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Print Version for the Minnesota Sustainable Building Guidelines Version 2.0

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THE STATE OF MINNESOTA
SUSTAINABLE BUILDING GUIDELINES
VERSION 2.0
Part of the Buildings, Benchmarks and Beyond (B3) Project

CONTENTS

Acknowledgements

The development of the Minnesota Sustainable Building Guidelines has been a multiyear process in collaboration with many people and departments in the state. The Executive Team provided direction and oversight while the Core Team provided ideas and review. We are grateful for all their contributions.

Executive Team

Janet Streff	Department of Commerce
Linda Kane	Department of Administration, State Architect's Office
Kath Ouska (*Through Ver. 2.0*)	Department of Administration, State Architect's Office
Wes Chapman *(Version 1.0)*	Department of Administration
Jim Jarvis *(Version 1.0)*	Department of Administration
Gordon Christofferson	Department of Administration, State Architect's Office

Core Team

Bruce Nelson	Department of Commerce
Rajan Thomas	Department of Administration - Plant Management
Ed Robinson	Department of Administration - Plant Management
Steve Hernick	Department of Administration - BCSD
Mark Wallace	Department of Natural Resources (DNR)
John Strohkirch	Department of Natural Resources (DNR)
Peter Paulson	Department of Natural Resources (DNR)
Linda Nelson	Department of Health Services (DHS)
Joe Dotson	Department of Health Services (DHS)
Richard L. Post	Minnesota Department of Transportation (MnDOT)
Lee Mehrkens	Department of Finance
Bill Sierks	Office of Environmental Assistance (OEA)
Laura Millberg	Office of Environmental Assistance (OEA)
Laura Oatman	Department of Health
Audrey Bomstad	Department of Children, Families & Learning (CFL)
Tom Vesely	Military Affairs
Todd Christenson	Department of Employee Relations (DOER)
Rolf Nordstrom	Minnesota Planning
Bill Breyfogle	Minnesota State Colleges and Universities (MnSCU)
Sally Grans	Minnesota State Colleges and Universities (MnSCU)
John Grundtner	University of Minnesota
Paul Kroening	Hennepin County (representing Association of Minnesota Counties)
Leslie Wilson	Carver County (representing Association of Minnesota Counties)

Credits

The team assembled to develop the Minnesota Sustainable Building Guidelines within the B3 Project represents regional and national expertise.

Management Team for the B3 Project

Rick Carter	LHB, Inc.
John Carmody	Center for Sustainable Building Research, University of Minnesota
David Eijadi	The Weidt Group
Graham Adams *(Version 1.0)*	The Adams Group

Guideline Project Team

John Carmody *(Leader)*	Center for Sustainable Building Research, University of Minnesota
Jonee Kulman Brigham	Center for Sustainable Building Research, University of Minnesota
Rebecca Foss	Center for Sustainable Building Research, University of Minnesota
Jim Wise	Center for Sustainable Building Research, University of Minnesota
Kerry Haglund	Center for Sustainable Building Research, University of Minnesota
Peter MacDonagh	University of Minnesota and The Kestrel Group
Annette Walby	The Kestrel Group
Bob Gunderson	University of Minnesota and ATS&R
David Grimsrud	University of Minnesota
Rebecca Ellis	Questions & Solutions Engineering, Inc.
Rachelle Schoessler Lynn	LHB, Inc.
Rick Carter	LHB, Inc.
Jerry Putnam	LHB, Inc.
David Williams	LHB, Inc.
David Eijadi	The Weidt Group
Tom McDougall	The Weidt Group
Prasad Vaidya	The Weidt Group
Jason Steinbock	The Weidt Group
Vinay Ghatti	The Weidt Group
Wayne Trusty	Athena Sustainable Materials Institute
Jim Keller	Gausman and Moore
Betti Iwanski	
Art Pearce	Idea Works
Ashraf Salama	The Adams Group
Leonard Krumm	CNA Consulting Engineers

Advisory Team

Ray Cole	University of British Columbia
Wayne Trusty	Athena Sustainable Materials Institute
Gail Lindsey	Design Harmony Inc.
Joyce Lee	City of New York - Office of Management & Budget
Jim Toothaker	Consultant, High Performance Green Building Services

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Introduction

Background

The Minnesota Legislature required the Departments of Administration and Commerce, with the assistance of other agencies, to develop sustainable building design guidelines for all new state buildings funded by bond money after January 15, 2004. According to the legislation, the guidelines must:

- Exceed the energy code in effect in January 2004 by at least 30 percent
- Achieve lowest possible lifetime costs for new buildings
- Encourage continual energy conservation improvements in new buildings
- Ensure good indoor air quality
- Create and maintain a healthy environment
- Facilitate productivity improvements
- Specify ways to reduce material costs
- Consider the long-term operating costs of the building including the use of renewable energy sources and distributed electric energy generation that uses a renewable source of natural gas or a fuel that is as clean or cleaner than natural gas.

To achieve these goals, The State of Minnesota Sustainable Building Guidelines (MSBG) build on previous local and national efforts. The guidelines are designed to be clear, simple and easily monitored with explicit documentation that will record progress. They are designed to be compatible with national guidelines such as LEED™ while maintaining regional values, priorities and requirements. Most importantly, the guidelines set up a process that will eventually lead to a full accounting of the actual costs and benefits of sustainable building design. The State has further clarified the scope of the guidelines to focus on new office and higher education classroom facilities, although many of the guidelines are suitable for other building types and renovation projects. Version 1.1 of The State of Minnesota Sustainable Building Guidelines was released in July 2004 and tested on several pilot projects. Version 2.0 reflects improvements based on lessons learned from the pilot projects.

Sustainable design is a means to reduce energy expenditures, enhance the health, well-being and productivity of the building occupants, and improve the quality of the natural environment. All of these can contribute to high-performance State buildings with lower life cycle costs. To move toward ensuring these outcomes, the guidelines attempt to quantify the human, community, environmental, and life-cycle economic costs and benefits for each project.

The guidelines are a part of the Buildings, Benchmarks & Beyond (B3) Project. Project management and delivery is led by LHB, Inc.; the guideline development process is led by the Center for Sustainable Building Research (CSBR) at the University of Minnesota; and public building benchmarking is led by The Weidt Group. Benchmarking will identify the energy performance of existing public buildings in order to direct energy conservation improvements where they are most needed and most cost-beneficial. As new state-funded projects are constructed and operated in accordance with the new sustainable guidelines, more detailed information on energy and other sustainable performance factors will also be tracked.

Applicability

All new buildings funded in whole or part by Minnesota bond monies after January 15, 2004 must comply with the guidelines. Remodeling and renovations are not considered new buildings, and thus

need not comply. Additions are considered new buildings that require compliance with the guidelines if they are substantially "stand alone" and have both of the following characteristics when applicable:

- If heated, the addition has its own heating plant(s) (eg. boiler, etc.) whether or not its source of energy (eg. fuel) is from an adjacent building
- If cooled, the addition has its own cooling plant(s) (eg. chiller, rooftop unit, etc.) whether or not its source of energy (eg. electricity) is from an adjacent building

If construction is not considered a building under the Minnesota Building Code then it is not considered a building under the Minnesota Sustainable Building Guidelines. Exceptions to compliance with the Minnesota Sustainable Building Guidelines as a whole are *not* allowed based on size of building, number of utility connections, or whether a building is heated, cooled or electrically lit. However, some individual guideline criteria are customized based on these or other variations. If an agency or design team feels certain guideline criteria do not apply to a particular building, this is handled for those specific criteria through a variance process described in guideline P.1 Guideline Management.

Guideline Development

In the past 15 years, many international, national and regional sustainable building guidelines have been developed. In this region, the Minnesota Sustainable Design Guide (MSDG) was initiated in 1997 by Hennepin County with a grant from the Minnesota Office of Environmental Assistance (OEA) and has been maintained by the University of Minnesota. The LEED™ Rating System (Leadership in Energy and Environmental Development) developed by the U.S. Green Building Council (USGBC) has emerged in recent years as a national standard with a high level of visibility and increasing market acceptance. Recently Green Globes™, used for many years in Canada, has been introduced into the U.S. as a sustainable building rating system and guide.

Sustainable or green building design is still an evolving field with rapid advances in knowledge, technology, and methods of measuring outcomes. Rating systems and guidelines continue to adapt and improve over time. The Minnesota Sustainable Building Guidelines attempt to address some fundamental problems that have not yet been resolved adequately in existing guidelines. For example, current guidelines such as LEED™ use prescriptive, point-based, and proxy measures that simplify both compliance and enforcement but in many cases do not connect to real human, environmental, and life-cycle economic outcomes and in some cases may lead away from desired results.

The development of the Minnesota Sustainable Building Guidelines is based on the following key concepts.

1. *Reduction in Guidelines*
   Guidelines have been eliminated that are either already required by code or do not apply in this region.

2. *Required Guidelines*
   There are no points for meeting certain criteria. Guidelines are simply required when they clearly contribute to the desired outcomes. Some guidelines are recommended rather than required until their benefits to the State can be clearly demonstrated. In some of these cases, however, the team is required to evaluate implementing a recommended guideline to calculate the costs and benefits for their particular project. Where any inconsistencies may appear as to the extent of performance required or whether an item is recommended or required, the more strict (higher performing) case shall apply.

3. *Connection to Real Outcomes*
   Performance-based guidelines replace prescriptive measures wherever appropriate. The outcomes are documented on six forms (Forms P-1 through P-6) with embedded calculation tools. The purpose is to collect data on outcomes wherever possible and educate all participants in the process of determining outcomes. The performance indicators of real outcomes to be calculated in applying these guidelines (to be further developed in following phases) include the following:

   Project Lifecycle Costs
   - Project capital costs
   - Operation and maintenance costs

   Human Impacts and Related Cost
   - Health and Well-being
   - Productivity
   - Absenteeism
   - Employee turnover
   - Health care costs

   Environmental Impacts
   - Primary energy
   - Global warming potential
   - Waste production

   Community Impacts and Related Cost
   - Community infrastructure demand and associated costs
   - Community assets contributed by project
   - Economic impacts
   - Social impacts

4. *Relationship to LEED™ and the existing Minnesota Sustainable Design Guide (MSDG)*
   It is not the intent of The State of Minnesota Sustainable Building Guidelines to follow LEED™ requirements specifically, but wherever requirements are the same or similar, documentation required for these guidelines may be useful in achieving LEED™ credit. There is no guarantee, however, that compliance with these guidelines will result in a LEED™ credit. Refer to LEED™ sources for specific requirements and documentation required for certification. One benefit of making The State of Minnesota Sustainable Building Guidelines transparent to LEED™ and other guidelines is that LEED™ certification serves as one incentive to achieve higher performance than the basic requirements of these guidelines.

How to Use the Guidelines

The guidelines are organized into the following topic categories.

- Performance Management
- Site and Water
- Energy and Atmosphere
- Indoor Environmental Quality
- Materials and Waste

At the beginning of each section, there is an overview, goals, objectives, and a list of guidelines for that topic. Parts or all of some guidelines are noted as recommended. This is followed by documentation for each guideline that states the intent, performance criteria, compliance tools and resources, related MSBG documents, and supplementary resources. Suggested implementation steps for each guideline are in the first Appendix in each section. These suggested steps are not the only way to achieve the performance criteria. A glossary is included at the end of the guidelines.

The process for implementing the guidelines is explained in the Performance Management section. Refer to Guideline P.1 for complete explanations and requirements for the guideline management process. Highlights of the process are described below.

- At the start of each phase (or year of operation), the Guideline Leader reviews the MSBG guidelines and required documentation, plans the tasks to be done for that phase to keep on track for meeting the guidelines, and communicates this with the work team.
- If exceptions to the MSBG guidelines are sought, the Guideline Leader shall request the variance in writing to the Appropriated Agency (the agency building and operating the building) for Variance Review before the completion of the schematic design phase.
- The Work Team for the responsible organization (planning team, design team, construction team, or operations team depending on phase) works towards the MSBG requirements. At the end of the phase, the work team completes the appropriate documentation (Forms P-1 through P-6) and gives them to the Guideline Leader.
- The Guideline Leader collects Forms P-1 through P-6 at the end of each phase (or annually during facility operation) and submits them to the Appropriated Agency for compliance review. A copy of the forms is also submitted to the Center for Sustainable Building Research at the University of Minnesota to track the project. The team should archive relevant documentation for that phase (or year) for future reference.

MSBG VERSION 2.0 GUIDELINES

PERFORMANCE MANAGEMENT

Required Guidelines

- P.1 Guideline Management
- P.2 Planning for Conservation
- P.3 Integrated Design Process
- P.4 Design and Construction Commissioning
- P.5 Operations Commissioning
- P.6 Lowest Life Cycle Cost

SITE AND WATER

Required Guidelines

- S.1 Avoidance of Critical Sites
- S.2 Stormwater Management
- S.3 Soil Management
- S.4 Sustainable Vegetation Design
- S.5 Light Pollution Reduction
- S.6 Erosion and Sedimentation Control
- S.7 Landscape Water Efficiency
- S.8 Building Water Efficiency

Recommended Guidelines

- S.9 Appropriate Location and Development Pattern
- S.10 Brownfield Redevelopment
- S.11 Heat Island Reduction
- S.12 Transportation Impacts Reduction
- S.13 Wastewater Management

ENERGY AND ATMOSPHERE

Required Guidelines

- E.1 Energy Use Reduction by at Least 30%
- E.2 Renewable and Distributed Energy Evaluation
- E.3 Efficient Equipment and Appliances

Recommended Guidelines

- E.4 Atmospheric Protection

INDOOR ENVIRONMENTAL QUALITY

Required Guidelines

- I.1 Restrict Environmental Tobacco Smoke
- I.2 Specify Low-emitting Materials
- I.3 Moisture Control
- I.4 Ventilation Design
- I.5 Thermal Comfort
- I.6 Quality Lighting
- I.7 Effective Acoustics and Positive Soundscapes
- I.8 Reduce Vibration in Buildings
- I.9 Daylight

Recommended Guidelines

- I.10 View Space and Window Access
- I.11 Personal Control of IEQ Conditions and Impacts
- I.12 Encourage Healthful Physical Activity

MATERIALS AND WASTE

Required Guidelines

- M.1 Life Cycle Assessment of Building Assemblies
- M.2 Evaluation of Environmentally Preferable Materials
- M.3 Waste Reduction and Management

Performance Management Guidelines

Required Guidelines
P.1 Guideline Management
P.2 Planning for Conservation
P.3 Integrated Design Process
P.4 Design and Construction Commissioning
P.5 Operations Commissioning
P.6 Lowest Life Cycle Cost

Required Forms
Form P-1 Compliance Summary
Form P-2 Performance Management Documentation
Form P-3 Site and Water Documentation
Form P-4 Energy and Atmosphere Documentation
Form P-5 Indoor Environmental Quality Documentation
Form P-6 Materials and Waste Documentation

Worksheets and Appendices
Appendix P-1 Suggested Implementation for All Performance Management Guidelines
Appendix P-2 Guideline Management Supporting Information
Appendix P-3 (Forthcoming)
Appendix P-4 Design and Construction Commissioning Supporting Information
Appendix P-5 Design and Construction Commissioning Matrix
Appendix P-6 Operations Commissioning Supporting Information
Appendix P-7 Operations Commissioning Matrix
Appendix P-8 Life Cycle Cost Supporting Information

Overview
The Performance Management section outlines a process to support successful performance improvements intended by *The State of Minnesota Sustainable Building Guidelines (MSBG)* by documenting progress towards performance criteria throughout the planning, design, and construction phases. Monitoring of key systems continues throughout occupancy provides information for continuous improvement of operations and for planning and constructing future State projects. In addition, the Performance Management guidelines address the creation and use of the team necessary for a well-integrated solution, and the thorough evaluation of current and future needs so that all facilities are well-utilized and represent a responsible use of economic and natural resources over time.

Goal
To employ processes that improve the ongoing performance of facilities towards the lowest lifetime costs, and to promote design and operational decisions based on improving environmental, human, and economic outcomes.

Objectives
- Define a process for tracking progress towards guideline compliance throughout the project development and operation.
- Document information that captures design intent and actual performance to track progress towards desired guideline outcomes and to facilitate guideline improvement.

- Define a planning, control and tracking process to ensure that specific steps take place that are needed to support the operational achievement of performance criteria.
- Initiate and utilize an integrated team approach to produce integrated solutions.
- Review needs and resources thoroughly so as to maximize utilization of space.
- Provide guidance on determining the lowest life cycle cost for project alternatives.

Required Performance Management Guidelines

P.1 Guideline Management

Intent
Track compliance, define a method of variances and collect information to measure outcomes leading to continual improvement of the Guidelines.

Required Performance Criteria

A. Follow Agency process for guideline management or follow Appendix P-2 Guideline Management Supporting Information. In either case, the complete the following forms and submit at the end of each phase. Submit forms to the Appropriated Agency and the Center for Sustainable Building Research (CSBR).
    - Form P-1 Compliance Summary
    - Form P-2 Performance Management Documentation
    - Form P-3 Site and Water Documentation
    - Form P-4 Energy and Atmosphere Documentation
    - Form P-5 Indoor Environmental Quality Documentation
    - Form P-6 Materials and Waste Documentation
B. Use Agency variance process or follow Variance Review Process when appropriate (see Appendix P-2) The agency variance process must include at least the elements shown in the Variance Review Process.

Recommended Performance Criteria

C. Share the story of your project and apply for awards programs for recognition.
D. Maintain a Project Archive that serves as the performance planning, design, and ongoing maintenance history of the project (see Appendix P-1). This body of information should include: performance parameters and basis for design, design actions taken towards MSBG criteria, ongoing monitoring, measurement and verification over time, actions to resolve problems over time, and results of those actions. It includes all reports. The Guideline Leader and Work Team maintain the Project Archive in each phase and facilitate its transition to leaders of following phases.

Related MSBG Documents

- Appendix P-1 Suggested Implementation for All Performance Management Guidelines
- Appendix P-2 Guideline Management Supporting Information

Supplemental Resources

- The Minnesota Office of Environmental Assistance offers environmental awards and recognition programs, including the coveted Governors Awards for Excellence in Waste and Pollution Prevention, the MNGreat Awards, and Minnesota Waste Wise Leaders Awards. www.moea.state.mn.us/P2/awards.cfm
- The United States Green Building Web Site: "The LEED (Leadership in Energy and Environmental Design) Green Building Rating System™ is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings." Buildings can be rated as Certified, Silver, Gold or Platinum. www.usgbc.org

P.2 Planning for Conservation

Intent
Maximize utilization of facilities and modify them less over time by careful analysis of needs and resources. Building less, remodeling existing facilities, and designing for flexibility lead to reductions in cost, energy, and environmental impacts of materials.

Required Performance Criteria
A. Evaluate the assumptions to build, expand or remodel facilities using these questions.
- Can the current facilities be shared or better utilized to reduce or eliminate the need for additional space?
- Can the current facilities be used more hours of the day or more days of the week to reduce or eliminate the need for additional space?
- Can the current space be reconfigured within its shell to meet the need?
- If not, can an existing building be reconfigured within its shell to meet the need?
- If not, would an addition to the current space or another existing building meet the need?
- If not, how can new space be optimized (including shared use of some facilities) and the building footprint be minimized?
- For all options, how can the space be configured best for future use and adaptability?

Related MSBG Documents

- Form P-2 Performance Management Documentation
- Appendix P-1 Suggested Implementation for All Performance Management Guidelines

Supplemental Resources
- Building Green in PA videos
  www.greenworks.tv/green_building/archives.htm
- WMEP Interdistrict Downtown School Minneapolis Case Study link
  www.sustainabledesignguide.umn.edu/MSDG/case/downtown/downtown.html

P.3 Integrated Design Process

Intent
Create an integrated approach to the design process by involving key design team members, users, occupants and operators. An integrated design process leads to improved communication and a systems approach to problem solving resulting in optimizing performance at the lowest cost.

Required Performance Criteria
A. Conduct an organization/kick-off meeting including the team.

Recommended Performance Criteria
B. Assemble appropriate stakeholder team
Include representation from every discipline that will be involved in the project: Owner's decision-making team, users, occupants, operations and maintenance representatives, at least one representative from the community, and at least one agency "client" or visitor representative. Also include Owner Representative and commissioning agent if applicable. Choose members who can make a commitment through post-occupancy review phase.
C. Conduct planning/ review workshops at key phases with all team members.
- Comprehensive Business Planning Workshop at Agency planning phase
- Programming Workshop during Predesign Programming
- Facility Performance Workshop within the first 2-3 weeks of the schematic design phase
- Convene multi-disciplinary team at least once per design phase for integrated progress review towards guidelines
- Convene stakeholder team regularly for integrated progress review. Stakeholder team to meet a minimum of once per phase.
- Convene General Contractor and Sub-contractors for pre-construction kick-off meeting to review the MSBG goals and objectives.
- Incorporate discussion about the progress toward project outcomes during every construction meeting.
- After occupancy, Facility Operations Manager, Human Resources Manager and others that offer cross disciplinary points of view on Facility Operations shall meet annually to review operation practices, complaints, and building maintenance issues.

Related MSBG Documents
- Form P-2 Performance Management Documentation
- Appendix P-1 Suggested Implementation for All Performance Management Guidelines

Supplemental Resources
- Malin, Nadav, “Integrated Design,” Environmental Building News, November 2004.
- Building Green in PA videos www.greenworks.tv/green_building/archives.htm
- The MOEA web site of Resources on Sustainability is an excellent source of information about community benefits from sustainable design. www.moea.state.mn.us/sc/resources.cfm

P.4 Design and Construction Commissioning

Intent
Verify that the building is constructed and calibrated to meet the design intent as represented in contract documents (which includes meeting performance criteria of the Agency, including MSBG as represented in the contract documents.)

Required Performance Criteria
A. Develop and refine a commissioning scope and project budget in programming and schematic design. The project budget should be sufficient to cover commissioning activities not already in other agency or departmental budgets. The total commissioning budget, including both project funds and other funded activities should be in the range of 0.75% to 1.5% of the total construction cost.
B. Verify that the design is compatible with the Operations Commissioning Plan. (See Guideline P.5 Operations Commissioning.)
C. Use Agency Commissioning Process. If no Agency Commissioning Process exists, use Appendix P-4 Design and Construction Commissioning Supporting Information and Appendix P-5 Design and Construction Commissioning Matrix. In either case, the elements in the Design and Construction Commissioning Process from Appendix P-4 must be included.
D. Scope of items to be commissioned
    1. Systems Commissioning: Mechanical HVAC system including testing, adjusting and balance, energy, (including renewable) systems, power and electrical systems, including lighting and daylighting controls; indoor air quality elements and systems. See Appendix P-4 for more details on requirements under Design and Construction Commissioning Plan.
    2. Indoor air quality procedures during construction and warranty period according to Construction Air Quality Management Plan and Warranty Period Air Quality Management Plan. (See Appendix P-4.)
    3. Construction waste management procedures during construction according to the Construction Waste Management Plan. See Appendix P-4 and Guideline M.3 Waste Reduction and Management for criteria that the plan must meet.
    4. User Comfort and Satisfaction Assessment as one indicator of overall IEQ performance. See details under Appendix P-4.

Recommended Performance Criteria
E. Additional scope of Commissioning:
    1. Plumbing Systems (In addition to required flow rate commissioning above.)
    2. Interior materials (specification, installation);
    3. Envelope integrity (In addition to required water infiltration commissioning above.)
    4. Physical measurement of vibrations/acoustics/noise (In addition to occupant surveys above.)

    Note: Portions of this guideline are adapted from LEED Version 2.0.

Related MSBG Documents

- Form P-2 Performance Management Documentation
- Appendix P-1 Suggested Implementation for All Performance Management Guidelines
- Appendix P-4 Design and Construction Commissioning Supporting Information
- Appendix P-5 Design and Construction Commissioning Matrix

Tools

IAQ Practices

- SMACNA, IAQ Guidelines for Occupied Buildings Under Construction, 1st Edition, 1995. www.smacna.org

Indoor Air Quality Operations, Measurement and Verification

- EPA's Building Air Quality can be found at www.epa.gov/iaq/largebldgs/baq_page
- EPA's I-BEAM can be found at www.epa.gov/iaq/largebldgs/ibeam_page

Supplemental Resources

- ASHRAE Guideline 1-1996, The HVAC Commissioning Process www.ashrae.org. See website for new guidelines for building commissioning
- Building Commissioning Association www.bcxa.org
- Designing Tools for Schools: Commissioning www.epa.gov/iaq/schooldesign/commissioning.html
- Federal Energy Management Program Building Commissioning Guide www.eren.doe.gov/femp/techassist/bldgcomgd.html
- LEED Green Building Reference Guide™ 2.0, United States Green Building Council
- National Strategy for Building Commissioning website www.peci.org/cx/natstrat.html
- State of Florida references NIBS program: www.state.fl.us/fdi/edesign/news/9811/total.htm
- Total Building Commissioning sustainable.state.fl.us/fdi/edesign/resource/totalbcx/index.html
- Stum, Karl, The Importance of Commissioning Green Buildings, P.E. Portland Energy Conservation, Inc. (PECI) 921 SW Washington, Suite 312, Portland, OR 97205 Tel: 503-248-4636 Fax 503-295-0820)
- The Cost-Effectiveness of Commercial-Buildings Commissioning; A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States. Lawrence Berkeley National Laboratory, Portland Energy Conservation Inc., Energy Systems Laboratory, Texas A&M University. December 2004. http://eetd.lbl.gov/emills/PUBS/Cx-Costs-Benefits.html

P.5 Operations Commissioning

Intent
Ensure (verify) the building is operated to meet the design intent as represented in contract documents (which includes meeting performance criteria of the Agency, including MSBG.)

Required Performance Criteria

A. Use Agency Operations Management Process. If there is no established Agency Operations Management Process, use Appendix P-6 Operations Commissioning Supporting Information and Appendix P-7 Operations Commissioning Matrix. In either case, the elements of the Operations Commissioning Process from Appendix P-6 must be included.
B. Evaluate performance over time according to the Measurement and Verification Plan for the following scope:
   - Water device and system level measurement and verification
   - Water whole building measurement and verification
   - Energy device and system level measurement and verification
   - Energy whole building measurement and verification based on metering and calibrated energy simulation as outlined in the following table.

Size (sq.ft.)	Metering	with Submetering	Calibrated Simulation (annual Energy Use)
<10,000	Required	Recommended	Recommended
10-50,000	Required	Required	Recommended
>50,000	Required	Required	Required

   - Indoor environmental quality (IEQ) measurement and verification: Air quality, thermal comfort, quality of lighting
   - Waste measurement and verification
   - User complaint/ work request logs related to user comfort and satisfaction as an indicator of ongoing IEQ performance
C. Implement Operations and Maintenance Practices and annual evaluation according to the Maintenance Plan.

Recommended Performance Criteria

D. Perform Measurement and Verification of the following additional areas of building performance over time according to the Measurement and Verification Plan.
   - Vibrations, acoustics, and noise verification
   - Access to daylight
   - View space and window access evaluation
   - Personal control of IEQ conditions and impacts
   - Opportunities and encouragement for healthful physical activity
   - Materials measurement and verification
   - User Comfort and Satisfaction Assessment surveys as an indicator of ongoing IEQ performance
E. Perform Systems Recommissioning: At least annually or in response to events or triggers at the discretion of owner.

Note: Portions of this guideline are adapted from LEED Version 2.0.

Related MSBG Documents

- Form P-2 Performance Management Documentation
- Appendix P-1 Suggested Implementation for All Performance Management Guidelines
- Appendix P-6 Operations Commissioning Supporting Information
- Appendix P-7 Operations Commissioning Matrix

Tools

Measurement and Verification

- US DOE's International Performance Measurement and Verification Protocol (IPMVP): www.ipmvp.org
  Volume I - Concepts and Options for Determining Savings
  Volume II -Concepts and Practices for Improving Indoor Environmental Quality Volume III - Applications

Indoor Air Quality Operations, Measurement and Verification

- EPA's Building Air Quality can be found at www.epa.gov/iaq/largebldgs/baq_page
- EPA's I-BEAM can be found at www.epa.gov/iaq/largebldgs/ibeam_page

Supplemental Resources

- LEED for Existing Buildings, United States Green Building Council, www.usgbc.org
- ASHRAE Guideline 4-1993, Preparation of Operating and Maintenance Documentation for Building Systems, www.ashrae.org.

P.6 Lowest Life Cycle Cost

Intent
Determine the lowest life cycle cost when comparing design alternatives.

Required Performance Criteria
A. Perform a life cycle cost analysis on the energy strategies for the whole building based on three energy use scenarios generated in Guideline E.1 using the life cycle cost calculation embedded in Form P-4 Energy and Atmosphere Documentation.

Recommended Performance Criteria
B. Include more extensive life cycle cost analysis of any design alternatives at the assembly, system or component scale.

Related MSBG Documents

- Form P-2 Performance Management Documentation
- Appendix P-1 Suggested Implementation for All Performance Management Guidelines
- Appendix P-8 Life Cycle Cost Supporting Information

Tools
To comply with this guideline, it is only necessary to use the Life Cycle Cost calculator embedded in Form P-4 Energy and Atmosphere Documentation. For any life cycle cost analysis, a discounted cash flow analysis of each project alternative under review is recommended. These analyses can be accomplished through use of a custom designed discounted cash flow model or through use of the NIST's BLCC computer model. In either case, refer to description of other considerations outside the model under the definition of Life Cycle Cost Formula above. (See Appendix P-8 Life Cycle Cost Supporting Information.)

Custom Designed Model
- It is very likely that any entity proposing a significant state funded project will have the resources needed to prepare a discounted cash flow analysis of the project. Such an analysis, typically prepared using Excel, will detail all of the initial costs of design and construction and then project future annual operating and maintenance costs, utility costs, replacement costs, and the residual value of the building and equipment. If these future costs are presented in current dollars in each year (showing the impact of inflation), they are then discounted back to the present using a nominal discount rate (a discount rate that recognizes inflation.) If future costs are expressed in constant dollars (not adjusted for inflation), then they are discounted back to the present using a real discount rate. (For example, FEMP discount and inflation rates, valid for energy and water conservation and renewable energy analyses conducted between 4/1/2004 and 3/31/2005 are: 3% Real Discount Rate, 4.8% Nominal Discount Rate, and a 1.75% Inflation Rate.) The initial costs and the discounted future costs are the summed to provide the discounted present value (discounted cost) of the proposed project over its life cycle. By completing a life cycle cost analysis of different options under consideration and then comparing the discounted present value of each, it is possible to work towards identifying the building option that has the lowest possible lifetime cost.

The BLCC Model

- The National Institute of Standards and Technology (NIST) Office of Applied Economics has produced, and annually updates, a Building Life-Cycle Cost (BLCC) computer model that is available at no charge from NIST and that can also be downloaded from their web site. The annual update of the BLCC is released each April and contains the federal government's latest estimates for inflation, energy price escalation by state, and federal discount rates (Nominal and Real.) This model is designed specifically to help the user identify building options that result in the lowest life cycle cost with particular attention paid to energy use and water consumption. The user of this model is expected to enter a base case (typically for a code-compliant basic building), one or more alternative designs, and then compare the results. While the BLCC model is focused on energy and water, with a little imagination it can be used to complete a comprehensive analysis of a project. The model allows the user to add new categories for initial capital expenditures, on going recurring charges, one time future charges, etc., so it is possible to build a comprehensive model of the life cycle costs of a proposed building. Numerous different building configurations can then be defined and evaluated and predefined reports can be used for easy comparisons of alternatives. The BLCC model has a module that compares the base case project to the alternative under review and calculates energy savings and emission reductions (CO2, SO2, NOx) achieved by the alternative.

Supplemental Resources

- Life-Cycle Costing Manual for the Federal Energy Management Program published by National Institute of Standards and Technology (NIST Handbook 135) (222 pages) A comprehensive manual containing a thorough discussion of both the concepts and underlying math of life cycle costing with numerous examples demonstrating the value of this approach. This publication can be ordered at no cost from NIST (301-975-6478) or the EERE Info Center (1-800-363-3732.) It can also be downloaded from the EERE web site: www.eere.energy.gov/femp/program/lifecycle.cfm
- Guidance on Life-Cycle Cost Analysis Required by Executive Order 13123, January 8, 2003 (27 pages) A brief but solid discussion of Life Cycle Cost Analysis concepts and definitions with some examples. Published by FEMP and available through the EERE web site: www.eere.energy.gov/femp/program/lifecycle.cfm
- 2003 Facilities Standards (P100), Section 1.8 Life Cycle Costing (5 pages) This section of the GSA's Facility Standards manual discusses Life Cycle Costing and contains a table summarizing key LCC formulas and their use. Available through GSA: www.gsa.gov (search for "P100", then go to section 1.8 "General Requirements; Life Cycle Costing")
- OMB Circular A-94 - Guidelines for Benefit-Cost Analysis of Federal Programs Presents guidance for the analysis of projects other than those that are primarily energy related. Broadens the discussion beyond just costs and cost-avoidance to include benefits. Available for download at: www.whitehouse.gov/omb/circulars/a094/a094.html
- Whole Building Design Guide is a web based resource containing extensive background information, research reports and references relating to the design, analysis, and construction of "Whole Buildings". Includes information on life cycle analysis, productivity, energy conservation and other topics pertinent to sustainable design. www.wbdg.org

Site and Water Guidelines

Required Guidelines

S.1 Avoidance of Critical Sites
S.2 Stormwater Management
S.3 Soil Management
S.4 Sustainable Vegetation Design
S.5 Light Pollution Reduction
S.6 Erosion and Sedimentation Control During Construction
S.7 Landscape Water Efficiency
S.8 Building Water Efficiency

Recommended Guidelines

S.9 Appropriate Location and Development Pattern
S.10 Brownfield Redevelopment
S.11 Heat Island Reduction
S.12Transportation Impacts Reduction
S.13 Wastewater Reduction and Management

Related Documentation

See Section 2 — Form P-3 Site and Water Documentation

Worksheets and Appendices

Worksheet S-1 Site Water Infiltration Calculator
Worksheet S-2 Building Water Calculator
Appendix S-1 Suggested Implementation for All Site and Water Guidelines
Appendix S-2 Storm Water Quality Table
Appendix S-3 Irrigation Water Consumption

Overview

Building construction transforms land that provides valuable ecological services. Society has only recently begun to understand that these services have a quantifiable economic value. For example, the City of Minneapolis has recently developed a stormwater management fee that better reflects the true costs of stormwater runoff and that provides more economic incentive for improved stormwater performance. Site selection and design affect transportation and energy use which leads to ground-level ozone, acid rain, smog, and global climate change. Current development practices on the land can lead to uncontrolled stormwater runoff, degraded water and soil quality, depletion of water, soil, and valuable vegetated areas, and destruction of habitat. The State of Minnesota Sustainable Building Guidelines (MSBG) seek to restore and improve site water and soil quality, and to reduce negative impacts associated with site selection and design.

Goal

To design and maintain sites which have soil and water quality capable of supporting healthy, bio-diverse plant, animal, and human communities, which reduce water and energy consumption, improve the rate, quantity and quality of stormwater runoff, and which minimize pollutant contributions related to transportation requirements.

Objectives

- Maintain and improve the ability of the soil to maintain its structure against adverse impacts.
- Restore/improve the hydrologic cycle of water on the site to avoid adverse impacts on the site and downstream of the site.
- Reduce consumption of potable water.
- Improve the biodiversity of the site by introducing flora/fauna which will help contribute to the sustainability of the site over time.
- Reduce energy consumption and pollution contributions to air and water related to site location and associated transportation requirements.
- Restore/improve the outdoor environmental quality (OEQ) of the site to enhance occupant productivity, building performance, and community benefits.

Required Site and Water Guidelines

S.1 Avoidance of Critical Sites

Intent

Avoid selecting sites, or minimize the development footprint on portions of sites whose natural features and functions are particularly valuable to the larger community. Avoid development on sites where soil, water, and flora/fauna indicators are in a fragile condition because of surrounding development or the natural state of the site.

Required Performance Criteria

Avoid selecting sites or minimize the development footprint on portions of sites that meet any one of the following criteria:

A. Land of national, state, regional, or local natural resource and biological/ecological significance as identified in national, state, regional, or local natural resources inventories, assessments and biological surveys and land within 150 ft of this type of these areas which functions as a buffer zone.
B. Prime farmland and farmed wetland as defined by state statute rules and identified in County Soil Surveys and/or County/regional farmland and natural areas conservation/preservation programs.
C. Land whose elevation is lower than 5 feet above the elevation of the 100-year flood (as defined by the local Watershed District, Watershed Management Organization, or Joint Powers organization) and land within 50 ft of these areas which functions as a buffer zone.
D. Land which provides habitat for any animal or plant species on the Federal or State threatened or endangered list. If rare, threatened, or endangered species occur on maps of subject site, then contact the County Biological Survey (CBS) for exact coordinates of the said species. and/or if the site provides habitat for any rare animal or plant species using County Biological Survey (CBS,) and land which is within 300 ft of these areas which functions as a buffer zone.
E. Land which prior to acquisition for the project was public parkland, unless land of equal or greater value as parkland is accepted in trade by the public landowner (Park Authority projects are exempt.)
F. Land which is under a conservation easement.

Note: If the site selected did not completely avoid the conditions in S.1A, S.1C, or S.1D, there are site management implications documented in S.4D, S.4E, and S.4F respectively.
Note: Portions of this guideline are adapted from LEED Version 2.0.

Compliance Tools and Resources

- Public Land Survey Plat Maps
- For S.1A Through S.1F Public Land Survey Notes (University of Minnesota, Twin Cities Campus, Wilson Library – must have range, township, and section information on the subject site to obtain notes.)
- For S.1A Marshner's Land Cover Map of Minnesota (www.dnr.state.mn.us/)
- For S1.A Comprehensive County "Critical Natural Resources" map and assessments such as County Biological Surveys, DNR Natural Resources Inventory and Assessment (NRI/A) (in 7 county Metro Area), local NRI/A's
- For S.1A National Wetland Inventory (www.fws.gov/nwi/)
- For S.1B See www.farmlandinfo.org/minnesota) as a starting point to help identify prime farmland and to identify other resources for this information.

- For S.1C The Minnesota Board of Water and Soil Resource (BWSR) can direct you to the source for most current local flood information.
- For S.1D National, state, or county databases and maps identifying habitat with identified or potential threatened or endangered flora/fauna
- For S.1E Comprehensive Plan
- For S.1F Minnesota Land Trust, Conservation Easement Holdings

Related MSBG Documents

Form P-3 Site and Water Documentation
Appendix S-1 Suggested Implementation for All Site and Water Guidelines

Supplemental Resources

- Minnesota Rules; Board of Soil and Water Resources, Chapters 8400-8420
- www.swcs.org/calender_of_events_andresources/
- ALTA Survey (American Land Title Association/ American Congress of Surveying and Mapping).

S.2 Stormwater Management

Intent

Minimize negative impacts on the natural site hydrologic cycle as much as possible by treating stormwater close to where it falls, reducing downstream impacts thereby improving the overall water quality and clarity, and recharging groundwater through infiltration as local soils and subsurface conditions allow and re-using stormwater wherever possible.

Required Performance Criteria

Runoff Rate:

A. 1. Control the quantity of runoff from the site to pre-settlement conditions for the 100 year 24 hour precipitation event (Note: Minneapolis 100 yr/24 hr = 5.9 inches [Source: NRCS TR-55]) and

2. There shall be no discharge from the site for a 1.25" rainfall based on the Rational Method (Source: MPCA Stormwater Manual, Chapter 1, Sections 1.1-5 and 6). Methods to achieve this shall be consistent with those found in the Minnesota Pollution Control Agency's "Minnesota Stormwater Manual".

B. Create micro catchments less than 1 acre and treat storm water at these 1 acre source points for a 2 year 1 hour storm event.

Runoff Quality:

C. For a 2 year, 24-hour rainfall event, provide treatment systems designed to remove 80% of the average annual post development Total Suspended Solids (TSS), by implementing Best Management Practices (BMPs) outlined in the handbook "Urban Small Sites Best Management Practices" (Metropolitan Council), "Protecting Water Quality in Urban Areas" handbook (Minnesota Pollution Control Agency), the "Minnesota Stormwater Manual" (Minnesota Pollution Control Agency), or the Local Governing Unit (LGU). All BMP treatment systems for subject site need to include safety factors, maintenance, and a back-up plan in case of failure. All manufactured devices require independent laboratory testing to confirm product claims.

D. For a 2 year, 24-hour rainfall event, provide treatment systems designed to remove 60% of the average annual post development Total Phosphorus (TP), by implementing Best Management Practices (BMPs) outlined in the handbook "Urban Small Sites Best Management Practices" (Metropolitan Council), "Protecting Water Quality in Urban Areas" handbook (Minnesota Pollution Control Agency), the "Minnesota Stormwater Manual" (Minnesota Pollution Control Agency), or the Local Governing Unit (LGU). All BMP treatment systems for subject site need to include safety factors, maintenance, and a back-up plan in case of failure.

E. NOT USED

F. NOT USED

G NOT USED

H. NOT USED

I. For Type D soils, abstract the difference in volume between the pre-settlement conditions and the proposed site conditions using the Rational Method for a 1.25" rainfall, which may be stored for irrigation, non potable uses, or other alternative purposes and/or transpired using proposed vegetation (e.g. trees, shrubs, herbaceous vegetation, green roofs, and green walls) with supporting calculations.

J. Sites' included within or adjacent to significant municipal or Local Governing Unit(LGU) potable well head protection areas may follow rules laid out in Section I.

K. All stormwater BMPs must have an Operations and Maintenance manual created which addresses all potential maintenance issues. Basins, ponds, and reservoirs must be cleaned of deposited materials two times per year minimum.

Infiltration Rate and Quality:

L. Maintain or increase infiltration rates from pre-project site conditions.
M. Provide treatment systems designed to remove solids and pollutants for on-site water quality to comply with "Urban Small Sites Best Management Practices" (Metropolitan Council).

Overall:

N. Implement a stormwater management plan that reduces impervious cover, promotes infiltration, and captures and treats the stormwater runoff from 90% of average annual rainfall using acceptable Best Management Practices (BMPs).

Note: Portions of this guideline are adapted from LEED Version 2.0.

Compliance Tools and Resources

- "Urban Small Sites Best Management Practices" (Metropolitan Council)
- "Protecting Water Quality in Urban Areas" handbook (Minnesota Pollution Control Agency)
- Minnesota Stormwater Manual" (Minnesota Pollution Control Agency)
- Local Governing Unit (LGU) BMPs for stormwater treatment systems
- MPCA Standards performance thresholds. www.pca.state.mn.us/water/standards
- Local Governing Unit (LGU) Water Quality Standards

Related MSBG Documents

Form P-3 Site and Water Documentation
Worksheet S-1 Site Water Infiltration Calculator
Appendix S-1 Suggested Implementation for All Site and Water Guidelines
Appendix S-2 Storm Water Quality Table

Supplemental Resources

- Best management practices for stormwater management authored by the EPA (Summarized in Appendix S-2 Storm Water Quality Table), MPCA, MetCouncil, or LGU.
- MetCouncil Small Sites BMP Manual
- Calculate runoff using Calculator and runoff coefficients in Worksheet S-1 Site Surface Base Data (Rational Method).
- Low- Impact Development Guidelines
- The Minnesota Stormwater Manual =, v.1.0, November 2005: available from the MPCA at http://www.pca.state.mn.us/publications/wq-strm8-14.pdfEPA BMPs (www.epa.gov/OST/stormwater/)
- www.mnwatershed.org/infiltration
- www.pca.state.mn.us/publications/mnenvironment/impaired-waters-edition/stormwaterplants.html
- http://soils.usda.gov/sqi/files/UrbanSQ.pdf
- www.bmpdatabase.org (International Stormwater BMP Database)
- www.mnerosion.org/meca_eandstools.htm
- www.stormwatercenter.net
- www.bmpdatabase.org/
- www.metrocouncil.org/environment/Watershed/BMP/manual.htm
- Plants for Stormwater Design: Species Selection for the Upper Midwest (MPCA.) Contact Kelly Turner 651-297-8679 for copies. (See web site above.)
- Protecting Urban Soil Quality (USDA) (See web site above.)

- Center for Watershed Protection. (www.cwp.org/)
- Minnesota Association of Watershed Districts. (www.mnwatershed.org/)
- Board of Water Quality and Soil Resources (BWSR). (www.bwsr.state.mn.us/)
- MNDOT Soil Bioengineering Handbook.
- EPA Guidance: Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters.

S.3 Soil Management

Intent

Maintain the permeable structure and biological health of the soil in order to optimize plant health and species richness and optimize water infiltration and filtration.

Required Performance Criteria

A. Create a Soil Management Plan for construction to protect soil profile of site.
B. For all sites: Limit site disturbance (defined as piling, tilling, scraping, storing, and removal of any and all soil) to 40 feet beyond the building perimeter, 5 feet beyond primary roadway curbs, walkways, and main utility branch trenches, 5 feet beyond tree driplines and the edges of site areas identified for protection and 25 feet beyond pervious paving areas and stormwater management features that require additional staging areas in order to limit compaction in the constructed areas
C. Maintain > 350' of undisturbed buffer for delineated wetland boundaries or to Board of Water and Soil Resources (BWSR) current buffer requirements, whichever is more stringent.
D. Protect trees as individuals or in groups (canopies < 10' apart) with tree protection fence prior to any and all site activities
E. Mitigate all compaction impacts to future planting areas during construction with deep vibration technology greater than or equal to 24". Maintain and install/re-spread topsoil to a minimum 12" depth.
F. Do not sell or export any top soil from project site
G. Maintain or mitigate mycorrhyzeae populations viable in all topsoil stockpiles per Mycorhizal standards per (MNDOT Standard Specification Section 3896.2 Soil and Root Additives) immediately prior to respread.
H. Innoculate all future planting areas with Mycorrhyzeae to Mycorryhizal standards per (Reforestation Technologies, Inc.)
I. Where trees are planted in hard surfaces (patios, driveways, car parks, plazas, parking islands) use a structural soil media mix of minimum soil volume of 500 cubic feet (cf) per tree (600-1,000 cf per tree recommended) if intending to meet S.7 Recommended Performance Criteria OR of minimum soil volume of 350 cubic feet (cf) per tree if intending to meet S.7 Required Performance Criteria (assumes trees are being watered when water content of soil drops below 15% of average water-holding capacity, or monthly). If soil volumes cannot be met it is recommended that trees be planted in minimum 8' wide by approximately 3' deep trenches so that small soil volumes per tree become "interconnected"
J. Mantain soil porosity through maintaining a soil column porosity greater than or equal to 36" as defined by the NRCS for that Soil Series type.

Note: Portions of this guideline are adapted from LEED Version 2.0.

Compliance Tools and Resources

- Cornell University Structural Soil (www.asla.org/latis/pdf/Structural_soils_updated081202.pdf)

Related MSBG Documents

Form P-3 Site and Water Documentation
Appendix S-1 Suggested Implementation for All Site and Water Guidelines

Supplemental Resources

- Philip J. Craul. *Urban Soils: Applications and Practices*. New York: John Wiley & Sons, 1999.
- Bassuk, Nina; Grabosky, Jason; Trowbridge, Peter; Urban, James. "Structural Soil: An Innovative Medium Under Pavement that Improves Street Tree Vigor". Urban Horticulture Institute, University of Michigan. Web resource from: http://www.personal.umich.edu/sarhaus/courses/NRE501_F2000/Lloyd/strctsoil.htm

S.4 Sustainable Vegetation Design

Intent

Conserve existing site features during planning and construction to promote biodiversity and both net and viable species populations and richness on the site and to restore natural areas damaged by construction so the site can sustain its water, soil, and plant cover functions.

Required Performance Criteria

Vegetation Design

A. On previously developed sites: maintain or improve natural site functions and biodiversity for 50% of site area (excluding building footprint) in accordance with existing conditions and surrounding site context.
B. On all sites: A minimum of 75% of total vegetated area on the site shall be native to the local area. In addition, a minimum of 75% of all trees and shrubs, by quantity, are to be native material. Native is defined as within 200 mile radius of the site. Cultivars may be used if they do not appear on the Minnesota Native Plant Society or University of Minnesota Extension Service "Invasive" or "Species of Concern" lists. Exception: do not remove existing, non-invasive vegetation solely in order to achieve this threshold.
C. Maintain or supplement tree trunk area of site so that there is no net loss of tree trunk area (square inches) at dbh (diameter at breast height=4.5 ft.) (Reference: International Society of Arboriculture (ISA) measurement tree area ratio for translating dbh to caliper.) Pre-project tree trunk area may disregard existing trees less than 6" in diameter. Replaced tree trunk area may include trees of any diameter.

Vegetation Management Plans:

D. If the site selected did not completely avoid (per guideline S.1A) land of national, state, regional, or local natural resource and biological/ecological significance as identified in national, state, regional, or local natural resources inventories, assessments and biological surveys and an associated 150 ft buffer zone, then for the portions of this site that include this type of land, create and implement a protection and maintenance plan that follows County Biological Survey (CBS) guidelines and with CBS staff input before any site work is done.
E. If the site selected did not completely avoid (per guideline S.1C) Land whose elevation is lower than 5 feet above the elevation of the 100-year flood the local Watershed District, Watershed Management Organization, or Joint Powers organization)) and an associated 50 ft buffer zone, then for the portions of this site that include this type of land, create and implement a protection and maintenance plan that follows BWSR guidelines and with BWSR staff input before any site work is done.
F. If the site selected did not completely avoid (per guideline S.1D) land (including a 300ft buffer zone)which provides habitat for any animal or plant species on the Federal or State threatened or endangered list, and/or if the site provides habitat for any rare animal or plant species, using County Biological Survey (CBS,) then, create and implement a protection and maintenance plan that follows CBS guidelines and with CBS staff input before any site work is done.
G. Determine if the vegetation on site includes invasive species using the Invasive Species County Weed Guideline. If the site does contain invasive species, create or implement a mitigation and maintenance plan as defined by the Minnesota Department of Agriculture.

Recommended Performance Criteria

H. On previously developed sites: maintain or improve natural site functions and biodiversity for 90% of site area in accordance with existing conditions and surrounding site context.

Compliance Tools and Resources

- www.nh.nrcs.usda.gov/technical/ This will lead to a page that has a link to the Electronic Field office Technical Guide (eFOTG)
- Seeding Manual - Latest Edition, Mn/DOT Office of Environmental Services, Turf Establishment & Erosion Control Unit
- The Minnesota County Biological Survey: www.dnr.stste.mn.us/ecological_services/mcbs/index,htmlFor Item F. While not needed for compliance, these resources may help in creating the required plan: BWSR's 2006 publication: "Restoring and Managing Native Wetland and Upland Vegetation" and MPCA's 2005 publication: "Minnesota Stormwater Manual"

Related MSBG Documents

Form P-3 Site and Water Documentation
Appendix S-1 Suggested Implementation for All Site and Water Guidelines

Supplemental Resources

- Municipal tree and natural resource inventory
- Geotechnical soils analysis
- www.epa.gov/owow/wetlands/restore
- United States Dept. of Agriculture, Natural Resources Conservation Service, Engineering Field Handbook
- Minnesota Department of Agriculture, Invasive Species (www.mda.state.mn.us/invasives/default.htm)
- International Society of Arboriculture (www.isa-arbor.com/publications/tree-ord/ordprt3d.aspx)
- Board of Water and Soil Resources website: www.bwsr.state.mn.us/index.html

S.5 Light Pollution Reduction

Intent

Eliminate light trespass from the site, improve night sky access, and reduce development impact on nocturnal environments.

Required Performance Criteria

Light Trespass:

A. Do not exceed the following night-time (sunset to sunrise) vertical illuminance values for each of the four exterior lighting zone types defined below. The illuminance measurement shall be at 5ft above ground level, along the site property line and facing into the site, perpendicular to the site property line. Vertical illuminance solely from site lighting fixtures may be used; light reflectance off of site surfaces may be ignored in meeting this criteria.

Table for S.5A Light Trespass Limitations

Environmental Lighting Zone	Description	Maximum Vertical Illuminance Levels [fc] at Property Line
E1: Intrinsically Dark	Parks and residential areas where controlling light pollution is a high priority	0.1
E2: Low Ambient Brightness	Outer urban and rural residential areas	0.1
E3: Medium Ambient Brightness	Urban residential areas	0.2
E4: High Ambient Brightness	Urban areas having both residential and commercial use and experiencing high levels of nighttime activity	0.6

Note: This Table was adapted from IESNA RP-33-99, using "post curfew" recommendations for all values to ensure that light trespass is minimized for each environmental zone. In situations where the property line is very close to the area of development (commonly referred to as "zero property line"), and where lighting is required for emergency egress purposes, it may not be possible to meet these recommendations and an exception may be made for lighting within 10 feet of these areas. Carefully explain and document these conditions.

Recommended Performance Criteria

Light Pollution or Sky Glow:

B. Reduce Upward Emissions:

For Parking Lot and Security Lighting areas:

For the same environmental lighting zones as defined above for light trespass, achieve the following light distribution characteristics:

- Zone E1: Use Luminaires with light distribution that meets IESNA's "Full Cutoff Fixtures"
- Zone E2: Use Luminaires with light distribution that meets IESNA's "Cutoff Fixtures"
- Zone E3: Use Luminaires with light distribution that meets IESNA's "Semi-Cutoff Fixtures"
- Zone E4: Use Luminaires with light distribution that meets IESNA's "Cutoff Fixtures

For façade, display, sculptural and sign lighting:

- For luminaires of 3500 or more lumens, light objects from above
- For luminaires of less than 3500 lumens, objects may be lit from below. Make an effort to minimize non-target light (maximize the percentage of uplight that falls on the target)

C. Create lighting control zones and provide lighting control devices for parking lot, security, and decorative and façade lighting so that each type of lighting can be controlled independently and can be turned off or reduced in response to reduced lighting needs during low use or non-use periods.

Note: The principles for sky glow criteria S.5 B-C are adapted from principles outlined in IESNA RP33-99, Lighting for Exterior Environments.

Light Quality:

D. Use lamps with a minimum CRI of 65 in areas of safety/security (i.e. main walking routes through large parking lots, isolated areas), at building entrances, and locations where identification of objects or individuals is essential.

Note: Portions of this guideline are adapted from LEED Version 2.2.

Compliance Tools and Resources

- Illuminating Engineering Society of North America (IESNA) Recommended Practice (RP-33-99)Lighting for Exterior Environments.

Related MSBG Documents

Form P-3 Site and Water Documentation
Appendix S-1 Suggested Implementation for All Site and Water Guidelines

Supplemental Resources

- Illuminating Engineering Society of North America (IESNA) Technical Memorandum TM-10-00, Addressing Obtrusive Light (Urban Sky Glow and Light Trespass) In Conjunction with Roadway Lighting.
- Illuminating Engineering Society of North America (IESNA) Technical Memorandum TM-11-00, Light Trespass: Research, Results and Recommendations.
- International Dark-Sky Association, www.darksky.org

S.6 Erosion and Sedimentation Control During Construction

Intent

Reduce erosion and sedimentation during construction.

Required Performance Criteria

Plan for and implement Erosion Control Management during construction (per NPDES site permit), until final punchlist that includes:

A. Leave no soil open for more than 48 hours (for example: use blankets, fences, slope interceptions)
B. Inspect, repair and cover erosion-damaged areas within 6 hours of every 24 hour storm event that is greater than or equal to _".
C. Create a Storm Water Pollution Prevention Plan (SWPPP) and submit it to MPCA and local watershed authority 4 days prior to any and all site disturbance.
D. Enact a fine structure (with a $1,000 minimum) for all erosion control infractions, to be set and enforced on Contractors by the Owner or Owner's representative.
E. Identify and protect all downstream (TMDL) impaired waters from identified impacts. (Examples: mercury, lead, calcium, chromium, copper, chloride, Total Suspended Solids (TSS), phosphorus, biota).
F. Limit sediment discharge to the most stringent of the following scenarios: a) 5 tons per acre per year using the RUSSLE method or other generally accepted soil runoff calculation. b) Met council small site Best Management Practices (BMP's) or c) (watershed district, watershed maintenance organization, joint powers association, local governing unit).
G. Maintain Temporary Erosion Control until the site is vegetated and stormwater infrastructure is fully functional.

Compliance Tools and Resources

- Best management practices for erosion and sedimentation control by the Environmental Protection Agency (EPA), Minnesota Pollution Control Agency (MPCA), MetCouncil, or Local Governing Unit (LGU), whichever is most stringent.
- MetCouncil Small Sites BMP Manual
- Minnesota Soil Bioengineering Handbook (available from the Minnesota Department of Transportation (MNDOT)
- Russle Method (NRCS)
- Minnesota Pollution Control Agency SWPPP Guidelines
- Minnesota Pollution Control Agency Publication: Minnesota's Impaired Waters

Related MSBG Documents

Form P-3 Site and Water Documentation
Appendix S-1 Suggested Implementation for All Site and Water Guidelines

Supplemental Resources

- www.pca.state.mn.us/water/pubs/sw-bmpmanual
- www.dot.state.mn.us/engserv/tecsup/index
- www.metrocouncil.org/environment/Watershed/BMP/manual.htm
- www.meca.com

S.7 Landscape Water Efficiency

Intent

Limit, or eliminate demand for municipal potable water or harvested groundwater (well water) used for maintaining plants and lawn areas.

Required Performance Criteria

A. Design and maintain landscape so that after a 2 year establishment period, the landscape uses 50% less municipal potable water or harvested ground water for irrigation than a base case landscape design. (Exception: annuals are exempt.) Any amount of site-harvested rainwater, storm water, or gray or waste water treated on site to tertiary standards may be used. The criteria may be met by any combination of: selection of native or low water use plants, use of alternatively sourced irrigation water as described, use of high efficiency irrigation systems, or other strategies.

Recommended Performance Criteria

B. Design and maintain landscape so that after 1-2 year establishment period, the landscape uses no (100% less) municipal potable water or harvested ground water than a base case landscape design. (Exception: annuals are exempt.) Any amount of site- harvested rainwater, storm water, or gray or waste water treated on site to tertiary standards may be used. The criteria may be met by any combination of: selection of native or low water use plants, use of alternatively sourced irrigation water as described, use of high efficiency irrigation systems, no irrigation systems, or other strategies.

Compliance Tools and Resources

- Typical Irrigation Water Use: See Appendix S-3 Irrigation Water Consumption
- Custom calculation or manufacturer worksheets such as Rainbird or Toro Irrigation Worksheet

Related MSBG Documents

Form P-3 Site and Water Documentation
Appendix S-1 Suggested Implementation for All Site and Water Guidelines
Appendix S-3 Irrigation Water Consumption

Supplemental Resources

- University of Minnesota Extension

S.8 Building Water Efficiency

Intent

Minimize municipal potable water or harvested groundwater (well water) use in buildings to conserve water resources and minimize water and wastewater treatment infrastructure impacts and cost.

Required Performance Criteria

A. Reduce municipal potable water or harvested groundwater use in building by 30% compared to code (1992 Energy Policy Act requirements) for any fixture types referenced by those requirements. The criteria may be met by any combination of: selection of low or no flow fixtures, use of alternatively sourced water, or other strategies.

Recommended Performance Criteria

B. Reduce municipal potable water or harvested groundwater use in building by 50% compared to code (1992 Energy Policy Act requirements) for any fixture types referenced by those requirements. The criteria may be met by any combination of: selection of low or no flow fixtures, use of alternatively sourced water, or other strategies.

Note: Portions of this guideline are adapted from LEED Version 2.0.

Compliance Tools and Resources

- Use Worksheet S-2 Building Water Calculator to calculate building water use for base and design. This also shows EPA required flow and flush fixture rates, and example fixture performance values.

Related MSBG Documents

Form P-3 Site and Water Documentation
Worksheet S-2 Building Water Calculator
Appendix S-1 Suggested Implementation for All Site and Water Guidelines

Recommended Site and Water Guidelines

S.9 Appropriate Location and Development Pattern

Intent

Direct development, where appropriate, to existing urban, suburban, or rural areas with in-place infrastructure to reduce development pressure on undeveloped land or greenfield sites; to conserve natural resources, reduce energy use and pollution contributions related to transportation requirements; and to promote a sense of increased community interaction. Develop the site to support existing patterns and goals for local density, open space, and land use.

Recommended Performance Criteria

Site Selection:

A. Select a site, considering the associated building concept, which presents the most comprehensively positive impact for environmental, economic, community, and human benefits.
   - Urban and suburban locations: Select sites which reuse existing urban/suburban and industrial sites; are located near mass transit and public amenities to encourage walking to services instead of driving; and can utilize existing infrastructure such as utilities, roadways, services, etc. Select sites that support regional development strategies and local comprehensive plans. Favor sites on which the project will disrupt the least amount of ecologically preferable land uses.
   - Rural locations: Avoid greenfield sites which might not meet the threshold for a potentially critical site under guideline S.1 , but which negatively impact green space and soil and water conditions. Favor sites on which the project will disrupt the least amount of ecologically preferable land uses.

Context and Planning Compatible Development

B. Land Use Maintain or improve upon site land use type and condition from pre-project to post project.
C. Density: Urban and suburban locations: Maintain or increase localized density to conform to existing or desired density goals as listed in Minnesota's Community-Based Planning Act.
D. Open Space: Maintain or increase open space compared to local or prevailing standards for the site.
E. Green Corridors: Maintain or increase Green Corridors compared to local or prevailing standards for the site.

Note: Portions of this guideline are adapted from LEED Version 2.0.

Compliance Tools and Resources

- Form P-3 Site and Water Documentation
- Minnesota Regional Development Organizations: www.mrdo.org/ (Regional Development Strategies)
- Minnesota Community Based Planning Act web addresses for:
- - Local Planning Laws in Mn: http://www.lpa.state.mn.us/laws/index.html
- - Resource Materials, Planning Guides, “Under Construction, Tools and Techniques for Local Planning:” http://server.admin.state.mn.us/resource.html?Id=2910
- Green Corridors: Minnesota DNR Natural Resource Planning, which includes green corridors, webpage: http://www.dnr.state.mn.us/nrplanning/index.html

Related MSBG Documents

Form P-3 Site and Water Documentation
Appendix S-1 Suggested Implementation for All Site and Water Guidelines

Supplemental Resources

- The Minnesota Stormwater Manual =, v.1.0, November 2005: available from the MPCA at http://www.pca.state.mn.us/publications/wq-strm8-14.pdf
- Open Space: National Recreation and Park Association webpage: www.nrpa.org/
- National Recreation and Park Association publication "Park, Recreation, Open Space and Greenway Guidelines." NRPA, 1995

S.10 Brownfield Redevelopment

Intent

Redevelop damaged or contaminated sites to reduce development pressure on undeveloped land and utilize existing investments in infrastructure, conserve natural resources, and promote a new sense of community renewal, identity, and revitalization.

Recommended Performance Criteria

A. Redevelop Brownfield sites to support Minnesota's Community-Based Planning Act.
B. Provide remediation as required for EPA's Sustainable Redevelopment of Brownfields Program and enroll site in the Minnesota Pollution Control Agency's Voluntary Investigation and Cleanup Program.
C. Develop a site classified as a Brownfield into a Greenspace (B2-G), for park or open space connected to building development.

Note: Portions of this guideline are adapted from LEED Version 2.0.

Compliance Tools and Resources

- County Brownfield map listing contamination source and degree of contamination
- Minnesota Community Based Planning Act web addresses for:
- - Local Planning Laws in Mn: http://www.lpa.state.mn.us/laws/index.html
- - Resource Materials, Planning Guides, "Under Construction, Tools and Techniques for Local Planning:" http://server.admin.state.mn.us/resource.html?Id=2910
- EPA Sustainable Redevelopment of Brownfields http://www.epa.gov/brownfields/sustain.htm
- Minnesota Pollution Control Agency's Voluntary Investigation and Cleanup Program http://www.pca.state.mn.us/cleanup/vic.html

Related MSBG Documents

Form P-3 Site and Water Documentation
Appendix S-1 Suggested Implementation for All Site and Water Guidelines

Supplemental Resources

- www.pca.state.mn.us/cleanup/brownfields.html
- County comprehensive development plan
- Municipal land use plan

S.11 Heat Island Reduction

Intent

Reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat.

Recommended Performance Criteria

A. Non-roof site surfaces:
Provide at any combination of the following characteristics for 50% of the site hardscape:
- Surface is light colored/high albedo (reflectance is .30 or greater.)
- Surface composed of an open-grid pavement system (less than 50% impervious)
- 50% of non-parking surfaces will be shaded within 5 years.
- 50% of parking surfaces will be shaded within 10 years.
- OR 100% of non-circulation parking surface will be shaded within 10 years.

OR
- Place a minimum of 50% of parking spaces underground or in a structured parking facility.

B. Roof Surfaces:
- Use ENERGY STAR Roof-compliant, high-reflectance AND high emissivity roofing (initial reflectance of at least 0.65 and three-year-aged reflectance of at least 0.5 when tested in accordance with ASTM #903 and emissivity of at least 0.9 when tested in accordance with ASTM 408) for a minimum of 75% of the roof surface.

OR
- Install a "green" (vegetated) roof for at least 50% of the roof area.

OR
- The two options can be combined by the following formula: (high albedo roof Area/.75) + (green roof area/.5) is greater than or equal to total roof area.

Note: Portions of this guideline are adapted from LEED Version 2.0 and Version 2.2.

Related MSBG Documents

Form P-3 Site and Water Documentation
Appendix S-1 Suggested Implementation for All Site and Water Guidelines

Supplemental Resources

- Public Technology, Inc., U.S. Green Building Council, U.S. DOE, U.S EPA. Sustainable Building Technical Manual, Part 3 (Part 3 deals with Site issues, all issues under S.11), Chapters 5, 6,7 and 8. Available from www.usgbc.org.
- Green Roofs for Healthy Cities website: www.greenroofs.net

S.12 Transportation Impacts Reduction

Intent

Reduce negative land development impacts on energy, and pollution caused by transportation. Reduce dependence on the automobile, reduce the amount of pavement impacting natural systems, and allow for more ecologically responsive approaches to the site.

Recommended Performance Criteria

Site selection and Design:

A. Locate the building within 1/4 mile of one or more bus lines OR a light rail/bus station, AND within 1/4 mile of retail and public services.
B. Locate project within 1/4 mile of restaurants and service facilities.
C. Provide means for securing bicycles, with convenient changing/shower facilities for use by cyclists, for 5% or more of building full time equivalent (FTE) occupants OR according to local bicycle parking guidelines OR zoning requirements, whichever is more stringent.
D. Install alternative-fuel refueling station(s) for 3% of the total vehicle parking capacity of the site.
E. Limit parking area by sizing parking capacity not to exceed minimum local zoning requirements, encouraging shared parking with adjacent uses, and adding no new parking for rehabilitation projects
F. Provide preferred parking for hybrid vehicle owners, carpools or van pools capable of serving 5% of the building occupants.
G. Locate preferred parking, bicycle parking, pick-up areas, and covered waiting spaces within close proximity of the main building entrances, with markings clearly designating these areas.

Operations Policies

H. Offer work pattern alternatives such as telecommuting, and teleconferencing facilities that reduce vehicle and air travel time.
I. Set a company policy to buy carbon emission offsets for business air travel.
J. Support mass transit riders by offering free or discounted bus or train passes for those that commit to not driving in at least 3 days per week. Make company cars (preferably alternatively fueled) readily available for daytime business travel for those who do not drive in.
K. Manage transportation impacts: Track commuting and business travel contributions to pollution impacts and include in annual environmental reporting. Evaluate the effectiveness of transportation policies and facilities and set goals for continual improvement in travel emissions performance.

Note: Portions of this guideline are adapted from LEED Version 2.0.

Related MSBG Documents

Form P-3 Site and Water Documentation
Appendix S-1 Suggested Implementation for All Site and Water Guidelines

Supplemental Resources

- For more information on Light Rail Transit see Metropolitan Council. http://metrocouncil.org/resources/resources.htm
- www.sprawlwatch.org
- Calthorpe, Peter. The Next American Metropolis. Princeton Architectural Press, 1993.

S.13 Wastewater Reduction and Management

Intent

Reduce wastewater generated for conventional treatment.

Recommended Performance Criteria

A. Reduce the volume of the subject sites' wastewater flow entering the municipal wastewater system or an on-site conventional septic system by 50%. Alternatives that can contribute to this guideline include, but are not limited to: peat moss drain fields, constructed wetlands, aerobic treatment systems, solar aquatic waste systems (or living machines), and composting or ecologically-based toilets or urinals. Reduction of building water and sewer discharge also contributes to reduced waste water generated without negatively impacting adjacent municipal water well heads. Reduction of building water consumption also contributes to reduced waste water generated.

Note: Portions of this guideline are adapted from LEED Version 2.0.

Related MSBG Documents

Form P-3 Site and Water Documentation
Appendix S-1 Suggested Implementation for All Site and Water Guidelines

Supplemental Resources

- www.waterrecycling.com/biblio
- www.attra.ncat.org
- 1988 United States Environmental Protection Agency Design Manual - Constructed Wetlands and Aquatic Plant Systems for Municipal Wastewater Treatment
- Constructed Wetlands for Wastewater Treatment and Wildlife Habitat, Environmental Protection Agency. www.epa.gov/owow/wetlands/construc/intro.html

Energy and Atmosphere Guidelines

Required Guidelines
E.1 Energy Use Reduction by at Least 30%
E.2 Renewable and Distributed Energy Evaluation
E.3 Efficient Equipment and Appliances

Recommended Guidelines
E.4 Atmospheric Protection

Related Documentation
See Section 2—Form P-4 Energy and Atmosphere Documentation

Worksheets and Appendices
Appendix E-1 Suggested Implementation for all Energy and Atmosphere Guidelines
Appendix E-2 Small Building Methodology (supporting information for E.1)
Appendix E-3 Refrigerant Properties (supporting information for E.4)

Overview
Energy consumption for building operations represents approximately one third of the total energy use in the State of Minnesota. This section of the MSBG provides guidance on mitigating both the cost of energy and associated ecological impacts which affect the state's economy. For each building, there are multiple paths to conservation. To further reduce impacts on the environment and to promote community economic development, this guide recommends the investigation of renewable and distributed forms of power generation using wind, solar and biomass technologies as well as other cleaner forms of hydrogen or hydrocarbon-based power generators. Combined Heat and Power (CHP) systems may be an appropriate solution for individual buildings or groups of State facilities.

Goal
To provide energy efficient buildings that reduce the State's expenditures on imported fuel and power and have the lowest reasonable environmental impacts resulting from energy generation and the use of refrigerants harmful to the atmosphere. A parallel goal is to support and enhance the State's building benchmarking activities for ongoing operations performance.

Objectives
- Design new buildings to use 30% less energy than code and encourage higher performance
- Provide building performance data for benchmarking activities
- Reduce plug loads and process energy through energy-smart purchasing practices
- Encourage the consideration of power usage from renewable energy and cleaner generation systems whether generated on-site or purchased from off-site, "green power" generated in Minnesota.
- Encourage the balanced consideration of Global Warming Potential, Ozone Depletion Potential and Atmospheric Lifetime in selecting refrigerants
- Help assure that long-term operations meet or exceed original design operating parameters

Required Energy and Atmosphere Guidelines

E.1 Energy Use Reduction by at Least 30%

Intent
Ensure annual energy costs are reduced by at least 30% as required by the Minnesota Legislature. Energy use reduction also results in lower greenhouse gas and other emissions from fossil fuel energy production.

Required Performance Criteria
Reduce design energy costs compared to the energy cost budget by at least 30% for regulated energy components as described in the Minnesota State Energy Code in effect as of 15 January 2003. Comparative analysis is required for all buildings over 5,000 square feet that are heated. The required process is similar for all buildings but there is a different path to compliance for buildings less than 30,000 gross square feet. Enter results on Form P-4 Energy and Atmosphere Documentation.

A. Buildings over 30,000 Square Feet:
   A whole building, comparative analysis methodology must be used before the Construction Document phase of the design process to determine the energy conservation solution with the lowest lifetime cost. Programs with the following simulation engines can be used: DOE2.1e, DOE2.2, Energy Plus, Energy-10 and TRANSYS. Compliance with the Performance Criteria are only valid under the following conditions:
   - Only one building geometry may be used for a given project analysis.
   - Only one set of plug and process loads may be used for a given project analysis.
   - Only one mechanical system type may be used for a given project analysis.
   - Design teams must first use the Indoor Environmental Quality section I.1 of this guide to establish base operation parameters for outside air requirements.

B. Buildings under 30,000 Square Feet:
   - Evaluate building envelope and system options in the Small Buildings Methodology included in this guide (Appendix E-1.)

Recommended Performance Criteria

C. Reduce design energy costs compared to the energy cost budget by at least 60%. Legislation governing this guideline requires a 30% conservation of energy relative to the Minnesota State Energy Code.

Related MSBG Documents

- Form P-4 Energy and Atmosphere Documentation
- Appendix E-1 Suggested Implementation for all Energy and Atmosphere Guidelines
- Appendix E-2 Small Building Methodology

Supplemental Resources

- The Minnesota Office of Environmental Assistance (MOEA) web page on Financing for Energy Improvements is a resource for information on utility programs, performance contracting, the MSBA lease purchase program for schools, and more. www.moea.state.mn.us/greenbuilding/financing.cfm
- The MOEA web page on Building Products and Materials provides links to the Energy Efficiency and Renewable Energy Network (EREN) and EnergyStar listings of products and buildings. www.moea.state.mn.us/greenbuilding/products.cfm

- The MOEA web page on Design Guidelines, Specifications and Rating Systems provides links to the Energy Star online design tools, Portfolio Manager and Target Finder. Also links to ASHRAE standards, the U.S. Department of Energy's Buildings for the 21st Century program, and the MN Commerce Department Energy Office. www.moea.state.mn.us/greenbuilding/design.cfm

E.2 Renewable and Distributed Energy Evaluation

Intent
Encourage the consideration and use of renewable energy sources and cleaner forms of hydrogen and hydrocarbon-based distributed generation systems to reduce atmospheric pollution. This can provide a stimulus to the State's economy through investments in local jobs and materials while reducing the State's expenditures on imported fuel and power.

Required Performance Criteria
A. During the Schematic Design phase, analyze at least two scenarios that include the environmental and economic impacts of supplying a percentage of the building's total energy use with on-site or off-site renewable or cleaner distributed generation systems. Enter results in Form P-4 Energy and Atmosphere Documentation. The evaluation may assess the benefits for solar, wind, or biomass energy systems as well as micro-turbines and fuel cells, if applicable. There is no required amount of renewable or distributed energy generation for State buildings at this time.
B. During the Design Development phase, update and complete the analysis of the two scenarios in Form P-4.

Note: Renewable and cleaner distributed generation percentages may be as little as 1% or as great as 100% depending on the outcome of the evaluation and may be achieved through the construction budget by paying for the design and installation of a renewable or cleaner distributed generation system or through the operating budget through a contract to purchase renewable or cleaner distributed generation. Calculations for the cost of the percentage of renewable and distributed generation for the project should be calculated after the requirement for 30% or greater energy conservation has been met.

Related MSBG Documents

- Form P-4 Energy and Atmosphere Documentation
- Appendix E-1 Suggested Implementation for all Energy and Atmosphere Guidelines

Supplemental Resources
- The MOEA web page on Building Products and Materials provides links to the Energy Efficiency and Renewable Energy Network (EREN) and EnergyStar listings of products and buildings. www.moea.state.mn.us/greenbuilding/products.cfm
- The Database of State Incentives for Renewable Energy (DSIRE) is a comprehensive source of information on state, local, utility, and selected federal incentives that promote renewable energy. www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=MN
- RETScreen International: Clean Energy Decision Support Center (www.retscreen.net). RETScreen software that analyzes costs and benefits of renewables can be downloaded from this web site.

E.3 Efficient Equipment and Appliances

Intent
Reduce energy use associated with plug loads and process loads in buildings. These energy savings are in addition to those attributed to the building itself which are accounted for in Guideline E.1.

Required Performance Criteria
A. Select new equipment and appliances that meet Energy Star criteria.

Compliance Tools and Resources
For Item A above:
- DOE Energy Star Program: www.eren.doe.gov/buildings/energystar.html
- For Energy Star Products: www.energystar.gov

Related MSBG Documents

- Form P-4 Energy and Atmosphere Documentation
- Appendix E-1 Suggested Implementation for all Energy and Atmosphere Guidelines

Supplemental Resources
- The MOEA web page on Building Products and Materials provides links to the Energy Efficiency and Renewable Energy Network (EREN) and EnergyStar listings of products and buildings. www.moea.state.mn.us/greenbuilding/products.cfm

Recommended Energy and Atmosphere Guidelines

E.4 Atmospheric Protection

Intent
Encourage the investigation and evaluation of refrigerants to reduce environmental impacts harmful to the atmosphere. Energy conservation should be achieved with the lowest reasonable environmental impacts.

Recommended Performance Criteria
There are no required levels for atmospheric pollution from refrigerants at this time except for CFC reduction which is required in the MN State Building Code. It is recommended that the following three criteria be met for refrigerants.

A. Achieve an atmospheric Lifetime (AtL) < 33. Atmospheric Lifetime is a measure of the average persistence of the refrigerant if released. A longer lifetime has worse environmental effects.
B. Achieve an Ozone Depletion Potential (ODP) < 0.034. Ozone Depletion Potential is a normalized indicator based on the ability of a refrigerant to destroy atmospheric ozone, where CFC-11 = 1.00. A higher ODP has worse environmental effects.
C. Achieve a Global Warming Potential (GWP) < 3500. Global Warming Potential is an indicator of the potency of the refrigerant to warm the planet by action as a greenhouse gas. A higher GWP has worse environmental effects.
D. Design, maintain and operate the mechanical equipment to reduce refrigerant leakage over the life of the building.

Compliance Tools and Resources
For Items A, B and C above:

- Appendix E-3 Refrigerant Properties

Note: CFCs generally have high Ozone Depletion Potential and Global Warming Potential with long Atmospheric Lifetimes. CFCs are therefore not allowed by these guidelines and prohibited by State law. Halons have a higher Ozone Depletion Potential though a lower Global Warming Potential but a much longer Atmospheric Lifetime. Halons should not be used if possible. HCFCs such as R-123, which other guides put in the same class as Halons, can have an Ozone Depletion Potential, a Global Warming Potential and an Atmospheric Lifetime two orders of magnitude less than CFCs and Halons. HFCs offer near zero Ozone Depletion Potential, but some have high Global Warming Potential. For example, R-134 has an Ozone Depletion Potential of 0.0 but a Global Warming Potential and an Atmospheric Lifetime approximately 10 times greater than R-123, an HCFC alternative. Substituting an HFC, which tends to be less energy efficient than an HCFC, may result in the use of more energy, resulting in a further increase in global warming.

Related MSBG Documents

- Form P-4 Energy and Atmosphere Documentation
- Appendix E-1 Suggested Implementation for all Energy and Atmosphere Guidelines
- Appendix E-3 Refrigerant Properties

Indoor Environmental Quality Guidelines

Required Guidelines

I.1 Restrict Environmental Tobacco Smoke
I.2 Specify Low-emitting Materials
I.3 Moisture Control
I.4 Ventilation Design
I.5 Thermal Comfort
I.6 Quality Lighting
I.7 Effective Acoustics
I.8 Reduce Vibration in Buildings
I.9 Daylight

Recommended Guidelines

I.10 View Space and Window Access
I.11 Personal Control of IEQ Conditions and Impacts
I.12 Encourage Healthful Physical Activity

Related Documentation

Section 2 – Form P-5 Indoor Environmental Quality Documentation

Worksheets and Appendices

Appendix I-1 Suggested Implementation for all Indoor Environmental Quality Guidelines
Appendix I-2 Calculating CO2 Concentrations in a Zone
Appendix I-3 Daylighting Factor Calculator
Appendix I-4 View Space Diagrams and Tables for I.10

Overview

The provision of indoor environmental quality at levels that support productive human habitation both complements and supports the environmental and economic goals for sustainable building. Appropriate indoor environmental qualities of air, temperature, sound, light, visible and physical space and occupants' ability to personally control these are the building's contributions to the biological bases of occupant comfort, health and well-being. Harmful effects on occupants of poor indoor environmental quality are well documented in laboratory and field studies. Similarly, enhanced indoor environmental quality helps occupants feel and perform at their best, with subsequent health, well-being and productivity benefits for themselves and their work organizations. These indoor environmental quality guidelines are constructed to first and foremost help prevent harm coming to occupants, then to optimize environmental quality conditions to correspond with human physiological processes, and finally to fine tune environmental conditions to work activities in a way that further enhances personal and organizational productivity.

Goal

The goal of the guidelines in this section is to provide exemplary indoor air quality and other interior environmental conditions to promote occupant health, well-being and productivity. Here, "health" is more than the absence of disease and "well-being" includes provision of physical comfort and psychological satisfaction with the physical work environment.

Objectives

- Provide a clean building that will minimize pollutant sources in the structure and its occupants.
- Provide a dry building to minimize structural and health problems associated with water intrusion and accumulation.
- Provide a well-ventilated building to dilute pollutants and bioeffluents emitted by the building materials, the occupants and their activities.
- Provide for occupant thermal comfort.
- Provide daylight for general ambient illumination.
- Provide interior view space or views to the exterior.
- Provide lighting solutions of high quality for visual tasks and preferred interior rendering.
- Provide interior conditions that avoid harmful vibration and noise effects and produce a positive acoustic environment acceptable to occupants and appropriate to their tasks.
- Provide for local occupant control of localized indoor environmental conditions in order to quickly correct harmful conditions and to better support work performance.
- Provide an interior spatial arrangement that encourages healthy human interaction and movement

Required Indoor Environmental Quality Guidelines

I.1 Restrict Environmental Tobacco Smoke

Intent

Reduce indoor pollutants by eliminating environmental tobacco smoke (ETS) from occupied areas of the building.

Required Performance Criteria

Owner/ Facilities Operations Manager

A. Establish a no smoking policy for the building.
B. Smoking policy will state where smoking outside of building can occur, such that design considerations will not introduce ETS into the building from outdoor sources.

Design Team:

C. Design documentation must state explicitly that the building was designed assuming that smoking would not occur in the building.
D. Design documentation shall show the designated smoking areas and non-smoking areas outside of the building.

Related MSBG Documents

Form P-5 Indoor Environmental Quality Documentation
Appendix I-1 Suggested Implementation for all Indoor Environmental Quality Guidelines

Supplemental Resources

- 2006 Surgeon General's Report

I.2 Specify Low-emitting Materials

Intent

Reduce indoor chemical pollution in a building by choosing low-emitting materials and furnishings during construction, operations and maintenance. Since material emissions are a major factor in determining air quality, lower emitting materials will improve the air quality in the space.

Required Performance Criteria

A. All interior materials (including but not limited to: flooring adhesives, sealants, and concrete sealers, carpets, resilient flooring, wood flooring, paints, thermal and acoustical insulation products, gypsum board, acoustical ceilings, acoustical wall panels, cabinetry, composite wood subflooring, and furnishings) shall be certified to comply with the most current Indoor Air Quality portion of California Section 01350 standard. Selection of a product listed in one of the approved databases below is sufficient to comply.
Exception 1 to requirement: if, in the sum of all the approved databases below, there are less than two supplying companies for a product type that are certified as compliant as of the end of the Design Development phase of the project, that product type does not need to comply.
Exception 2 to requirement: Paints containing a minimum of 20% recycled content, which might not comply with this guideline, may be used as a primer in spaces unoccupied for 72 hours after application and covered with final topcoat(s) that meet the requirements of this guideline.

Approved databases of materials that are recognized as substantially compliant with the most current Indoor Air Quality portion of California Section 01350 standard:

- California High Performance Schools (CHPS) Low Emitting Materials (LEM) Table
- Carpet and Rug Institute (CRI) Green Label Plus Certification (for Adhesives)
- Carpet and Rug Institute (CRI) Green Label Plus Certification (for Carpet)
- Scientific Certification Systems (SCS) Gold Indoor Advantage Certification
- Scientific Certification Systems (SCS) FloorScore™ Certification
- GREENGUARD Product Emission Standard For Children & Schools™

B. All modular office furnishings shall comply with the most current version of the document "State of California Office Furniture Systems INDOOR AIR QUALITY-VOC EMISSIONS" Dated June 7, 2006. Contract Documents shall state that manufacturers must send a sign letter affirming that the product to be provided have been tested to comply with this standard within a year of delivery to the project.

Compliance Tools and Resources

For Item A above:

- As of MSBG Version 2.0, the most current version of the Indoor Air Quality portion of California Section 01350 standard is in a document called: "STANDARD PRACTICE FOR THE TESTING OF VOLATILE ORGANIC EMISSIONS FROM VARIOUS SOURCES USING SMALL-SCALE ENVIRONMENTAL CHAMBERS" dated JULY 15, 2004 and including ADDENDUM 200401. As of MSBG version 2.o it can be found at: http://www.dhs.ca.gov/ps/deodc/ehlb/iaq/VOCS/Section01350_7_15_2004_FINAL_PLUS_ADDENDUM-2004-01.pdf

Links for Approved Databases for item A above as of MSBG Version 2.0

- California High Performance Schools (CHPS) Low Emitting Materials (LEM) Table
  http://www.chps.net/manual/lem_table.htm
- Carpet and Rug Institute (CRI) Green Label Plus Certification (for Adhesives)
  http://www.carpet-rug.com/drill_down_2.cfm?page=8&sub=18&requesttimeout=350
- Carpet and Rug Institute (CRI) Green Label Plus Certification (for Carpet)
  http://www.carpet-rug.org/drill_down_2.cfm?page=8&sub=17&requesttimeout=350
- Scientific Certification Systems (SCS) Gold Indoor Advantage Certification
  http://www.scscertified.com/manufacturing/manufacture_certclients.html
- Scientific Certification Systems (SCS) FloorScore™ Certification
  http://www.rfci.com/int_FS-ProdCert.htm
- GREENGUARD Product Emission Standard For Children & Schools™
  http://www.greenguard.org (then click on the "find products" tab)

For Item B: Above:

- "State of California Office Furniture Systems INDOOR AIR QUALITY-VOC EMISSIONS."
  As of MSBG version 2.0 this file can be found at: http://www.cal-iaq.org/VOC/CA_FurnitureBid-EnvIAQ_Specification_2006-06-07.pdf
- Optional tool: State of California Office Furniture IAQ Specification Workbook.xls revised 5/12/06
  As of MSBG Version 2.0 this file can be found at:
  http://www.cal-iaq.org/VOC/CA_FurnitureBid-EnvIAQ_Specification_2006-05-12_Worksheet.xls

Optionally, for reference for both A and B above:

- As of MSBG Version 2.0
  the index page which leads to the files listed above is:
  http://www.cal-iaq.org/VOC/

  and the main page for the program that manages these documents is:
  http://www.cal-iaq.org/

Related MSBG Documents

Form P-5 Indoor Environmental Quality Documentation
Appendix I-1 Suggested Implementation for all Indoor Environmental Quality Guidelines

Supplemental Resources

- GreenSpec, Environmental Building News, www.buildinggreen.com. For information on low-emitting products, search database for attribute "release minimal pollutants" (subscriber service)
- The Minnesota Office of Environmental Assistance (MOEA) web page on Building Products and Materials www.moea.state.mn.us/greenbuilding/products.cfm.
- The MOEA web page on Design Guidelines, Specifications and Rating Systems www.moea.state.mn.us/greenbuilding/design.cfm
- SCIENCE. Every Breath You Take. May 14 2004, 304 (5673)

I.3 Moisture Control

Intent

Prevent exterior water intrusion, leakage from interior water sources, or other uncontrolled accumulation of water.

Required Performance Criteria

A. Design the building envelope to resist moisture penetration. Since all buildings have potential for moisture penetration, and since Minnesota is a heating dominated climate, provide drainage planes to the exterior.
B. During the coldest portion (99.5% cold temperature design value) of the heating season keep the indoor dew point below 35ºF(2ºC).
C. Specify maximum moisture content of materials used in construction to assure that subsurface layers are dry enough to prevent moisture trapping by surface finish materials (Consult: Lstiburek and Carmody, 1993, Harriman et al., 2001)

Note: Other related and critical items for moisture control are covered under other sections: I.5 Thermal Comfort which includes criteria for relative humidity and P.5 Operations Commissioning which includes practices for detection and management of unintended accumulation or intrusion of water.

Compliance Tools and Resources

- Suggested resource: Lstiburek, J, and J Carmody (1993) Moisture Control Handbook, New York, Van Nostrand. (Can be purchase from a general on line bookstore such as Amazon.com)
- Suggested resource: Harriman, L. I., G. Brundrett, et al. (2001.) Humidity Control Design Guide for Commercial & Institutional Buildings. Atlanta, ASHRAE. (can be purchased at ASHRAE online Bookstore)

Related MSBG Documents

Form P-5 Indoor Environmental Quality Documentation
Appendix I-1 Suggested Implementation for all Indoor Environmental Quality Guidelines

Supplemental Resources

- For supplemental information for Item A consider Lstiburek and Carmody, 1993; Lstiburek, 2002, Lstiburek, 2006 listed below.
- For supplemental information for Item B consider Consult: Lstiburek (2002))listed below.

- ASHRAE 62.1-2004 requirements:
  - 62.1-2004 - §5.9 Filtration requirements for HVAC ductwork upstream of all cooling coils and other devices with wetted surfaces
  - 62.1-2004 - §5.11-5.14 Condensate management and maintenance of moisture conditions in ductwork.
  - 62.1-2004 - §5.5 Requirements that ductwork be resistant to mold growth.
  - 62.1-2004 - §5.10 & 5.15 Humidity control and pressure control in spaces that are mechanically cooled
  - 62.1-2004 – Addendum a. §5.10 Dehumidification Systems.
- ASHRAE (2005). 62.1 User's Manual, ANSI/ASHRAE Standard 62.1-2004, Ventilation for Acceptable Indoor Air Quality. Atlanta, GA, ASHRAE.
- Lstiburek, J, and J Carmody (1993) Moisture Control Handbook, New York, Van Nostrand.
- Lstiburek, J. (2002.) "Moisture Control for Buildings." ASHRAE Journal 44(2): 36-41.
- Lstiburek, J. (2006) “Understanding Drainage Planes” ASHRAE Journal 48(2) 30-35
- Harriman, L. I., G. Brundrett, et al. (2001.) Humidity Control Design Guide for Commercial & Institutional Buildings. Atlanta, ASHRAE.

- California Occupational Safety and Health Standards Board, Title 8, Chapter 4, Article 9, Section 3362(g) "uncontrolled accumulation of water" (2002.)
- Horner, W. E., P. R. Morey, et al. (2001.) "How quickly must gypsum board and ceiling tile be dried to preclude mold growth after a water accident". Moisture, Microbes, and Health Effects: Indoor Air Quality and Moisture in Buildings, San Francisco, CA, IAQ 2001.
- Kosar, D. (2006). "Dehumidification system enhancements." ASHRAE Journal 48(2): 48-58.
- Wyon, D., L. Fang, et al. (2002.) "Limiting Criteria for Human Exposure to Low Humidity Indoors". Indoor Air 2002, Monterey, CA, Vol. 4, pp. 400-405.

I.4 Ventilation Design

Intent

Promote good indoor air quality by requiring a ventilation baseline based on the general procedures and information contained in the latest approved version of ASHRAE Standard 62.1. Encourage better indoor air quality by recommending that, in addition, ventilation design intent be demonstrated on a regular basis to building owners and operators. Encourage best indoor air quality by further recommending adjusting ventilation requirements upward from the baseline based on setting target CO_2 concentration maxima.

Required Performance Criteria

A. Radon is best controlled using source prevention techniques rather than ventilation. If construction is to occur in one of the 68 Minnesota counties considered "Zone 1" by the US EPA, guidance contained in the EPA document, "Radon Prevention in the Design and Construction of Schools and other Large Buildings", must be followed.

B. Ventilation Baseline: meet current ASHRAE ventilation standard 62.1 for commercial and institutional buildings (currently ASHRAE 62.1-2004. Updates are scheduled to be issued in 2007 and every three years thereafter.)

Recommended Performance Criteria

C. Ventilation Performance Validation: in addition to required ventilation baseline criteria above, design the ventilation system so that CO_2 concentrations can be monitored continuously in all continuously occupied spaces. Continuously occupied spaces are those intended for human occupancy excluding spaces intended for other purposes such as storage rooms or equipment rooms. Compare the expected values of CO_2 concentrations found in high-occupancy spaces* in the building with those expected from the building design using ASHRAE 62.1. This should be done at three-month intervals during the initial year of occupancy and annually thereafter.

D. Carbon Dioxide Limits on Ventilation: in addition to required and recommended criteria within this guideline above design the ventilation system so that they CO_2 concentration in continuously occupied breathing zones (between 3 and 72 inches above the floor and 2 feet or larger from walls) shall not exceed 450 ppm above outdoor concentrations. Compare the expected values of CO_2 concentrations found in high-occupancy spaces* in the building with those expected from the building design using ASHRAE 62.1 supplemented by the more rigorous CO_2 concentration limit of I.4C. Do this at three-month intervals during the initial year of occupancy and annually thereafter.

* Note: For this guideline, “high-occupancy spaces” are defined as spaces in the building with normal occupancy densities higher than the average density for the entire building.

Compliance Tools and Resources

- For Item A: US EPA, Radon zone map: www.epa.gov/iaq/radon/zonemap.html
- For Item A: US EPA, "Radon Prevention in the Design and Construction of Schools and other Large Buildings", EPA document 625-R-92-016, June 1994. www.epa.gov/iaq/radon.pubs/index.html
- For Items B, C, D: Reference Standard: ASHRAE (2004). ANSI/ASHRAE Standard 62.1-2004: Ventilation for acceptable indoor air quality. Atlanta, GA, USA, American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.
- For Items B, C, D: ASHRAE (2005). 62.1 User's Manual, ANSI/ASHRAE Standard 62.1-2004, Ventilation for Acceptable Indoor Air Quality. Atlanta, GA, ASHRAE.
- For Item D: MSBG Appendix I-2 Calculating CO2 Concentrations in a Zone

Related MSBG Documents

Form P-5 Indoor Environmental Quality Documentation
Appendix I-1 Suggested Implementation for all Indoor Environmental Quality Guidelines
Appendix I-2 Calculating CO2 Concentrations in a Zone

Supplemental Resources

For I.4C and D:

There is a robust literature examining the technique of monitoring CO_2 concentrations in a space and using that information to extract information about the ventilation delivered to the space. The literature comparing design and performance of ventilation systems in commercial buildings, on the other hand, is modest. Readers should consult the 2006 paper by Persily for further perspectives. This paper is based on an invited plenary presentation he made at the ***Indoor Air 05*** conference in Beijing, China in Sept 2005.

- Persily, A. (1997.) "Evaluating building IAQ and ventilation with indoor carbon dioxide." *ASHRAE Transactions* 103(2.)
- Schell, M. B., S. C. Turner, et al. (1998.) "Application of CO_2-based demand-controlled ventilation using ASHRAE Standard 62: Optimizing energy use and ventilation." *ASHRAE Transactions* 104(2): Paper TO-98-21-1.
- Persily, A. (2006). "What we think we know about ventilation." *Ventilation*: submitted for publication.

For I.4D:

The choices about CO_2 concentrations come from many sources. Primary are the studies that relate CO_2 concentrations to ventilation rates and to occupant complaints. A representative collection of references are:

- Apte, M. G., W. Fisk, et al. (2000.) "Associations between indoor CO_2 concentrations and sick building syndrome symptoms in US office buildings: An analysis of the 1994-96 BASE study." *Indoor Air 10*: 246-257.
- Engvall, K., P. Wickman, et al. (2005). "Sick building syndrome and perceived indoor environment in relation to energy saving by reduced ventilation flow during heating season: 1 year intervention study in dwellings." *Indoor Air* **15**(2): 120-126.
- Mumma, S (2004.) Transient occupancy ventilation by monitoring CO_2, *IAQ Applications,* 5(1): pgs. 21-23.
- Persily, A. (1997.) "Evaluating building IAQ and ventilation with indoor carbon dioxide." *ASHRAE Transactions* 103(2.)
- Schell, M. B., S. C. Turner, et al. (1998.) "Application of CO_2-based demand-controlled ventilation using ASHRAE Standard 62: Optimizing energy use and ventilation." *ASHRAE Transactions* 104(2): Paper TO-98-21-1.
- Seppänen, O. A., W. J. Fisk, et al. (1999.) "Association of ventilation rates and CO_2 concentrations with health and other responses in commercial and institutional buildings." *Indoor Air-International Journal of Indoor Air Quality and Climate* 9(4): 226-52.
- Sundell, J., T. Lindvall, et al. (1994.) "Associations between type of ventilation and airflow rates in office buildings and the risk of SBS-symptoms among occupants." *Environment International* 20: 239-251.
- Wargocki, P., D. P. Wyon, et al. (2000.) "The effects of outdoor air supply rate in an office on perceived air quality, sick building syndrome (SBS) symptoms and productivity." *Indoor Air-International Journal of Indoor Air Quality and Climate* 10(4): 222-36.
- Wargocki, P., J. Sundell, et al. (2002.) "Ventilation and health in non-industrial indoor environments: Report from a European Multidisciplinary Scientific Consensus Meeting (EUROVEN.)" *Indoor Air-International Journal of Indoor Air Quality and Climate* 12(2): 113-28

I.5 Thermal Comfort

Intent

Provide for occupant thermal comfort through control of ambient temperature, and operative temperature which includes wet bulb, dry bulb and globe temperatures, relative humidity (RH), mean radiant temperature (MRT), and air velocity.

Required Performance Criteria

A. Maintain continuous indoor exposure to ambient temperature in continuously occupied spaces less than 80°F and greater than 64°F. For transition spaces (entries, hallways, exterior walls) temperatures may fall outside the limits for continuously occupied spaces to save energy.
B. In continuously occupied spaces where MRT asymmetry could be a problem (for example: spaces such as glass atria, rooms adjacent to boiler rooms, and areas under an exposed roof structure), maintain the wall, floor, and ceiling surface temperatures within 20 °F when taken from all continuously occupied positions OR Maintain no continuous indoor exposure to greater than 0.30 asymmetry in MRT across three body plane hemispheres (front-back, side-side, top-bottom)
C. Maintain air velocity greater than or equal to 10 fpm for continuously occupied spaces. Exception: Spaces with natural ventilation or mixed mode ventilation are exempt from I.5C during the times that they are operating in a natural or mixed mode ventilation mode.
D. Maintain interior relative humidity (RH) greater than 20% and less than 50% in continuously occupied spaces. Exception: Spaces with natural ventilation or mixed mode ventilation are exempt from I.5D during the times that they are operating in a natural or mixed mode ventilation mode.

Recommended Performance Criteria

E. Full compliance in keeping thermal variables within ASHRAE 55-2004 winter and summer comfort zones.
F. Vary dry bulb temperature (DBT) via building control system so as to avoid thermal boredom. Produce ramped drifts of up to + 2.0°F/hr in peak-to-peak variation around neutral temperature. Note: Operative Temperature (OT) is also known as Wet Bulb Globe Temperature, (OT or WBGT = 0.7 Natural Wet Bulb Temperature + 0.3 Globe Temperature)

Compliance Tools and Resources

- ASHRAE 55-2004.
- Woodson, W. E, Tillman, P. & Tillman, B. (1992) Human Factors Design Handbook, 2nd Edition. McGraw-Hill, NY.
- Calculate or simulate thermal comfort using guideline performance criteria and other appropriate thermal comfort indices. Operative Temperature is determined by dry bulb temperature, relative humidity and mean radiant temperature (DBT, RH, MRT), and air velocity. Calculation can also include Clo value (the insulation value of clothing), physical activity, and time. See especially ASHRAE Standard 55-2004, and the Human Factors Design Handbook for explanation of conditions and measures to provide for thermal comfort. See other references, particularly Engineering Data Compendium and NASA MSIS for handling special condition problems. See Handbook of Environmental Psychology for discussion of thermal issues for particular settings (e.g. offices, industrial environments) and for perceived control of thermal variables.

Related MSBG Documents

Form P-5 Indoor Environmental Quality Documentation
Appendix I-1 Suggested Implementation for all Indoor Environmental Quality Guidelines

Supplemental Resources

- Bechtel, Robert B. & Churchman, Azra, (Eds.) (2002) Handbook of Environmental Psychology. John Wiley & Sons, NY.
- Boff, K. & Lincoln, J. (Eds.) (1988) Engineering Data Compendium: Human Perception and Performance. Harry G. Armstrong Aerospace Medical Research Laboratory, Wright Patterson AFB, Ohio.
- NASA (1995) Man-System Integration Standards. Johnson Space Center, Houston, TX. msis.jsc.nasa.gov
- Salvendy, Gavriel (Ed.) (1987) Handbook of Human Factors. John Wiley & Sons, NY.
- Stokols, Daniel, & Alt man, Irwin (Eds.) (1991) Handbook of Environmental Psychology. Krieger Publishing Co. NY.

I.6 Quality Lighting

Intent

Electric lighting should be designed to supplement and support the use of daylight as the primary source of light for visual tasks. This is vitally important to achieving environmental, health and economic goals. The integrated design of artificial and natural light must also maintain these lighting quality characteristics and effects: tolerable glare, natural color rendering, and attractive illumination of people for social exchanges. Quality lighting enhances and contributes to creating the perception of a 'bright and cheery' workplace through volumetric brightness by illuminating upper wall areas and ceiling planes.

Required Performance Criteria

A. The electric lighting design must be operable in multiple modes responsive to both daylight zones and differentiated uses within a given space such as separating controls for media projection areas from general task areas within a space.

Recommended Performance Criteria

B. For general illumination in most space types, attain an average electrical illumination at the work plane of 35 to 50 foot-candles. A minimum of 25 foot-candles is recommended at any point 3 ft or more from a wall.
C. Consult the current version of the IESNA handbook for other recommended light levels. You may design closer to the minimum recommended values to reduce the connected load and conserve energy, but in this case note that the contrast ratios in item D below become even more important to maintain, and the overall volumetric rendering should be bright.
D. Keep contrast ratios in the field of view within the space as seen from the task areas to no greater than 10:1
E. Achieve a Color Rendering Index (CRI) for each space type based on recommendations in the current version of the IESNA handbook.

Methods:

F. At a minimum, conduct a point-by-point analysis of horizontal illumination levels at the work plane in each lighting mode for each space.
G. Preferably, use a computer program to determine the performance characteristics of the electric lighting system in each primary space type. Computer models should be used to analyze illumination levels on vertical planes when they have been defined as a task or work area.

Compliance Tools and Resources

- Rea, M. S., ed. IESNA Lighting Handbook, Ninth Edition. New York: Illuminating Engineering Society of North America, 2000.
- Lighting design tables, luminaire specification sheets.
- Lighting design software including Lumen Micro 2000, Lumen Designer, AGI32, Radiance, Desktop Radiance, LightPro and Luxicon

Related MSBG Documents

Form P-5 Indoor Environmental Quality Documentation
Appendix I-1 Suggested Implementation for all Indoor Environmental Quality Guidelines

Supplemental Resources

- Boff, K. & Lincoln, J. (Eds.) (1988) Engineering Data Compendium: Human Perception and Performance. Harry G. Armstrong Aerospace Medical Research Laboratory, Wright Patterson AFB, Ohio.
- NASA (1995) Man-System Integration Standards. Johnson Space Center, Houston, TX. msis.jsc.nasa.gov
- Watson, Donald. Crosbie, Michael. Crosbie, Michael J. & Callender, Michael H. (1997.) Time-Saver Standards for Architectural Design Data. McGraw-Hill, NY.
- Woodson, W. E, Tillman, P. & Tillman, B. (1992) Human Factors Design Handbook, 2nd Edition. McGraw-Hill, NY.

I.7 Effective Acoustics

Intent

Provide interior conditions that avoid harmful noise effects and produce a basis for a positive soundscape acceptable to occupants and appropriate to their tasks. The benefits are avoiding exposure to: unhealthy noise levels, the elevated stress which accompanies higher background noise levels and noise distraction impacts on mental work. Effective acoustics enable effective speech communications at normal speaking voice while providing for local speech privacy.

Required Performance Criteria

Prevent Harmful Acoustic Conditions

A. Recurrent background noise from external and internal sources shall not exceed 70 dBA.
B. All continuously occupied office space shall meet a NC (Noise Curve) of no greater than NC-50.(See recommended levels below.)
C. All classroom space shall meet an NC of no greater than NC-45.(See recommended levels below.)
D. Reverberation time for all continuously occupied space shall be no less than 0.2 sec and no greater than 0.8 sec. Reverberation time shall be based on the 500 Hz octave band, and shall be appropriate to the uses of the space. (See recommended levels below.)

Recommended Performance Criteria

E. Articulation Index shall be less than 0.20 for open offices, where a low level of speech intelligibility is required (speech privacy is desired), and greater than 0.70 for enclosed offices where a high level of speech intelligibility is required.

Promote Positive Acoustics Appropriate to Tasks:

F. Reduce NC criterion to NC 45 or lower for continuously occupied spaces.
G. NC shall be no greater than NC 40 for intermittently occupied meeting spaces like conference rooms and classrooms. (Note that this is less stringent than the ANSI S12.60 standard for classrooms.)
H. Provide Reverberation Times optimal for space use based on professional acoustic judgment. General Guidelines are as follows:
    - Open Office: 0.2-0.5 seconds
    - Enclosed offices: 0.2-0.4 seconds
    - Classrooms 0.2-0.7 seconds
    - For other space types, such as gymnasiums and auditoriums, use acoustic professional judgment and advice.

Compliance Tools and Resources

- Professional acoustical advice and consulting
- Acoustics modeling and analysis software programs.

Related MSBG Documents

Form P-5 Indoor Environmental Quality Documentation
Appendix I-1 Suggested Implementation for all Indoor Environmental Quality Guidelines

Supplemental Resources

- There are several US University programs focused on architectural acoustics and many sources of room acoustics modeling software that are commercially available. There are also free acoustics modeling and analysis software programs available from some universities and companies. These programs provide calculated estimates of quantities like reverberation time and sound pressure levels given certain parameters that account for room size, shape, surface absorption and activity types.
- Very informative introductions to room acoustics modeling are given by Lokki & Jarvelainen, (2001) and Rindel, (2000.) A very helpful, illustrated, online PowerPoint presentation that includes room acoustics modeling is given by Lokki & Savioja (2002.) The University of California at Berkeley, The Rensselaer Technical Institute, and McGill University all have extensive online resources available on architectural acoustics.

Helpful Internet resources include:

- The Engineering Toolbox www.engineeringtoolbox.com/27_521qframed.html or Room Acoustics www.roomacoustics.info/calculator/arch/room-acoustics-arch.htm. Both websites reference a calculator for architectural acoustics calculations.
- IRCAM (a French research project with many useful publications and free software) www.ircam.fr/departements/recherche/page-e.html
- ODEON (distributes room acoustics modeling software) www.dat.dtu.dk/~odeon
- SARA (a Spatial Audio & Room Acoustics Project from the Academy of Finland) www.acoustics.hut.fi/~vpv/projects/sara.htm

Other Supplemental Resources

- Bechtel, Robert B. & Churchman, Azra, (Eds.) (2002) Handbook of Environmental Psychology. John Wiley & Sons, NY.
- Boff, K. & Lincoln, J. (Eds.) (1988) Engineering Data Compendium: Human Perception and Performance. Harry G. Armstrong Aerospace Medical Research Laboratory, Wright Patterson AFB, Ohio.
- Harris, C. M. (1979) Handbook of Noise Control. McGraw-Hill, New York.
- Hass, Ellen, & Edworthy, Judy (Eds.) (2002) The Ergonomics of Sound. Human Factors & Ergonomics Society, Santa Monica, CA.
- Lokki, T. & Jarvelainen Hanna, (2001) Proceedings of the 2001 International Conference on Auditory Display, July 29-August 1, 2001. Pgs. 26-31 Espoo, Finland. (Available online.)
- Lokki, T. & Savioja, L. (2002) VR Research at HUT and Real-Time Auralization. Future Workplaces, Stuttgart, 10-11 October 2002. (Available online.)
- NASA (1995) Man-System Integration Standards. Johnson Space Center, Houston, TX. msis.jsc.nasa.gov
- Rindel, J.H. (2000) The use of computer modeling in room acoustics. Journal of Vibroengineering. No. 3(4) Index 41-72. (Available online)
- Salvendy, Gavriel (Ed.) (1987) Handbook of Human Factors. John Wiley & Sons, NY.
- Watson, Donald. Crosbie, Michael. Crosbie, Michael J. & Callender, Michael H. (1997.) Time-Saver Standards for Architectural Design Data. McGraw-Hill, NY.
- Wise, James. The Human Nature of Noise and Vibration. Eco-Integrations, Inc.
- Woodson, W. E, Tillman, P. & Tillman, B. (1992) Human Factors Design Handbook, 2nd Edition. McGraw-Hill, NY.

I.8 Reduce Vibration in Buildings

Intent

Provide interior conditions that avoid harmful vibration effects produced by wind sway, transmitted outdoor sources, indoor machinery (especially HVAC) and foot traffic. This will avoid prolonged exposure to unhealthy vibration levels, and enable prolonged comfortable work at a workstation. It will also diminish anxiety and stress due to wind sway on upper floors as well as maintain the value of the building.

Required Performance Criteria

A. For steel structures, control vibrations in accordance with AISC Design Guide 11
B. For Steel Joists, control vibrations in accordance with SJI Technical Digest #5: Vibration of Steel Joist-Concrete Slab Floors
C. For Wood or Concrete Construction, control deflection as follows:
Live Load Deflection: L/480
Total Deflection: L/360

Recommended Performance Criteria

D. To better control vibration, do not construct floors using bar joists

The following recommendations for improved vibration control come from Human Factors Research on the effects of vibration on health and well-being of occupants:

E. Return period of greater than 0.5% g horizontal acceleration in top third of a high rise (7 stories or greater) building shall not be less than 6 years.
F. Floor vibration shall be kept above Splittgerber Minimum Complaint Level (approximately 0.001 A rms,g across 4-8 hz resonant with human body components) or 8 hr reduced comfort level (approximately 0.15m/sec2 across 4-8 hz resonant with human body components) for all continuously occupied spaces, restrooms and meeting rooms.
G. Go beyond Item F to extend floor vibration criterion to all intermittently occupied spaces except storage areas.

Compliance Tools and Resources

- For Item A: The American Institute of Steel Construction Inc. (AISC) AISC Design Guide 11 can be purchased from AISC Bookstore at http://www.aisc.org/Template.cfm?Section=Bookstore&template=/Ecommerce/ProductDisplay.cfm&ProductID=2098
- For Item B: Steel Joist Institute (SJI) SJI Technical Digest #5: Vibration of Steel Joist-Concrete Slab Floors can be purchased from SJI at http://www.steeljoist.org/publications/
- For Items E through G: Vibration control practices. Lookup tables. Calculation. See NASA MSIS, Chapter 10 of the Engineering Data Compendium, the Human Factors Design Handbook, and the ISO 2631 (Guide for the Evaluation of Human Exposure to Whole-Body Vibration), all referenced below.

Related MSBG Documents

Form P-5 Indoor Environmental Quality Documentation
Appendix I-1 Suggested Implementation for all Indoor Environmental Quality Guidelines

Supplemental Resources

- Bechtel, Robert B. & Churchman, Azra, (Eds.) (2002) Handbook of Environmental Psychology. John Wiley & Sons, NY.
- Boff, K. & Lincoln, J. (Eds.) (1988) Engineering Data Compendium: Human Perception and Performance. Harry G. Armstrong Aerospace Medical Research Laboratory, Wright Patterson AFB, Ohio.
- International Organization for Standardization (ISO) (1982.) Guide for the Evaluation of Human Exposure to Whole-Body Vibration. (ISO 2631-1978/AI 1982) Geneva: ISO.
- NASA (1995) Man-System Integration Standards. Johnson Space Center, Houston, TX. msis.jsc.nasa.gov
- Salvendy, Gavriel (Ed.) (1987) Handbook of Human Factors. John Wiley & Sons, NY.
- Watson, Donald. Crosbie, Michael. Crosbie, Michael J. & Callender, Michael H. (1997.) Time-Saver Standards for Architectural Design Data. McGraw-Hill, NY.
- Woodson, W. E, Tillman, P. & Tillman, B. (1992) Human Factors Design Handbook, 2nd Edition. McGraw-Hill, NY.

I.9 Daylight

Intent

Provide daylight for ambient illumination at levels and conditions known to produce physiological and psychological benefits. Daylight contributes to a perception of a 'bright and cheery' workplace through provision of volumetric brightness (also called "room-surface brightness".) The important qualities of daylight are its inherent variation, power spectrum (color), and the predominantly horizontal component of its illumination vector (direction of illumination.) Some studies have also shown a correlation between daylighting and improved productivity and test scores.

Required Performance Criteria

A. At least 75% of the floor area of continuously occupied spaces in the building shall have a minimum daylight factor of 1% when measured without furniture and at 2'6" above the floor. This may be demonstrated using the Daylight Factor Calculator provided in the guidelines, through daylight simulation, or physical daylight modeling.
B. In every continuously occupied space with daylight, not more than 15% of the floor area shall exceed a uniformity ratio of 10:1 when measured without furniture and at 2'6" above the floor.
C. To be considered a good daylighting design, direct solar penetration must be controlled with fixed or operable shading devices and kept from falling on the work plane beyond 4 ft from the exterior walls during most operating hours.
D. Automatic controls should be employed to turn off or dim the electric lights when daylighting is available.

Note: For spaces with daylight the Window to Floor Area Ratio (WFAR) should not need to exceed 25% in order to meet daylighting criteria listed here. Note that exceeding this WFAR may introduce excess energy use and possibly glare.

Compliance Tools and Resources

- Daylighting Factor Calculator See Appendix I-3.
- For more advanced and refined analysis, using physical models is one very effective way to analyze daylighting performance of a building. Even the simplest foam core models will inform the design team about how the behavior of daylight changes as building parameters are varied. Daylight apertures and reflectance values of material surfaces must be accurately modeled for valid results. Such daylighting models can then be tested on site or under artificial sky conditions in a daylighting laboratory to determine daylight factors. Sundials attached to the model base allow such models to be tested so as to simulate annual variation of direct sunlight.
- In addition, also for more advanced and refined analysis, computer analysis and simulation may be used to generate a daylighting solution. Some widely available programs are noted below. Usually, three-dimensional digital models are constructed using (CAD) computer-aided design software that is then imported into the lighting software. Such programs usually require the user to define location, sky conditions, and date and time and interior surface characteristics. Some programs produce lifelike renderings of the design but do not provide accurate quantitative results.

Related MSBG Documents

Form P-5 Indoor Environmental Quality Documentation
Appendix I-1 Suggested Implementation for all Indoor Environmental Quality Guidelines
Appendix I-3 Daylighting Factor Calculator

Supplemental Resources

The US Department of Energy and its associated national laboratories and their outreach programs are rich sources of information and simulation and analysis programs for daylighting. Among these are

- ADELINE (Advanced Daylighting and Electric Lighting Integrated New Environment) at www.ibp.fhg.de/wt/adeline/, which "provides architects and engineers with accurate information about the behavior and the performance of indoor lighting systems. Both natural and electrical lighting problems can be solved, in simple rooms or the most complex spaces."
- Radiance. radsite.lbl.gov/radiance/, The primary advantage of Radiance over simpler lighting calculation and rendering tools is that there are no limitations on the geometry or the materials that may be simulated. Radiance is used by architects and engineers to predict illumination, visual quality and appearance of innovative design spaces, and by researchers to evaluate new lighting and daylighting technologies..
- EREC Reference Brief "Daylighting for Commercial, Institutional an d Industrial Buildings" www.eere.energy.gov/consumerinfo/factsheets/cb4.html an excellent introduction to daylighting fundamentals.
- DOE Buildings Program: Daylighting www.eere.energy.gov/buildings/info/design/integratedbuilding/passivedaylighting.html for everything you ever wanted to know about daylighting, and more.
- Efficient Windows Collaborative www.efficientwindows.org contains references, resources and simulation tools for window design and selection for daylighting.
- An entire course in daylighting is provided by the online available Vital Signs Curriculum Materials Project by Marc Schiller and Schweta A. Japee (both at the University of Southern California School of Architecture): "Interior Illuminance, Daylight Controls, and Occupant Response." It is "a complete range of exercises covering everything from an understanding of how your eye works to how to do image processing on a digitized video scan."

Other Supplemental Resources:

- Baker, Nick, & Steemers, Koen (2002) Daylight Design of Buildings: A Handbook for Architects and Engineers. James & James, Publishers.
- Bechtel, Robert B. & Churchman, Azra, (Eds.) (2002) Handbook of Environmental Psychology. John Wiley & Sons, NY.
- Boff, K. & Lincoln, J. (Eds.) (1988) Engineering Data Compendium: Human Perception and Performance. Harry G. Armstrong Aerospace Medical Research Laboratory, Wright Patterson AFB, Ohio.
- NASA (1995) Man-System Integration Standards. Johnson Space Center, Houston, TX. msis.jsc.nasa.gov
- Rea, Mark S. (Ed.) (1999) The IESNA Lighting Handbook: Reference & Application. Illuminating Engineering Society of North America, NY.
- Watson, Donald. Crosbie, Michael. Crosbie, Michael J. & Callender, Michael H. (1997.) Time-Saver Standards for Architectural Design Data. McGraw-Hill, NY.

Recommended Indoor Environmental Quality Guidelines

I.10 View Space and Window Access

Intent

Provide interior view space or views to the exterior, that possesses preferred and demonstrably beneficial characteristics. The benefits are the ability for focal rest to avoid eyestrain, and access to visual information about changing outside conditions. A view amenity also aids varying attention cycles and relieves the stress of mental work.

Recommended Performance Criteria

See "Appendix I-4 View Space Diagrams and Tables for I.10" for further illustrations of these criteria.

A. From every continuously occupied position in spaces there shall be visual access to an external window view that is at least 10 degrees in horizontal and vertical visual angle at no greater than the 50th percentile standing average eye height of 64 inches.
B. From every assigned and continuously occupied workstation position at seated eye height of 48 inches there shall be visual access to a view space that is at least 20 feet away. The view space shall be at least a continuous 20 degrees horizontal angle beginning at not more than 10 degrees from the centerline of sight. The view space shall also be at lease a continuous 15 degrees vertical view angle beginning at not more than 10 degrees from the horizontal centerline of sight and shall also be above that horizontal centerline.. As an alternate to the 20 degree horizontal by 15 degree vertical dimensions of the line of sight, the table "View Space Aperture Approximately Corresponding to a 20 degree Horizontal by 15 degree Vertical View Angle" found in Appendix I-4 may be used.
C. Higher performance is achievable if views are provided to horizon lines, clouds, tree lines and clusters and natural waterscapes.

Compliance Tools and Resources

- Appendix I-4 View Space Diagrams and Tables for I.10
- Calculation from drawings or simulation via analytic software.

Related MSBG Documents

Form P-5 Indoor Environmental Quality Documentation
Appendix I-1 Suggested Implementation for all Indoor Environmental Quality Guidelines
Appendix I-4 View Space Diagrams and Tables for I.10

Supplemental Resources

- Software broadly incorporating view space calculations is embedded in the "Spatialist" program from the School of Architecture, Georgia Institute of Technology, Atlanta, GA.
- Baker, Nick, & Steemers, Koen (2002) Daylight Design of Buildings: A Handbook for Architects and Engineers. James & James, Publishers.
- Bechtel, Robert B. & Churchman, Azra, (Eds.) (2002) Handbook of Environmental Psychology. John Wiley & Sons, NY.
- Boff, K. & Lincoln, J. (Eds.) (1988) Engineering Data Compendium: Human Perception and Performance. Harry G. Armstrong Aerospace Medical Research Laboratory, Wright Patterson AFB, Ohio.

- NASA (1995) Man-System Integration Standards. Johnson Space Center, Houston, TX. msis.jsc.nasa.gov
- Rea, Mark S. (Ed.) (1999) The Iesna Lighting Handbook: Reference & Application. Illuminating Engineering Society of North America, NY.
- Watson, Donald. Crosbie, Michael. Crosbie, Michael J. & Callender, Michael H. (1997.) Time-Saver Standards for Architectural Design Data. McGraw-Hill, NY.
- Woodson, W. E, Tillman, P. & Tillman, B. (1992) Human Factors Design Handbook, 2nd Edition. McGraw-Hill, NY.

I.11 Personal Control of IEQ Conditions and Impacts

Intent

Provide for local occupant control of interior conditions to better support work performance. Personal control will enable immediate improvement of intermittent discomfort and will help indicate personal availability or current work status. It will also allow workers to increase personal comfort in changing organizational contexts. However, occupants shall not be put in recurrent uncomfortable conditions, so that continuous adaptation is necessary to maintain comfort.

Recommended Performance Criteria

A. Provide adjustable task lighting to include 'on', 'off', and intermediate levels.
B. Provide means of alleviating direct solar gain at all continuously occupied and assigned positions.
C. Provide means of mitigating intermittent noise, drafts or low air circulation at all continuously occupied and assigned positions.
D. Provide means of alleviating building control system malfunctions at all continuously occupied and assigned positions.
E. Provide access to operable windows at all continuously occupied and assigned positions.
F. Neck extension for continuously viewing monitors at workstation shall not be greater than 0 degrees vertical. Head rotation for continuous viewing shall not be greater than 10 degrees horizontal.
G. At keyboard rest, there shall be no continuous deviation from an approximate 0 degree angle in elevation from elbows at sides at rest through wrists to fingertips on keyboard.

Higher performance is achievable with the following personal control criteria:

H. Increase flexibility of workspace through adoption of standards for ergonomically adjustable and movable furniture elements. (BIFMA Office Furniture Standard, European CEN Workplace Standard, NASA Man-System Integration Standards.)
I. Use tools to perform Spatial Syntax and other (e.g. Isovist) analyses that can be used to improve flexibility and habitability of workspace.

Compliance Tools and Resources

- BIFMA (Business and Institutional Furniture Manufacturers Association) (2001) Ergonomics Guideline for VDT Furniture Used in Office Workspaces. BIFMA G1-2001, Grand Rapids, MI.

Related MSBG Documents

Form P-5 Indoor Environmental Quality Documentation
Appendix I-1 Suggested Implementation for all Indoor Environmental Quality Guidelines

Supplemental Resources

- Bechtel, Robert B. & Churchman, Azra, (Eds.) (2002) Handbook of Environmental Psychology. John Wiley & Sons, NY.
- Boff, K. & Lincoln, J. (Eds.) (1988) Engineering Data Compendium: Human Perception and Performance. Harry G. Armstrong Aerospace Medical Research Laboratory, Wright Patterson AFB, Ohio.
- Human Factors Society (1988) American national standard for human factors engineering of visual display terminal workstations. (ANSI/HFS 100-1988.) Santa Monica, CA. Human Factors and Ergnomics Society.
- NASA (1995) Man-System Integration Standards. Johnson Space Center, Houston, TX. msis.jsc.nasa.gov

- Salvendy, Gavriel (Ed.) (1987) Handbook of Human Factors. John Wiley & Sons, NY.
- Watson, Donald. Crosbie, Michael. Crosbie, Michael J. & Callender, Michael H. (1997.) Time-Saver Standards for Architectural Design Data. McGraw-Hill, NY.
- Woodson, W. E, Tillman, P. & Tillman, B. (1992) Human Factors Design Handbook, 2nd Edition. McGraw-Hill, NY.

I.12 Encourage Healthful Physical Activity

Intent

Provide spatial conditions conducive to incidental physical activity. Movement (like walking) between workplace destinations helps maintain cardiovascular fitness, mental alertness, and encourages synergistic staff interactions that improve morale and well-being.

Recommended Performance Criteria

A. Provide an 'open' or 'enhanced' stair design that is visible and/or easy to locate connecting the main (entry level) floor with at least the next two floors above it and the first floor beneath it. This encourages and enables building occupants to safely and conveniently use the stairs to travel between floors in their daily building circulation.

B. Encourage staff to walk to routinely used building service centers and interior destinations through design of circulation path and its amenities. Features that encourage physical activity include:
   - Separation of restrooms and service centers (like mailrooms and refreshment dispensers and break rooms) from work areas
   - Enhanced daylight and views along a circulation path
   - Different routes to popular interior destinations
   - Interior circulation paths that allow round trips without reversal of direction.

C. Interior circulation paths with adjoining meeting niches and nooks that encourage spontaneous staff interaction along the path lengths.

D. Amenities that encourage casual and continuous use of stairs include: position of stairs in floor plan, openness of stairway to surrounding interior views, provision of rest and incidental meeting nooks along stairway length, reversal or curving of stairway to facilitate expanded user view of stair traffic, proper stairway riser/tread ratios, surfacing, and grab handle meeting HFES (not minimum building code) design recommendations.

Related MSBG Documents

Form P-5 Indoor Environmental Quality Documentation
Appendix I-1 Suggested Implementation for all Indoor Environmental Quality Guidelines

Supplemental Resources

- Bechtel, Robert B. & Churchman, Azra, (Eds.) (2002) Handbook of Environmental Psychology. John Wiley & Sons, NY.
- Boff, K. & Lincoln, J. (Eds.) (1988) Engineering Data Compendium: Human Perception and Performance. Harry G. Armstrong Aerospace Medical Research Laboratory, Wright Patterson AFB, Ohio.
- Pauls, J. L. (1982) "Recommendations for Improving the safety of Stairs", Building Practice Note No. 35, June, Division of Building Research, National Research Council Canada, Ottawa.
- Pauls, J. "What Can We Do to Improve Stair Safety?" (1984) Building Standards, May-June, pp 9-12, 42-43; July-August, pp 13-16, p. 42.
- (1984) Southern Building, April-May, pp. 14-20; June-July 1984, pp. 22-28; (1984) The Building Official and Code Administrator. May-June, pp.30-36; July-August, pp. 10-15.
- Pauls, J. (1991) "Cost of Injuries in the United States and the Role of Building Safety." The Building Official and Code Administrator, Jan/Feb, pp. 19, 31-35;
- _____ (1991) Building Standards, July/Aug, pp. 18-22, 24;
- _____(1991) Southern Building, July/Aug, pp. 6, 8-10, 12, 51; etc

- Pauls, Jake. (1992) "What Should Inspectors Look for Regarding Safe Stair Construction?." Building Official and Code Administrator, July/August, pp. 32-39.
- NASA (1995) Man-System Integration Standards. Johnson Space Center, Houston, TX. msis.jsc.nasa.gov
- Salvendy, Gavriel (Ed.) (1987) Handbook of Human Factors. John Wiley & Sons, NY.
- Watson, Donald. Crosbie, Michael. Crosbie, Michael J. & Callender, Michael H. (1997.) Time-Saver Standards for Architectural Design Data. McGraw-Hill, NY.
- Woodson, W. E, Tillman, P. & Tillman, B. (1992) Human Factors Design Handbook, 2nd Edition. McGraw-Hill, NY.

MATERIALS AND WASTE GUIDELINES

Required Guidelines
M.1 Life Cycle Assessment of Building Assemblies
M.2 Evaluation of Environmentally Preferable Materials
M.3 Waste Reduction and Management

Related Forms
Form P-6 Materials and Waste Documentation

Worksheets and Appendices
Worksheet M-1: Life Cycle Assessment Calculator
Worksheet M-2: Construction Waste Recycling Economics
Worksheet M-3: Packaging Waste Recycling Economics
Appendix M-1: Suggested Implementation for All Material and Waste Guidelines

Overview
Selection and use of materials and resources for more sustainable building has been an evolving process since the first recycled content products hit the market in the early 1970s. Costs related to increased waste from construction, depletion of non-renewable resources, and air and water pollution from production and distribution are becoming increasing drains on the State's economy. Because the building industry consumes over three billion tons of raw materials annually—around 40 percent of the total material flow in the global economy—the need to reduce the effects of building material extraction, processing, delivery, use, and disposal has become imperative to improving the health of the economy and the environment. To this end, guidelines and rating systems have sought to guide practitioners toward choices that reduce waste and the negative environmental impacts associated with materials through prescriptive requirements for salvaged materials, recycled content, locally produced or assembled products, and renewable materials. The State of Minnesota Sustainable Building Guidelines (MSBG) are moving away from prescriptive requirements toward material selection based on Life Cycle Assessment (LCA) which will provide a better connection to real effects and costs. However, until there is more complete data available, MSBG will also recommend prescriptive requirements to effect change. This section focuses on the selection of building assemblies and materials. Guideline P.2 Planning for Conservation addresses designing for reduced construction through shared use of spaces, building reuse, and design for flexibility and adaptability,

Goal
To produce projects with the lowest reasonable life cycle environmental impact at the lowest first cost based on material resource use and waste management.

Objectives
- Evaluate building assemblies to optimize their total life cycle performance based on the *Athena Environmental Impact Estimator.*
- Evaluate material alternatives to optimize their total life cycle performance based on material properties such as: salvaged, recycled content, locally/regionally produced, renewable, appropriate service life, and ability to be reused, recycled, or biodegradable.
- Reduce, recycle and manage wastes generated during the construction process and occupancy.
- Determine the project's life cycle environmental impacts related to quantity and type of materials used and waste reduction and management.

Required Materials and Waste Guidelines

M.1 Life Cycle Assessment of Building Assemblies

Intent
To inform early building assembly material choices using life cycle assessment of alternatives. Building assembly choices significantly affect global warming, air pollution, water pollution, energy use, and waste.

Required Performance Criteria
A. During schematic design, evaluate a base case and at least two alternative scenarios for building assembly material choices on the project and enter results in Form P-6 Materials and Waste Documentation. Assemblies to be documented are foundations, intermediate floors, roof, exterior walls, windows, and interior partitions. Outcomes are global warming potential, air pollution index, water pollution index, primary energy, weighted resource use, and solid waste produced over the life cycle of the material. The analysis is calculated over a 60-year life cycle. The tool for these calculations is Worksheet M-1: Life Cycle Assessment Calculator which contains pre-run assembly scenarios based on the *Athena Environmental Impact Estimator* software. Teams may alternately run the *Athena Environmental Impact Estimator* for a more customized approach.

Recommended Performance Criteria
B. Use BEES or other tools to perform similar types of analysis for interior finish materials. This type of assessment usually occurs in the DD or CD phase.

Compliance Tools and Resources
For Item A above:
- Worksheet M-1: Life Cycle Assessment Calculator
- *The Environmental Impact Estimator* — software from the Athena Institute (www.athenasmi.ca)

For Item B above:
- BEES (**B**uilding for **E**nvironmental and **E**conomic **S**ustainability) software (www.bfrl.nist.gov/oae/software/bees.html)

Related MSBG Documents
- Form P-6 Materials and Waste Documentation
- Worksheet M-1: Life Cycle Assessment Calculator
- Appendix M-1: Suggested Implementation for All Material and Waste Guidelines

Supplemental Resources
- The Minnesota Building Materials Database www.buildingmaterials.umn.edu

M.2 Evaluation of Environmentally Preferable Materials

Intent
To encourage the use of materials and products that have specific properties intended to improve life cycle performance.

Required Performance Criteria
A. Evaluate materials with environmentally preferable properties and document the extent of their application in Form P-6 Materials and Waste Documentation. Materials and products which have more than one recommended characteristic will, in most cases, provide higher cumulative benefits than those with only one characteristic.
   Material properties to be documented:
   - Salvaged or reused materials
   - Recycled content beyond normal practice
   - Locally/regionally produced and manufactured
   - Renewable, bio-based materials
   - Appropriate durability for service life
   - Materials made from reusable, recyclable, or biodegradable resources.
   - Designed for disassembly or deconstruction
   - Reduce material use and waste by modular use of materials, simplified design and detailing.

Recommended Performance Criteria
Evaluation targets:
B. Use salvaged or reused materials for 5% of the total materials used in the project.
C. Use materials that contain, in aggregate, a minimum weighted average of 20% post-consumer recycled content material, OR, a minimum weighted average of 50% post-industrial recycled content material. These percentages will be increased over time to meet an eventual goal of zero waste.
D. Use materials manufactured regionally within a radius of 250 miles of project site to specified qualifications, or are manufactured within the State of Minnesota and contain products from state-sponsored, approved, or acknowledged recycling programs.
E. Use renewable, bio-based raw materials for 5% of the total value of all products used in the project. Qualifying materials must be either: (a) residues from the processing of renewable, bio-based materials; OR (b) grown or harvested under a recognized sustainable management system. Programs that do not require third-party certification may be included. At a minimum, the management system must be subject to audit by the authority responsible for the system.
F. Use materials with appropriate durability for service life. In many cases, State buildings are intended to have a 50-100 year service life for the structure and envelope.
G. Use materials made from reusable, recyclable, or biodegradable resources
H. If you are pursuing LEED certification or following other guidelines and standards in addition to these, provide any detailed volume and cost information as required by those guidelines.

   Note: Portions of this guideline are adapted from LEED Version 2.0.

Related MSBG Documents
- Form P-6 Materials and Waste Documentation
- Appendix M-1: Suggested Implementation for All Material and Waste Guidelines

Supplemental Resources

- The Minnesota Office of Environmental Assistance (MOEA) web page on Building Products and Materials is an excellent resource for information on recycled-content products, including the OEA Recycled Products Directory, other directories, and informative fact sheets (including the Environmentally Preferable Purchasing Guide.) The page also provides links to standards and product lists from ASTM, EPA (Comprehensive Procurement Guidelines), Forest Stewardship Council for certified wood, Green Seal, and Scientific Certification Systems. Links to ATHENA, BEES 3.0, BuildingGreen (EBN), the OIKOS directory and more. www.moea.state.mn.us/greenbuilding/products.cfm
- The Minnesota Building Materials Database www.buildingmaterials.umn.edu
- National Association of Home Builders, Advanced Framing Techniques; www.nahb.org.

M.3 Waste Reduction and Management

Intent
Minimize use of resources and negative environmental impacts through careful reduction and management of wastes generated during the construction process and building occupancy.

Required Performance Criteria
A. Construction waste: Minimize waste generated from construction, renovation and demolition of buildings through detailing and specifications.
B. Construction waste: Divert at least 75% (by weight) construction, demolition, and land clearing debris from landfill disposal.
C. Packaging waste: Reduce and recycle packaging waste associated with the construction process, and encourage manufacturers to ship their product using reusable, recyclable, returnable, or recycled content packaging. Reuse or return 50% of all packaging material, by weight, to suppliers or manufacturers.
D. Operations waste: Reduce and recycle at least 50% of the waste generated during building operation. Provide dedicated recycling areas, processing and holding space, and reverse distribution space in the building.

Recommended Performance Criteria
E. Construction waste: Reuse, recycle and/or salvage an additional 15% (90% total by weight) of the construction, demolition, and land clearing waste.
F. Packaging waste: Return an additional 25% (75% total by weight) of all packaging material to suppliers or manufacturers

Note: Portions of this guideline are adapted from LEED Version 2.0.

Compliance Tools and Resources
For Item A, B and E above:
- Worksheet M-2 Construction Waste Recycling Economics

For Item C, D and F above:
- Worksheet M-3 Packaging Waste Recycling Economics

Related MSBG Documents
- Form P-6 Materials and Waste Documentation
- Appendix M-1: Suggested Implementation for All Material and Waste Guidelines
- Worksheet M-2 Construction Waste Recycling Economics
- Worksheet M-3 Packaging Waste Recycling Economics

Supplemental Resources
- The Minnesota Office of Environmental Assistance (MOEA) web page on C&D Waste is an excellent resource for information on reduction and management of construction and hazardous waste. Includes OEA's Recycling Markets Directory and MN Materials Exchange. Provides links to MPCA's hazardous waste rules and fact sheets for each special waste. Links to EPA's C&D Debris web site. www.moea.state.mn.us/greenbuilding/waste.cfm
- The MOEA web page on Efficient Transport Packaging Options is an excellent resource for reducing packaging waste. Includes a searchable directory on Reuseable Transport Packaging. www.moea.state.mn.us/berc/transpack.cfm

- Construction Waste Management Specification Language (Example: Section 01690)
- The Resourceful Waste Management Guide (RWM Guide) is produced by the Solid Waste Management Coordinating Board (SWMCB.) The SWMCB is a joint powers board of six metropolitan counties for the purpose of planning and coordinating solid waste management activities. The RWM Guide provides a list of Twin Cities material outlets which building owners, contractors, or design professionals can contact to recycle demolition waste and donate equipment, materials, and other items generated from a building demolition. The following sections of the RWM Guide relate to building demolition: Donation Opportunities; Appliances; Building Materials Reuse, Computers, Electronics, and Office Machines; Concrete and Bituminous Asphalt; Fluorescent Lamps, Landscaping and Tree Waste; Office Furniture and Equipment; Railroad Ties; Scrap Metal; Textiles; and Wood Waste. For a copy of the Resourceful Waste Management Guide, email your name and address to: paul.kroening@co.hennepin.mn.us or call (612) 348-6358.
- Refer to WasteSpec www.tjcog.dst.nc.us/cdwaste.htm
- Building Construction and Reuse, article, Center for Construction & Environment, University of Florida; www.cce.ufl.edu/past/deconstruction/reuse.html.
- Twin Cities Free Market: http://www.twincitiesfreemarket.org