Fundamentals for High-Performance Operators

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Outline

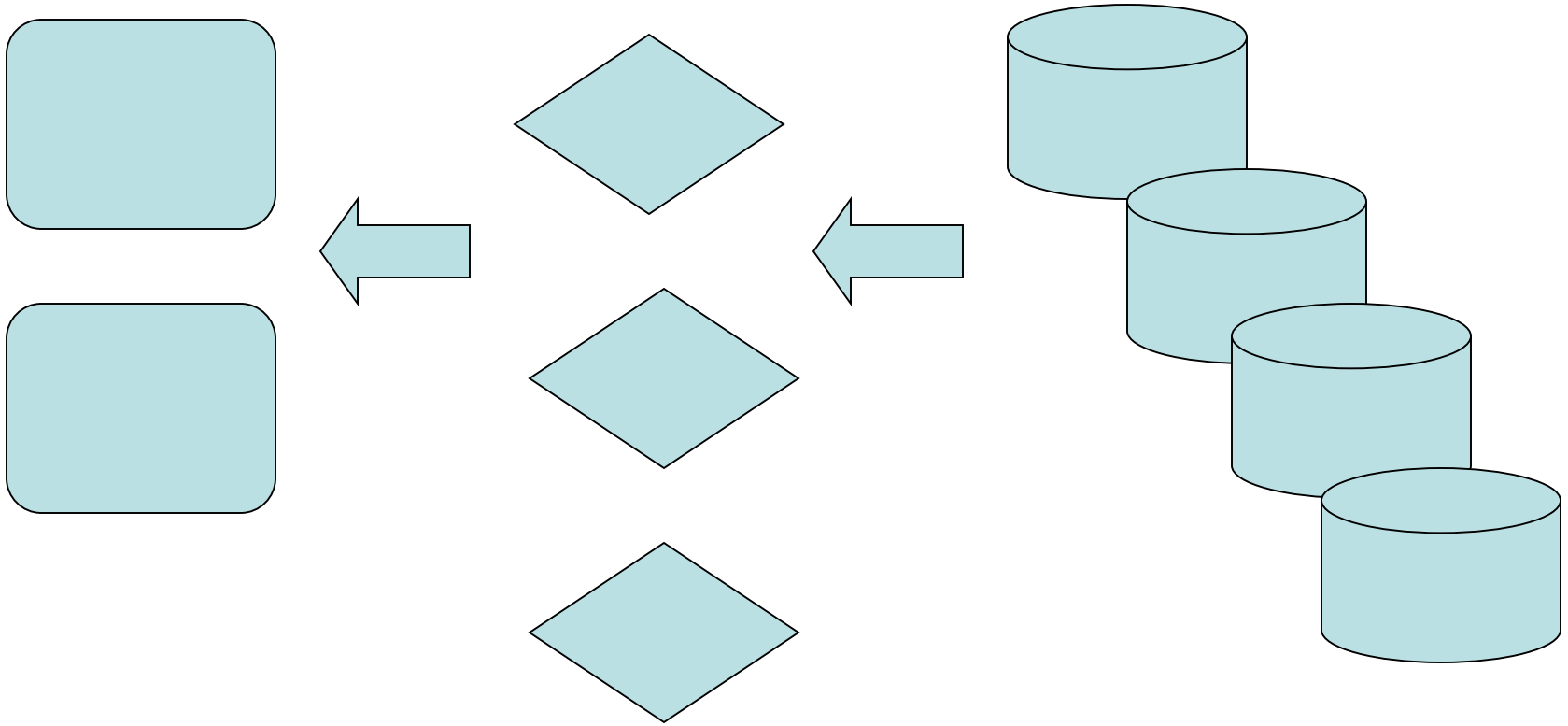
- High-Performance Outcomes
- What Operators need to do
- What Operators need to know
- How we teach and train

Logic Model

BUILDING OUTCOMES

OPERATOR BEHAVIORS

OPERATOR COGNITION



“Begin with the end in mind”

- *Stephen Covey*

What do we expect of Building Operating Engineers?

- Operate equipment, systems and buildings
  - Safely
  - Effectively (ie - IEQ outputs)
  - Efficiently (ie - energy and water inputs)
  - For reliability and extended life

High-Performance Outcomes

- Low energy use
- Superior IEQ
- Measured and Verified

New Behaviors, Skills & Knowledge

- Energy management & system optimization
- Pro-active indoor environment monitoring
- Measurement and quantification

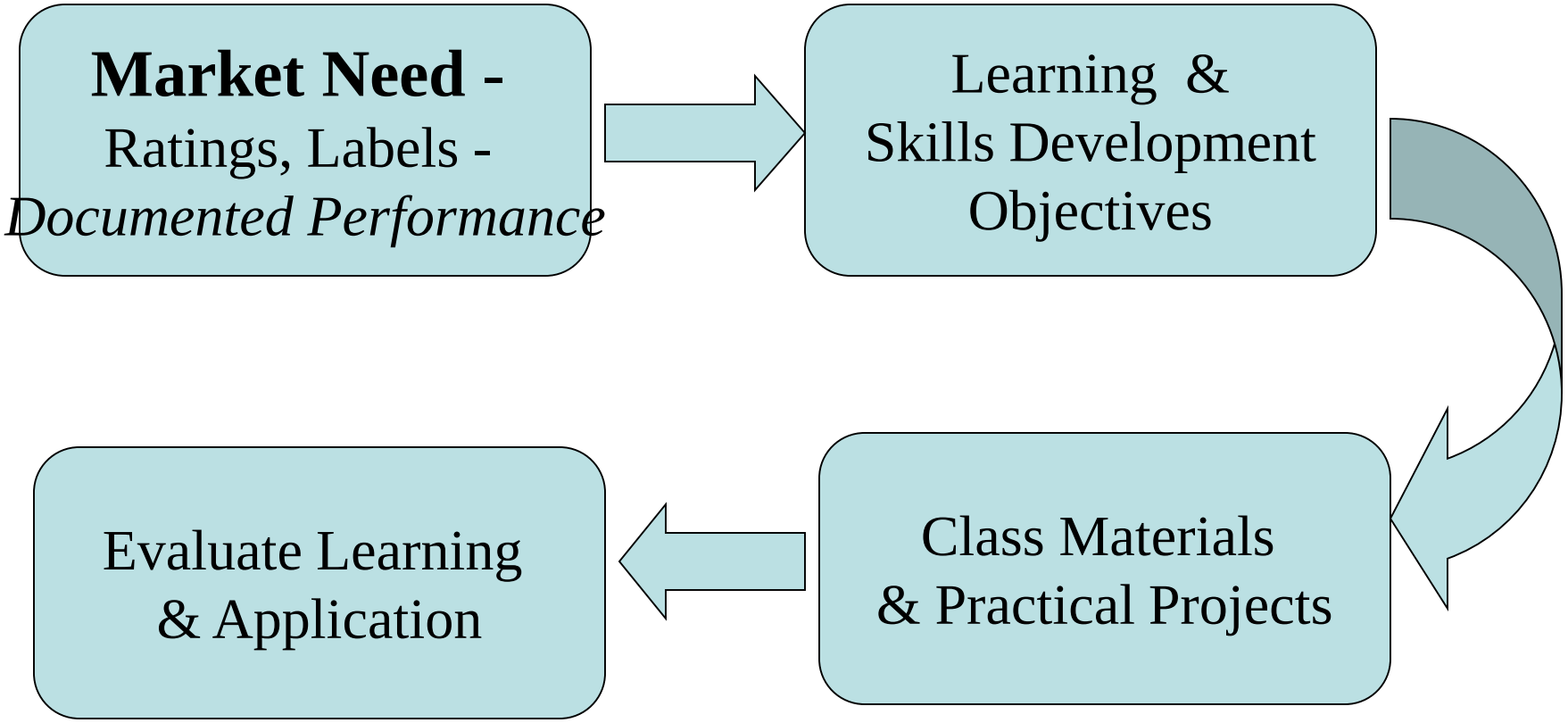
Regulatory-driven

SEC. 2. TRAINING OF FEDERAL BUILDING PERSONNEL.

IDENTIFICATION OF **CORE COMPETENCIES**. Not later than 18 months after the date of enactment of this Act, and annually thereafter, the Administrator of General Services, in consultation with representatives of relevant professional societies, industry associations, and apprenticeship training providers, and after providing notice and an opportunity for comment, shall identify the core competencies necessary for Federal personnel performing building operations and maintenance, energy management, safety, and design functions to comply with requirements under Federal law. ***The core competencies identified shall include competencies relating to building operations and maintenance, energy management, sustainability, water efficiency, safety (including electrical safety), and building performance measures.***

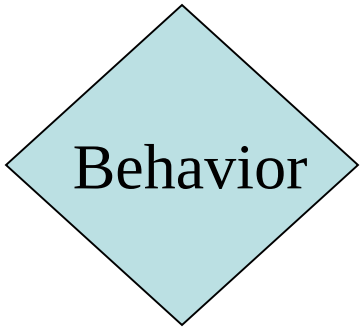
- Intro HR 5112, S3250

Market-driven



Behaviors

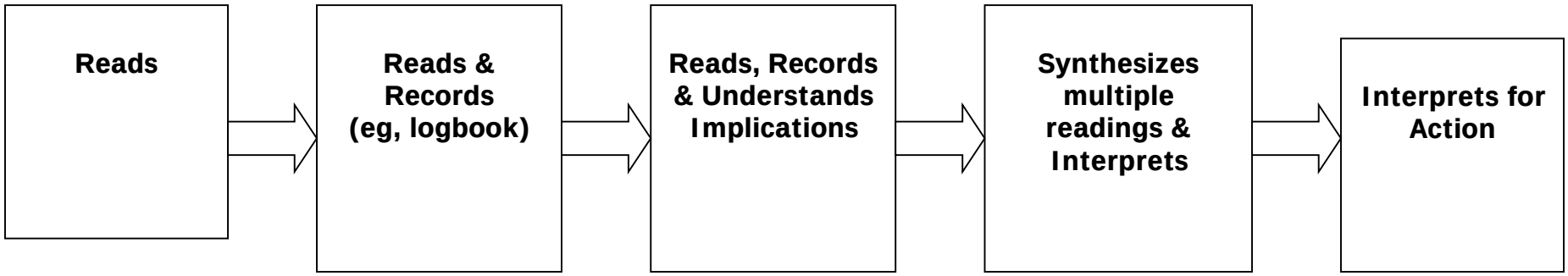
- Fix
- Inspect and maintain
- Monitor inputs, outputs, outcomes
  - What and how to measure
  - Interpretation -- performance issues
- Respond and adjust

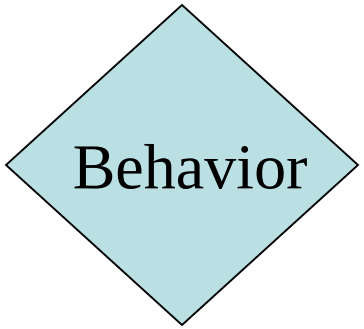


Acquire Data

- Energy units, meters & bills
- Hand-held instruments & data-loggers
- BAS trend logs

Progression of Cognitive Skill Levels in Use of Instrumentation





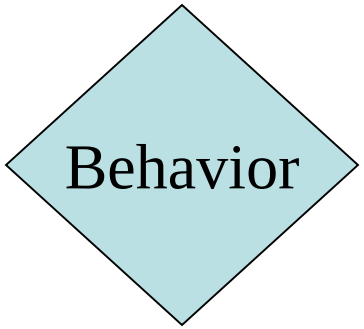
Acquire Data

- Energy units, meters & bills
- Hand-held instruments & data-loggers
- BAS trend logs

Comfort with Spreadsheets

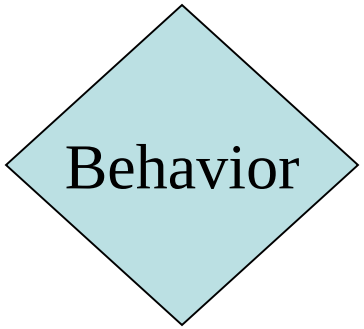
Acquire Data

- Basic Measurements
  - Temperature
  - RH
  - Pressure
  - Flow
  - Light
  - Power



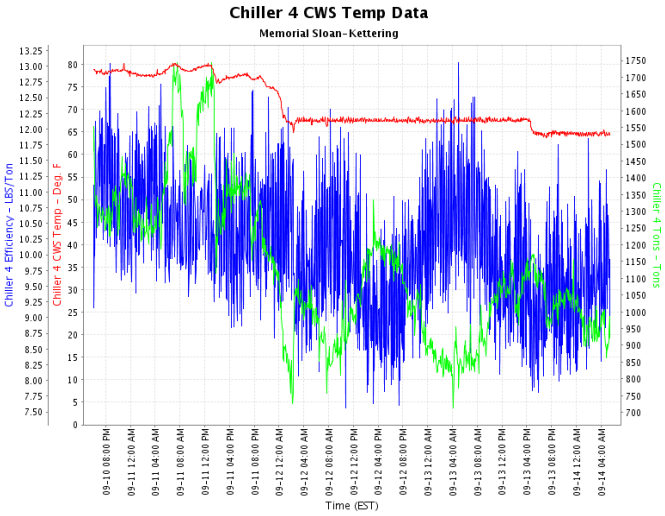
Acquire Data

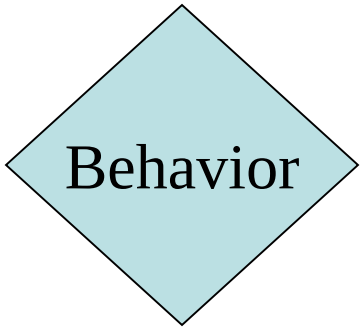
- What system instrumentation?
  - Locate on ***Schematics***
  - What's missing
  - Use data-loggers



Interpret Data

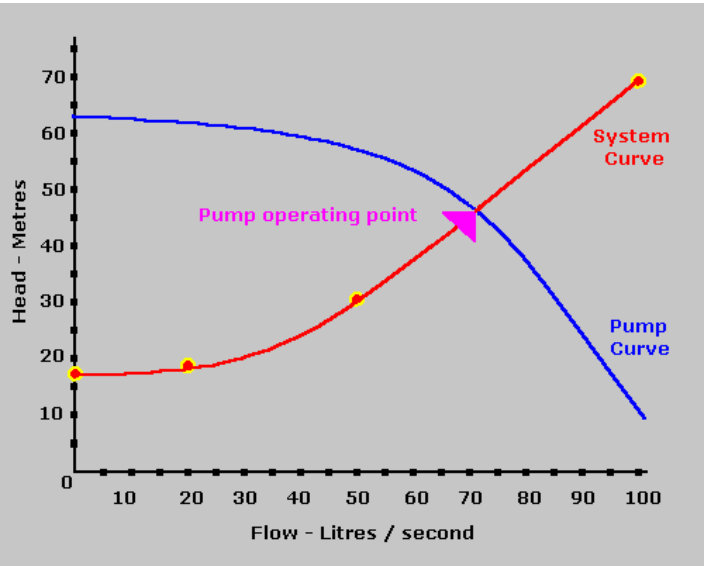
- Benchmarks
- Graphical Plots
  - Time-series
  - Scatter
  - Histograms
- System-level energy and indicators

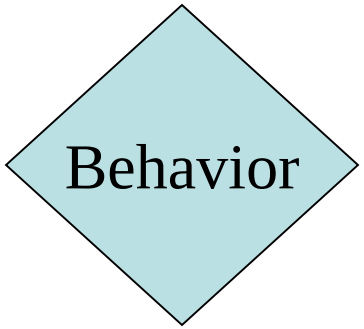




Interpret Data

- Understand relationships between fundamental dimensions
  - Flows, temperature and energy (heat balances)
  - Pressure, flow and power (pump/fan curves and power laws)
  - Use of graphs, charts, some basic calculations





Interpret Data

Perform some basic calcs

A chilled water system is pumping 3,000 GPM through the secondary loop, with supply water at 54 dF and return water at 64 dF. The plant consists of three 1,000 ton chillers (12,000 btuh = 1 ton). How many chillers should be on-line to meet the load of the secondary loop?

HVAC CALCULATION FORMULAE

Heat Loss / Heat Gain

Conduction:
BTUH = U x A x d T

Where U is the conduction value of materials, U = 1/ R
(note: *can add RÕs of different materials but not UÕs*)
A is the area of the surface
dT is the temperature difference (outside to inside)

Infiltration / Ventilation:
Sensible: BTUH = CFH x .018 x dT ***or*** ACH x V x .018 x dT

Where 018 is a constant, specific heat of air
ACH is Air-changes per Hour, in cubic feet per hour
V is room volume, cubic feed

Latent: BTUH = CFH x .68 x dW

Where: dW is the starting Š final absolute humidity in grains per # of air
(*note, find from Psychrometric chart*, using relative humidities)
.68 is a constant for the latent heat per grain of humidity

Heat Delivery

by a ducted air flow
BTUH = CF M x 1.08 x dT

Where: 60 is minutes per hour
1.08 is a combined factor, 60 x .018
Where dT is supply air temperature Š return air temperature

by circulating water distribution
BTUH = GPM x 500 x dT

Where: 500 is a combined factor, 60 min/hr x 8.3 #/gal of water
dT is supply water temperature Š return water temperature

CFM from air velocity measurement in duct

CFM = FPM x duct cross-section Area

Where: FPM is feet per minute, measured
or Feet per second, measured x 60 sec/min

Deriving Outside Air (OSA) Quantity from air temperature readings

% OSA = (R eturn Air T Š Mixed Air T) / (Return Air T Š Outside Air T) x 100

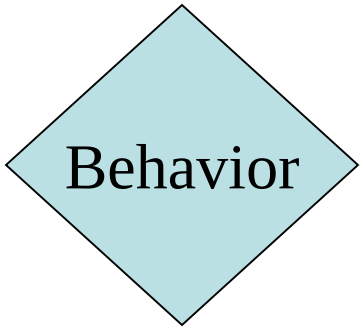
OSA Quantity = total CFM x % OSA

Respond and Adjust

- Understand intent and dynamics
  - Equipment efficiency factors (combustion efficiency, refrigerant charge, steam traps)
  - Equipment sizing and part-load operations
  - Control sequences of operation
  - How systems and buildings respond

Respond and Adjust

- Understand intent and dynamics
  - Classroom and project activities to document types of systems and baseline operating conditions
    - Develop Schematics
    - System Narratives
    - Equipment Inventory
  - Identify and characterize improvement opportunities

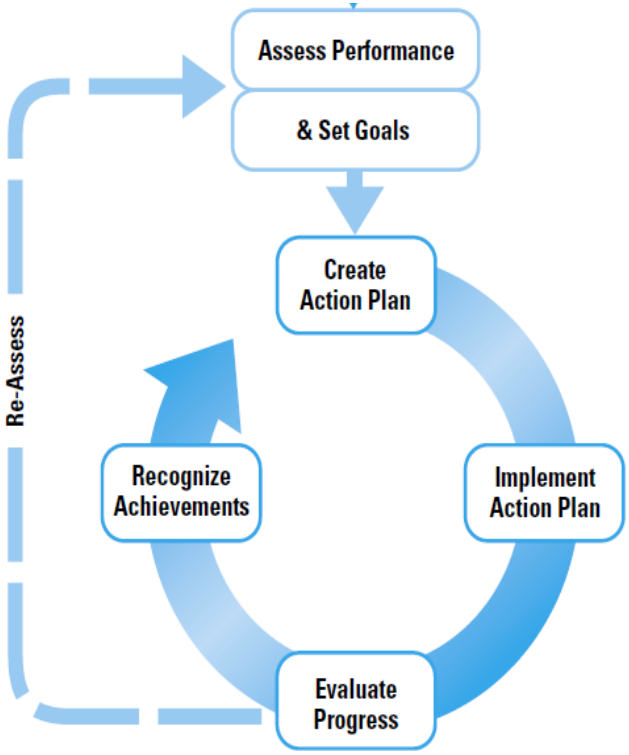


Respond and Adjust

- Understand intent and dynamics
- Apply basic science principles to help understanding
  - Combustion
  - Change of state
    - steam, refrigerant, ice
  - Pressure, velocity and flow
    - Nozzles, fluid mixing, Power Laws
  - 1st law thermo - heat transfer

Respond and Adjust

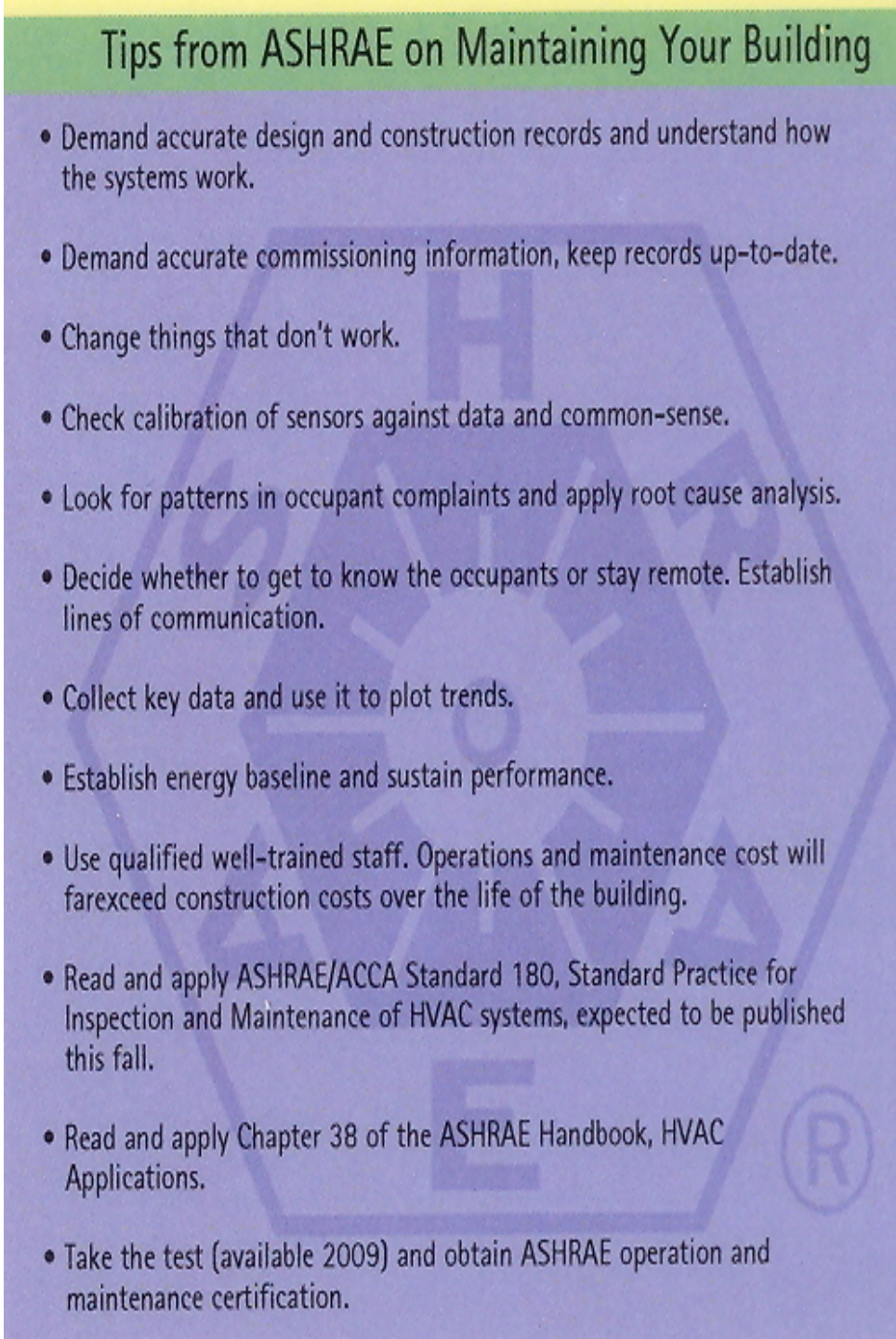
- Testing and Tuning
  - Train to develop rigorous process
    - Baseline data
    - Careful observation & recording
- Six Sigma



Source: EPA "Teaming Up to Save Energy"

Summary & Conclusion

- Engineering basics can be usefully incorporated into education & training for building operators
- New expectations about building performance require it!



- Thank you for your attention.
- Questions?

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