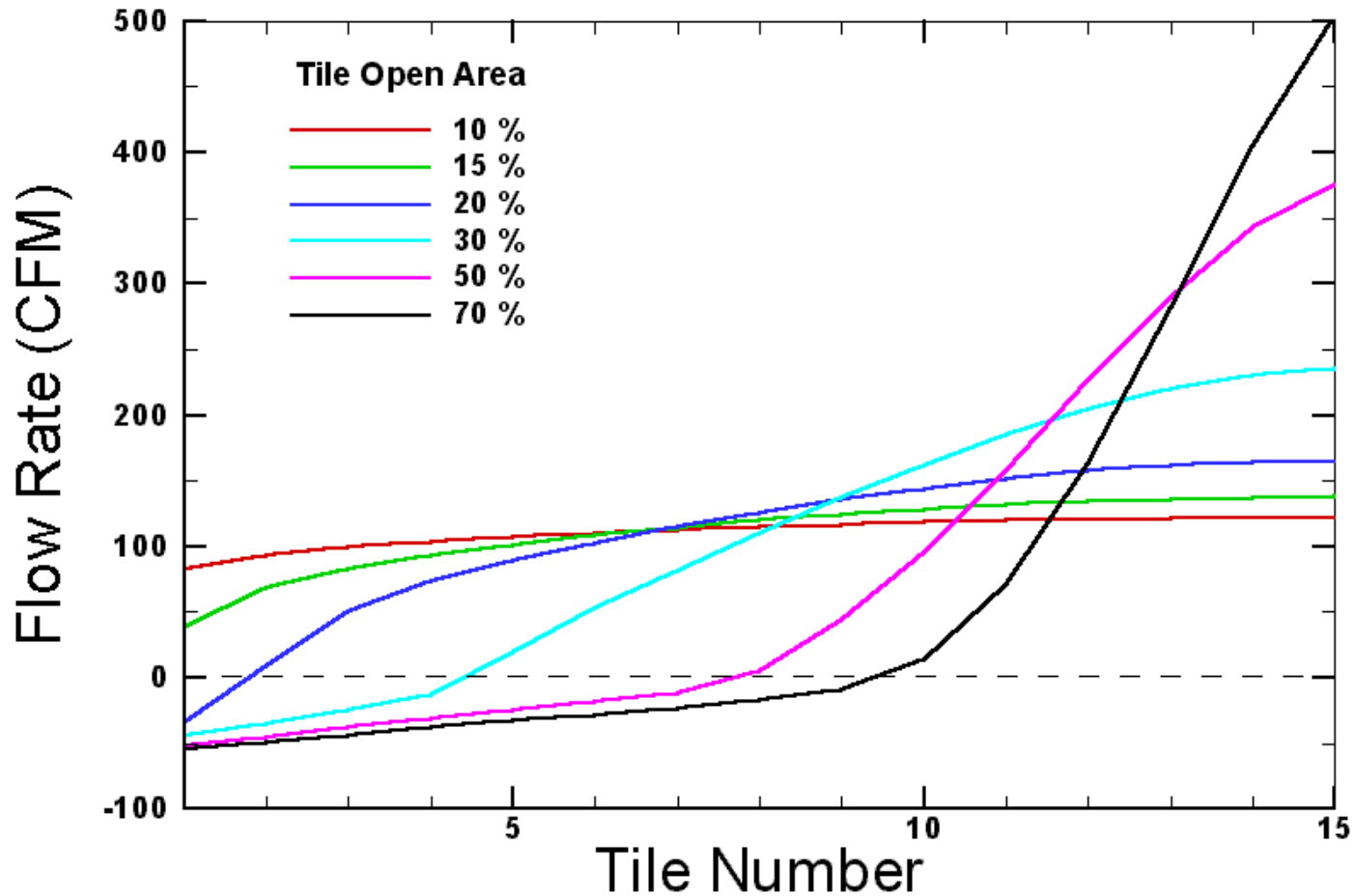
Test 23 (Chiller A Off)



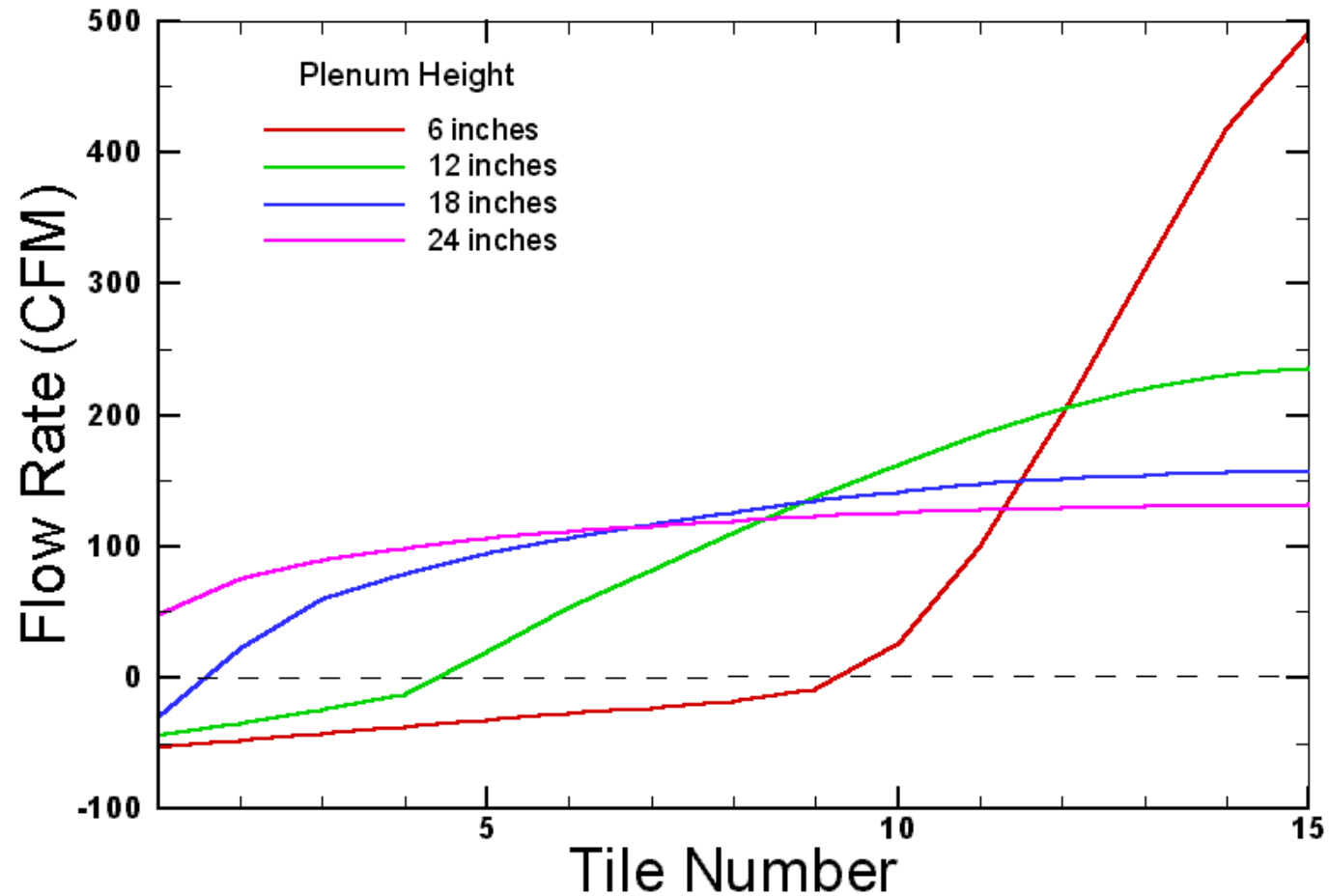
Flow Maldistribution Revisited



Effect of Tile Open Area



Effect of Plenum Height



Industry Needs

- Heat loads of Data Processing Equipment are increasing.
- Sufficient chilled airflow must be supplied to maintain high reliability.
- Complex layouts of systems, chillers, and perforated tiles present extra challenges.
- A validated predictive tool is needed to aid in balancing/optimizing airflow distribution throughout the data center.

Our Contribution

- Detailed airflow measurements have been conducted on a data center with a variety of chiller and tile arrangements.
- A computational model has been developed for the prediction of the flow through the perforated tiles.
- The model predictions give good agreement with the measurements.
- One run of the model requires 1-2 minutes on a 300MHz Pentium computer.