

## **Workshop Report**

# **Improving the Applications Volume of the ASHRAE Handbook**

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**Prepared on behalf of the  
workshop participants by:**

Lew Harriman - Mason-Grant Consulting

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## Introduction

The Applications volume may possibly be “the most practical” of the four-volume Handbook series. It contains a wealth of industry-specific background information, written from the HVAC perspective, that would be very difficult to find in any other reference. The chapters provide an introduction to dozens of application areas for the HVAC professional who has not been active in those application area.

Workshop participants noted that, while there is far more detail needed to design an economical system in each of these application areas, the existing chapters provide a good starting point. And for the most part, the chapters are quite readable and well-structured. Workshop participants have provided dozens of specific suggestions in their chapter-by-chapter reviews for each TC to consider. But there is no wholesale restructuring or rewriting suggested.

Also, in the Applications volume the division of chapters into major sections seems current. The chapter titles are usefully-specific descriptions of their content, and the words used in those titles are self-explanatory to an interested professional. Consequently, unlike the three other workshops, our group did not feel that significant improvements in navigation would come from reorganizing and renaming chapters and sections.

On the other hand, the chapters need additional information if they are to support the Society’s stated mission of serving the global community, in support of a sustainable future. The content of most chapters does not discuss common HVAC application practices in parts of the world other than the U.S. and Canada. And there is little or no discussion of sustainable design practices. Further, there is little or no information about retrofitting buildings in any of these application areas, even though replacement/retrofit/remodeling represents more than half of the work performed in the HVAC industry today.

In addition, workshop participants noted that conditioning outdoor air is a requirement of all HVAC applications. But there is little or no focused, comprehensive discussion of that topic in any of the Handbook volumes.

Finally, and perhaps most important are the problems of the invisibility of Handbook content to Google searches, and the lack of web access to the ASHRAE Handbook.

Paraphrasing the impressions provided by the workshop participants: “Google search is the first place that most of us look for information, even if we have the printed Handbooks on our personal bookshelves (which most of us do not). Google searches do not return any ASHRAE Handbook chapter information, much less any link to easily purchase those chapters. ASHRAE has fallen behind the day-to-day work habits of HVAC professionals, and is ignoring a huge potential revenue source. Beyond those problems, consider the future. *We* know about ASHRAE. But without web visibility and access, ASHRAE is losing an entire generation of young designers. To them, the ASHRAE Handbook is invisible.”

Workshop participants have addressed all of these concerns in their deliberations. This report provides specific suggestions for improving the Applications volume in particular, and for establishing a web presence for the Handbook as a whole.

## I. Summary of Recommendations

As in previous years, participants in this workshop were impressed with the breadth of the information contained in the Applications volume. Many new subjects have been added over the last 16 years, keeping the overall volume close to North American HVAC practice. Also, in most chapters the information is quite easy to grasp. Other Handbook volumes were not always described that way by their workshop participants.

Still, there is room for improvement, especially in light of ASHRAE's mission statement requiring us to: "... advance the arts and sciences of HVAC&R to serve humanity and promote a sustainable world." The principal recommendations for improvement are divided into three categories:

- **Adding two new chapters**, specifically: one chapter to discuss the conditioning of ventilation air and another chapter to discuss retrofitting, replacing or expanding HVAC systems in existing buildings.
- **Adding information to existing chapters** on the subjects of; retrofitting systems in existing buildings, sustainable design and for commissioning, operation and maintenance.
- **Suggestions for moving to the web-centric Handbook**, including funding sources, as well as examples of both good and bad practices for web-based delivery of technical information by not-for-profit organizations.

### Adding two new chapters

Two large, cross-cutting topics are missing from the Applications volume, and also from the handbook as a whole: conditioning ventilation air and retrofitting existing buildings. Workshop participants noted that these topics need discussion in dedicated chapters, to give our readers the "big picture" of the issues and alternatives:

1. **"Dedicated Ventilation Systems."** As buildings become tighter and better insulated in response to the requirements of standard 90.1, the ventilation air load becomes a larger and larger percentage of the annual dehumidification, humidification, heating and cooling loads. Further, the outdoor air filtration and gas cleaning recommendations of Standard 62.1 are changing significantly. Both of these sets of changes are making major changes in technical alternatives for conditioning ventilation air. The workshop participants have generated a detailed outline for a new chapter which can discuss these factors in the context of the many available hardware alternatives.
2. **"Retrofitting Commercial and Institutional Buildings."** Worldwide, more than half of HVAC construction is centered on retrofitting systems, or adding systems to existing buildings. The Handbook is largely silent about retrofit issues, which are technically quite difficult and very important to both commercial sustainability and to worldwide energy reduction. Workshop participants have generated a detailed outline for a chapter which can discuss how retrofitting existing buildings differs from new construction, and therefore what factors the designer, owner and contractor might wish to keep in mind when planning a retrofit project.

### Adding information to existing Applications chapters

Promoting sustainability in any quantifiable way will depend on factors which are specific to each application. Sustainable practices for a research laboratory are different from those in a retail department store or an elementary school. Also, the commissioning, operations and maintenance budgets and management focus in these three environments is quite different. So too are the key considerations different when planning retrofit projects.

To provide the technical committees with specifics and to ground these suggestions in reality, the workshop developed outlines for additions for three chapters. The buildings discussed in these chapters account for more than 80% of the commercial and institutional buildings built each year in the US and Canada. (Workshop participants believe that eventually, these three topics should be added to all chapters in the Applications volume.)

3. **Expand Chapter 2 - Retail Facilities.**

Workshop participants have generated an outline which includes specific suggestions for adding retrofit, sustainability, commissioning, operations and maintenance information to this chapter.

4. **Expand Chapter 3 - Commercial and Public Buildings.** Workshop participants have generated a similarly-specific outline to expand this chapter.

5. **Expand Chapter 6 - Educational Facilities.**

Workshop participants have generated a similarly-specific outline to expand this chapter.

### Suggestions for moving to the web-centric Handbook

It is abundantly clear that a web-centric ASHRAE Handbook is a necessary step in the very near future. Current members expect it, potential members would be attracted by it. And the potential access to worldwide revenue for the Society is enormous. Also, to “serve humanity” as required by the ASHRAE mission statement, a web-centric Handbook is the most cost-effective way to provide access to ASHRAE information for 6.2 billion people.

In addition, the web-centric Handbook provides the means to address the great need (identified by every one of the four Handbook workshops) for a clear, well-structured overview of all ASHRAE information resources, and a better way to navigate within those resources.

Consequently, the workshop participants have developed a set of suggestions for the Society, as it deals with the many financial, organizational and interface challenges of expanding beyond paper and DVD’s to the web-centric Handbook:

6. **Dedicated project with startup capital and full-time staff.**

Any “spare time of existing staff,” and any “current surplus ASHRAE budgets” are very unlikely to accommodate the effort required to generate a world-class, high-revenue-generating, web-centric Handbook. The workshop participants have outlined suggestions for site construction, for start-up funding and suggestions for the ongoing financial model to make the web-centric handbook a powerful revenue generator rather than a catastrophic revenue drain.

7. **Good site models and good web practices.**

The workshop participants have identified several sites which can serve as models to both inspire and to measure future plans for the web-centric handbook.

8. **Web practices to avoid.**

Participants have also identified aspects of web interaction which anger rather than delight the user.

Recommendation	Effort	Resources			Implementation Requires Action From...			
		Funds	Staff	Pages	TAC	Handbook	Other	Board
<b>Add two new chapters</b>								
1. Dedicated Ventilation Systems	1	-	Moderate	30+	Agree & Assign TC	Approve	-	-
2. Retrofitting Systems in Existing Buildings	1	-	Moderate	15+	Agree & Assign TC	Approve	-	-
<b>Expand existing chapters</b>								
3. Chapter 2 - Retail Facilities	1	-	Minor	4	Agree & Assign TC	Approve	-	-
4. Chapter 3 - Commercial & Public Buildings	1	-	Minor	4	Agree & Assign TC	Approve	-	-
5. Chapter 6 - Educational Facilities	1	-	Minor	4	Agree & Assign TC	Approve	-	-
<b>Suggestions for the web-centric Handbook</b>								
6. Dedicated Staff + Budget	3	Major	Larger Staff	7000+	Agree & Participate	Approve & Manage	Joint Project SubComm	Approve & Fund
7. Good site models + practices	3	Major	Larger Staff	-	Agree & Participate	Approve & Manage	Joint Project SubComm	-
8. Web practices to avoid	3	Major	Larger Staff	-	Agree & Participate	Approve & Manage	Joint Project SubComm	-
<b>Effort Codes</b>								
1	An improvement which can be implemented with volunteers							
2	Significant improvement, at little or no additional cash outlay							
3	Major Improvement which needs cash outlay or major staff time							

Figure 1. Summary of recommendations with requirements for implementation

## II. Implementation Plan

Figure 1 provides a summary of our recommendations and their general categories, along with their priorities and the approval levels which will probably be needed. Below, we discuss how these suggestions can be implemented

### 1. New chapter: “Dedicated Ventilation Systems”

Implementing a new chapter requires the agreement of the Handbook and TAC committees, and also requires that TAC assign a technical committee to generate the chapter, perhaps with assistance from other technical committees.

Provided that TAC and Handbook agree that there should be a new chapter dealing with the subject of dedicated ventilation systems, the workshop participants have generated a relatively detailed outline of the topics that such a chapter should address. That outline is attached, as appendix 1.

Because this topic cuts across nearly all HVAC systems and applications, it is not immediately obvious which technical committee would be most appropriate for assignment as the cognizant TC. Nor is it clear whether such a chapter would be best placed in the Applications volume, or the Systems & Equipment volume. These are decisions for the Handbook and TAC committees to make jointly. As nominations for the cognizant

and coordinating committees, TAC and Handbook could note the probable interest and expertise of these groups:

- a. Standing Committee - ASHRAE Std 62
- b. TC 1.12 - Moisture Management in Buildings
- c. TC 4.2 - Duct Design
- d. TC 4.3 - Ventilation Requirements & Infiltration
- e. TC 5.3 - Room Air Distribution
- f. TC 5.5 - Air-to-air Heat Recovery
- g. TC 5.7 - Evaporative Cooling
- h. TC 5.11 - Humidifying Equipment
- i. TC 8.10 - Mechanical Dehumidification Equipment & Heat Pipes
- j. TC 8.12 - Desiccant Dehumidification Equipment & Components

### 2. New chapter: “Retrofitting Commercial and Institutional Buildings”

As with our first recommendation for a new chapter, the Handbook and TAC committees would first agree, and then TAC would assign a cognizant TC and coordinating TC's. Also as with our first recommendation, the workshop participants

have generated a detailed outline to serve as a starting point for a new chapter on retrofitting existing systems and existing buildings. That outline is attached as appendix 2.

As nominations for cognizant and coordinating TC's, TAC might note the probable interest and technical expertise of:

- a. TG-3 - HVAC & R Contractors and Design-build firms
- b. TC 7.3 - Operation and Maintenance Management
- c. TC 9.5 - Residential and Small Building Applications
- d. TC 9.6 - Healthcare Facilities
- e. TC 9.7 - Educational Facilities
- f. TC 9.8 - Large Building Applications

### 3. Expand Chapter 2 - Retail Facilities

Implementing the expansion of an existing chapter only requires Handbook committee approval, and that TAC agree and assign the task to the cognizant TC for the chapter. For chapter 2, the cognizant technical committee is TC 9.8 (Large Building Applications).

If the TAC and Handbook committees agree with our workshop recommendation to add suggestions for sustainability, retrofit, commissioning, operation and maintenance to chapter 3, an outline for a few retail-building-specific suggestions is attached as appendix 3.

No doubt the members of TC 9.8 will have many additional suggestions to add to this outline which did not surface during our brief workshop brainstorming session.

### 4. Expand Chapter 3 - Commercial & Public Buildings

Again, if the TAC and Handbook committees agree with our workshop recommendation to add information to chapter 3, TC 9.8 can be given that task, along with a copy of appendix 4, which contains suggestions relevant to commercial and public buildings. And again, the workshop participants fully expect that this outline will simply be a starting point for the chapter's expansion.

### 5. Expand Chapter 6 - Educational Facilities

As with chapters 2 and 3, the workshop participants have generated an outline to serve as a starting point for the members of TC 9.7 (Educational Facilities) as they add information to chapter 6. That outline is attached as appendix 5.

### 6. Web-centered Handbook Project

Workshop participants commented extensively on the lack of web-based access to the handbook content, and on the lack of its visibility to web-based searched engines.

Mark Owen, Handbook Editor, explained that a web-centric Handbook may well be in the future of the Society. However, Mark also noted that there are no current plans nor any funds allocated. It is not certain is when a web-centric Handbook will happen, how the transition will be managed, what it would look like and how it would be funded.

With those practical questions in mind, the suggestions and recommendations developed during the workshop are attached as appendix 7.

To summarize the deliberations, participants believe that sooner is better. It is time to begin moving to a web-centric Handbook with a well-planned and well-funded program. Such a web-based effort has the potential to be either an economic sinkhole, or a huge revenue-generator. So the effort should not be casual. Perhaps the most important of the recommendations is that the web-centric Handbook not be expected to be accomplished by the existing ASHRAE Handbook and IT staff, "in their spare time."

The suggestions assume a dedicated special project, with dedicated funding and dedicated staff, managed by the current Handbook staff and guided by a joint special project subcommittee. That committee would logically be overseen by Handbook, with membership which includes a member of the ASHRAE Board, as well as TAC, publications sales and the electronic communications committees. "Seed money" funds for project planning could perhaps come from existing, board-approved budgets. But the first order of business for the project committee would be to estimate and then obtain the necessary funds for website development, from new revenue sources. Suggestions for these efforts are included in appendix 7.

### 7. Good Site Models & Good Web Practices

When TAC, Handbook and the ASHRAE Board agree that it is time to begin a project to move to a web-centric handbook, the project committee will need suggestions for good site models. Specifically, websites which provide the user experience which is appropriate for a world-class, not-for-profit technical society and its members and potential members. Workshop participants have identified the IEEE, U.S. EPA and Wikipedia websites as exemplifying many of the more positive attributes that would be appropriate for a web-centric Handbook site. These are described in more detail on attachment 8, which also includes examples of other positive attributes from other sites.

### 8. Web Practices to Avoid

Inevitably, no discussion of positive site attributes occurs without a contrasting discussion of negative attributes. Workshop participants have compiled a list of negative attributes in appendix 9.

Also, while many of the workshop participants were quite familiar with the existing ASHRAE website, other participants had not had occasion to visit the site. Consequently, that site was sometimes used during deliberations to explain aspects of site design or interaction which would best be excluded or included in a web-centric Handbook site. A few of those observations are included in appendix 9.

### Implementation Summary

Certainly, the recommendation to move the web-centric Handbook forward into an organized effort is the most important and far-reaching of the workshop conclusions.

The effort will not be small, nor will it be cheap, quick or easy. But the sooner the project is begun, the sooner it can act as a revenue generator as well as the means of distributing handbook information instantly, to a worldwide audience, 24 hours a day, 7 days a week. This level of access is what modern designers, contractors and owners expect, and in some form they will be prepared to pay for it.

The other workshop recommendations focus more on incremental improvements to the Applications volume by itself. These are achievable within the existing structure of the TAC and Handbook committees, without the need for board approval, nor any need for approval from other committees within the Society.

The workshop participants salute the Handbook and TAC and all the technical committee volunteers for devoting their time and resources to improving the Handbook. We look forward to implementation of some or all of the recommendations contained in this report and its appendices.

## Workshop Participants

Scott Pegler, GHT, Arlington, VA  
 Rick Kmiecik, Nebraska Medical Center, Omaha, NE  
 Kent T. Bell, Harris Consulting, Las Vegas, NV  
 Amanda Bogner, BVM Engineering, Omaha, NE  
 Hoy Bohannon, Winston-Salem, NC  
 Leonard Chow, Intelligent Buildings, Hong Kong, PRC  
 S.L. Li, Hong Kong, PRC  
 C. F. Wong, Hong Kong, PRC  
 K.Y. Tsang, Hong Kong, PRC  
 Albert So, Hong Kong, PRC  
 Betsy Goll, FPL Energy, Orlando, FL  
 Dave Strickland, Poole & Kent, Miami, FL  
 Firouz Kiekavousi, Florida Hospital, Orlando, FL  
 Darcy Carbone, Stebbins-Duffy, Boston, MA  
 Dave Parkman, Scientific Climate Systems, Detroit, MI  
 Rob Smith, Munters, Amesbury, MA



## Oversight

TAC Chair - Craig Wray  
 TAC Liason - Frank Mills  
 Handbook Chair - Brian Rock  
 2011 Applications Volume Chair - Rex Noble



## Staff Support

Mike Vaughn - Manager of Technical Activities  
 Mark Owen - Handbook Editor



## Facilitator

Lew Harriman - Mason-Grant, Portsmouth, NH



**Appendix 1**

**New Chapter - Dedicated Ventilation System**

(Also see the attached WORD document)

- ▶ Introduction
- ▶ Basic functions & components
- ▶ Typical system configurations
- ▶ Design guidelines and suggestions
- ▶ Climate & site suggestions
- ▶ Application-specific suggestions
- ▶ Commissioning dedicated systems
- ▶ Operating & maintaining dedicated systems
- ▶ Comparing dedicated vs. combined ventilation systems
- ▶ References
- ▶ Bibliography

## New Chapter Outline – “Dedicated Ventilation Systems”

### A. Introduction

1. The importance and consequences of ventilation air
2. Ventilation and net-zero-energy buildings
3. The difference between dedicated and combined ventilation systems

### B. Basic functions & components

#### 1. Cooling

a. *Capacity in Btu/h* = scfm (Outdoor air design dry bulb °F – Supply air dry bulb °F) (0.24 Btu/ft<sup>3</sup> specific heat of air) (xx.xxx local design air density lb/ft<sup>3</sup>) 60 min/h

#### 2. Dehumidification

a. *Capacity in lb/h* = scfm (Outdoor air design humidity ratio gr/lb – Supply air humidity ratio gr/lb) (0.24 Btu/ft<sup>3</sup> specific heat of air) (xx.xxx local design air density lb/ft<sup>3</sup>) (60 min/h) / (7000 gr/lb)

#### 3. Heating

a. *Capacity in Btu/h* = scfm (Supply air dry bulb °F – Outdoor air design dry bulb °F) (0.24 Btu/ft<sup>3</sup> specific heat of air) (xx.xxx local design air density lb/ft<sup>3</sup>) 60 min/h

#### 4. Humidification

a. *Capacity in lb/h* = scfm (Supply air humidity ratio gr/lb – Outdoor air design humidity ratio gr/lb) (0.24 Btu/ft<sup>3</sup> specific heat of air) (xx.xxx local design air density lb/ft<sup>3</sup>) (60 min/h) / (7000 gr/lb)

#### 5. Filtration

- a. *Particulate*
- b. *Gases*

#### 6. Air flow control

#### 7. Energy recovery & reuse

- a. *Exhaust air*
- b. *Precool – reheat*
- c. *Condenser heat*

#### 8. Recirculation path

#### 9. Sensors and controls

### C. Typical system configurations

#### 1. DX cooling

- a. *Diagram and description*
- b. *Advantages and limitations*
- c. *Common problems and solutions*
  - i. *Poor inlet mixing and stratification*
  - ii. *Low & high ambient refrigerant pressures*
  - iii. *Tall coils and condensate carryover*
  - iv. *Condensate drainage failure*
  - v. *Narrow fin spacing & coil clogging*

#### 2. CW Cooling

- a. *Diagram and description*
- b. *Advantages and limitations*
- c. *Common problems and solutions*
  - i. *Low-flow – loss of DH capacity*
  - ii. *CW reset – loss of DH capacity*
  - iii. *Low temperature energy penalty*

#### 3. All- desiccant

- a. *Diagram and description*
- b. *Advantages and limitations*
- c. *Common problems and solutions*
  - i. *Reactivation energy cost*

4. **Hybrid desiccant**
  - a. *Diagram and description*
  - b. *Advantages and limitations*
  - c. *Common problems and solutions*
    - i. *Clogged reactivation filters*
    - ii. *Randomly-set air flows*
    - iii. *Condensate drainage failure*

**D. Design guidelines and suggestions**

1. **ASHRAE Std. 62 provides basic guidance**
  - a. *Setting air flow rates*
  - b. *Filtration types and levels*
  - c. *Commissioning, operation & maintenance*
  - d. *Local codes vs. Std. 62*
2. **Measuring, controlling and reporting ventilation air flow**
  - a. *Using desiccant wheels and cooling coils to measure air flow*
  - b. *Controlling ventilation air flow with time clocks*
  - c. *Demand-controlled ventilation*
    - i. *Locating CO2 sensors*
    - ii. *Sensor recalibration*
3. **Selecting climatic design conditions**
  - a. *Peak dew point vs. peak dry bulb*
  - b. *Rooftop air inlet*
    - i. *Dry bulb above ambient*
    - ii. *Dew point above ambient*
    - iii. *Volatile organics above background*
4. **Selecting supply air conditions**
  - a. *Neutral vs. below or above indoor design*
  - b. *Additional DH for morning startup loads*
  - c. *Overnight cooling and drying to offset peak daytime loads*
5. **Locating outdoor air inlets**
  - a. *Higher is often cleaner*
  - b. *Exhaust air separation*
6. **Design for maintenance**
  - a. *Stair vs. ladder rooftop access*
  - b. *Accessible inlet location*
  - c. *Adequate aisle width*
7. **Interfacing with building automation**
  - a. *Matching output & input signals*
  - b. *Controlling supply air dew point*
  - c. *Controlling supply air dry bulb*
  - d. *Fan speed interconnected with smoke control logic*
8. **Air-side economizer cautions**
  - a. *Risk of adding moisture to building materials*
  - b. *Dew point control minimizes risks*
9. **Architectural effects on ventilation cost**
  - a. *Tall ceilings allow periodic ventilation*
  - b. *Central atria provide ventilation reservoir*
  - c. *Large volumes provide ventilation reservoir*
  - d. *Small rooms increase air distribution costs*

**E. Climate & site suggestions**

1. **Humid & hot climates**
  - a. *Reducing energy*
    - i. *Enthalpy heat recovery*

- b. Limiting mold risks*
      - i. Continuous dehumidification*
      - ii. Low supply air dew point*
      - iii. Positive average building pressure*
      - iv. Short wide cooling coils*
      - v. Drain pans which drain*
- 2. Dry & cold climates**
  - a. Reducing energy*
    - i. Enthalpy heat recovery*
    - ii. Evaporative cooling*
  - b. Design for snow and ice*
  - c. Avoiding humidification risks*
    - i. Modular and modulatable capacity*
    - ii. Hybrid humidification*
    - iii. Seasonal air pressure reset*
- 3. Sites with poor outdoor air quality**
  - a. Defining outdoor air quality*
  - b. Std. 62 for air cleaning guidance*
  - c. Higher inlet – less pollution*
  - d. Consequences of poor maintenance access*
    - i. Negative pressure*
      - (1) High humidity & mold risk
      - (2) Particulate soiling & health risk
    - ii. Filter blowout = zero filtration*

**F. Application – specific suggestions**

- 1. Interfacing with natural ventilation**
  - a. Periodic vs. continuous ventilation*
  - b. Lock-out mechanical systems by zone*
  - c. Atrium as ventilation air reservoir*
- 2. Secure facilities**
  - a. Secure inlet location and hardware*
  - b. Gas-phase air filtration*
  - c. Biological air cleaning*
  - d. Recirculation mode*
- 3. Public buildings**
  - a. Variable-volume ventilation air*
  - b. Periodic vs. continuous ventilation*
  - c. Recirculation mode*
- 4. Classrooms**
  - a. Implications of highly-variable occupancy*
    - i. Recirculation during unoccupied periods*
    - ii. Demand-controlled ventilation*
    - iii. Periodic vs. continuous ventilation*
  - b. Instructional noise limits*
  - c. Automatic vs. teacher ventilation control*
- 5. Single-family houses & multi-unit residential**
  - a. Standard 62.2 for design guidance*
  - b. Problems of exhaust-only ventilation fans*
    - i. Humid infiltration air – comfort problems and risk of mold*
    - ii. Unfiltered infiltration air – health risk of outdoor particulate*
    - iii. Condensation inside cooled walls during both hot and cold seasons*
  - c. Hot & humid climates – Continuous dehumidification if continuous ventilation*

- d. *Heat recovery ventilators*
    - e. *Periodic vs. continuous ventilation*
  - 6. **Tall & large buildings – smaller zones are important**
    - a. *Limits stack effect problems*
    - b. *Ensures local air pressurization*
    - c. *Allows natural ventilation*
    - d. *Reduces wasted ventilation energy*
  - 7. **Hospitals and surgical centers**
    - a. *Locate filters away from cooling coils*
    - b. *Cautions for sound attenuation materials*
    - c. *UV antimicrobial protection for coils*
    - d. *Staging humidification capacity*
    - e. *Trimming building pressures*
  - 8. **Cruise ships**
    - a. *High-occupant-density health implications*
    - b. *Continuously high humidity loads*
- G. **Commissioning dedicated systems**
  - 1. **Measuring and setting air flows**
  - 2. **Calibrating humidity sensors**
  - 3. **Measuring and setting water flows**
  - 4. **Connecting with building automation**
- H. **Operating & maintaining dedicated systems**
  - 1. **Operation & maintenance consequences**
    - a. *The cost of conditioned ventilation air*
    - b. *Effects of inadequate ventilation air flow*
    - c. *Effects of inadequate dehumidification*
  - 2. **Don't forget the dedicated ventilation system**
  - 3. **Seasonal change – set point log**
  - 4. **The importance of clean filters**
    - a. *Building pressure and mold risk*
    - b. *Particulate soiling and health risk*
  - 5. **Annual recalibration of system sensors**
    - a. *Best time – under peak load conditions*
  - 6. **Measuring, setting and controlling ventilation air flow**
    - a. *Measure and match to combined exhaust air flows*
  - 7. **The importance of coil drainage**
    - a. *Cleaning out drain lines*
    - b. *UV antifouling protection for coils and drain pans*
- I. **Comparing dedicated vs. combined ventilation systems**
  - 1. **Combined systems**
    - a. *Description*
    - b. *Advantages*
      - i. *Potentially low construction cost*
      - ii. *Takes advantage of occupancy diversity*
      - iii. *Some configurations allow low-cost energy recovery*
    - c. *Limitations*
      - i. *Over and under-ventilation is common*
      - ii. *High operational cost*
      - iii. *Humidity control difficulties*
      - iv. *Some configurations prevent energy recovery*
  - 2. **Dedicated systems – Advantages and limitations**
    - a. *Description*
    - b. *Advantages*

- i. Improved indoor air quality – Allows close match between occupancy and air flow*
- ii. Lower operational cost of adequate ventilation*
- iii. Potentially excellent humidity control*
- iv. Potentially excellent building pressure control*
- v. Potentially lower cost of cooling & heating*
- vi. Simplifies secure facility HVAC*

*c. Limitations*

- i. Potentially higher construction cost*
- ii. Easy to forget adequate maintenance*

**J. References**

**K. Bibliography**

## **Appendix 2**

### **New Chapter - Retrofitting Commercial & Institutional Buildings**

(Also see the attached WORD document)

- ▶ Introduction
- ▶ Project purpose, scope & responsibilities
- ▶ Understanding the existing building
- ▶ Evaluating existing HVAC systems
- ▶ Designing for occupied construction
- ▶ References
- ▶ Bibliography

## **New Chapter Outline – “Retrofitting Commercial & Institutional Buildings”**

### **A. Introduction**

- 1. 50% of all non-residential space will be built or redeveloped after 2000 (BOMA 2008)**
- 2. 98% of annual building energy is used by existing buildings (only  $\pm 2\%$  additions per year)**
- 3. How retrofits differ from new construction**
- 4. What this chapter includes and excludes**
  - a. Retrofits vs. additions*
  - b. Commercial/institutional vs. residential*
  - c. Key differences vs. comprehensive guidance*

### **B. Project purpose, scope & responsibilities**

- 1. The importance of managing expectations**
  - a. Understanding client expectations*
  - b. Understanding occupant expectations*
  - c. Matching the budget to expectations*
- 2. Defining the purpose of the project**
  - a. Establishing the list of clients*
  - b. Client definition of project success*
- 3. Defining the project scope**
  - a. Agreement to owners requirements*
  - b. What is included to achieve the project purposes*
  - c. What is excluded from the project*
- 4. Defining & limiting responsibilities**
  - a. Defining the commissioning authority*
  - b. Client-provided information, guidance & materials*
  - c. Designer-provided services*
  - d. Contractor-provided deliverables*
  - e. 3<sup>rd</sup>-party deliverables*

**C. Understanding the existing building**

- 1. Structural systems vs. codes and loads**
- 2. Fire protection vs. codes and loads**
- 3. Electrical systems vs. codes and loads**
- 4. Building enclosure**
  - a. Gaps, holes and open joints*
  - b. Insulation voids & sags*
  - c. Asbestos insulation, fireproofing or siding*
  - d. Visible and hidden water leakage*
  - e. Visible and hidden mold growth*

**D. Evaluating existing HVAC systems**

- 1. Current vs. required HVAC performance**
  - a. Thermal comfort – Levels & stability*
  - b. Process requirements – Levels & stability*
  - c. Perceived & measured indoor air quality*
  - d. Defining and diagnosing relevant problems*
- 2. Measuring existing loads**
  - a. Major sensible cooling & heating loads*
    - i. Plug loads*
    - ii. Lighting load*
    - iii. Glazing load*
    - iv. Ventilation, pressurization, & exhaust air makeup*
  - b. Major humidity load*
    - i. Ventilation, infiltration & exhaust makeup*
    - ii. People*
    - iii. Door activity*

### **3. Document current system characteristics**

- a. Equipment list*
- b. Ventilation air flows*
- c. Air side leakage & insulation*
- d. Water side balance & insulation*
- e. Air side balance*
- f. Asbestos insulation*
- g. Controls*
  - i. Sensors and sensor locations*
  - ii. Controllers, actuators and locations*
  - iii. Sequence & control logic*
- h. Codes and standards compliance*
  - i. Local ventilation codes*
  - ii. Local energy codes*
  - iii. Standard 62 – Ventilation*
  - iv. Standard 90.1 - Energy*

### **E. Designing for occupied construction**

#### **1. Phased construction**

- a. Occupant operations during construction*
- b. Construction seasons in extreme climates*

#### **2. Isolating construction dust**

#### **3. Partial system operation**

- a. Mid-project rebalancing*
- b. Temporary heating and air conditioning*

### **F. References**

### **G. Bibliography**

### Appendix 3

#### Adding Information to Chapter 2 - Retail Facilities

(Also see the attached WORD document)

- ▼ Chapter 2. Retail facilities
  - ▼ Retrofit of existing buildings
    - ▶ Building energy
    - ▶ Air system energy & comfort
    - ▶ Adding cooling to open store fronts
  - ▼ Commissioning, operation and maintenance
    - ▶ Air balance in shopping malls
    - ▶ Air systems in retail food stores
  - ▼ Sustainability
    - ▶ Lighting loads are especially influential
    - ▶ Ventilation requirement varies widely

## Expanded Outline - Chapter 2 – Retail Facilities

### A. Chapter 2 – Retail Facilities

#### 1. Retrofit of existing buildings

##### *a. Building Energy*

- i. Lighting load is higher than other buildings
- ii. HVAC usually forces outdoor air infiltration

*(1). Return air plenums*

*(2). Roof parapet caps*

- iii. Wall & roof insulation often incomplete or deteriorated

##### *b. Air system energy & comfort*

- i. Return air plenums and rooftop curbs typically leak waste capacity

##### *c. Adding cooling to open store fronts*

- i. Minimizing open wall loads

*(1). Air curtains*

*(2). Ceiling level glass air trap*

*(3). Positive pressure air*

#### 2. Commissioning, operation and maintenance

##### *a. Air balance in shopping malls*

- i. Sealing return air plenums in strip malls
- ii. Sealing curbs of rooftop units
- iii. Food court air balance in covered malls

##### *b. Air systems in retail food stores*

- i. Dew point, store profits & energy
- ii. Leaking below-case return plenums
- iii. Deli department air balance

*(1) Measure and control exhaust and makeup air*

- iv. Ventilation air flows

*(1). Measuring and controlling flows*

*(2). Ventilation air dehumidification*

*(3). The importance of clean filters*

**3. Sustainability**

*a. Lighting loads are especially influential*

- i. Largest power consumption & sensible cooling load**
- ii. Day-lighting reduces power and draws customers inward**
- iii. Dual-level lamping reduces overnight power consumption**

*b. Ventilation requirement varies widely*

- i. Periodic or reduced ventilation during low-occupancy hours**
- ii. Overnight drying & cooling builds afternoon peak load capacity**
- iii. Dehumidification avoids oversized cooling systems, cold customers and slow system response**

#### **Appendix 4**

##### **Adding Information to Chapter 3 - Commercial & Public Buildings**

(Also see the attached WORD document)

- ▼ Chapter 3. Commercial & public buildings
  - ▼ Retrofit of existing buildings
    - ▶ Large, complex, multi-use, multi-tenant buildings
    - ▶ Historic buildings and systems
  - ▼ Commissioning, operation and maintenance
    - ▶ Large, complex, multiuse buildings
  - ▼ Sustainability
    - ▶ Large, complex, multi-use, multi-tenant buildings

## Expanded Outline – Chapter 3 – Commercial & Public Buildings

### A. Chapter 3 – Commercial & public buildings

#### 1. Retrofit of existing buildings

##### a. Large, complex, multi-use, multi-tenant buildings

- i. Re-commission systems to match constant use changes
- ii. Add smaller systems to avoid operating central systems

*(1). Understand who will be responsible for maintenance – assure they can access equipment*

*(2). Adjust overall building systems and controls to reflect added systems*

##### b. Historic buildings and systems

- i. *Potential restrictions on exterior modifications*
- ii. *Probability of asbestos insulation and fireproofing*
- iii. *Importance of examining electrical service and capacity*
- iv. *Antique HVAC – Obtaining parts and documenting O&M*

#### 2. Commissioning, Operation and maintenance

##### a. Large, complex, multiuse buildings

- i. *The importance of documenting & understanding all interrelated systems*

*(1). Identifying O&M personnel responsible for different systems*

*(2). Providing training to overlapping O&M personnel*

- ii. *Large, but lightly-occupied buildings*

*(1). Segmenting capacities & controls to match occupancy variations*

*(2). Match ventilation air flow to occupancy*

- iii. *Sub metering systems often needs commissioning*

*(1). Provide and calibrate sensors and meters*

*(2). Financial consequences often important*

*iv. Understand, separate and document mission-critical systems*

- (1). **Data centers, High-security areas, Laboratories and research rooms, Telecom and internet equipment closets**
- (2). **Establish distinct set point logs and alarms**
- (3). **Commission & schedule operation of redundant systems**

**3. Sustainability**

**a. Large, complex, multi-use, multi-tenant buildings**

*i. Light, but continuous occupancy has many implications*

- (1). **Avoid single, large systems which must run to serve very few overnight occupants**
- (2). **Small lighting zones to avoid whole-floor lighting to serve very few overnight occupants**
- (3). **Provide two-stage lamping – lower lighting for security and night time cleaning crews**
- (4). **Periodic and variable ventilation based on occupancy**

*ii. Ideal for day lighting*

- (1). **Heavy daytime occupancy leads to high daytime lighting**
- (2). **Large buildings have large lighting loads and many windows**
- (3). **Tall ceilings allow deep daylight penetration**
- (4). **Day lighting atrium also provides ventilation**
- (5). **Mass of large building reduces peak afternoon cooling load, when day lighting reduces cooling load from lighting**

*iii. Large roof area provides opportunities*

**(1). Ideal for rain water harvesting (irrigation and toilets)**

- (a). **Locate storage tanks in covered parking**

Σ *Roughing filter, easily accessible*

Σ *Provide low-point cleanout drain*

- (b.). **Feed toilets and irrigation with stored rain, backed up with conventional water**

**(2). Cool roofs for cooling-dominated climates**

**(3). Vegetated roofs to reduce urban heat island**

## Appendix 5

### Adding Information to Chapter 6 - Educational Facilities

(Also see the attached WORD document)

- ▼ Chapter 6. Educational facilities
  - ▼ Retrofit of existing buildings
    - ▶ Vacations allow time for retrofit & recommissioning with less occupant interruption
    - ▶ Retrofit energy reduction opportunities
    - ▶ Large systems usually run inefficiently and poorly during vacations
  - ▼ Commissioning, operation and maintenance
    - ▶ Recommission systems during breaks to reflect seasonal changes in space utilization and outdoor air loads
    - ▶ Schedule thermostats to reset to automatic default values, after temporary overrides typical during evenings, weekends and vacations
    - ▶ Provide and prominently post near the equipment a written log of occupied vs. shut-down set points and checklists to aid vacation shut-down and after-vacation start-up
    - ▶ Provide paper and web-based notebooks documenting key equipment for remote access by central or contracted operating and maintenance staff
  - ▼ Sustainability
    - ▶ Labeling, logging and monitoring systems in real time provides instructional opportunity, allows constant commissioning, which saves energy and improves comfort
    - ▶ Large roof area provides opportunities
    - ▶ Large lots and short buildings provide geothermal opportunity
    - ▶ Dedicated ventilation system allows potential benefits
    - ▶ Small investment in taller ceiling height provides multiple opportunities

## Expanded Outline - Chapter 6 – Educational Facilities

### A. Chapter 6, educational facilities

#### 1. Retrofit of existing buildings

- a. *Vacations allow time for retrofit & re-commissioning with less occupant interruption*
- b. *Retrofit energy reduction opportunities*
- c. *Large systems usually run inefficiently and poorly during vacations*

#### 2. Commissioning, operation and maintenance

- a. *Re-commission systems during breaks to reflect seasonal changes in space utilization and indoor air loads*
- b. *Schedule thermostats to reset to automatic default values after temporary overrides typical during evenings, weekends and vacations*
- c. *Provide and prominently post near the equipment a written log of occupied vs. shut-down set points and checklists to aid vacation shut-down and after-vacation start-up*
- d. *Provide paper and web-based notebooks documenting key equipment for remote access by central or contracted operating and maintenance staff.*
  - i. *Equipment data sheets with in-situ photographs to aid in locating each item*
  - ii. *Start-up & shut-down checklists*
  - iii. *Occupied vs. shut-down set points*
  - iv. *Easy-to-understand photo-based documentation*
    - (1). *Key maintenance locations and access*
    - (2). *Set point locations and proper values*

#### 3. Sustainability

- a. *Labeling, logging and monitoring systems in real time provides instructional opportunity, allows constant commissioning, which saves energy and improves comfort*
- b. *Large roof area provides opportunities*
  - i. *Ideal for rain water harvesting (irrigation of sports fields)*

- (1). **Locate storage tanks in mechanical space (winter freeze protection unnecessary)**
  - (a). Roughing filter, easily accessible
  - (b). Provide low-point cleanout drain
- (2). **Primary irrigation with stored rain, backed up with conventional water**
- ii. *Cool roofs for cooling-dominated climates*
- iii. *Vegetated roofs to reduce urban heat island*
- c. *Large lost and short buildings provide geothermal opportunity*
  - i. *Allows shallower, wider-area, lower-cost geothermal wells*
  - ii. *Less pumping power needed in short buildings*
- d. *Dedicated ventilation system allows potential benefits*
  - i. *Allows variable volume to avoid over or under-ventilating classrooms as occupancy changes*
    - (1). **High indoor air quality during instruction, which improves test results (ref. Technical University of Denmark – David Wyon, January 08 ASHRAE meeting seminar report)**
    - (2) **Avoids wasted energy during low occupancy and during weekends and vacations**
  - ii. *With recirculation connection and damper, allows dehumidification without ventilation during shutdown*
    - (1). **Reduces the most common mold risk in schools**
    - (2). **Saves energy by eliminating need for running entire AC system during shutdown.**
  - iii. *Isolates mechanical equipment noise far from classroom, reducing teacher speaking strain and student comprehension difficulties (ref – ASHA – American Speech-Language and Hearing Association)*
- e. *Small investment in taller ceiling height provides multiple opportunities*
  - i. *Allows day lighting through clerestory windows to penetrate deeply into classrooms, reducing lighting load*
  - ii. *Provide vertical temperature stratification opportunity, reducing cooling load*

*iii. Provides larger ventilation reservoir, allowing periodic rather than continuous ventilation*

## Expanded Outline - Chapter 6 – Educational Facilities

### A. Chapter 6, educational facilities

#### 1. Retrofit of existing buildings

- a. *Vacations allow time for retrofit & re-commissioning with less occupant interruption*
- b. *Retrofit energy reduction opportunities*
- c. *Large systems usually run inefficiently and poorly during vacations*

#### 2. Commissioning, operation and maintenance

- a. *Re-commission systems during breaks to reflect seasonal changes in space utilization and indoor air loads*
- b. *Schedule thermostats to reset to automatic default values after temporary overrides typical during evenings, weekends and vacations*
- c. *Provide and prominently post near the equipment a written log of occupied vs. shut-down set points and checklists to aid vacation shut-down and after-vacation start-up*
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  - ii. *Provide vertical temperature stratification opportunity, reducing cooling load*

*iii. Provides larger ventilation reservoir, allowing periodic rather than continuous ventilation*

## Appendix 6

### Moving to the Web-centric Handbook

(Also see the attached WORD document)

- ▼ A web-centered Handbook
  - ▶ Basic construction
  - ▶ Startup funding
  - ▶ Operational funding

## **Moving to the web-centered handbook**

### **A. A web-centered handbook**

#### **1. Basic Construction**

- a. Google search access to Handbook contents, in some form, is a basic requirement*
- b. IEEE, U.S. EPA, Wikipedia and the book section of the National Academies website provide good models and examples of good practices for the web-centered ASHRAE Handbook*
- c. A quickly-built, low-budget, part-time efforts by existing staff which performs poorly and which does not include a smooth path to publication sales would be a mistake. Make it something to be proud of rather than something which shows readers that the web-centric handbook is clumsy, loads slowly or is difficult to use. Get the money, upfront, to do it right. Not only to be consistent with ASHRAE self-image and desired worldwide public image, but because its financial sustainability depends on “Amazon.com-grade” smooth path to greatly-increased pub sales.*
- d. The current ASHRAE website shows more examples of what “not” to do than what \*to\* do for the web-centered Handbook. The web-centered Handbook needs to start with a clean sheet and new assumptions rather than being tacked onto the structure of the current society website.*
- e. Use the web-centered Handbook to highlight and access ASHRAE information, with direct links to the bookstore*

#### **2. Start-up funding**

- a. One-time membership assessment*
- b. One-time transfer of research funds*
- c. Grants from worldwide government agencies and private foundations concerned with energy & carbon emissions*
- d. Commercial sponsorship (Fund-raising seeking donations)*
- e. Commercial partnership (Joint venture with commercial partner)*

#### **3. Operational funding**

- a. For members*
  - i. Option 1 – Free to members, in addition to printed volume*
    - (1). Huge extra benefit, promoting ASHRAE membership**

(2). Money flows from members easily purchasing related PDFs and other ASHRAE publications linked from handbook pages

ii. *Option 2 – Free to members – in lieu of printed volume*

(1). Members get free web access – if they want printed volume, they pay membership price for the book

(2). Makes clear the value and the cost of printed publications

iii. *Option 3 – Extremely low additional fee – 10% for non-member annual subscription*

(1). Significant new membership benefit, promoting full ASHRAE membership

(2). Makes members aware that web-based services have value and also costs

b. *For non-members*

i. *Option 1 – No access of any kind, at any price, ASHRAE membership is required to locate, search and read handbook content*

ii. *Option 2 – Free access to tables of contents, including all chapter subheads – Embedded links on web pages to allow easy purchase of single-chapter PDFs as well as printed volume from bookstore*

(1). Bookstore automatically offers all chapter-linked publications for sale in a list visible on the shopping page.

iii. *Option 3 – Free access to all handbook content which is fully searchable and includes all links – However, in the public access mode, each page loads separately and requires clicking to move to the next page. Printing all single pages is possible, but user cannot print multiple pages with single point command. Links to purchase chapter PDFs and printed volume embedded on each page.*

(1). See books at National Academies' website for examples, e.g.:

[http://books.nap.edu/openbook.php?record\\_id=11011&page=17](http://books.nap.edu/openbook.php?record_id=11011&page=17)

iv. *Option 4 – Single-user annual subscription fee – Member-grade accesses for a one-year period, at 50% of full annual membership cost.*

- (1). **Ideal for broader international participation, and for technical library access – These users cannot make use of other ASHRAE member benefits**
  - (2). **Registration and password required. Access depends on both password and correct answer to registration-generated question.**
- v. *Option 5 – One-month subscription fee – Member-grade access for a 30-day period, at 10% of annual membership fee*
- (1). **Ideal for potential users worldwide who have a short-term need.**
  - (2). **Registration and password required. Access depends on both password and correct answer to registration-generated question.**
- vi. *Option 6 – Annual web-only site license for companies, at cost equal to two annual ASHRAE memberships*
- (1). **Access controlled by server and/or individual machine MAC addresses rather than by passwords (Out-of-office access requires a different subscription).**
  - (2). **Taps cash from the phenomenon of large manufacturing companies and large HVAC design and design-build firms with many designers and others who use ASHRAE Handbooks, which come to a single ASHRAE member.**
  - (3). **Additional money flows from subscribers easily purchasing related PDFs and other ASHRAE publications linked from handbook pages.**

## **Appendix 7**

### **Good Site Models & Good Web Practices**

(Also see the attached WORD document)

- ▼ **Good Site Models & Good Web Practices**
  - ▶ Intelligent search
  - ▶ "Obvious" navigation
  - ▶ Intelligent interaction
  - ▶ Examples of good site practices

## **Good Site Models & Good Web Practices**

### **A. Good web site models and practices**

#### **1. Intelligent search**

- a. Successive narrowing within search results*
- b. Search restricted to peer-reviewed documents*
- c. Easily build, save and edit multiple-criteria searches*
- d. Search across all databases on a given site*

#### **2. “Obvious” navigation**

- a. Site map is obvious and single-click accessible from opening page*
  - i. All major categories are shown*
  - ii. The structure and sub-categories within categories is shown*
  - iii. The extent (number of pages or records) in each category is indicated*
- b. Both constant and context-dependent navigation bars (e.g., IEEE.org)*

#### **3. Intelligent interaction**

- a. Expert systems/wizards which guide the user through steps of complex process*

#### **4. Examples of good site practices**

- a. U.S. Environmental Protection Agency (<http://eps.gov/>)*
  - i. Loads very quickly*
  - ii. Easy to locate information from the opening page in very few steps*
  - iii. Intelligent links to related information throughout the site*
  - iv. “Breadcrumbs” to indicate where you are and the trail you need to take to get there*
  - v. Geographic location and main phone number obvious and accessible from all pages*
  - vi. Organization-wide search is extremely quick and results page shows single-click links to narrow the search results*

*vii. Google returns the U.S. EPA site as the second link for a search of “indoor air”*

- (1). The Indoor Air Quality Association is the 3<sup>rd</sup> link
- (2). Neither the word ASHRAE nor any ASHRAE information appears in those Google search results – even after 10 pages

*viii. IEEE.org*

- (1). Very clean site – no distracting ads
- (2). Loads very quickly
- (3). Navigation menus are easy to read and descriptive
- (4) Excellent site map accessible from front page show full range of information, with links to sections and subsections
- (5) Both Google and IEEE-specific search engines on IEEE site (Therefore Google search will return IEEE information)

*ix. Amazon.com provides excellent user experience, leading to profitable up-selling as well as grateful customers*

- (1). The user is well-known by the site after login
- (2). Previous purchases are easily visible
- (3). Publications (and other goods) related to chosen items are respectfully displayed and fully-described, without interrupting the purchase process
- (4) Search is highly intelligent – does not require perfect spelling, nor knowledge of “correct category” of possible products offered on the site. Also allows easy narrowing of the search, when single-category search is desirable.

## Appendix 8

### Web Practices to Avoid

(Also see the attached WORD document)

- ▼ Web Practices To Avoid
  - ▶ Page-loading time greater than 1 second
  - ▶ Difficult-to-find physical location and contact phone number for the organization
  - ▶ Apparently public information that suddenly requires work, passwords, money or personal information
  - ▶ Ads which clutter & distract rather than inform
  - ▼ Current ASHRAE site shortcomings argue against adding a web-centric Handbook to existing structure - Policies, structure, search problems and bookstore difficulties
    - ▶ Difficult to locate information
    - ▶ Graphic and animated ads throughout the site are distracting, give the pages a very cluttered look and take up valuable information space (See IEEE.org for alternative look and feel)
    - ▶ Difficult to buy handbook chapters and handbook-referenced information
    - ▶ Bookstore search is difficult and unproductive

## Web Practices to Avoid

### A. Practices to avoid

1. **Page-loading time greater than 1 second**
2. **Difficult-to-find physical location and contact phone number for the organization**
3. **Apparently public information that suddenly requires work, passwords, money or personal information**
  - a. Password access from links which do not indicate that passwords will be required
  - b. Registration from links which do not indicate that survey participation will be required
  - c. Surveys from links which do not indicate that survey participation will be required
4. **Ads which clutter & distract rather than inform**
  - a. Ads not directly-related to page content
  - b. All pop-up ads
  - c. All animated ads
  - d. Graphic-heavy ads which consume screen space
  - e. Any ads on technical pages other than HTML text
    - i. Google ad-works would be acceptable, perhaps linking to.
    - ii. Static graphic ads provided they are located on a commercial rather than technical page.
5. **Current ASHRAE site shortcomings argue against adding a web-centric Handbook to existing structure – Policies, structure, search problems and bookstore difficulties**
  - a. Difficult to locate information
    - i. No information on the ASHRAE site is accessible through Google search
    - ii. No site map
    - iii. Many layers between front page and what is sought

- iv. **Site-wide search is incomplete, highly misleading and not intelligent**
  - (1). **No ability to search within search results**
  - (2). **A search of ASHRAE.org does not include searching standards, Handbook, special publications, Journal articles, Transactions, TC sites, TC minutes or research projects**
  - (3). **You must know in which category the information is published and where on the site you would search for that single category of information.**
  - (4). **Search results come up very slowly – close to 10 seconds instead of one or two.**
  
- b. **Graphic and animated ads throughout the site are distracting, give the pages a much cluttered look and take up valuable information space (See IEEE.org for alternative look and feel).**
  
- c. **Difficult to buy handbook chapters and handbook – referenced information**
  - i. **No direct links from publication descriptions (e.g., Handbook chapters, standards, special publications, research, journal articles) to the appropriate item in the bookstore – You have to search again, to find the item and buy it.**
  
- d. **Bookstore search is difficult and unproductive**
  - i. **Very slow (10 seconds or more to return search results)**
  - ii. **Misleading tabs on the bookstore search page**
    - (1). *Suggests search can be narrowed by clicking on a category tab, but such is not the case*
    - (2). *Suggests search includes all categories described by tabs, but such is not the case.*

- iii. Does not search ASHRAE Handbook chapter, Journal articles or final reports from research projects- you have to know those are in separate databases rather than a unified publications database, although tabs suggest these are included in the bookstore search**
- iv. When the search results are negative, there is no indication of what the original search terms were that produced those negative results – was there a typo in the search term originally?**
- v. Cannot search within search results**
- vi. Cannot build and save multiple criteria searches**
- vii. Search result list does not always clearly identify the type of product located. In that text-only list, papers look like books and vice-versa. The list is not divided by product type.**
- viii. No intelligent links to related information, or “Publications bought by those who also bought this item”**

**Appendix 9**

**Individual Chapter Reviews**

(See the attached WORD Document)