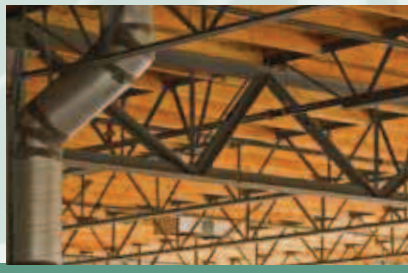

Preventive Maintenance Guidebook

Best Practices to Maintain Efficient and Sustainable Buildings

Lawrence J. Schoen, P.E., Fellow ASHRAE

BOMA International

About BOMA International

Founded in 1907, the Building Owners and Managers Association (BOMA) International is an international federation of more than 100 local associations and affiliated organizations. The 16,500-plus members of BOMA International own or manage more than 9 billion square feet of commercial properties in North America and abroad. BOMA's mission is to enhance the human, intellectual and physical assets of the commercial real estate industry through advocacy, education, research, standards and information. On the Web at www.boma.org.

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Foreword to the Third Edition

BOMA International is proud to present the Third Edition *Preventive Maintenance: Best Practices to Maintain Efficient and Sustainable Buildings*, a revision of the 2003 version, *Preventive Maintenance and Building Operation Efficiency*. The publication was first issued in 1996 under the title, *How to Design and Manage Your Preventive Maintenance Program*.

This new edition contains greater emphasis on predictive maintenance, sustainability, commissioning, use of electronic tools and resources, renewable and recovered energy. It contains more checklists and has an updated peer-reviewed Appendix on Building Systems Useful Life.

Acknowledgements

About the Author

The BOMA International *Preventive Maintenance Guidebook: Best Practices to Maintain Efficient and Sustainable Buildings* is authored by Lawrence J. Schoen, P.E., president of Schoen Engineering, Inc., an international building services engineering firm based in Columbia, Maryland. Schoen's experience includes engineering management for a commercial developer/operator where he was responsible for operation, maintenance and capital improvements to mechanical and electrical systems and environmental compliance and risk reduction in 60 million square feet of shopping centers, office/industrial buildings and hotels located throughout the world. He was also a design engineer at one of the largest international building services engineering consulting firms. He has conducted DOE-funded energy research at Princeton University's Center for Energy and Environmental Studies. He has a B.S. in Mathematics from SUNY at Buffalo and an M.S. in Mechanical Engineering from New Jersey Institute of Technology. He is a licensed Professional Engineer (P.E.) in several States, Fellow of American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), Operating Engineer past Chair Baltimore Section of American Society of Mechanical Engineers (ASME), IEEE, International Society of Indoor Air Quality and Climate (ISIAQ) and International Council of Shopping Centers (ICSC).

Schoen is a voting committee member of ANSI/ASHRAE/USGBC/IES 189.1, Standard for the Design of High-Performance Green Buildings, Chair of ASHRAE's Environmental Health Committee, chaired its IAQ 2007 Conference, Healthy and Sustainable Buildings, was BOMA's voting member for Standard 62.1, Ventilation for Acceptable Indoor Air Quality from 1996 to 2008, serves on the ICSC Energy / Environmental Committee and is ASME's voting member on the Maryland Department of the Environment Air Quality Control Advisory Council.

Schoen has published technical articles in the fields of HVAC, IAQ, building maintenance, operations and energy and has spoken at numerous forums for BOMA International, ASHRAE, the National Realty Committee, Associated General Contractors, IAQ Publications and others. He was the author of the 2003 BOMA International *Preventive Maintenance and Building Operation Efficiency* publication.

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Appendix 7: Building Systems Useful Life

The following list of systems and average useful life years is the opinion of the author based on regular preventive maintenance properly performed at prescribed frequencies. Many factors can affect the average useful life and like any average, individual systems and components will have lifetimes far from average. Lifetimes can often be extended significantly through robust maintenance programs that go beyond the norm, and many facilities currently have functioning equipment older than the lifetimes listed.

Climatic conditions and challenging environments (for instance in wet locations, near salt water or heavy industry) will shorten life. Selection of heavy-duty equipment features, such as hinged access doors, double wall panels, serviceable components, corrosion-resistant materials and other factors will lengthen life.

Due to hardware and software revisions, central control equipment for HVAC, fire alarms, security and other computerized systems can become "orphaned" and no longer supported by vendors. Users may consider new or enhanced functionality essential and these may be compatible only with new hardware and software. Vendors have incentives to force upgrades. Any of these factors can shorten the useful life of central control hardware and software.

Despite all the limitations of averages, this list serves as a general guide for future planning. Energy cost reduction may justify replacement or major upgrade of equipment prior to the end of its useful life.

SYSTEMS	AVERAGE USEFUL LIFE YEARS
A. HVAC[6]	
1. Air Conditioners	
a. Window Unit	10
b. Residential Single or Split Package	15
c. Commercial	10
d. Water-Cooled Package	20
e. Computer Room Unit	15
2. Air Handling Units	
a. Built-Up Heavy Duty	30
b. Packaged Medium-Duty	25
c. Severe Duty or 100% Outside Air	20
3. Heat Pumps	
a. Residential Air-to-Air	12
b. Commercial Air-to-Air	15
c. Commercial Water-to-Air	18
4. Roof-Top Air Conditioners	
a. Single Zone	18
b. Multizone	18
c. VAV	20
5. Boilers, Hot Water	
b. Steel Water-Tube	30
c. Steel Fire-Tube	30
d. Cast Iron	30
e. Electric	25
f. Condensing	15
6. Boilers, Steam	
a. Steel Water-Tube	28
b. Steel Fire-Tube	25
c. Cast Iron	30
7. Burners	18
8. Furnaces	
a. Gas Fired	18
b. Oil Fired	18
c. Condensing	15
9. Unit Heaters	
a. Gas	13
b. Electric	15
c. Hot Water	20
d. Steam	20
10. Heaters	
a. Electric Radiant or Convector	10
b. Radiant Hot Water	25
c. Radiant Gas	18
d. Steam or Hot Water Convector, Cast Iron	50
e. Steam or Hot Water Fin Tube	15

[6] HVAC Equipment life is based on approximately 3500 operating hours, 1800 equivalent full load hours use/year and a normal amount of on-off cycles. This is equivalent to 21 percent annual average load factor. More hours of use/year and more frequent cycling will decrease lifetime.

SYSTEMS	AVERAGE USEFUL LIFE YEARS
11. Air Terminals	
a. Diffusers, Grilles, Registers, Heavy Gauge, Coated	30
b. Diffusers, Grilles, Registers Perforated or Light Gauge	15
c. Induction Units	35
d. Fan-Coil Units	20
e. VAV Boxes Cooling Only	25
f. CAV Boxes	25
g. Double Duct Boxes	25
h. Fan Powered VAV Boxes	17
i. Variable Volume Temperature Boxes	15
12. Air Washers & Humidifiers	
a. Spray	12
b. Steam	15
c. Pan, Wheel or Wetted Element	8
13. Ductwork	
a. Galvanized Steel, Aluminum and Black Iron	30
b. Fiberglass	15
c. Flexible Round	10
14. Dampers	
a. Operable or Automatic	20
b. Fixed (balancing) or Fusible Link (fire)	30
15. Fans	
a. Centrifugal	25
b. Axial	20
c. Propeller	15
d. Ventilating Roof-Mounted, Mild Exhaust	20
e. Kitchen or Other Soiled Exhaust	15
16. Coils—Fluid to Air	
a. Direct Expansion (refrigerant)	18
b. Water/Steam Heating	20
c. Cooling and Dehumidifying	12
d. Electric	12
17. Heat Exchangers	
a. Commercial—Shell and Tube	
i. Steam to Domestic Water	13
ii. Steam to Heating Water	20
iii. Water to Domestic Water	15
iv. Water to Water	25
b. Residential Immersion Coil	25
c. Plate and Frame	25
d. Energy Recovery Wheel	15
e. Energy Recovery Water	12
f. Energy Recovery Air to Air	12
g. Energy Recovery Heat Pipe	20
18. Reciprocating Air Compressors	15

SYSTEMS	AVERAGE USEFUL LIFE YEARS
19. Package Chillers[7]	
a. Reciprocating	20
b. Centrifugal	20
c. Absorption	30
d. Screw	20
e. Scroll	15
20. Cooling Towers	
a. Galvanized or Coated Steel	18
b. Wood	20
c. Ceramic	35
d. Fiberglass	35
e. Stainless Steel	25
f. Fill Media	15
21. Condensers	
a. Air-Cooled	20
b. Evaporative	15
22. Insulation (not subject to condensation or leaks)	
a. Molded	20
b. Blanket	25
23. Pumps	
a. Base Mounted	25
b. In-line	15
c. Sump-Submerged	10
d. Well-Submerged	10
e. Condensate	15
24. Reciprocating Engines	
a. Continuous Service	5
b. Back-Up Service	20
25. Steam Turbines	30
26. Electric Motors	
a. Without Soft Start	18
b. With Soft Start	25
27. Motor Starters	
a. In Dry Noncorrosive Areas	25
b. In Wet or Corrosive Areas (cooling towers)	10
28. Electric Transformers	
a. Oil-Filled	30
b. Dry Type	30
29. Controllers	
a. Pneumatic	18
b. Electric	20
c. Electronic	20
d. Computer Front End Controls[8]	15
30. Valve and Damper Actuators	
a. Hydraulic	15
b. Pneumatic	20
c. Motorized Electric	18
d. Self-Contained	10

[7] Chillers using CFCs, especially R-12 may require replacement or significant upgrade before the end of their life due to refrigerant unavailability. Chillers using HFCs such as R-123 are expected to have access to an active market of recycled refrigerant. Companies with large inventories of equipment can get full service life of existing equipment by "banking" their own refrigerants reclaimed from retired equipment in accordance with EPA and other regulations.

[8] See note at top of this list regarding shortened useful life of central control hardware and software.

SYSTEMS	AVERAGE USEFUL LIFE YEARS
31. Control Sensors	
a. Temperature	20
b. Humidity, CO2	5
c. Water Flow	5
d. Air Flow	10
32. Heating and Cooling Piping System	
a. Above Ground	30
b. Ground Source Heat Exchange Loops	40
33. Oil Storage Tank with Corrosion Protection	
a. Above Ground	25
b. Underground	20
c. Underground: FRP Coated Steel	30
34. Boiler Chimneys and Flues	
a. Metal Flue and Breeching	20
b. Steel Chimney	30
c. Masonry Chimney	50

B. ELEVATOR/ESCALATOR

1. Elevator[9]	
a. Hydraulic	
i) Underground Cylinder Dry Location	15
ii) Car and Pump Unit	35
b. Traction[10]	50
c. Geared Traction	35
d. Cab Interior Finish	10
e. Carpet	0.5
2. Escalator	
a. In Dry Location Not For Mass Transit	40
b. In Wet Location or For Mass Transit	20
3. Controllers	
a. Electromechanical Relay Based[11]	30
b. Computer Based	20
4. Elevator Door Operators	
a. Passenger	20
b. Freight or Service Used For Carts	10
5. Wheelchair and Stairway Chair Lift	25

C. PLUMBING[12]

1. Water Heaters with Longer Warranties	
a. Electric, Normal Use	15
b. Electric, Heavy Use or Tankless	10
c. Oil Fired	18
d. Gas Fired, Normal Use	15
e. Gas Fired, Heavy Use or Tankless	10
f. Solar Thermal Collectors	20
2. Flush Valves	12
3. Fixtures: Commercial	
a. Faucets	7
b. Water Closets	30
c. Urinals	30
d. Sinks	30
e. Refrigerated Drinking Fountain	15
4. Pumps	
a. Base Mounted	25
b. In-line	15
c. Sewage Ejector	10
d. Sump-Submerged or Pedestal	10
e. Well-Submerged	10
5. Backflow Prevention	
a. Light Duty	10
b. Heavy Duty (Main Service)	30
6. Domestic Water Piping Systems	
a. Hot and Cold Water (Copper or Plastic)	30
b. Waste Piping (PVC or Cast Iron)	30
c. Kitchen Waste	20
7. Gas Piping Systems	
a. Fuel Gas Threaded	30
b. Fuel Gas Welded	40
c. Medical Gas	40
d. Compressed Air	20
8. Water Softeners	25
9. Compressors and Vacuum Pumps	15

D. ROOFING AND SIDING

1. 4-Ply Built-Up	
a. Asphalt	
i. Flat (Dead Level)	18
ii. Sloped (1/4 inch per foot)	25
b. Cold-Tar	35
c. Hot Applied Rubberized Asphalt (Protected Membrane Assembly)	30
2. 2-Ply Modified Bitumen (Mopped Down)	
a. Flat (Dead Level)	15
b. Sloped (1/4 inch per foot)	20
3. Single Ply	
a. EPDM	
i. Flat (Dead Level)	15
ii. Sloped (1/4 inch per foot)	20
b. Thermoplastic (Hypalon, PVC)	20
c. Modified Bitumen (Touched On)	
i. Flat (Dead Level)	10
ii. Sloped (1/4 inch per foot)	15

[9] Elevator hoistways are expected to last for the life of the building, though rails, ropes, doors and landing plates and other trim may require renewal.

[10] Gearless traction elevators may warrant earlier replacement or costly upgrade for performance reasons.

[11] Earlier replacement may be driven by energy, performance, reliability or safety.

[12] For energy and water conservations reasons, it may be advantageous to replace water heaters and fixtures prior to the end of useful life.

SYSTEMS	AVERAGE USEFUL LIFE YEARS
4. Metal	
a. Structural Roof Panels (Prefinished Galvanized Steel)	25
b. Premanufactured Architectural Roof Panels (Prefinished Aluminum or Galvanized Steel)	25
c. Custom Fabricated Standing Seam Roofing (Copper, Lead Coated Copper, Terne Coated Stainless Steel)	75+
d. Custom Fabricated Flat Seam (Copper, Lead Coated Copper, Terne Coated Stainless Steel)	50+
5. Asphalt Shingles	
a. 15 Year	15
b. 20 Year	20
c. 25 Year	25
d. 30 Year	30
6. Slate	
a. S-1	100
b. S-2	75
c. S-3	50
7. Clay/Concrete Tile	50+
8. Spray-On Polyurethane Foam Roofing	10
9. Siding	
a. Wood (Painted 7-10 years)	30
b. Metal	30
c. Vinyl	30
d. Masonry	75
e. Stone	100

E. ELECTRICAL IN DRY, NONCORROSIVE LOCATIONS (EXCEPT FOR EQUIPMENT DESIGNED TO BE OUTDOORS OR IN WET LOCATIONS)

1. Electric Motors	18
2. Electric Transformers	
a. Oil-Filled	30
b. Dry Type	30
3. Motor Control Center	30
4. Automatic Transfer Switch	25
5. Uninterrupted Power Supply	
a. Battery	10
b. Rotary	15
6. Batteries	5
7. Power Panels	
a. Light and Power Distribution Panel Boards	30
b. Switchgear and Service Entrance Equipment	40
8. Circuit Breakers	30
9. Light Fixtures	20
10. Emergency Engine Generator Set	20
11. Ground Fault Circuit Interrupter (GFCI) Switch	25
12. Wire and Cable	
a. 600 V and below	40
b. Above 600 V	30
13. Solar Photovoltaic Collector Panels	20
14. Branch Circuit Wiring and Devices	30
15. Lightning **Protection**	40

F. FIRE/LIFE SAFETY/SECURITY SYSTEM

1. Fire Alarm Systems	
a. Activation Devices (Pull Station, Smoke Detector, etc.)	10
b. Notification Devices (AV Horn/Strobe)	15
c. Control Panels[13]	15
d. Wiring	30
2. Fire Pumps	
a. Electric Motor Driven	25
b. Engine Driven	20
3. Sprinkler Systems	
a. Heads	25
b. Piping Systems	40
c. Equipment and Devices (Flow Switch, Dry Pipe Valve, etc.)	20
4. Security Systems	
a. Activation Devices (Access Entry, Motion Sensor, etc.).	10
b. Notification Devices (Horn, Dialer)	15
c. Control Panels[14]	15
5. Closed Circuit TV System	
a. Monitors	53
b. Pan and Tilt Motors	53
c. Cameras	65
e. Computer Control[15]	10
6. Standby Power Supply: Battery	5

G. INTERIOR FINISHES

1. Flooring (Sealed When Porous, Except For Carpet)	
a. Vinyl	
i. Tile	12
ii. Sheet	12
b. Carpet: Common Area	
i. Broad Loom	5
ii. Carpet Tiles	5
iii. Loop Pile	15
c. Epoxy Coating (Two Part)	10
d. Stone	
i. Granite	75+
ii. Marble	50
e. Terrazzo	50
f. Hardwood	
(i) Finish	10
(ii) Substrate	50
g. Concrete	50

[13] See note at top of this list regarding shortened useful life of central control hardware and software.
[14] See note at top of this list regarding shortened useful life of central control hardware and software.
[15] See note at top of this list regarding shortened useful life of central control hardware and software.

SYSTEMS	AVERAGE USEFUL LIFE YEARS
2. Walls	
a. Vinyl Wall Covering	10
b. Painted	5
c. Wall Paper	4
d. Epoxy (Two Part)	15
e. Fabric	5
f. Wood Finishes	15
3. Ceilings	
a. Plaster/Drywall with Skim Coat	30
b. Suspended	
i. Spline System	20
ii. Lay-In System	25
iii. Ceiling Tiles	13
c. Metal	25
d. Wood	30
4. Door Hardware	
a. Entry Lock Sets	7
b. Closures	7
c. Automatic Doors	5

H. STRUCTURAL

1. Steel	Life of Building
2. Concrete	Life of Building
3. Wood	Life of Building
4. Façade	
a. Brick, Block and Stone	Life of Building
b. Concrete: Poured in Place	Life of Building
c. Metal Curtain Wall	50
d. Glass Curtain Wall	50
e. Precast Panels	35
f. Stone Veneer	50
g. Windows (Operable or Gasketed)	30

I. PARKING DECKS/LOTS SURFACE

1. Underground	Life of Building
2. Outside	
a.Exposed Paving at Grade or Topmost Level	30
b. Covered Paving (Open at Sides)	40