CRITICAL FACILITIES ROUNDTABLE

HEAT REMOVAL IN DATA CENTERS
ENGINEERED SOLUTIONS

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HISTORICAL PERSPECTIVE

I appreciate the opportunity to speak before you all today. I've seen a lot of changes occur in the field of facility engineering. But despite the changes there are some ironic similarities. When I founded ESC some 25 year ago, energy management was emerging as a hot button issue. The Arab oil embargo of 1974 had created an urgency to reduce the dependence on Middle East oil. Indeed, Jimmy Carter's energy conservation initiatives led to significant reductions in consumption, in fact, more than at any other time in history. However, oil and gas prices moderated in the mid 80's and the motivation to conserve energy lost its momentum.

TODAY'S SITUATION

So here we are…some 25 years later… on the verge of experiencing a global peaking of oil production as well as global warming both of which can be mitigated by way of energy conservation. But that's an entirely different conference. However, I think we need make energy conservation a national issue. Today we are going to talk about one aspect of this issue…how to get the enormous amount of heat generated by modern computer server equipment out of the data center as efficiently as possible.

CONSULTING ENGINEERS NEED TO LEAD THE WAY

Bill Henry and I take pride in serving the energy end user with effective and energy efficient solutions. We've done this for years. On the other hand, we respect innovative products and the vendors that sell them but we want to lead toward a return to basic principals of systems engineering as they relate to data center cooling designs. I guess that when you are a consulting engineer this point of view is expected. Anyhow, we know there are many innovative products created by some really smart engineers that work for companies like APC and Leibert. These products are very good at removing the heavy heat loads produced by full racks of blade servers. And they appear to offer good solutions for upgrading an existing data center or computer lab where the blade servers are a small percentage of the entire floor area. However, when a data center is being renovated for full on blade server service and particularly if a new data center is being planned Bill and I recommend considering a systems approach that gets the heat out, substantially improves energy efficiency and controls infrastructure cost.

THE RAISED FLOOR DATA CENTER IS A LEGACY DESIGN

On a recent project, we gained interesting insight as to the limits of raised floor data centers in effectively removing large heat loads. The compute ranch we investigated was a 10, 805 gross square foot data center with a 10-foot ceiling and a 21 inch raised floor.

The facility operates at a computer equipment demand of about 1,300 kW, which is equivalent to about 3 kW per rack. One of our objectives was to determine the ultimate capacity of the facility based on the potential for heat removal. We used a computer simulation tool called "Tile Flow". It simulates the fluid dynamic characteristics of the under floor air distribution. We determined that, using standard perforated tiles, the capacity could be pushed to say 5 kW per rack. Rack cooling greater than 5 to 6 kW requires extraordinarily high raised floors and perforated tile designs.

THE TIME HAS COME FOR THE OVERHEAD DUCTED PLENUM

OK… so if the raised floor design is limited to say 5 to 6 kW per rack… where do we go from here? We're going to present to you today a concept that removes a lot of heat in a very energy efficient way. It features overhead ducting, a medium pressure air supply fan and the controls necessary to utilize outside air for cooling. These designs can provide heat removal at a rate greater than 5 kW per rack. And do it on a slab floor and with greater energy efficiency than conventional raised floor or vender designs. Similar designs have been used for years to provide the high air volumes needed in clean room design. So now the time has come to utilize them in data center designs.

So, without any further ado, I give you my colleague Bill Henry. He will present the overhead ducted plenum concept and point out why it is an energy efficient way to get a lot of heat out of the data center.

Please feel free to ask your questions at any point during the presentation.

I present my colleague Bill Henry.

Overhead **D**ucted **P**lenum

Let’s Just Say “ODP”

Discussion Summary

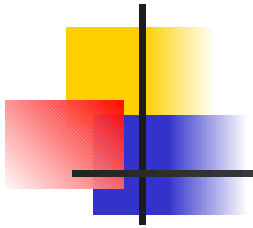
- Background and Areas of Expertise
- Common Design Characteristics
- Legacy Design vs New Innovations
- Description of the ODP Concept
- Energy Efficient Solutions Made Possible with the ODP

William R. Henry P.E.

Mechanical Engineer

- Professional Engineer
  - Registration: California, New York
- HVAC Design Background
  - Microelectronics Fabrication Facilities
    - Clean Rooms
    - Central Plants
    - Intel, AMD, LSI Logic etc.
  - Aerospace
    - Electronics Fabrication Facilities
    - High Bay Satellite Assembly
    - Central Plants
    - Satellite Test Computer Rooms
    - TRW, TAC, Lockheed

HVAC Characteristics of Data Center (Clean Room) Operations



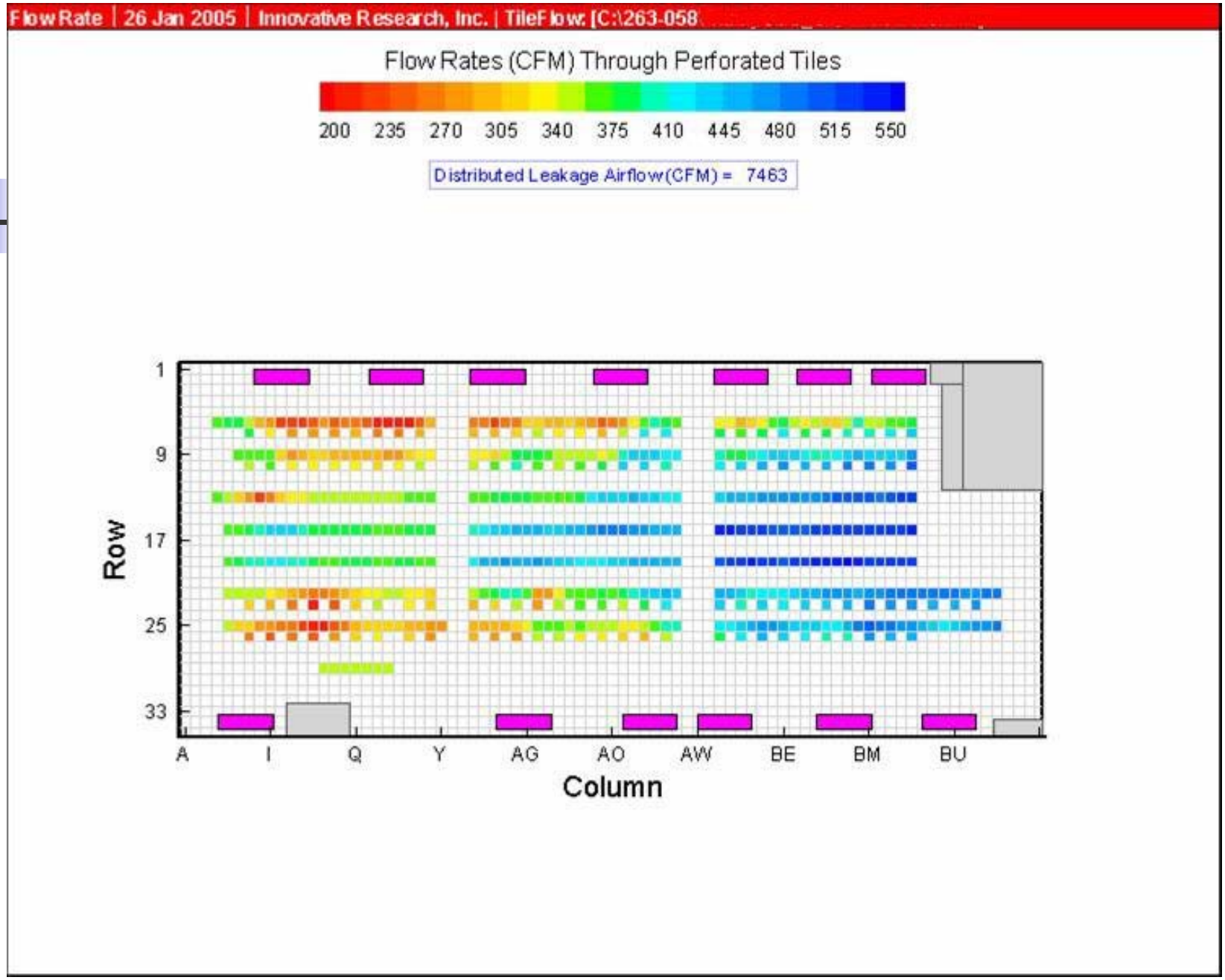
- Large Heat Loads
- High Air Flow Requirements
- Crowded Overhead Spaces
- Competing Utilities - Power, and Air Distribution
- Critical Operations Require Redundancy.

Summary of Cooling and Air Distribution Methods

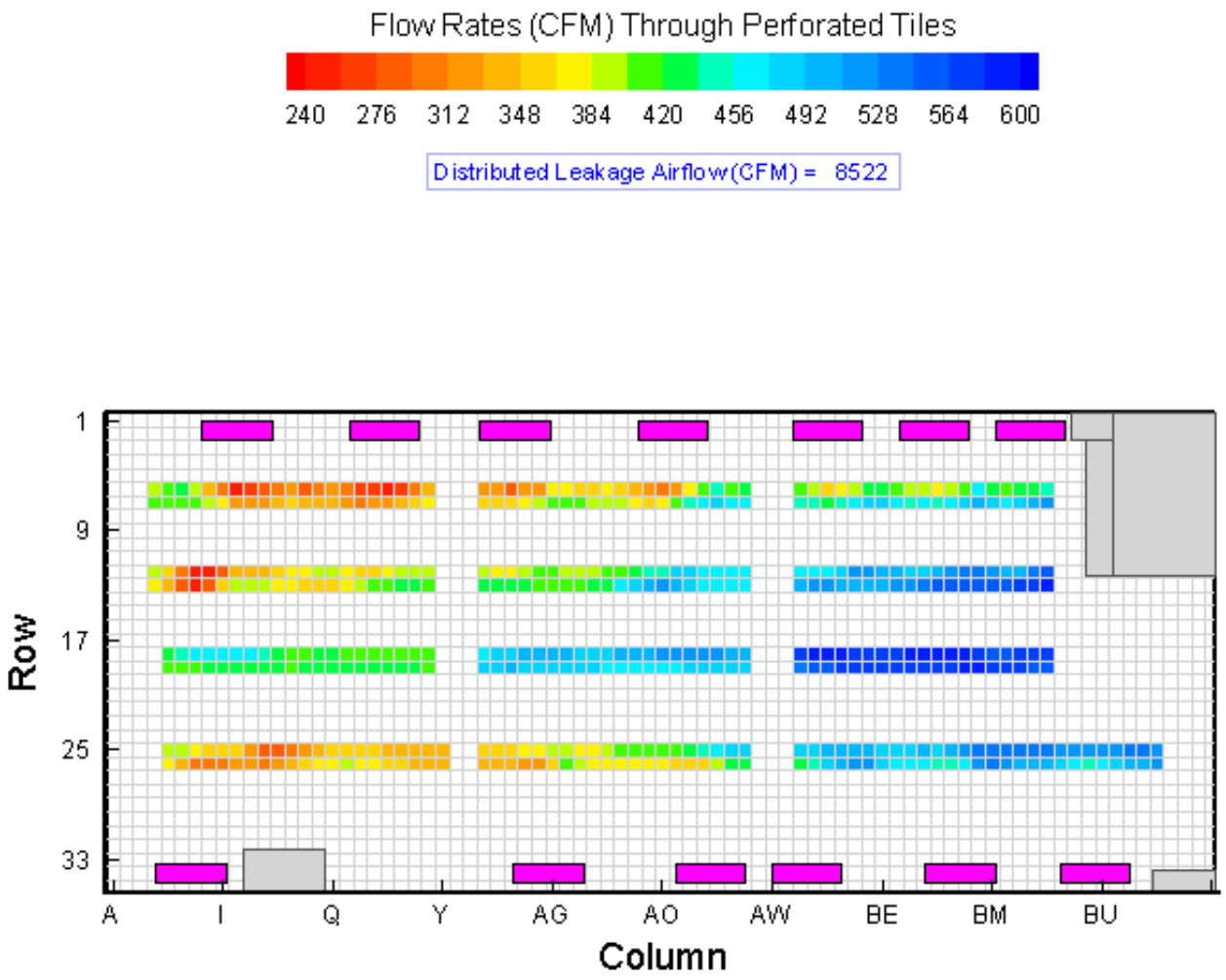
- Under Floor with Perforated Tile
- In-Rack Cooling Equipment
- Independently Controlled Fan Coil or DX Units
- Overhead Air Distribution – Equal Friction Air Flow Design.
- Overhead Ducted Plenum (ODP)

Under Floor Air Distribution

- Raised Floor
  - Theoretically - Even Air Flow Distribution
  - Flexibility – (Moving/Adding Floor Tiles)
  - High Air Flow
- Independent FC/DX Air Supply Units
  - Redundancy w/Multiple CRAHS/CRACS
  - Simple Temperature Control
  - Accessible Equipment for Maintenance


Flow Rate | 26 Jan 2005 | Innovative Research, Inc. | TileFlow: [C:\263-058
Flow Rates (CFM) Through Perforated Tiles
200 235 270 305 340 375 410 445 480 515 550
Distributed Leakage Airflow (CFM) = 7463
Row
1
9
17
25
33
A I Q Y AG AO AW BE BM BU
Column

Flow Rate | 26 Jan 2005 | Innovative Research, Inc. | TileFlow: [C:\263-058\Sunnyvale_Lab HC Aisle.tlf]



ODP
What IT IS

- Over Head Air Distribution
- Constant Cross Section Duct Design
- Interconnected or Looped Duct Work
- +1” wg Pressurized Duct Design
- Operable Air Supply Outlets
- Zoned Temperature Controls

Benefits of Overhead Air Distribution

- Overhead Ducted Plenum
  - Higher Air Flows than Raised Floor
  - Better Localized Cooling Control with Automatic Dampers
  - Redundancy of a Plenum Design
  - Larger More Efficient Fan Coil Units
  - Common Service Aisle
  - Integrate Outside Air Economizer For Free Cooling Applications

Energy Efficiency

- Using “Free Cooling” to Save Energy
  - Requires Designs That Allow Removal of Hot Air To Be Replaced By Cooler Outside Air
  - Outside Air Dew Point Temperature is between 46° & 55° F More Than 5000 Hours/Year
- Increased Supply Air Temperatures To Improve Efficiency
  - Requires Higher Air Flows
  - Say 60-65°F Supply Air Temp

Fan Coil In Service Aisle vs. Floor/Rack Mounted

- Larger Fans W/ Control
  - Variable Speed Drives w/DP Control
  - Fan Efficiencies to 70%
  - Min. Three Units to Provide Full Redundancy
  - Higher External Pressures for ODP
  - Service Aisle/Plenum Facilitates Economizer System Integration

Floor / Rack Mounted ...continued

- CRAH / CRAC
  - Squirrel Cage Fan Efficiency of 40%
  - Variable Speed Drives – the exception
  - Low Pressure Air Supply
  - Takes up Useable Space
  - Limited Individual Capacity
  - Multiple x Multiple Units
  - Still Poor Air Distribution.
  - Unitary Controls – Large Zones.

Capital Cost of Installation

- Compared to What! Electrical Distribution Systems? Server Racks?
- HVAC Part of the Process not an adjunct to it! (aka Clean Room Designs)
- Plus Raised Floors Ain’t Cheap!
- And How Does One Value Better Localized Control?