Summary

Occupational and environmental health specialists spend much of their time recognizing and evaluating potential health or safety hazards. However, these activities, by themselves, do not alleviate problems. Control measures must be implemented to reduce the risk of disease or injury among exposed populations. This course investigates qualitatively and quantitatively the options for reducing human exposure to airborne hazards, particularly in the workplace. Among the options considered will be general and local exhaust ventilation, air pollution control equipment, and personal protective equipment. The course will include lectures, a tour, a laboratory session, and a design project. Many of the assignments undertaken during this course will have no single correct answer; the selection and design of a control method will vary depending on assumptions and approaches taken by the students.

Course Information

Mondays, 4:40 – 7:40 PM (we'll try to take two 5-10 minute breaks during lectures)
Moos Tower 2-118
3 credits

Instructor Information

Lead Instructor:
Pete Raynor, Ph.D., Assistant Professor
Office: Mayo 1230  Office hours: By appointment
Office phone: (612) 625-7135  Home phone: (952) 513-0729 (before 10:00 PM)
Email: praynor@umn.edu

Additional Instruction:
Gerhard Knutson, Ph.D., Adjunct Assistant Professor
Business phone: (952) 928-0195

Nicole McCullough, Ph.D., Adjunct Assistant Professor
Business phone: (651) 575-8294

Mike Austin, M.S., J.D., Adjunct Instructor
Office phone: (612) 626-6436

Seung Won Kim, Ph.D.
Office phone: (612) 626-0494
Course Materials


For supplemental reading, a copy of the book *Ventilation for Control of the Work Environment* by W. A. Burgess, M. J. Ellenbecker, and R. D. Treitman has been placed in the Industrial Hygiene Library in S36 Boynton Health Service. The book should not be removed from the IH Library in order to give all students equal access to the text. Another copy of the book may be borrowed on a short-term basis from Dr. Raynor directly.

Web-based reading assignments will also be required for some classes.

Course Objectives

By the end of the course, students should be able to:

- explain the reasons that air moves
- measure air movement
- design a simple dilution ventilation system
- evaluate the effectiveness of a local exhaust ventilation system
- design a simple local exhaust ventilation system
- explain the operating principles behind air pollution control devices
- select appropriate personal protective equipment for different hazardous situations
- state the requirements for a respiratory protection program
- prioritize potential control solutions when confronted with a hazard
- discuss industrial ventilation systems and air pollution control equipment effectively with design engineers

Course Grading

The course will include 10 homework assignments and a laboratory report. These assignments, due in the hands or mailbox of Dr. Raynor on the dates indicated on the course schedule, will each be graded on a 20-point scale. At the discretion of the instructor, the grades may be reduced by 1 point for each weekday that the assignment is late. Students may work together on homework and lab reports. However, each student should submit her/his own assignment for grading.

Two take-home exams will be administered as part of the course. Students are expected to do all work themselves on these exams. For both exams, students will be allowed to use their books and notes and any other resources they choose. These exams will include short answer questions on information covered during classes and longer quantitative questions similar to the homework assignments.

The design project will allow the students to demonstrate their grasp of course material by integrating the control concepts they have learned about and applying them to a problem
modeled on a real workplace. The project will require design of hoods and duct systems, selection of fans and air pollution control equipment, and an economic analysis. Details of the design project requirements will be provided to students near the mid-point of the semester.

For all work, partial credit will be awarded generously, so students should show all work. In addition, the neatness of the work is important because the instructor will be able to follow the students' reasoning more easily when trying to award partial credit.

The breakdown of grading for the course is:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework assignments</td>
<td>30 %</td>
</tr>
<tr>
<td>Lab report</td>
<td>3 %</td>
</tr>
<tr>
<td>Take-Home Exam #1</td>
<td>17 %</td>
</tr>
<tr>
<td>Take-Home Exam #2</td>
<td>17 %</td>
</tr>
<tr>
<td>Design project</td>
<td>33 %</td>
</tr>
</tbody>
</table>

Final grades will be assigned on an A/F basis as follows:

- A   (93-100 %)  Outstanding achievement relative to course expectations
- A−  (90-93 %)
- B+  (87-90 %)
- B   (83-87 %)  Achievement above minimum course expectations
- B−  (80-83 %)
- C+  (77-80 %)
- C   (73-77 %)  Achievement meeting the minimum course expectations
- C−  (70-73 %)
- D+  (67-70 %)
- D   (60-67 %)  Achievement below minimum expectations, but sufficient for credit
- F   (< 60 %)    No credit awarded

The instructors reserve the right to modify this grading structure to the advantage of the students should the minimum course expectations prove to be too ambitious.

**What the Instructors Expect from Students**

- Students are expected to attend all classes and to arrive on time.
- Because the course text will be referred to repeatedly during many lectures, students should look at assigned readings prior to class and bring the text to class.
- Students will download handouts and assignments from the course's web site that can be accessed through [http://www.myu.umn.edu](http://www.myu.umn.edu)
- Students should bring a calculator to all classes.
- Students are expected to answer questions posed by the instructors and participate in classroom discussions.
- Students are responsible for asking questions and/or letting instructors know when they do not understand lectures or course materials.
• Although students may work together on homework assignments and laboratory reports, each student should turn in a separate paper. Students should understand that they are responsible for knowing how to do all homework problems.
• Students must work independently on take-home exams.
• Students may discuss their design projects with one another in general, but they must perform all the detailed work on their own.
• Students are encouraged to provide constructive feedback to the instructors when they are dissatisfied with the course content or teaching methods.

What Students Should Expect from the Instructors

• The instructors will be enthusiastic about the class and the subject matter.
• The instructors will post handouts and assignments on the course's web site more than 24 hours before class time.
• The instructors will begin and conclude classes on time.
• The instructors will state objectives for each class session.
• Respecting the students' styles of learning, the instructors will use a variety of instructional methods.
• The instructors will answer all questions posed during class by students. Whenever possible, questions will be answered immediately. As an alternative, an instructor may indicate that the question will be addressed later in the class or that he will answer the question at the beginning of the next lecture if he does not know the answer.
• The instructors will ensure that all discussions in class are conducted in a professional and collegial manner.
• The instructors will create assignments with clear expectations.
• The instructors will grade and return assignments within one week of submission.
• The instructors will grade assignments objectively on criteria shared with the students in advance.
• The instructors will provide feedback on assignments that identifies both strengths and weaknesses in student work with constructive suggestions for improvement.
• Periodically, the instructors may solicit and respond to feedback on ways to improve the course.
• The instructors will make themselves available outside of class to discuss any aspect of the course with students.

Additional Information

Every class is influenced by the fact that participants bring diverse values, experiences, and abilities into the classroom. All participants will be expected to listen to those with differing views, disagreeing with the views while remaining respectful of the individuals who hold them. Students should feel free to question the instructors and each other collegially at any time.

School of Public Health students may withdraw from a course through the second week of the semester without permission. No "W" will appear on the transcript. After the second week students are required to do the following:
• The student must contact and notify their advisor and course instructor informing them of the decision to withdraw from the course.
• The student must send an e-mail to the SPH Student Services Center (SSC). The email must provide the student name, ID#, course number, section number, semester and year with instructions to withdraw the student from the course, and acknowledgement that the instructor and advisor have been contacted.
• The advisor and instructor must email the SSC acknowledging the student is canceling the course. All parties must be notified of the student’s intent.
• The SSC will complete the process by withdrawing the student from the course after receiving all emails (student, advisor, and instructor). A "W" will be placed and remain on the student transcript for the course.

After discussion with their advisor and notification to the instructor, students may withdraw up until the eighth week of the semester. There is no appeal process.

An incomplete grade is permitted only in cases of extraordinary circumstances and following consultation with the instructor. In such cases an "I" grade will require a specific written agreement between the instructor and student specifying the time and manner in which the student will complete the course requirements. Extension for completion of the work will not exceed one year.

Students are responsible for knowing the University of Minnesota, Board of Regents' policy on Student Conduct and Sexual Harassment found at www.umn.edu/regents/polindex.html.

Scholastic dishonesty as defined in the policy and will be reported to the Office for Student Conduct and Academic Integrity (http://www1.umn.edu/oscai/index.html) and will result in a grade of "F" or "N" for the entire course. Plagiarism is an important element of this policy. It is defined as the presentation of another's writing or ideas as your own. Serious, intentional plagiarism will result in a grade of "F" or "N" for the entire course. For more information on this policy and for a helpful discussion of preventing plagiarism, please consult University policies and procedures regarding academic integrity: http://www.writing.umn.edu/sws/quicktips/online_resources.htm#plagiarism. Students are urged to be careful that they properly attribute and cite others' work in their own writing. For guidelines for correctly citing sources, go to http://tutorial.lib.umn.edu/ and click on "Citing Sources". In addition, original work is expected in this course. It is unacceptable to hand in assignments for this course for which you receive credit in another course unless by prior agreement with the instructor. Building on a line of work begun in another course or leading to a thesis, dissertation, or final project is acceptable. If you have any questions, consult the instructor.

Any student with a documented disability (e.g., physical, learning, psychiatric, vision, hearing, etc.) who needs to arrange reasonable accommodations must contact the instructor and Disability Services at the beginning of the semester. All discussions will remain confidential. For further information contact the University of Minnesota Disability Services website at http://ds.umn.edu/ or call (612) 626-1333 (V/TTY). Disability Services is located in Suite 180 McNamara Alumni Center, 200 Oak Street.
COURSE SCHEDULE

1/26/09  Week 1  **Course Introduction**
Course syllabus; units; hierarchy of control; types of ventilation systems

**Properties of Air**
Composition of air; kinetic theory of gases; concept of pressure; ideal gas law; air density; humidity

Supplemental Reading: *Vent Manual*, Chapter 1

2/2/09  Week 2  **Airflow**
Basic fluid mechanics; concepts of static, velocity, and total pressure

**Ventilation Measurements**
Manometers, aneroid gauges, and micromanometers for pressure readings; pitot tubes, vane anemometers, and thermal anemometers for velocity measurement; orifice and venturi meters for flow measurement; tracer gases; flow visualization

Supplemental Reading:  Burgess et al., Chapters 2 & 3

HOMEWORK #1 DUE

2/9/09  Week 3  **Ventilation Measurements Laboratory**
★★★ Meet in Industrial Hygiene Lab, Boynton S-35 ★★★
Measure velocity and flow in a duct; calibrate instruments for measuring velocity; measure face velocity of a laboratory hood; measure hood static pressure; measure static pressure entering and leaving a fan

The lab session will be led by Dr. Seung Won Kim

Required Reading:  Instructions for Ventilation Measurement Lab
Supplemental Reading:  Burgess et al., Chapter 7

HOMEWORK #2 DUE
2/16/09 Week 4  **Tour**
★★★ Meet in Regis Center for Art, West Bank Campus ★★★
Led by Mike Austin, Department of Environmental Health and Safety

**General Exhaust Ventilation**
Control by displacement and dilution; models for a well-mixed room; reasons to supplement general exhaust ventilation with local exhaust ventilation

Required Reading:  *Vent Manual*, Chapter 4
Supplemental Readings:  (1) *Vent Manual*, Chapters 7 & 8, (2) Burgess et al., Chapters 4 & 15

2/23/09 Week 5  **Ducts & Hoods**
Types of duct; friction losses; types of hoods, booths, and enclosures; face velocity; capture velocity; consideration of cross flow drafts; entry losses; push-pull ventilation

Required Reading:  *Vent Manual*, Chapters 5 & 6
Supplemental Reading:  Burgess et al., Chapters 5 & 13

LAB REPORT DUE

HOMEWORK #3 DUE

3/2/09 Week 6  **Local Exhaust Ventilation System Design #1**
Single-hood systems; calculation sheets; tracking pressure through a system; bends; expansions/contractions; stacks

Required Reading:  *Vent Manual*, Chapter 9
Supplemental Reading:  Burgess et al., Chapter 8

Assign Take-Home Exam #1
Exam covers Weeks 1-5

HOMEWORK #4 DUE

3/9/09 Week 7  **Local Exhaust Ventilation System Design #2**
Multiple-hood systems; blast gates; branch entries; balancing ventilation systems

Supplemental Reading:  Burgess et al., Chapter 9

TAKE-HOME EXAM #1 DUE

3/16/09  *SPRING BREAK!!  ☺*
3/23/09 Week 8  **Fans**
Types of fans; operating characteristics; fan static pressure curves; fan selection; fan efficiencies and power consumption; placement of fans

**Required Reading:** *Vent Manual*, Chapter 7
**Supplemental Reading:** Burgess et al., Chapter 10

**Introduction to Design Project**
Discuss design project requirements

**HOMEWORK #5 DUE**

3/30/09 Week 9  **Air Pollution Control Equipment**
Evaluation criteria for control devices; absorbers; adsorbers; oxidizers; settling chambers; inertial collectors; cyclones; scrubbers; electrostatic precipitators; fibrous and fabric filters;

**Required Reading:** *Vent Manual*, Chapter 8
**Supplemental Reading:** Burgess et al., Chapter 11

**HOMEWORK #6 DUE**

4/6/09 Week 10  **Air Pollution Control Equipment**
Integration of control equipment into ventilation systems

**Replacement Air Considerations**
Flow rates; pressure differential; temperature considerations; humidity considerations; inlet/outlet placement; energy costs

**Assign Take-Home Exam #2**
Exam covers Weeks 6-10

**Required Reading:** *Vent Manual*, Chapters 10 & 11

**HOMEWORK #7 DUE**
4/13/09  Week 11  This lecture will be presented by Dr. Knutson

**Control Economics**
Operating costs; capital costs; hidden costs; estimating costs; ramifications of cost estimates

**Example of a Real Ventilation Design**

**Required Reading**: *Vent Manual*, Chapter 12

**TAKE-HOME EXAM #2 DUE**

4/20/09  Week 12  Introduction to Personal Protective Equipment
Regulations governing use of PPE; acceptable uses for PPE; types of PPE

**Types of Personal Protective Equipment**
Respiratory protection; hearing protection; head protection; eye protection; foot protection; hand protection

**PPE Programs**
Elements of PPE programs; resources for developing your own program

**Respiratory Protection Programs**
Elements of respiratory protection programs; resources for developing your own program

**Hearing Conservation Programs**
Elements of hearing conservation programs; resources for developing your own program


**HOMEWORK #8 DUE**
4/27/09  Week 13  This lecture will be presented by Dr. McCullough

**Respiratory Protection**
Types of respiratory protection; selection of respiratory protection; demonstrations and hands-on activities with respiratory protection; certification of respiratory protection; respirator fit testing; respiratory protection against chemical, biological, and radiation/nuclear agents


**HOMEWORK #9 DUE**

5/4/09  Week 14  **Chemical Protective Clothing**
Selection of chemical protective clothing; demonstrations and hands-on activities with chemical protective clothing; special considerations for emergency response

**HVAC Systems**
Types of systems used to supply fresh air to buildings; common elements to all systems; similarities and differences between HVAC systems and ventilation systems for control of pollutants


**HOMEWORK #10 DUE**

5/15/09  **DESIGN PROJECTS DUE BY 5:00 PM**