VENTILATION 2006

Ventilation Science Technology Opportunities for Cross Cutting Technologies (Industrial – Mine Ventilation)

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May 13-18, 2006, Chicago
OUTLINE

- Historical Perspective of Industrial Ventilation
- Steps to Holistic Approach to IAT
- Cross-Cutting Opportunities
- Future Directions
Historical Perspectives

• Neanderthal
  – Design of caves
• Before B.C., Roman architect Vitruvius
  – Ventilation w.r.t. buildings
• Egypt (large funnels on houses)
• Desaquilers (1734 AD) – funnels on ships
AD23-79
Pliny the Elder

Connect two mine shafts with an underground passageway and have a slave continuously wave a linen cloth.
AD1494-1555
Georgia Agricola De Re Metalliea

Hand operated wooden centrifugal fan for use in mines
Benjamin Franklin Sturtevant
Local exhaust ventilation system to control dust for operation making wooden pegs for shoes
<table>
<thead>
<tr>
<th>Year</th>
<th>Pioneer</th>
<th>Area of Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>1914</td>
<td>Dr. Willis Carrier</td>
<td>Fan Engineer</td>
</tr>
<tr>
<td></td>
<td>Richard Madison</td>
<td>Fan Engineering</td>
</tr>
<tr>
<td>1925, 1933, 1938, 1945</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1932</td>
<td>DallaValle and Hatch</td>
<td>Airflow Equations</td>
</tr>
<tr>
<td>1939</td>
<td>John Alden</td>
<td>Design of Industrial Exhaust Systems</td>
</tr>
<tr>
<td>1951</td>
<td>AGGIH</td>
<td>Industrial Ventilation Manual</td>
</tr>
<tr>
<td>1954</td>
<td>Wes Hemeon</td>
<td>Plant and Process Ventilation</td>
</tr>
<tr>
<td>1972</td>
<td>Baturin</td>
<td>Fundamentals of Industrial Ventilation</td>
</tr>
<tr>
<td>1985</td>
<td>Goodfellow</td>
<td>Advanced Design of Ventilation Systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For Contaminant Control</td>
</tr>
<tr>
<td>2001</td>
<td>Goodfellow/Tahti</td>
<td>Industrial Ventilation Design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Guidebook</td>
</tr>
</tbody>
</table>
Plant Ventilation Progress

In 20th Century
Kenneth Robinson

Process Focused

People Focus
1920

Effective temperature chart by ASHVE

FIGURE 1. Effective-temperature chart developed by ASHVE in the 1920s.
1930’s

Military research

Prof. T. Hatch

Dr. Bedford

effective temperature
Late 1930’s

Established Industrial Hygiene Department by U.S. Department of Health

All companies with government contracts during World War II provide a safe and healthy work environment
1943

Director of Michigan Division of Occupational Health

- Established a ventilation division
- Kenneth Robinson responsible
- Courses at Michigan State
- Industrial Ventilation Manual (1951)
1943

First Time

Anyone considered the use of ventilation and air supply in providing an acceptable environment for the worker.
Specific Examples of Custom Design Ventilation Systems

1. Mine Ventilation
   Factors
   - High Capital Costs
   - High Operating Costs

2. Semi-Conductor Industry
   - ISO 1 to 9

3. Radioactive Dusts
   - Total Containment

4. Metals Industry (EAF Fume Control)
   - High Temperature

5. Pulp and Paper (Paper Machine)
   - High Speed

6. Operating Theaters
   - Cross Contamination

7. Food Processing Industries
   - Cross Contamination
Overview

Industrial Ventilation
  Very complex
  No harmonization

International Regulations
  Vary widely
  Different regions
  Different industries
Research in the Ventilation Field
(North America)

- Residential
- Commercial
- Industrial

**AHSRAE** (founded in 1894)
American Society of Heating, Refrigerating Engineers

**ACGIH** (founded in 1951)
American Conference of Governmental Industrial Hygienists
KEY ACTIVITIES OF INDUSTRIAL VENTILATION

STATE – OF – THE ART STUDY
E. Tähti
1989

INVENT TECHNOLOGY PROGRAMME
Finalnd
1991-1996

Center of Excellence (COE)
Helsinki Univ. of Technology
1996

Design Guide Book

Fundamentals

Applications
• Systems & Equipment
• Customer oriented applications
• Generic applications

Newsletter

Standardisation
1996-2003

COST Action
1996-2003

Thermie B
1996-1998

INVENTNET
2000-2002

EUROPE

NORTH AMERICA

PACIFIC RIM

Vent’85
Toronto, Canada

Vent’88
London, UK

Vent’91
Cincinnati, USA

Vent’94
Stockholm, Sweden

Vent’97
Ottawa, Canada

Vent 2000
Helsinki, Finland

Vent 2003
Sapporo, Japan
STEPS TO HOLISTIC APPROACH TO INDUSTRIAL AIR TECHNOLOGY
STEP 1

1982 PUBLICATION on AIHA Journal
Industrial Ventilation – A Review and Update
Professors Goodfellow and Smith (UofT)

Need to organize an International Symposium on
Industrial Ventilation
1985 Organization of Vent ’85 Conference in Toronto

Very Successful Conference more than 300 attendees from 10 countries
VENTILATION CONFERENCES

Achievements for Specialty Conferences

More than 500 technical papers published
More than 3000 attendees
Is a global network forum
STEP 3

2001 Publication – Industrial Ventilation Design Guidebook

Goodfellow & Tahti

Features
Systematic approach to design
Current scientific research and engineering
New concepts
Design Methodology
Target Levels
INDUSTRIAL Ventilation Design

New Developments

Tuesday May 16th  2:00 – 6:00pm

Session RT D4
Design Methodology

- Process Description
  - Building Layout and Structures
    - Target Level Assessment
      - Source Description
        - Calculation of Local Loads
          - Local Protection
            - Calculation of Total Building Loads
              - Selection of System
                - Selection of Equipment
                  - Detailed Design
Target Levels

- Health and Comfort Effects
- Target levels of Industrial Air Quality
- Current situation (Database at FIOH)
- Benchmark Air Quality
- Technological approach
- Risk assessment approach
OUTLINE

Historical Perspective of Industrial Ventilation

Steps to Holistic Approach to IAT

Cross-Cutting Opportunities

Future Directions
Mine Ventilation

- Mine ventilation - fluid dynamics
  - air quality & direction

Occupational Health

- Total mine air conditioning
  - air quality/quantity/Temp/RH
- Airborne contaminants
- Temperature/Relative Humidity
Factors that feature in the creation and control of hazards in the sub surface environment

<table>
<thead>
<tr>
<th>Factors that contribute to hazards</th>
<th>Methods of control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NATURAL FACTORS</strong></td>
<td></td>
</tr>
<tr>
<td>Depth below surface</td>
<td>Dust</td>
</tr>
<tr>
<td>Surface climate</td>
<td>Dust suppression</td>
</tr>
<tr>
<td><strong>DESIGN FACTORS</strong></td>
<td>Main fans</td>
</tr>
<tr>
<td>Method of working</td>
<td></td>
</tr>
<tr>
<td>Layout of mine or facility</td>
<td></td>
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<tr>
<td><strong>HAZARD CONTROL</strong></td>
<td></td>
</tr>
<tr>
<td>Gas emissions</td>
<td>Gas drainage</td>
</tr>
<tr>
<td>Heat and humidity</td>
<td></td>
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<tr>
<td>Refrigeration systems</td>
<td></td>
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<tr>
<td>Airlocks, stopping, air crossings, Regulators</td>
<td></td>
</tr>
<tr>
<td><strong>ANCILLARY CONTROL</strong></td>
<td></td>
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<tr>
<td>Mineral clearance</td>
<td></td>
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<tr>
<td>Fires and explosions</td>
<td></td>
</tr>
<tr>
<td>Monitoring systems</td>
<td></td>
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<tr>
<td>Number, size, lining and layout of airways</td>
<td></td>
</tr>
<tr>
<td><strong>AIRFLOW</strong></td>
<td></td>
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<tr>
<td>Physical and chemical properties of rocks</td>
<td></td>
</tr>
<tr>
<td>Gas content of strata</td>
<td></td>
</tr>
<tr>
<td>Ground water and other subsurface liquids</td>
<td></td>
</tr>
<tr>
<td>Age of airways</td>
<td></td>
</tr>
<tr>
<td>Stored materials</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3. Hazards and Methods of Control.  
Source: Van Rensburg 1996.
SIMPLE SCHEMATIC OF MINE VENTILATION
## Applications

<table>
<thead>
<tr>
<th></th>
<th>Mine</th>
<th>Industrial</th>
<th>Opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FANS</strong></td>
<td>✓</td>
<td>✓</td>
<td>High</td>
</tr>
<tr>
<td><strong>Volumes of AIR</strong></td>
<td>✓</td>
<td>✓</td>
<td>High</td>
</tr>
<tr>
<td><strong>(Design Methodology)</strong></td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>Contaminants</strong></td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>Gases</strong></td>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td><strong>Dusts</strong></td>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td><strong>(Target Levels)</strong></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pressure Drop Calculations</strong></td>
<td>✓</td>
<td>✓</td>
<td>High</td>
</tr>
<tr>
<td><strong>Significant Ventilation Costs</strong></td>
<td>✓</td>
<td>✓</td>
<td></td>
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<tr>
<td><strong>Capital</strong></td>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td><strong>Operatives</strong></td>
<td>✓</td>
<td>✓</td>
<td>High</td>
</tr>
<tr>
<td><strong>Dust Control for Materials</strong></td>
<td>✓</td>
<td>✓</td>
<td>High</td>
</tr>
<tr>
<td><strong>Handling</strong></td>
<td></td>
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</tbody>
</table>
OUTLINE

1. Mining Engineer
   - Ventilation is the most versatile atmospheric control tool

2. Mine Ventilation
   - Application of the principles of fluid dynamics to the flow of air in mine openings
   - Responsible for the circulation of air in both amount and direction throughout the mine

3. Total Mine Air Conditioning - Simultaneous control of mine air
   - Quantity
   - Quality
   - Temperature - humidity
4. Historical Perspectives

Miners

Paleolithic ⇒ oxygen deficiency
40,000 BC ⇒ toxic gases
        ⇒ harmful dusts
        ⇒ debilitating heat
1,000 BC ⇒ course the air through multiple
        ⇒ openings
1,500 AD ⇒ Agricola - early “ventilating
        ⇒ machines”
        (Middle Ages)
TODAY = Vastly improved mine ventilation
5. Today, Environmental Challenges

Underground

- Airborne contaminants
- Depth
  - rock pressure
  - rock temperature
  - high temperatures (air conditioning = cost)
6. Control Processes
   - Air Conditioning
     • only temperature - humidity control
   - Total Air Conditioning
     • quality of atmosphere
     • quantity
     • temperature - humidity
7. Total Air Conditioning

- **Quality control** (purifying air and removing contaminants)
  - Gas control - vapors and gaseous matter, including radiation
  - Dust control - particulate matter
- **Quantity control** (regulating magnitude and direction of airflow)
  - Ventilation
  - Auxiliary or face ventilation
  - Local exhaust
- **Temperature - humidity control** (controlling latent and sensible heat)
  - Cooling
  - Heating
  - Humidification
  - Dehumidification
8. Engineering Control Principles

- Prevention or avoidance
- Removal or elimination
- Suppression or absorption
- Containment or isolation
- Dilution or reduction
9. Four Developments Over the Last 3 Decades

1. The high-speed, electronic *digital computer*, permitting advanced solutions to ventilation circuits and networks heretofore unsolvable.

2. The *systems approach*, which optimizes complex industrial operations, permitting personnel, materials, and methods to be coordinated in the most efficient way.

3. Extensive federal *legislation*, embodying a strict code of regulations to improve the safety of mining operations.

4. The advent of *socioengineering*, the applying of technology with full consideration of the social, political, economic, and environmental consequences, as well as the technical benefits.
Centrifugal Fan (Double Width Double Inlet)
Systematic Approach to Mining/Ventilation Systems

• Method/rate of production
• Environmental Standards
• Heat/gas/dust emissions
• Air/Refrigeration
• Optimize alternatives
• Select system
Opportunities for Cross Cutting Technologies

• Dust control for mining operations

• Computer models for design of mine ventilation

• Fan design

• Target Levels for contaminants (diesel emission exhausts)
Dust Control for Mining Operations

- Ore Pass Dust Control
- Drill Dust Control
- Blasting Dust Control
- Conveyor Belt Dust Control
- Transfer Point and Crusher Dust Control
- Road Header Dust Control
Future Directions

**Strategy/Challenges**

- Holistic Approach
- Cross Cutting Technology
- Create Sustainable Business Model
- Global Reach
- Disseminate Technical Information
- Accurate Commercialization of Technology
Business @ the Speed of Thought…
Bill Gates 1999

Flow of Digital Information

Nature of Business
STABLE
UNSTABLE

Unstable rapid changes

1990 2000 2010
Digital Nervous System

“corporate digital equivalent of the human nervous system”

INTEGRATED APPROACH

Right time

Right part of the organization

Right information
COLLABORATION

MINING VENTILATION

COMMERCIAL & RESIDENTIAL

INDUSTRIAL VENTILATION
OUTLINE

Historical Perspective of Industrial Ventilation

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