

Integrating Occupational Safety and Health into the U.S. Green Building Council LEED New Construction Credits: A Preliminary Report

National Occupational Research Agenda (NORA) Construction Sector
Council Green Construction Coordinating Committee

National Institute for Occupational Safety and Health Office of Construction
Safety and Health

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EXECUTIVE SUMMARY

As green and sustainable practices become more common in the U.S, there is an opportunity to promote worker safety and health as a fundamental dimension of true sustainability. The U.S. Green Building Council *Leadership in Energy and Environmental Design* (LEED ®) rating system provides a valuable benchmark for green and sustainable building design and construction practices. The LEED system is improved and updated over time to incorporate new information and developments.

Construction and maintenance worker occupational safety and health is one area that is not currently addressed by LEED. The National Institute for Occupational Safety and Health (NIOSH) is the federal agency responsible for conducting research and making recommendations for the prevention of occupational illness and injury. NIOSH and its construction industry stakeholders identified the integration of safety and health into green and sustainable construction as a priority issue. A Green Construction Coordinating Committee performed a credit-by-credit review of the LEED New Construction Credits to evaluate the potential positive or negative impact of LEED activities on construction and maintenance worker safety and health. Seven credits were found to have a positive potential with eleven credits having a negative potential. One credit was found to have both positive and negative potential. Thirty eight of the credits were considered neutral towards construction worker safety and health. The Committee then selected six credits for additional evaluation. Safety and health language was inserted into these credits to address the potential hazards. In addition, reference guides were developed to provide additional guidance and detail similar to what is typically provided for LEED credits.

In sum, this preliminary report provides specific examples of how LEED credits could address construction and maintenance worker safety and health. Additional discussions with USGBC can be used to improve the credits and ready them for use as pilot credits.

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(1) Introduction: Safety and Health and the Built Environment

Improving sustainability and the environmental performance of buildings is an important mission, and the U.S. Green Building Council (USGBC) *Leadership in Energy and Environmental Design* (LEED ®)¹ rating system provides a valuable framework for rating buildings on eight performance categories: Location and Planning, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation and Design Process, and Regional Priority. The LEED rating system has gained wide acceptance. For example, the General Services Administration (GSA) requires that all new federal buildings meet LEED gold certification as a way to move the government's federal buildings to a more sustainable future (GSA, 2010).

Buildings play an important role in society, touching economic, environmental, historic, cultural and other aspects of modern life. Because buildings function as workplaces, they also directly relate to occupational safety and health. **Our premise is that a holistic, lifecycle approach to a sustainably built environment needs also to include enhanced occupational safety and health.**

Green and Sustainable Practices

The terms “Green” and “Sustainable” are often used interchangeably in describing building practices that improve the environment. We view their transposable use as incorrect. Green buildings are structures that have significantly reduced or eliminated negative impacts on the environment and the occupants. Sustainability is a broader term that encompasses social equity aspects, including occupational safety and health. The USGBC recognizes that transformation towards achieving sustainability requires a broader effort and that social equity is a value and outcome that has not received enough attention. The USGBC added “Foster Social Equity” to its organizational guiding principles in their strategic plan for 2009-2012 [USGBC, 2009].

Current green construction practices include attention to health needs of building occupants, and this represents a foundation upon which to build. Broadening this focus to include safety and health considerations for construction and maintenance workers is an important next step. Construction workers are the earliest occupants in the initial lifecycle stage of green buildings, and they build, renovate, refurbish, maintain, and eventually decommission green buildings throughout their lifecycle. They face significant hazards – for example the construction industry typically employs 7% of the US workforce in a given year, but yet accounts for 20% of its fatalities.

Being green is becoming a mainstream concept, and eventually green design and construction will merge with conventional practice. Unless, however, we take steps to integrate safety and health best practices into green design and construction, there is no reason to think that the industry safety record will change. On the other hand, integrating safety and health into green construction has an important potential to bring

¹ LEED ® is a registered trademark of the US Green Building Council

about positive change on industry safety performance. This is because green initiatives serve as an entry point for industry leadership and diffusion of new ideas, thus broadly influencing the building and construction industry. In sum, efforts to integrate construction and maintenance worker safety and health into LEED will provide important public health and social equity value. These efforts will also further the goal of putting LEED onto a trajectory towards a broader, more comprehensive vision of sustainability.

Design and “PtD”

LEED uses better building design as its major intervention. Improving safety and health for construction and maintenance workers can also be accomplished via better design. “Prevention through Design” (PtD) is the term used by NIOSH and the safety and health community to describe the prevention of occupational safety and health hazards through design. Using design to improve safety for the public and occupants is common, and is incorporated in some cases in building codes. However, the use of design to explicitly address safety for construction and maintenance workers is a relatively novel and little used intervention in the United States. It is common in the United Kingdom and Australia, both of which have had safe construction design regulations and codes of practice in place for almost two decades. The linkage between design decisions and construction fatalities has been made clear through research from the U.S., the UK, and Australia. The fatality rate of the U.S. construction industry is more than double that of the UK and Australia, and while a factorial analysis has not been conducted, the role of PtD as an important intervention to improve construction safety and health conditions has been expressed by numerous researchers, practitioners, and governmental agencies. NIOSH and a cross-section of practitioners are embracing PtD and we expect mutual benefits for both LEED and PtD as we work more closely together. Design is an essential strategy for integrating construction and maintenance worker safety and health into sustainable construction.

LEED and Occupational Safety and Health

LEED currently addresses occupational health—but in a limited fashion. LEED Environmental Quality category credits are intended primarily to enhance occupant comfort and well-being, although several also explicitly mention the intent to reduce exposures to potentially hazardous or harmful contaminants. These credits primarily target building occupants; however, several do mention construction workers and maintenance workers.

LEED currently does not address occupational safety (i.e., injury prevention) for occupants, and none of the LEED credits directly mention construction, operation, or maintenance worker safety. While each LEED credit includes a requirement section to provide details and references to additional standards or guidance, the scope does not currently include mention of any relevant safety standards or guidance.

There is no available evidence that construction practices for green buildings are safer for workers. Rajendran, Gambatese, and Behm (2009) compared recordable injury rates among LEED and non-LEED construction projects and found no statistically significant difference in rates among the projects included in the study. Occupational

safety and health practitioners and researchers have expressed reservations about the hazards inherent in some green building construction activities. Gambatese (2009) pointed out that some green building design features could actually increase jobsite hazards. For example, the greater use of skylights and atria in buildings increase light and give a sense of greater space on the one hand, but they also increase fall hazards during construction, and later, during cleaning and maintenance activities. In another example, there could also be greater risks of musculoskeletal injuries from increased jobsite manual handling and separation of materials to meet project recycling goals. Gambatese described a “blind spot” in sustainable design practice when it comes to worker safety and health.

Furthermore, Chen (2010) pointed out that green practices such as use of solar energy can involve hazards. She describes a case in which a worker fell off of a roof while installing solar panels. Working 43 feet off the ground, the worker was walking backward when he fell off the two-story building and was killed. She explains that unlike a traditional system where an electrician can isolate the load from the power source, working on a solar panel means working on the power source itself thus introducing electrical hazards.

Gillen and Gittleman (2010) described the increasing interest in “beneficial reuse” of waste materials such as fly ash in construction materials as an example of a green construction activity that could lead to potential occupational concerns. These materials are typically evaluated for environmental attributes (e.g., assessing toxic heavy metals in coal combustion products to determine if they will leach out of the product to pollute water). An equivalent evaluation for occupational safety and health exposures and concerns are needed as well because construction practices that use such materials involve airborne dust-generating tasks such as drilling, grinding, cutting, or milling. Such tasks could result in exposures to heavy metals such as arsenic, mercury, cadmium, and chromium. Hazardous exposure scenarios for construction workers need to be addressed during the product development stage so that appropriate safety and health precautions and interventions can be developed and information disseminated.

In summary, the current LEED rating system does address occupational health in a limited way, and does not address occupational safety at all. In fact, it promotes activities (i.e., installation of skylights, use of green roofs) that may increase exposure to hazards such as falls for construction, maintenance and operations workers. With its welcoming attitude toward continuous improvement and an expectation that credits will be added and revised over time, LEED offers a pilot credit system to provide an incubator for new credit concepts. It is within this milieu of innovation, continuous improvement and an expectation of revisions that we offer our recommendations for integrating safety and health into LEED.

(2) Construction Occupational Safety and Health Experts' Review of USGBC LEED Credits for Potential Safety and Health Impact

Who We Are

The National Institute for Occupational Safety and Health (NIOSH) is the federal agency responsible for conducting research and making recommendations for the prevention of occupational illness and injury. NIOSH is part of the Centers for Disease Control and Prevention (CDC) in the Department of Health and Human Services. The NIOSH Construction Program was established in 1990. The program includes internal researchers along with support for academic researchers and a large external "National Construction Center" designed to interact with construction industry and labor stakeholders. The NIOSH Construction Program also works closely with academia, and professional organizations, and the Occupational Safety and Health Administration (OSHA), which is the Department of Labor Agency responsible for regulation and enforcement of worker safety and health.

NIOSH and its construction safety and health stakeholders developed national goals for eight industry sectors under a National Occupational Research Agenda (NORA) initiative. A NORA Construction Sector Council developed 15 construction goals, including goals to reduce falls and to prevent construction hazards through design, an approach called "Prevention through Design (PtD) by occupational safety and health practitioners. The NORA construction goals include the following:

"Within 4-6 years, develop methods to utilize the U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) rating system and the sustainability movement to implement Construction Hazard Prevention through Design (CHPtD)."

NIOSH prepared a White Paper titled: "NIOSH Perspective on Sustainable Buildings: Green...and Safe" [NIOSH, 2010] to describe the case for further dialogue and collaboration between the occupational and environmental communities and how USGBC and NIOSH are in unique positions to advance this discussion. The paper was provided to the USGBC for a February 2011 meeting of principals that led to a decision to work more closely together.

What We Did

The NORA Construction Sector Council identified integration of safety and health into green construction as a priority issue for activity in 2011 and 2012 and established a committee to take additional steps to achieve this goal. Members of the committee along with additional safety and health researchers conducted the assessment and review contained in this report. Three activities were undertaken:

(a) Evaluation of LEED credits for safety and health potential

The committee created a matrix of LEED New Construction Credits to facilitate review. The review used expert opinion to provide an initial determination of the safety and health potential for all LEED credits. Four additional safety and health researchers

working on green construction were also asked to review the credits for this purpose. The review examined impacts on construction and maintenance workers over the lifecycle of the building – it did not consider general building occupants. The determination used three categories:

Positive potential: The likely activities associated with the credit, if coupled with additional safety design and planning measures, could act to reduce construction and maintenance worker exposures and risks

Negative potential: The likely activities associated with this credit, if not coupled with additional safety design and planning measures, could act to increase construction and maintenance worker exposures and risks.

Neutral: While safety hazards cannot be ruled out, the likely activities associated with this credit appear less likely to either increase or reduce construction and maintenance worker exposures and risks, regardless of safety design and planning measures.

The resulting findings were placed into Table 1, entitled: *LEED NC (New Construction) CREDIT-BY-CREDIT REVIEW FOR SAFETY AND HEALTH POTENTIAL* which is provided on page 9. Seven credits were classified as having positive potential and 11 were classified as having negative potential. The remaining 38 credits were classified as neutral. One credit was considered to have both positive and negative potential.

(b) Identification of credits for safety enhancement

Committee members each selected three credits that they considered to provide the biggest opportunity for safety enhancements and improvements for construction and maintenance worker safety and health. Four additional safety and health researchers working on green construction were also asked to nominate credits for this purpose. The following three groupings of individual LEED credits were selected for initial evaluation:

- Sustainable Sites (SS) Credit 7.2
- Indoor Environmental Quality (IEQ) Credits 3.1, 4.1, 8.1, and 8.2
- Materials and Resources (M&R) Credits 1.1, 1.2, and 2

(c) Development of draft enhanced credits and reference guide materials.

The committee invited additional subject matter experts to participate in this process, and formed workgroups to discuss the credits, identify hazards, and begin developing credit language to address hazards. In addition, more detailed supplemental information similar to that contained in LEED Reference guides was developed. After preliminary discussions, the committee prepared language for six of the eight draft credits. The committee solicited three LEED Accredited Professionals (APs) to review and comment on the draft credits. Their suggestions are incorporated in the material presented in this preliminary report.

What We Recommend

Please see section 3 beginning on page 14 for our suggested occupational safety and health integrations into LEED. For each credit, we inserted new suggested language into the current LEED credit. For suggested reference guide material, we provided the suggested additional text along with the suggested location. Also, where relevant and if available, we include photographs for illustrations.

We also describe additional longer term recommendations and next steps in section 4 at the end of the report.

TABLE 1 LEED NC (New Construction) CREDIT-BY-CREDIT REVIEW FOR SAFETY AND HEALTH POTENTIAL

Green = positive impact; **Red** = negative impact; Black = neutral impact

Credit	Potential S& H impact	Type of Hazard/ Exposure	Workers affected	Ranking	Notes
	<i>Positive, Negative, Neutral</i>	<i>Safety, MSD,* Health</i>	<i>Construction, Maintenance</i>	<i>High, Medium, Low</i>	
Sustainable Sites				26 Possible Points	
Prerequisite 1 Construction Activity Pollution Prevention Required	Positive	Health	Construction	High	Requirement to “prevent pollution of the air with dust and particulate matter” focuses on erosion. Could add language to explicitly address construction-generated silica and diesel exposures
Credit 1 Site Selection	Neutral				
Credit 2 Development Density and Community Connectivity	Neutral				
Credit 3 Brownfield Redevelopment	Negative	Health	Construction	Medium	Re-use of contaminated sites without planning can lead to construction worker exposures. See http://www.osha.gov/SLTC/brownfields/brownfld_qna.html
Credit 4.1 Alternative Transportation—Public Transportation Access	Neutral				
Credit 4.2 Alternative Transportation—Bicycle Storage and Changing Rooms	Neutral				
Credit 4.3 Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	Neutral				
Credit 4.4 Alternative Transportation—Parking Capacity	Neutral				

Credit 5.1 Site Development—Protect or Restore Habitat	Neutral				
Credit 5.2 Site Development—Maximize Open Space	Neutral				
Credit 6.1 Stormwater Design—Quantity Control	Neutral				
Credit 6.2 Stormwater Design—Quality Control	Negative	Safety	Construction	Medium	Construction of detention systems can increase exposure to equipment and moving equipment hazards, and excavation, trenching and standing water hazards.
Credit 7.1 Heat Island Effect—Nonroof	Neutral				
Credit 7.2 Heat Island Effect—Roof	Negative	Safety	Construction and Maintenance	High	Construction and maintenance of vegetative roofs can increase exposure to falls.
Credit 8 Light Pollution Reduction	Neutral				
Water Efficiency					10 Possible Points
Prerequisite 1 Water Use Reduction Required	Neutral				
Credit 1 Water Efficient Landscaping	Neutral				
Credit 2 Innovative Wastewater Technologies	Neutral				
Credit 3 Water Use Reduction	Neutral				
Energy and Atmosphere					35 Possible Points
Prerequisite 1 Fundamental Commissioning of Building Energy Systems Required	Neutral				
Prerequisite 2 Minimum Energy Performance Required	Neutral				
Prerequisite 3 Fundamental Refrigerant Management Required	Neutral				
Credit 1 Optimize Energy Performance	Neutral				
Credit 2 On-site Renewable Energy	Negative	Safety	Construction and Maintenance	High	Placement of solar and wind energy sources, for example on roofs, can increase risks of falling, exposure to overhead power lines, and material

					access issues for construction and maintenance workers.
Credit 3 Enhanced Commissioning	Neutral				
Credit 4 Enhanced Refrigerant Management	Neutral				
Credit 5 Measurement and Verification	Neutral				
Credit 6 Green Power	Neutral				
Materials and Resources					14 Possible Points
Prerequisite 1 Storage and Collection of Recyclables Required	Neutral				
Credit 1.1 Building Reuse—Maintain Existing Walls, Floors and Roof	Negative	Safety, Health	Construction	Medium	Building reuse can present a variety of hazards to construction workers. Falls cave-ins, and collapses of temporarily shored structural members; exposures to toxic materials such as asbestos and lead; and fire hazards when welding or cutting adjacent to existing flammable elements. Safety planning and design is needed to address these risks.
Credit 1.2 Building Reuse—Maintain Existing Interior Nonstructural Elements					
Credit 2 Construction Waste Management	Negative	Safety, MSD	Construction	High	On-site diversion and sorting activities can expose construction workers to scrapes, abrasions, and lacerations. On-site work on the uneven surfaces of sorting containers/dumpsters creates sprain and strain exposures. Manual handling can lead to MSDs. Exposures are outsourced when using off-site waste sorting and management facilities.
Credit 3 Materials Reuse					
Credit 4 Recycled Content	Neutral				
Credit 5 Regional Materials	Neutral				
Credit 6 Rapidly Renewable Materials	Neutral				
Credit 7 Certified Wood	Neutral				
Indoor Environmental Quality					15 Possible Points
Prerequisite 1 Minimum Indoor Air Quality Performance Required	Neutral				
Prerequisite 2 Environmental Tobacco	Neutral				

Smoke (ETS) Control Required					
Credit 1 Outdoor Air Delivery Monitoring	Neutral				
Credit 2 Increased Ventilation	Positive	Health	Maintenance	Medium	While neutral for construction workers, this credit is expected to provide positive benefits for maintenance workers.
Credit 3.1 Construction Indoor Air Quality Management Plan—During Construction	Negative	Health	Construction	Medium	Current emphasis on covering ducts does not minimize the generation of contaminants, which is what causes exposures for construction workers. It might also increase ladder use in some settings.
	Positive	Health	Construction	Medium	A focus on source reduction and control such as local exhaust ventilation has the potential to reduce exposures to construction workers and minimize duct contamination. Also better housekeeping can reduce exposures to dust sources during construction.
Credit 3.2 Construction Indoor Air Quality Management Plan—Before Occupancy	Neutral				
Credit 4.1 Low-Emitting Materials—Adhesives and Sealants	Positive	Health	Construction and Maintenance	High	Encourages use of low VOC (Volatile Organic Compound) materials which may or may not reduce toxic exposures. Could add language to encourage use of low toxicity materials to explicitly address construction and maintenance exposures.
Credit 4.2 Low-Emitting Materials—Paints and Coatings	Positive	Health	Construction and Maintenance	High	Encourages use of low VOC materials which may or may not reduce toxic exposures. Could add language to encourage use of low toxicity materials to explicitly address construction and maintenance exposures.
Credit 4.3 Low-Emitting Materials—	Positive	Health	Construction	Medium	Encourages use of low VOC materials

Flooring Systems			and Maintenance		which may or may not reduce toxic exposures. Could add language to encourage use of low toxicity materials to explicitly address construction and maintenance exposures.
Credit 4.4 Low-Emitting Materials—Composite Wood and Agrifiber Products	Positive	Health	Construction and Maintenance	Medium	Encourages use of low VOC materials which may or may not reduce toxic exposures. Could add language to encourage use of low toxicity materials to explicitly address construction and maintenance exposures.
Credit 5 Indoor Chemical and Pollutant Source Control	Positive	Health	Maintenance	High	Design to use exhaust systems to capture contaminants to reduce exposure potential.
Credit 6.1 Controllability of Systems—Lighting	Negative	Safety	Construction	Low	Installation and wiring for occupancy sensors throughout a facility might increase exposure to falls (e.g. work on ladders) for installation workers.
Credit 6.2 Controllability of Systems—Thermal Comfort	Neutral				
Credit 7.1 Thermal Comfort—Design	Neutral				
Credit 7.2 Thermal Comfort—Verification	Neutral				
Credit 8.1 Daylight and Views—Daylight	Negative	Safety	Const. and Maintenance	High	Skylight hazards; access for cleaning atria and other daylighting features increases exposure to fall hazards.
Credit 8.2 Daylight and Views—Views					
Innovation in Design					6 Possible Points
Credit 1 Innovation in Design	Neutral				
Credit 2 LEED Accredited Professional	Neutral				
Regional Priority					4 Possible Points
Credit 1 Regional Priority	Neutral				

* MSD refers to musculoskeletal disorders.

(3) Integrating Safety and Health into LEED credits: Six Examples

For each credit, new suggested language is shown inserted into the current LEED credit. **Bold blue Arial font** is used to make it easier to find the suggested inserts.

For suggested reference guide material, the suggested additional text is provided along with the suggested location in **blue Arial font**.

Sustainable Sites (SS) Credit 7.2: Heat Island Effect—Roof 1 Point

Intent

To reduce heat islands¹ to minimize impacts on microclimates and human and wildlife habitats.

Requirements

OPTION 1

Use roofing materials with a solar reflectance index² (SRI) equal to or greater than the values in the table below for a minimum of 75% of the roof surface. **Develop and implement a safe roof plan to prevent falls and other hazards involved with construction and maintenance of high-albedo roofs.**

Roofing materials having a lower SRI value than those listed below may be used if the weighted rooftop SRI average meets the following criteria:

$$\frac{\text{Area Roof Meeting Minimum SRI}}{\text{Total Roof Area}} \times \frac{\text{SRI of Installed Roof}}{\text{Required SRI}} \geq 75\%$$

Roof Type	Slope	SRI
Low-sloped roof	≤ 2:12	78
Steep-sloped roof	> 2:12	29

OR

OPTION 2

Install a vegetated roof that covers at least 50% of the roof area. **Develop and implement a safe roof plan to prevent falls and other hazards involved with vegetated roof installation and maintenance.**

OR

OPTION 3

Install high-albedo and vegetated roof surfaces that, in combination, meet the following criteria:

$$\frac{\text{Area Roof Meeting Minimum SRI}}{0.75} + \frac{\text{Area of Vegetated Roof}}{0.5} \geq \text{Total Roof Area}$$

Roof Type	Slope	SRI
Low-sloped roof	≤ 2:12	78
Steep-sloped roof	> 2:12	29

Develop and implement a safe roof plan to prevent falls and other hazards involved with high-albedo and vegetated roof installation and maintenance. ²

Potential Technologies & Strategies

Consider installing high-albedo and vegetated roofs to reduce heat absorption. Default values will be available in the LEED Reference Guide for Green Building Design and Construction, 2009 Edition. Product information is available from the Cool Roof Rating Council Web site at <http://www.coolroofs.org/> and the ENERGY STAR® Web site at <http://www.energystar.gov/>.

Safe roof design information is available at the Design for Construction Safety <http://www.designforconstructionsafety.org/> or NIOSH Web site at <http://cdc.gov/NIOSH>. ³

1 Heat Islands are defined as thermal gradient differences between developed and undeveloped areas.

2 The solar reflectance index (SRI) is a measure of the constructed surface’s ability to reflect solar heat as shown by a small temperature rise. It is defined so that a standard black surface (reflectance 0.05, emittance 0.90) is 0 and a standard white surface (reflectance 0.80, emittance 0.90) is 100. To calculate the SRI for a given material, obtain the reflectance value and emittance value for the material. SRI is calculated according to ASTM 1980. Reflectance is measured according to ASTM E903, ASTM E 1918, or ASTM C 1549. Emittance is measured according to ASTM E 408 or ASTM C1371.

Suggested Reference Guide Material for SS 7.2

Requirements section:

Modify to include new credit wording.

1. Benefits and Issues to Consider

Insert new section after Economic Issues.

Health and Safety Issues

Identifying and mitigating health and safety risks ensures that practices are safe, improves productivity, and ensures worker well-being. Vegetated roofs primarily present fall hazards to construction workers building the roof; landscaping workers installing the vegetation; and landscaping or maintenance workers providing periodic care for vegetated roofs. Reflective surface roofs may present visual, heat, and fall hazards to construction workers building them and to maintenance workers performing periodic washing to maintain solar reflective index levels.

² **Safety requirements were inserted into each of the three options to match the current structure of the credit. Alternatively, a general requirement to develop and implement a safe roof plan to prevent falls and other hazards involved with construction and maintenance for whatever option is selected could be inserted once after option 3.**

³ **Note: These have been identified as two sites where such information can be located.**

4) Implementation

Insert new section after Vegetated Roofs.

Elements of a Safe Roof Plan

The following are elements of a safe roof plan:

1. Structural Integrity.

Ensure a structural engineer has established the maximum load bearing capacity of the roof; design to ensure this is not exceeded during installation and maintenance.

2. Fall prevention / protection.

Incorporate fall safety into design considerations by selecting one of the options listed below in order of preference. Engage a safety and health professional to further develop an effective fall prevention strategy that can be used by construction and maintenance workers for roof work.

Option #1 Design for a minimum 39" parapet around the roof top edge to serve as fall protection during high-albedo or vegetated roof installation, inspection, and maintenance.

Option #2 Design for a minimum 39" guardrail around the roof top edge to serve as fall protection during high-albedo or vegetated roof installation inspection, and maintenance.

Option #3 Design for a roof-edge fall restraint system to limit access to the roof edges where workers could fall. It prevents a fall from occurring by keeping a person from reaching the roof edge fall point.

Option #4 Design for installation of a horizontal lifeline system for fall arrest protection. It does not prevent a fall from occurring, but is designed to catch a person who falls from a roof edge.

a) On flat roofs, the lifeline system must be within 6 feet from the roof's edge, and accessed easily from the fixed stairs through the building's core. The entrance opening onto the roof needs to be designed with the system to ensure that the worker does not need to be within 6 feet of the edge unattached.

b) On sloped roofs, the lifeline system must be able to be accessed immediately when stepping onto the roof.

Option #5 Where no other fall protection is designed into a flat roof, specify that vegetation and any rock or decorative border be installed 12 feet from the roof's edge and that the 12 foot border be of a flat traditional roof surface (i.e., not the rock border) to ensure that weeding or other vegetative roof work does not take place within 12 feet of the roof's edge.

This form of fall protection would only be acceptable if there is access to the roof through the building's core leading to the center of the roof, and if water spigot(s) are available on the roof within 12 feet of the roof's edge. In other words, the work to be performed on the roof should not encourage workers to be within 12 feet of the roof's edge at any time [Ellis, 2001]. Where vegetation is hanging over the edge of a building's roof (trees, ivy type plants, etc.); ensure that a horizontal lifeline system or approved anchorage is available near the projected work. Even if a parapet is available here, the scope of the maintenance work could encourage workers to use ladders or lean over rendering the parapet ineffective or to lean over the parapet to conduct the necessary work.

3. Safe Access.

Option #1 Design fixed stairs to the roof through the building's core so that workers and necessary equipment can access the roof in a safe and efficient manner.

Option #2 Where interior stairs are not designed into the structure for worker roof access, an exterior building caged ladder should be designed for roof access. Designation of a rooftop storage area for maintenance equipment is recommended if this option is used. See U.S. OSHA regulations, 29 C FR 1910.26 for specifications.

4. Unique Building Hazards

Minimize the toxic ingredient content of adhesives and sealants selected for use with vegetated roof membranes and high albedo surfaces. These can cause exposures for construction workers during installation.

High-albedo surfaces may cause glare for construction and maintenance workers and this can contribute to disorientation. They also radiate more heat and could contribute to heat stress risks. Surfaces may be slippery when installed or cleaned. All of these factors can contribute to fall risks reinforcing the importance of fall prevention.

When specifying rooftop vegetation, borders which need maintenance, and any irrigation system components near skylights or other fragile roof materials, consider specifying permanent guardrails around these roof openings or that the permanent protective screens within the skylight be installed to prevent falls through to lower levels.

Consider the roof and the work to be performed in relation to existing electrical power lines. Power lines should be moved or vegetation not be placed on roof areas where the work may encourage workers and their equipment to be within 10 feet of the overhead power line.

When specifying rooftop vegetation, borders which need maintenance, and any irrigation system components near other mechanical or electrical rooftop equipment, specify physical guards on that equipment to prevent accidental contact.

7) Documentation Guidance

Insert new bullet

- Include description of safe roof plan design features and documentation on implementation. Describe provisions for safe maintenance of vegetative and high albedo roofs over the building lifecycle.

11) Operations and Maintenance

Insert new sentence:

See Elements of a Safe Roof Plan (especially sections Implementation sections 2, 3, and 4) for discussion relevant for operations and maintenance safety.

12) Resources

Insert these new resources:

American National Standards Institute (ANSI)

<http://webstore.ansi.org/default.aspx>

Standard A10.24 Roofing – Safety Requirements for Low-sloped Roofs

Standard A10.32 Personal Fall Protection Used in Construction and Demolition

Occupational Safety and Health Administration (OSHA) Fall Protection Topic

Page <http://www.osha.gov/SLTC/fallprotection/index.html>

OSHA Standard 1926 Subpart M governs Fall Protection

National Institute for Occupational Safety and Health (NIOSH) Falls from

Elevations topic page: <http://www.cdc.gov/niosh/topics/falls/>

Ellis, N. (2001). Introduction to Fall Protection, Third Edition. American Society of Safety Engineers. Des Plaines, I L.

OSHA Alliance Program Construction Roundtable (2010). Construction Workplace Design Solution: Roof Hatch Access and Hole Protection. At Design for Construction

Safety Website: [http://www.designforconstructionsafety.org/Documents/DS4%20-%20Roof%20Hatch%20Access%20and%20Hole%20Protection%20\(LG%20update%205-10-10\).pdf](http://www.designforconstructionsafety.org/Documents/DS4%20-%20Roof%20Hatch%20Access%20and%20Hole%20Protection%20(LG%20update%205-10-10).pdf)

OSHA Alliance Program Construction Roundtable (2010). Construction Workplace Design Solution: Specify Sufficient Wall Height to Allow Parapets to Function as Fall Prevention. At Design for Construction Safety Website:

[http://www.designforconstructionsafety.org/Documents/DS6%20-%20Parapets%20\(MG-TB%20update%205-3-10\).pdf](http://www.designforconstructionsafety.org/Documents/DS6%20-%20Parapets%20(MG-TB%20update%205-3-10).pdf)

13) Definitions

Insert these definitions

Roof-edge fall restraint system. A system designed to prevent a fall from occurring by keeping a person from reaching a fall point (a place from where he/she can fall). The system is positioned six feet from the fall hazard when using a shock absorbing lanyard.

Fall-arrest system. A system whose main objective is to minimize the fall distance and arrest the user from falling onto the ground or surrounding structure.

Horizontal Lifeline system. A system using wire or synthetic rope to allow one or more workers wearing fall harnesses to remain tied off while in horizontal transition between two anchor points. The lifelines are connected to the anchor points using various compatible connectors. A line tensioner is used for line adjustment and proper tension.

IEQ Credit 8.1: Daylight and Views—Daylight
1 Point

Intent

To provide building occupants with a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.

Requirements

Through 1 of the 4 options, achieve **safe** daylighting in at least the following spaces:

Regularly Occupied Spaces	Points
75%	1

OPTION 1. Simulation

Demonstrate through computer simulations that 75% or more of all regularly occupied spaces areas achieve daylight illuminance levels of a minimum of 25 footcandles (fc) and a maximum of 500 fc in a clear sky condition on September 21 at 9 a.m. and 3 p.m. Areas with illuminance levels below or above the range do not comply. However, designs that incorporate view-preserving automated shades for glare control may demonstrate compliance for only the minimum 25 fc illuminance level.

OR

OPTION 2. Prescriptive

Use a combination of side-lighting and/or top-lighting to achieve a total daylighting zone (the floor area meeting the following requirements) that is at least 75% of all the regularly occupied spaces. For the Side-lighting Daylight Zone (see diagram on the next page):

- Achieve a value, calculated as the product of the visible light transmittance (VLT) and window-to-floor area ratio (WFR) of daylight zone between 0.150 and 0.180. The window area included in the calculation must be at least 30 inches above the floor.

$$0.150 < vlt \times wfr < 0.180$$

- The ceiling must not obstruct a line in section that joins the window-head to a line on the floor that is parallel to the plane of the window; Is twice the height of the window-head above the floor in, distance from the plane of the glass as measured perpendicular to the plane of the glass.
- Provide sunlight redirection and/or glare control devices to ensure daylight effectiveness.

(DIAGRAM ON PAGE 78 not included)

For Top-lighting Daylight Zone (see diagram on the next page):

- The daylight zone under a skylight is the outline of the opening beneath the skylight, plus in each direction the lesser of:
 - 70% of the ceiling height,

OR

- 1/2 the distance to the edge of the nearest skylight,

OR

- The distance to any permanent opaque partition (if transparent show VLT) farther than 70% of the distance between the top of the partition and the ceiling.
- Achieve skylight roof coverage between 3% and 6% of the roof area with a minimum 0.5 VLT.
- The distance between the skylights must not be more than 1.4 times the ceiling height.
- A skylight diffuser, if used, must have a measured haze value of greater than 90% when tested according to ASTM D1003. Avoid direct line of sight to the skylight diffuser.

Exceptions for areas where tasks would be hindered by the use of daylight will be considered on their merits.

(DIAGRAM on page 79 not included)

OR

OPTION 3. Measurement

Demonstrate through records of indoor light measurements that a minimum daylight illumination level of 25 fc has been achieved in at least 75% of all regularly occupied areas. Measurements must be taken on a 10-foot grid for all occupied spaces and recorded on building floor plans. Only the square footage associated with the portions of rooms or spaces meeting the minimum illumination requirements may be counted in the calculations.

For all projects pursuing this option, provide daylight redirection and/or glare control devices to avoid high contrast situations that could impede visual tasks. Exceptions for areas where tasks would be hindered by daylight will be considered on their merits.

OR

OPTION 4. Combination

Any of the above calculation methods may be combined to document the minimum daylight illumination in at least 75% of all regularly occupied spaces. The different methods used in each space must be clearly recorded on all building plans.

In all cases, only the square footage associated with the portions of rooms or spaces meeting the requirements may be applied toward the 75% of total area calculation required to qualify for this credit.

In all cases, provide glare control devices to avoid high-contrast situations that could impede visual tasks.

Exceptions for areas where tasks would be hindered by the use of daylight will be considered on their merits.

Potential Technologies & Strategies

Design the building to maximize interior daylighting. Strategies to consider include building orientation, shallow floor plates, increased building perimeter, exterior and interior permanent shading devices, high-performance glazing, and high-ceiling reflectance values; additionally, automatic photocell-based controls can help to reduce energy use. Predict daylight factors via manual calculations or model daylighting strategies with a physical or computer model to assess footcandle levels and daylight factors achieved. **Design to allow for safe installation and maintenance of daylighting features. Prepare and implement a safe daylighting plan for use in construction and maintenance of daylighting features.**

Reference Guide Information for IAQ 8.1

Requirements section:

Modify to include new credit wording.

1. Benefits and Issues to Consider

Insert new section after Economic Issues.

Health and Safety Issues

Daylighting strategies (atria, skylights, etc.) can present hazards and risks during installation and maintenance over the lifecycle of the building. For example, Bobick (2004) reported that falls through skylights accounted for 150 U.S. worker fatalities during the period 1992-2000. These risks can be predicted and reduced during the design phase of the project. Preparing and implementing a safe daylighting plan will help improve safety during construction and during ongoing safe maintenance of daylighting features.

4) Implementation

Insert new section:

Strategies for safe daylighting

Skylights

Design suggestions include the following:

1) Use non-fragile glass. Lewis (2009) reported that the American Society for Testing and Materials (ASTM) has developed a work group to investigate the development of skylight fall-protection test standards. This includes development of testing standards for non-fragile glass.

2) Use screen guards and/or guard rails. Bobick (2004) suggests that safety best practices for skylights should include a screen guard. He reported that protective safety screen costs approximately \$125 and

requires two workers about twenty minutes to install. Alternatively, standard guard rails can also be used around skylights. Guard rails are especially helpful adjacent to larger banks of skylights.

3) Design domed, rather than flat, skylights with shatterproof glass or add strengthening wires to skylights (see Figures 1 and 2).



Figure 1 – Skylight guard on domed skylight



Figure 2 – Skylight guard with strengthening

Photo Credit: National Roofing Contractors Association, “Building Design Elements for Enhanced Fall Protection for Construction and Maintenance Personnel: An NRCA Perspective”

4) Consider design specifications that minimize the frequency of cleaning required, such as self-cleaning glass.

5) Provide for maintenance worker access and fall protection near skylights, especially banks of skylights. Design special attachments or holes into structural members for use as fall protection anchors. These anchors should be rated to withstand 5,000 lbs. force to provide permanent, stable connections for supports, lifelines, fall protection tie-off, guardrails, and scaffolding.

Atria

Atria are also utilized as a means to provide natural daylighting. They may include skylight and window features. Safe access to install and maintain the features of the atrium should be considered in the design phase of the project. Once the atrium is built, fall protection provisions are likely to be necessary to ensure safe access to all areas that need to be maintained, cleaned, replaced, etc. Figures 4 and 5 illustrate the types of access needed for maintenance and the types of unsafe work practices that can result when designs do not anticipate

future maintenance needs. Design can positively or negatively influence behavior, actions, and planning.



Figure 4. Atrium maintenance activity representing serious fall hazard risk.



Figure 5. Close up of maintenance workers setting up for an atrium maintenance activity representing a serious fall hazard risk. A design that incorporates guardrails or built-in anchors for use with fall harnesses would substantially reduce this hazard.

Atria Design suggestions include the following:

1. Consider design specifications that minimize the frequency of cleaning required, such as self-cleaning glass, or that minimize the frequency that workers need to work at height by specifying adjustable windows that can be cleaned from both sides where one side has a permanent access.
2. Include maintenance and cleaning considerations during design. Avoid building permanent obstructions under atria, such as pools, planter boxes, stairways and steps, or built counters, that would preclude the use of portable areal lifts needed to install, clean and maintain glass or ceiling devices such as detectors, alarms, diffusers, etc. See Figure 6 for examples of aerial lift use.



Figure 6. Use of aerial lifts to clean and maintain atria.

3. Design special attachments or holes into structural members in areas where anchorages will facilitate use of fall prevention devices during construction or maintenance work at height. Anchors should be rated to withstand 5,000 lbs. force to provide permanent, stable connections for supports, lifelines, fall protection tie-off, guardrails, and scaffolding. See Figure 3 for examples of anchors.



Figure 3 – Examples of anchors

4. Incorporate other safe design features depending on atria design features. This might include parapets to provide immediate guardrail protection and eliminate the need to construct a guardrail during construction or future roof / balcony maintenance. Provide permanent guardrails around floor openings. Specify the installation of tie-off straps along the perimeter of the building for use by workers on leading edge work that can be removed once the glazing is installed.

Other daylighting features

Skylights and atria are two examples of common daylighting strategies. Other examples such as extended and larger windows, raised windows, glazing features, etc. can present risks and hazards that should be evaluated for safe access and fall protection (among other potential hazards) for reduction of risk through safe design.

7) Documentation Guidance

Insert new bullet

Provide safe daylighting plan to describe installed design features and safe maintenance strategies.

11) Operations and Maintenance

Insert new language:

As described in Section 4 (Implementation), both skylights and atria require maintenance and cleaning that can entail important fall hazards. The safe daylighting plan should spell out safe access provisions tailored to the specific design.

12) Resources

Insert these new resources:

National Institute for Occupational Safety and Health (NIOSH)
Preventing Falls of Workers through Skylights and Roof and Floor Openings
NIOSH Publication No. 2004-156: <http://www.cdc.gov/niosh/docs/2004-156/>

Bobick, T. (2004). Falls through Roof and Floor Openings and Surfaces, Including Skylights: 1992–2000. *Journal of Construction Engineering and Management*, 130 (6), 895-907.

Lewis, J. (2009). Skylight fall protection: More than just the manufacturer's Responsibility. *Glass Magazine*, 4, 2-3.
<http://www.glassmagazine.com/article/commercial/skylight-fall-protection-more-just-manufacturer%E2%80%99s-responsibility>

OSHA Alliance Program Construction Roundtable (2010). Construction Workplace Design Solution: Specify Non-Fragile Skylights and/or Skylight Guards. At Design for Construction Safety Website:
[http://www.designforconstructionsafety.org/Documents/DS5%20-%20Skylight%20\(MG-TB%20update%205-3-10\).pdf](http://www.designforconstructionsafety.org/Documents/DS5%20-%20Skylight%20(MG-TB%20update%205-3-10).pdf)

IEQ Credit 3.1: Construction Indoor Air Quality Management Plan— During Construction 1 Point

Intent

To reduce indoor air quality (IAQ) problems resulting from construction or renovation and promote the comfort and well-being of construction workers and building occupants.

Requirements

Develop and implement an IAQ management plan for the construction and preoccupancy phases of the building as follows:

- **During construction, use source reduction and control methods to minimize generation of contaminants from chemical use, combustion and hot work, and cutting, grinding, or other disturbance of materials.**
- During construction, meet or exceed the recommended control measures of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines For Occupied Buildings Under Construction, 2nd Edition 2007, ANSI/SMACNA 008-2008 (Chapter 3).
- Protect stored on-site and installed absorptive materials from moisture damage.
- If permanently installed air handlers are used during construction, filtration media with a minimum efficiency reporting value (MERV) of 8 must be used at each return air grille, as determined by ASHRAE Standard 52.2-1999 (with errata but without addenda¹). Replace all filtration media immediately prior to occupancy.

Potential Technologies & Strategies

Adopt an IAQ management plan to protect the heating, ventilating and air conditioning (HVAC) system during construction, control pollutant sources and interrupt contamination pathways. **Use source reduction and controls to minimize contaminants from chemical products, combustion sources or hot work such as welding. Restrict all cutting, drilling, grinding, sanding, or disturbance of construction materials to tools equipped with either local exhaust ventilation or wet controls.** Sequence the installation of materials to avoid contamination of absorptive materials, such as insulation, carpeting, ceiling tile and gypsum wallboard. Coordinate with IEQ Credit 3.2: Construction IAQ Management Plan — Before Occupancy and IEQ Credit 5: Indoor Chemical & Pollutant Source Control to determine the appropriate specifications and schedules for filtration media.

If possible, avoid using permanently installed air handlers for temporary heating/cooling during construction. **Note that arrangements for temporary cooling may be needed to avoid heat illnesses among construction workers in summer months.** Consult the LEED Reference Guide for Green Building Design and Construction, 2009 Edition for more detailed information on how to ensure the well-being of construction workers and building occupants if permanently installed air handlers must be used during construction.

¹ Project teams wishing to use ASHRAE approved addenda for the purposes of this credit may do so at their discretion. Addenda must be applied consistently across all LEED credits.

Reference Guide information for IEQ 3.1

Requirements section:

Modify to include new credit wording.

1. Benefits and Issues to Consider

Insert new section after Economic Issues.

Health and Safety Issues

Certain construction tasks can generate airborne contaminants leading to direct exposures for construction workers and indirect exposures to occupants.

Exposures to contaminants can affect construction worker health. Preventable exposures fall into three categories:

- 1) Chemical use, such as epoxies, paints, and adhesives;
- 2) Combustion and hot work operations, such as use of internal combustion engines inside a building or welding or cutting operations; and
- 3) Disturbance of construction materials, such as cutting, drilling, grinding, or sanding of various building materials such as masonry or floors.

Construction operations generate air contaminants in sufficient quantities to adversely affect air quality for current or future building occupants. Construction workers can experience overexposures during these operations as they are closest to the point of contaminant generation. Controlling exposures at the source is the top choice in both the environmental and occupational practice hierarchy. Source reduction provides a double benefit by reducing both construction worker exposures and the contaminant levels available for contamination of ductwork and building surfaces.

2) Related credits

Add to those already listed.

Sustainable Sites (SS) Prerequisite 1: Construction Activity Pollution Prevention which addresses generation of outdoor contaminants. SS 1 applies to the initial construction operations up through the completion of exterior walls. IEQ 3.1 is intended to apply to remaining construction operations.⁴

⁴ SS Prerequisite 1 was identified as having potential for reducing construction worker exposure to contaminants such as silica dust and diesel exhaust. This wording is intended to suggest a boundary between SS 1 and IEQ 3.1 requirements.

Materials and Resources (MR) Credits 1.1 and 1.2 on Building Re-use and in MR Credit 2 on Waste Management.

4) Implementation

Insert new section after discussion of SMACNA

The following best practices complement these five SMACNA guidelines to ensure optimal safety and health.

Option 1: Source reduction methods:

Chemical use: Select less toxic products. Minimize use of spray products. Minimize quantities used.

Combustion and Hot work: Use electric powered equipment instead of combustion powered equipment. For example, use battery-powered scissor lifts instead of diesel, gas, or propane units. Locate combustion equipment outside. If combustion equipment is needed, propane fueled equipment is preferred. Minimize equipment idling when machines are not working. Reduce diesel emissions by utilizing low sulfur diesel fuel or by converting to natural gas powered engines. Where possible, have welding work done at off-site locations.

Materials disturbance: Design or purchase materials that minimize the need for on-site cutting, grinding, etc.

Option 2: Control methods

Chemical use: Use local exhaust ventilation to capture vapors and contaminants. Vent exhaust to outside or to pollution control equipment.

Combustion and Hot work: Use carbon monoxide alarms where combustion equipment must be used. Vent exhaust to outside. Use combustion equipment with emission controls. Use local exhaust ventilation to capture welding fumes and contaminants. Vent contaminants to outside or to pollution control equipment. Where combustion-heaters (e.g. salamander or torpedo heaters) are used to provide temporary heat during cold weather months, provide carbon monoxide alarms.

Disturbance of Construction materials: Use “controlled disturbance” approach by using power tools equipped with local exhaust ventilation and a vacuum device to capture emissions from cut-off saws, drywall sanders and similar dust-generating tools. Or use wet methods for controlling dust generation from tools such as masonry saws.

Indoor Air Quality management – thermal comfort and heat stress prevention:

Lack of an air handling system during construction can lead to construction worker health problems during weather extremes.

During hot weather conditions, high indoor temperature and humidity conditions can lead to heat illnesses among construction workers. This can be exacerbated once curtain wall and/or window installation is complete due to reduced natural air movement. Similarly, this can be a concern when plastic sheeting is used as an IAQ strategy to interrupt contamination pathways.

Heat illnesses can be prevented by providing temporary cooling or by employing a heat illness prevention plan during warm weather construction.

During cold weather conditions, the use of kerosene or propane powered salamander or torpedo heaters for temporary heating can produce excessive carbon monoxide levels. Option 2 above includes the need to provide carbon monoxide alarms where such heaters are used

7) Documentation Guidance

Insert new bullets

- Maintain a detailed log of source reduction and control methods used. For example, log all dust-generating power tool use and include photos of local exhaust ventilation or wet methods used.
- Maintain a log of heat stress prevention measures taken during hot weather conditions.

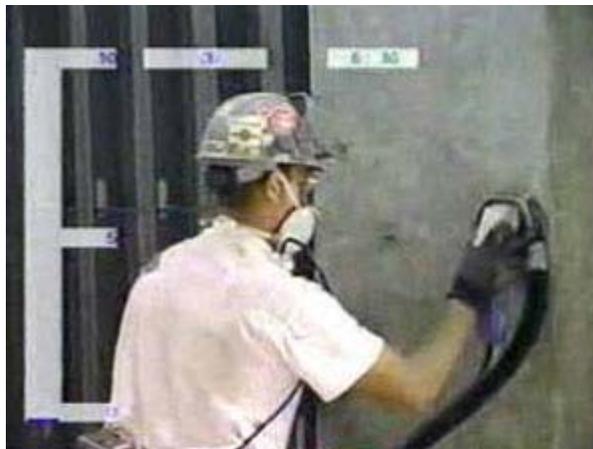
8) Examples

Insert following information



Figure 1. Grinder in use with the control in place.

Examples: Use of Local Exhaust Ventilation and wet methods to control dust creation from concrete grinding and masonry cutting



Example: NIOSH masonry cutting engineering controls

<http://www.cdc.gov/niosh/topics/silica/constructionControlMain.html>

Without dust controls →



Dust suppression with water →



12) Resources

Insert these new resources:

National Institute for Occupational Safety and Health (NIOSH)

<http://www.cdc.gov/niosh/topics/heatstress/>

NIOSH provides research-based recommendations to minimize heat stress and related illnesses.

<http://www.cdc.gov/niosh/topics/silica/cutOffSaws.html>

Controls for cut-off saws.

<http://www.cdc.gov/niosh/topics/silica/grinders.html>

Controls for concrete grinders.

Center to Protect Workers' Rights (CPWR)

<http://www.cpwrconstructionsolutions.org/>

Various types of controls

<http://www.elcosh.org/en/document/535/d000520/maintaining-indoor-air-quality.html> General reference on maintaining indoor air quality during construction

Various tool vendors provide local exhaust and wet method options for power tools used in construction.

Section 13 Definitions

Insert new definitions

Local Exhaust Ventilation (LEV): a type of engineering control that utilizes a shroud or hood to collect air contaminants via suction supplied by a fan or vacuum. LEV controls are options for many construction tools and they are also available as aftermarket options. Construction tool LEV typically is used with a heavy duty vacuum.

Wet methods: a type of engineering control that utilizes a water spray to minimize generation of dust. Wet method controls are options for many construction tools and they are also available as aftermarket options. Construction tool wet methods are typically used with a fine spray to minimize water use.

IEQ Credit 4.1: Low-Emitting Materials—Adhesives and Sealants
1 Point

Intent

To reduce the quantity of indoor air contaminants that are odorous, **toxic**, **flammable**, irritating and/or harmful to the comfort and well-being of installers and occupants.

Requirements

All adhesives and sealants used on the interior of the building (i.e., inside of the weatherproofing system and applied on-site) must comply with the following requirements as applicable to the project scope¹:

- Adhesives, Sealants and Sealant Primers must comply with South Coast Air Quality Management District (SCAQMD) Rule #1168. Volatile organic compound (VOC) limits listed in the table below correspond to an effective date of July 1, 2005 and rule amendment date of January 7, 2005.

Architectural Applications	VOC Limit (g/L less water)	Specialty Applications	VOC Limit (g/L less water)
Indoor carpet adhesives	50	PVC welding	510
Carpet pad adhesives	50	CPVC welding	490
Wood flooring adhesives	100	ABS welding	325
Rubber floor adhesives	60	Plastic cement welding	250
Subfloor adhesives	50	Adhesive primer for plastic	550
Ceramic tile adhesives	65	Contact adhesive	80
VCT and asphalt adhesives	50	Special purpose contact adhesive	250
Drywall and panel adhesives	50	Structural wood member adhesive	140
Cove base adhesives	50	Sheet applied rubber lining operations	850
Multipurpose construction adhesives	70	Top and trim adhesive	250
Structural glazing adhesives	100		
Substrate Specific Applications	VOC Limit (g/L less water)	Sealants	VOC Limit (g/L less water)
Metal to metal	30	Architectural	250
Plastic foams	50	Nonmembrane roof	300
Porous material (except wood)	50	Roadway	250
Wood	30	Single-ply roof membrane	450
Fiberglass	80	Other	420
Sealant Primers	VOC Limit (g/L less water)		
Architectural, nonporous	250		
Architectural, porous	775		
Other	750		

¹The use of a VOC budget is permissible for compliance with this credit

- ~~Aerosol~~**All** Adhesives must comply with Green Seal Standard for Commercial Adhesives GS-36 requirements in effect on October 19, 2000

Aerosol Adhesives	VOC Limit
General purpose mist spray	65% VOCs by weight
General purpose web spray	55% VOCs by weight
Special purpose aerosol adhesives (all types)	70% VOCs by weight

Note: Box at left may not be needed if the scope is expanded to all adhesives

- **Select all sealants and sealant primers using the Green Seal Standard GS-36 toxicity requirements in effect for adhesives on October 19, 2000. For example, sealants must not contain known carcinogens or reproductive toxins in excess of 0.1% by weight of the product.**
- **Some low VOC and low toxicity adhesives, sealants, and sealant primers may nevertheless be flammable. Use of flammable materials should be avoided where possible and products known to be flammable should be identified prior to use so that they can be safely stored and handled on site.**

Potential Technologies & Strategies

Specify low-VOC, **low health hazard materials** in construction documents. **Specify non-flammable materials when feasible.** Ensure that VOC limits **and low health hazard criteria** are clearly stated in each section of the specifications where adhesives and sealants are addressed. Common products to evaluate include general construction adhesives, flooring adhesives, fire-stopping sealants, caulking, duct sealants, plumbing adhesives and cove base adhesives. Review product cut sheets, material safety data (MSD) sheets, signed attestations or other official literature from the manufacturer clearly identifying the VOC contents or compliance with referenced standards.

Suggested Reference Guide Material for IEQ 4.1

Requirements section:

Modify to include new credit wording.

1. Benefits and Issues to Consider

Insert new section after Economic Issues.

Health and Safety Issues

Adhesives and sealants generate odorous, irritating, or harmful air contaminants during use. Construction and maintenance workers applying these materials have the potential for the highest exposures. Using the procurement process to select adhesives and sealants with minimal toxic ingredients directly benefits

construction, maintenance and also occupant employees. The purpose of this credit is to minimize construction and maintenance worker exposures to cancer-causing agents; reproductive toxins; persistent, bioaccumulative and toxic compounds; and toxic solvents. Flammable ingredients pose fire hazards during construction and maintenance and procurement can also be used to minimize these ingredients to reduce hazards.

3) Summary of Referenced Standards

Expand description of Green Seal Standard 36 (GS-36) as follows:

GS-36 also includes the following criteria related to toxic substances:

Carcinogens

Products shall not be formulated with any carcinogens. Any carcinogen that is known to be present as a contaminant shall not exceed 0.1% by weight of the product.

Reproductive Toxins

Products shall not be formulated with any reproductive toxins. Any reproductive toxin that is known to be present as a contaminant shall not exceed 0.1% by weight of the product.

Persistent, Bioaccumulative, and Toxic Compounds (PBTs)

Products shall not be formulated with any persistent, bioaccumulative, and toxic compounds (PBTs). Any PBT that is known to be present as a contaminant shall not exceed 0.1% by weight of the product.

Toxic Compounds

The solvent portion of the adhesive shall not be toxic to humans when inhaled. A product is considered toxic if the following lethal dose (LD) criterion applies:

Inhalation LC50 < 2,000 ppm of vapor or gas or 20 mg/L of mist, dust, or fumes
The toxicity testing procedures shall follow the protocols put forth in the Organization for Economic Cooperation and Development (OECD) Guidelines for the Testing of Chemicals, which includes: Acute Inhalation Toxicity Test (TG 403). To demonstrate compliance with this requirement, a solvent need not be tested if existing toxicological information demonstrates that it complies. Data from the Registry of Toxic Effects of Chemical Substances (RTECS) and from the Hazardous Substances Data Bank (HSDB) will be accepted as well as peer-reviewed primary data.

See GS-36 for additional definitions and criteria

Insert new referenced standard

Federal Hazardous Substances Act

Flammability is defined under the Federal Hazardous Substances Act as follows: The term *flammable* shall apply to any substance having a flashpoint above 20 °F (-6.7 °C) and below 100 °F(37.8 °C), as determined by the method described at § 1500.43a, except that:

(A) Any mixture having one component or more with a flashpoint at or above 100 °F (37.8 °C) which comprises at least 99 percent of the total volume of the mixture is not considered to be a flammable substance; and

(B) Any mixture containing 24 percent or less of water miscible alcohols, by volume, in aqueous solution is not considered to be flammable if the mixture does not present a significant flammability hazard when used by consumers.

4) Implementation

Insert new section

Implementation for adhesives can utilize either the existence of a Green Seal GS-36 compliant label, or an independent review of product properties using the Green Seal toxicity criteria described in Section 3.

GS-36 does not apply to sealants and sealant primers, so products must be independently reviewed using the Green Seal toxicity criteria described above in Section 3.

If flammable adhesives, sealants or sealant primers are used, provide for proper flammable liquid storage and use equipment and provide protection from sparks, welding, or open flames that occur during construction operations.

7) Documentation Guidance

Insert new bullet

Maintain a list of each adhesive, sealer, and sealant primer used on the job along with the manufacturers name, product name, and listing of toxic and flammable ingredients.

12) Resources

Insert these new resources:

Federal Hazardous Substances Act

http://edocket.access.gpo.gov/cfr_2010/janqtr/pdf/16cfr1500.3.pdf

MR Credit 1.1: Building Reuse—Maintain Existing Walls, Floors and Roof

1–3 Points

Intent

To extend the lifecycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport.

Requirements

Maintain the existing building structure (including structural floor and roof decking) and envelope (the exterior skin and framing, excluding window assemblies and non-structural roofing material).

Develop and implement a safe building reuse plan during design and planning to mitigate construction safety and health hazards. The minimum percentage building reuse for each point threshold is as follows:

Building Reuse	Points
55%	1
75%	2
95%	3

Hazardous materials that are remediated as a part of the project must be excluded from the calculation of the percentage maintained. If the project includes an addition that is more than 2 times the square footage of the existing building, this credit is not applicable.

Potential Technologies & Strategies

Consider reusing existing, previously-occupied building structures, envelopes and elements. Remove elements that pose a contamination **or safety and health** risk to building occupants and upgrade components that would improve energy and water efficiency such as windows, mechanical systems and plumbing fixtures.

Suggested Reference Guide Material for MR 1.1

Requirements section:

Modify to include new credit wording.

1. Benefits and Issues to Consider

Insert new section after Economic Issues.

Health and Safety Issues

Building reuse may involve removal of old building systems and include structural changes; for example to improve available space or allow additional windows. Health and safety hazards can range from exposure to lead or asbestos to fire hazards from cutting and welding to fall and collapse hazards from temporarily shored structural members. Development of a safe building reuse plan at the

design and planning stages enables identification and mitigation of these risks. Implementation of the plan supports a safe and productive reuse project.

4) Implementation

Add new section

Elements of a Safe Building Reuse Plan

Elements of an effective and efficient plan should include the following:

1. **Structural Integrity.** Ensure a structural engineer has established the maximum load bearing capacity of the existing structural elements that are to remain and be reused. Ensure that the capacity of the existing structural elements that remain can support the expected construction loads. Design the new facility such that the existing elements that will be reused can support the expected loadings during construction, maintenance, and operations of the facility. Design the temporary construction structures to sufficiently support the existing elements to be reused during construction.
2. **Fall and cave-in prevention/protection.** Provide temporary shoring of all existing load-bearing building elements that remain. Ensure that the existing building elements and temporary shoring are designed to support all expected construction loading. Provide safe ingress and egress throughout the existing structure by means of temporary or permanent stairs, ladders, passageways, etc. Plan for use of fall prevention to protect construction workers from fall exposures associated with features such as new or larger window openings in existing exterior walls.
3. **Hazardous materials.** Conduct an inspection of all areas of the existing facility that will be impacted during the construction project to determine the nature, amount, and location of all hazardous materials (e.g., asbestos, lead, etc.).
Option #1: Remove all hazardous materials prior to construction and ensure proper disposal.
Option #2: Design the new facility such that there is no interaction with the existing hazardous materials.
Option #3: Provide containment of all hazardous materials prior to construction.
4. **Flammable materials.** Conduct an inspection of all areas of the existing facility that will be impacted during the construction project to determine the nature, amount, and location of all flammable materials.

Option #1: Remove all flammable materials in the area of construction work prior to commencing the construction work.

Option #2: Design the new facility such that construction operations involving sparks, welding, or open flames do not need to be conducted adjacent existing flammable materials.

Option #3: Provide protection of all flammable materials from sparks, welding, or open flames that occur during construction operations.

7) Documentation Guidance

Insert new bullet

- Submit Safe Building Reuse Plan

12) Resources

Insert these new resources:

Formwork for Concrete, by M.K. Hurd (American Concrete Institute, 1995).

Design Loads on Structures during Construction, (American Society of Civil Engineers, 2002)

Handbook of Temporary Structures in Construction, by R.T. Ratay, (McGraw-Hill, 1996).

OSHA Safety and Health Standards for Construction, Part 1926.

MR Credit 2.1: Construction Waste Management: Divert 50% From Disposal 1 Point

Intent

Divert construction, demolition and land-clearing debris from disposal in landfills and incinerators. Redirect recyclable recovered resources back to the manufacturing process. Redirect reusable materials to appropriate sites.

Requirements

Recycle and/or salvage at least 50% of non-hazardous construction and demolition debris. Develop and implement a construction waste management plan that, at a minimum identifies: **1) the non-hazardous materials to be diverted from disposal and whether the materials will be sorted on-site or co-mingled; and 2) the practices that will be used to ensure safe material handling of anticipated construction and demolition waste. Describe safe recycling provisions for on-site sorting and demolition, and manual handling, sorting, and transport of recyclable materials.** Excavated soil and land-clearing debris do not contribute to this credit. Calculations can be done by weight or volume, but must be consistent throughout.

Potential Technologies & Strategies

Establish goals for diversion from disposal in landfills and incinerators and adopt a construction waste management plan to achieve these goals. **Evaluate materials and insure that hazardous materials are identified and disposed of separately and safely prior to demolition, deconstruction, or salvage operations.** Consider recycling cardboard, metal, brick, acoustical tile, concrete, plastic, clean wood, glass, gypsum wallboard, carpet and insulation. Designate a specific area(s) on the construction site for segregated or comingled collection of recyclable materials, and track recycling efforts throughout the construction process. **Assure safe recycling via practices such as the use of powered and non-powered handling assist aids, the minimization of weight and carry distances for materials to be handled manually, and the use of personal protective equipment. Provide sufficient clearance around material storage areas and containers so as not to inhibit safe access to the construction site for pedestrians and vehicles.** Identify construction haulers and recyclers to handle the designated materials. Note that diversion may include donation of materials to charitable organizations and salvage of materials on-site.

Suggested Reference Guide Material for MR Credit 2

Requirements section:

Modify to include new credit wording.

1. Benefits and Issues to Consider

Insert new section after Economic Issues.

Health and Safety Issues

It is important to identify hazardous materials for separate disposal prior to initiating recycling operations. Develop and implement precautions for any construction workers involved with disposal of hazardous materials.

On-site recycling and reuse of non-hazardous materials entails manual handling activities. Construction workers may be exposed to cuts, punctures, strain and sprain injuries, and other musculoskeletal disorders. It is important to evaluate site specific hazards and to develop safe recycling provisions for on-site demolition and subsequent sorting, manual handling, and transport of recyclable materials. These risks can be easily prevented through best practices. These provisions and practices are a necessary component of the construction waste management plan.

4) Implementation

Add to end of discussion of pros and cons of offsite vs onsite recycling:

In either case, good housekeeping and clearances/pathways around waste will help to ensure worker safety.

Insert new section

At the beginning of plan development, determine whether there are hazardous materials on the site. It is also useful to know whether some debris have been in contact with hazardous materials, (e.g. chemical spill onto wallboard or cardboard). In addition to hazardous materials impact, it is important to remember that original material properties can change after being in contact with moisture, chemicals and/or other materials.

Manual handling operations, including lifting and transporting materials should include consideration of the capabilities and limitations of workers. The simplest approach is to minimize the weight of loads and to use mechanical aids with heavier loads so the worker does not need to reach, lift or carry beyond that which they can do without risking potentially costly musculoskeletal strains or sprains. Ramps or docks with guard rails can also be built to allow construction workers to place debris into containers with minimal lifting of materials.

- Evaluate for the presence of hazardous materials and other potential hazards and ensure that they are appropriately controlled.
- Utilize powered machinery and powered and non-powered handling assist devices/aids in the transport of materials to the maximum extent feasible.
- When manual handling of recycled materials and debris is necessary, develop a plan for minimizing weight of individual materials and transport distance.
- Plan for the provision of personal protective equipment (e.g. respirator, gloves, glasses, hearing protection, etc.) appropriately for respiratory protection (e.g. dust-causing illnesses), protection from laceration (cuts), skin contact (including rashes, burns, etc.), and protection from demolition noise. Ensure that asbestos containing materials, Mercury (Hg) and Polychlorinated biphenyls (PCBs) have been removed from the building and disposed of properly prior to demolition or deconstruction, as to not inhibit salvage operations.
- Plan for provision of facilities to allow thorough washing of hands with soap and water before eating or smoking.
- When heavy materials must be handled manually, provide for use wheeled transport devices (e.g. carts, dollies, hand trucks) to the extent feasible
- When sheet materials must be hand carried, provide carrying handles.
- When heavy materials are to be manually transported, make sure walkways are clear and free from debris and potential trip hazards.

7) Documentation Guidance

Change second bullet to

A project's construction waste management plan should at a minimum, identify: 1) the diversion goals, relevant construction debris and materials to be diverted, implementation protocols, and parties responsible for implementing the plan; and 2) relevant tests for presence of hazardous materials, and specific strategies and practices that will be used to ensure safe material handling of anticipated construction and demolition waste.

8) Examples

Insert following information

Safe material handling example: The photo on the right is an example of one device in the category of "mini track haulers" – useful in demolition and debris, transport, and sorting. The mini-track hauler eliminated the need for manual wheelbarrow transport and lifting of materials (left) and resulting physical stress on the worker.



Original Method



Safer Material Handling Method

(4) Discussion and next steps

The title of this report indicates it is a preliminary report. This preliminary status is because we would like to take additional time to further review and improve the draft credits and reference guide materials. We believe that feedback from USGBC at this time would be useful to us to further improve the materials. Our interest is in developing the credits described in this report into pilot credits under the USGBC system for developing new credits.

Additional next step activities and strategies include the following:

- Develop draft credits for other LEED New Construction credits with either positive or negative potential for safety and health such as the Sustainable Sites prerequisite for a Construction Activity Pollution Prevention.
- Evaluate other LEED credit systems such as Existing Buildings Operations and Maintenance.
- Explore and develop concepts for new stand-alone safety and health credits. For example, a credit for implementing a best practice noise reduction plan during construction or a credit for developing an injury and illness prevention plan.
- Work with academic partners to develop and pilot a comprehensive separate rating system for safety and health. Researchers at Oregon State University have developed The Sustainable Construction Safety and Health rating system, a tool to help reduce construction worker injuries and fatalities by eliminating hazards and minimizing risks. The rating system assesses the extent to which construction worker safety and health is given priority and is addressed in planning, design, and construction of a project. The rating system is available at <http://sustainablesafetyandhealth.org/>.
- Continue work to further develop PtD, including research and development of additional design and planning tools and resources.
- Continue work on PtD educational materials for engineers and construction professionals and develop short course and other professional development materials for integration of safety and health into sustainable construction and design.
- Perform additional outreach to green design and construction professionals about construction and maintenance worker safety and health.
- Develop business case materials for building owners.

In summary, sustainable practices are critically important and will play an increasing role in the years ahead. The meaning of “sustainability” is evolving, and a strong case can be made that a truly comprehensive perspective on sustainability must include occupational safety and health.

The USGBC and its LEED rating system play an important role in providing benchmarks for evaluation of buildings for green and sustainable performance. The USGBC recognizes that sustainable thinking is evolving and it has created a process for piloting and improving the rating system over time to incorporate new findings and developments.

NIOSH and its construction industry stakeholders are interested in collaborating with the USGBC to integrate construction and maintenance worker safety and health into LEED. We believe that an important opportunity for doing this is to enhance existing credits that have a potential impact on safety and health. We have performed a credit-by-credit review and we have prepared draft credit language for six LEED credits, along with draft reference guide information. We appreciate your consideration of this preliminary report and we look forward to additional collaboration.

Appendix 1: List of NORA Construction Sector Council Green Construction Coordinating Committee Members and Reviewers

NORA Green Construction Coordinating Committee Co-Chairs	
Brian Kleiner, Ph.D. Professor and Director Myers-Lawson School of Construction Virginia Tech, Blacksburg, VA	Michael Behm, Ph.D. Dept. of Technology Systems - Occupational Safety East Carolina University, Greenville, NC
NORA Construction Sector Council Members	
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