National Institute of BUILDING SCIENCES

An Authoritative Source of Innovative Solutions for the Built Environment
Whole Building Design Guide
An Online Resource to Achieve High-Performance Buildings
What Is a High-Performance Building?


A building that integrates and optimizes on a life cycle basis **all major high performance attributes**, including energy conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations.
What Else is Important?

We get Energy Conservation, Green Buildings, Greenhouse Gas Reduction, Sustainability.

What else is important to achieving high-performance buildings?

• Durability [hurricane/earthquake resistant. Won’t burn, leak, rot, mold or corrode]

• Resilience [robustness, resourcefulness & recovery; continue to function & provide shelter]

• Other high-performance attributes
High Performance Attributes

- Accessibility
- Aesthetics
- Cost Effectiveness
- Functionality
- Historic Preservation
- Productivity
- Security/Safety
- Sustainability

The Office of Governmentwide Policy at the GSA headquarters building in Washington, DC was designed to maximize flexibility, allowing new occupants to change the space to fit their group and individual needs.
Green Buildings

What’s Working, What’s Not*

- Occupants of green buildings generally show a higher level of satisfaction with their built environment than do occupants of standard buildings, but their buildings fall short in some key areas.

- Common complaints had to do with:
  - Acoustics (too noisy, not enough privacy)
  - Thermal comfort (limited temperature control)
  - Daylighting (too much glare and light spill)

Similar results from other studies done over last 5 years

*HOK Post Occupancy Evaluation Report of 7 HOK-designed green buildings as reported in BD&C June 9, 2006
‘Whole Building’ Approach

- Materials, systems, and assemblies reviewed from many different perspectives

- Building components, sub-systems and materials are interdependent, can impact the total performance of the whole, and can perform ‘double duty’
Impact of WBDG as a Tool

WBDG average visitors each month

2008 – 250,000 vis/mo
2009 – 430,000 vis/mo
2010 – 555,000 vis/mo
2011 – 546,000 vis/mo*

*New Record in Oct. 2011, 697,342 Visitors

WBDG average pdf downloads each month

2008 – 1.7 million dl/mo
2009 – 2.5 million dl/mo
2010 – 3.1 million dl/mo
2011 – 4.2 million dl/mo*

*New Record in Oct. 2011, 5,286,003 downloads
The Gateway to Up-To-Date Information on Integrated 'Whole Building' Design Techniques and Technologies

The goal of 'Whole Building' Design is to create a successful high-performance building by applying an integrated design and team approach to the project during the planning and programming phases.

PARTICIPATING AGENCIES

FEATURED PROGRAM

DHS, Science & Technology Directorate, High Performance Resilience Program
This program was created by the U.S. Department of Homeland Security (DHS) in 2009 to improve the security and resilience of our nation's buildings and infrastructure. For more information on security, visit the WBDG's Secure/Safe Design Objective pages.

NEW & UPDATED PAGES

Magnify Credit Union - South Lakeland Branch Case Study - 11/21/2011


MIDG Resources
Mechanical Insulation Design Guide (MIDG) - 11/02/2011

Functional / Operational – Including Account for Functional Needs, Ensure Appropriate Products/Systems Integration, and Meet
Design Guidance

Architects, engineers, and project managers can improve the performance and quality of their buildings by following the guidance and recommendations provided within the categories of this web site. Start by navigating through one of the sections below:

- **Design Objectives**
  contains information organized by the specific design goal

- **Building Types**
  contains information organized by the type of building or use

- **Space Types**
  contains information organized by the type of functional space within buildings

- **Design Disciplines**
  contains information organized by the professional disciplines' role in the 'whole building' process

- **Products & Systems**
  contains information organized by CSI MasterFormat™ or UniFormat™

Multiple links between various sections of the WBDG and the Internet allow you to easily access all relevant online information related to a topic, including design tools, federal mandates, and government and non-government standards. At the bottom-most level of the site, browse in-depth technical summaries, called Resource Pages, written by industry experts.
High Performance Attributes = WBDG Design Objectives

- Accessibility
- Aesthetics
- Cost Effectiveness
- Functionality
- Historic Preservation
- Productivity
- Security/Safety
- Sustainability
Optimize Energy Use
by the WBDG Sustainable Committee
Last updated: 08-16-2011

OVERVIEW
On an annual basis, buildings in the United States consume 39% of America’s energy and 68% of its electricity. Furthermore, buildings emit 38% of the carbon dioxide (the primary greenhouse gas associated with climate change), 49% of the sulfur dioxide, and 25% of the nitrogen oxides found in the air. Currently, the vast majority of this energy is produced from nonrenewable, fossil fuel resources. With America’s supply of fossil fuel dwindling, concerns for energy supply security increasing (both for general supply and specific needs of facilities), and the impact of greenhouse gases on world climate rising, it is essential to find ways to reduce load, increase efficiency, and utilize renewable fuel resources in facilities of all types.

During the facility design and development process, building projects must have a comprehensive, integrated perspective that seeks to:

- Reduce heating, cooling, and lighting loads through climate-responsive design and conservation practices;
- Employ renewable energy sources such as daylighting, passive solar heating, photovoltaics, geothermal, and groundwater cooling;
- Specify efficient HVAC and lighting systems that consider part-load conditions and utility interface requirements;
- Optimize building performance by employing energy modeling programs and optimize system control strategies by using occupancy sensors, CO₂ sensors and other air quality alarms; and
- Monitor project performance through a policy of commissioning, metering, annual reporting, and periodic recommissioning.

Apply this process to the reuse, renovation or repair of existing buildings as well.
Documents & References

FEDERAL HIGH PERFORMANCE AND SUSTAINABLE BUILDINGS
This section provides the key information needed by Federal personnel to meet high performance and sustainable building (HPSB) requirements. More

FEDERAL MANDATES
This section contains links to key federal mandates such as executive orders, federal regulations, etc. that apply to the areas of building design, construction and management. More

CONSTRUCTION CRITERIA BASE (CCB)
CCB is an extensive electronic library of construction guide specifications, manuals, standards and many other essential criteria documents linked throughout the WBDG. More

Recent Updates

- VA Criteria - LED and Conventional Lighting Systems Comparison Study - Appendix: Cutsheets
  Posted: 12-27-2011

- VA Criteria - LED and Conventional Lighting Systems Comparison Study
  Posted: 12-27-2011

  Posted: 12-27-2011

- Air Force Criteria - ETL 11-26 Using Asphalt Surface Treatments as Preventive Maintenance on Asphalt Airfield Pavements
  Posted: 12-27-2011

- Air Force Criteria - ETL 11-28 Mandatory Review and Update of Record Drawings for Nuclear-Capable Weapons and Munitions Storage and Maintenance Facilities
  Posted: 12-20-2011

- Air Force Criteria - ETL 11-27 Solar Lighting for Airfields
  Posted: 12-20-2011
Federal High Performance and Sustainable Buildings

The Federal Government is the nation’s single largest landlord and energy consumer, operating more than 500,000 facilities comprising more than 3 billion square feet. Historically, approximately $30 billion is spent annually on acquiring or substantially renovating Federal facilities, and about $7 billion is spent on energy for Federal facilities. Almost $200 billion is spent on personnel compensation and benefits for civilian employees. This footprint represents an enormous opportunity to transfer sustainable technologies and practices on a large scale, thereby helping to transform the marketplace and create a more healthy work environment.

This section provides the key information needed by Federal personnel to meet high performance and sustainable buildings (HPSB) requirements including:

Policy Background
Several Executive Orders and legislative mandates direct Federal Agencies to achieve specific HPSB goals. This section provides an overview of these requirements.

New Construction & Major Renovation
Executive Orders 13514 and 13423 require all Federal agencies to comply with the Guiding Principles for New Construction and Major Renovation. This section includes technical guidance needed to meet each of these Guiding Principles.

Existing Buildings
Executive Order 13514 requires at least 15% of each agency’s existing facilities and building leases (above 5,000 gross square feet) to meet the Guiding Principles by 2015. To meet this goal, most agencies must upgrade their existing building stock, which means compliance with a separate set of Guiding Principles for Sustainable Existing Buildings that are detailed in this section.

Supporting Technical Guidance
This section includes additional supporting technical guidance to help agencies meet HPSB requirements.
Construction Criteria Base (CCB)

Construction Criteria Base (CCB) is an extensive electronic library of construction guide specifications, manuals, standards and many other essential criteria documents. Published and updated continuously, CCB contains the complete unabridged, approved, current electronic equivalents of over 10,000 documents direct from participating federal agencies. CCB is the most effective tool available for finding and using current, approved U.S. construction criteria. Documents are available as Adobe® PDF files and some documents are also furnished by agencies in word-processing formats or in the SPECSINTACT specification processing program used by the Army, NAVFAC and NASA. Documents are organized first into Libraries, then by Source and Category.

For document inquiries or additional information, please contact us either by phone at 877-CCB-5667 or by email at ccbsupport@nibs.org.

Keep current with CCB additions and updates via our CCB RSS.

CONSTRUCTION CRITERIA BASE INDEX

Specifications Library
- Unified Facilities Guide Specifications (UFGS)
- NAVFAC Specifications
- NAVFAC Standard Specifications
- NAVFAC Guide Performance Work Statements
- VA Specifications
- Federal Green Construction Guide for Specifiers
- DOE General Design Criteria
- NIBS Specifications

Regulations Library
## Custom Library

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Continuing Education

Welcome to the WBDG continuing education system. The WBDG contains a wealth of information and is your gateway to up-to-date information on integrated ‘Whole Building’ Design Techniques and Technologies. The courses featured offer an introduction to whole building design concepts as well as more specific applications for design objectives, building types and operations and maintenance.

The content in the WBDG has been developed by top experts in the fields of architecture, engineering, planning, and facility management, among others. So you can be assured that the information is up to date and relevant and will inspire you to engage in the process of whole building design contributing to the stock of America’s building.

Distance education is a great and very convenient way for architecture, engineering, and building design professionals to gain valuable knowledge about whole building design while earning continuing education credits. As a registered CE provider, the WBDG CE system is a source of Health, Safety and Welfare (HSW) and Sustainable Design (SD) AIA Continuing Education System learning units (LUs) for registered architects and USGBC GBCI CE hours for LEED Professionals. AIA members will receive their learning units and certificate of completion upon passing the course test, completing an evaluation form and filling out an affidavit. Other building design professionals will receive a certificate of completion for approval and processing with their professional membership organization upon passing the course test and completing an evaluation form and filling out an affidavit.

Enroll now or log in to begin taking a class with the WBDG Continuing Education System.

COURSES

WBDG01 The Integrated Design Process
This course will introduce you to the concepts of whole building design and the elements of an integrated design process.

WBDG02 Whole Building Approach to Laboratories
BIM Libraries

Last updated: 03-22-2011

A structure is needed in order to scope the inter-relationship of projects as well as define the overall range of projects to define a Building Information Model. Without such a structure, there is no end to the effort and no understanding of what we are collectively developing.

Based on the work to date we have been able to generate a map of the scope and structure of BIM. BuildingSMART International has long had a logo of four interlocking squares symbolizing the interoperability needed throughout the facilities industry. We have identified each of those four squares as life cycle aspects of the industry and the basis for our vision. While there are currently many ways to describe the life cycle of a facility, all link back to this universal structure.

Click a square to see a list of associated resources...
FEMP Guide to Integrating Renewable Energy in Federal Construction

The FEMP Guide is available online at www.femp.energy.gov/reconstructionguide/.

The WBDG resources pages accompanying the Guide are:

- Biogas
- Biomass for Electricity Generation
- Biomass for Heat
- Daylighting
- Fuel Cells and Renewable Hydrogen
- Geothermal Electric Technology
- Geothermal Energy – Direct-Use
- Geothermal Heat Pumps
- Hydropower
- Ocean Energy
- Photovoltaics
- Passive Solar Heating
- Solar Ventilation Air
- Preheating
- Solar Water Heating
- Wind Technology

National Institute of BUILDING SCIENCES
• Description: How does it work; types & cost of technology
• Application: Economics; assessing resource availability
• Design & Procurement considerations
• Operations & Maintenance
• Special considerations

The Judith Gap Wind Energy Center in Montana is comprised of 90 GE 1.5 MW turbines, for a total capacity of 135 MW.
New Energy/Sustainable WBDG Content

- Green Building Standards & Certification
- Greenhouse Gas Emissions in Federal Buildings
- Living, Regenerative & Adaptive Buildings
- Zero Net Energy Buildings
- Biomimicry
- Alternative Energy
- Smart Whole-Building Controls*
- DC L-V Distribution System*
- Wireless, Self-Powered Devices*

*coming in 2012

EcoSense in British Columbia is one of the first 3 Living Buildings certified in the world
(Photo Credit: ILBL.org.)
Building Envelope Design Guide

The National Institute of Building Sciences (NIBS) under guidance from the Federal Envelope Advisory Committee has developed this comprehensive guide for exterior envelope design and construction for institutional/office buildings. The Envelope Design Guide (EDG) is continually being improved and updated through the Building Enclosure Councils (BECs). Any edits, revisions, updates or interest in adding new information should be directed to the BEDG Review Committee through the 'Comment' link on this page.

INTRODUCTION

BELOW GRADE SYSTEMS
- Foundation Walls
- Floor Slabs
- Plazas, Tunnels, Vaults

WALL SYSTEMS
- Cast-In-Place Concrete
- Exterior Insulation and Finish System (EIFS)
- Masonry
- Panelized Metal
- Precast Concrete
- Thin Stone

FENESTRATION SYSTEMS
- Glazing
- Windows
- Curtain Walls
- Sloped Glazing
- Exterior Doors
Building Envelope Design Guide - Wall Systems

by Daniel J. Lemieux, AIA and Paul E. Totten, PE

Warmer outdoor temperature

Water drains along drainage planes
Higher vapor pressure (Higher RH)

Water redirected at flashings beyond exterior wall surface

Lower air pressure (ideal)

Positively pressurized building higher air pressure

Cooler indoor temperature

Lower vapor pressure (Lower RH)

Cycling of air pressure due to wind, stack, or mechanical system variations

performance considerations and environmental conditions unique to each project and, therefore,
1. EXTERIOR SHEATHING
2. AIR AND VAPOR BARRIER MEMBRANE, WRAP INTO OPENING
3. MASTIC AT LEADING EDGE OF OVERLAP OF MEMBRANE OR ELASTOMERIC FLASHING
4. RIGID INSULATION (WITHOUT VOIDS)
5. CAVITY DRAINAGE MATERIAL (MORTAR NETTING)
6. FACE BRICK
7. MORTAR
8. SELF-ADHERING MEMBRANE FLASHING, 3" MINIMUM OVERLAP AT MEMBRANE JOINTS (VERIFY COMPATIBILITY WITH AIR & VAPOR BARRIERS)
9. TWO PIECE METAL FLASHING WITH END DAMS (HEMMED EDGE AT FACE OF BRICK)
10. LINE OF METAL FLASHING END DAM (DASHED)
11. BRICK LINTERL WITH OPEN JOINT WEEPS 2" O.C.
12. LINTER SUPPORT ANGLE SHOWN (LINTER SUPPORT ANGLE SPREADS LOAD TO ADJACENT BRICK NOT TO STRUCTURE) RELIEVING ANGLE SIMILAR (ATTACHES TO STRUCTURAL STEEL NOT TO STUD CONSTRUCTION)
13. SEALANT AND BACKER ROD
14. THERMAL BREAK
15. HEEL BEAD OF SEALANT TO PROVIDE AIR TIGHTNESS (SNAP-IN GLAZING BEAD LEAKS AIR) CONTINUOUS AT ALL FOUR SIDES OF GLASS
16. HIGH PERFORMANCE INSULATING GLASS UNIT (TRIPLE GLAZED INSULATED UNIT WILL IMPROVE ENERGY PERFORMANCE)
17. SPRAY POLYURETHANE FOAM TO IMPROVE THERMAL PERFORMANCE
18. MINERAL WOOL
19. SEALANT AND BACKER ROD (VERIFY COMPATIBILITY WITH ELASTOMERIC FLASHING)
20. INTERIOR GYPSUM BOARD AND CASING BEAD
21. WINDOW ANCHOR CLIP AND FASTENER (SIZE AND SPACING AS REQUIRED)
22. BLOCKING AS REQUIRED
23. ELASTOMERIC FLASHING (EXTRUDED SILICONE SET IN SILICONE SEALANT OR SELF-ADHERING MEMBRANE FLASHING) (VERIFY COMPATIBILITY WITH AIR AND VAPOR BARRIER) 3" MINIMUM OVERLAP AT MEMBRANE JOINTS
24. BRICK AT JAMBS BEYOND
25. SPRAY POLYURETHANE FOAM (PREFERRED), OR RIGID INSULATION
26. ALUMINUM WINDOW
27. STUD CAVITY (NO INSULATION)
28. REMOVABLE TRIM HERE TO FACILITATE FUTURE WINDOW REPLACEMENT
29. LINE OF ELASTOMERIC FLASHING BETWEEN ANCHOR CLIPS
Building Envelope Design Guide - Roofing Systems

by Tom Smith, AIA
TJSmith Consulting Inc.
Last updated: 10-21-2011

INTRODUCTION

Roofing systems are one of the most important elements of a building's envelope. They protect the building from the elements while also allowing the transfer of heat and moisture to the atmosphere. The selection of the correct roofing system is critical to the overall performance and durability of the building. For a project, the architect should develop a general understanding of the available material options. The purpose of this section is to provide design guidance to architects designing low- and steep-slope roof assemblies on new Federal office buildings.

Note: Low-sloped roofs are defined as roofs with a slope of 2:12 or less (2 percent). However, with the exceptions of roofs with slopes between 1/4:12 and 1/2:12 (1/2 percent) and roofs with slopes between 1/2:12 and 2:12 (2 percent), steep-slope roofs are defined as roofs with slopes greater than 1/2:12 (1/2 percent). As discussed in the Design section, some roofs may include both low- and steep-slopes, while others are limited to either low- or steep-slopes.

Scope

The Description section discusses the benefits and drawbacks of various lamination types, such as tar and gravel, metal, and EPDM membranes. The remaining section are Emerging Issues, Relevant Codes and Standards, and Additional Resources.
Building Envelope Design Guide - Atria Systems

by Todd Gritch, AIA, ACHI and Brian Eason, AIA
HKS Inc.
Last updated: 06-07-2010

INTRODUCTION

(a'trem), term for an interior court in Roman domestic architecture and also a type of entrance court in early Christian churches. Today atrium means an enclosed multi-storied space that is open vertically to multiple stories.

NFPA 92B the current standard for smoke control in large spaces defines atrium as a large volume space created by a floor opening or series of floor openings connecting two or more stories that is covered at the top of the series of openings and is used for purposes other than an enclosed stairway; or other mechanical and utility service to the building. The International Building Code (IBC) defines Atrium similarly as an opening connecting two or more stories other than enclosed stairways, elevators, hoist ways, escalators, plumbing, electrical, air-conditioning or other equipment, which is closed at the top and not defined as a mall.

Atriums have many advantages as a building form over conventional modern building configurations. Atrium buildings appeal to people not only logically, but also emotionally by providing a connection to the outside inside. By bringing natural light into the interior, atriums offer larger, more efficient floor areas than conventional buildings. Atriums provide more desirable work environments by providing more space with a connection to natural daylight and the outside environment. Many believe that access to natural full spectrum lighting creates a more healthful and productive environment. There have been several studies that support this view.

The view into an atrium can and in most cases is more entertaining and connective than an exterior view as illustrated below at The Plaza of the Americas in Dallas, Texas.

An atrium is a pleasant all weather gathering place providing shelter from the more extreme climate conditions outside. The atrium replicates a desirable outdoor environment by providing the benevolent aspects of the outdoor environment; natural light, moderate temperatures while sheltering us from the harsher elements of extreme temperatures, rain, and winds.
Performance - Based P100 Facilities Standard for the Public Buildings Service

Office of Design and Construction
U.S. General Services Administration
P100 Objectives

- Performance-based Standard - Design to Performance Benchmark, then Verify it
- Design Team has Full Flexibility to create design solutions that perform
- First Update - the three pillars of Integrated Design – Enclosure, Lighting, HVAC
- Second Update – Urban Transportation, Site, Structure, Interiors, Electrical, Fire/Life Safety
- Update includes Criteria Tables, verification standards, explanations
- P100 will shorten to 33% of current length

- **Title IV – Sec 401. Definitions.**
- **High Performance Building** – The term “high-performance building” means a building that integrates and optimizes on a life cycle basis all major high performance attributes, including energy conservation, environment, safety, security, durability, cost-benefit, productivity, sustainability, functionality, and operational considerations.
Performance Based P100

- Whole Building
  - Energy Use
  - Sustainability

- Facility Systems
  - Site, Urban Transportation
  - Enclosure
  - Structure
  - Interiors
  - Lighting
  - Mechanical
  - Electrical
  - Fire and Life Safety

- Facility Functional Areas
  - Major Spaces
  - Support Spaces

Mission
Operational
Scope of Work for SME Teams

- Identify attributes
- Select metrics
- Identify baseline performance level
- Establish benchmark performance levels
- Define validation methods and standards
- Compile cost differentials
- Establish attribute interactions
- Develop matrices for electronic tool
Major Attributes – First Update

- Enclosure – Wall, Fenestration, Roof
  - Thermal
  - Water Penetration
  - Moisture Control
  - Air Leakage
  - Service Life

- Lighting – Artificial Interior/Exterior, Daylighting
  - Lighting Quality
  - Lighting Quantity
  - Energy Use
  - Maintenance

- HVAC
  - Temperature
  - Humidity Control
  - Air Movement
  - Pressurization
  - Energy Performance
  - System Efficiency
  - Service Life
  - Maintenance
P100 Second Update

- Structure
  - Blast
  - Natural Disasters
- Interior Systems
  - Flooring, Ceilings, Walls, Paint
- Civil and Landscaping
  - Storm Water Management
  - Landscaping
- Urban and Transportation
- Fire and Life Safety
Performance Levels

• Baseline is the minimum performance level for GSA facilities based on Laws, EOs, Codes and Standards, or PBS P100 2010 requirements.
• Multiple higher performance level benchmarks
• Interactions and cost differentials for higher performance levels
<table>
<thead>
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<th>Attribute</th>
<th>Baseline</th>
<th>P*</th>
<th>P**</th>
<th>HP</th>
<th>Verification</th>
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<td>Blast Resistance</td>
<td>ISC Level II</td>
<td>ISC Level III</td>
<td>ISC Level IV</td>
<td>Site Specific Risk Assessment</td>
<td>Blast Mockup Testing</td>
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<td>Envelope - Protective Security</td>
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<td>Site Planning</td>
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<td>Envelope - Natural Hazard</td>
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<td>Seismic Resistance</td>
<td>Life Safety</td>
<td>Reduced Damage</td>
<td>Immediate Occupancy</td>
<td>Operational</td>
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<td>Windborne Debris Resistance</td>
<td>Large Missile &lt; 30-ft from Grade &amp; Small Missile &gt; 30-ft of Grade</td>
<td>Large Missile &lt; 30-ft from Grade &amp; Small Missile &gt; 30-ft of Grade</td>
<td>Site Specific Risk Assessment (Tornado Hazard)</td>
<td>Wind Tunnel Testing &amp; Projectile Impact Testing</td>
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<td>Flood Resistance</td>
<td>100-Year Flood Hazard; Critical Action Facilities Must be Located above the 500-Year Base Flood.</td>
<td>500-Year Flood Hazard and/or Storm Surge Induction</td>
<td>Site Specific Risk Assessment (Dam, Levee, and Floodwall Failure Hazards)</td>
<td>Site Planning</td>
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<td>Attribute</td>
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<td><strong>Moisture and Condensation Control</strong></td>
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<td><strong>Moisture Control Opaque Assemblies</strong></td>
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<td>Design of the above-grade building enclosure must be demonstrated early in the design development. ASHRAE 160 [2009], Criteria for Moisture Control Design Analysis in Buildings is an acceptable basis of design. Provide continuous exterior insulation for wall roof, below grade walls and all slab-on-grade containing conditioned space. Conduct moisture control design analysis for each exterior assembly and exposure to document understanding of condensation and drying potential.</td>
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<td><strong>Condensation Resistance Fenestration</strong></td>
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<td>Relevant standards: NFRC 500, Thermal Analysis and Modeling</td>
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<td><strong>Air Tightness</strong></td>
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<td>Relevant standards: GSA PBS P-100-2010, AAMA 101-2008</td>
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<td>Performance data correlated to performance testing</td>
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<td>0.25 cfm/ft² @ 0.3 in w.c.</td>
<td>0.15 cfm/ft² @ 0.3 in w.c.</td>
<td>0.10 cfm/ft² @ 0.3 in w.c.</td>
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<td>0.40 cfm/ft² @ 0.3in w.c.</td>
<td>0.25 cfm/ft² @ 0.3in w.c.</td>
<td>0.15 cfm/ft² @ 0.3in w.c.</td>
<td>0.10 cfm/ft² @ 0.3in w.c.</td>
<td>ASTM E779/E1627</td>
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### Thermal Performance

<table>
<thead>
<tr>
<th>Building Enclosure Commissioning</th>
<th>ASHRAE 90.1-2010</th>
<th>ASHRAE 90.1-2010 \times 1.15</th>
<th>ASHRAE 90.1-2010 \times 1.30</th>
<th>ASHRAE 90.1-2010 \times 1.50</th>
<th>Yes</th>
<th>ASHRAE 90.1-2010</th>
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<tbody>
<tr>
<td>Total Building Commissioning with Building Enclosure Commissioning</td>
<td>Fundamental Building Enclosure Commissioning (BECx)</td>
<td>Enhanced BECx with increased performance testing as determined by GPR</td>
<td>Enhanced BECx</td>
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### Enclosure Acoustic Control

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<tr>
<th>Assuming NC-35 interior</th>
<th>STC-40/OITC-35 based on standard performance values reported for assemblies</th>
<th>STC-45/OITC-40 &amp; site assessment and lab tests of enclosure components</th>
<th>STC-45/OITC-45 &amp; site assessment and site mockup testing</th>
<th>STC-50/OITC-45 &amp; site assessment, mockup field tests and one field test per 20,000 sf of enclosure</th>
<th>Yes</th>
<th>E366 &amp; E366 Classification by E132</th>
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### Enclosure Durability

<table>
<thead>
<tr>
<th>Walls (In years to replacement/major rehabilitation)</th>
<th>50/25</th>
<th>75/30</th>
<th>100/40</th>
<th>150/50</th>
<th>No</th>
<th>yes, Design Review, P+ and higher: Enclosure Cx CSA S478 plan, Maintainance plan</th>
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</table>

<table>
<thead>
<tr>
<th>Roofs (Replacement)</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>No</th>
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<table>
<thead>
<tr>
<th>Fenestration (years to frame replacement / IGU-gaskets and seals replacement)</th>
<th>30/15</th>
<th>40/20</th>
<th>50/25</th>
<th>75/25</th>
<th>Yes</th>
<th>Design Review, P+ and higher: Enclosure Cx CSA S478 plan, Maintainance plan</th>
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<table>
<thead>
<tr>
<th>Attribute</th>
<th>Baseline</th>
<th>P+</th>
<th>P++</th>
<th>HP</th>
<th>M&amp;O</th>
<th>P&amp;S</th>
<th>C</th>
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<tbody>
<tr>
<td>Lighting Quality - Interior Electric</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Luminance Balance</td>
<td>None</td>
<td>3 to 1 (task to immediate surround); 40 to 1 (non work areas)</td>
<td>3 to 1 (task to immediate surround); 20 to 1 (non work areas)</td>
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<td>Yes</td>
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<tr>
<td>Spectral Distribution</td>
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<tr>
<td>CCT</td>
<td>&lt;3500K</td>
<td>&lt;3500K</td>
<td>&lt;3500K</td>
<td>Tunable</td>
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<td>&gt;80</td>
<td>&gt;90</td>
<td>&gt;95</td>
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<td>Lighting Layers</td>
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<tr>
<td>Ambient</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>Yes</td>
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<td>Visual Comfort (Glare)</td>
<td>Minimal</td>
<td>Direct/indirect</td>
<td>Direct/indirect</td>
<td>Direct/indirect</td>
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<td>Yes</td>
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<td>&gt;70%</td>
<td>&gt;80%</td>
<td>&gt;90%</td>
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<tr>
<td>Lighting Quality - Interior Daylight</td>
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<td>Luminance Balance</td>
<td>View Perserving Blinds</td>
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<tr>
<td>Lighting Layers</td>
<td>None</td>
<td>Maximize daylight access with toplighting, sidelighting, interior glazing, and low partitions on the perimeter spaces.</td>
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<tr>
<td>Visual Comfort (Glare)</td>
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<td>&gt;80%</td>
<td>&gt;90%</td>
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<td>Views (11 degree minimum)</td>
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<td>80%</td>
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<tr>
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<td>Daylight Autonomy (10-500 ft)</td>
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<td><strong>Lighting Energy Use - Interior Electric</strong></td>
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<td>System Efficiency</td>
<td>Exceeds Ashrae 2007 by 30%</td>
<td>Exceeds Ashrae 40% 2007</td>
<td>Exceeds Ashrae 50% (performance)</td>
<td>Exceeds Ashrae 70% (performance)</td>
<td>Yes</td>
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<td>Controls</td>
<td>Exceeds Ashrae 2007 by 30%</td>
<td>Automatic OC + personal</td>
<td>DALI Equivalent + personal</td>
<td>DALI Equivalent + personal</td>
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<td>Real Time Energy Use</td>
<td>Minimal</td>
<td>Modeling</td>
<td>Modeling + Monitoring</td>
<td>Modeling, Monitoring, Feedback</td>
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<td><strong>Lighting Energy Use - Exterior</strong></td>
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<tr>
<td>Lighting Power Density (w/sf)</td>
<td>Exceeds Ashrae 2007 by 30%</td>
<td>Exceeds Ashrae 40% 2007</td>
<td>Exceeds Ashrae 50% (performance)</td>
<td>Exceeds Ashrae 70% (performance)</td>
<td>Yes</td>
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<tr>
<td>Controls</td>
<td>Nighttime setback controls added (Not less than 50% maximum output)</td>
<td>Nighttime setback controls added (Not less than 50% maximum output)</td>
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<td>Network Controls (Not less than 50% maximum output)</td>
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<td>Real Time Energy Use</td>
<td>Minimal</td>
<td>Modeling</td>
<td>Modeling + Monitoring</td>
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<tr>
<td><strong>Metric</strong></td>
<td><strong>Baseline</strong></td>
<td><strong>P+</strong></td>
<td><strong>P++</strong></td>
<td><strong>HP</strong></td>
<td><strong>Verification</strong></td>
<td><strong>Cx M&amp;V</strong></td>
<td><strong>Plans &amp; Specs</strong></td>
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<td><strong>Temperature</strong></td>
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<tr>
<td><strong>Performance</strong></td>
<td>75±2°F summer, 72±2°F winter, Allowance for unoccupied hour setup and setback optimized with re-occupancy pick-up and pull-down energy demands within a range of 55°F to 83°F, Thermal zones limited to 300 sf at the perimeter 15' (no more than 1 private office) and 800 sf interior</td>
<td>Baseline features and add control or provide that surface temperatures are ±7°F of the air temperature, Thermal zones limited to 300 sf at the perimeter 15' (no more than 1 private office) and 800 sf interior</td>
<td>P+ features and add control or provide that surface temperatures are ±2°F of the air temperature, or inversely offset expanded air temperature ranges and do not form condensation.</td>
<td>P++ and occupant controlled surface temperatures and optimized air at 75-80°F cooling 65-72°F heating</td>
<td>Baseline: No P+: No P++: Yes HP: Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>System assumptions and predominant enhancements</strong></td>
<td>All Air VAV (incl. DOAVS @ $0.39/gsf)</td>
<td>All Air VAV, fine zone control, enhanced enclosure thermal</td>
<td>P+ VAV DA, and Radiant surfaces (ext wall and 15' perimeter)</td>
<td>(P++) and add personal controls (sub-zoning)</td>
<td></td>
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<td><strong>Humidity Control</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Performance</strong></td>
<td>Maximum 62°F dew point</td>
<td>RH setpoint (Historic annual average at indoor dry bulb temperature = 70°F, default 45%RH), Class C control (no short term RH range), 25% to 75% seasonal setpoint adjustment, and 62°F dew point maximum. Architectural &quot;medium vulnerability&quot; woodwork present. No archival storage (fabric, photos, books, art)</td>
<td>RH setpoint (Historic annual average at indoor dry bulb temperature = 70°F, default 45%RH), Class A controlled range of +/- 5% RH short term, +/- 10% seasonal setpoint adjustment, and 62°F dew point maximum. Architectural &quot;high vulnerability&quot; woodwork present. No archival storage (fabric, photos, books, art)</td>
<td>RH setpoint (Historic annual average at indoor dry bulb temperature = 70°F, default 45%RH), Class A controlled range of +/- 5% RH short term, +/- 10% seasonal setpoint adjustment (OR +/- 10% RH and NO seasonal setpoint adjustment), and 62°F dew point maximum. Architectural &quot;high vulnerability&quot; woodwork present. No archival storage (fabric, photos, books, art)</td>
<td></td>
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<tr>
<td><strong>System assumptions and predominant enhancements</strong></td>
<td>Chilled water coils in central AHU, no auxiliary equipment</td>
<td>Add moisture recovery in dedicated outside air ventilation system</td>
<td>P+ system and add central system or dedicated space humidifiers</td>
<td>P++ system and add purpose-built spaces for exhibit, use, or storage</td>
<td>Baseline: No P+: Yes P++: Yes HP: Yes</td>
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**Air Movement**
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<tr>
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<th>Baseline</th>
<th>P+</th>
<th>P++</th>
<th>HP</th>
<th>Verification</th>
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<tr>
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<td>ASHRAE 55-2010</td>
<td>ASHRAE 55-2010</td>
<td>ASHRAE 55-2010</td>
<td>ASHRAE 55-2010</td>
<td>ASHRAE 55-2010; Cx M&amp;V: ASHRAE 1.1 SMACNA; Plans &amp; Specs: ASHRAE 1.1; POE: HP: Yes</td>
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<td>Reference</td>
<td>Less than 40 fpm at occupied level</td>
<td>Occupant controlled between 20 and 150 fpm</td>
<td>Occupant controlled between 20 and 150 fpm</td>
<td>Same as P++</td>
<td>Baseline: No; P+: Yes; P++: Yes; HP: Yes; HP: Yes; HP: Yes; HP: Yes; HP: Yes</td>
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<tr>
<td>Performance</td>
<td>All Air VAV</td>
<td>Multi-person space fans, up to 6 people/fan</td>
<td>1 person space fans</td>
<td>Same as P++</td>
<td>Baseline: No; P+: Yes; P++: Yes; HP: Yes; HP: Yes; HP: Yes; HP: Yes; HP: Yes</td>
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<tr>
<td>System assumptions and</td>
<td></td>
<td></td>
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<tr>
<td>predominant enhancements</td>
<td></td>
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<tr>
<td>Reference</td>
<td>Active pressure control by floor to achieve 0.05” w.c. or less positive building pressure when occupied, and when outside dewpoint is higher than 47°F when unoccupied.</td>
<td>Maintain building perimeter zones at 0.05” w.c. positive with respect to outdoor; control per exposure per floor when outside dewpoint is higher than 47°F when unoccupied.</td>
<td>Same as P++, except allow mandatory negative pressure spaces at building perimeter and provide active envelope cavity pressurization at 0.02” w.c. positive with respect to interior occupied space when outside temperature drops below dew point of inside air.</td>
<td>Same as P++, except allow mandatory negative pressure spaces at building perimeter and provide active envelope cavity pressurization at 0.02” w.c. positive with respect to interior occupied space when outside temperature drops below dew point of inside air</td>
<td>Baseline: Yes; P+: Yes; P++: Yes; HP: Yes; HP: Yes; HP: Yes; HP: Yes; HP: Yes</td>
</tr>
<tr>
<td>Performance</td>
<td>Central AHU and EF with flow tracking</td>
<td>Add façade SP (1 per 3 floors in height) and enhanced box control</td>
<td>Add branch duct for 0.15 cfm/sf façade surface</td>
<td>Add indoor dew point sensors and enhanced control algorithms.</td>
<td>Baseline: Yes; P+: Yes; P++: Yes; HP: Yes; HP: Yes; HP: Yes; HP: Yes; HP: Yes</td>
</tr>
<tr>
<td>System assumptions and</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>predominant enhancements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reference</td>
<td>30% reduction in energy usage compared to an ASHRAE Standard 90.1-2007</td>
<td>40% reduction in energy usage compared to an ASHRAE Standard 90.1-2007</td>
<td>50% reduction in energy usage compared to an ASHRAE Standard 90.1-2007</td>
<td>The expected annual EUI when the building is designed in compliance with a goal to achieve zero-net-energy (ZNE)</td>
<td>Baseline: No; P+: No; P++: No; HP: No; HP: No; HP: No; HP: No; HP: No; HP: No; HP: No</td>
</tr>
<tr>
<td>Whole Building Energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole-Building Carbon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Building Enclosure

Click the cells below to choose a level of standard for each attribute.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Baseline</th>
<th>P+</th>
<th>P++</th>
<th>HP</th>
<th>Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>M&amp;O</td>
</tr>
<tr>
<td>Thermal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall (U-Value)</td>
<td>0.124-0.057</td>
<td>0.084-0.045</td>
<td>0.064-0.037</td>
<td>0.33</td>
<td>ASHRAE 90.1 2010</td>
</tr>
<tr>
<td>Fenestration (U-Value)</td>
<td>0.70-0.35</td>
<td>0.60-0.20</td>
<td>0.35-0.10</td>
<td>0.35-0.10</td>
<td>ASHRAE 189.1 2010</td>
</tr>
<tr>
<td>Roof (U-Value)</td>
<td>0.063-0.048</td>
<td>0.048</td>
<td>0.039-0.28</td>
<td>0.017</td>
<td>HP ZNEB</td>
</tr>
<tr>
<td>Air Leakage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole Building (cfm/sf@75Pa)</td>
<td>0.8</td>
<td>0.4</td>
<td>0.25</td>
<td>0.1</td>
<td>WB ASTM E779</td>
</tr>
<tr>
<td>Wall (cfm/sf@75Pa)</td>
<td>0.03</td>
<td>0.037</td>
<td>0.015</td>
<td>0.1</td>
<td>WB ASTM C1000</td>
</tr>
<tr>
<td>Fenestration (cfm/sf@300Pa)</td>
<td>0.3</td>
<td>0.06</td>
<td>0.03</td>
<td>0.02</td>
<td>WB ASTM E1188</td>
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<tr>
<td>Water Penetration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enclosure (PSF from Pressure Test)</td>
<td>0.624</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>ASTM E331</td>
</tr>
<tr>
<td>Moisture Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acoustics</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>NTC</td>
<td>&lt;35</td>
<td>30-35</td>
<td>25-30</td>
<td>&gt;25</td>
<td>ASTM E1332-10A</td>
</tr>
<tr>
<td>OITC</td>
<td>27-35</td>
<td>27-40</td>
<td>30-45</td>
<td>35-50</td>
<td>ASTM E1332-10A</td>
</tr>
</tbody>
</table>
P100 Online

• Frequent P100 Updates Catalogued and Posted Online
• Online information about Impending Changes
• Online Forum for P100 idea exchange
OPR Tool

• Building security process implementation in a multihazard environment, and how this can improve overall safety and performance at reasonable costs.

• Application of modern decision-making concepts, such as risk, resiliency, performance-based design (PBD), and life cycle analysis (LCA) in a unified security framework.

• High-performance issues as they relate to building security.
## The OPR Project Team

### Management

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earle Kennett (Program Manager)</td>
<td>National Institute of Building Sciences</td>
</tr>
<tr>
<td>Roger Grant (Project Manager)</td>
<td>National Institute of Building Sciences</td>
</tr>
<tr>
<td>Philip Schneider</td>
<td>National Institute of Building Sciences</td>
</tr>
</tbody>
</table>

### Architectural Committee

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wagdy Anis, FAIA (Chair)</td>
<td>Wiss, Janney, Elstner Associates, Inc.</td>
</tr>
<tr>
<td>Jeff Fullerton</td>
<td>Acentech</td>
</tr>
<tr>
<td>Paul Male</td>
<td>Faithful &amp; Gould</td>
</tr>
</tbody>
</table>

### Fenestration Committee

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joe Deringer, AIA (Chair)</td>
<td>Institute for the Sustainable Performance of Buildings</td>
</tr>
<tr>
<td>J. Elliot Nahman</td>
<td>Institute for the Sustainable Performance of Buildings</td>
</tr>
<tr>
<td>Joseph Valancius, PE</td>
<td>Karagozian and Case</td>
</tr>
</tbody>
</table>

### Mechanical Committee

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>James Woods, PhD, PE (Chair)</td>
<td>James Woods Consultant</td>
</tr>
<tr>
<td>Kenneth Schram</td>
<td>Syska, Hennessey Group, Inc.</td>
</tr>
</tbody>
</table>

### Structural Committee

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bob Smilowitz, PhD, PE (Chair)</td>
<td>Weidlinger Associates Inc.</td>
</tr>
<tr>
<td>Ross Cussen</td>
<td>Weidlinger Associates Inc.</td>
</tr>
<tr>
<td>Walter Hartnett</td>
<td>Israel Berger Associates, Inc.</td>
</tr>
<tr>
<td>Marc Weissbach</td>
<td>Israel Berger Associates, Inc.</td>
</tr>
</tbody>
</table>

### Owner Committee

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mohammed Ettouney, PhD, PE (Chair)</td>
<td>Weidlinger Associates Inc.</td>
</tr>
<tr>
<td>Mark Sands, PE</td>
<td>Performance Building Systems</td>
</tr>
<tr>
<td>Daniel Lemieux</td>
<td>Wiss, Janney, Elstner Associates, Inc.</td>
</tr>
</tbody>
</table>
Owners Performance Requirements and the OPR Tool

The OPR Tool is a web-based system to:

- Establish Performance-based Project Requirements for Building Owners
- Evaluate tradeoffs between high performance goals required and energy and environmental demands, threats, hazards, and building functions
- Performance goals may range from minimum standards (baseline) to high performance solutions (benchmarks)
- Produces Owner Project Requirements that initiate the Commissioning Process in keeping with NIBS and ASTM standards
- Limited to Building Enclosures in this version
The Enclosure Challenge

• Competing Demands between Energy, Environmental and Resilience
• First line of Defense
• Integrated Systems of disparate Components
• Prescriptive Codes mandate minimum performance
• Increased performance requires evaluation, analysis and testing
High Performance-based Design

• Takes place early in the lifecycle of a project – before design
• Focuses on functional performance, not prescriptive solutions
• The project owner leads the process working with design and cost planning specialists as needed
• Evaluate range of alternatives based on Total Cost of Ownership in addition to First Costs
• Includes Measurable Goals and Reference Standards
• Develop a plan that aligns level of performance – from baseline to high performance – with the Owner’s needs
National Priority


• Title IV – Sec 401. Definitions - High Performance Building - The term “high-performance building” means a building that integrates and optimizes on a life cycle basis all major high performance attributes, including energy conservation, environment, safety, security, durability, cost-benefit, productivity, sustainability, functionality, and operational considerations.
Attributes Relevant to the Building Envelope as Defined in EISA 2007

- **Energy Conservation**
  - Thermal Transfer
  - Air Leakage
  - Renewable Energy
  - Day Lighting

- **Environment**
  - Environmental Footprint
  - Acoustic Transmission

- **Safety**
  - Seismic Resistance
  - Wind Resistance
  - Flood Resistance
  - Fire Resistance

- **Security**
  - Blast Protection
  - Chemical/Biological/Radio-logical Protection
  - Ballistic Protection

- **Durability**
  - Service Life
  - Water Vapor Migration
  - Water Penetration

- **Operational**
  - Interruption of Operations
High Performance Building – Key Concepts

• **Attributes** are specific performance characteristics.
• **Demands** are natural forces and man-made events that impact a building
• **Metrics** are the quantifiable measurements used to gauge a level of performance.
• **Systems** are the major functional parts of a building
• **Baselines** are performance levels that are currently being achieved that can be used for comparison.
• **Benchmarks** are points of reference for evaluating specific levels of performance.
• **Verification** is the method by which a benchmark can be validated or ascertained.
High Performance Building – Key Concepts

- **Resilience** – a function of Robustness, Resourcefulness and Recovery is a product of quality of function loss and the time to recover.

- **Risk** – a function of hazard extent times the probability of occurrence and the resulting consequences or outcomes.

- **Operational** – a function of performance level and resulting outcomes from that performance level at a given demand level.
The High Performance Design Process

- **Attributes**
  - Safety
  - Security
  - Energy
  - Environment
  - Durability

- **Demands**
  - Man-made Hazards
  - Natural Hazards
  - Environmental Conditions

- **Systems**
  - Architectural
    - Mechanical
    - Fenestration
    - Structural

- **Performance**
  - Baseline
  - Improved Performance
  - Enhanced Performance
  - High Performance

**Outcomes**
- Risk
  - Relative/Monetary

- Resilience
  - Continued Operations

- Operational
  - Costs
Enclosure Performance - Architectural

Sub-Attributes:

- Water penetration
- Moisture migration
- Air leakage
- Thermal transfer
- Acoustic transmission

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Metric</th>
<th>Baseline Value (NOW)</th>
<th>Benchmark Value (NEW)</th>
<th>Future Value (NEXT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Penetration</td>
<td>ASTM E1105 – ASTM E 331</td>
<td>No uncontrolled water penetration</td>
<td>Zero Leakage Redundancy</td>
<td>Zero Leakage Durability</td>
</tr>
<tr>
<td>Moisture Migration</td>
<td>% RH equilibrium moisture content in materials inboard of drainage plane</td>
<td>No more than 70-80% RH. Code req. or default VB</td>
<td>Understanding of drying potential and need for, location of VB</td>
<td>Data collection to refine understanding</td>
</tr>
<tr>
<td>Air Leakage</td>
<td>ASTM E 779</td>
<td>0.30 cfm/ft² @ 0.3° w.g.</td>
<td>0.10 cfm/ft² @ 0.3° w.g.</td>
<td>Durability</td>
</tr>
</tbody>
</table>
Enclosure Performance - Structural

Security and Safety Sub-Attributes:

- Blast protection
- Ballistic protection
- Seismic resistance
- Wind resistance
- Flood resistance
- Fire protection

<table>
<thead>
<tr>
<th>Range</th>
<th>Charge Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>100ft</td>
<td>M H</td>
</tr>
<tr>
<td>300ft</td>
<td>L M H</td>
</tr>
<tr>
<td>1000ft</td>
<td>Out of Range</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Metric</th>
<th>Baseline Value</th>
<th>Benchmark Value</th>
<th>Future Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blast Resistant</td>
<td>Debris Hazard (ASTM 1642)</td>
<td>Low Hazard (Level 3B/4) Glass Cracks, debris propelled into occupied space (no further than 10 ft. from the window.)</td>
<td>Minimal Hazard (Level 2/3A) Glass Cracks, debris remains in frame or falls to floor (no further than 3.3 ft. from the window.)</td>
<td>No Break (Level 1) Glass does not crack.</td>
</tr>
<tr>
<td>Glass</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blast Resistant</td>
<td>Debris Hazard (based on</td>
<td>Low Hazard (Level 3B/4) Panel disengages, debris propelled into occupied space (no further than 10 ft. into occupied space.)</td>
<td>Minimal Hazard (Level 2/3A) Panel damaged, debris remains in frame or falls to floor (no further than 3.3 ft. into occupied space.)</td>
<td>No Damage</td>
</tr>
<tr>
<td>Metal Panel</td>
<td>ASTM 1642)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Enclosure Performance - Mechanical

Sub-Attributes:

- Chemical, Biological, Radiological protection
- Environmental (Carbon) footprint
- Renewable energy
Enclosure Performance - Fenestration

Sub-Attributes:

- Thermal transfer
- Day lighting
- Natural Ventilation
- Ballistic resistance
- Seismic resistance
- Wind resistance
Selecting Levels of Performance

- Many High Performance Attributes Interact at the Envelope
- Owners need to balance competing requirements to achieve highest overall performance
- Requires multi-attribute analysis
- Difficult to do manually
Economic Outcomes

- Costs
  - Capital Expense for Demand/Performance Upgrades
  - Interaction Impacts on Upgrade Costs
  - Operations Costs
  - Capital Recovery Costs
  - Exposure
Owner Project Requirements (OPR) Tool

- Web-based planning tool for High Performance Based Design
- Establish requirements and view results
- Change performance objectives and evaluate scenarios
- Develop a performance based plan for the design team
- Coordinated with ASTM Cx standard
Applying the OPR Tool to Evaluate a Project

• Relevant during Early Planning Phases of Project
• Collect Project Information (Input Parameters)
• Create Project and Scenarios
  • Use Scenarios to test Impact of Increasing Performance
  • Determine most viable Scenarios and Compare Results
  • Select best fit to Needs
• Generate Performance Report for the Design Team
Applies to New or Existing Office Building Enclosure Retrofits

Image courtesy Karagozian & Case

Image courtesy Weidlinger & Associates, Inc.
Create A Project – New Building

Input Project Information

Office Building Project

Scenario Information
- Scenario Name: High Performance Test
- Scenario Type: New Building Construction
- Gross Building Area: 30000 SF
- Total Floors: 3
- Quality Class: G2C2 (Class 2)
- State: MA
- Climate Zone: Cool–Humid (Humid: 5400 < HDD<86°F < 72°F)

Project Performance Benchmark
- Risk: RL (Low Risk)
- Resilience: HRc (High Resilience)
- Operational: HP (High Performance)

Evaluate Results

Project Benchmarks
- OPERATIONS
  - Enhanced Performance
  - Enhanced Resilience
  - Moderate Risk
- RESILIENCE
  - Enhanced Resilience

Summary
- Net Energy
- Safety
- Security
- Facility Improvement

National Institute of BUILDING SCIENCES
Create A Project – Existing Building

Input Condition Information

- Scenario Type: Existing Building Retrofit
- Principal Project Purpose: Functional Use Adaptations
- Originally Constructed: 1954; Last Code Upgrade: 1984
- Exterior Wall System: Load Bearing
- Facility Condition Assessment:
  - Roof Frame/Deck: Poor
  - Roofing System: Poor
  - Exterior Wall System: Poor
  - Window System: Poor
  - Interruption of Operations: Coordinated Interruption Expected

Select Strategy

- Recommended Exterior Wall: L1 - Retrofit
- Exterior Wall: L1 - Retrofit
- Recommended Roofing System: L1 - Repair
- Roofing System: L2 - Recover/Thermal Upgrade

- Portion of Enclosure to be upgraded:
  - Exterior/Common Wall Percent: 100%
  - Roofing Percent: 100%
Compare Alternative Scenarios
**OPR Report (Version: 1.0)**
Prepared By: Mark Sands, Performance Building  
Prepared on: Monday, January 02, 2012

### Project Information
- **Scenario Name:** ROC 2 - P++ and RI--  
- **Project Name:** Regional Office Center  
- **Location:** Bemidji, MN  
- **Gross Building Area:** 100,000 SF  
- **Number of Floors:** 2 (Including 0 Below Grade)  
- **Quality:** Class B

### Performance Targets:
- P++ Enhanced Performance  
- R++ Enhanced Resilience  
- RI-- Moderate Risk

### Project Type:
- New Building Construction

### Facility Safety and Security Guide

<table>
<thead>
<tr>
<th>Safety</th>
<th>Risk Summary[1]: Medium: 5 – 7</th>
<th>Resilience Summary[1]: High: 8 – 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seismic</td>
<td>Benchmark: Reduced Damage</td>
<td>Performance Standard(s)</td>
</tr>
<tr>
<td></td>
<td>Level of Damage and Continuity of Operations: Moderate damage to cladding may occur but cladding remains anchored to building structure. Seals and gaskets may tear and ability to provide weather protection is locally compromised. Glass edge damage may occur and glass may fall off setting blocks, but glass breakage is mitigated. The building remains safe to occupy; structural and nonstructural repairs are minor. There shall be no failure or gross permanent distortion of the building envelope system anchorage and framing. Minor cracking and deformation of cladding may occur, but is not expected. Interstory drift limits at structures: 0.0075h to 0.01h, h = story height.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Performance Standard(s): IBC-2009, ASCE 7-05, ASCE 41-06, NEHRP Recommended Provisions for Seismic Regulations, FEMA E-74, ASTM E 2026</td>
<td></td>
</tr>
</tbody>
</table>

### Seismic Risk[1]: Medium: 3 – 5

### Seismic Resilience[2]: High: 6 – 8

### Financial Results
- Capital Expens[e[3]: $265K — $266K ($3.0/SF — $3.9/SF)
- Exposure[4]: $613K — $1,139K ($6.1/SF — $11.4/SF)
Using the OPR Report

• Puts Objective Focus on Performance
• Documents Performance Expectations and Measurement Standards
• Identifies Energy Consumption and Carbon Footprint Targets
• Provides Relative Financial Evaluation
• Establishes Intent for Owner and Design Team
• Promotes Creativity and Teamwork
• Starts your Project off on a Track to Success
Technical Report

Organization and Content

The information is arranged in sections in the following order:

- Chapter 1: Introduction
- Chapter 2: Project Approach
- Chapter 3: The Owner Performance Requirements (OPR) Process
- Chapter 4: The OPR Tool in the Planning and Design Process
- Chapter 5: Technical Analysis
- Chapter 6: OPR Model Algorithms and Decision-Making Methodologies
- Chapter 7: Validation and Verification of Results
- Chapter 8: Conclusions and Recommendations

Appendices

- Appendix A: Attribute Performance Summary Tables
- Appendix B: EnergyPlus Simulation Analysis
- Appendix C: Detailed Mechanical Analysis
Second Phase

- Extend Phase I (Enclosure) to cover Whole Building Functions for:
  - Architectural – Phase I + shading
  - Structural – add structure and foundations
  - Electrical – lighting and plug loads
  - Mechanical – add whole building load analysis
- Add coverage of Internal Demands and Threats
- Working with team from Phase I
- Completion end of 2012
Welcome, Roger Grant!

Click here to start working on a project.

Or use the navigation links below the Owner Performance Requirements Tools logo.

More about the OPR Tool...
- Tool Definitions
- EISA 2007 Act
- DHS HP ID Program
- NIBS HPB Programs

Organization Information
- Organization: National Institute of Building Sciences
- Address: 20 Meetinghouse Road, Duxbury, MA, 02332
- E-mail: rogergrant@gmail.com

Update Organization Information

Terms of Use Agreement / Disclaimer:

The information and project performance requirements planning tool appearing on this site is provided for the use of the building industry to assist in achieving performance-based design of buildings. It is intended to provide assistance to building owners to evaluate performance options and communicate intent to design professionals. The building performance and cost information is for planning purposes only and should be further evaluated by design and costing professionals prior to use in an actual building project. Neither the National Institute of Building Sciences, NIBS nor the Department of Homeland Security (DHS) conducts its own tests to verify the results generated or included in actual performance. Use of this site does not imply endorsement by NIBS or DHS of any material contained herein or output generated from the use of the Owner Performance Requirements (OPR) tool. Neither NIBS or DHS represents or warrants with respect to any of the information or results obtained that the published data and calculations are accurate or complete, or that the performance results of buildings designed to the targets identified will achieve any specific performance goals. NIBS and DHS assume no liability with respect to the use of, or for damages resulting from the use of, the information published here or the performance requirements identified by the OPR Tool.
• WHOLE BUILDING DESIGN GUIDE (WBDG)
  BUILDING ENVELOPE DESIGN GUIDE

• GSA PERFORMANCE BASED DESIGN STANDARD
  ENCLOSURE SYSTEM

• DHS OWNERS PROJECT REQUIREMENTS TOOL
  FOR THE BUILDING ENCLOSURE