Maintenance and Operations of Building Systems

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Credit(s) earned on completion of this course will be reported to American Institute of Architects (AIA) Continuing Education Session (CES) for AIA members.

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

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Course Description

Maintenance & Operations of Building Systems APPAU201909B
This session will present an overview of the basic principles in maintaining and operating the various systems in higher education facilities. The discussion will identify building systems and their components, operating characteristics, and general maintenance practices. This course is intended to provide a basic overview as a foundation for electives that will address more detailed, technical information related to specific facility systems.

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Learning Objectives

1. Learn to ensure effective implementation and control of operation activities
2. Learn to ensure efficient, safe, and reliable process operations
3. Learn to be cognizant of status of all equipment
4. Learn to ensure that operator knowledge and performance will support safe and reliable facilities operation

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Goal

To provide background on maintenance and operating issues of building systems so that facilities management personnel can understand the advantages and limitations of these systems and their operating practices.

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Course Outline

- Introduction
- Building System Identification
- Building System Requirements
- Major Building Systems
- Operation and Maintenance Issues

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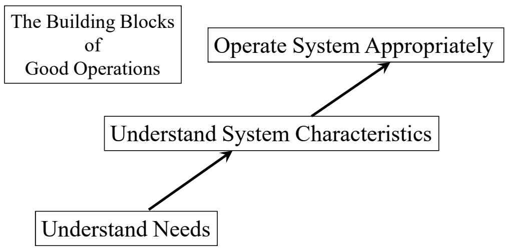

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Why are there systems in buildings?

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Building System List

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Mechanical System-Heating, Cooling, Ventilating

- Human Thermal Comfort
- Indoor Air Quality Control

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Six Variables of Human Thermal Comfort

1.____________________
2.____________________
3.____________________
4.____________________
5.____________________
6.____________________
7.____________________

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Human Thermal Comfort Relationships

Variable	Range	Relationship

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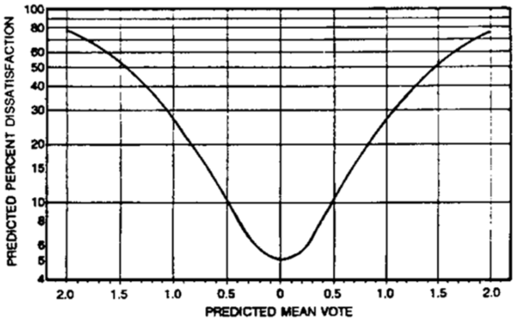

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ANSI/ASHRAE 55

ASHRAE STANDARD

Thermal Environmental Conditions for Human Occupancy

The American Society of Heating, Refrigerating, and Air-conditioning Engineers, Inc.

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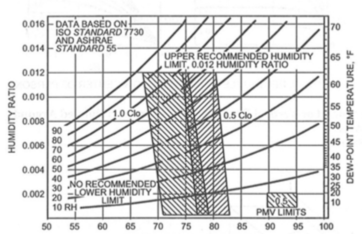

Fig. 5 ASHRAE Summer and Winter Comfort Zones
[Acceptable ranges of operative temperature and humidity with air speed ≤ 40 fpm for people wearing 1.0 and 0.5 clo clothing during primarily sedentary activity (≤1.1 met).]

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Typical Relative Humidity Levels

- Museums - 40% to 50%
- Libraries - 40% to 50%
- High Tech - 20% to 70%
- Laboratories - 30% to 70%
- Office - 30% to 40%

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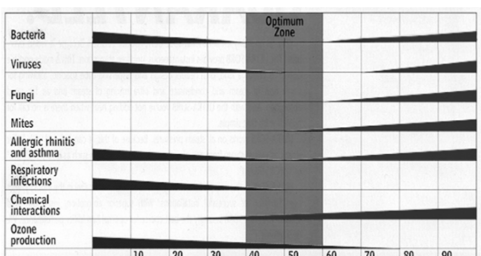

Criteria for Human Exposure to Humidity -1985 by Dr. Elia Sterling

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INDOOR AIR QUALITY

Sick Building Syndrome (SBS)
Building Related Illness (BRI)

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Causes of SBS and BRI

- Toxic Gases
- Volatile Organic Compounds
- Biologicals
- Particulates
- Long-term Hazards
  - Asbestos
  - Radon

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Three Methods to Control Indoor Air Quality

1. ______________________

2. ______________________

3. ______________________

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Odor Threshold for Common Pollutants (mg/m^3)

Ammonia - 33
Carbon Dioxide - Infinite
Carbon Monoxide - Infinite
Formaldehyde - 1.2
Hydrogen Sulfide - 0.007
Ozone - 0.2
Propane - 1800
Sulfur Dioxide - 1.2

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ANSI/ASHRAE 62

ASHRAE
STANDARD

Ventilation
for Acceptable
Indoor Air Quality

The American Society of Heating, Refrigerating, and Air-conditioning Engineers, Inc.

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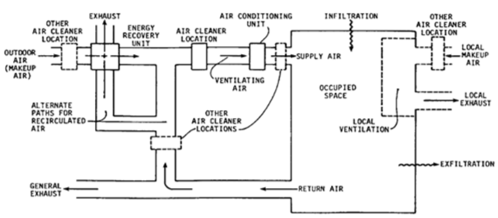

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Space Type	Ventilation Rate	
	CFM/SQFT	CFM/Per
Offices	0.06	5
Classrooms	0.06	7.5
Conference	0.06	5
Computer Lab	0.12	10
Lobbies	0.06	7.5
Bedroom	0.06	5
Restaurant/Dining	0.18	7.5

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$$\% \text{ of Outside Air} = \frac{[Tra - Tma]}{[Tra - Toa]}$$

NOTE: [Tra - Toa] greater than 10 °F.
Mixed air is really mixed.

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Heating, Cooling, Ventilating Design Issues

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________

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Heat = K x __ x ___

All heating and cooling systems are governed by this equation.

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Three Fundamental Types of Systems

1. ________________________________

2. ________________________________

3. ________________________________

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Types of Control

- Two Position
- Floating
- Proportional
- Integral
- Derivative

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Types of Control Power

- Electric
- Electronic
- Pneumatic
- Fluidic
- Hydraulic
- Microprocessor

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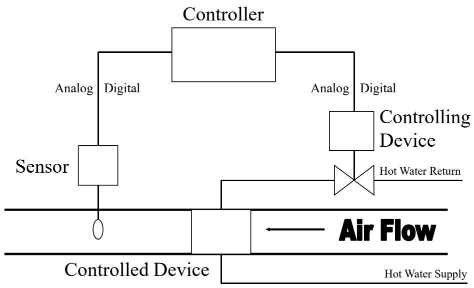

CONTROL LOOP

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Energy Conservation Strategies

- Off-hour Setback
- Reset (Master/submaster)
  - Mixed Air Control
  - Drybulb Economizer
- True Economizer
- PID Control
- Adaptive Control

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Psychrometric Chart

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Building Codes

- AIA (American Insurance Association)
- ICBO (International Conference of Building Officials)
- BOCA (Building Officials and Code Administrators)
- SBC (Standard Building Code)

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Fire Codes

- NFPA (National Fire Protection Association)
- UFC (Uniform Fire Code)
- BOCA (Basic Fire Prevention Code)
- Southern Standard Fire Prevention Code
- Fire Prevention Code by AIA

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Fire protection based on:

- Building Classification
  - Non-combustible
  - Combustible
  - Building Elements
    - Exterior Wall
    - Primary Structural Frame
    - Floor Construction
      - **AND**

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Occupancy Classification (NFPA 101)

Example Criteria

- Assembly - automatic sprinkler system
- Labs (Research) - automatic extinguishing
- Business - no specific requirements
- Residence Halls - no specific requirements

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NFPA 101

- Classrooms under 50 people - Business
- Classrooms over 50 people - Assembly
- Labs, instructional - Business
- Labs, research - Industrial

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Fire Detection Methods

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

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Fire Extinguishing Systems

Automatic Sprinklers

- Wet Pipe
- Dry Pipe
- Deluge
- Fire Cycle

Chemical Systems

- HALON
- CO_2

Standpipe Systems - Dry & Wet

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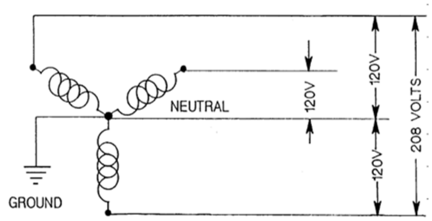
4160/2400 480/277 208/120



3 Phase - 4 Wire Y-System

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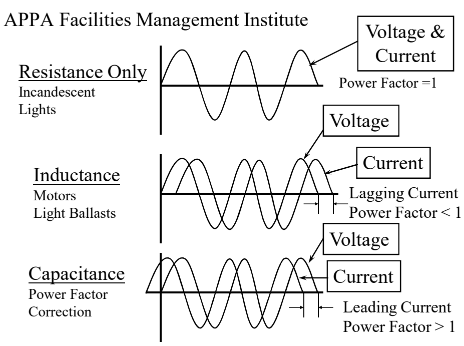

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Power Line Treatment Devices

- Isolation Transformers
- Line Regulators
- Line Conditioners
- Motor Generators
- Uninterruptable Power Supply (UPS)
- Combinations of the above

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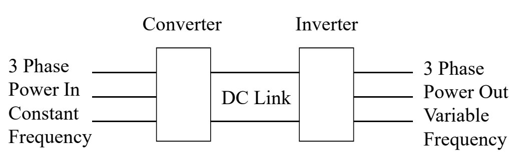

Variable Frequency Drive (VFD)
Schematic Design

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Two Basic Converter Designs

- Diode Rectifier
  - Output is constant DC volts
- Silicon Controlled Rectifier (SCR)
  - Output is variable DC volts

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	Diode Rectifier	SCR
Advantages	Least cost High Power Factor Less affected by noise Puts out less noise	Controls voltage Can regenerate power
Disadvantages	Voltage change Cannot regenerate power	Power factor varies Sensitive to line noise Creates line noise

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Motor Issues on VFDs

- PWM is harder on motors
- OK when less than 60% turn down
- Must have phase insulation
- High class of insulation
- Operate at low temperature rise
- Do not operate into service factor
- Add load reactor between VFD and motor

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Maximum Allow Surface Temperatures

- Class A Motor - 126 ^oF
- Class B Motor - 221 ^oF
- Class F Motor - 266 ^oF
- Class H Motor - 311 ^oF

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IES LIGHTING HANDBOOK

Application Volume

ILLUMINATING ENGINEERING SOCIETY OF NORTH AMERICA

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Space Type	Footcandles
Office Space	20 - 50
Classrooms	50 - 100
Conference Rooms	20 - 50
Laboratories	50 - 100
Libraries	20 - 50
Lobbies	10 - 20
Dining Rooms	5 - 10
Outdoors	1 - 3

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Lamp Coloring

- Color of lamps is determined by temperature and is expressed in degrees kelvin, i.e. 3000^{o}K, 3500^{o}K, etc.
- An index has been created called the Color Rendering Index (CRI). It is arbitrarily based on an incandescent lamp having a CRI of 100.
- Typical office and classroom values are 3500^{o}K and a CRI of 70 to 75.

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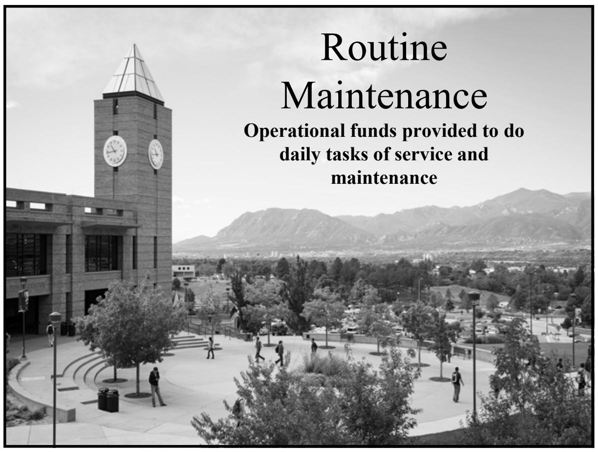
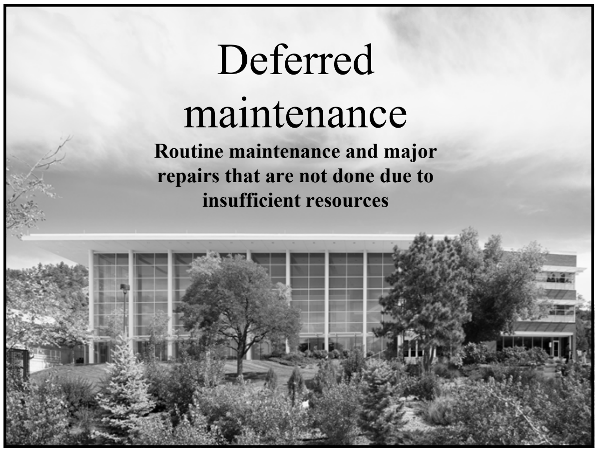
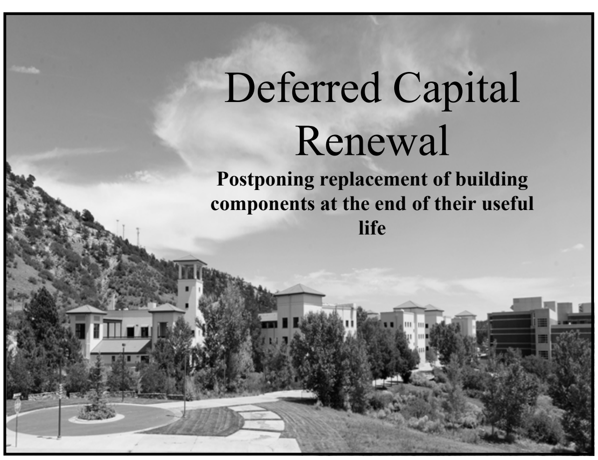
LAMP	Lumens/Watt	CRI	Life (hrs)
Incandescent	17-22	100	800
Mercury Vapor	42-57	Blue/White	4,000
Fluorescent	65-80	70	6,000
Metal Halide	75-85	65	15,000
HPS	85-125	21	25,000
LPS	125-140	0	25,000
Induction	130-190	85	100,000
LED	60	Varies	100,000



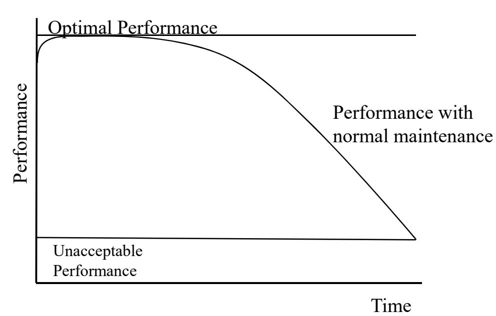

Deferred maintenance
Routine maintenance and major repairs that are not done due to insufficient resources


Capital Renewal
Funds that are provided to replace building components at the end of their useful life

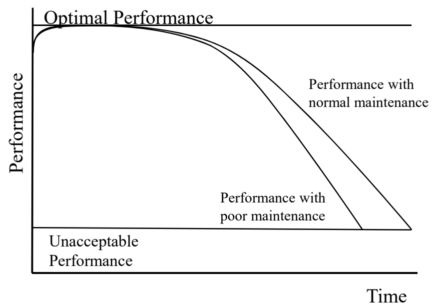

Deferred Capital Renewal
Postponing replacement of building components at the end of their useful life

Building Performance - Normal

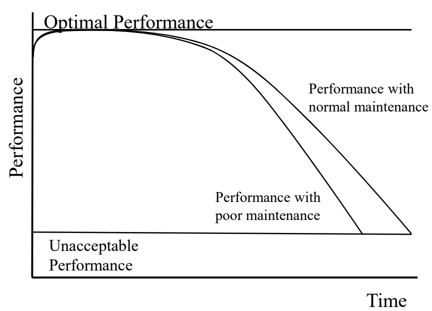
Building Performance – Poor Maintenance



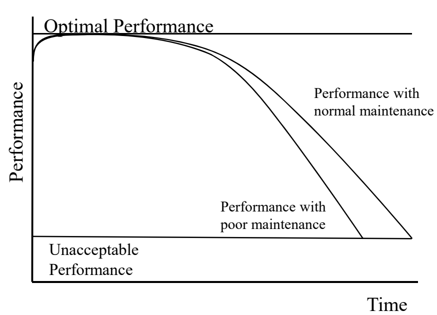
Building Performance – Deferred Maintenance



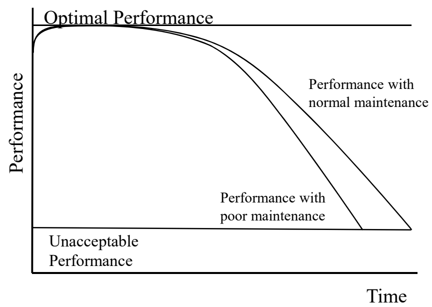
Building Performance – Deferred Maintenance



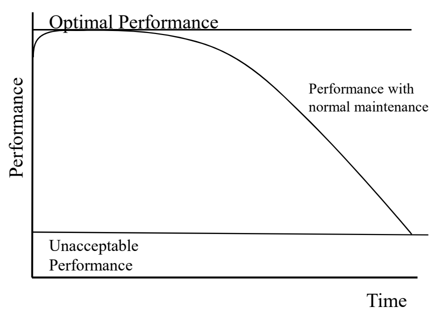
Building Performance – Some Deferred Maintenance



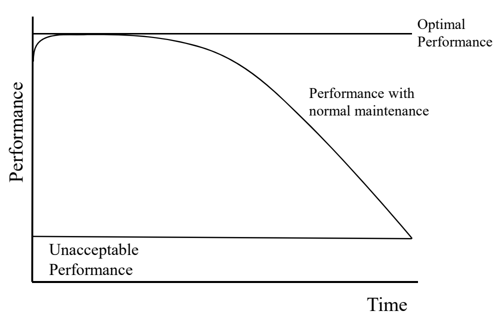
Building Performance – Some Deferred Maintenance



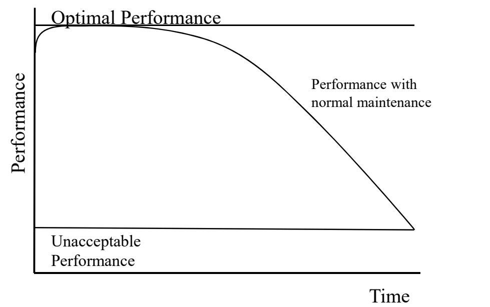
Building Performance – Capital Renewal



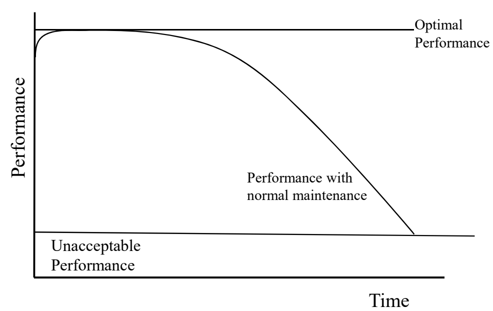
Building Performance – Changing Expectations



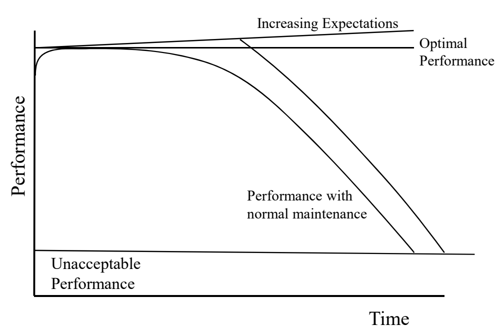
Building Performance – Capital Improvement

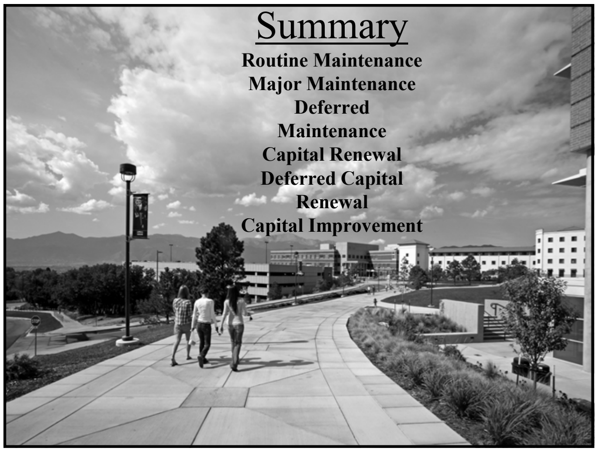


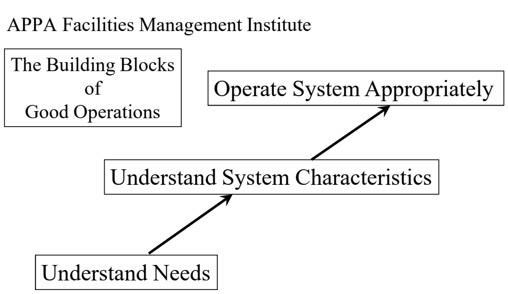
Building Performance – Capital Renewal & Improvements



Building Performance – Capital Improvement & Renewal







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THE END