Control Strategies and Applications

(MECH3023)

Contents

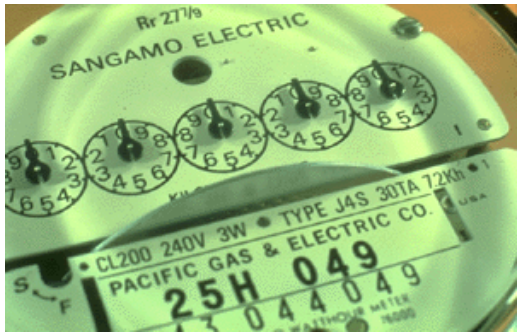
- Energy Management Strategies
- Air Handling System Applications

Control Strategies and Applications

- Energy Management Strategies

Energy Mgt. Strategies

- Aims:
  - Improve operating efficiency of equipment
  - Reduce operating costs through
    - Flexible scheduling
    - Limiting operation
    - Altering set points
    - Utilizing 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:
  - 1. Time of day scheduling
  - 2. Optimum start/optimum stop
  - 3. Duty cycling
  - 4. Demand limiting
  - 5. Temperature reset
  - 6. Airside economizer

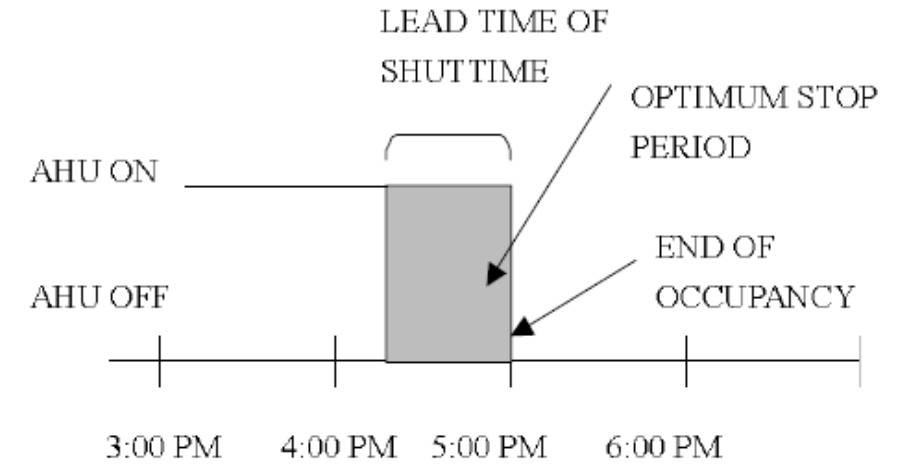
Energy Mgt. Strategies

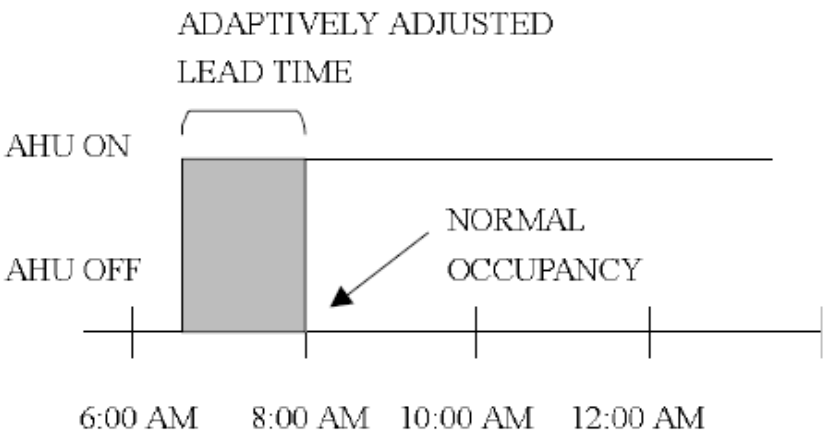
- Time of Day (TOD) scheduling
  - Turn off equipment when it is not needed
  - Reduce operating hours of equipment
  - Methods:
    - Time clocks (Timer)
    - Time of day programming, such as
      - Operating schedule: day, week, month or season
      - Holiday schedule

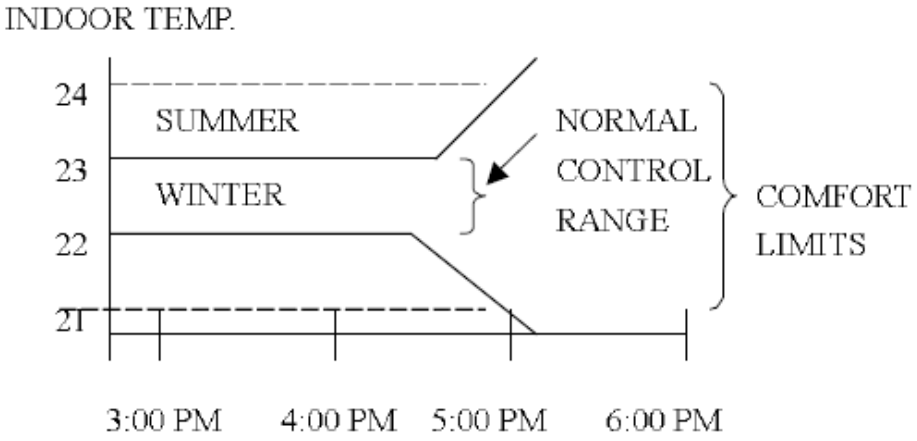
Energy Mgt. Strategies

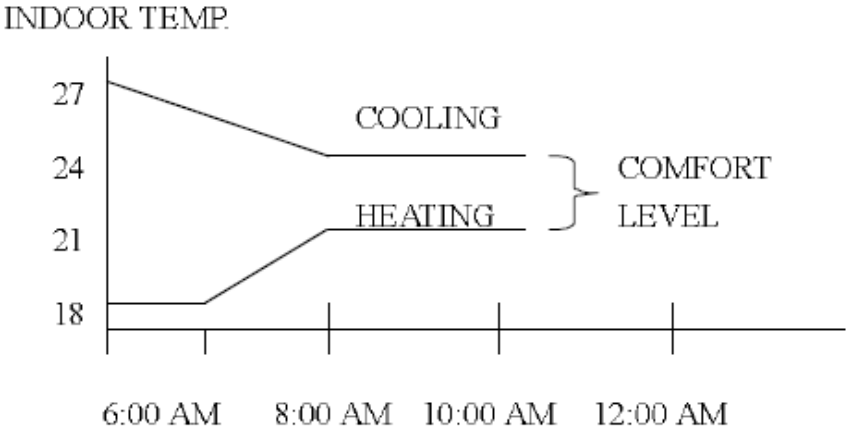
- Optimum start/optimum stop
  - Vary the scheduled start/stop times based upon current environmental conditions
  - Optimum start
    - Start *as late as possible* while ensuring comfort level
    - Variables: zone conditions, outdoor air, thermal mass
  - Optimum stop
    - Based on thermal time constant of a zone to *reduce/shut off system earlier* before unoccupied
      - Zones with large thermal capacities can be shut off earlier
    - Particularly useful when shutting down chiller plant and rely on old chilled water in the chiller to provide the remaining cooling
    - Considerations: loss of air movement & background noise may be disruptive

Time + Energy vs Comfort









Optimum Stop

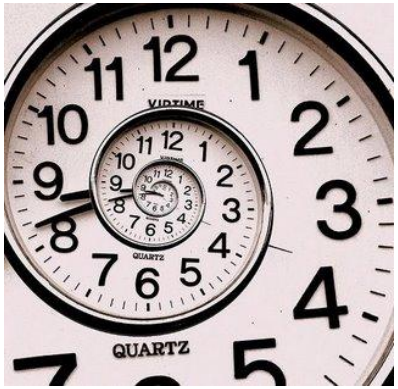
Optimum Start

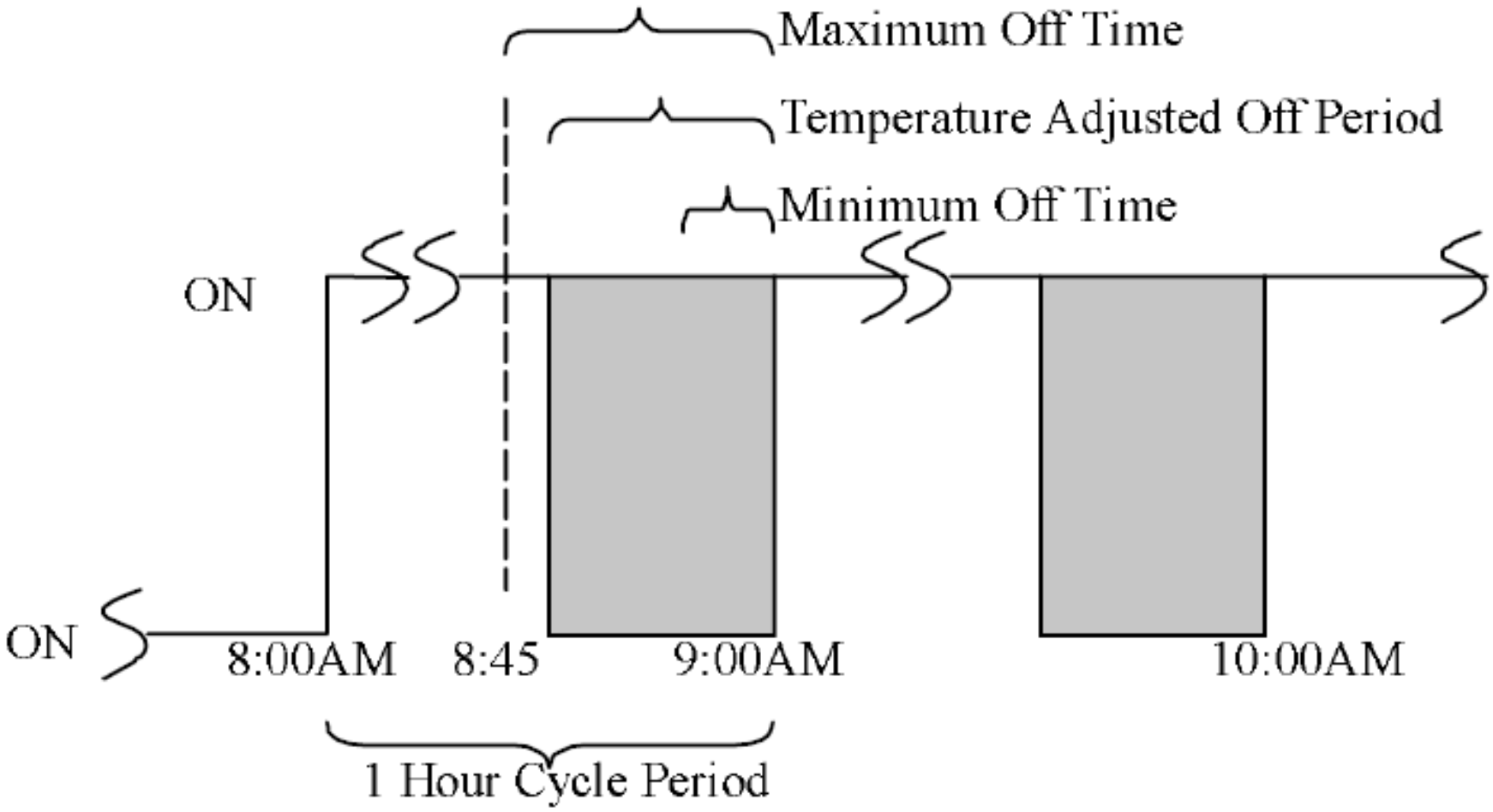
Optimum start / Optimum stop

(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



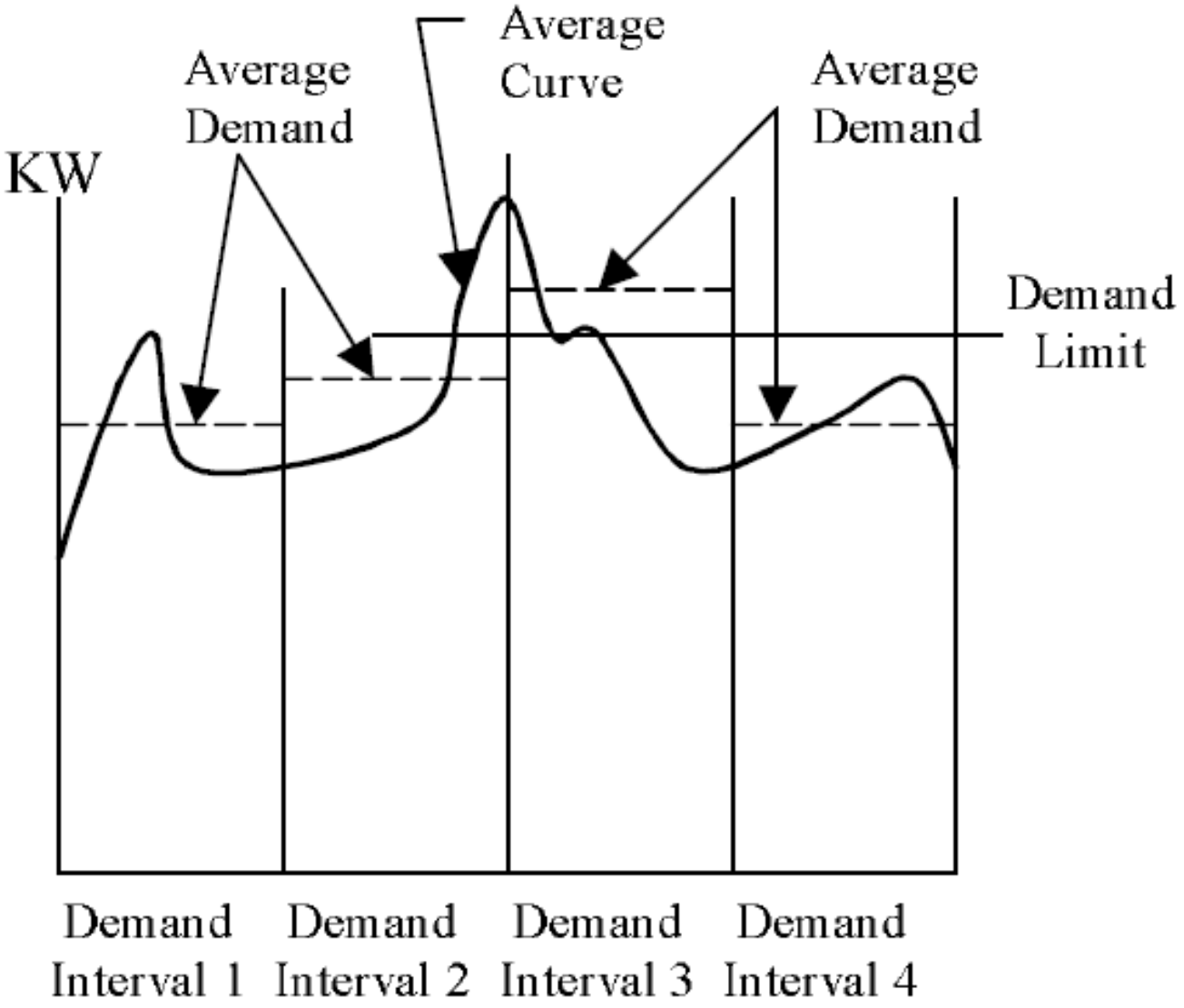


Duty Cycle Application

(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, minimum operation time, min. & max. off time
  - Drawbacks
    - Periodic reductions in production or comfort

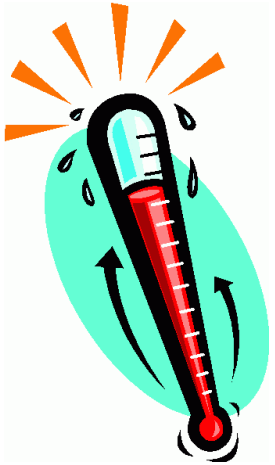


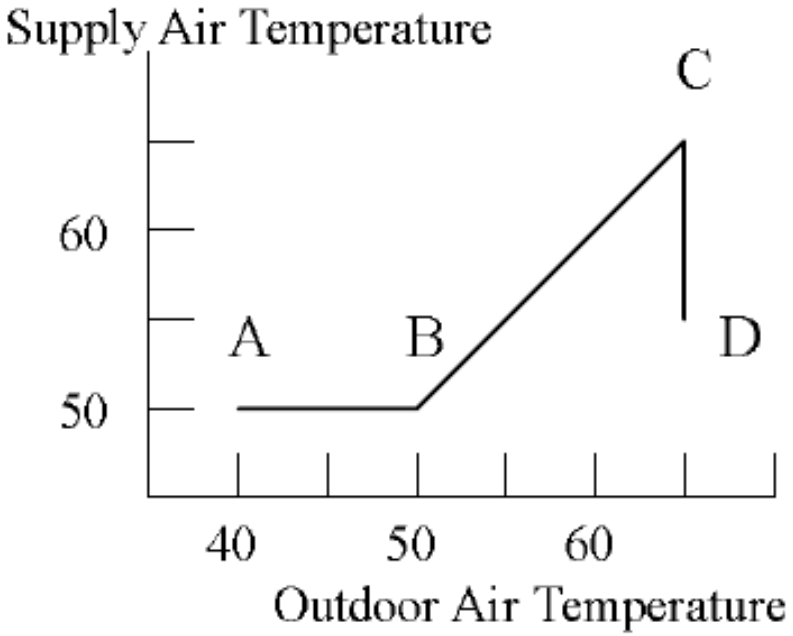
Typical Power Curve Over Four Successive Demand Intervals

(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





Supply Air Temperature Reset (Single Duct VAV)

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

(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

Control Strategies and Applications

- Air Handling Systems

Air Handling Systems

- Reference:
  - 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

(Students should print out the reference for discussion in class)
http://customer.honeywell.com/techlit/pdf/77-0000s/77-1200.pdf

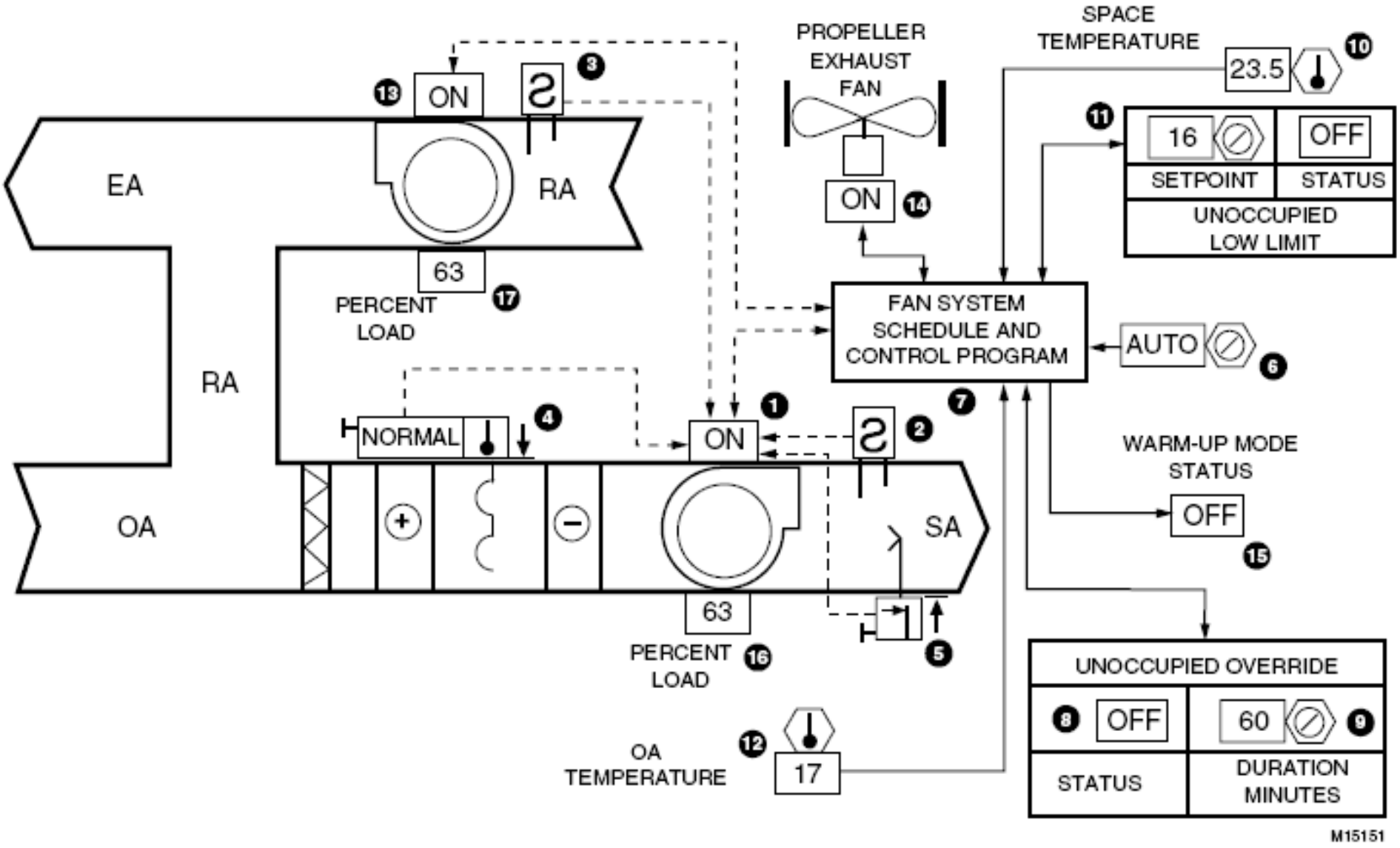
Air Handling Systems

- 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

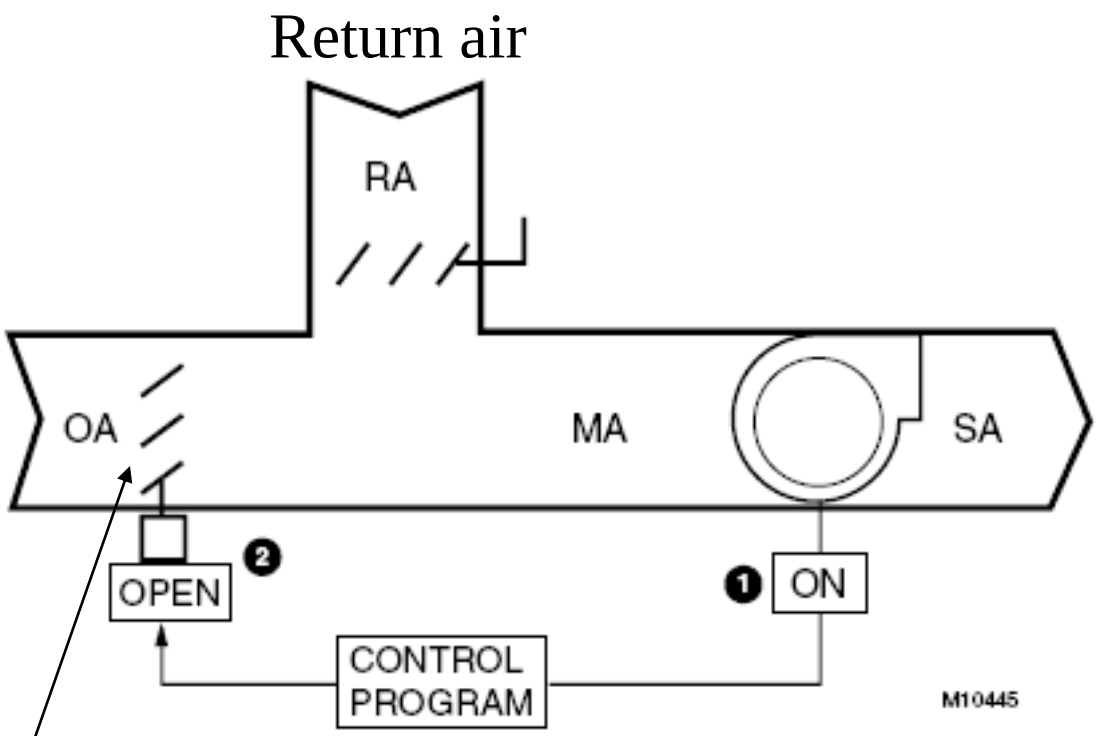
- Typical format (see the document)
  - Functional description (w/ diagram)
  - Features
  - Conditions for successful operation
  - Limitations
  - Specifications
  - Psychrometric aspects

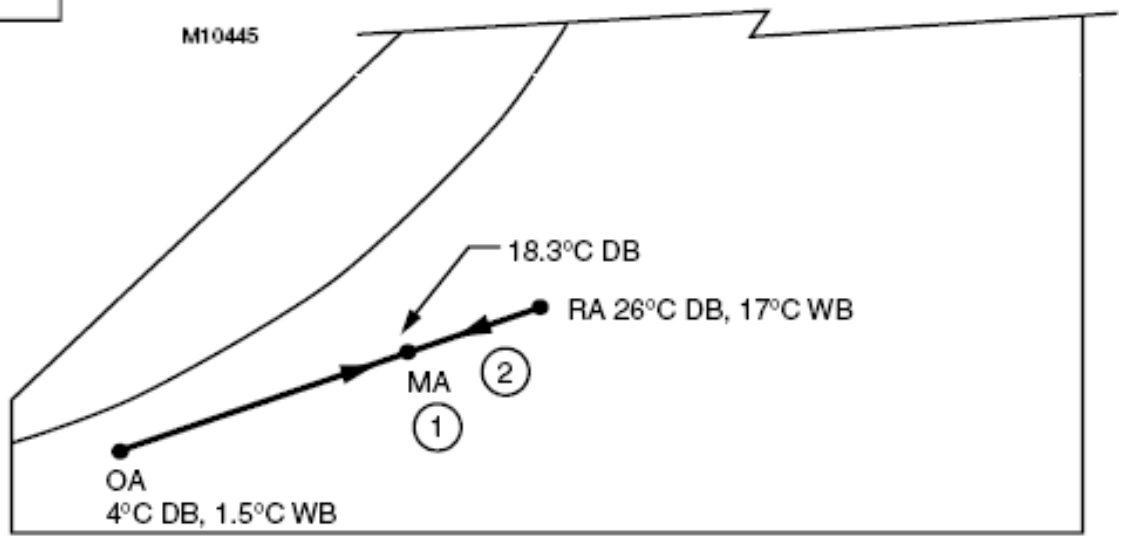
Fan System Start-Stop Control (page 209-210)



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

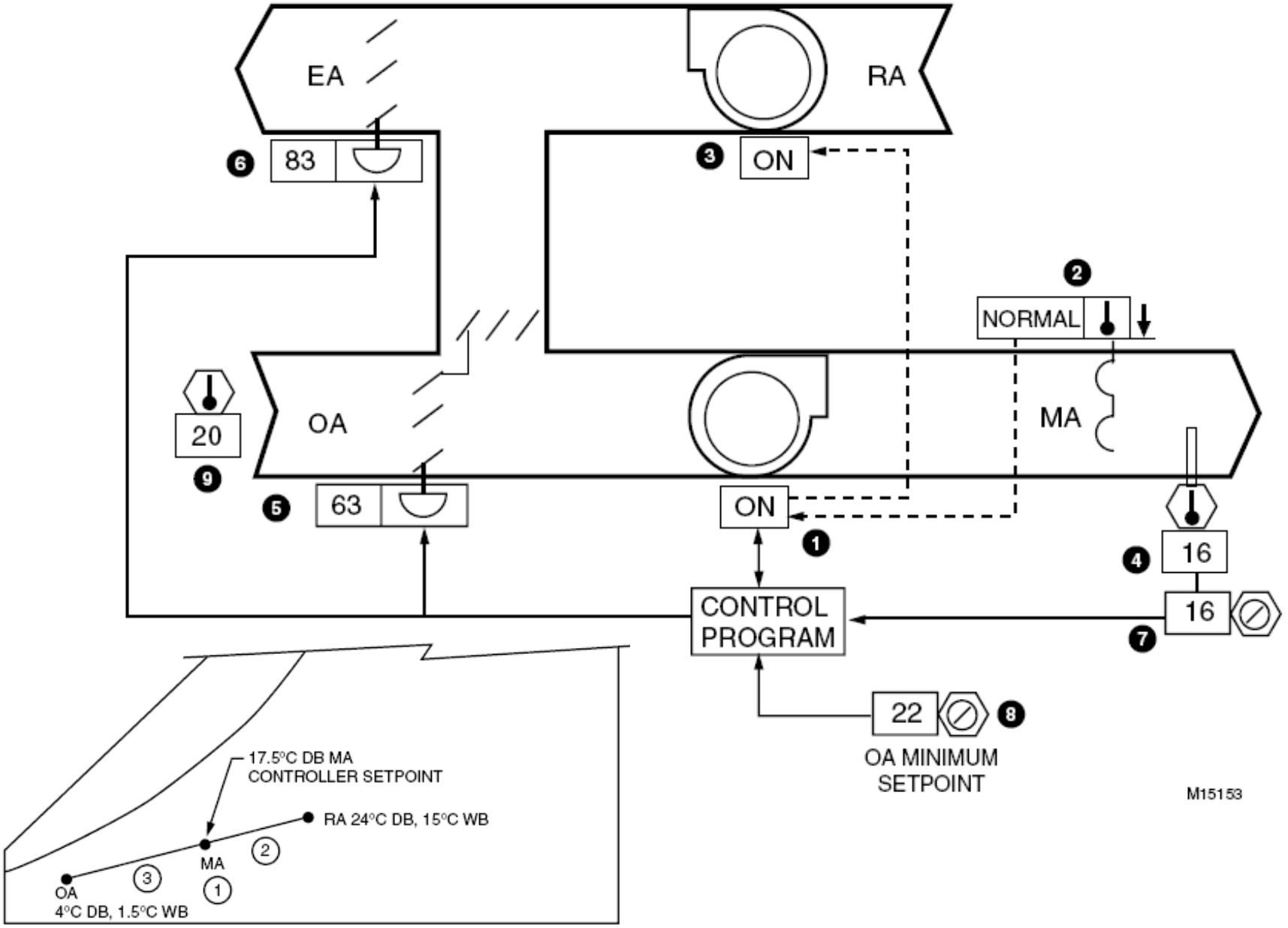
Fixed Quantity of Outdoor Air Control (page 211)





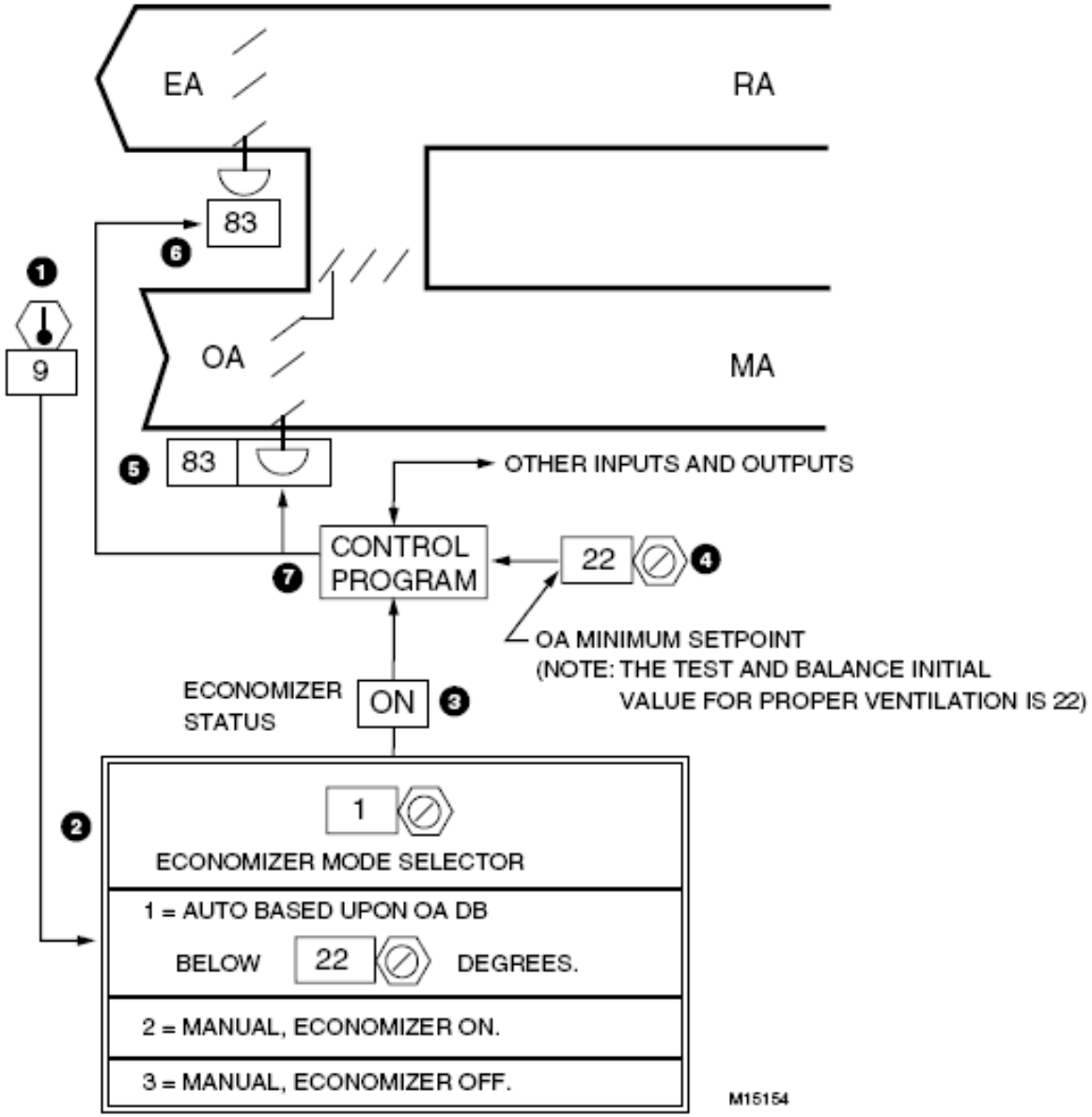
[Source: Honeywell, 1997. *Engineering Manual of Automatic Control: for Commercial Buildings*]

Mixed Air Control (page 213-214)



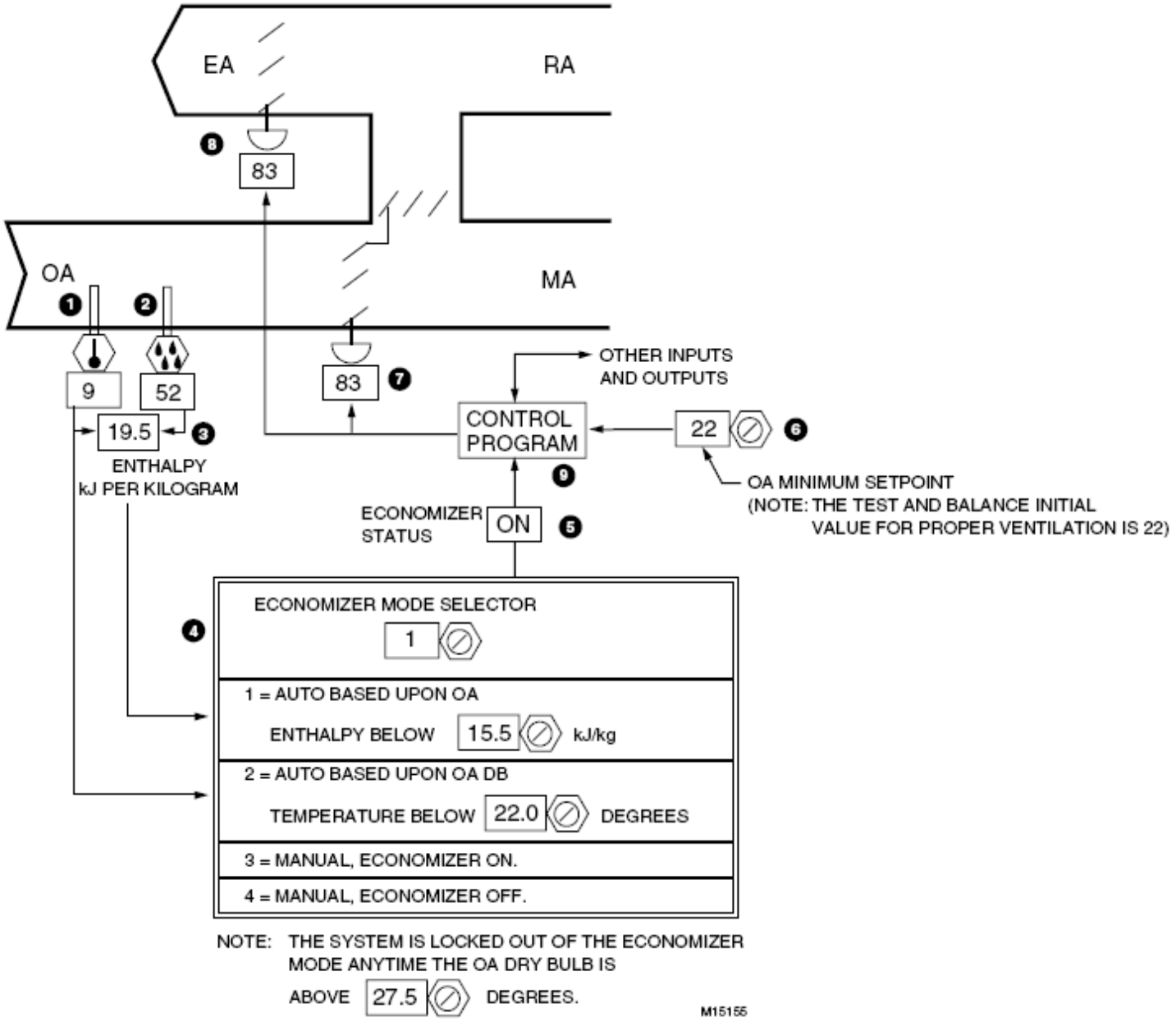
[Source: Honeywell, 1997. *Engineering Manual of Automatic Control: for Commercial Buildings*]

Economizer Cycle Control (Outdoor Air Dry Bulb) (page 215)

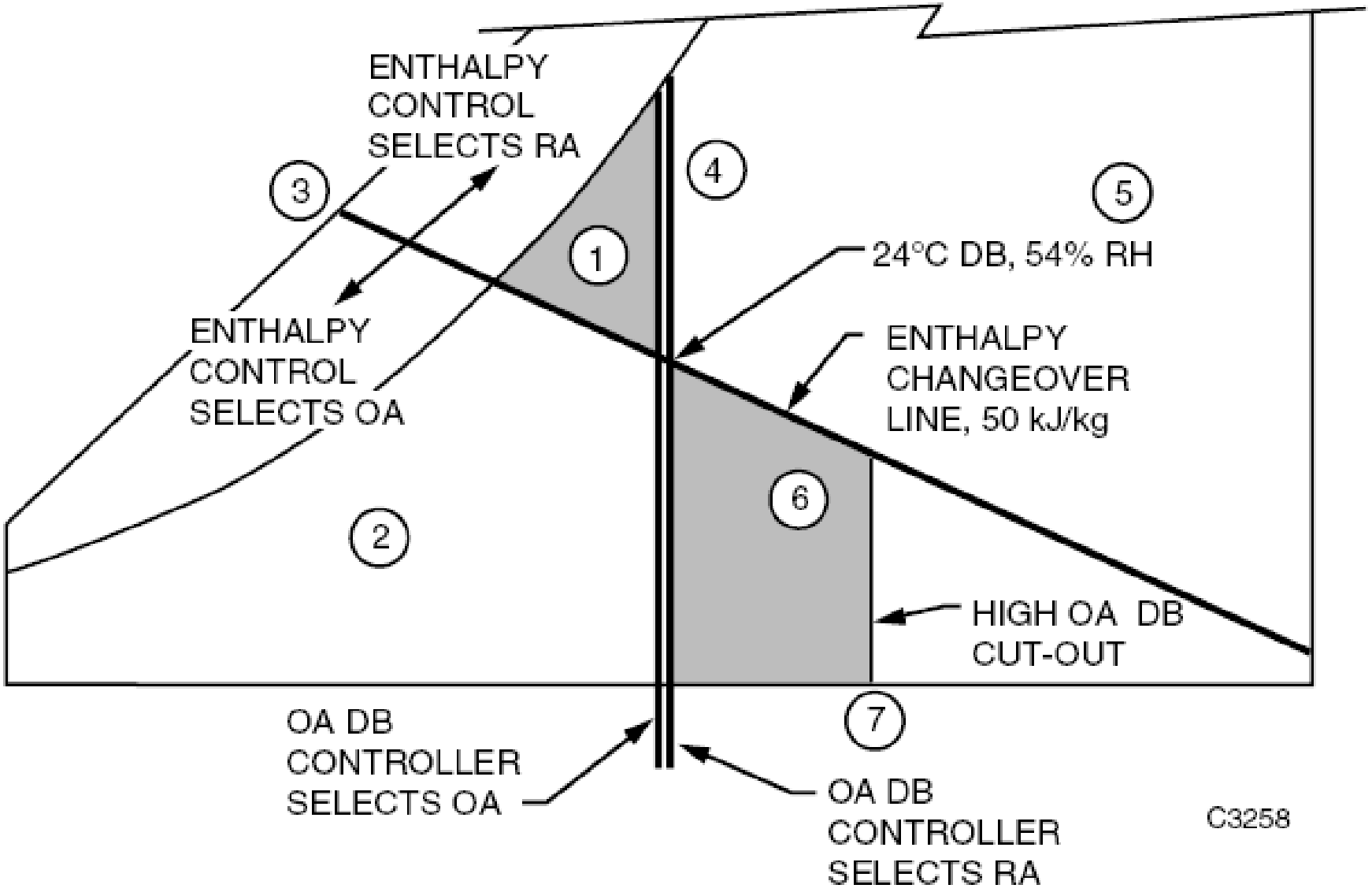


[Source: Honeywell, 1997. *Engineering Manual of Automatic Control: for Commercial Buildings*]

Economizer Cycle Control (Outdoor Air Enthalpy) (page 216)

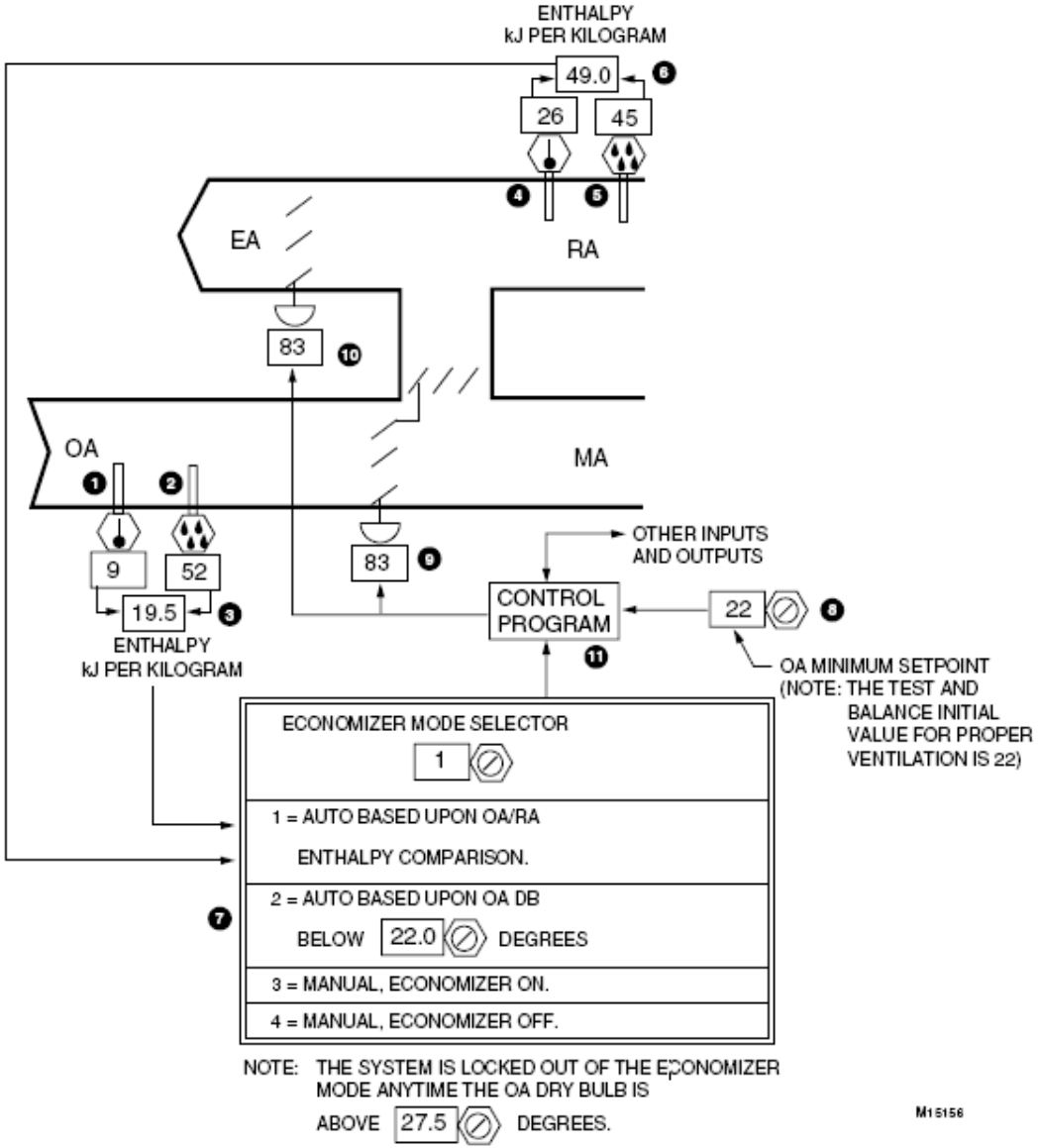


[Source: Honeywell, 1997. *Engineering Manual of Automatic Control: for Commercial Buildings*]



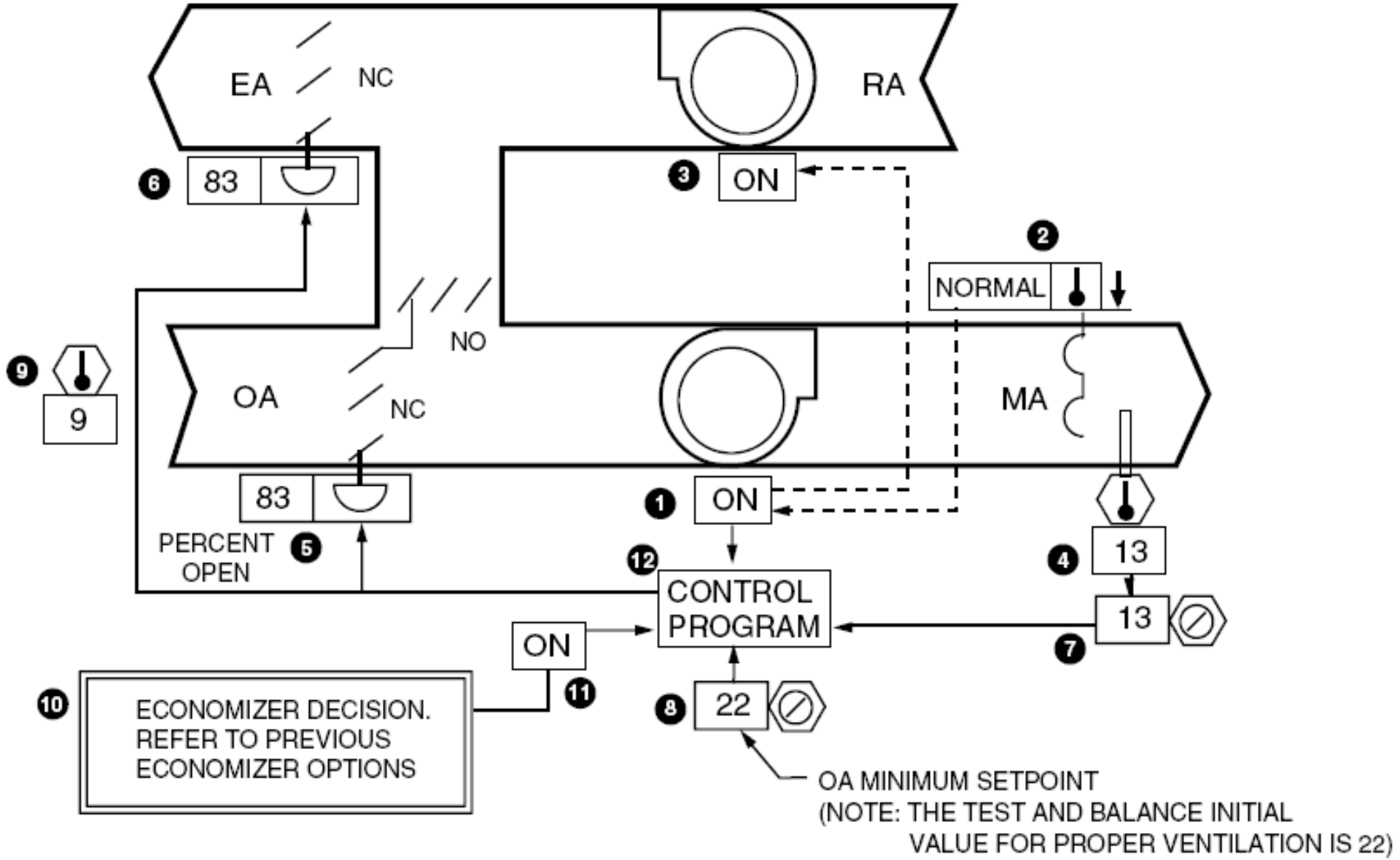
[Source: Honeywell, 1997. *Engineering Manual of Automatic Control: for Commercial Buildings*]

Economizer Cycle Control
(Outdoor Air/Return Air Enthalpy Comparison) (page 218-219)

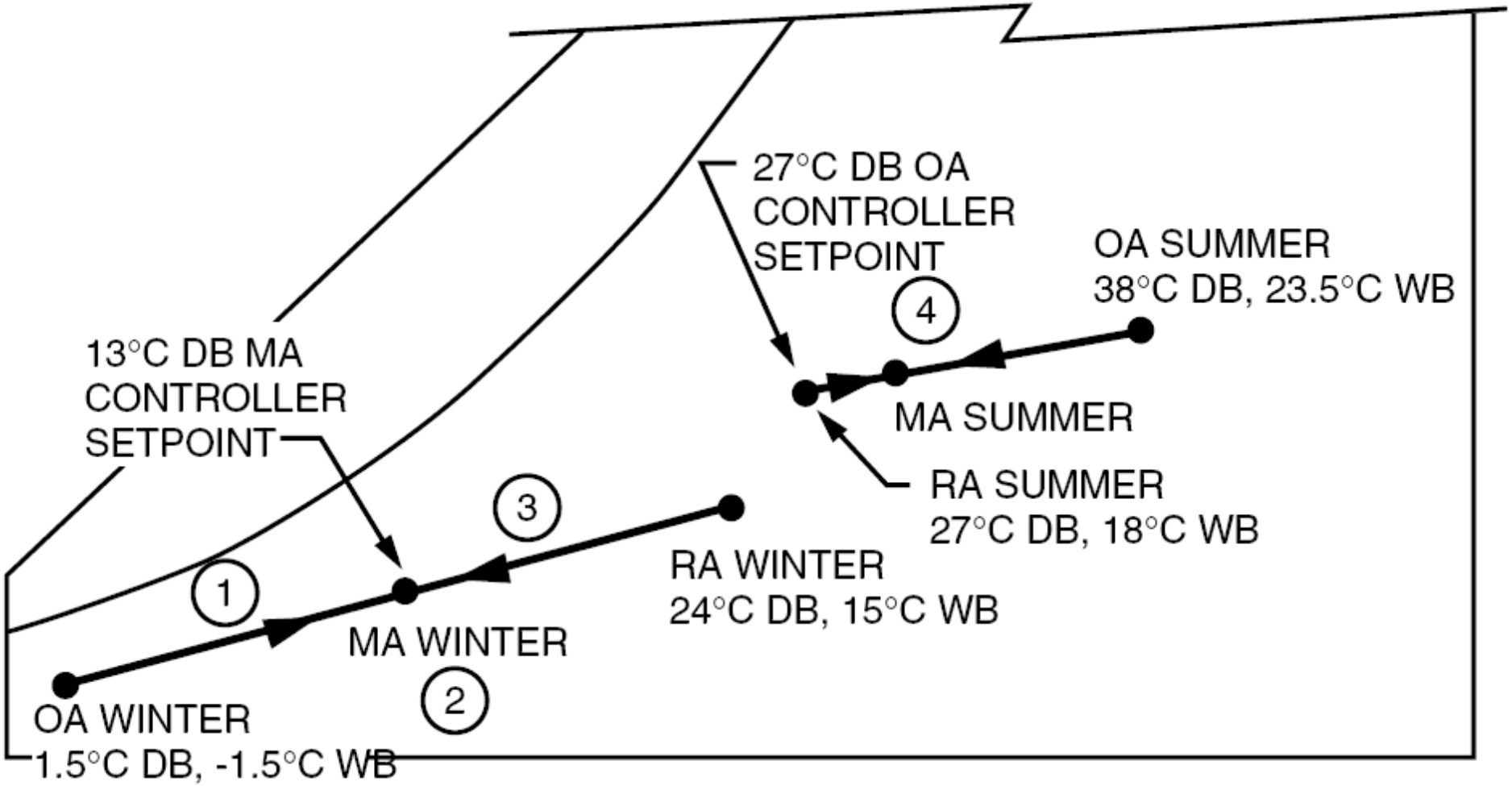


[Source: Honeywell, 1997. *Engineering Manual of Automatic Control: for Commercial Buildings*]

Mixed Air Control with Economizer Cycle (page 220)

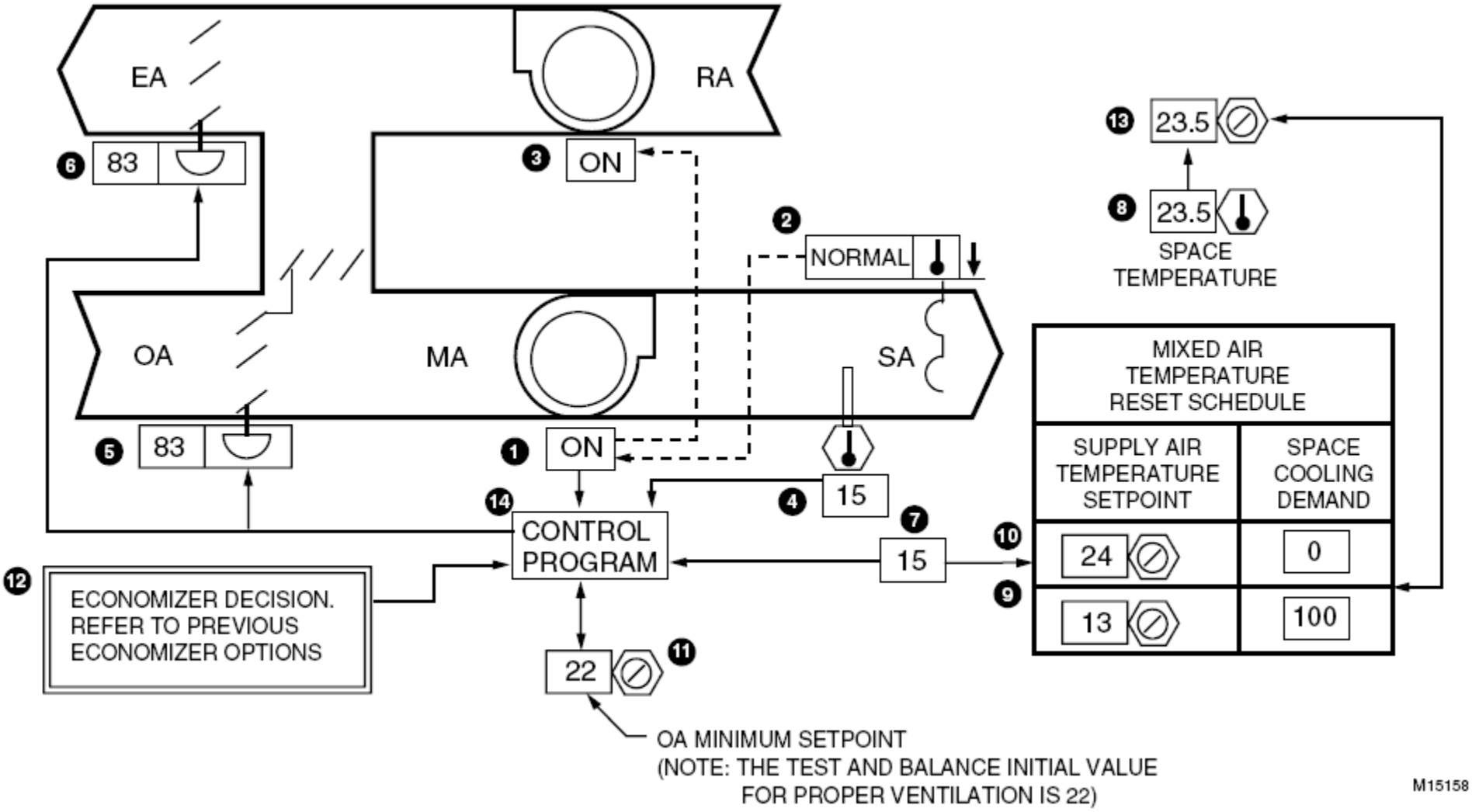


[Source: Honeywell, 1997. *Engineering Manual of Automatic Control: for Commercial Buildings*]



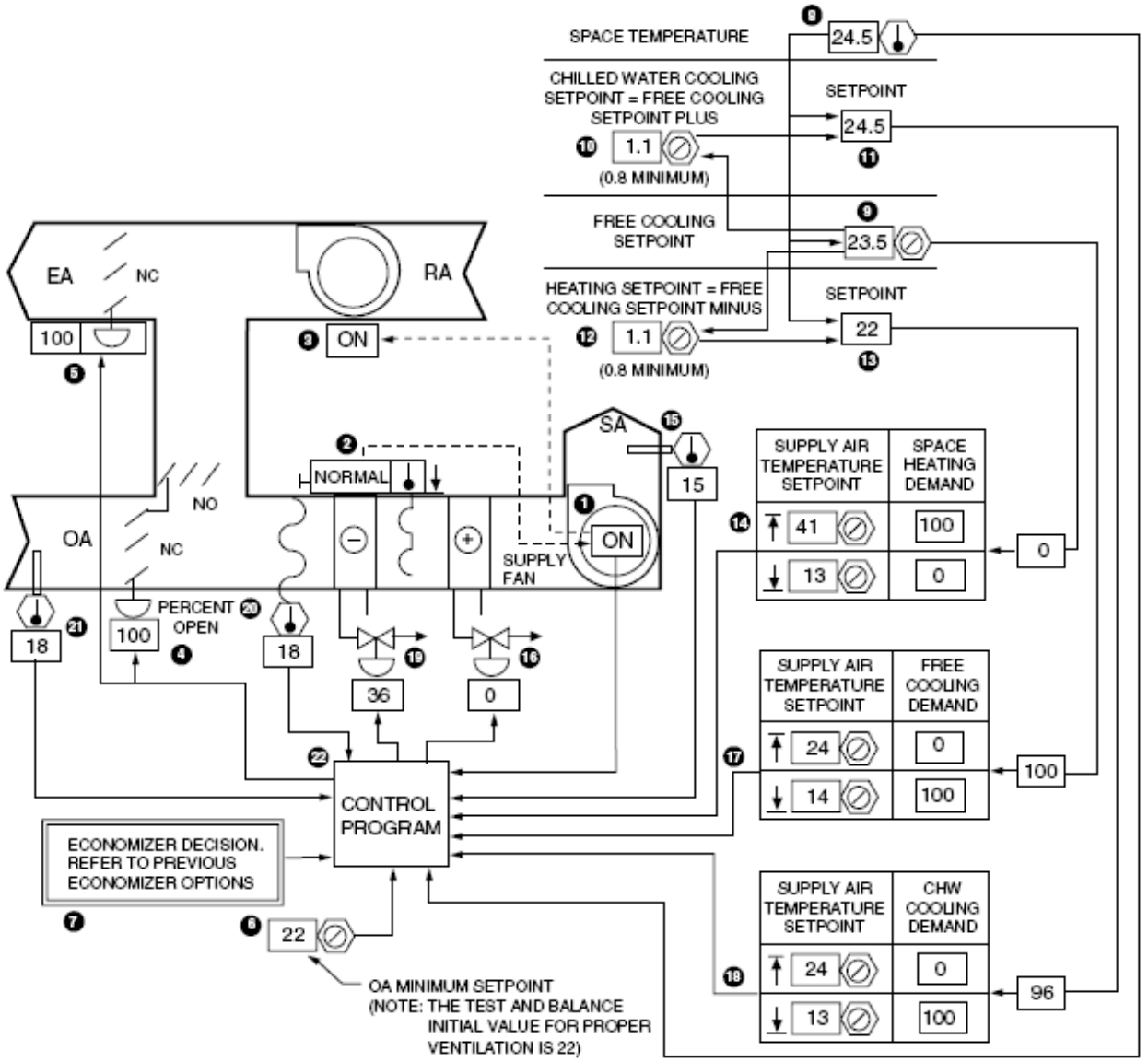
[Source: Honeywell, 1997. *Engineering Manual of Automatic Control: for Commercial Buildings*]

Economizer Cycle Control of Space Temperature with Supply Air Temperature Setpoint Reset (page 221)



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

Year-round System Control – Heating, Cooling, and Economizer (page 248)



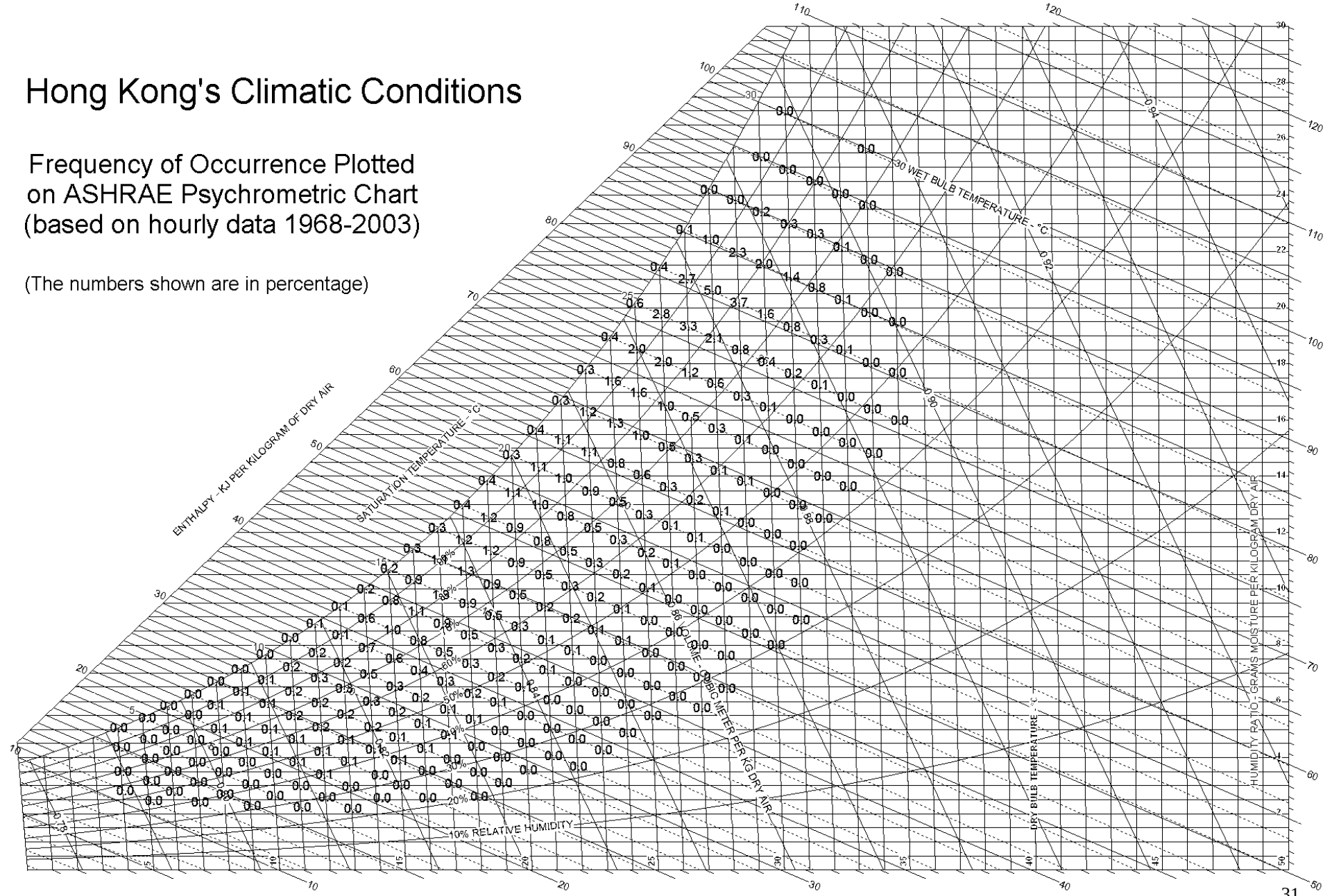
[Source: Honeywell, 1997. *Engineering Manual of Automatic Control: for Commercial Buildings*]

Analysis of the climate conditions on a psychrometric chart

Hong Kong's Climatic Conditions

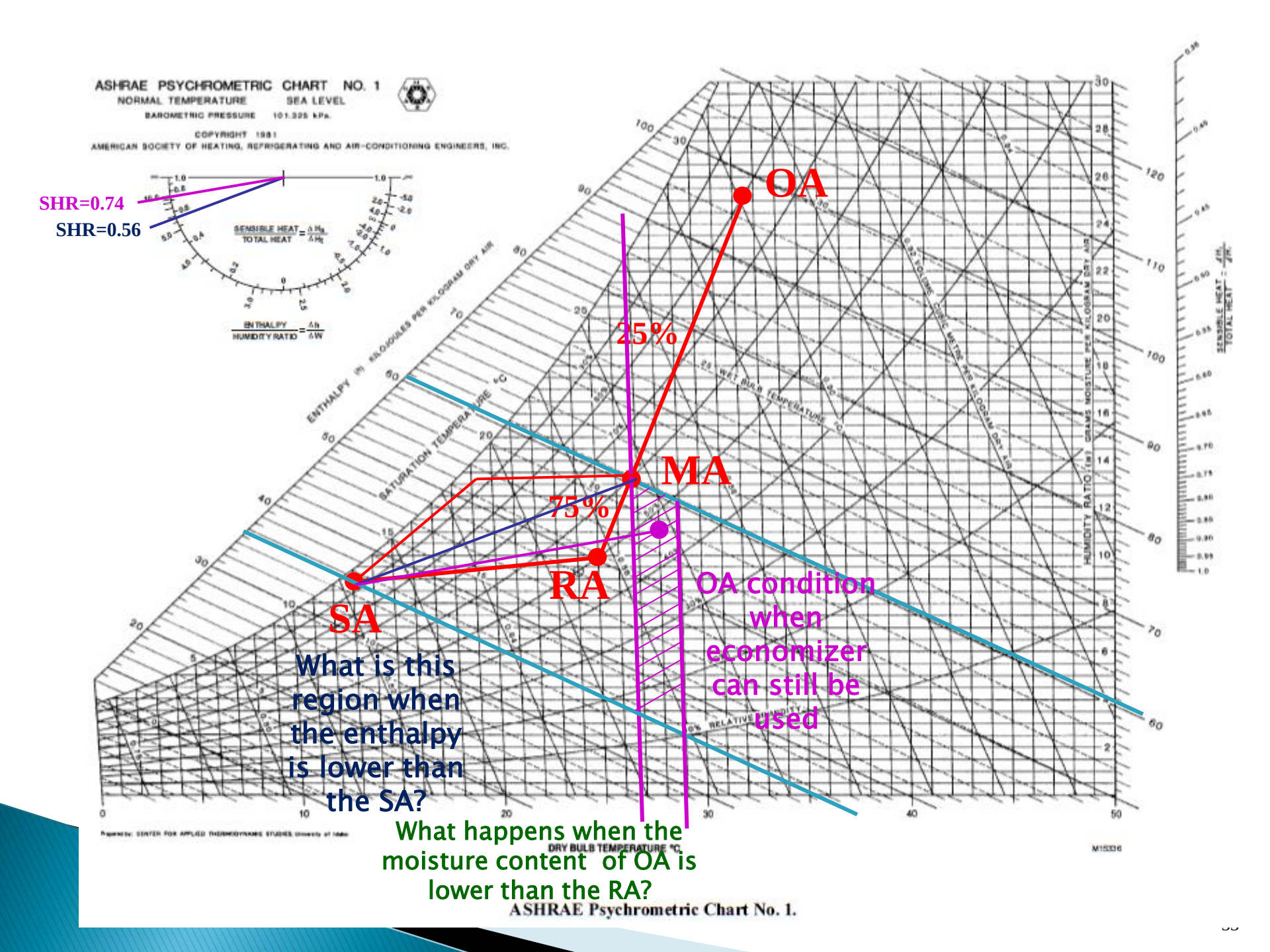
Frequency of Occurrence Plotted on ASHRAE Psychrometric Chart (based on hourly data 1968-2003)

(The numbers shown are in percentage)



exercise

- Mixed air control with economizer cycle is applied to a HVAC system. If the mixed air (MA) consists of 25% outdoor air (OA) and 75% of return air (RA), determine the dry-bulb (DB) and relative humidity (RH) of the mixed air. OA condition is 32.5°C DB and 80% RH; RA condition is 25°C DB and 50% RH. (May 2009 exam paper)
- Further questions:
  - What if the economizer cycle adopts 'Outdoor Air Enthalpy Control', what is the suggested set point enthalpy to invoke this economizer cycle?
  - At what temperature when no more chilled water is required? What is the advantage of adopting 'Supply Air Temperature' reset?
  - From the psychrometric chart, what further findings can be observed?



ASHRAE Psychrometric Chart No. 1.