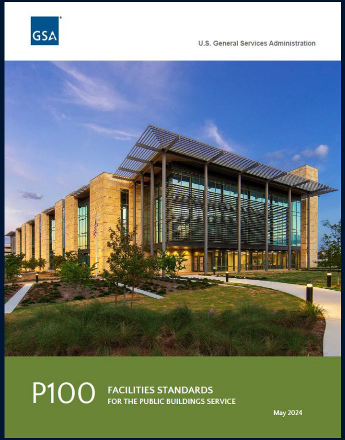
2024 P100 Training



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- GSA Participants who attend 95% of the session will be provided CLPs
- If you join by phone, please email your name and the phone number you joined with so we can record your attendance. Address email to: mark.kutchi@gsa.gov & benjamin.pisarcik@gsa.gov
- Mute microphone when not speaking
- Use Q & A to ask questions; questions will be taken at specific intervals throughout and at the end of the presentation

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- Approach each topic in a positive and constructive manner
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- Slides will be added in a few days but recordings will take a few weeks.
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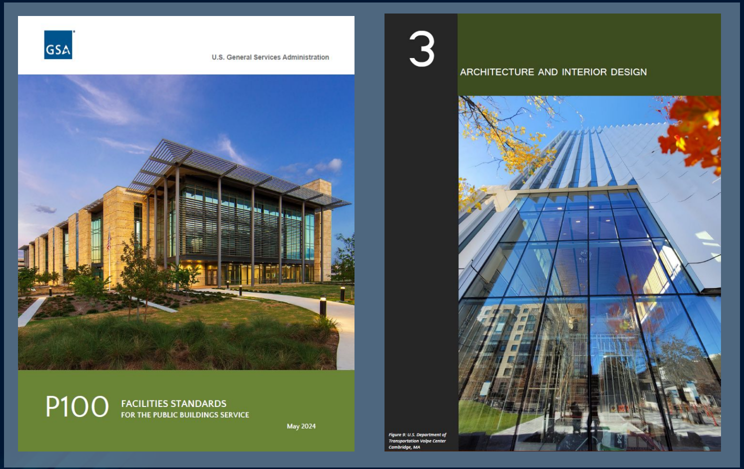
Training

Building Envelope
Chapter 3



This session is being recorded.

Presenter

Jason Danielson AIA, LEED AP, QCxP
Building Envelope National Architect

Chapter 3.1
Enclosure Performance Table

3.1 ENCLOSURE PERFORMANCE TABLE

Envelope – Natural Hazard	
Seismic Resistance	
Baseline	Life Safety
Tier 1	Reduced Damage
Tier 2	Immediate Occupancy
Tier 3	Operational
M & V	Performance Mockup Testing
Plans & Specs	Provide Connection details and complete load path information
Calculations & Analysis	IBC, ASCE 7, FEMA356, ASTM E 2026, Project team Calculations & Inspection
References	
Basis of Design	Describe seismic resistance design assumptions
Construction Verification	
Windborne Debris Resistance	
Baseline	Comply with IBC
Tier 1	Large Missile < 30-ft from Grade & Small Missile > 30-ft of Grade

Flood Resistant Design moved to Chap 4

P100 v2022

Basis of Design	Describe windborne debris resistance des
Construction Verification	Witness mockup test when provided
3.1.2 Envelope - Serviceability	
Wind Resis	
Baseline	Deflection within code limits. Deflection lir breakage at design load.
Tier 1	Deflection less than code limits. Deflectio probability of breakage at design load
Tier 2	N/A
Tier 3	N/A
M & V	ASTM E 330, ASTM E 1300, Wind Tunne

Table 3.1 sub-numbering returns for easier navigation

P100 v2024

1.3.9
Facility Definitions

Essential Facilities

Critical Action Facilities

Mission Critical Facilities

1.3.9 FACILITY DEFINITIONS

1.3.9.1 ESSENTIAL FACILITIES

The International Building Code (IBC) has defined essential facilities as "Any building and other structure that are intended to remain operational in the event of extreme environmental loading from flood, wind, snow or earthquake". Buildings and other structures designated as essential facilities include but are not limited to: Group I-2 occupancies that have surgery or emergency treatment facilities, aviation control towers, or fire and police stations.

1.3.9.2 CRITICAL ACTION FACILITIES

The Department of Homeland Security Federal Emergency Management Agency has defined a facility as "Critical Action" when even a slight chance of flooding is too great. If critical action structures must be located within a 1-percent-annual-chance (also known as the 100-year), 0.2-percent-annual-chance (500-year) or the Federal Flood Risk Management Standard (FFRMS) floodplain (i.e., there are no practicable alternatives), critical infrastructure must be elevated above the applicable floodplain elevation. Critical actions include, but are not limited to:

- storage of irreplaceable records
- the production, use, or storage of highly volatile, flammable, explosive, toxic, or water-reactive materials
- hospitals and nursing homes, and housing for the elderly, which are likely to contain occupants who may not be sufficiently mobile to avoid the loss of life or injury during flood and storm events.

The critical action designation is established under the decision-making process outlined in the accompanying Desk Guide for GSA Order PBS 1095.8A, Floodplain Management. The U.S. Courts has determined that all new court houses are critical action facilities. Refer to Chapter 4, Flood Resistant Design Requirements.

1.3.9.3 MISSION CRITICAL FACILITIES

The tenant will determine this designation during project development. A mission critical facility contains any operation that, if electrical supply is interrupted, will cause a negative impact on business activities, ranging from losing revenue to jeopardizing legal conformity, and loss of life. Examples may include data centers, hospitals, laboratories, public safety centers, court houses, land ports of entry, research facilities, law enforcement, and critical file and payroll centers. See Chapter 1, Resilience, Chapter 3, Enclosure, Chapter 5, Wildfire Smoke Mode, and Chapter 6, Primary Distribution for requirements.

The Federal Data Center Enhancement Act notes a "growing need for Federal agencies to use data centers and cloud applications that meet high standards for cybersecurity, resiliency, and availability". The minimum requirements applicable to data centers will be documented and published by the IT Modernization Division (GSA). Please contact dccoi@gsa.gov for more information.

Chapter 3

Water Penetration Resistance

Moisture and Condensation Control

Air Tightness

Thermal Performance

Building Enclosure Commissioning

Service Life

Chapter 3.1.3
Enclosure Performance Table

3.1.3 Water Penetration Resistance	
	Fenestration
Baseline	6.24 psf Design Pressure
Tier 1	10 psf Design Pressure, Minimum Design - ASCE 7 105 mph+ Locations
Tier 2	15 psf Design Pressure, Minimum Design - Mission Critical Facilities, Highrise, or ASCE 7 115 mph+ Locations
Tier 3	18 psf Design Pressure, Minimum Design - ASCE 7 140 mph+ Locations
M & V	ASTM E331, ASTM E1105, AAMA 501.1, ASTM E2268, AAMA 501.2, No reduction allowed for water infiltration field testing
Plans & Specs	Yes, Water Leakage = Uncontrolled Water Penetration, Delete Test Pressure Upper Limits from AAMA 101
Calculations & Analysis	ASCE 7, AAMA 101
References	
Basis of Design	Describe fenestration water penetration resistance level utilized in the design.
Construction Verification	CxP to witness Performance Mock-Up Test outlined in ASTM E331, E1105 as applicable

Water Penetration Resistance / Fenestration

Replaced CW and AW references with clear Design Pressure requirements

Ties Design Pressure requirements to ASCE 7 wind speeds and Facility types based on risk

No 1/3 reduction in field testing pressures

Chapter 3.1.3
Enclosure Performance Table

Verification		[illegible]
		Below Grade Waterproofing
Baseline		Relieve hydrostatic pressure on substructure walls and allow water drainage to the level of the drain. Membrane waterproofing must be fully bonded to the substrate and seamless. Below-grade waterproofing must be applied to the positive pressure side and must be covered by a protection drainage and protection course.
Tier 1		Baseline AND Tier 1 designation in Ground Water Control Provide a system that does not rely on unpredictable or difficult to control site conditions to develop and maintain a water-tight installation. Complete "Bathtub" waterproofing in the presence of water table to mitigate demand on dewatering system. May require foundation modification. System must not rely on compression to maintain the performance criteria, allowing construction activities and future earthwork without compromising the system.
Tier 2		Tier 1 AND Includes redundant below grade waterproofing systems, such as a water repellant additive to the concrete masonry foundation walls.
Tier 3		Tier 2 AND Include secondary drainage layer within below-grade horizontal concrete slab assemblies.
M & V		ASTM E1643, ASTM E1745, ASTM E1993
Plans & Specs		[illegible] Section 1805
Calculations & Analysis		IBC, Section 1805
References		
Basis of Design		Describe waterproofing system for below grade waterproofing and test method proposed.
Construction Verification		CxP must witness below grade waterproofing test.

3.1.4 Moisture and Condensation Control

Water Penetration Resistance / Below Grade Waterproofing

ASTM testing methodology referenced

Chapter 3.1.3
Enclosure Performance Table

Verification	CxP to test emergency back-up pump, where applicable.
Below Grade Waterproofing	
Baseline	Relieve hydrostatic pressure on substructure walls and allow water drainage to the level of the drain. Membrane waterproofing must be fully bonded to the substrate and seamless. Below-grade waterproofing must be applied to the positive pressure side and must be covered by a protection drainage and protection course.
Tier 1	Baseline AND Tier 1 designation in Ground Water Control Provide a system that does not rely on unpredictable or difficult to control site conditions to develop and maintain a water-tight installation. Complete "Bathtub" waterproofing in the presence of water table to mitigate demand on dewatering system. May require foundation modification. System must not rely on compression to maintain the performance criteria, allowing construction activities and future earthwork without compromising the system.
Tier 2	Tier 1 AND Includes redundant below grade waterproofing systems, such as a water repellant additive to the concrete masonry foundation walls.
Tier 3	Tier 2 AND Include secondary drainage layer within below-grade horizontal concrete slab assemblies.
M & V	ASTM E1643, ASTM E1745, ASTM E1993
Plans & Specs	IBC, Section 1805
Calculations & Analysis	IBC, Section 1805
References	
Basis of Design	Describe waterproofing system for below grade waterproofing and test method proposed.
Construction Verification	CxP must witness below grade waterproofing test.
3.1.4 Moisture and Condensation Control	

Water Penetration Resistance / Roofing and Horizontal Waterproofing / Testing and Monitoring

Reminder to include conductivity scope for testing

Test before any placing overburden

Overburden provisions for passive and active monitoring

3.2.3.1
Water Penetration Resistance / Fenestration

2 test samplings per condition typical minimum

Include air and water testing for untested systems

No 1/3 reduction for field tests

3.2.3 WATER PENETRATION RESISTANCE

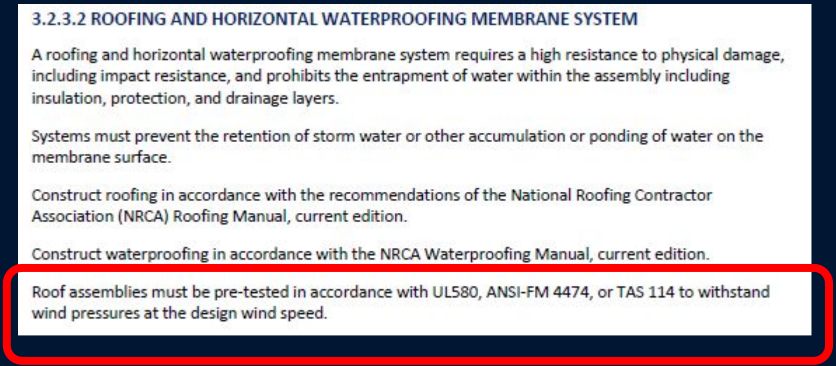
3.2.3.1 FENESTRATION

Fenestration water penetration resistance requires calculation or wind tunnel testing to determine the project-specific design pressure (DP) and water penetration test pressure. Requirements must be communicated to the contracting parties in the construction documents. Water penetration resistance can be confirmed with product testing, laboratory mock-up testing, field mock-up testing, and in-situ field testing. Consideration must be given to prescriptive minimum sampling requirements based on the type of test and number of assemblies to be included. Typically 2 samplings per condition is the minimum, but the design team may determine more are appropriate. Proposed fenestration systems without prior satisfactory testing results must include air and water infiltration testing.

- The maximum limits provided in AAMA 101 have been removed to allow higher test pressures as warranted by the project conditions. "No Uncontrolled Water Penetration" is also a departure from the AAMA 101 definition and does not allow water penetration on any interior surface that is not drained to the exterior or otherwise controlled.
- The 1/3 reduction of test pressure for water infiltration field testing referenced in AAMA 503 have been removed. Test pressures referenced in Table 3.1 apply to field tests, as representative of the performance of the delivered final condition to the owner. Team may elect to perform laboratory tests at a higher pressure.

3.2.3.2
Water Penetration Resistance / Roofing and Horizontal Membrane

Roof assemblies pre-tested to UL, FM or TAS



3.2.3.2 ROOFING AND HORIZONTAL WATERPROOFING MEMBRANE SYSTEM

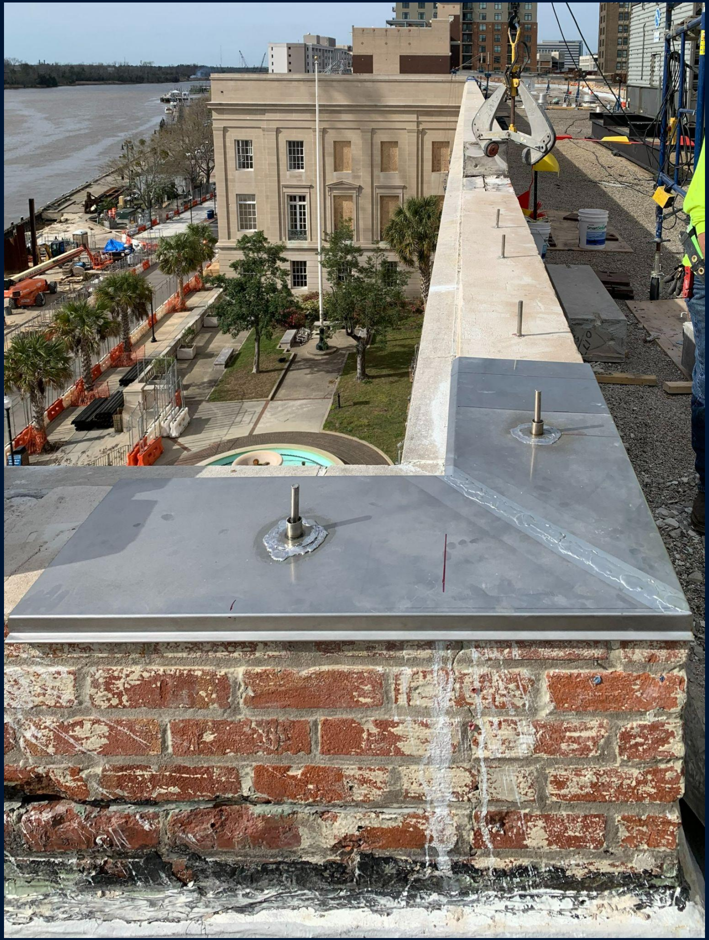
A roofing and horizontal waterproofing membrane system requires a high resistance to physical damage, including impact resistance, and prohibits the entrapment of water within the assembly including insulation, protection, and drainage layers.

Systems must prevent the retention of storm water or other accumulation or ponding of water on the membrane surface.

Construct roofing in accordance with the recommendations of the National Roofing Contractor Association (NRCA) Roofing Manual, current edition.

Construct waterproofing in accordance with the NRCA Waterproofing Manual, current edition.

Roof assemblies must be pre-tested in accordance with UL580, ANSI-FM 4474, or TAS 114 to withstand wind pressures at the design wind speed.



Chapter 3

Water Penetration Resistance

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Chapter 3.1.4
Enclosure Performance Table

Verification	CxP must witness below grade waterproofing test.
3.1.4 Moisture and Condensation Control	
Moisture Control Opaque Assemblies	
Baseline	Design of the above-grade building enclosure must be demonstrated early in the design development. ASHRAE 160, Criteria for Moisture Control Design Analysis in Buildings, is an acceptable basis of design.

	Provide monitoring of "vulnerable" exposures of the assemblies that alerts the building staff to approaching conditions that may be harmful to the assembly or the occupants.
Tier 3	Tier 2 AND All thermal controls are outboard of the air and vapor control layers of the assembly.
M & V	ASTM C1601, ASTM C1193, ASTM E1643, ASTM E1745, ASTM E1993
Plans & Specs	Yes
Calculations & Analysis	ASHRAE 160
References	
Basis of Design	Document requirement in basis of design
Construction Verification	CxP to witness tests outlined in ASTM C1601, if applicable

Moisture and Condensation Control / Moisture Control Opaque Assemblies

Expanded list of QC testing standards

Chapter 3.1.4
Enclosure Performance Table

Condensation Resistance Fenestration	
Baseline	Condensation resistance of fenestration is required to ensure no condensation occurs on uncontrolled surfaces based on project-specific interior and exterior design criteria using National Fenestration Rating Council (NFRC) 500 Thermal Analysis and Modeling
Tier 1	Baseline AND AAMA 1503, Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors, and Glazed Wall Sections to verify no condensation on uncontrolled surfaces at project-specific interior and exterior design criteria.
Tier 2	Tier 1 AND Testing on project specific extrusion profiles and assemblies, including typical anchors to verify no condensation on uncontrolled surfaces at project-specific interior and exterior design criteria.
Tier 3	Tier 2 AND Provide a modified AAMA 501.5, Test Method for Thermal Cycling of Exterior Walls to include thermal couples of a full-scale, project specific laboratory mock-up to verify the NFRC 500 analysis.
M & V	NFRC 500 NFRC 102 AAMA 1503 AAMA 501.5 ASTM E2190 IgCC/IGMA Certification
Plans & Specs	NFRC 500 Testing and Modeling to show that no condensation occurs on uncontrolled surfaces based on the interior and exterior design criteria
Calculations & Analysis	NFRC 500
References	
Basis of Design	Document requirement in basis of design
Construction Verification	NFRC 500 and NFRC 102 (test procedure) are intended for the laboratory for establishing ratings, not field testing, so there is no CxP witness activity

3.1.5 Air Tightness

Moisture and Condensation Control / Condensation Resistance Fenestration

Provides background why certain reference standards were referenced for each tier

Expanded list of QC testing standards

3.2.3.5
Green Roofing Systems

Consult with Central Office landscape SME if considering a green roof

3.2.3.5 GREEN ROOFING SYSTEMS

A Green Roof (Vegetated Roof, Rooftop Garden, Landscaped Roof), intensive or extensive, must be designed and constructed in accordance with ASTM E2777-14, Standard Guide for Vegetative (Green) Roof Systems and ASTM E2400M, Standard Guide for Selection, Installation, and Maintenance of Plants for Vegetative (Green) Roof Systems. Project teams must reach out to a regional or central office landscape professional for guidance and approval on appropriate soil media types/ depths, assemblies, and plant palettes to ensure long term health of the living system with reasonable maintenance requirements. Media depth must be greater than 3”.

Access to green roofs must be accomplished by a safe permanent means, and not by ladder, through non-full height windows, or by use of temporary devices such as hoists or lifts. Use 29 CFR §1910.29 Fall Protection Systems and Falling Object Protection criteria and practices to ensure adequate considerations for maintenance access and personnel safety. Access must consider the spatial environment available that is necessary for the efficient transfer of organic material generated by the landscape. If adequate clearance for common tools and the transfer of waste cannot be provided, including both on the roof itself and within the circulation access to the roof, then the green roof should not be considered viable and should not be proposed for the project. Refer to the GSA Preventive Maintenance Guide to ensure the proposed design meets the requirements of Facility Management staff and budget.

Green Roofs must also be installed and maintained in accordance with the requirements in the ICC International Fire Code (IFC) to ensure access and safety.

Blue roof systems for the purpose of water storage and controlled release are prohibited from use.

3.2.4.1
Moisture Control Opaque Assemblies

Analyze the performance of unique or custom opaque assemblies

Use 2D or 3D thermal and hygrothermal tools

ASTM E3054, ISO 10211, CSA ZS010, ASHRAE 1365 RP

3.2.4.2
Condensation Resistance – Fenestration

Analyze the performance of fenestration

2D or 3D thermal and hygrothermal example conditions given

3.2.4 MOISTURE AND CONDENSATE CONTROL

3.2.4.1 MOISTURE CONTROL OPAQUE ASSEMBLIES

Where unique or custom opaque assemblies are proposed, analyze the performance and exposures to ensure the control of moisture and to mitigate the risk of condensation and uncontrolled moisture migration. Implement tools such as two-dimensional or three-dimensional thermal and hygrothermal simulation tools early in the project cycle to evaluate condensation risk. See ASTM E3054.

Condensation risk may be evaluated using dew point calculations following the Glaser Method outlined in the ASHRAE Handbook of Fundamentals under design conditions. For scenarios where transient/dynamic conditions are required, such as changing environmental conditions, moisture storage within materials, impact of thermal mass, one-dimensional or two-dimensional transient hygrothermal simulations with software (e.g. WUFI) may be required. These hygrothermal simulations must follow the ASHRAE 160 standard requirements.

For assemblies where thermal bridging may impact local surface temperatures within the assembly, condensation risk may be evaluated using thermal simulations under design conditions. Condensation risk analysis using thermal simulations must be performed with either two-dimensional or three-dimensional finite element heat transfer analysis and follow applicable simulation standards such as ISO 10211 or CSA Z5010, or follow the approach outlined in ASHRAE 1365 RP.

3.2.4.2 CONDENSATION RESISTANCE–FENESTRATION

Condensation resistance in fenestration is required to ensure no condensation occurs on uncontrolled surfaces based on the interior and exterior design criteria. Condensation resistance may be determined using two-dimensional or three-dimensional thermal simulations. These simulations must include sections of the fenestration and opaque assembly since connection details between the two assemblies may impact the surface temperatures of the fenestration. Thermal simulations must be evaluated following NFRC-500 for fenestration and ISO 10211 or CSA Z5010 for fenestration to opaque assembly details. Three-dimensional thermal simulations may be required for details with highly conductive materials such as aluminum framing or with discrete thermal bridges to evaluate surface temperatures at critical locations such as corners where vertical framing intersects with horizontal framing (e.g. window corners).

Include in the analysis project spandrel panel size and conditions, adjacent assemblies (e.g., transparent vision glazing sections, non-spandrel opaque assemblies), intermediate floor attachments and anchorages, spandrel construction (e.g., backpan configuration, insulation type, cladding type, interior wall construction), and airflow in and around the spandrel assembly. Do not rely on a single interior film coefficient factor.

3.3.7.7
Skylights and Sloped Glazing

Provide a controlled condensate path

develop a rigorous course of design- and construction-phase testing as part of the BECx plan to assure quality and performance.

Skylights and sloped glazing must use low emissivity glass. Placement should be calculated to prevent glare or overheating in the building interior. Provide a controlled path for condensate. Condensation gutters and a path for the condensation away from the framing must be designed.

Consideration must be given to cleaning of all sloped glazing and skylights, including access and equipment required for both exterior and interior faces.

Skylights must be guarded for fall protection or meet OSHA structural requirements.

Chapter 3

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Chapter 3.1.5
Enclosure Performance Table

Verification	testing, so there is no CxP witness activity
3.1.5 Air Tightness	
Fenestration	
Baseline	CW30 Minimum Performance Class
	Curtain wall, window wall and storefront, < 0.3 L/s*m (0.06 cfm/ft) @ 75 Pa (0.3" wc) Performance and durability testing of fenestration assemblies and interface conditions or documented.
Tier 1	Baseline AND Punch windows, AW40 Minimum Performance Class, fixed < 0.5 L/s*m (0.10 cfm/ft) @ 300 Pa (1.2" wc), operable < 1.5 L/s*m (0.3 cfm/ft) @ 300 Pa (1.2" wc) Curtain wall, window wall and storefront, < 0.3 L/s*m (0.06 cfm/ft) @ 300 Pa (0.3" wc) Required for mission critical facilities as defined under 1.3.9.3, Highrise locations, or at locations ASCE 7 115 mph+ Durability Testing as required for Performance Class or as appropriate for the systems anticipated use, whichever is greater.
Tier 2	N/A
Tier 3	N/A
M & V	ASTM E283 ASTM E783 Failure protocol = retest +1 additional sampling per failure.
Plans & Specs	AAMA 101 NAFS
Calculations & Analysis	AAMA 101 NAFS
References	
Basis of Design	Document requirement in basis of design
Construction Verification	CxP to witness Performance Mock-up Test outlined in ASTM E783 and ASTM E283.

Air Tightness / Fenestration

Defined high risk facilities and weather locations meet Tier 1

Clarified requirements for punch windows, curtainwall window wall and storefront conditions

Clarified durability requirements

Chapter 3.1.5
Enclosure Performance Table

Verification		testing, so there is no CxP witness activity
3.1.5 Air Tightness		
		Fenestration
Baseline		CW30 Minimum Performance Class
		Curtain wall, window wall and storefront, < 0.3 L/s*m (0.06 cfm/ft) @ 75 Pa (0.3" wc) Performance and durability testing of fenestration assemblies and interface conditions or documented.
Tier 1		Baseline AND Punch windows, AW40 Minimum Performance Class, fixed < 0.5 L/s*m (0.10 cfm/ft) @ 300 Pa (1.2" wc), operable < 1.5 L/s*m (0.3 cfm/ft) @ 300 Pa (1.2" wc) Curtain wall, window wall and storefront, < 0.3 L/s*m (0.06 cfm/ft) @ 300 Pa (0.3" wc) Required for mission critical facilities as defined under 1.3.9.3, Highrise locations, or at locations ASCE 7 115 mph+ Durability Testing as required for Performance Class or as appropriate for the systems anticipated use, whichever is greater.
Tier 2		N/A
Tier 3		N/A
M & V		ASTM E283 ASTM E783 Failure protocol = retest +1 additional sampling per failure.
Plans & Specs		AAMA 101 NAFS
Calculations & Analysis		AAMA 101 NAFS
References		
Basis of Design		Document requirement in basis of design
Construction Verification		CxP to witness Performance Mock-up Test outlined in ASTM E783 and ASTM E283.

Air Tightness / Enclosure Airtightness (All Six Sides of the Building)

Baseline air infiltration tighter, .17 cfm/sf from .25 cfm/sf

Tier 1 air infiltration match PHIUS

3.2.5.2
Enclosure Air Tightness (all six sides of the building)

Diagrammatically demonstrate continuity of air and thermal barriers on drawings (industry best practice)

Improvement of building envelope performance as part of net zero strategy (industry best practice)

Quantitatively and qualitatively measure existing performance for major modernizations

Include garage doors in energy models where they are integral to air and thermal barriers

3.2.5.2 ENCLOSURE AIR TIGHTNESS (ALL SIX SIDES OF THE BUILDING)

Enclosure air tightness is critical to ensuring the performance of the building enclosure and HVAC systems. The construction of a continuous air barrier is required. Construction documents must demonstrate constructability and clearly illustrate the entire continuity of the air barrier system.

Consider illustrating air and thermal barriers in a separate diagram or other clearly understandable methodology.

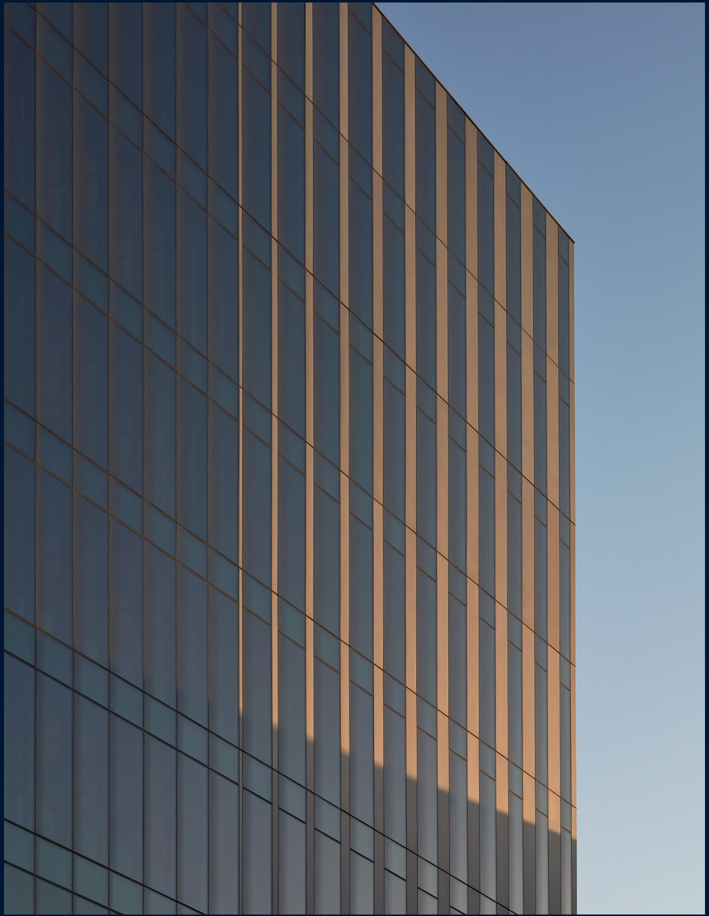
Confirm the compatibility of specified products to ensure barrier life cycle performance.

Enclosure air tightness on all six sides of the building must be tested and verified.

Consider improving the building envelope for load reduction, in concert with HVAC optimum sizing, as the initial step towards Net Zero Energy Ready.

For major modernization or projects involving significant building enclosure work, obtain ASTM E779 blower door and ASTM E1186 test results of existing buildings as a prerequisite during the project planning phase to quantitatively and qualitatively measure existing enclosure performance and appropriately guide enclosure improvement scope. May be performed in conjunction with or as part of initial studies (e.g., BER (Building Evaluation Report), BCS (Building Conditions Survey), PDS (Program Development Study).

Where a garage door is integral to air or thermal barriers, include that component in energy calculations; and improve component performance if necessary.



Chapter 3

Water Penetration Resistance

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Chapter 3.1.6
Enclosure Performance Table

Thermal Performance		
Baseline		ASHRAE 90.1, Section 5.5 and where section 5.5 is referenced
Tier 1		N/A
Tier 2		N/A
Tier 3		N/A
M & V		ASHRAE 90.1, IECC
Plans & Specs		Yes
Calculations & Analysis		ASHRAE 90.1
References		ASHRAE 1365 RP, BETB Guide, Low TEDI Guide
Basis of Design		Provide thermal performance characteristics of the enclosure assemblies. Increased R-values over and above code may be considered when life cycle cost benefits can be demonstrated.
Construction Verification		CxP to perform HVAC system testing per ASHRAE Guideline 1.1 (Guideline 30 was integrated into Guideline 1 in 2007)

Thermal Performance

References to IECC, ASHRAE 1365 RP, BETB Guide, Low TEDI Guide (thermal short circuiting)

3.2.6
Thermal Performance

Mitigate the effect of thermal bridges, including material conductivity and thermal continuity

Building Envelope Thermal Bridging Guide reference

Analyze unique spandrel assemblies that are part of curtain walls as opaque assemblies

Account for aged thermal performance of materials, performance when wet, performance throughout full range of seasonal temperatures

For modernizations, consider measuring performance before and after work

3.2.6 THERMAL PERFORMANCE

Thermal performance is critical to ensuring occupant comfort and the energy efficiency of the building. Thermal performance must comply with requirements of section 5.5 of ASHRAE 90.1, which includes the impact of thermal bridging.

Where possible, provide continuous exterior insulation to move the dew point outboard of the drainage plane. Mitigate cold spots or locations within the assembly that may be below the dew point caused by thermal bridging with:

- thermal breaks,
- use low thermal conductivity materials,
- closer alignment insulation/thermal control layers between adjacent assemblies,
- convert continuous thermal bridging components (e.g. Z-girts) to discrete components (e.g. clips),
- provide insulation around structural thermal bridging details such as beam and column penetrations.

Spandrel assemblies that are part of unitized systems such as curtain wall and window wall assemblies are opaque assemblies and must be evaluated as such. NFRC thermal analysis is only applicable for fenestration.

Where unique or custom opaque assemblies are proposed, analyze their performance and exposures to ensure the control of moisture and to mitigate the risk of condensation and uncontrolled moisture migration.

- Pre-calculated thermal bridging details with linear and point transmittances can be found in the Building Envelope Thermal Bridging Guide (thermalenvelope.ca)
- Identify high impact thermal bridging details by performing whole building enclosure thermal bridging calculations following the method outlined in the Building Envelope Thermal Bridging Guide

Account for the tested or calculated aged thermal performance at the midpoint of assembly service life, assembly service life duration defined in Table 3.1. Design towards any thermal migration, performance when wet and the expected thermal performance throughout the full range of seasonal temperatures.

For work performed on existing buildings, consider measuring the actual enclosure performance prior to and after work, to obtain qualitative and quantitative data of the improvement.

3.3.6.2
Window Frames

Thermally break aluminum frames per NFRC 600 in climate zones 2-8

3.3.6.2 WINDOW FRAMES

Aluminum frames must be thermally broken as defined by NFRC 600 in climate zones 2-8. In climate zones 0 to 1, aluminum frames must be at least thermally improved as defined by NFRC 600. At curtainwalls, window mullions must be coordinated with the floor-planning grid to permit the abutment of interior partitions.

3.3.7.4
Insulation

Insulation considerations for historic properties

Insulation options and factors described

3.3.7.4 INSULATION

Install continuous roof insulation in a manner that minimizes thermal bridging. Where board insulation is installed in multiple layers, offset the boards in adjacent layers so that the joints are not aligned. When making insulation type selections, consider the long-term thermal performance characteristics (e.g. thermal migration and thermal aging), sustainability effects (e.g. harmful blowing agents), and thermal performance if wet. Thermal calculations must account for insulation performance characteristics because of expected thermal migration at the midpoint of assembly service life, determined in table

3.1/service life. Account for the performance across the entire expected range of temperatures, and performance when damp or wet.

Consider ultra-high performing insulation products, especially for historic properties requiring low-profile roofs. Consider the expected structural and edge durability and service life of roofing insulations. Consider the likelihood or accommodations of future penetrations when selecting some insulations.

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Chapter 3.1.7
Enclosure Performance Table

3.1.7 Building Enclosure Commissioning

Building Enclosure Commissioning	
Baseline	Fundamental Building Enclosure Commissioning per ASTM E2813
Tier 1	Baseline plus Enhanced Building Enclosure Commissioning per ASTM E2813; required for mission critical facilities as defined in Chapter 1, Facility Definitions, projects located in high-risk or volatile weather locations, or with untested enclosure assemblies
Tier 2	Tier 1 plus increased performance testing as required by OPR. Refer to ASTM E2813, Table A2.1, for possible testing.
Tier 3	N/A
M & V	ASTM E2813, Table A2.1 ASTM E2947 ASHRAE 202 ASHRAE Guideline 0
Plans & Specs	ASTM E2813, Table A2.1 ASTM E2947 ASHRAE 202 ASHRAE Guideline 0
Calculations & Analysis	ASTM E2813, Table A2.1 ASTM E2947 ASHRAE 202 ASHRAE Guideline 0
References	
Basis of Design	Provide any special testing requirements anticipated during commissioning.
Construction Verification	CxP inspection and verification to be performed as outlined in ASTM E2813. Confirm air, vapor, and thermal continuity during construction, including via ISO 6781-23, ASTM C1060, ASTM C1153, ASTM E1186, and ASTM C1153

Building Enclosure Commissioning

Defined high risk facilities and weather locations meet Tier 1

Verification of air, vapor, and thermal barrier continuity during construction

3.2.7
Building Enclosure Commissioning

Perform BECx before installing finish materials

Establish failure protocol early

BECx results valid 6 months after substantial completion

Mock-ups for new or atypical conditions

3.2.7 BUILDING ENCLOSURE COMMISSIONING

Use ASTM E2813, Standard Practice for Building Enclosure Commissioning (BECx) for BECx. BECx is part and parcel to Total Building Commissioning. The BECx provider must demonstrate a minimum of five (5) years of experience delivering BECx in accordance with this standard and must provide documentation demonstrating compliance with the minimum core competencies outlined in ASTM E2813. The Owner's Project Requirements (OPR) must be developed in accordance with ASTM E2813 based upon the performance objectives established for the project and further refined as appropriate using the best practices established in ASTM E2947, Standard Guide for Building Enclosure Commissioning.

- BECx must be performed before interior finish materials are installed or may need to be removed to obtain clear visual access.
- The BECx plan must include a failure protocol, established before construction of the building envelope begins.
- No water pressure 1/3 reduction of onsite testing pressures allowed, described in AAMA 503.
- Mission-critical or project locations at extreme weather-prone locations default at water infiltration in situ testing pressure of 15lb/sf or greater. GSA test pressure requirements are for delivered, installed enclosure assemblies, including the contiguous moisture and air barriers.
- BECx results valid for 6 months after substantial completion
- Mock-ups are strongly recommended for new or atypical enclosure or curtainwall assemblies

3.3.8.2
Air Barrier Testing

Updated IgCC reference

ASTM E1186 IR imaging and smoke pencil testing in regular construction progress inspections in order to catch defects early

3.3.8.2 AIR BARRIER TESTING

For new construction, demonstrate performance of the air barrier system for the building enclosure. Comply with IgCC-Section 10.6 Building Envelope Airtightness. Prior to testing, verify that the continuous air barrier system has been installed as per the design in accordance with the specifications. Incorporate the use of infrared (IR) and smoke pencil tools (ASTM E1186) into regular inspections throughout completion of the air, water and thermal lines of facade and roof construction sequencing, preferably before interior finishes are installed. This quickly validates the continuity of each. Testing must occur during construction and prior to the installation of insulation and exterior cladding materials that could impede access to the air barrier and prevent the identification of failures and required repairs.

Chapter 3

Water Penetration Resistance

Moisture and Condensation Control

Air Tightness

Thermal Performance

Building Enclosure Commissioning

Service Life

Verification	
3.1.9 Enclosure Service Life	
Walls (In years to replacement/major rehabilitation)	
Baseline	50/25
Tier 1	75/30
Tier 2	100/40; required for mission critical facilities as defined in Chapter 1, Facility Definitions
Tier 3	150/50
M & V	No
Plans & Specs	Review deliverables to confirm. Provide building enclosure commissioning.
Calculations & Analysis	No
References	
Basis of Design	Describe expected service life for each enclosure wall type proposed.
Construction Verification	CxP must confirm through submittal review.
Roofs (Replacement)	
Baseline	20
Tier 1	[illegible]
Tier 2	40; required for mission critical facilities as defined in Chapter 1, Facility Definitions
Tier 3	50
M & V	Manufacturer's warranty certificate.
Plans & Specs	Review deliverables to confirm. Provide building enclosure commissioning
Calculations & Analysis	No
References	
Basis of Design	Describe expected service life for roof type proposed. Replacement includes labor and materials warranty.
Construction Verification	CxP must confirm through submittal review.
Fenestration (years to frame replacement / IGU + gaskets and seals replacement)	
Baseline	30/15
Tier 1	40/20
Tier 2	50/20; required for mission critical facilities as defined in Chapter 1, Facility Definitions
Tier 3	75/20
M & V	ASTM E2188, ASTM E2190, ASTM E218
Plans & Specs	Review deliverables to confirm. Provide building enclosure commissioning.
Calculations & Analysis	No
References	
3.8.4	Describe expected service life for each fenestration assembly proposed.
Construction Verification	CxP must confirm through submittal review.

Chapter 3.1.9
Enclosure Performance Table

Enclosure Service Life

Defined high risk facilities meet Tier 2 including walls, roofs, and fenestration

Manufacturer's warranty certificate required

Replacement includes labor and materials warranty

3.2.9
Enclosure Service Life

Service life must be based on proven industry best practices and must be designed against the potential for deferred maintenance

3.2.9 ENCLOSURE SERVICE LIFE

Two targets for each performance level have been identified: the full-service life and the time between major rehabilitation. Where successful tests or reliable methods of predicted service life do not exist, use proven industry best practices. The most important tools are material selection based on experience and design reviews by third parties who have experience and knowledge related to durability. Designers must recognize the differential durability of materials, products, and assemblies when attempting to realize maximum service life.

Enclosure service life must meet those listed in table 3.1 and be designed robust and resilient enough to guard against the potential for deferred maintenance.

3.3.4.1
Connections, Fasteners, and Miscellaneous Metals Exposed to Weather

Clarified material requirements for marine environments and included additional alternatives

3.3.4.1 CONNECTIONS, FASTENERS, AND MISCELLANEOUS METALS EXPOSED TO WEATHER

Products of carbon steel that are directly or indirectly exposed to the weather must have corrosion protection consisting of a galvanic -zinc coating of at least 460 grams per m^2 (1.5 ounces per sq. ft.) of surface or other equivalent corrosion protection. Where possible, use stainless steel connections and fasteners. Specify SAE 316 or higher performance grade for use in marine environments. Marine/naval brass, aluminum-bronze and silicon-bronze are also acceptable marine grade metals; aluminum and copper may be acceptable in limited applications. Separate dissimilar metals with a gasket to prevent galvanic action.

3.3.4.4
Sealants

New section, including design for redundancy in sealant joints

3.3.4.4 SEALANTS

Sealants have become an increasingly vital component of the enclosure assembly, including water and air infiltration lines, especially in barrier type assemblies. Because it is a maintenance item, often with a service life lower than adjacent components within the assembly, design towards limiting the reliance on sealants to the greatest extent possible. Design for redundancy, never relying on sealants as the sole line of defense. Refer to ASTM C1193 for sealant design, application, and installation guidelines. Refer to ASTM D4541 for sealant adhesion testing. Provide redundancy and continuity in designs to prevent water intrusion and air infiltration. Provide a 2-stage sealant strategy in exterior wall assemblies that rely on sealant in a barrier methodology, including wall-to-fenestration, wall-to-roof, and wall-to-foundation interfaces.

3.3.5
Masonry and Concrete Materials

Concrete specs to be performance-based, including the allowance of several reference standards

Clarified requirement to use 2-stage sealant joints in precast design

3.3.5 MASONRY AND CONCRETE MATERIALS

Architectural precast concrete design must follow the recommendations of the Precast Concrete Institute (PCI) contained in the PCI publication, Architectural Precast Concrete, Current Edition. Use a 2-stage sealant design as described in PCI. Follow ASTM C1193 for any joint sealants within the system.

3.3.6
Fenestration Systems

Strategies for window replacements

Service life must take into account the potential for deferred maintenance

3.3.6 FENESTRATION SYSTEMS

If full fenestration system replacement is not possible for retrofits of buildings in cold climates with single pane windows, consider window upgrades such as highly insulating commercial secondary glazing systems (window inserts, secondary storm windows), vacuum insulating glazing (VIG), low-e films, and insulating shades.

In single pane windows, significant thermal losses also occur at the frame (since these are typically non-thermally broken). For poor thermally performing curtain wall, replacing aluminum with non-metal (polyamide, fiberglass) pressure plates can improve thermal performance without replacing the frame.

Full fenestration replacement (frame and glass) will have the most impact on the final thermal performance. Where full fenestration replacement is feasible and for new construction, consider fenestration with high-thermal performance frames (wide thermal breaks) and insulating glass with a double or triple silver low-e coating (depending on solar control needs) using inexpensive improvement strategies such warm-edge spacer and argon gas-filling. A fourth surface low-e coating can also be used to increase performance further before moving to even higher thermal performance strategies such as triple pane insulating glass or a dual-pane hybrid vacuum insulating glass system.

Service life of fenestration must meet that listed in table 3.1 and be designed robust and resilient enough to guard against any potential deferred maintenance.

3.3.6.1
Windows

Updated reference to ANSI/AAMA 101-17

Historic window strategies described

3.3.6.1 WINDOWS

Aluminum windows must meet the requirements of ANSI/AAMA Standard 101-17, but not less than fenestration performance requirements listed elsewhere within P100. Only optimal performance classes may be used.

Metal windows other than aluminum must meet the requirements of Steel Window Institute's (SWI) Specifier's Guide to Steel Windows for the performance class required.

Wood windows must meet the requirements of ANSI/NWMA Standard I.S. 2-87, Grade 60 and AAMA/WDMA 101/I.S.2/NAFS. AW Architectural Class.

Replacement windows in historic structures should exactly match original frame and muntin profiles, and consideration given to including highly insulating commercial secondary windows (also known as window inserts, low-e panels, or interior storm windows), vacuum insulating glazing (VIG), low-e films, insulating shades, and automated blinds and shades. Glazing installed in historic sashes must meet applicable safety glazing standards for the installation location, as well as any other project-specific safety and security requirements. See Upgrading Historic Building Windows for more information.

3.3.6.3
Entrance Doors

Clarified that entrance doors must follow service life requirements for windows listed above

3.3.6.3 ENTRANCE DOORS

Entrance doors may be aluminum and/or glass of heavy-duty construction. Glazed exterior doors and frames must be steel and meet the requirements of SDI Grade III with a G-90 galvanic zinc coating. Vestibules are desired to control air infiltration and reduce stack effect. Sliding automatic doors are preferred over the swinging type. Motion detectors and push plates are preferred over mats as actuating devices. Historic entrance doors must be retained and upgraded with care to preserve the original appearance of the building. Where missing, replicas of the original doors should be installed. All door assemblies installed in the means of egress must meet the requirements of the National Fire Protection Association (NFPA), 101 Life Safety Code. Follow service life fenestration requirements listed under table 3.1. See additional requirements in table 3.5 All Glass Entrances.

3.3.7.1
Roofing Design

Requirement for "solar-ready" roof design

Recommendation to perform a hygrothermal analysis prior to selecting a roofing membrane system

3.3.7.1 ROOFING DESIGN

Roofing designs must follow the recommendations of the National Roofing Contractors Association (NRCA) Roofing Manual–, –current edition. Additionally, follow the recommendations of the NRCA Roofing Manual–to coordinate the design of metal flashing, trim, etc., with roofing terminations. The Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) Manual is a trusted resource for the design, fabrication, and installation of sheet metal roofing accessories. All roof assemblies and rooftop structures must meet the requirements in the IBC and the IFC.

Where there is a likely ability [solar, physical constraints] to implement solar panels within the intended service life of the roof, include provisions in the roofing design to be solar-ready.

Consider performing a hygrothermal analysis prior to selecting a roofing membrane system

3.3.7.2
Re-Roofing

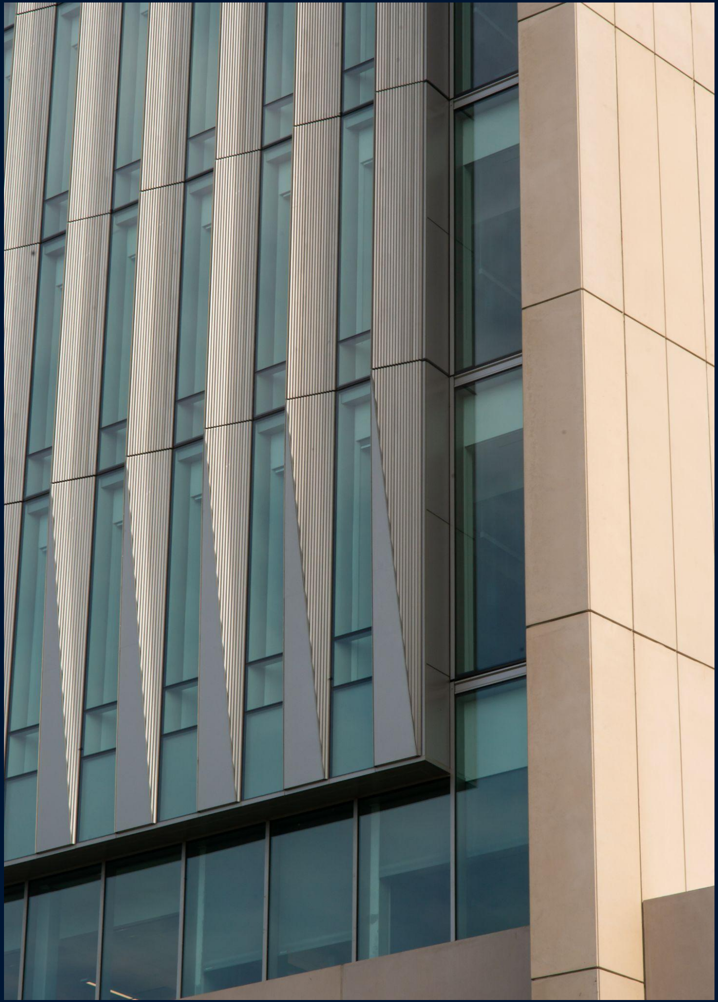
Potential reuse of insulation

3.3.7.2 RE-ROOFING

Full replacement of roofing including insulation is the preferred approach to restoring the integrity of the enclosure system and realizing life cycle cost benefits; unless it can be demonstrated that the prior insulation used has an expected service greater than the re-roofing membrane specified and complying with table 3.1 service life; and that it maintains its original thermal, structural and edge integrity. Where full replacement is not feasible, roof recovery or partial replacements are permitted to restore the integrity of the roofing system, protect the asset, and ensure continuity of operations. Where new roofs are installed over existing roofing, comply with the IBC and prevailing local code requirements.

Survey and investigate the condition of the existing substrate to acquire warranties from the manufacturer and installer. Substrate must be determined structurally adequate before the new roofing assembly is applied. The new roofing system must not be of greater weight than the old roofing system, unless a structural analysis shows that the building can carry the additional weight. Ensure the integrity of the building enclosure system takes precedence over less critical repairs or alterations. See the technical guidelines for Historic Building Roofing for guidance on repair, replacement, and modification of roofing on historic buildings.

Re-roofing projects at existing buildings must evaluate the capacity of the roof drainage system to accommodate predicted future precipitation volumes. Re-roofing projects must also address requirements for fall protection and safe suspended access.



Chapter 3

Miscellaneous

3.3.7.1.1
Cool Roofs

New section with requirements for solar reflectance of roofing

3.3.7.1.1 COOL ROOFS

Cool roofs are designed to reflect more sunlight than a conventional roof, which saves energy by lowering air conditioning demands. ASHRAE 90.1 sets minimum requirements for cool roofs but exempts steep-slope roofs and the requirements only apply in climate zones 0-3. GSA buildings must follow the requirements in ASHRAE 189.1, section 5.3.5.3 and 5.3.5.4, which set a minimum performance requirement for steep-slope roofs and require cool roofs in climate zones 4A and 4B. Buildings in other climate zones should assess cool roofs when considering design options; summer cooling energy savings are typically greater than the "heating penalty" caused by reduced solar heat gain in winter months.

Buildings in climate zones 1-6 must meet a mandatory initial solar reflectance or 0.85 and a 3-year solar reflectance of 0.75.

3.3.7.8
Roof Fall Protection

Renamed section

Questions

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Thanks!