MECH3023: Building Energy Management & Control Systems

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Control Strategies and Applications

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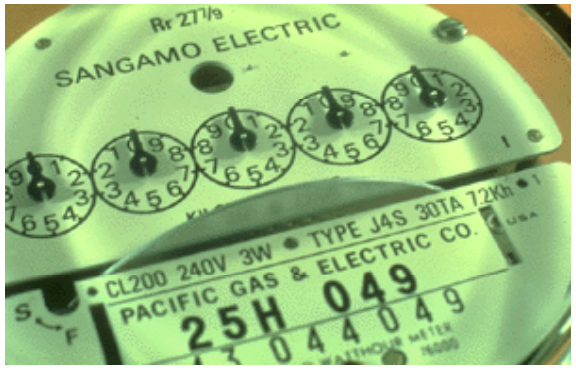
- Energy Management Strategies
- Air Handling System Applications

Energy Mgt. Strategies

- Aims:
  - Improve operating efficiency of equipment
  - Reduce operating costs through
    - Flexible scheduling
    - Limiting operation
    - Altering set points
    - Utilising natural or free cooling



- Reduce electrical consumption & demand
  - Energy (consumption) charge ($ per kWh)
  - Demand charge ($ per peak kW or kVA)

Energy Mgt. Strategies

- Typical energy management strategies: (see also the handouts for more description)
  - 1. Time of day scheduling
  - 2. Optimum start/optimum stop
  - 3. Duty cycling
  - 4. Demand limiting
  - 5. Temperature reset
  - 6. Airside economizer

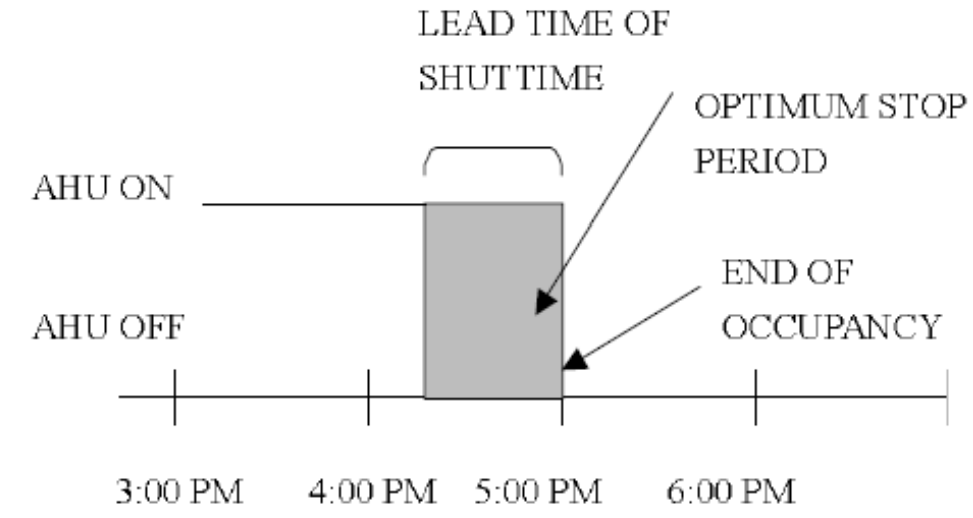
Energy Mgt. Strategies

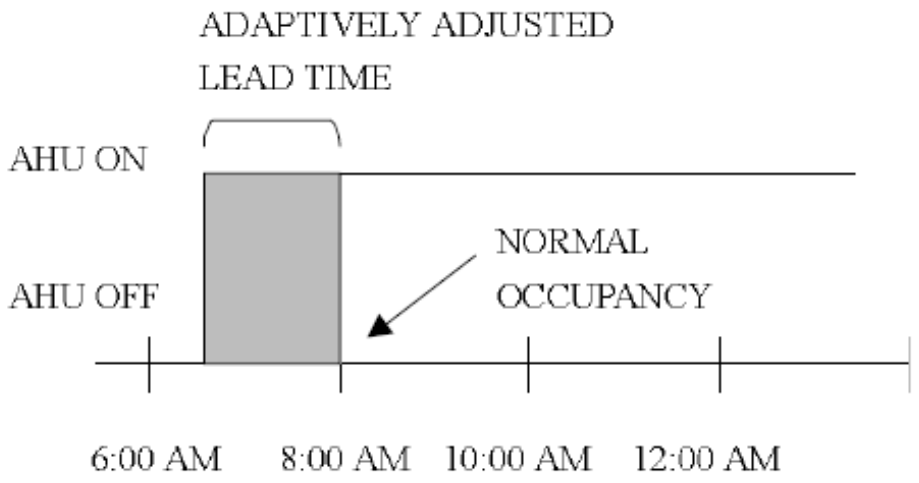
- Time of Day (TOD) scheduling
  - Turn off equipment when it is not needed
  - Reduce operating hours of equipment
  - Methods:
    - Time clocks (Timer)
    - Time of day programming, such as
      - Operating schedule: day, week, month or season
      - Holiday schedule

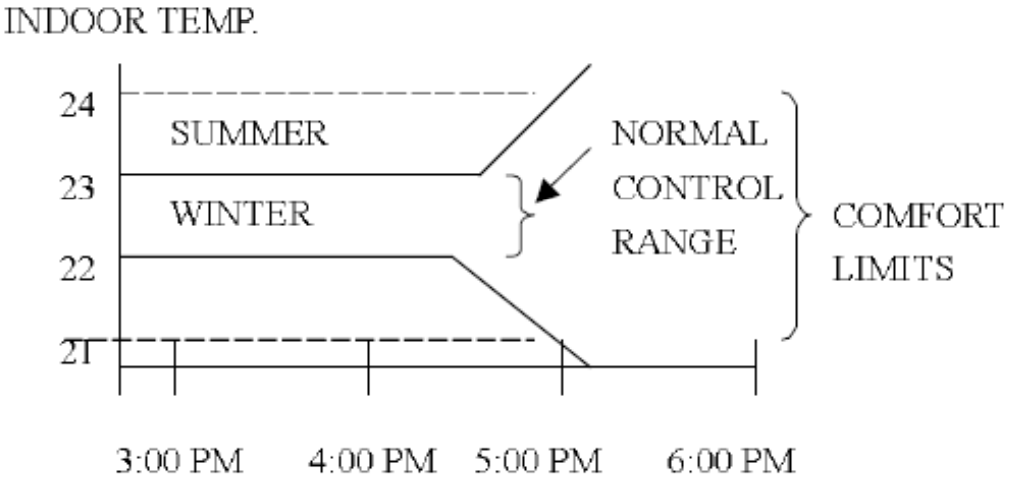
Energy Mgt. Strategies

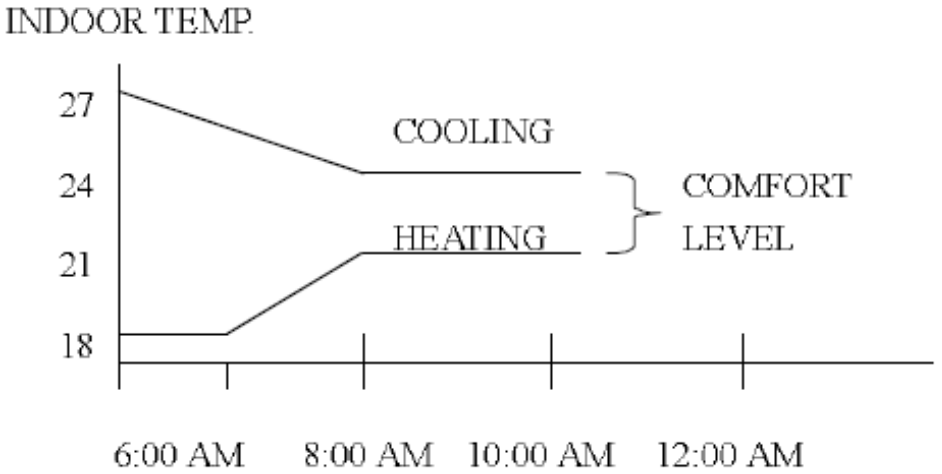
- Optimum start/optimum stop
  - Vary the scheduled start/stop times based upon current environmental conditions
  - Optimum start
    - Start as *late* as possible while ensuring comfort level
    - Variables: zone conditions, outsider air, thermal mass
  - Optimum stop
    - Time constant of a zone's thermal characteristics
      - Zones with large thermal capacities can be shut off earlier
    - Considerations: loss of air movement & background noise may be disruptive

Time + Energy vs Comfort









Optimum Stop

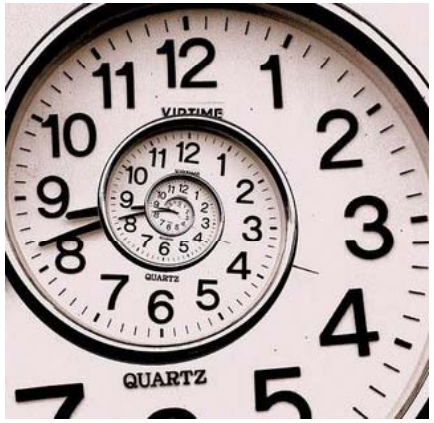
Optimum Start

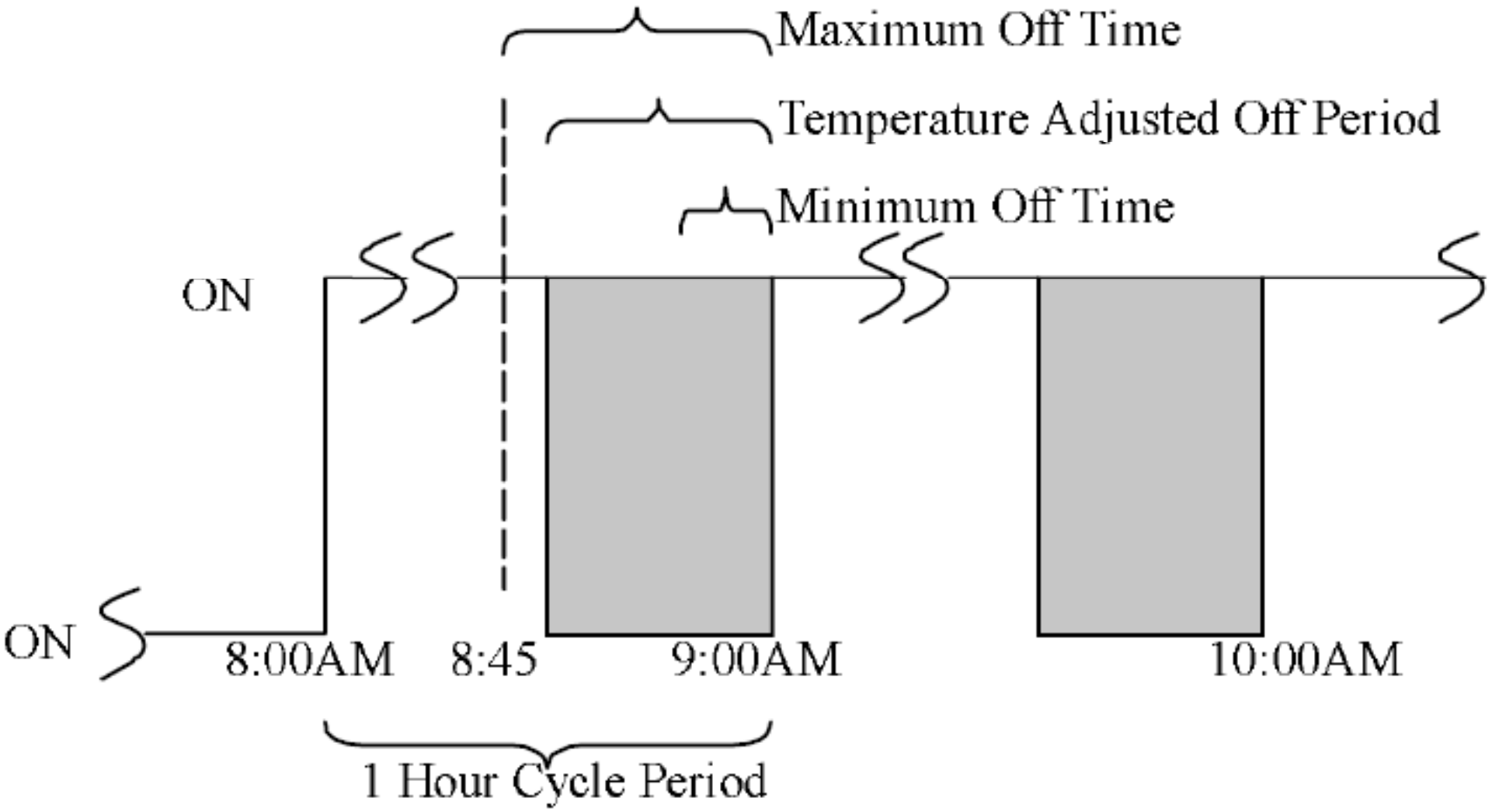
Optimum start/optimum stop

(Source: *EMSD, 2002. Guidelines on Application of Central Control and Monitoring Systems*)

Energy Mgt. Strategies

- Duty cycling
  - Cycles equipment ON/OFF based on elapsed time
  - To improve overall operating efficiency
  - Two methods:
    - Based on time
    - A function of zone's temperature
  - Drawbacks
    - Belt & bearing wear when aggressively scheduled
    - May generate noise in ductwork/pipework



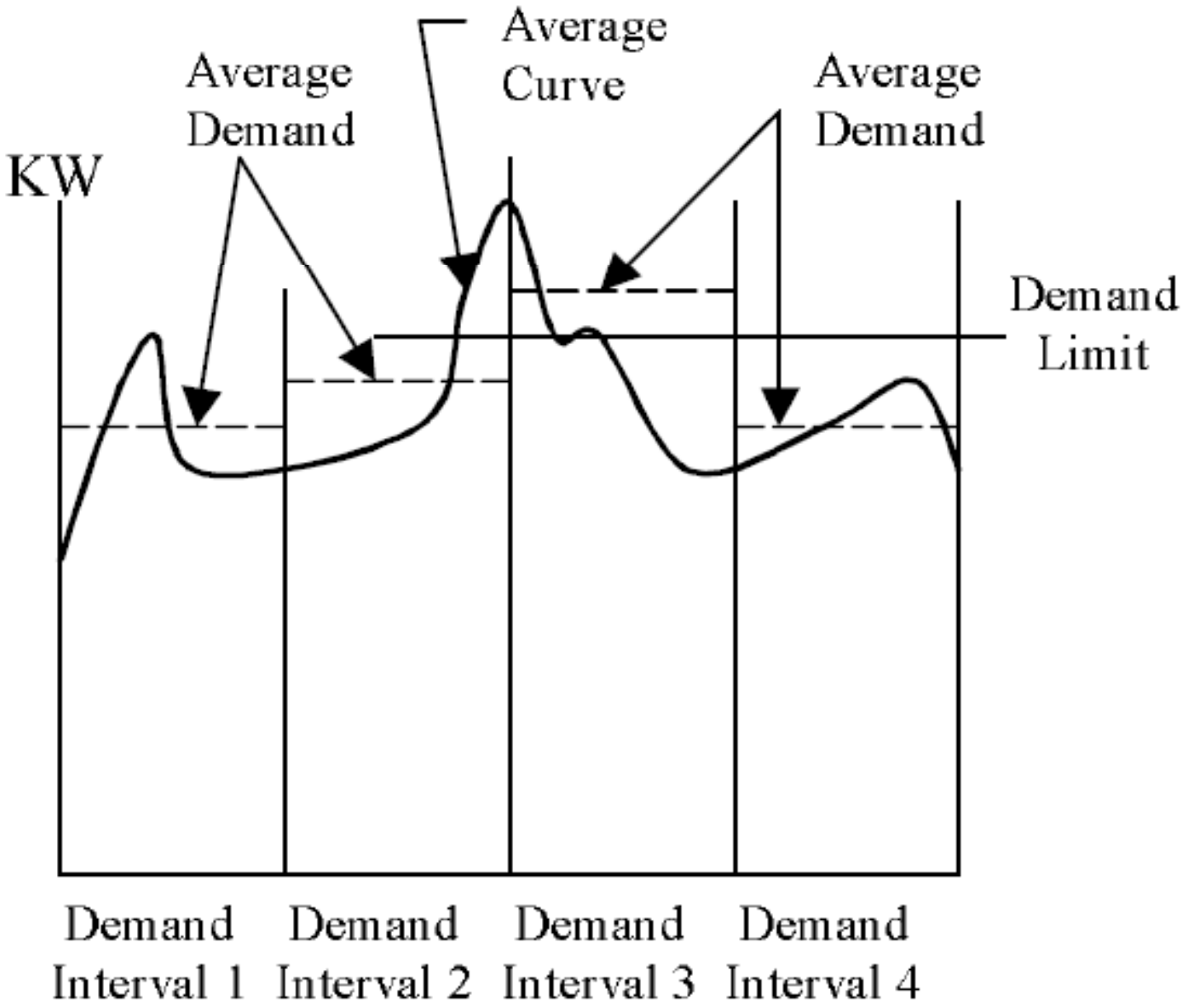


Duty Cycle Application

(Source: *EMSD, 2002. Guidelines on Application of Central Control and Monitoring Systems*)

Energy Mgt. Strategies

- Demand limiting
  - Cycle off or ‘shedding’ equipment to limit the peak electrical demand (e.g. for ‘ratchet’ demand charges apply)
  - Loads are restored when the demand decreases
  - Parameters:
    - Load’s priority, min. operat. time, min. & max. off time
  - Drawbacks
    - Periodic reductions in production or comfort

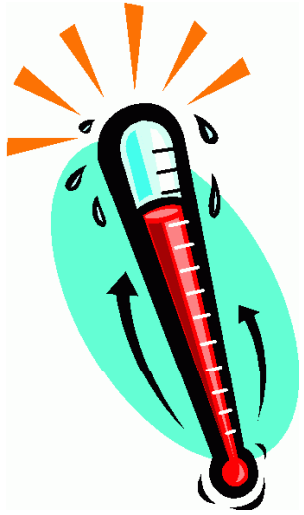


Typical Power Curve Over Four Successive Demand Intervals

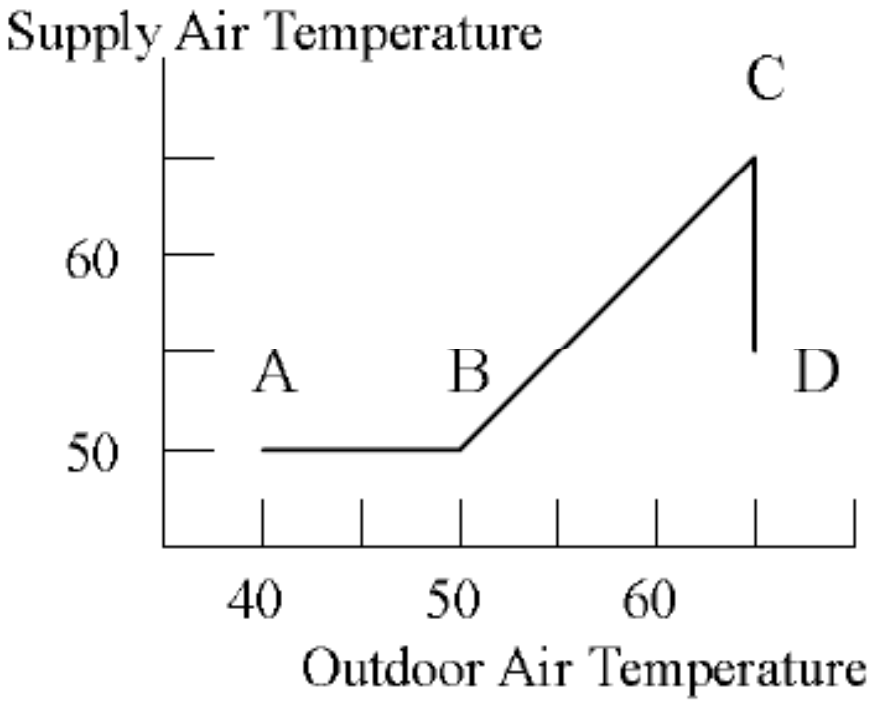
(Source: *EMSD, 2002. Guidelines on Application of Central Control and Monitoring Systems*)

Energy Mgt. Strategies

- Temperature reset
  - To reduce HVAC load & electrical consumption
  - Example:
    - Reset of discharge/supply air temperature
    - Reset of chilled water set points
  - Temp. in unoccupied zone is allowed to drift



- Other DDC software functions
  - Point trending: to analyse processes
  - Point commanding: override system status/values



Note:

(1) A to B: Mix Outdoor and Return Air.

(2) B to C: 100% Outdoor Air

(3) C to D: Economizer Cooling or Enthalpy Control

Supply Air Temperature Reset (Single Duct VAV)

(Source: *EMSD, 2002. Guidelines on Application of Central Control and Monitoring Systems*)

Energy Mgt. Strategies

- Airside economizers
  - Use outdoor air to help satisfy building cooling load (i.e. natural cooling or free cooling)
  - Control of economizer cycle: by monitoring the enthalpy or temperature of outside air
    - When outside air enthalpy/temp. drops below the limit, the position of the outside/return air dampers is modulated to introduce more outdoor air
  - Design issues: selection & placement of enthalpy sensors, humidity control, air duct size & air intake location

Air Handling Systems

- Reference document: (see handouts)
  - Honeywell, 1997. *Engineering Manual of Automatic Control for Commercial Buildings - Heating, Ventilating, Air Conditioning*, SI Edition., Honeywell, Inc., Minneapolis, MN, pp. 201-260.
    - Air Handling System Control Applications
      - Abbreviations and symbols
      - Requirements for Effective Control (general guidelines)
      - Different HVAC processes
      - ASHRAE Psychrometric Charts

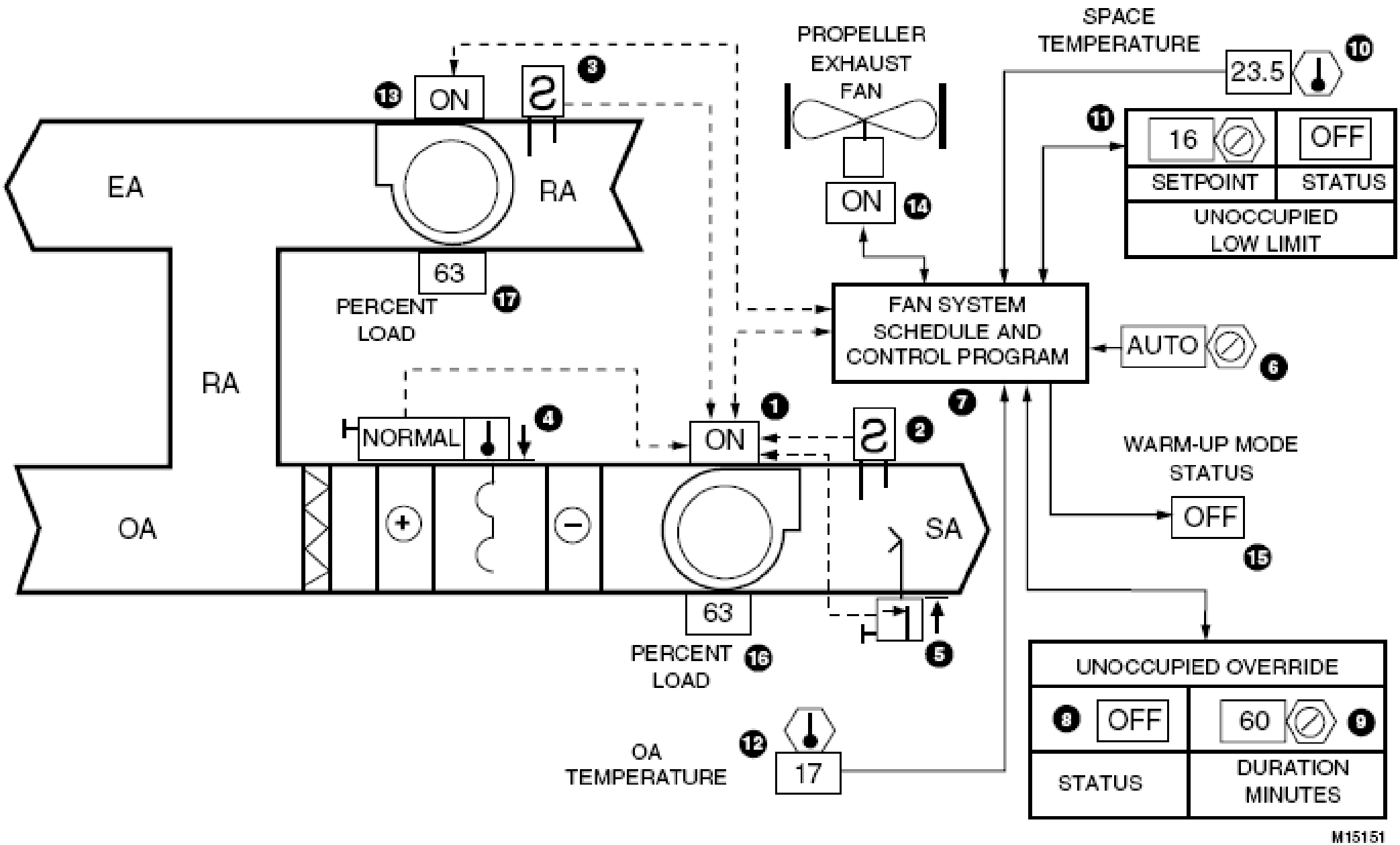
Air Handling Systems

- Control processes selected for our study:
  - Ventilation Control Processes
    - Fan System Start-Stop Control
    - Fixed Quantity of Outdoor Air Control
    - Mixed Air Control
    - Economizer Cycle Control (outdoor air dry bulb or enthalpy)
    - Mixed Air Control with Economizer Cycle
    - Economizer Cycle Control of Space Temperature with Supply Air Temperature Setpoint Reset
  - Year-round System Control Process
    - Heating, Cooling, and Economizer

Air Handling Systems

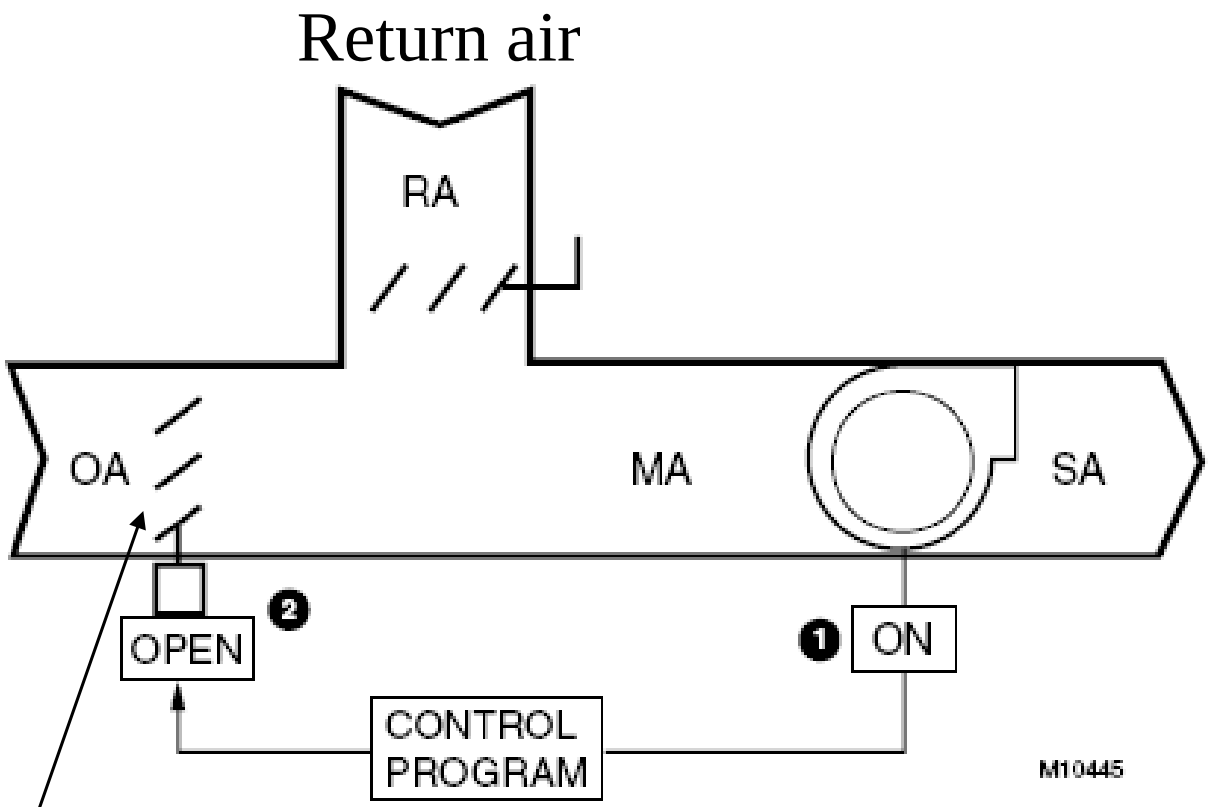
- Typical format (see the document)
  - Functional description (w/ diagram)
  - Features
  - Conditions for successful operation
  - Limitations
  - Specifications
  - Psychrometric aspects

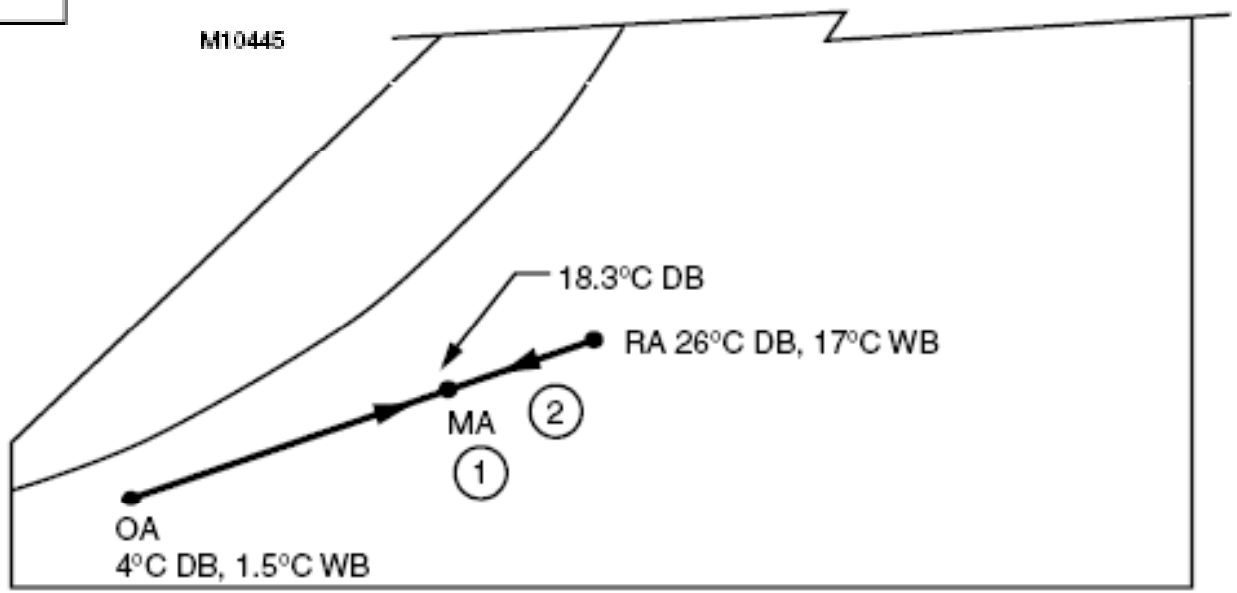
Fan system start-stop control



[Source: Honeywell, 1997. *Engineering Manual of Automatic Control: for Commercial Buildings*]

Fixed quantity of outdoor air control





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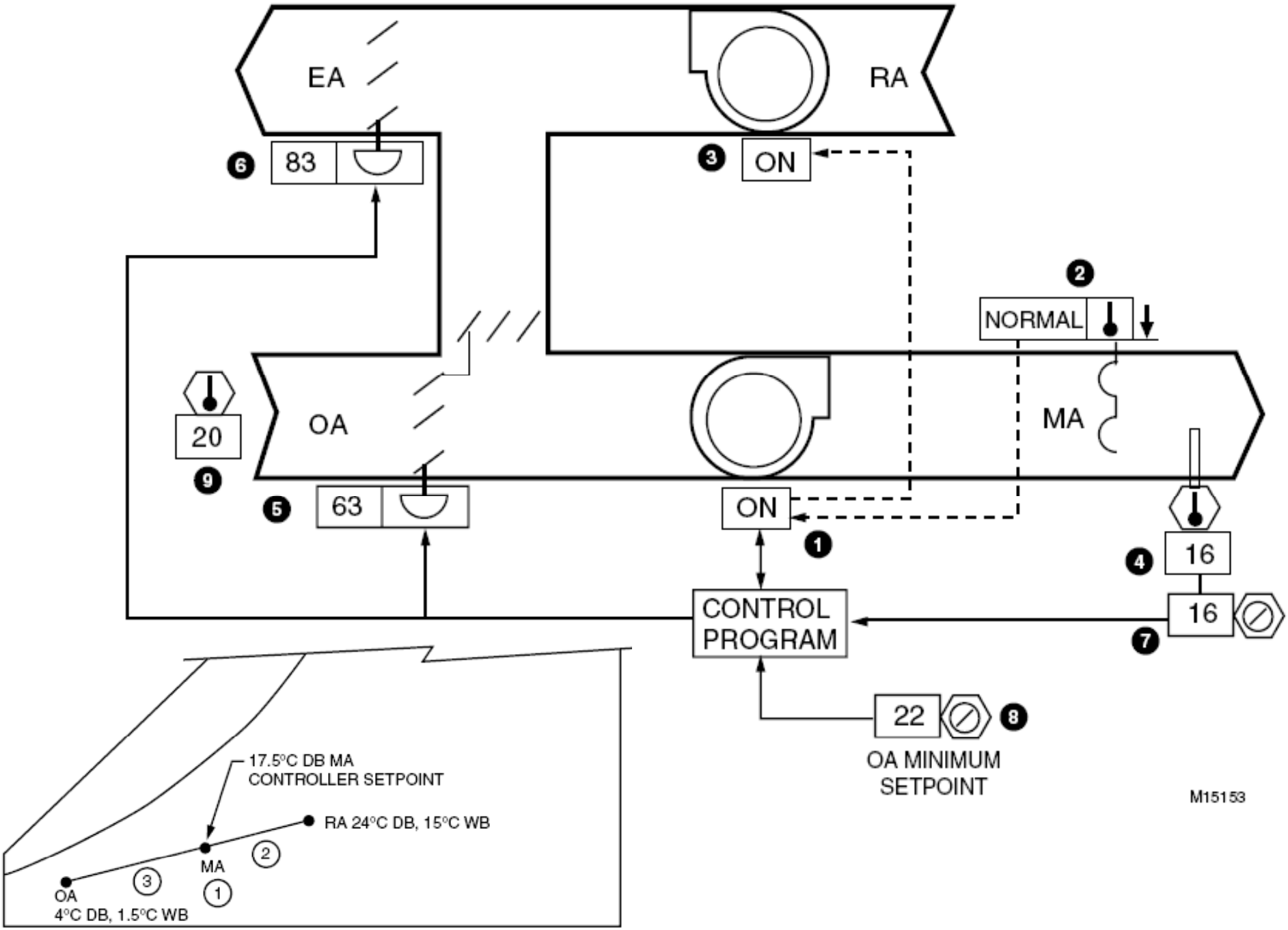
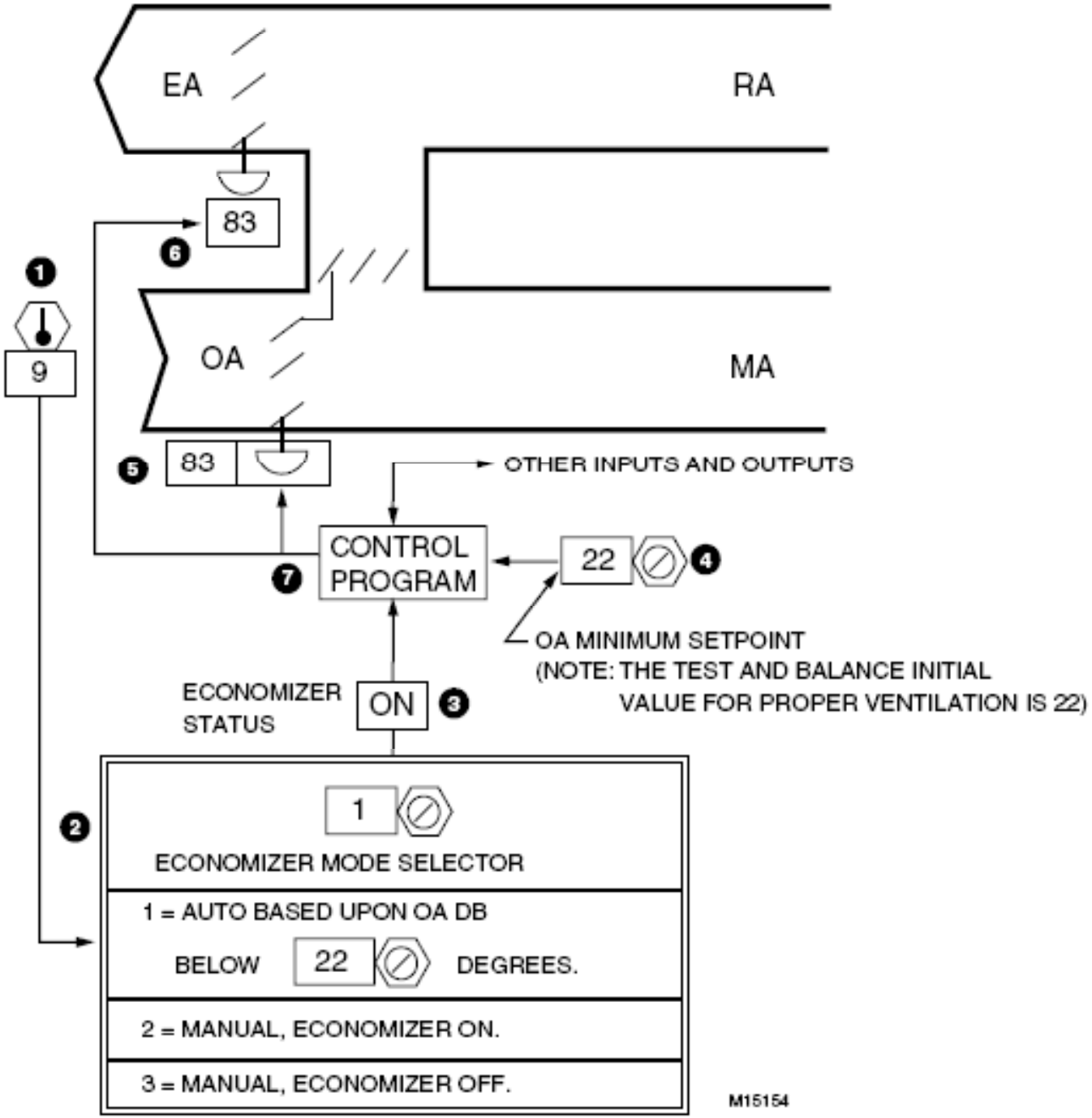
Mixed air control



[Source: Honeywell, 1997. *Engineering Manual of Automatic Control: for Commercial Buildings*]

Economizer cycle control (outdoor air dry bulb)



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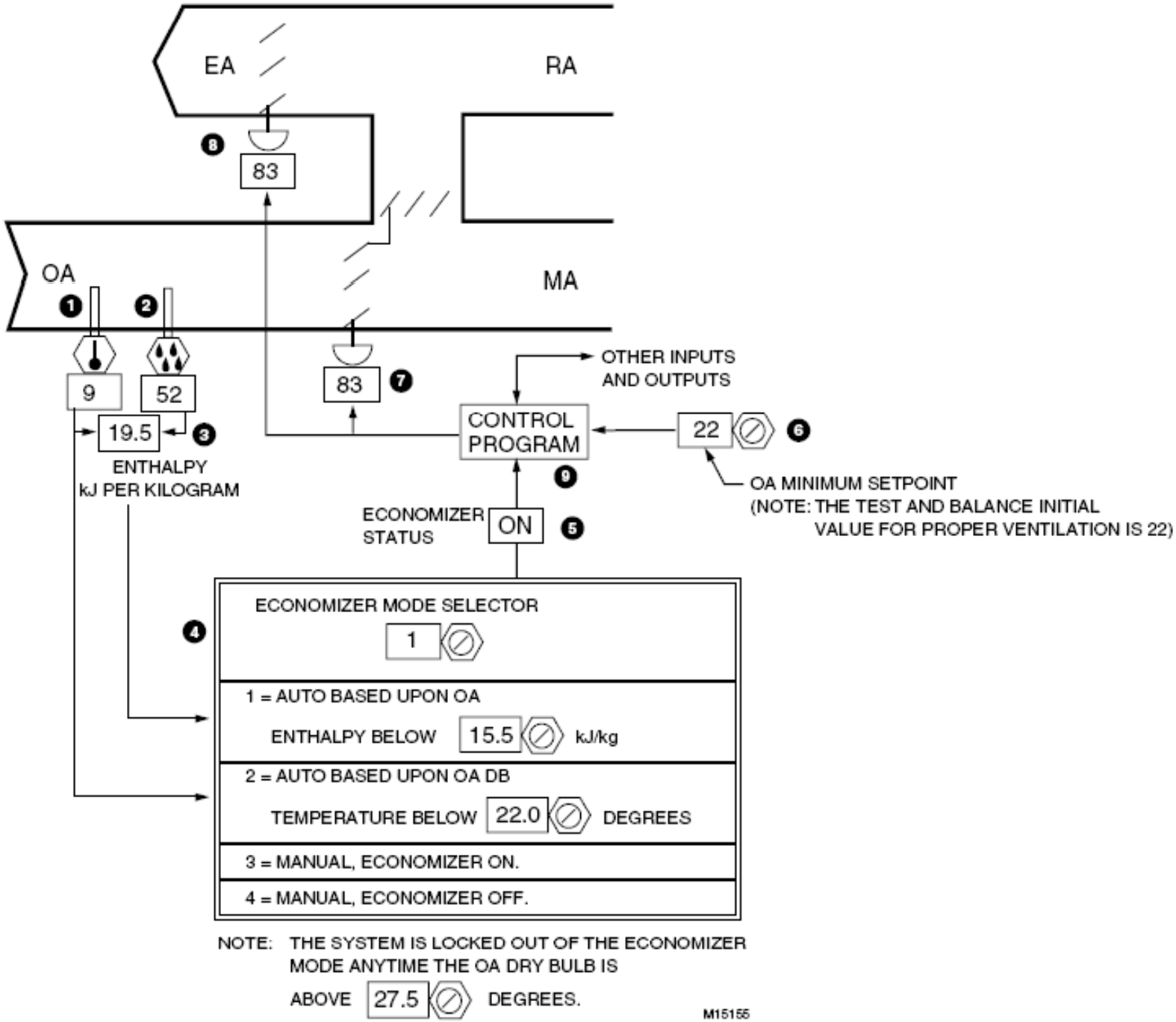
Economizer cycle control (outdoor air enthalpy)



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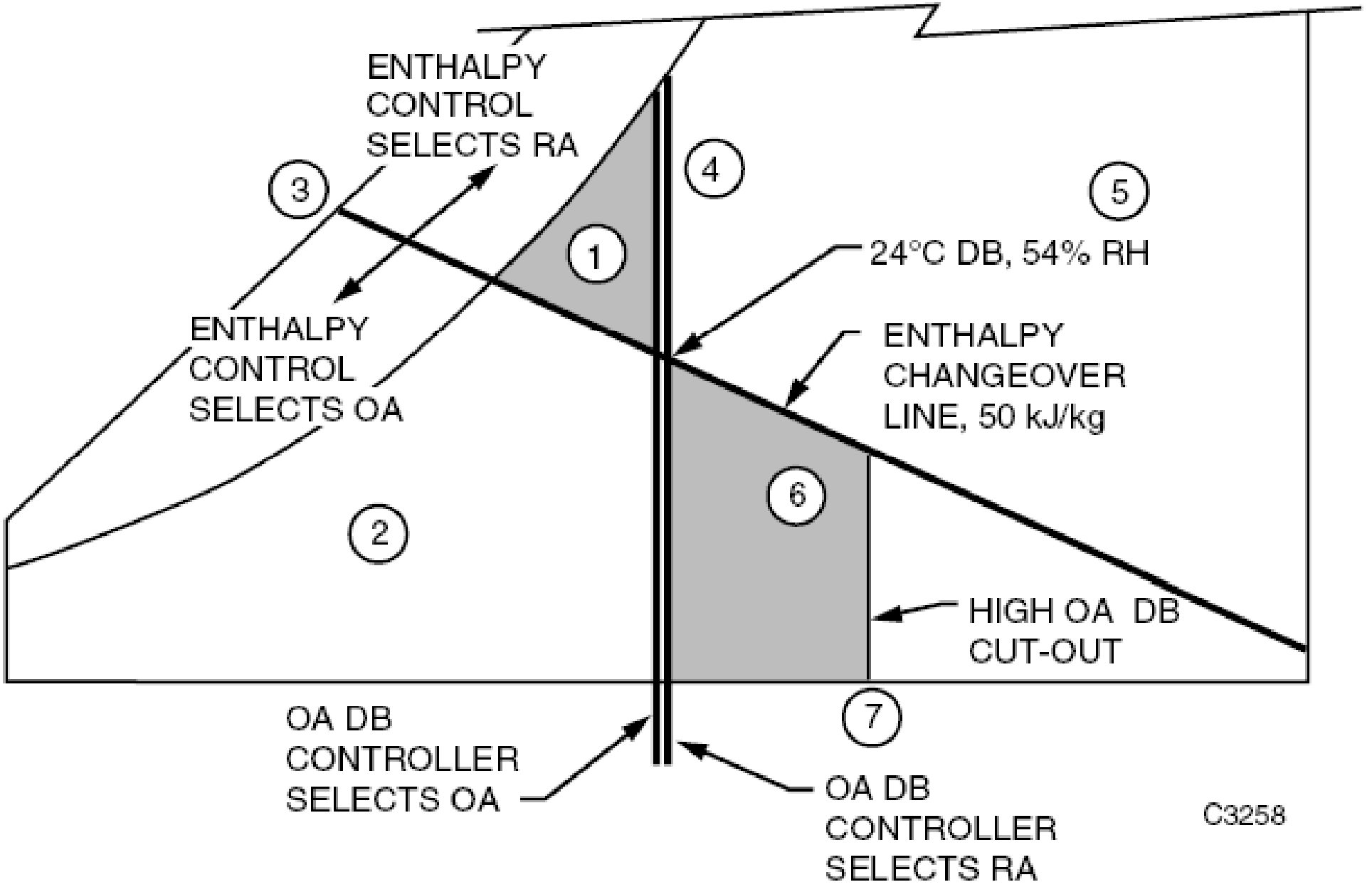
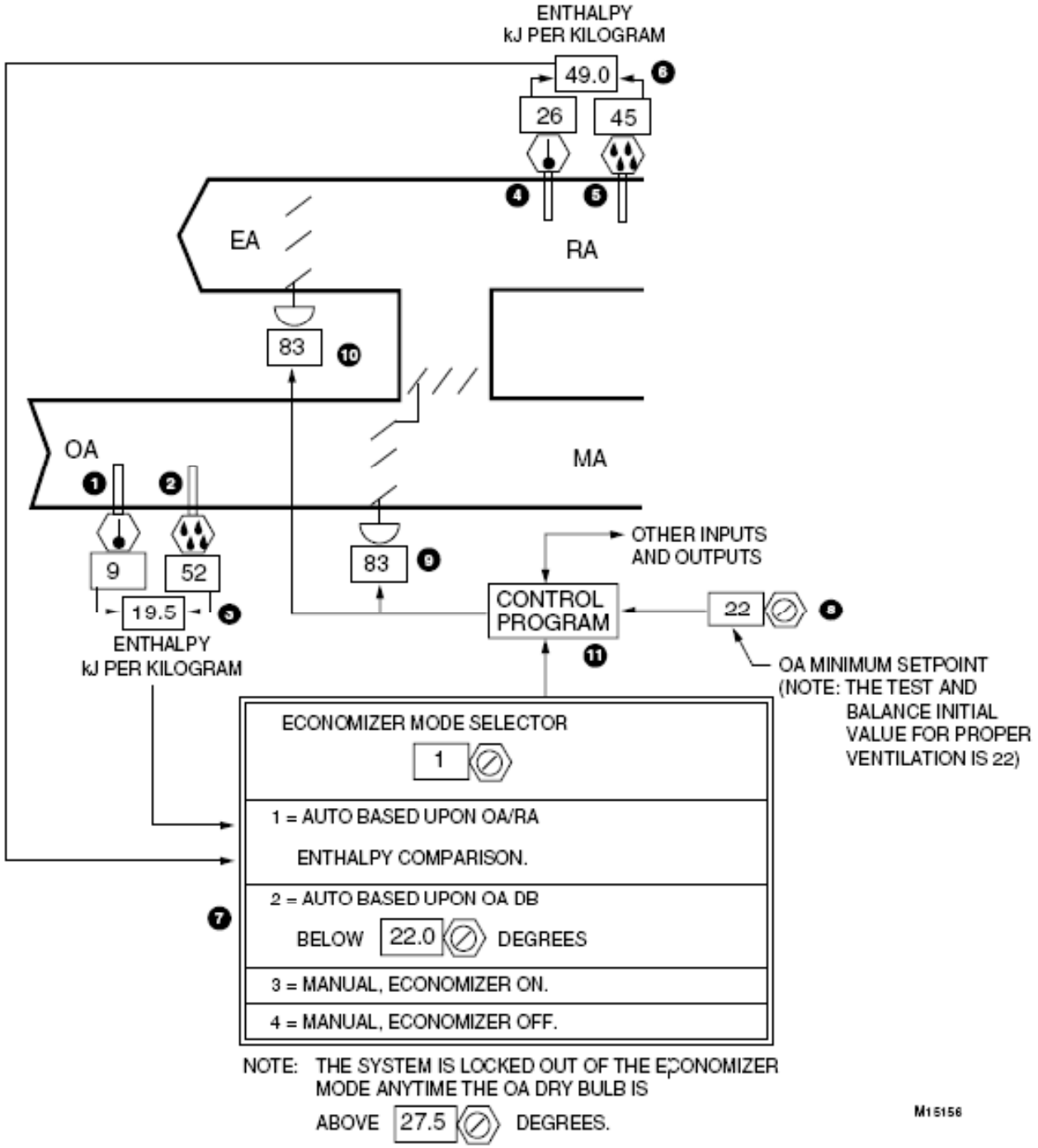
Economizer cycle control (outdoor air enthalpy)



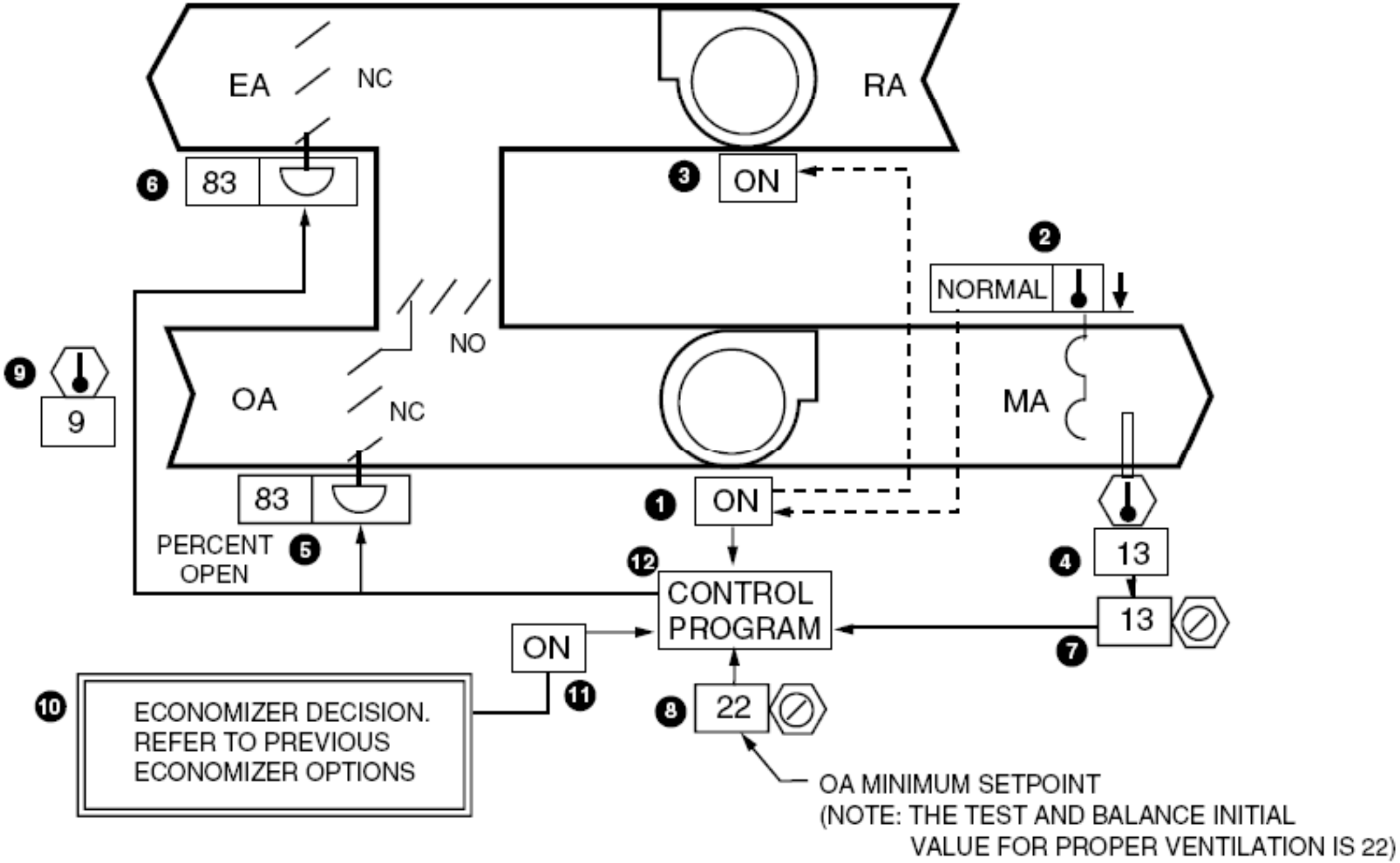
[Source: Honeywell, 1997. *Engineering Manual of Automatic Control: for Commercial Buildings*]

Economizer cycle control (outdoor air/return air enthalpy comparison)



[Source: Honeywell, 1997. *Engineering Manual of Automatic Control: for Commercial Buildings*]

Mixed air control with economizer cycle



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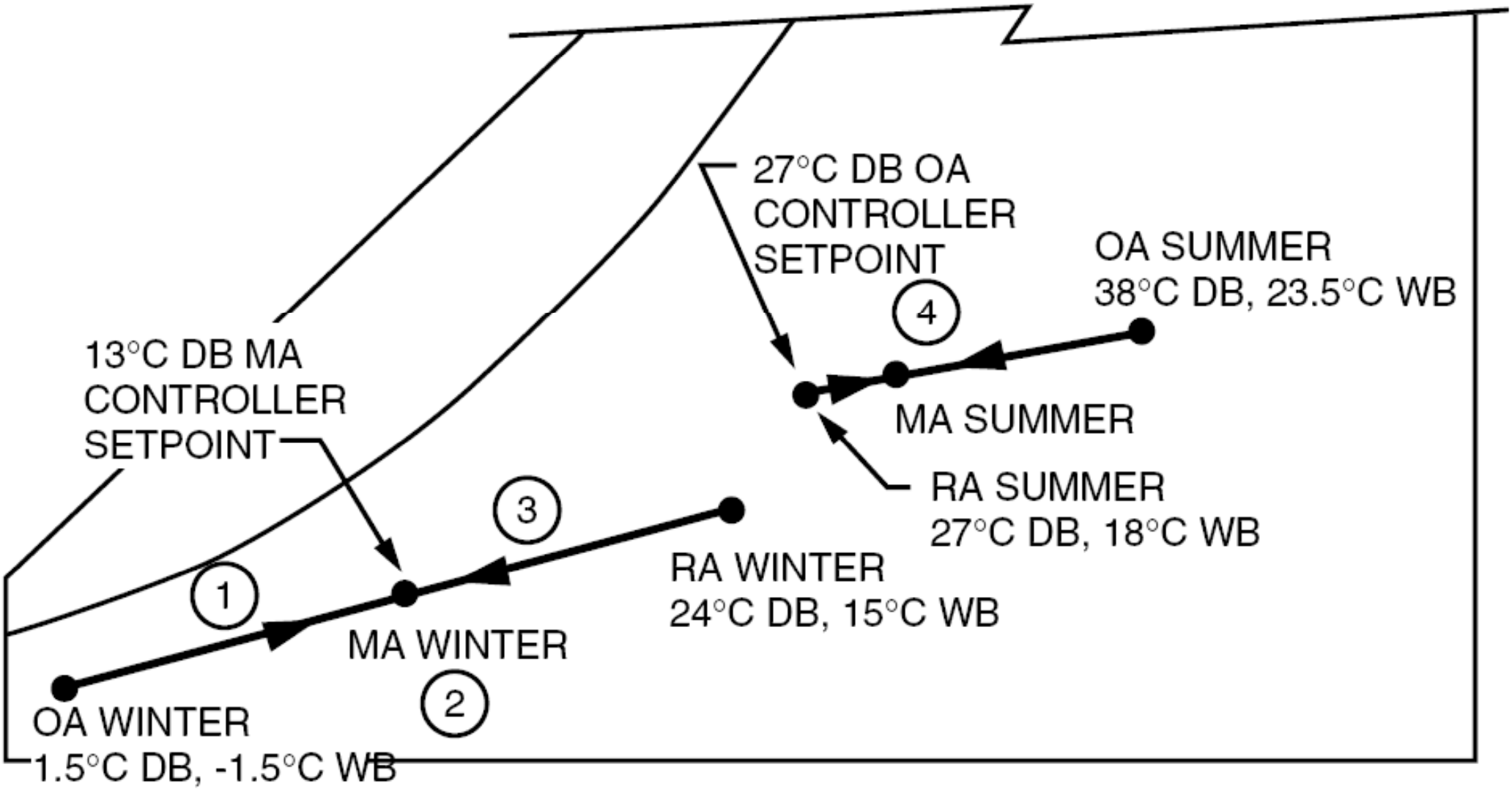
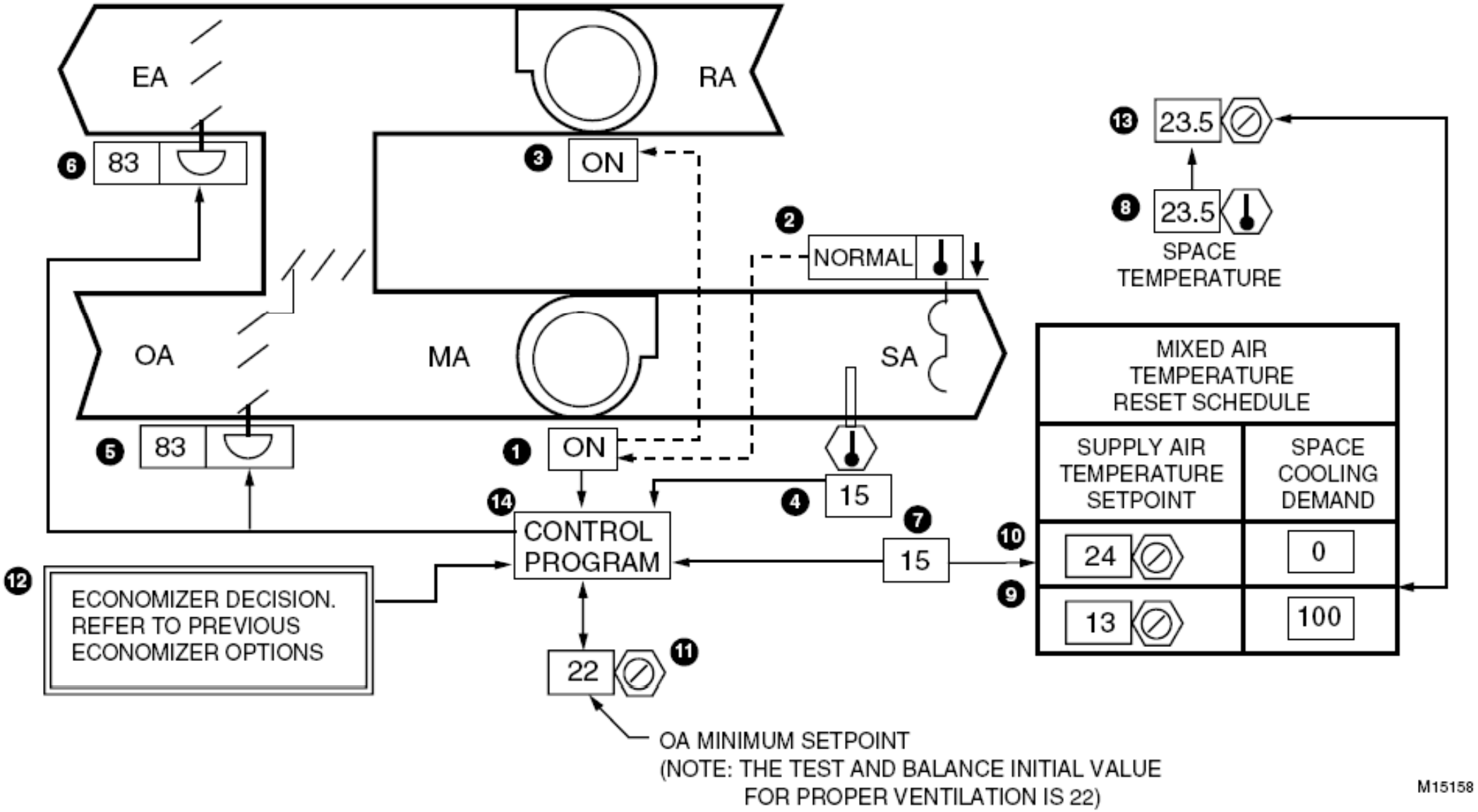
Mixed air control with economizer cycle



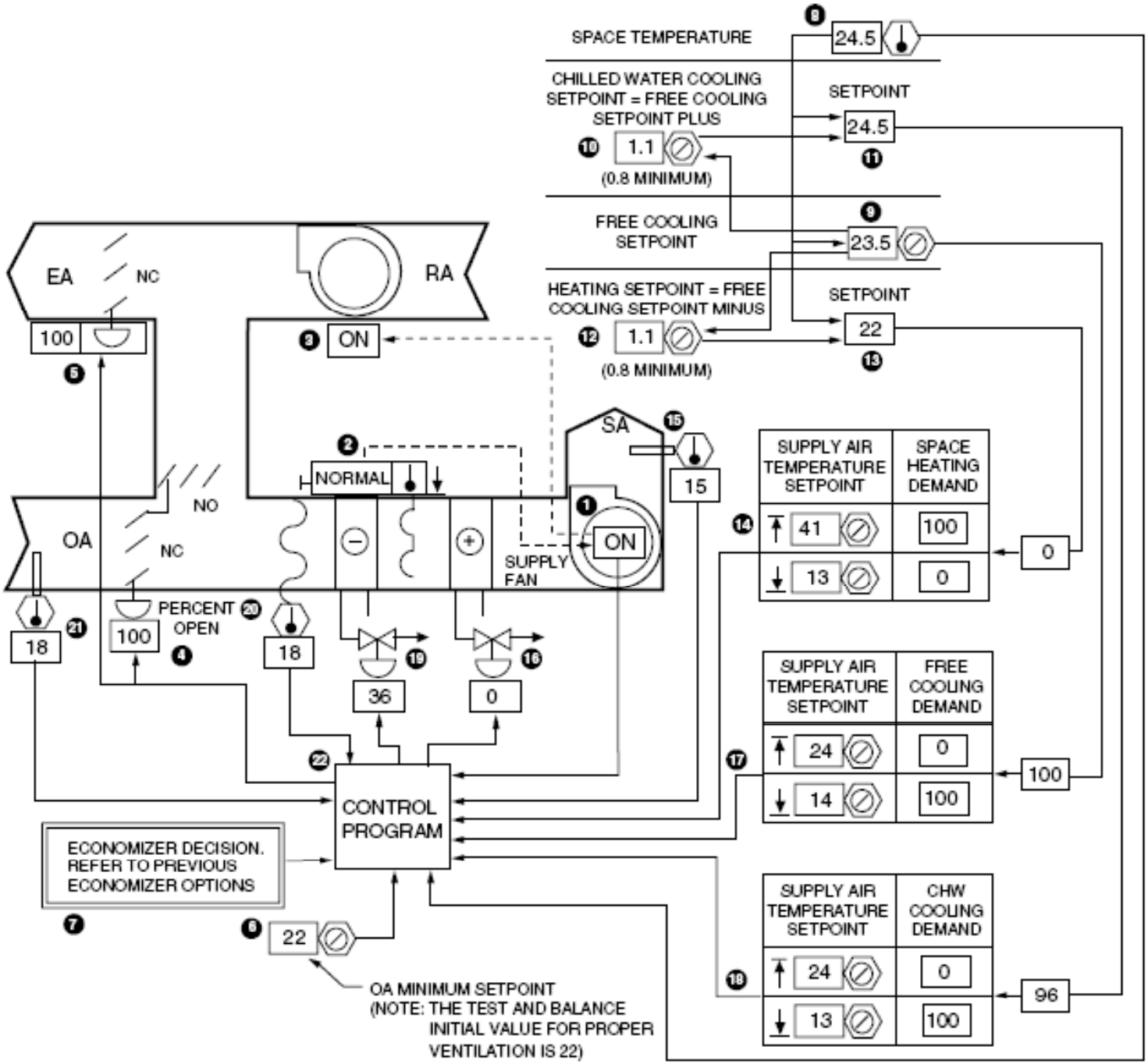
[Source: Honeywell, 1997. *Engineering Manual of Automatic Control: for Commercial Buildings*]

Economizer cycle control of space temperature with supply air temperature setpoint reset



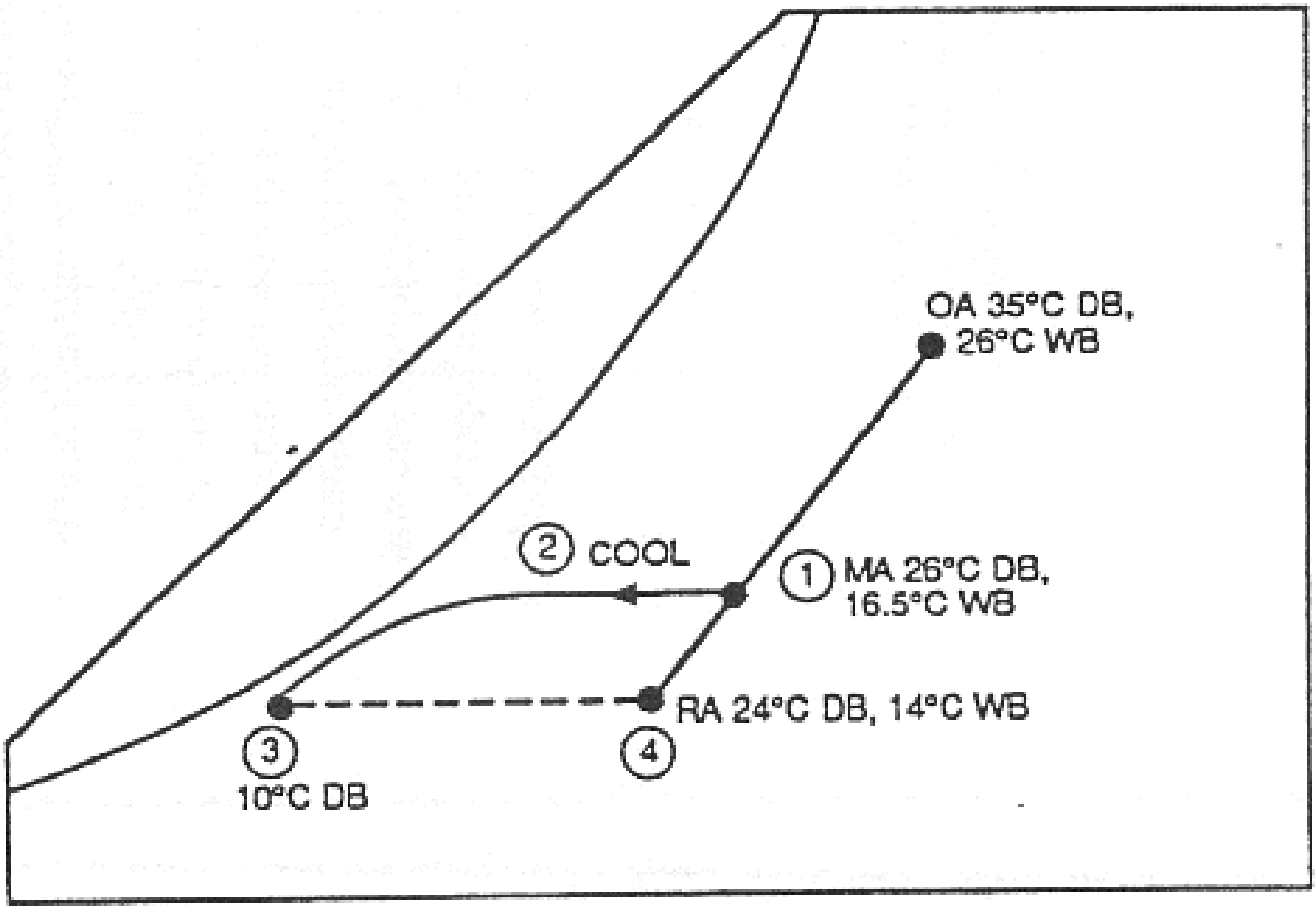
[Source: Honeywell, 1997. *Engineering Manual of Automatic Control: for Commercial Buildings*]

Year-round system control – heating, cooling, and economizer



[Source: Honeywell, 1997. *Engineering Manual of Automatic Control: for Commercial Buildings*]

VAV System with Cooling and Duct Reheat – Psychrometric Aspects



Analysis of the climate conditions on a psychrometric chart

Hong Kong's Climatic Conditions

Frequency of Occurrence Plotted
on ASHRAE Psychrometric Chart
(based on hourly data 1968-2003)

(The numbers shown are in percentage)