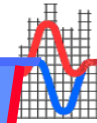


# Fundamentals of DDC



## Mixed Air Section



**Presented by:**  
**J. Jay Santos, P.E.**

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Columbia, MD 21046  
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jays@facilitydynamics.com*



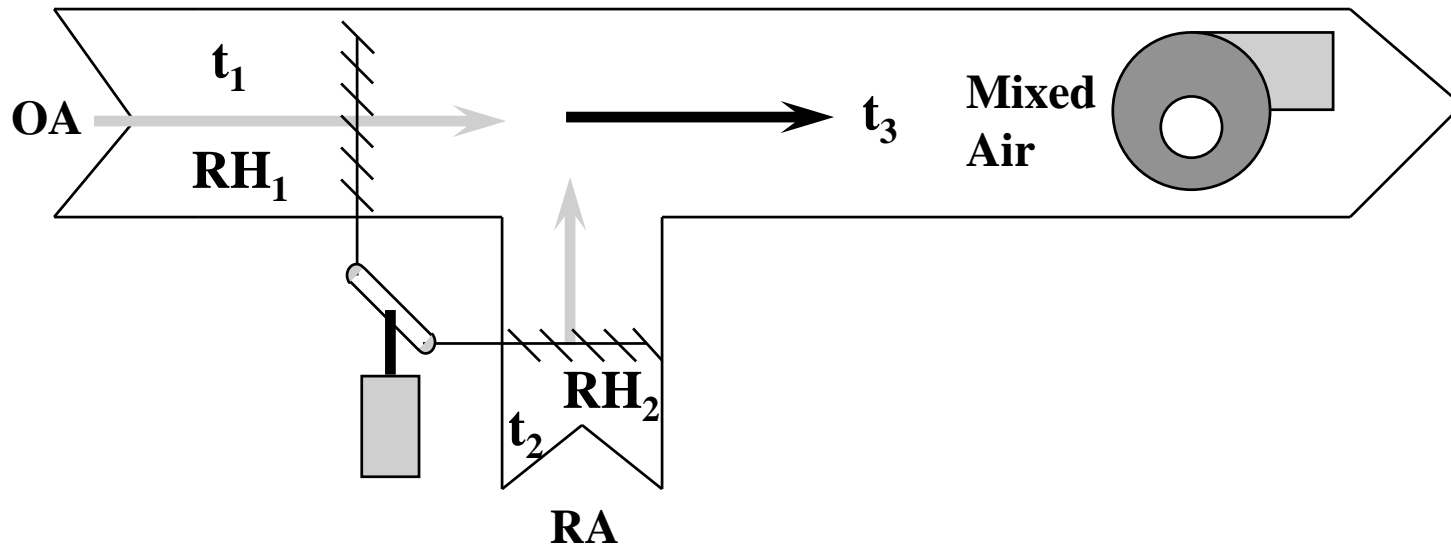
# Block Objective

**A primary objective of this block is to introduce and implement a basic approach to developing control logic diagrams.**

**A variety of mixed air section configurations will also be introduced with corresponding control strategies. The student will gain an appreciation of the complications and issues that are important in controlling the mixed air section.**

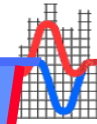
**Through the use of examples, the student will gain an understanding of the importance of the use of logic diagrams to communicate and document control concepts.**

# Mixed Air Section



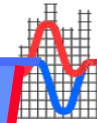
$$t_3 = \frac{[SCFM_1 \times t_1] + [SCFM_2 \times t_2]}{SCFM_3}$$

# Purpose of Mixed Air Section

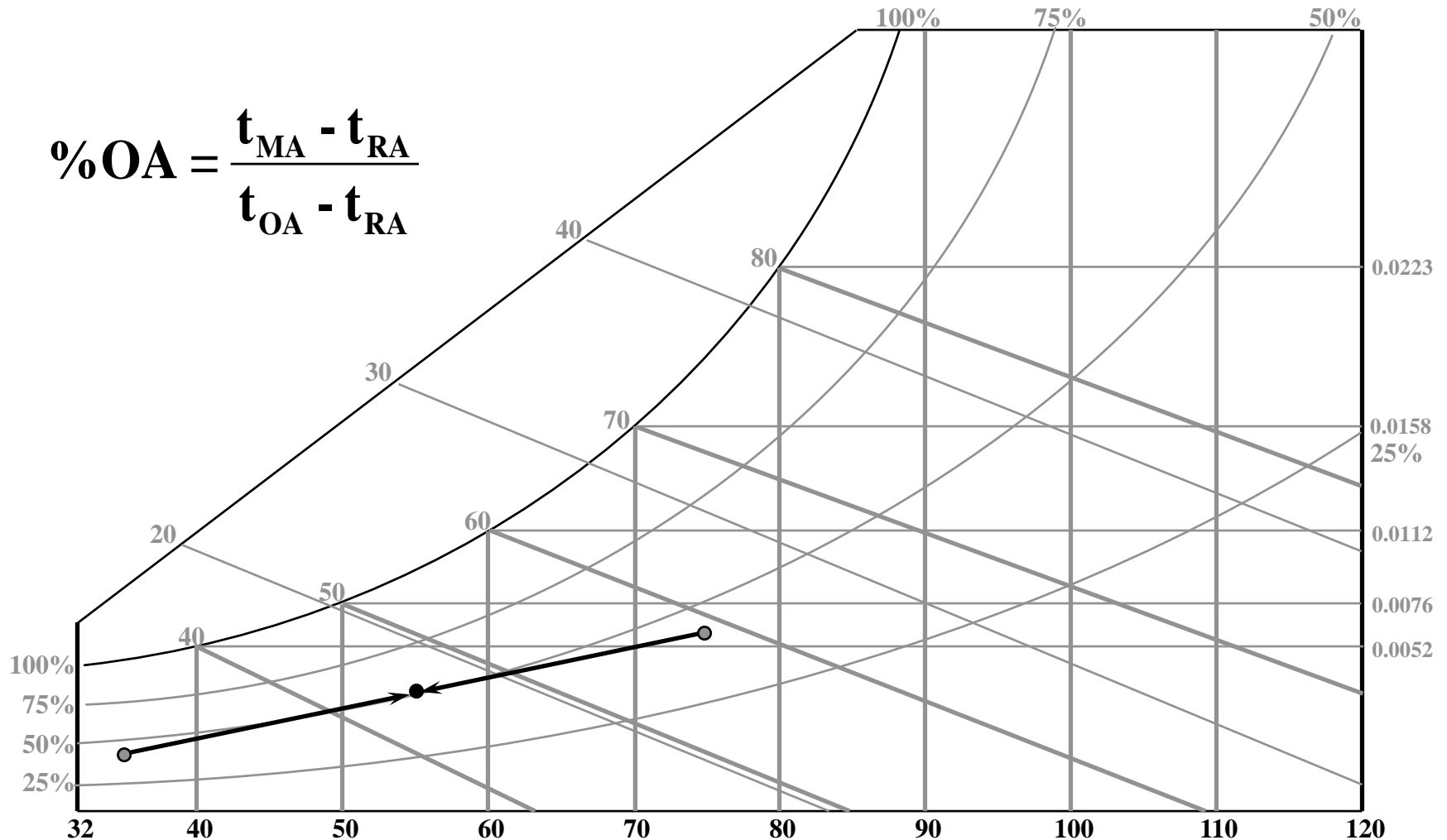


- **Mixes outside air with return air and sends the mix on to the air handling unit.**
- **Provides outside air for ventilation and allows the use of outside air for cooling when the outside air is cool enough and there is a demand for cooling.**
- **Issues**
  - **Energy Impacts**
  - **Indoor Air Quality**
  - **Pressurization**
  - **Relative Complexity**
  - **Freeze protection**

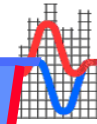
# Psychrometrics of Mixing



$$\%OA = \frac{t_{MA} - t_{RA}}{t_{OA} - t_{RA}}$$



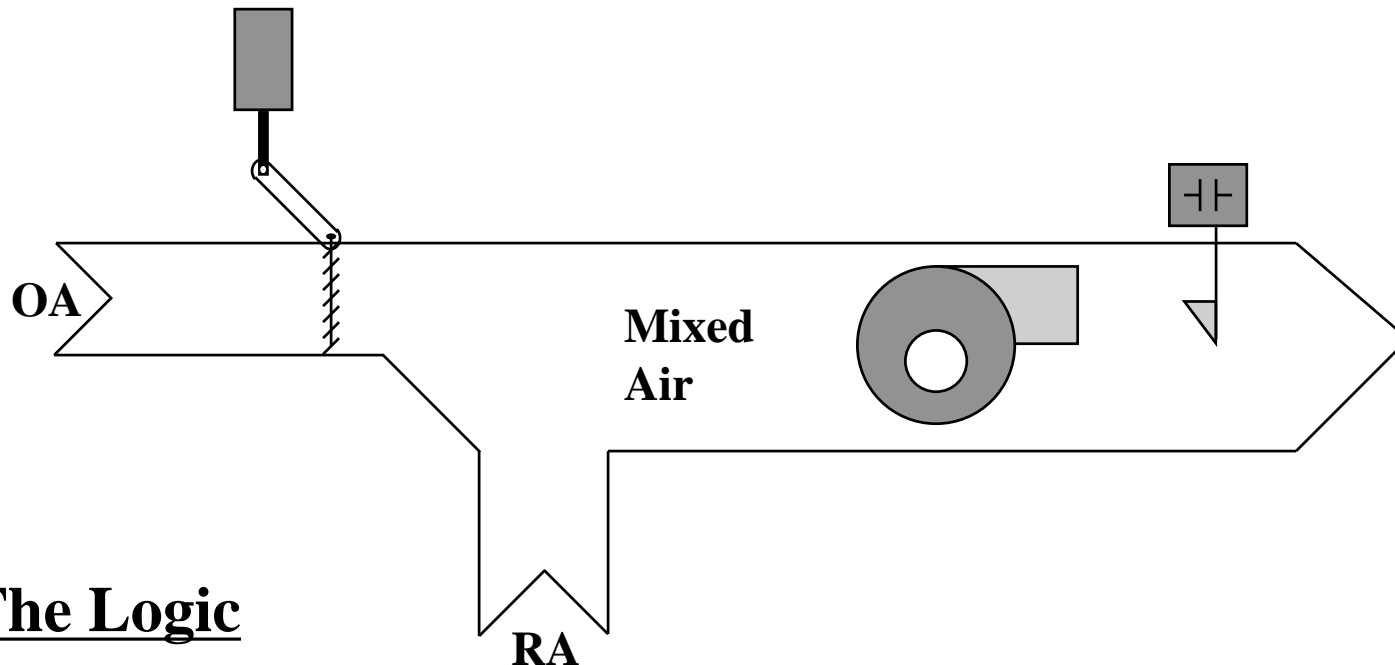
# The System Choices



- ❑ **Fixed minimum air only**
- ❑ **Mixing box with temperature high limit**
- ❑ **Mixing box with enthalpy high limit**
- ❑ **Zone reset of mixed air SP**
- ❑ **CO<sub>2</sub> override/reset of minimum position**
- ❑ **Mixing box with fixed minimum air**

# Fixed Minimum Air

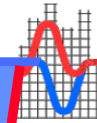
## The System



## The Logic

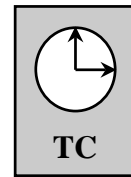
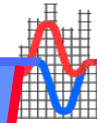
**If the fan is on (proved by air flow) and the time schedule indicates the building is occupied, the outside air dampers shall be open.**

# The Damper

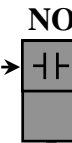


- **The Process**
  - **Two Position Control based on time schedule**
- **Limits/Conditions**
  - **Airflow**
- **Measured Variables**
  - **Airflow**
  - **Time**
- **Communication**
  - **Minimum Air Dampers - Fan**

# The Primary Control Loop

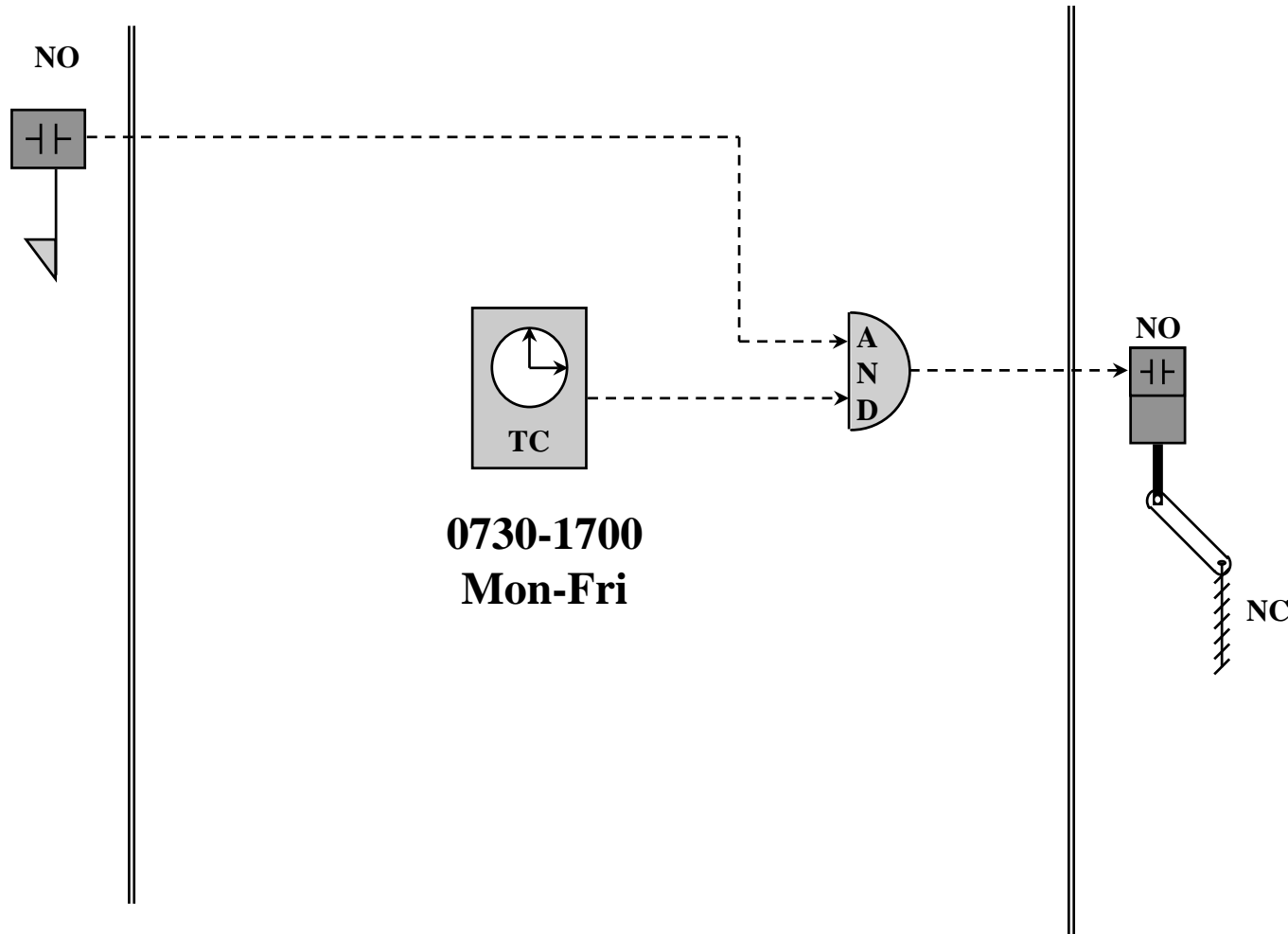


**0730-1700**  
**Mon-Fri**



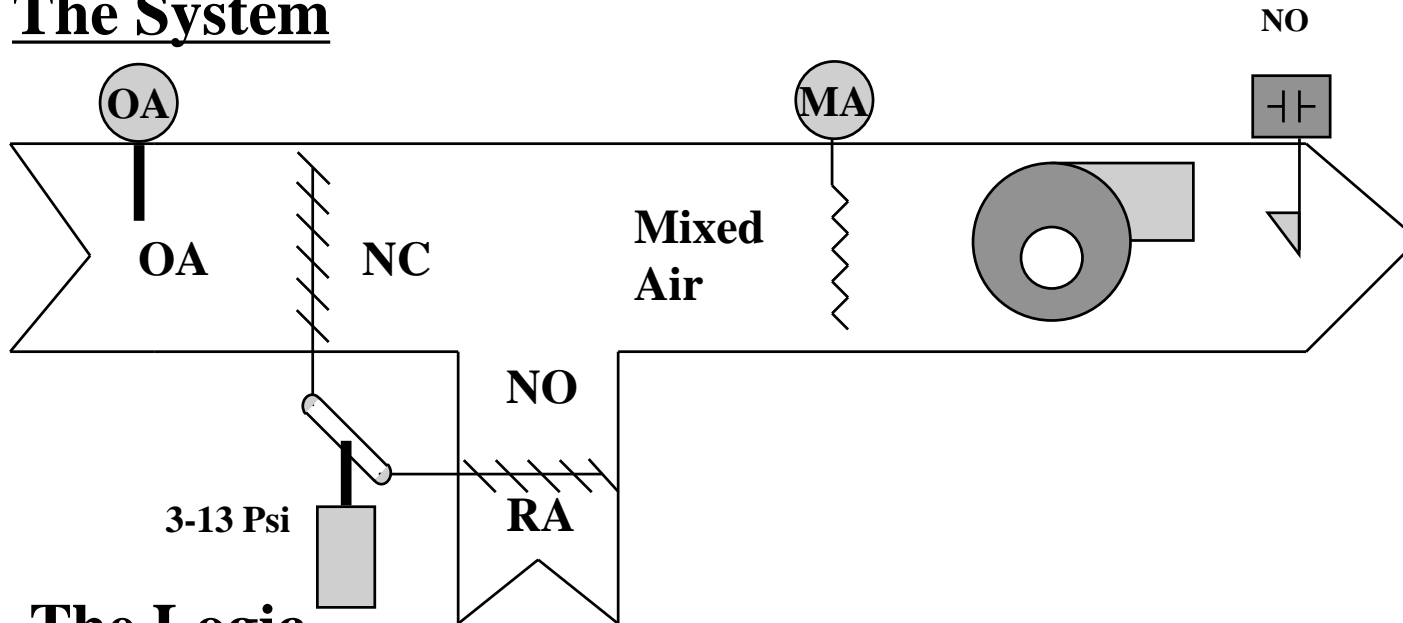
NC

# Loop with Limits & Conditions



# Mixed Air w/ Dry Bulb Economizer

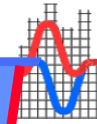
## The System



## The Logic

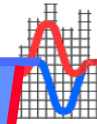
The mixed air dampers shall modulate to control a mixed air temperature of 55 F. +/- 3 F. The OA dampers will close on fan shut down. The OA dampers shall maintain 25% OA when the building is occupied. The OA dampers shall maintain minimum (occ.) or bypass minimum (unocc.) when the OA temperature exceeds 68 F. with a 2 F. differential.

# Mixed Air w/ Dry Bulb Economizer



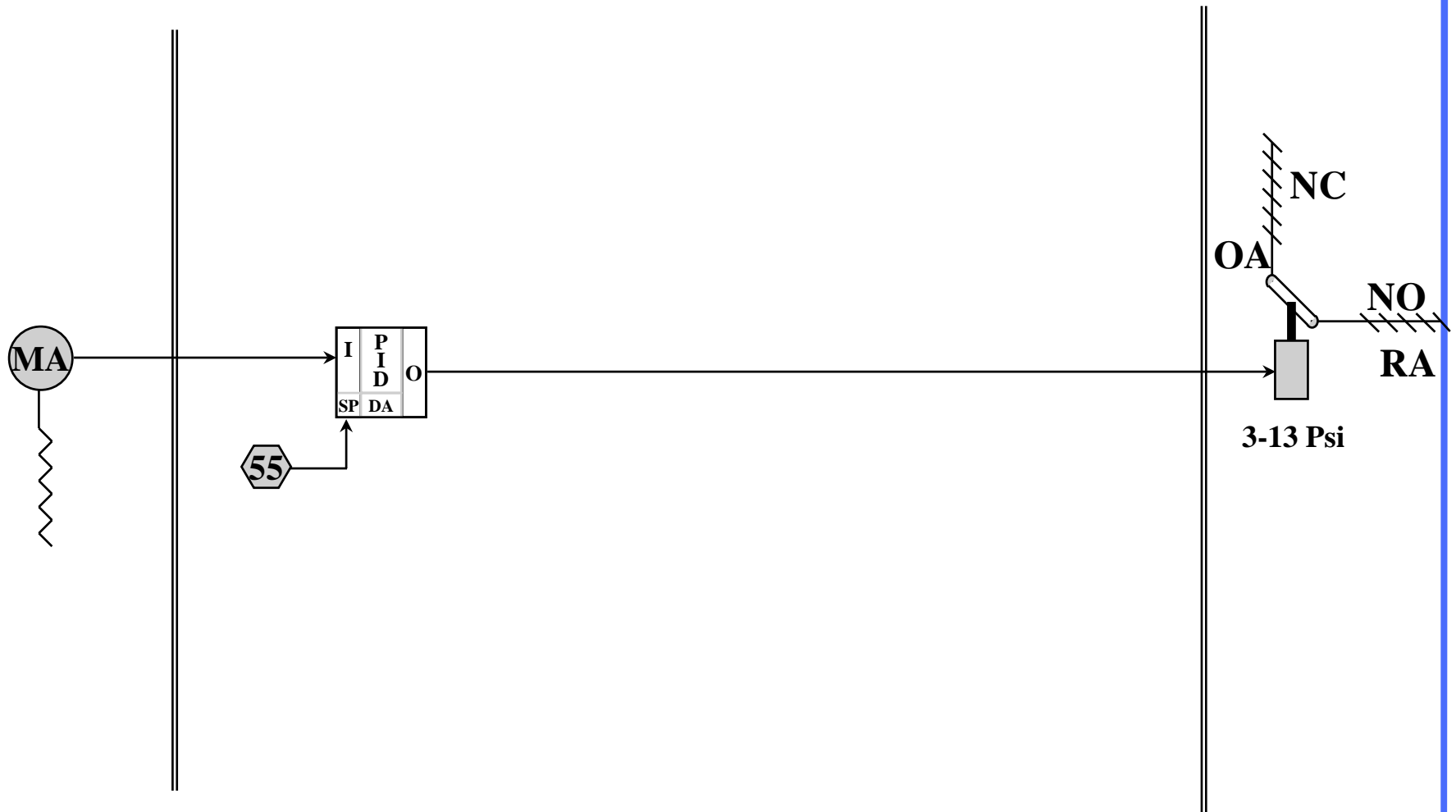
- **The Process**
  - **Proportional Control of OA/RA Dampers**
  - **Fixed setpoint of 55 F. with 6 F. TR**
- **Limits/Conditions**
  - **Airflow**
  - **High Limit of 68 F. with 2 F. differential**
  - **Minimum OA of 25%**
  - **Bypass minimum OA when unoccupied**

# Mixed Air w/ Dry Bulb Economizer

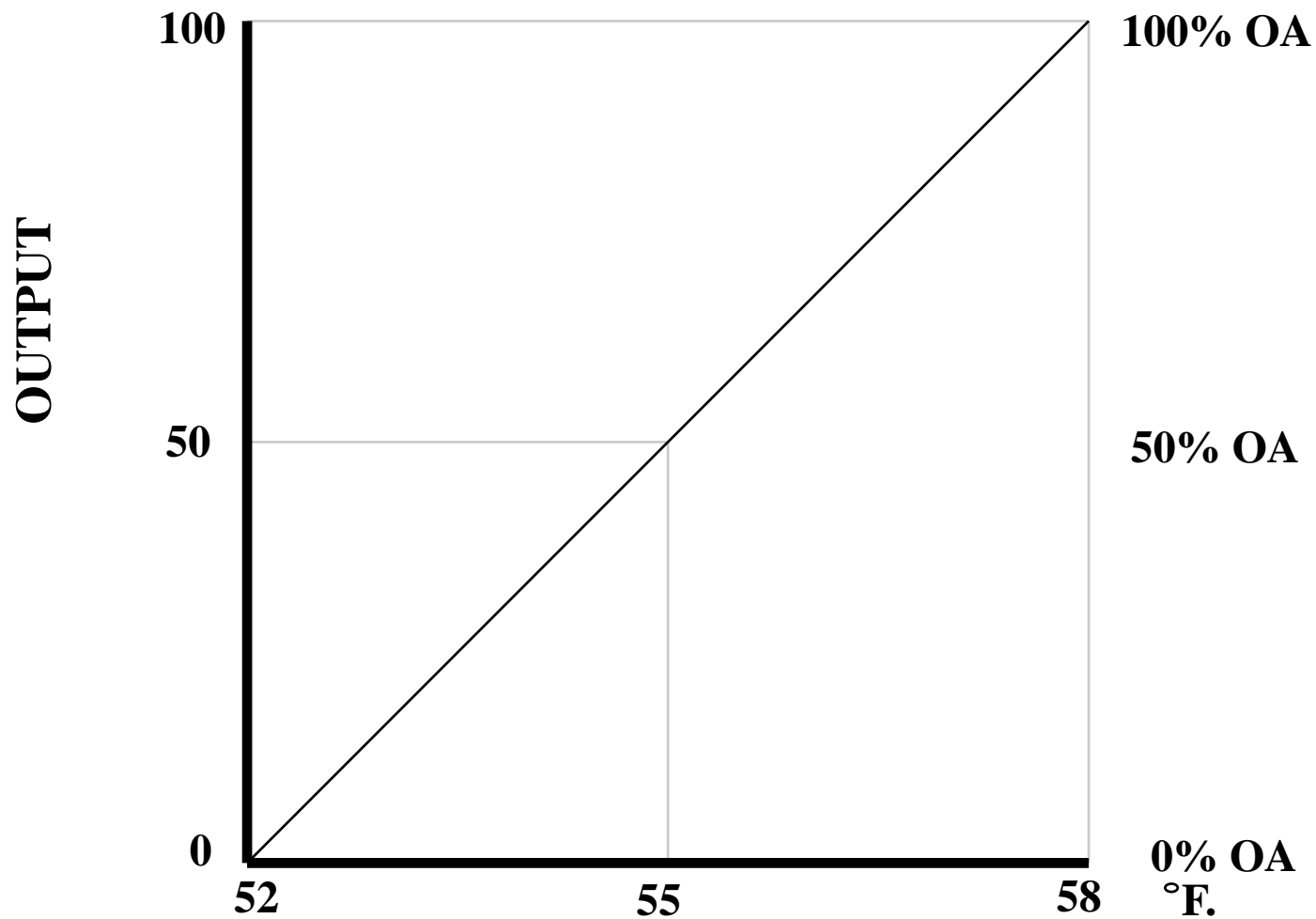
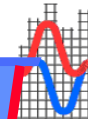


- ▣ **Measured Variables**
  - ▣ **Mixed air temperature**
  - ▣ **Outside air temperature**
  - ▣ **Airflow**
  - ▣ **Time**
- ▣ **Communication**
  - ▣ **Mixed Air Dampers - Fan**

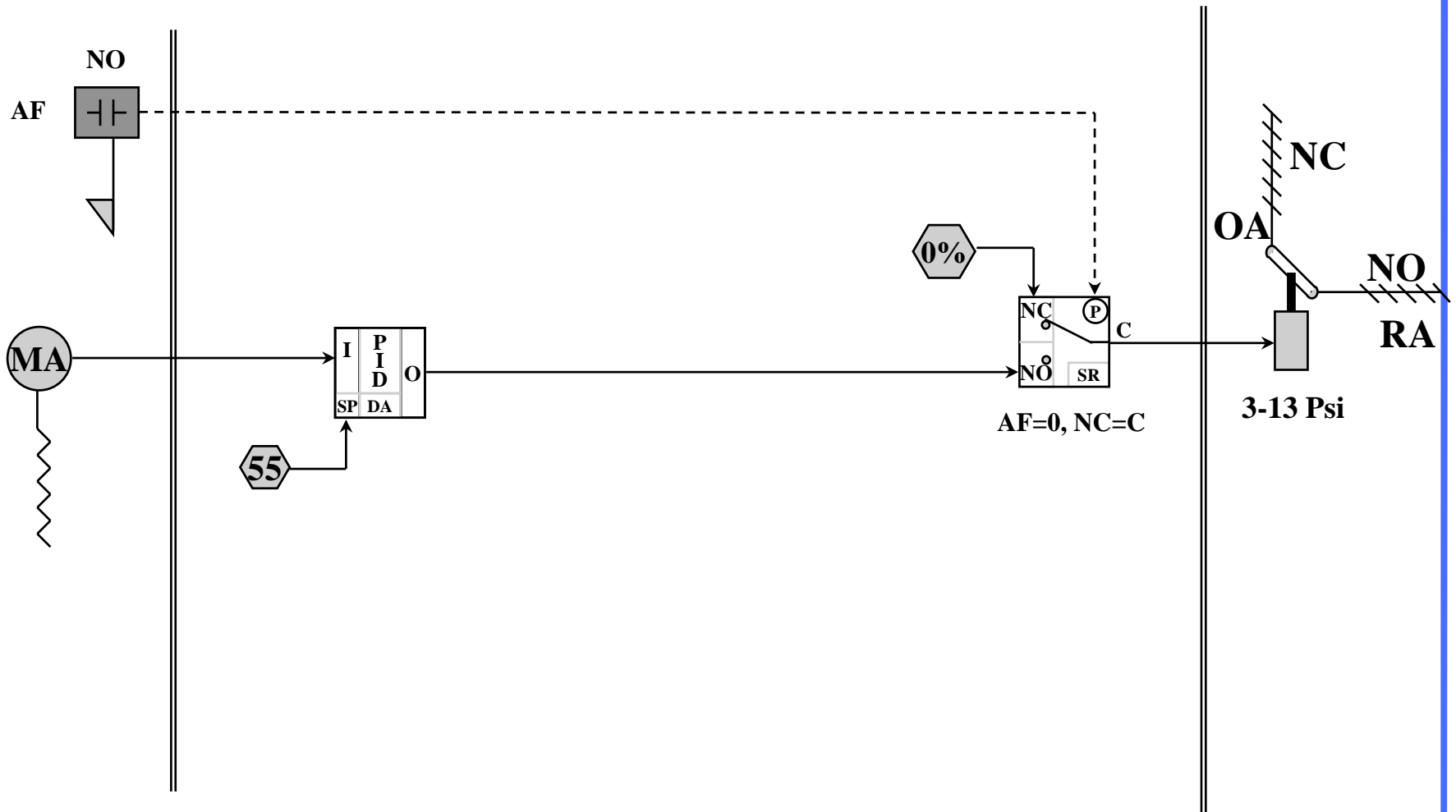
# The Primary Control Loop



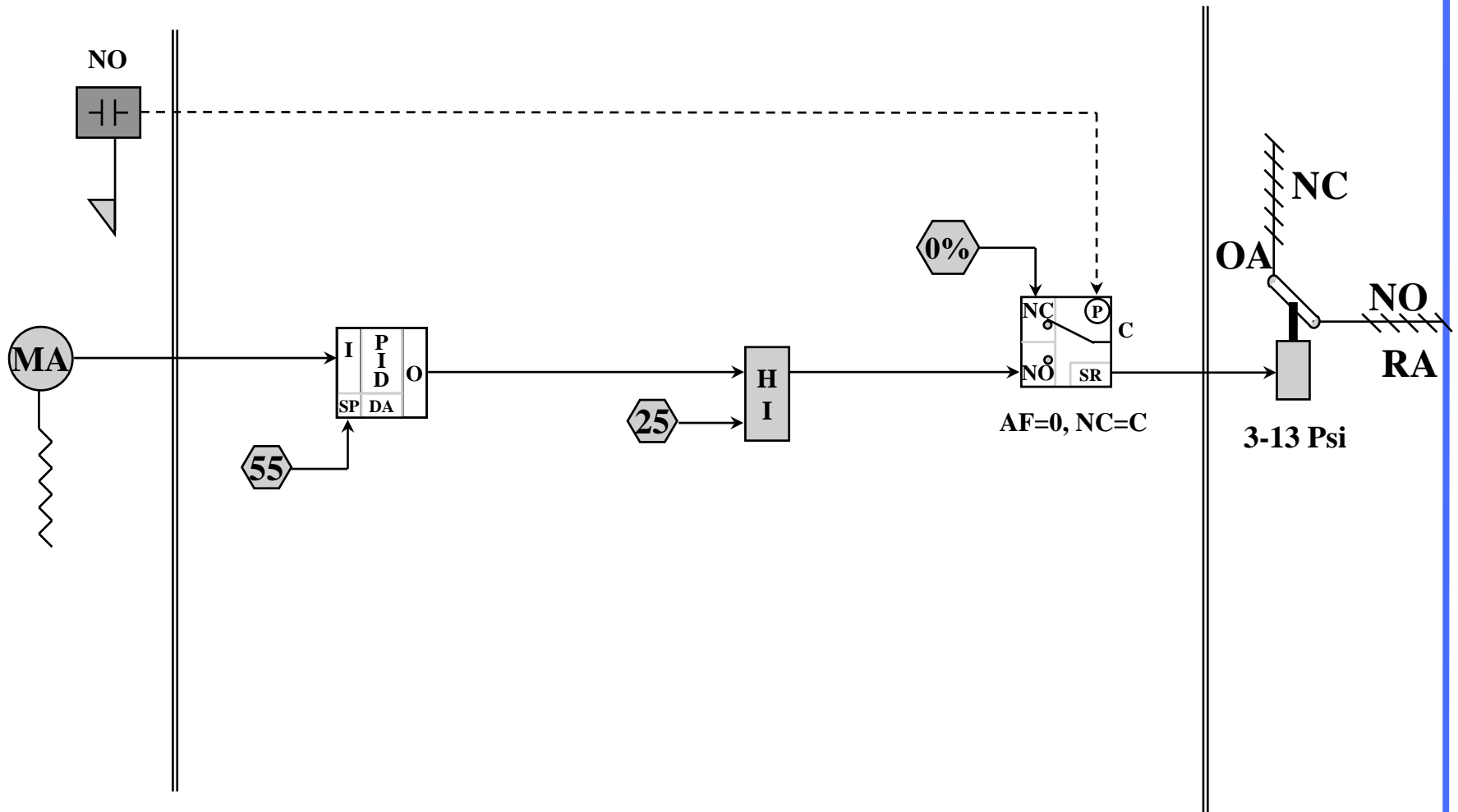
# Controller Performance



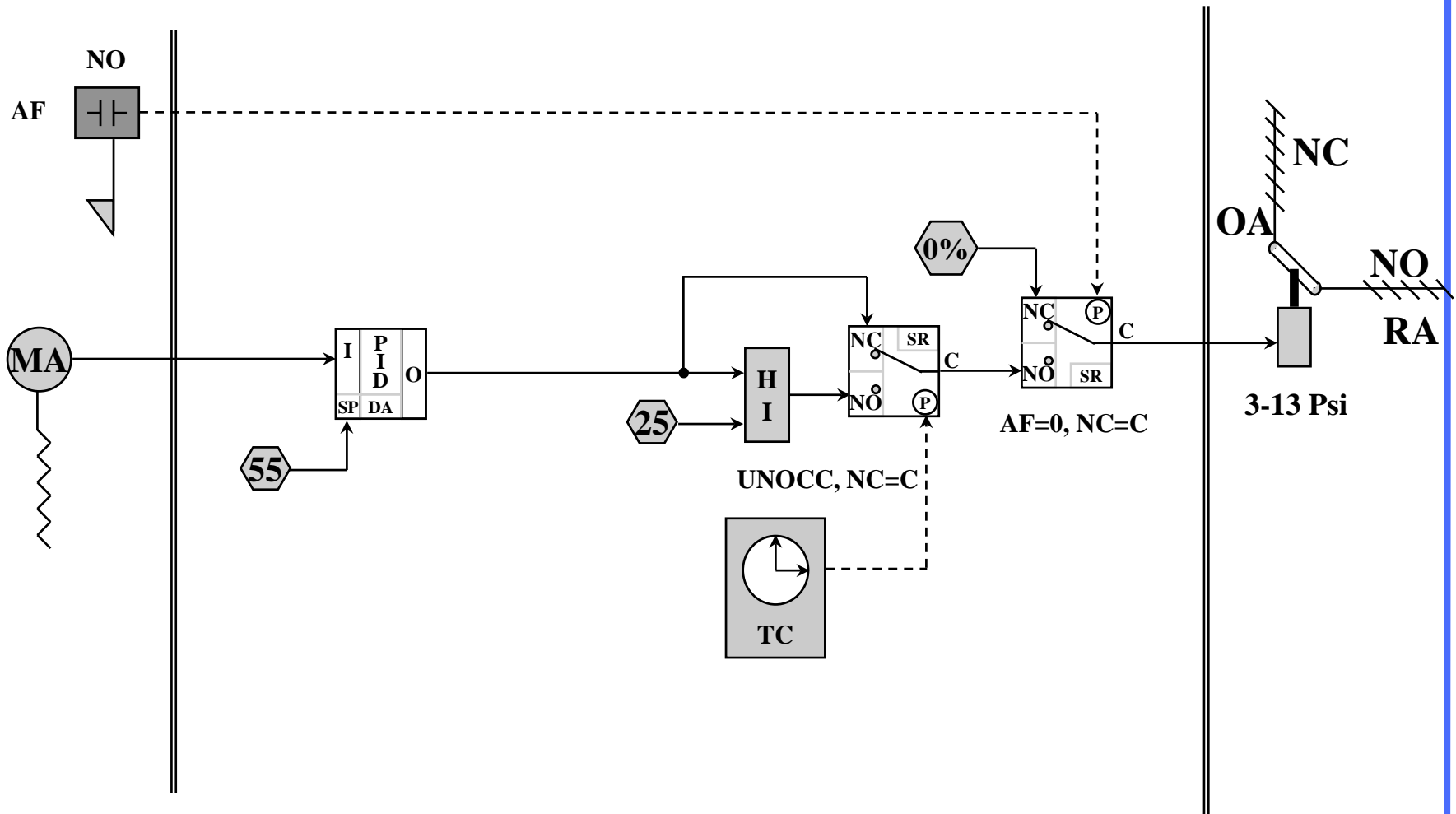
# Air Flow Limit



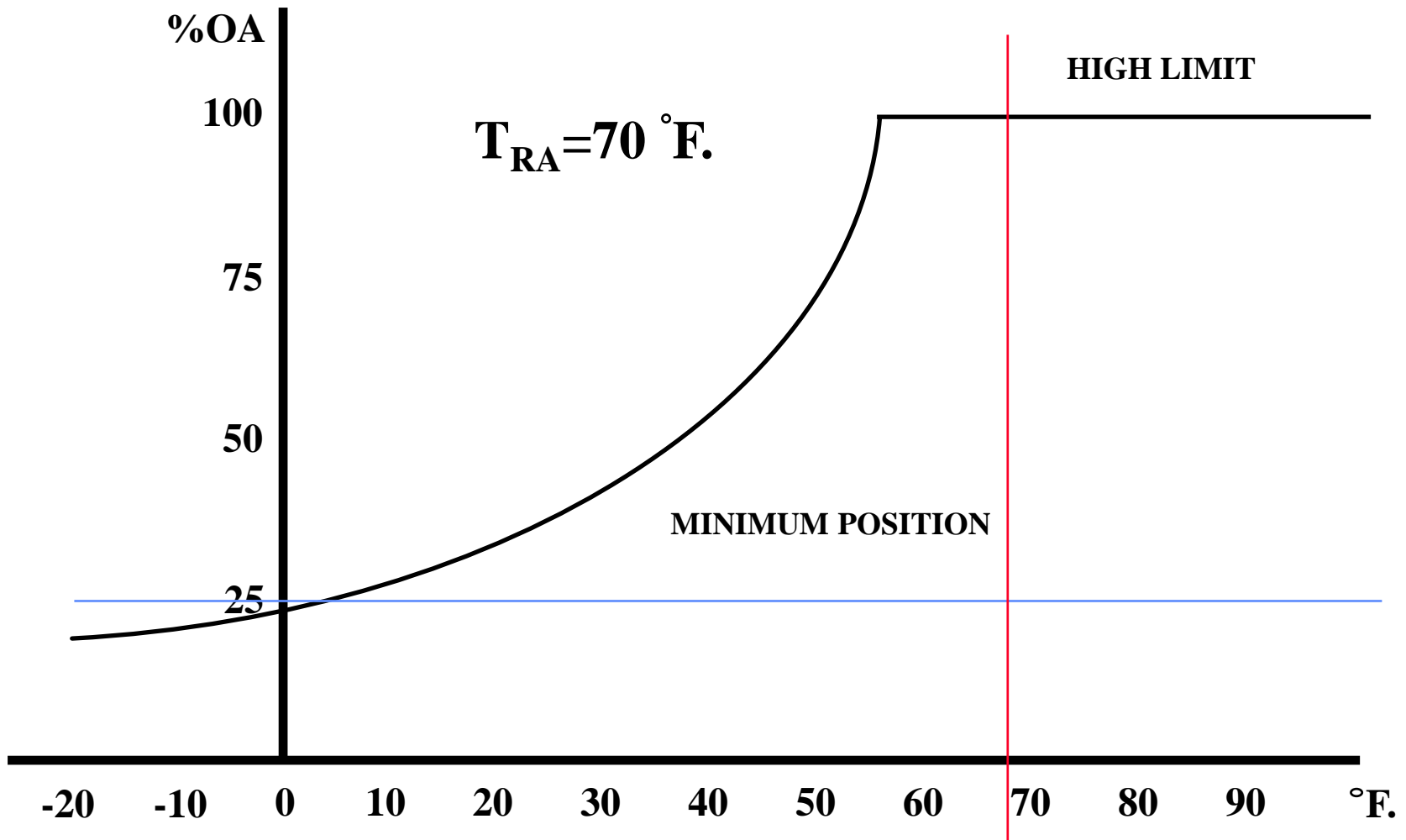
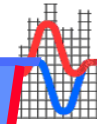
# Minimum Position



# Unoccupied Override of MP

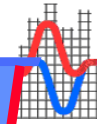


# Economizer Section Performance



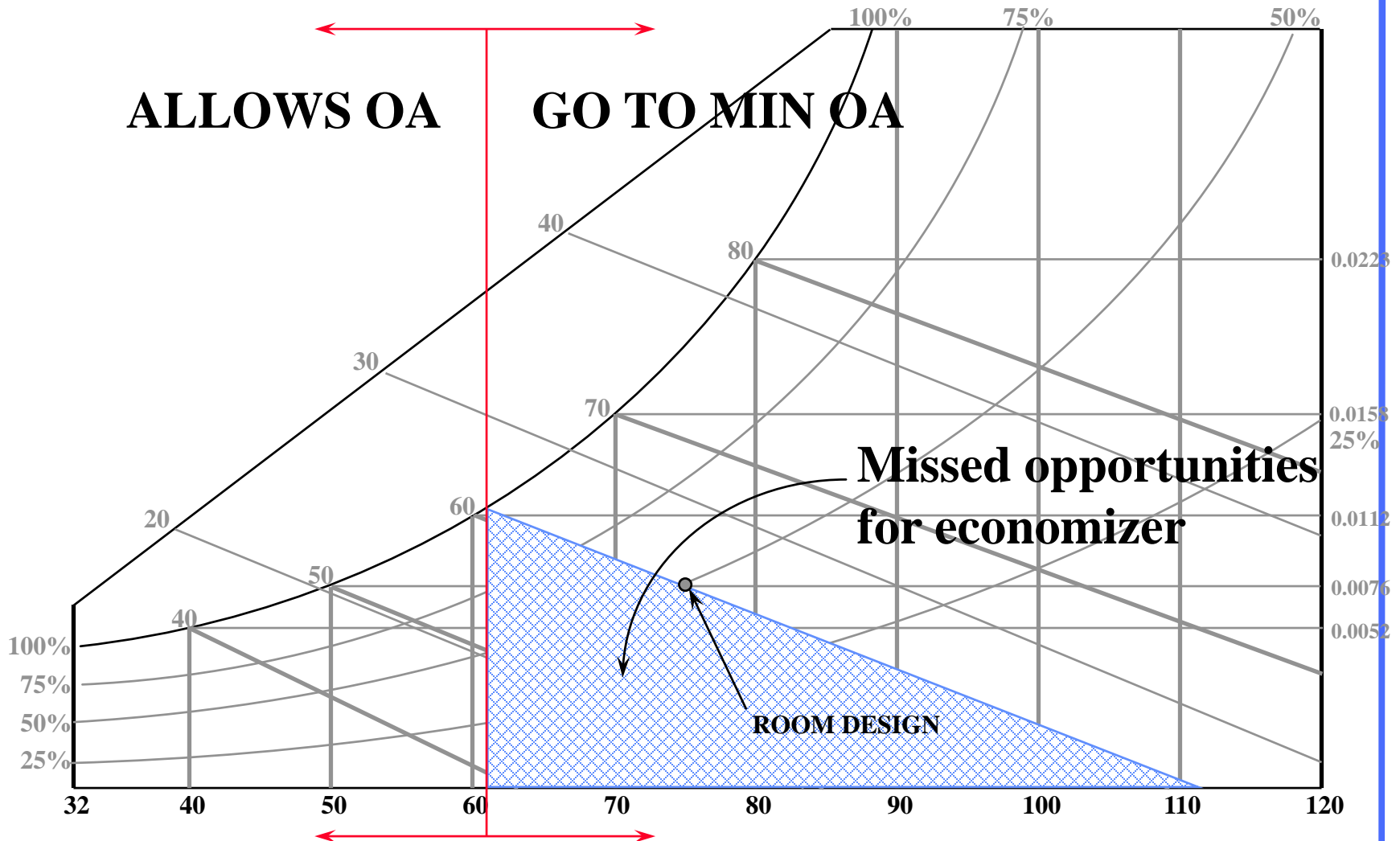
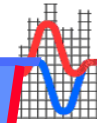


# The High Limit Function Options

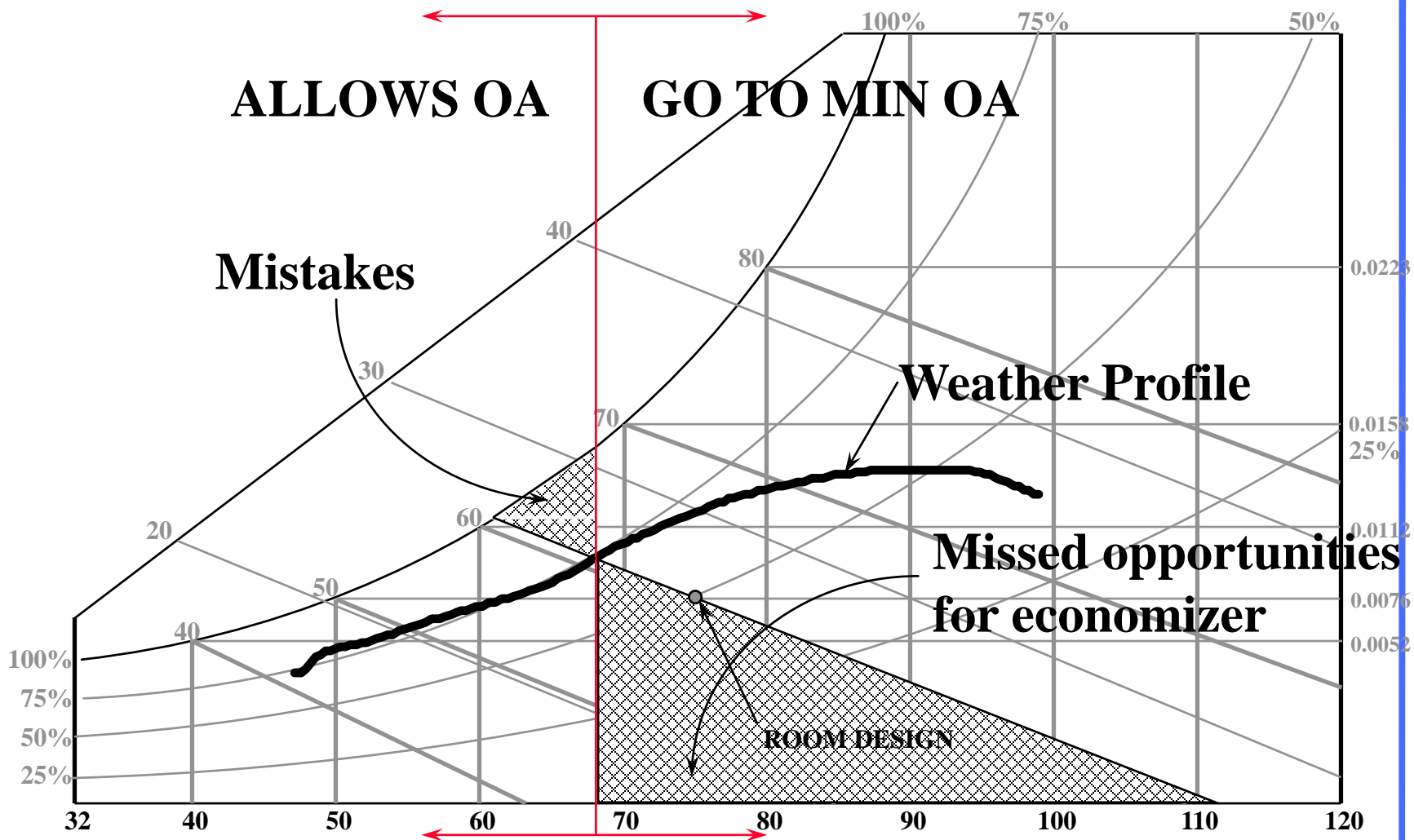
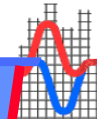


- **Dry Bulb Economizer**
  - The high limit is equal to the wet bulb temperature for the room design conditions
  - Very inefficient approach
- **Optimized Dry Bulb Economizer**
  - The high limit is equal to the dry bulb temperature at the intersection of the room wet bulb line and a plot of the statistical weather data
  - Avoids the use of relative humidity sensors
- **Enthalpy Economizer**
  - Uses temperature and relative humidity inputs from the outside air and the return air
  - Selects the air stream with the lowest enthalpy

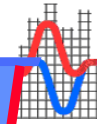
# Dry Bulb Economizer



# Optimized Dry Bulb Economizer

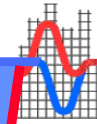


# Optimized Dry Bulb



- **Plot the weather data for your location on a psychrometric chart**
- **Plot the enthalpy line for the room design conditions**
- **Select the high limit at the point of intersection**

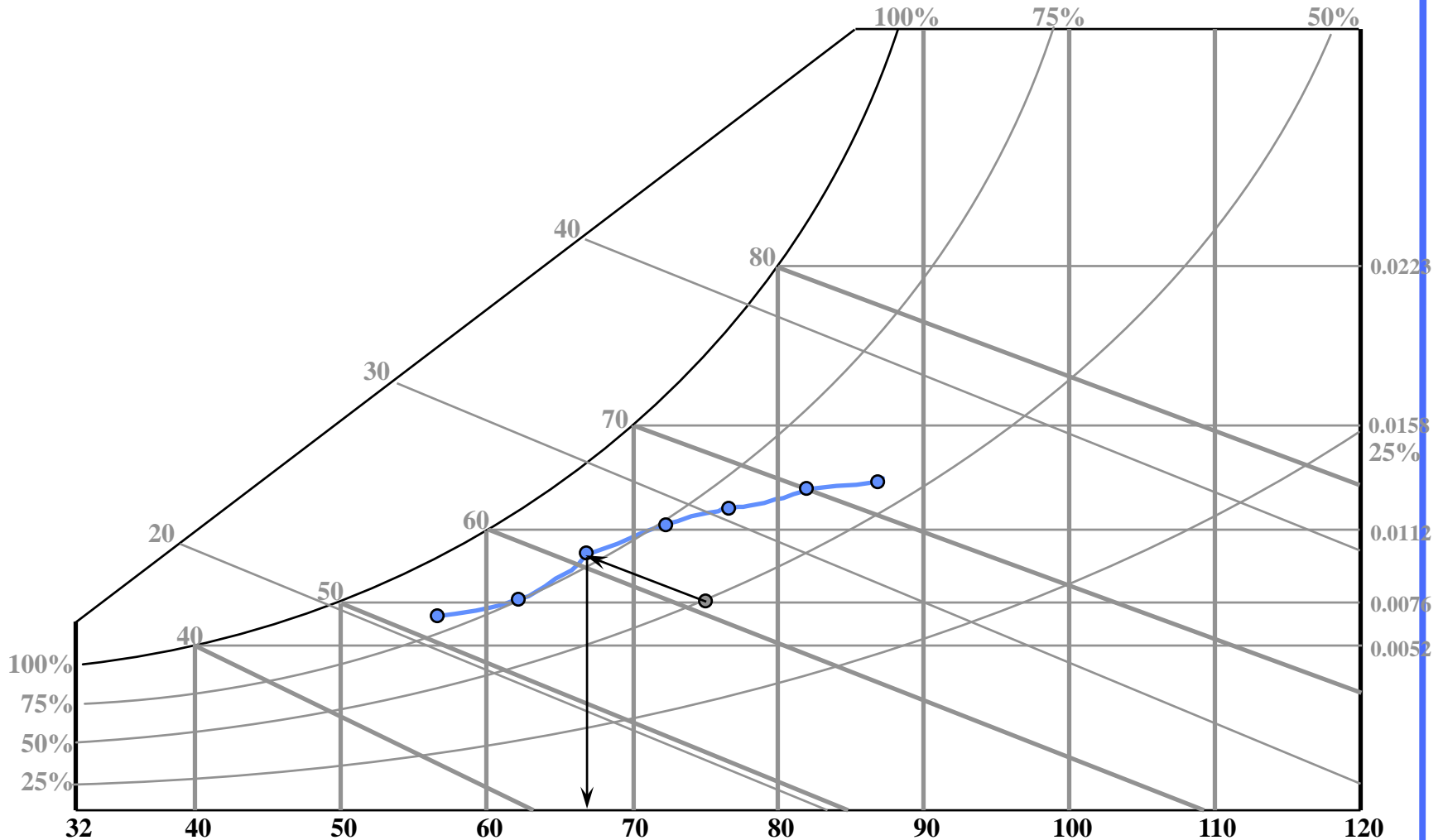
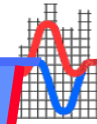
# Weather Data For Des Moines, IA



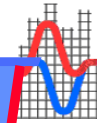
<u>Dry bulb temp</u>	<u>MCWB</u>	<u>Hrs / Year</u>
57	52	602
62	56	711
67	61	762
72	64	719
77	67	552
82	70	383
87	72	209

**MCWB: Mean coincident wet bulb temperature**

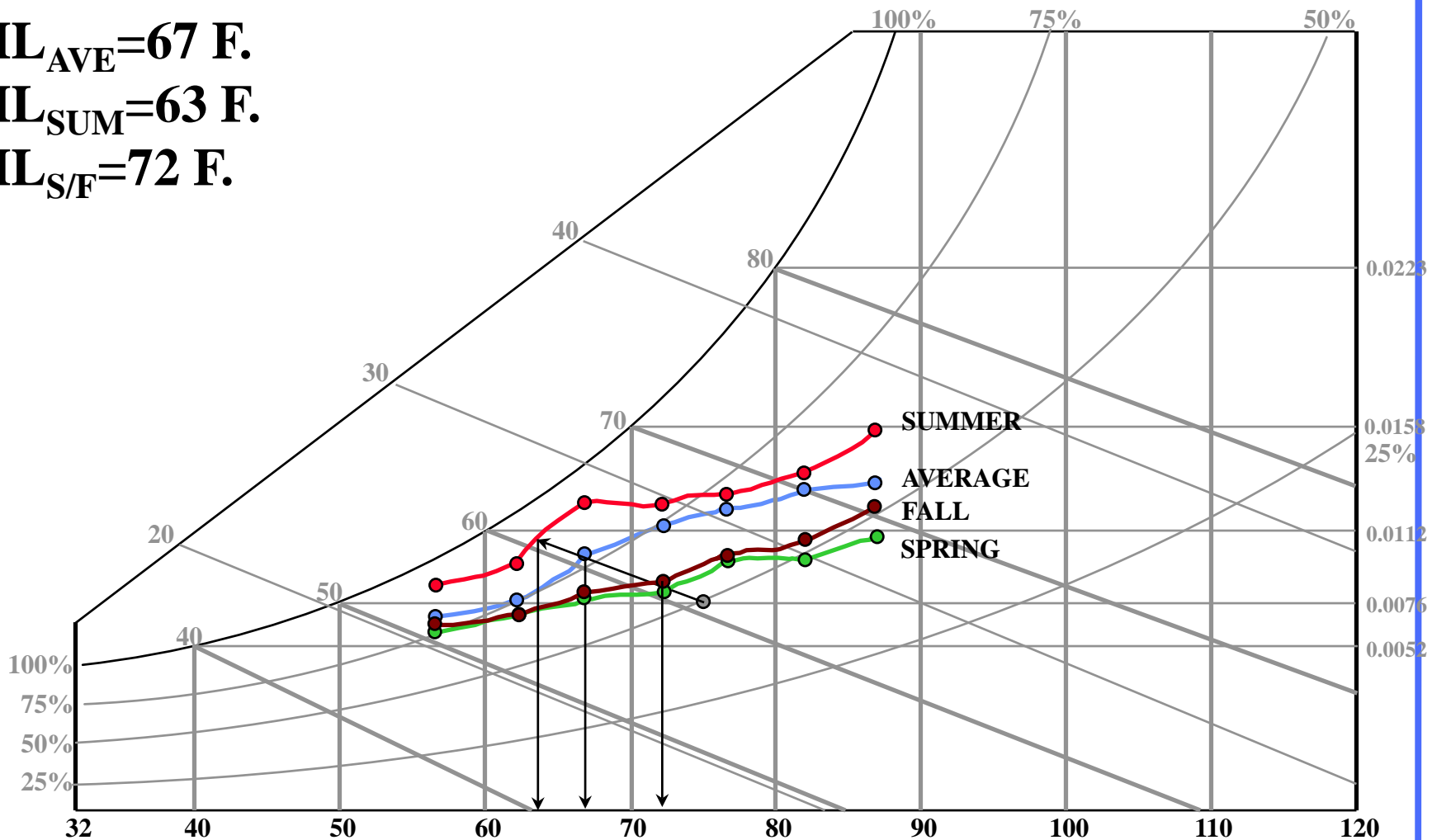
# Plot of Weather Conditions



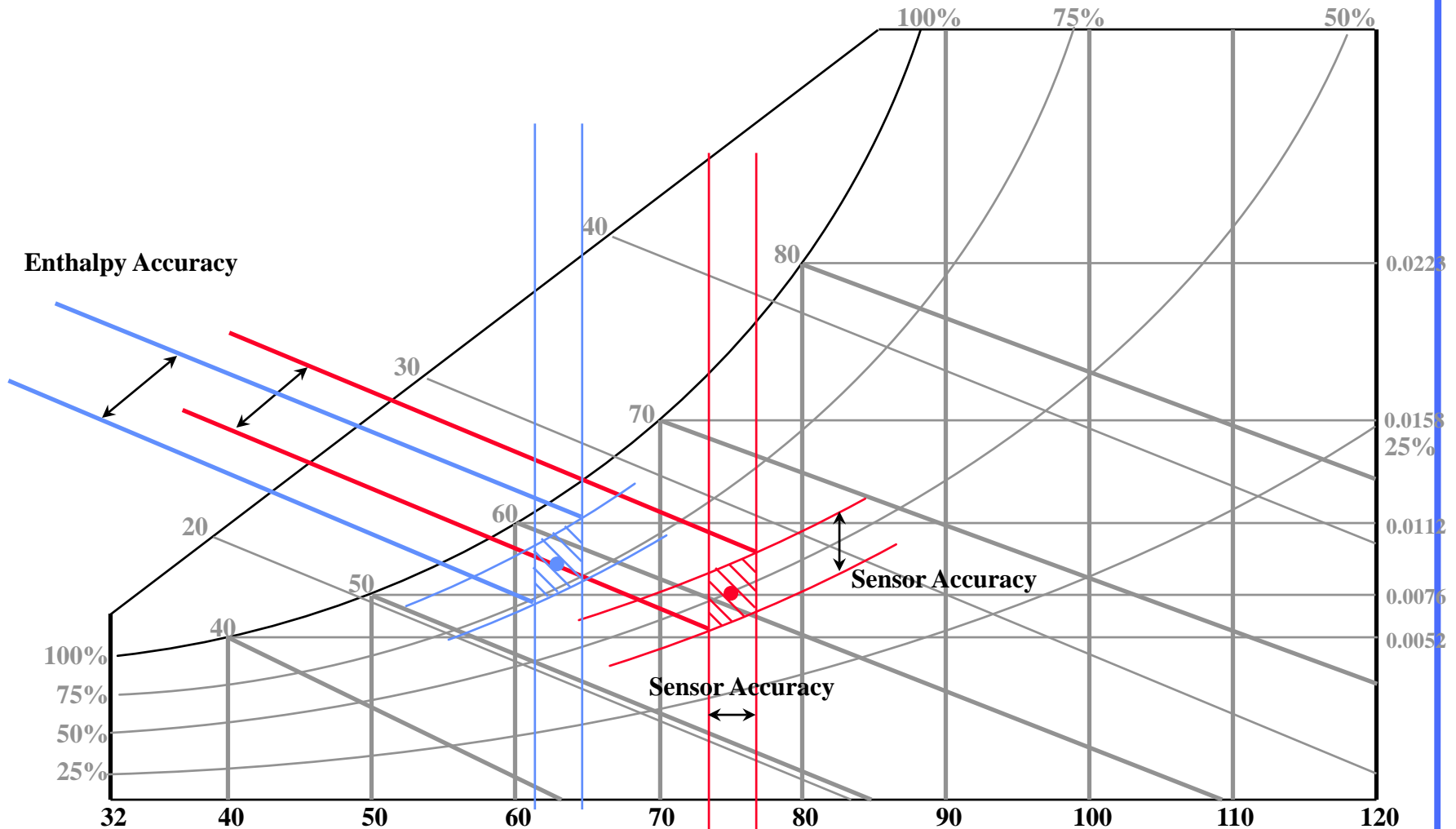
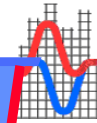
# Seasonal Weather Conditions



$HL_{AVE}=67\text{ F.}$   
 $HL_{SUM}=63\text{ F.}$   
 $HL_{S/F}=72\text{ F.}$

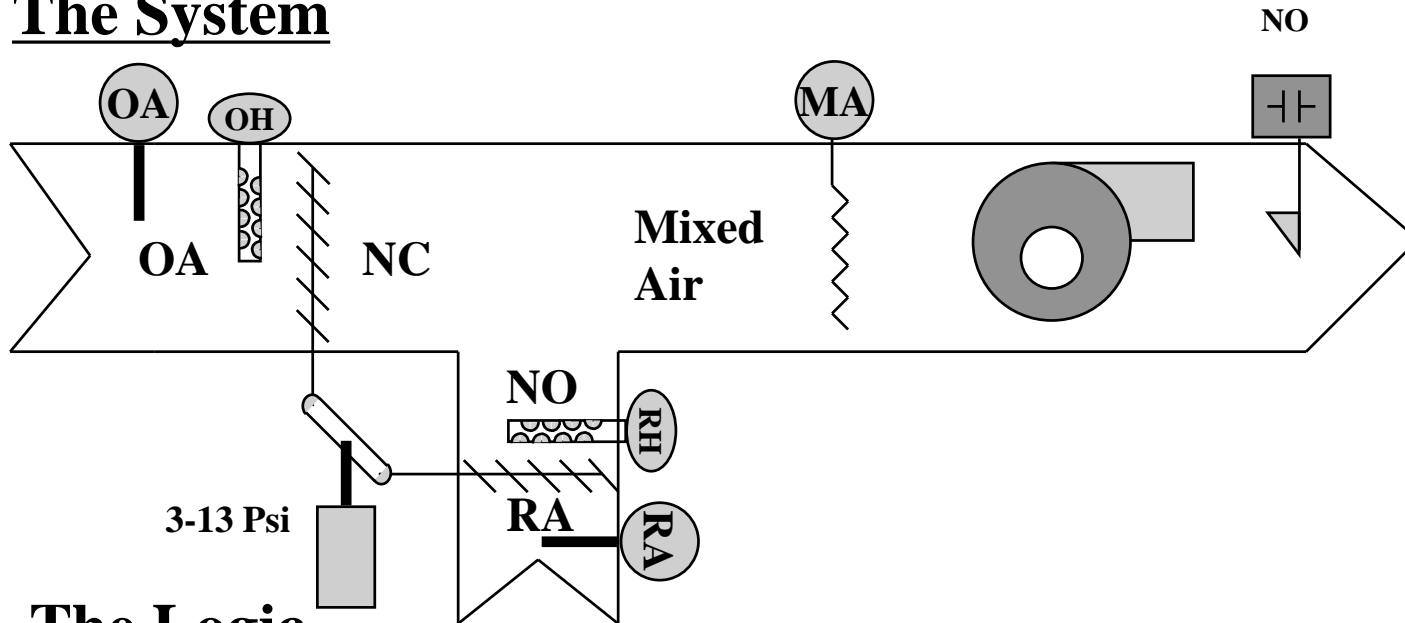


# Enthalpy Control



# Mixed Air w/ Enthalpy Comparison Economizer

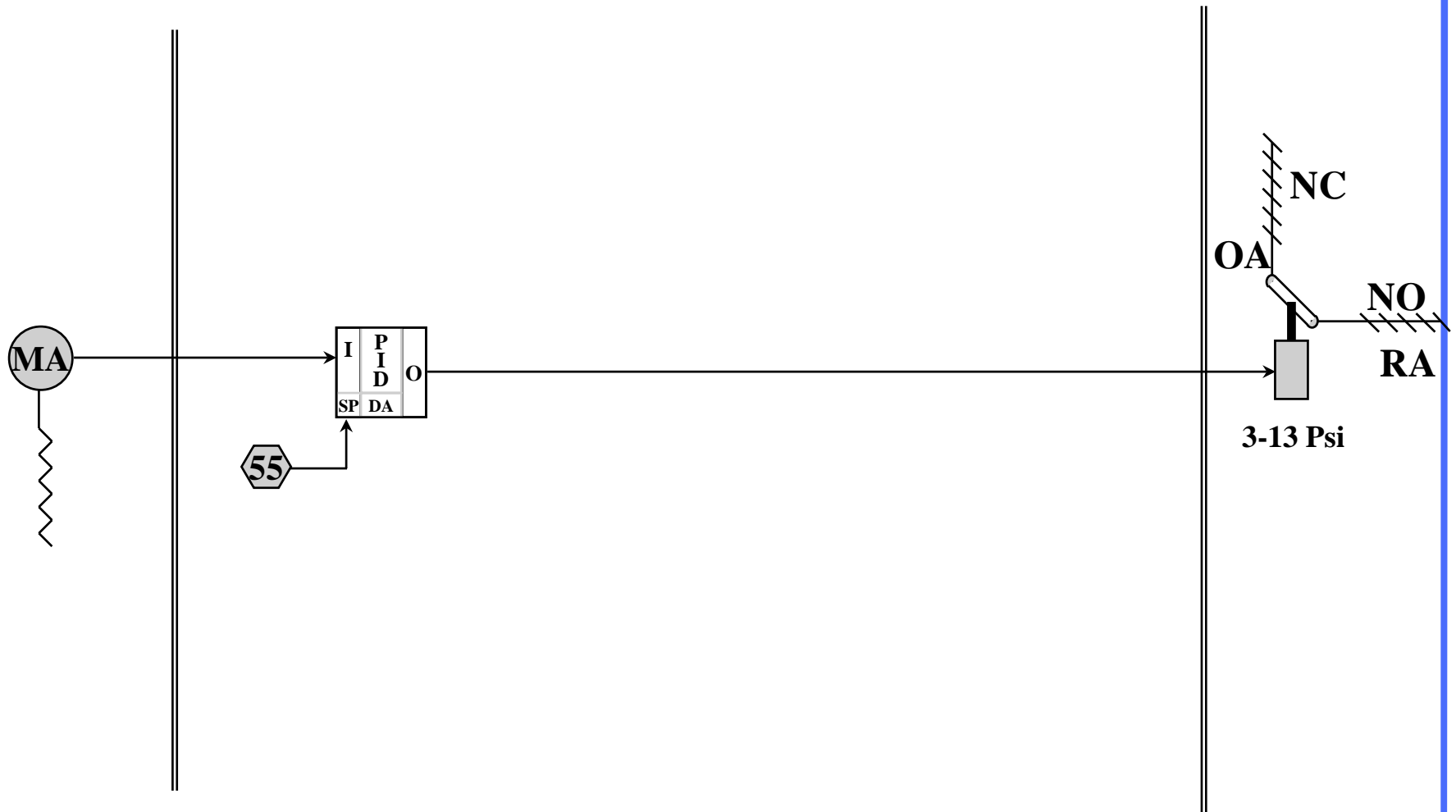
## The System

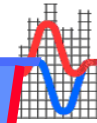


## The Logic

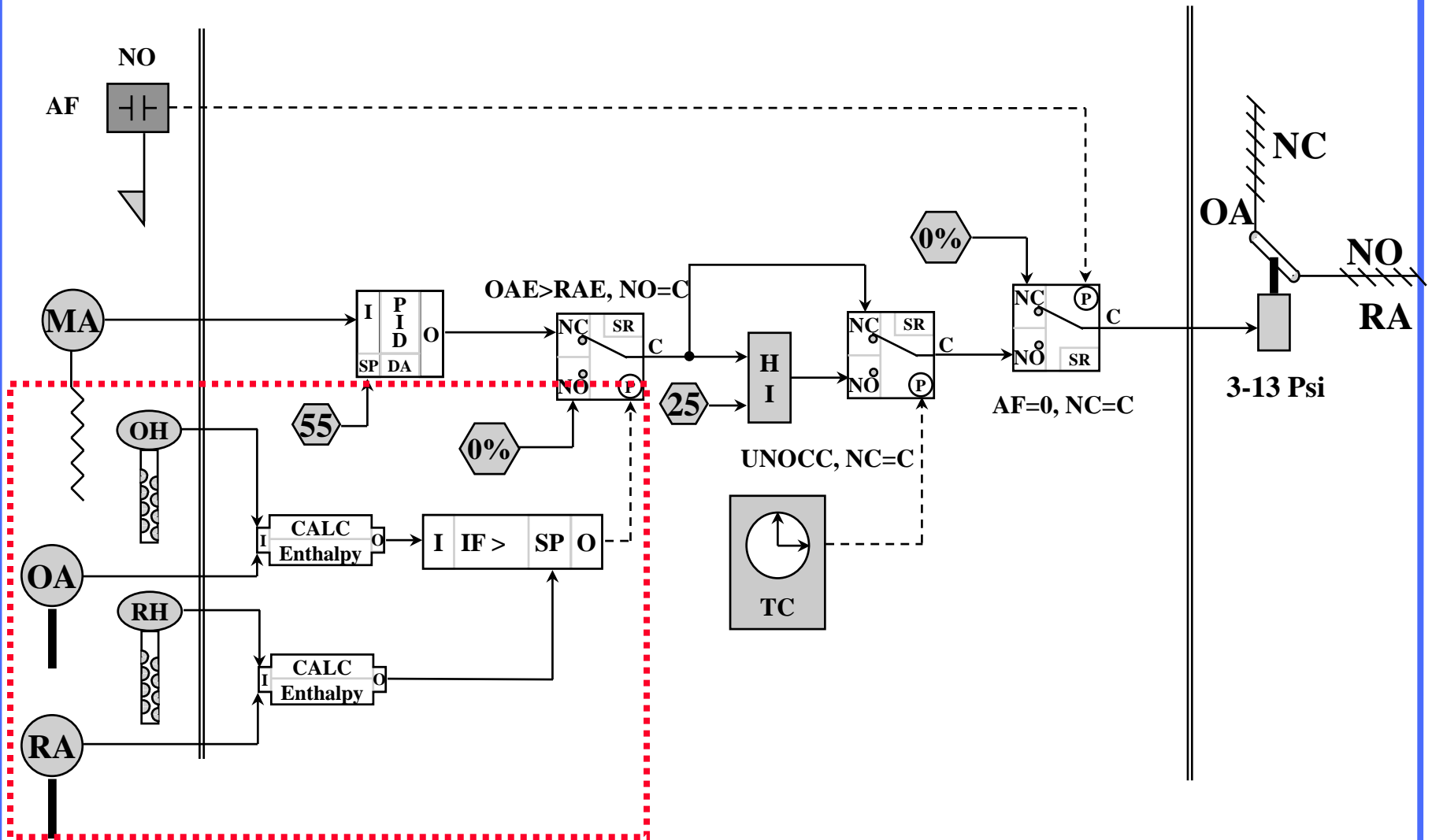
The mixed air dampers shall modulate to control a mixed air temperature of 55 F. +/- 3 F. The OA dampers will close on fan shut down. The OA dampers shall maintain 25% OA when the building is occupied. The OA dampers shall maintain minimum (occ.) or bypass minimum (unocc.) when the OA enthalpy exceeds the RA enthalpy with a 0.4 Btu/lb. differential.

# The Primary Control Loop





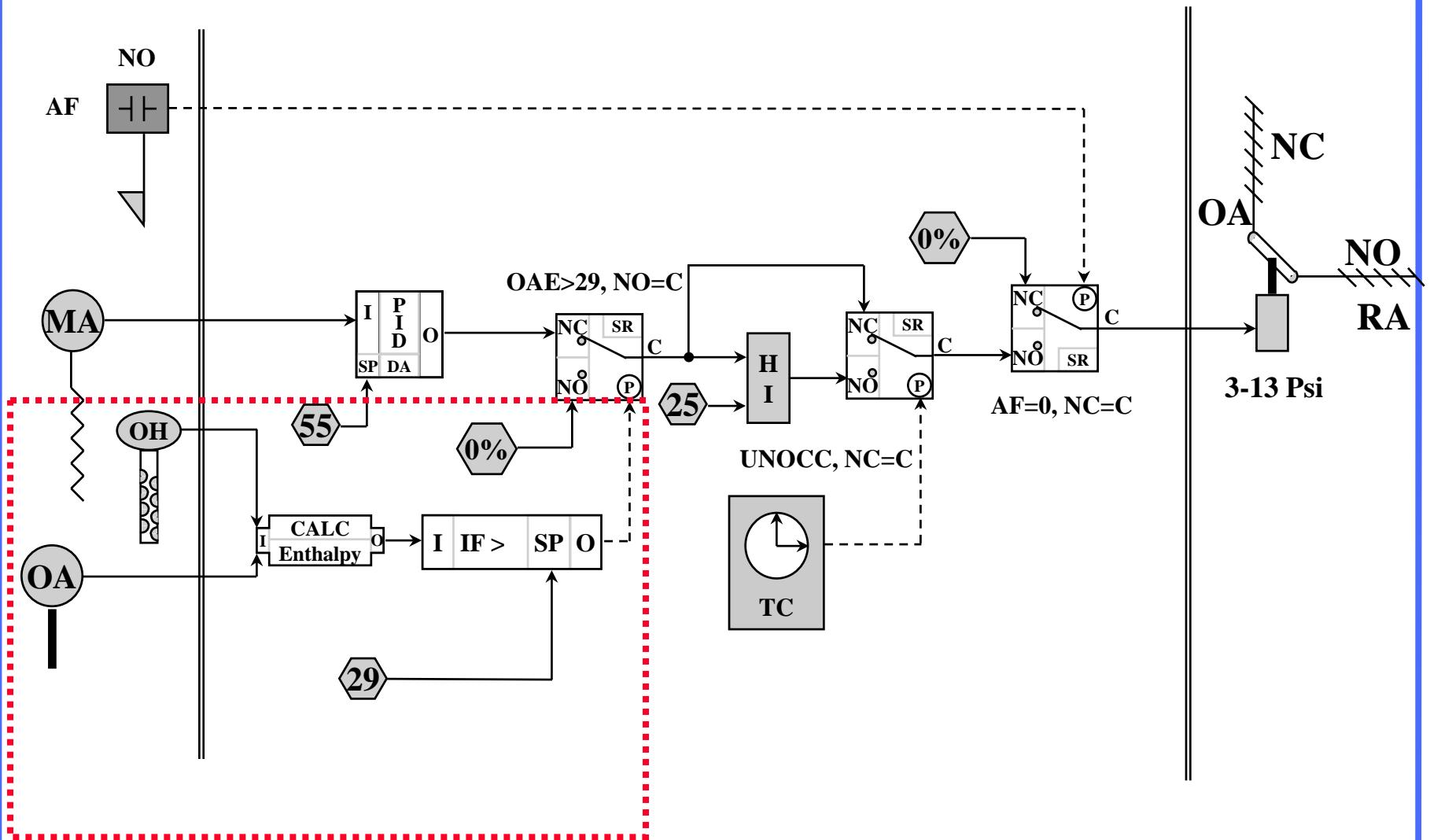
# Enthalpy High Limit



The diagram shows a pneumatic circuit. The main supply line includes a pressure-reducing valve (OA), a filter (OH), a check valve (NC), and a pressure gauge (MA). A solenoid valve (RA) is controlled by a 3-13 Psi pressure source. The system is labeled 'Mixed Air' and 'The Logic'.

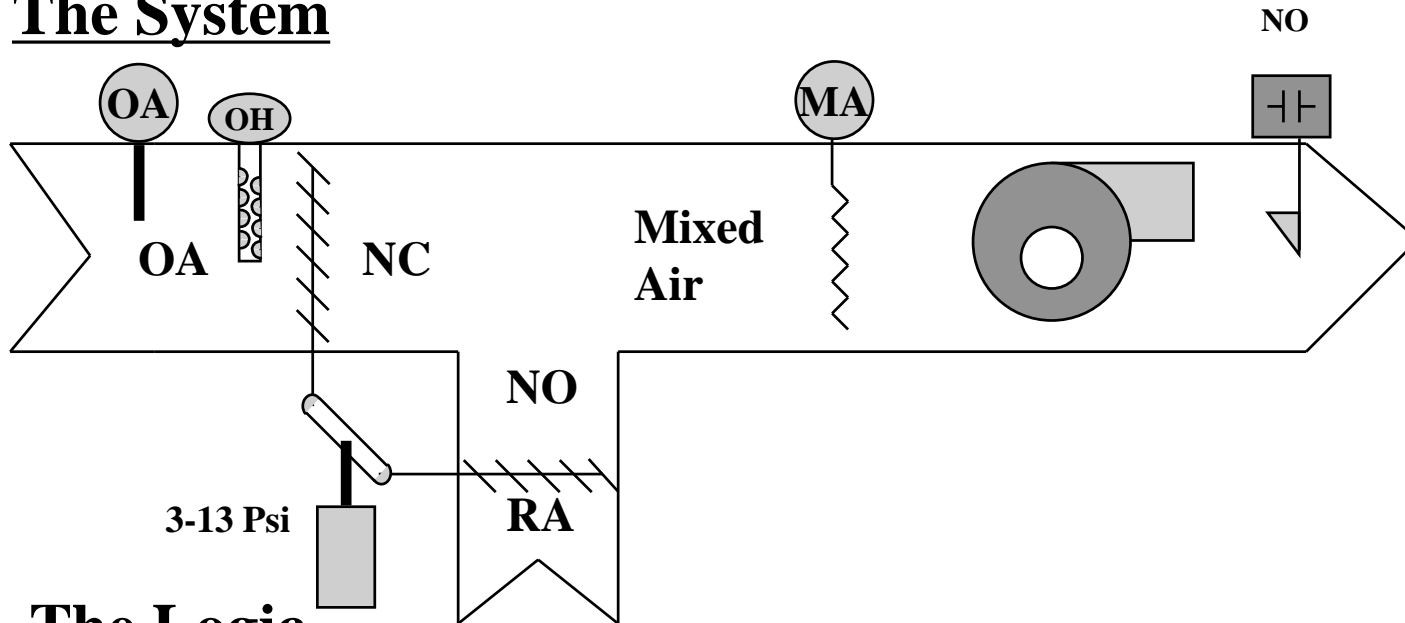
**The mixed air dampers shall modulate to control a mixed air temperature of 55 F. +/- 3 F. The OA dampers will close on fan shut down. The OA dampers shall maintain 25% OA when the building is occupied. The OA dampers shall maintain minimum (occ.) or bypass minimum (unocc.) when the OA enthalpy exceeds 29 Btu/lb. with a 1 Btu/lb. differential.**

# Enthalpy High Limit



# Mixed Air w/ OAT/RAT Comparison OR Enthalpy SP

## The System

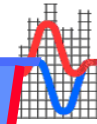


## The Logic

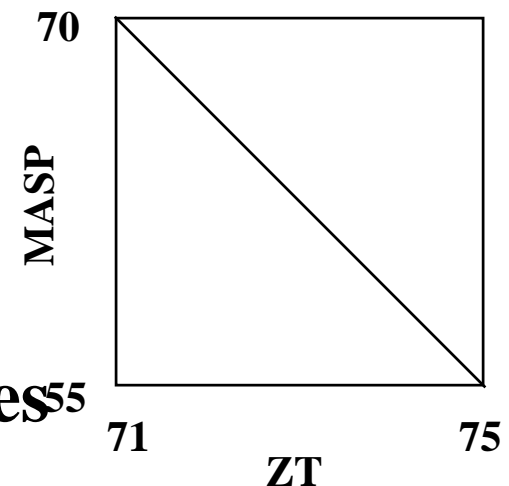
The mixed air dampers shall modulate to control a mixed air temperature of 55 F. +/- 3 F. The OA dampers will close on fan shut down. The OA dampers shall maintain Minimum OA when the building is occupied. The OA dampers shall maintain minimum (occ.) or bypass minimum (unocc.) when the OA temperature exceeds RA temperature (2 F. differential) or when the OA enthalpy is greater than 28 Btu/# (0.5 Btu/# differential).



# Zone Reset of Mixed Air Section

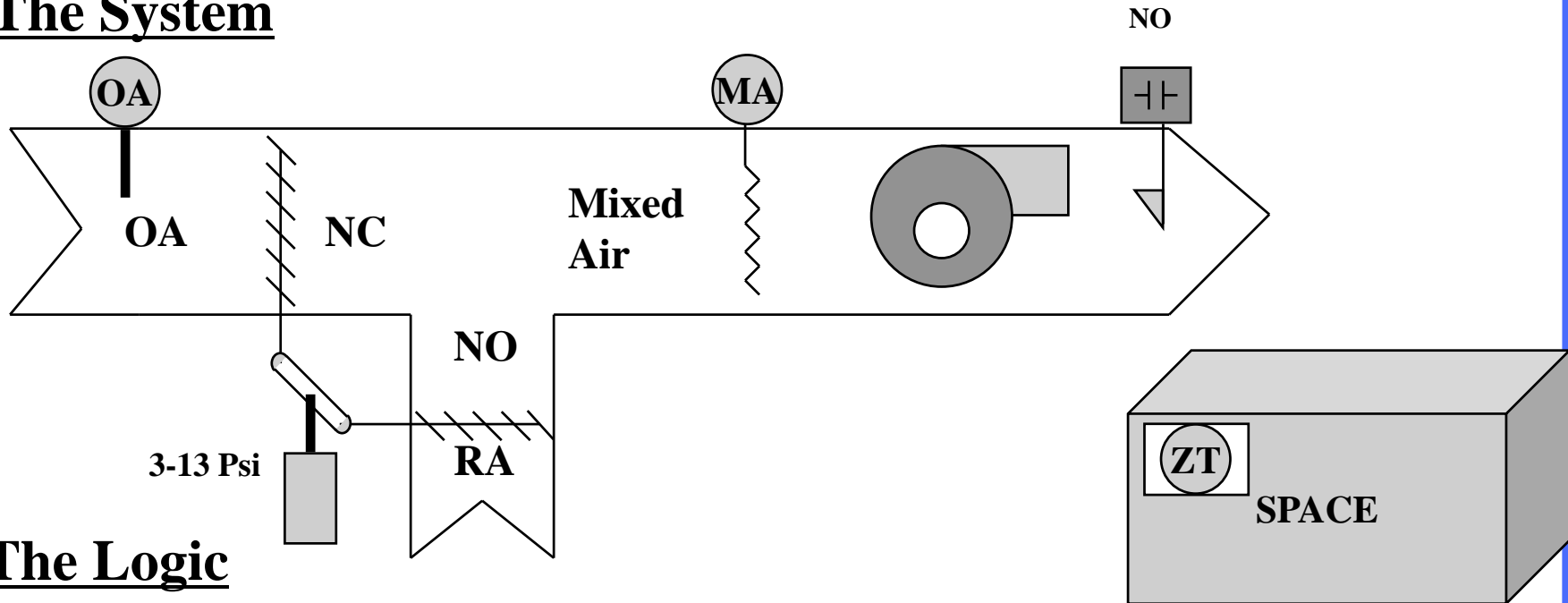


- Under light loads in the space when the outside air is cool, it is possible for the mixed air section to provide more cooling than is required.
- To match the cooling capacity of the mixed air section with the load, zone reset of the mixed air control loop is incorporated into the strategy.
- This reverse reset strategy requires<sup>55</sup> a reset schedule with a minimum setpoint limit be incorporated into the logic.



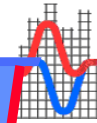
# Zone Reset of Mixed Air Section

## The System



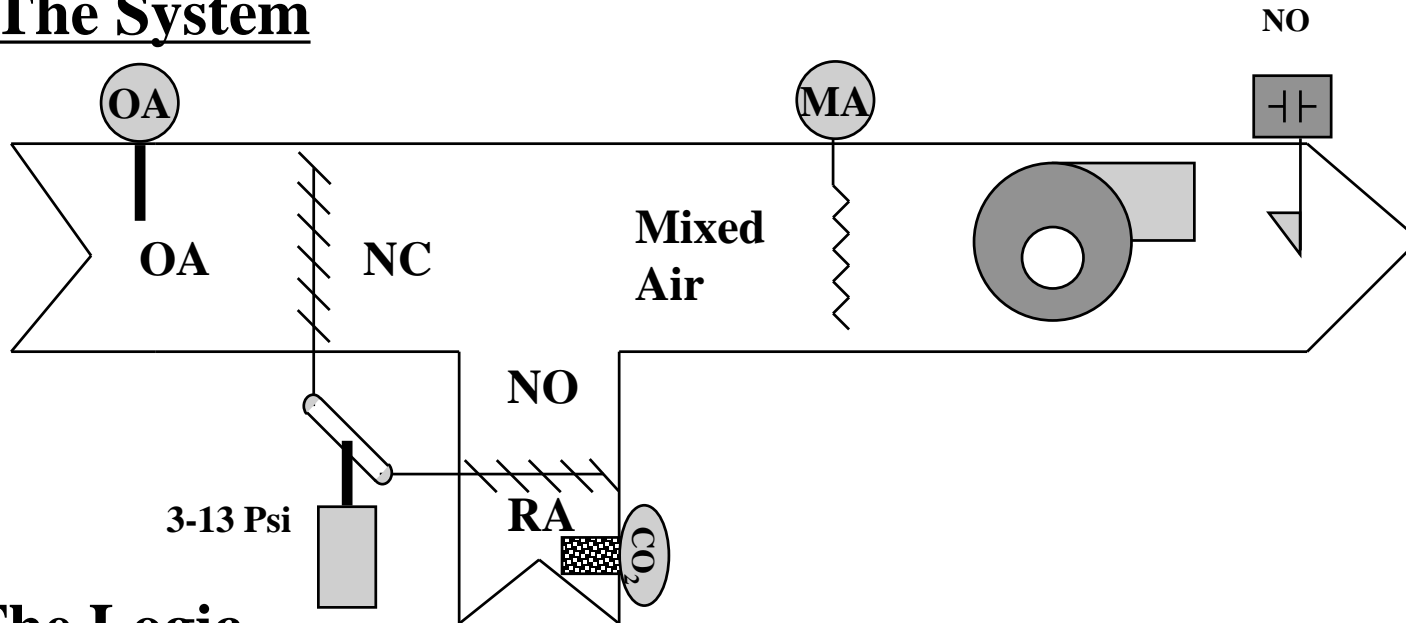
## The Logic

The mixed air dampers shall modulate to control a mixed air temperature SP which is reset based on the zone temperature. The OA dampers will close on fan shut down. The OA dampers shall maintain 25% OA when the building is occupied. The OA dampers shall maintain minimum (occ.) or bypass minimum (unocc.) when the OA temperature exceeds 68 F. with a 2 F. differential.



# Mixed Air w/ Dry Bulb Econ. & CO<sub>2</sub> Override of Minimum OA

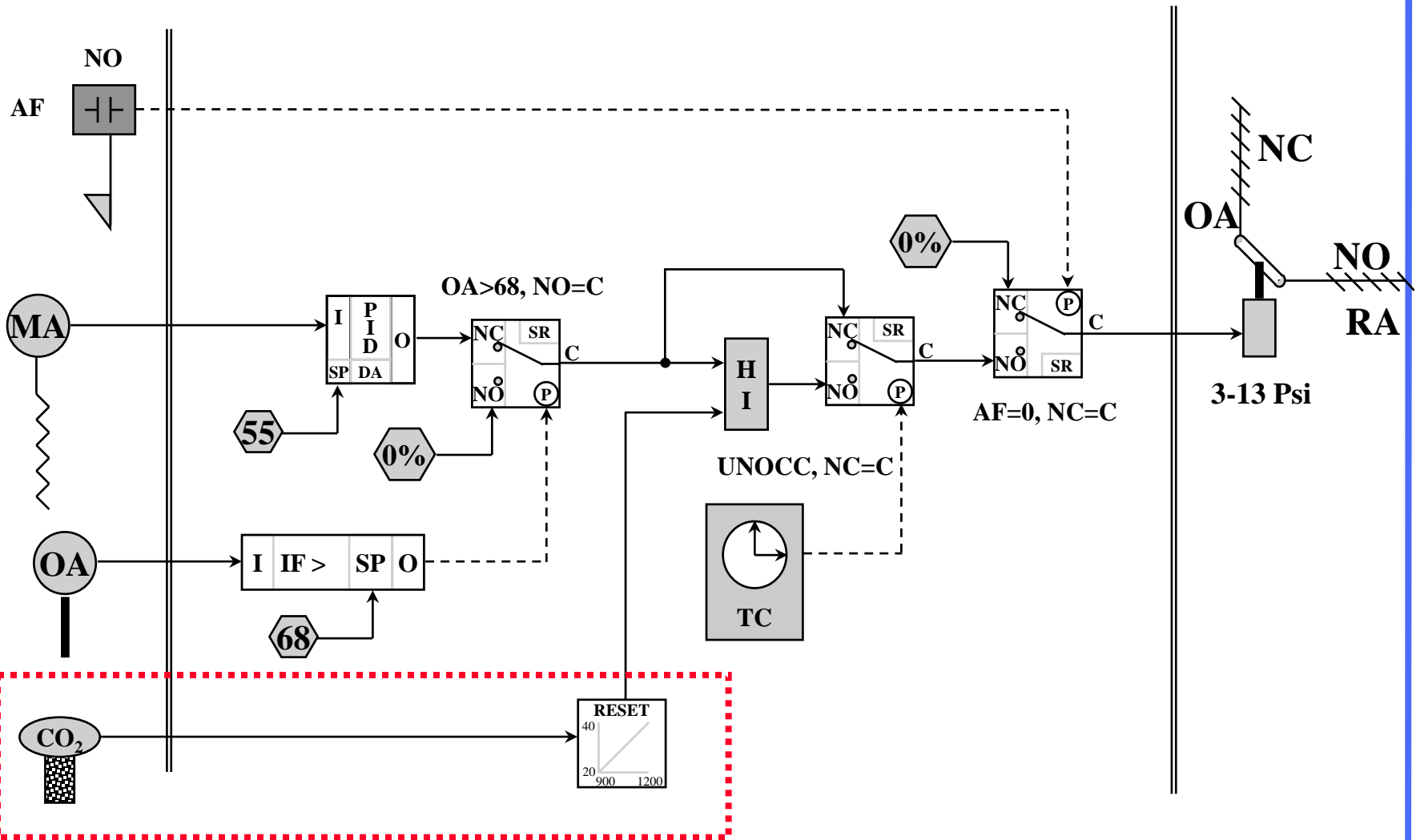
## The System



## The Logic

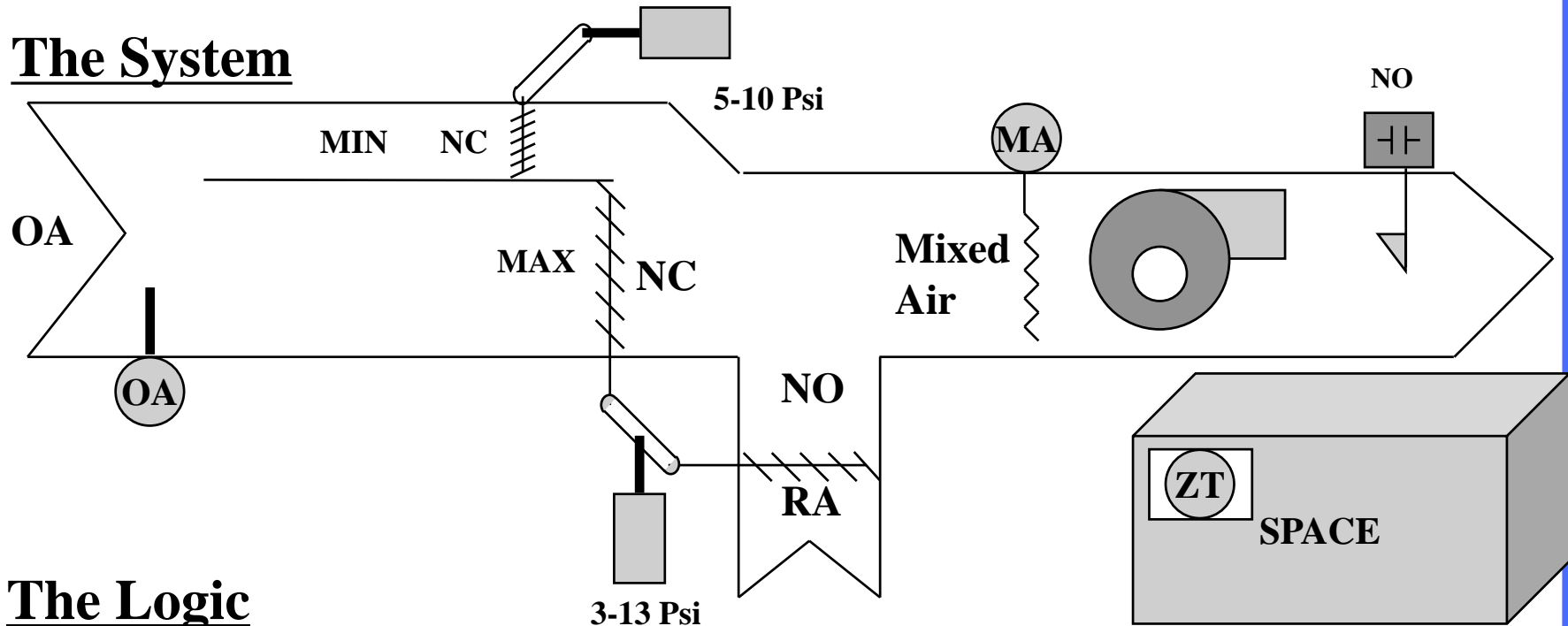
The mixed air dampers shall modulate to control a mixed air temperature of 55 F. +/- 3 F. The OA dampers will close on fan shut down. The OA dampers shall maintain Min. OA when the building is occupied. The OA Min SP shall be reset by RA CO<sub>2</sub>. The OA dampers shall maintain minimum (occ.) or bypass minimum (unocc.) when the OA temperature exceeds 68 F. with a 2 F. differential.

# Logic Diagram



# Minimum/Maximum OA Section

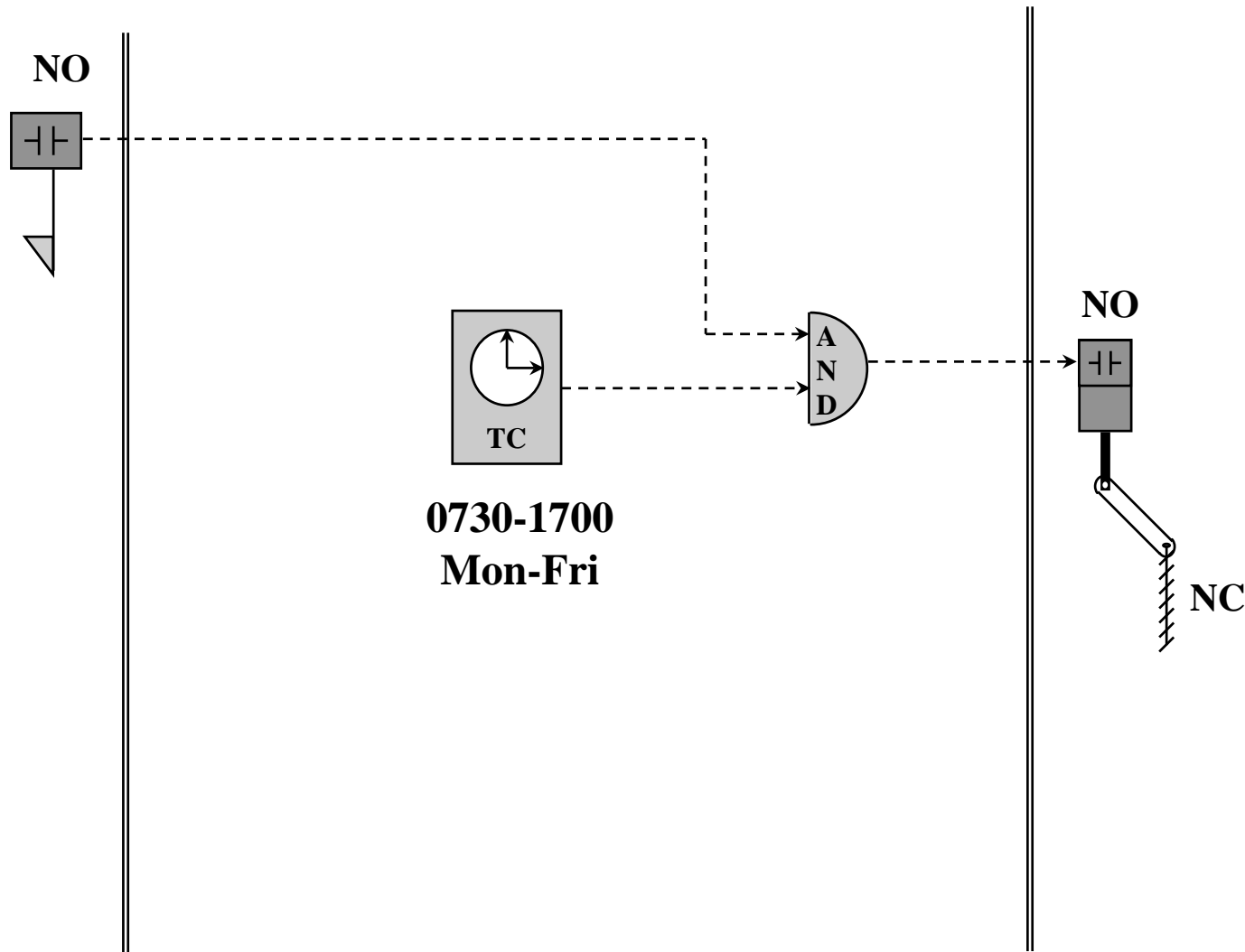
## The System



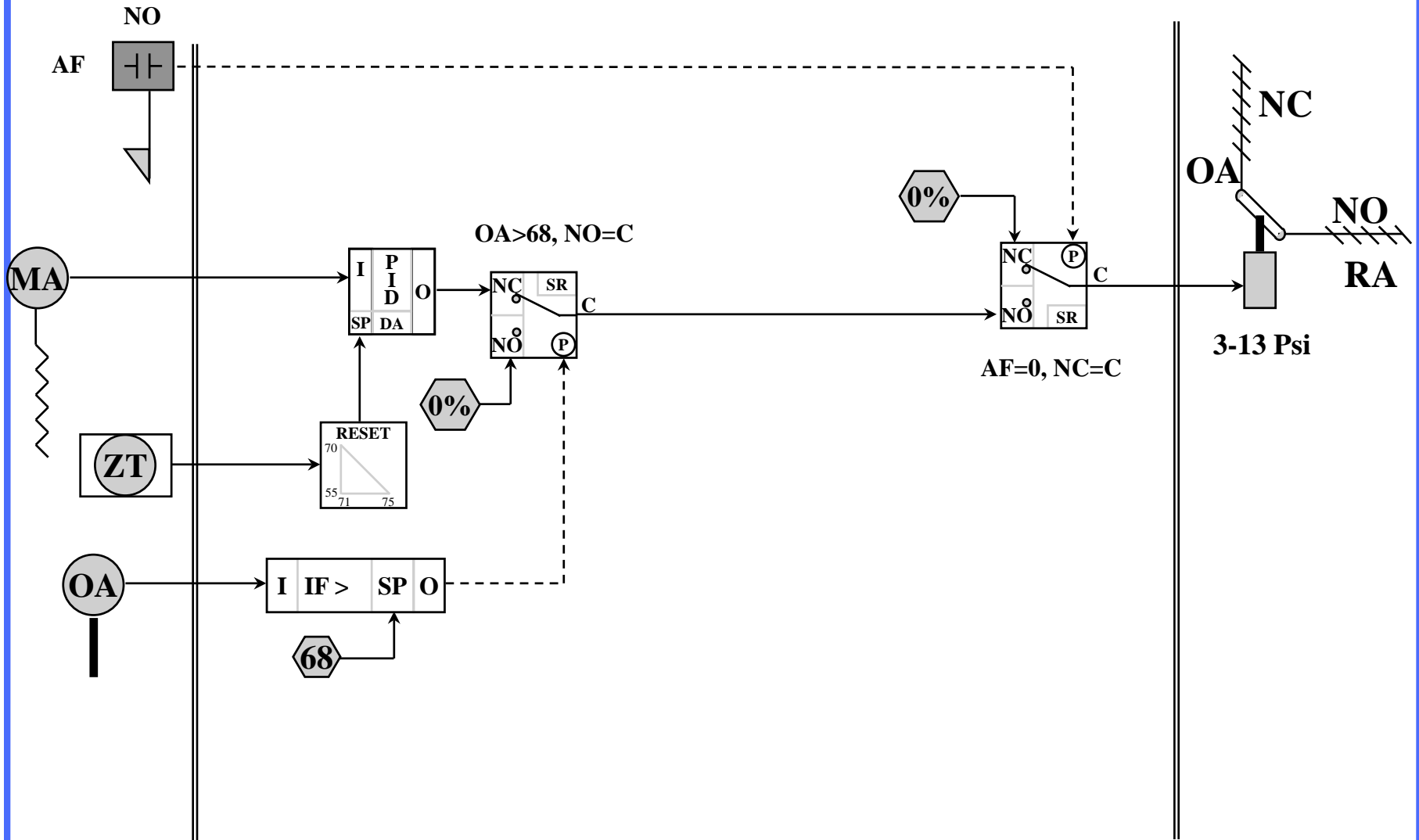
## The Logic

The Max OA and return air dampers shall modulate to control a mixed air temperature SP (MASP) which is reset based on the zone temperature. Both Max & Min OA dampers will close on fan shut down. The Min OA dampers shall open when the building is occupied. The Max dampers shall close when the OA temperature exceeds 68 F. with a 2 F. differential.

# Logic Diagram (Min Damper)



# Logic Diagram (Max Damper)



# Logic Diagram (Complete)

