

Fundamentals of DDC



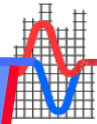
Constant Volume Systems



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

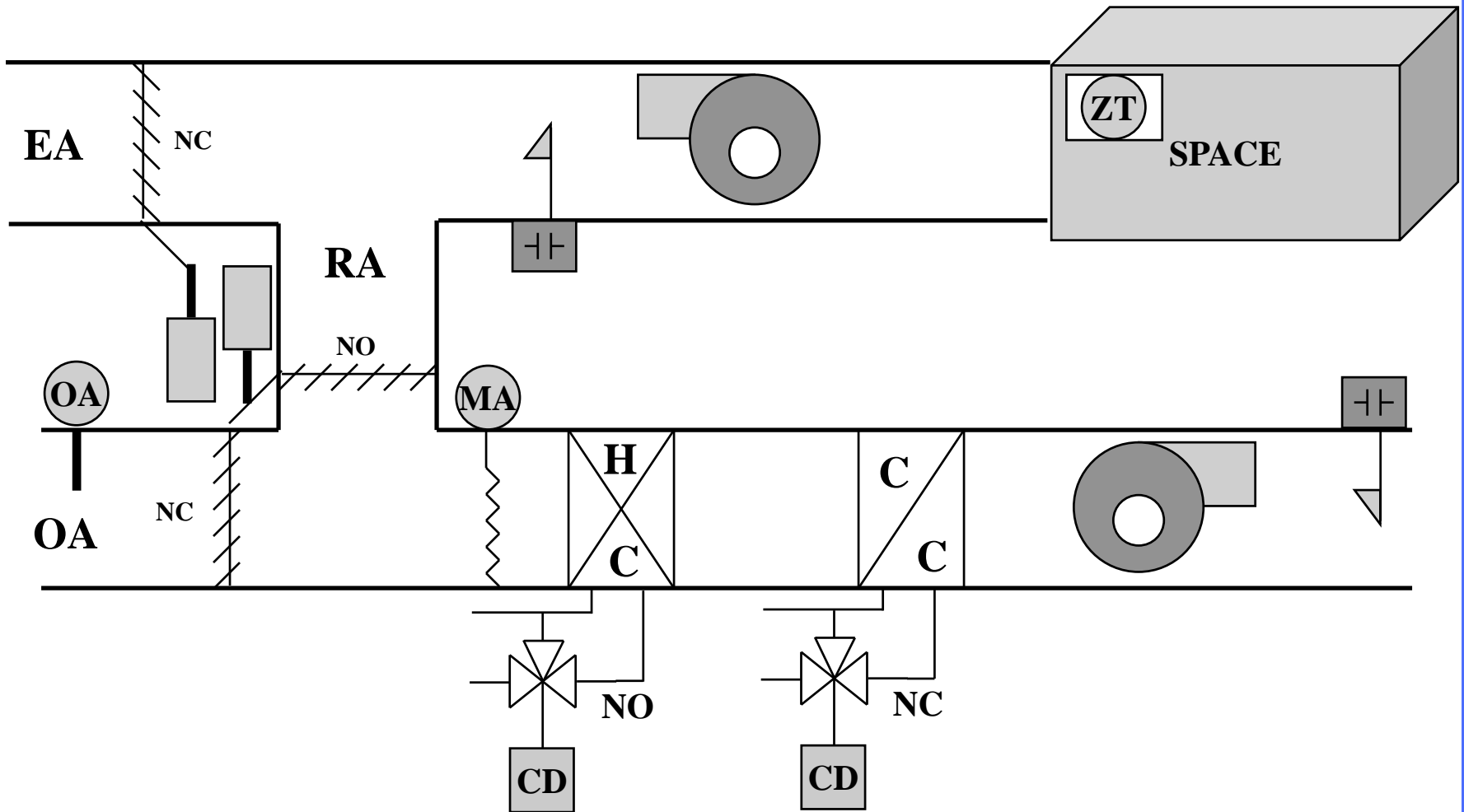
*6760 Alexander Bell Drive, Suite
200
Columbia, MD 21046
(410) 290-0900
jays@facilitydynamics.com*

Block Objective

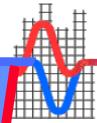


This is the first “Systems” block. The objective of this block is to introduce the concepts necessary to develop complete system control logic diagrams. Subsystem logic will be developed drawing on the previous course presentations. This will serve as a review of key subsystem sequences. The focus of this systems block will be in the communication between individual loops and the procedure necessary to develop complete system logic.

Single Zone System



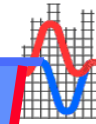
Single Zone



m Subsystems

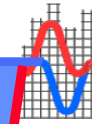
- q Heating
- q Cooling
- q Mixed Air
- q Supply Fan
- q Return Fan

The Control Logic



- ❑ The hot water valve shall modulate to control a zone air temperature of 70 F. +/- 2 F.
- ❑ The chilled water valve shall modulate to control a zone air temperature of 76 F. +/- 2 F.
- ❑ 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 20% 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.
- ❑ The supply fan runs based on a time schedule. During unoccupied periods, fans will run when space temperature drops below 60 F. or rises above 85 F.(with 3 F. differential) . The fan shall de-energize and latch off on a “proof” alarm or message from either fan.
- ❑ The return fan runs when the supply fan runs. The fan shall de-energize and latch off on a “proof” alarm or message from either fan.

Single Zone



m The Process

q Heating Coil

- | Proportional Control of HW valve, based on zone, variable SP table
- | Occupied, Fixed SP=70 F. with TR=4 F.
- | Unoccupied, Fixed SP=60 F. with TR=4 F.

q Cooling Coil

- | Proportional Control of CHW valve, based on zone, variable SP table
- | Occupied, Fixed SP=76 F. with TR=4 F.
- | Unoccupied, Fixed SP=85 F. with TR=4 F.

q Mixed Air Dampers

- | Proportional Control of OA/RA Dampers
- | Variable setpoint reset from zone with 6 F. TR
- | Reset Schedule

ZT	MASP
71	70
75	55

q Supply Fan Control

- | Two position control based on a time schedule or hi/lo zone temp

q Return Fan Control

- | Two position control based on a time schedule

Single Zone



m **Limits/Conditions**

- q **Heating Coil - None**
- q **Cooling Coil - None**
- q **Mixed Air Dampers**
 - | **Airflow**
 - | **High Limit of 68 F. with 2 F. differential**
 - | **Minimum OA of 20%**
 - | **Bypass minimum OA when unoccupied**
- q **Supply Fan Control**
 - | **Air Flow w/ Latch**
 - | **Return Fan w/Latch**
- q **Return Fan Control**
 - | **Air Flow w/ Latch**
 - | **Supply Fan w/Latch**

Single Zone



m **Measured Variables**

q **Heating Coil**

- | Zone temperature

q **Cooling Coil**

- | Zone temperature

q **Mixed Air Dampers**

- | Mixed air temperature
- | Outside air temperature
- | Zone temperature
- | Airflow
- | Time

q **Supply & Return Fan Control**

- | Time
- | Airflow

Single Zone



m **Communication**

q **Heating Coil**

- | **Cooling**

q **Cooling Coil**

- | **Heating**

q **Mixed Air Dampers**

- | **Cooling Coil**

- | **Fan Control**

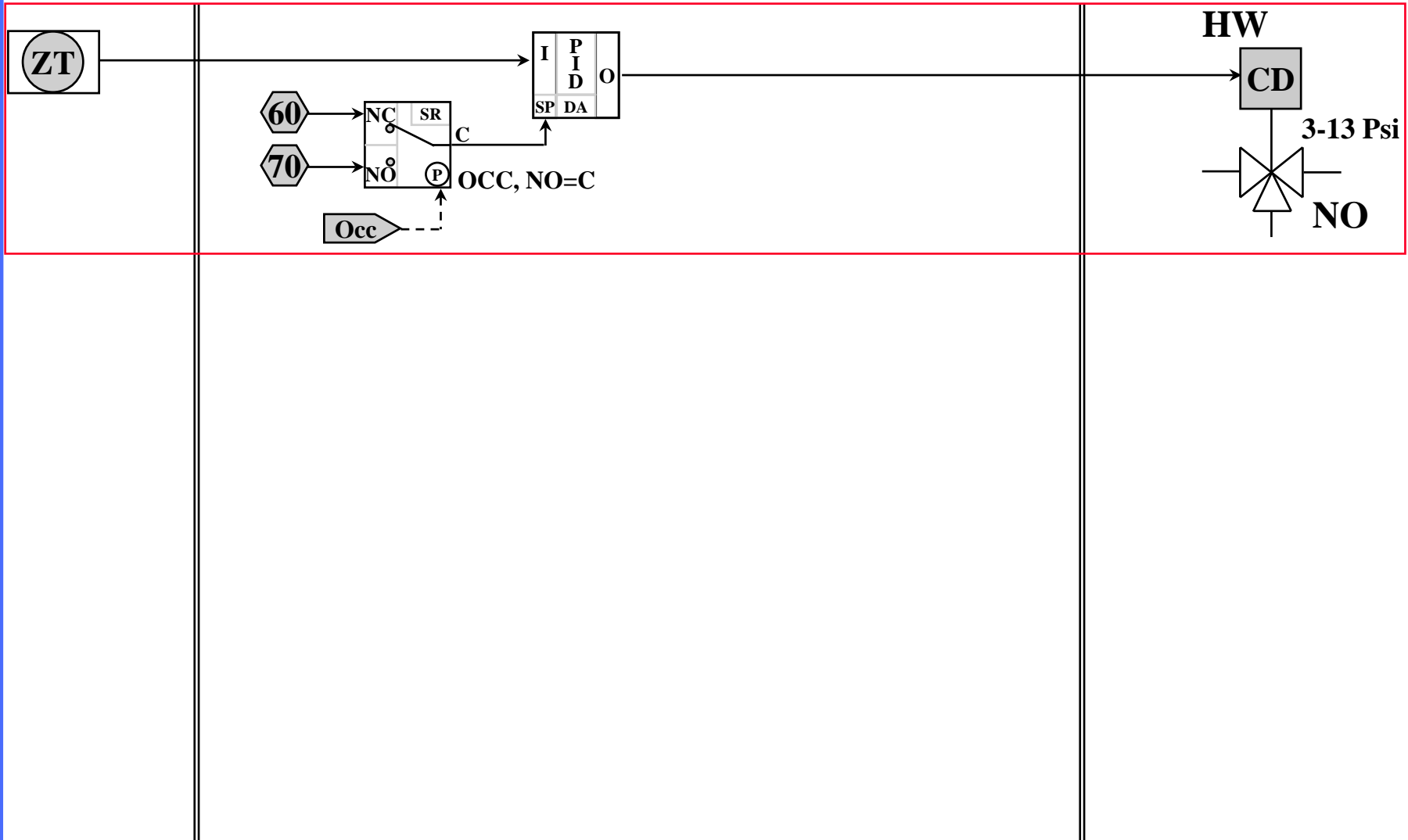
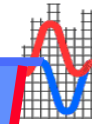
q **Supply Fan**

- | **Return Fan**

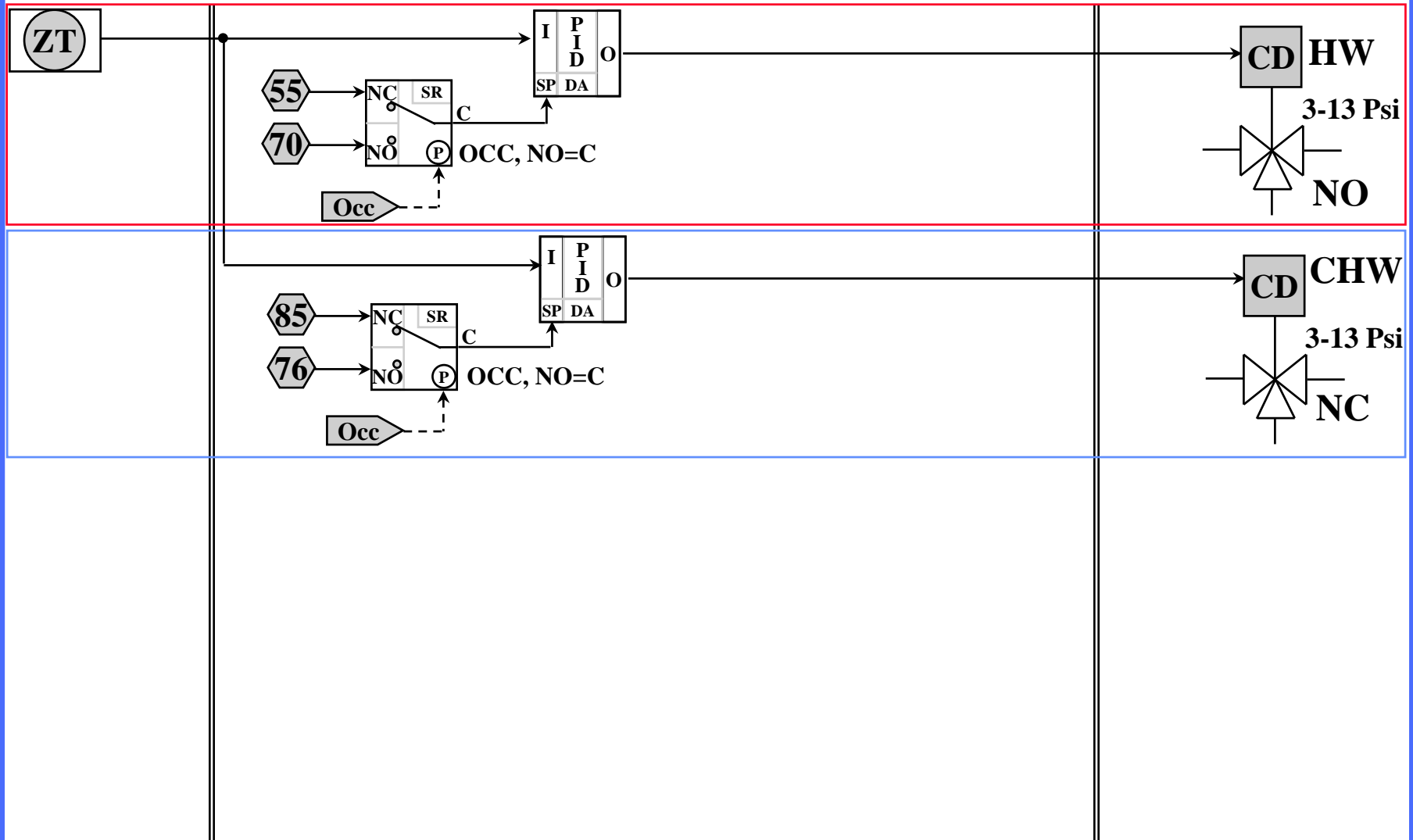
q **Return Fan**

- | **Supply Fan**

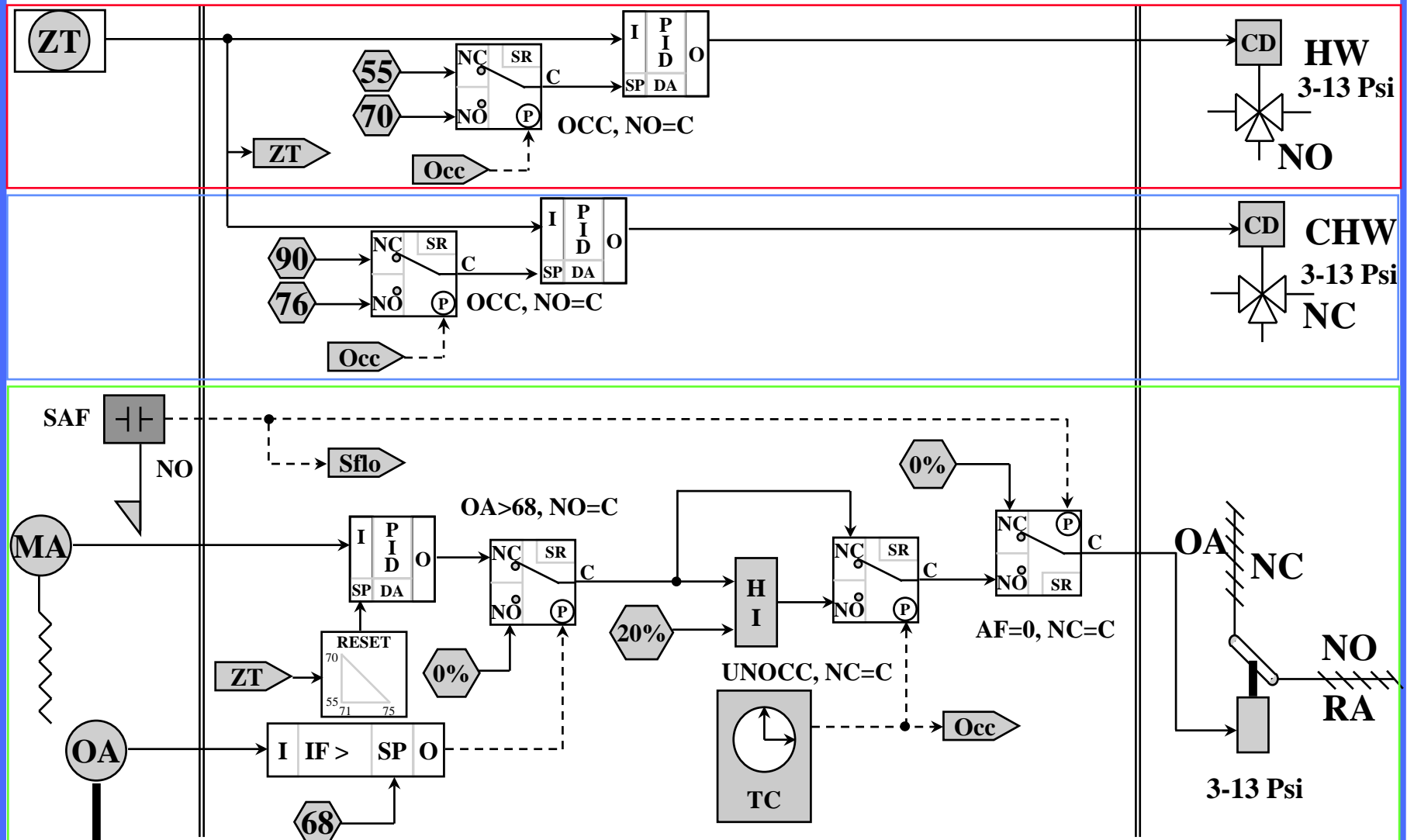
SZ Logic Diagram (heating)



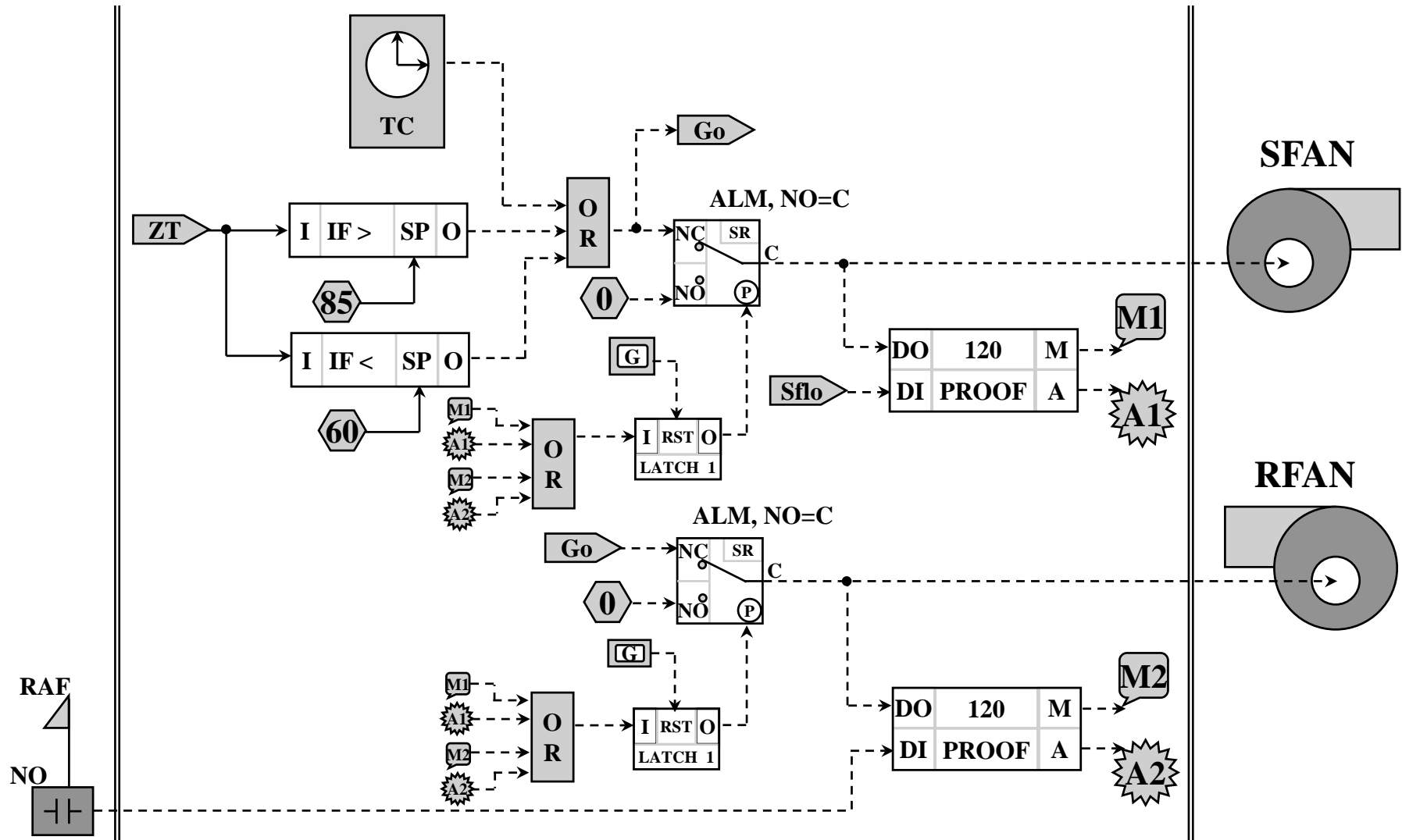
SZ Logic Diagram (cooling)



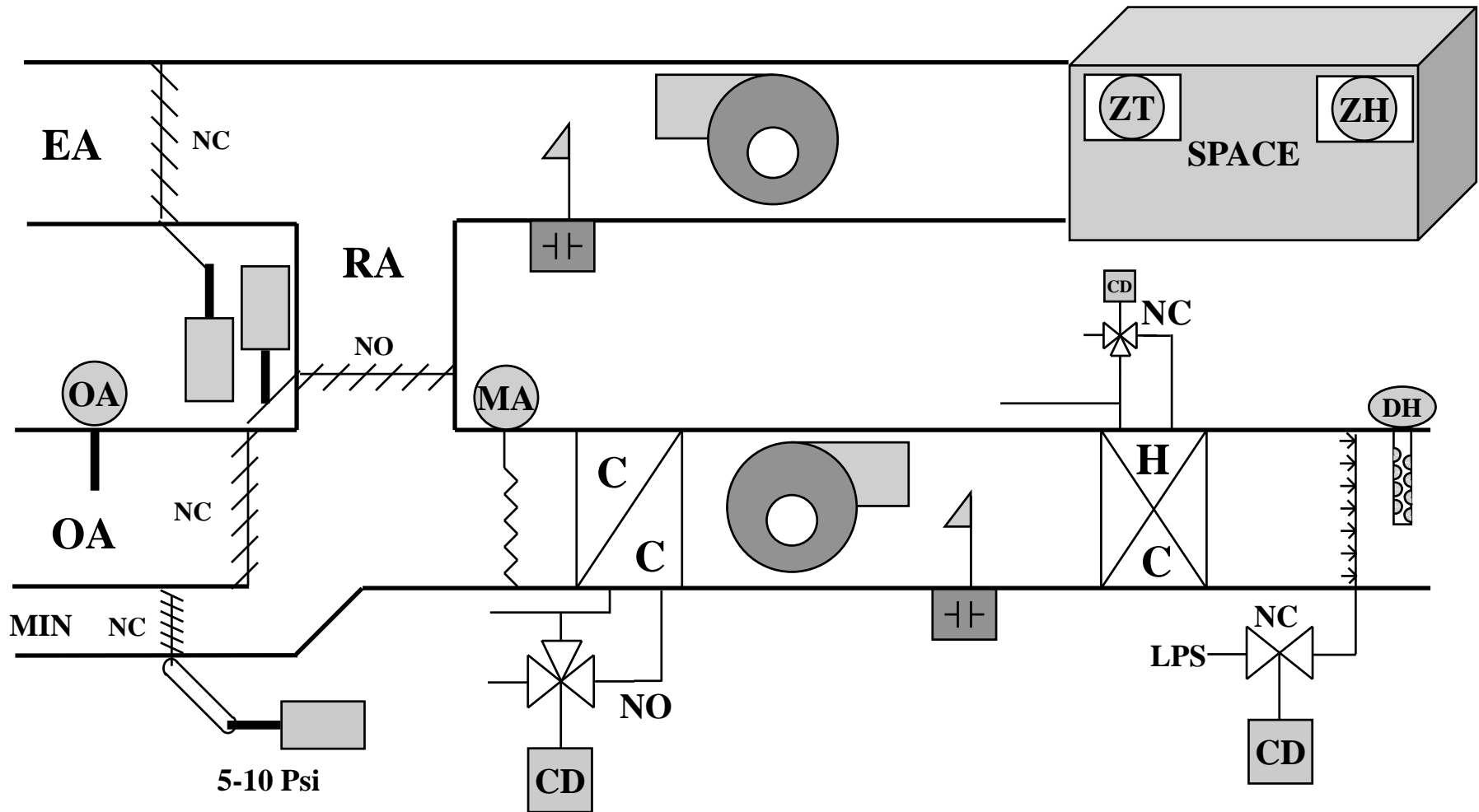
SZ Logic Diagram (mixed air)



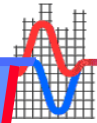
SZ Logic Diagram (fan control)



Single Zone Reheat w/ Humidity Control & Min/Max OA



Single Zone Reheat w/ Humidity Control & Min/Max OA



m Subsystems

- q Maximum OA Dampers/RA Dampers
- q Minimum OA Damper
- q Cooling Coil
- q Reheat Coil
- q Humidifier
- q Supply Fan
- q Return Fan

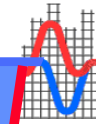
Single Zone Reheat w/ Humidity Control & Min/Max OA



The Logic

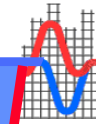
- ▣ The Max OA and return air dampers shall modulate to control a mixed air temperature SP (MASP) which is reset based on the zone temperature. Both Max & Min OA dampers will close on fan shut down. The Min OA dampers shall open when the building is occupied. The Max dampers shall close when the OA temperature exceeds 68 F. with a 2 F. differential.
- ▣ The chilled water valve shall modulate chilled water to maintain a space temperature of 72 F. +/- 2 F. or a space humidity of 50% RH +/- 5% RH air SP whichever demand is greater during occupied periods. When the fan runs during unoccupied periods, the SP shall be 80 F.
- ▣ The reheat coil valve shall modulate to maintain the 72 F. +/- 2 F. space temperature during occupied periods. When the fan runs during unoccupied periods, the SP shall be 62 F.

Single Zone Reheat w/ Humidity Control & Min/Max OA



- The humidifier steam valve shall modulate to control a space humidity of 50% RH +/- 5 %RH. The valve shall close on a rise of discharge humidity above 85% or if there is no air flow.
- The supply fan runs based on a time schedule. During unoccupied periods, fans will run when space temperature drops below 62 F. or rises above 80 F (with 3 F. differential). The fan shall de-energize and latch off on a “proof” alarm or message from either fan. During unoccupied periods, chilled water valve will be controlled based on temperature only. Humidifier shall remain off.
- The return fan runs when the supply fan runs. The fan shall de-energize and latch off on a “proof” alarm or message from either fan.

Single Zone Reheat w/ Humidity Control & Min/Max OA



m The Process

q Max OA & RA Dampers

- | Proportional Control of OA/RA Dampers, variable SP
- | Variable setpoint reset from zone with 6 F. TR
- | Reset Schedule

ZT	MASP
71	70
75	55

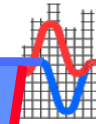
q Min OA Damper

- | 2 position control based on time schedule

q CHW Coil

- | Proportional control of the chilled water valve, based on higher demand of two control variables, variable setpoint
- | Setpoint table Occ SP=72 F., Unocc SP=80 F. with 4 F. TR
- | Fixed Zone humidity SP=50% RH with 10% RH TR

Single Zone Reheat w/ Humidity Control & Min/Max OA



m **The Process (cont.)**

q **Reheat Coil**

- | Proportional control of reheat coil valve based on zone, variable SP
- | Setpoint table Occ SP=72 F., Unocc SP=62 F. with 4 F. TR

q **Humidifier**

- | Proportional Control of Steam Valve, based on zone humidity, fixed SP
- | Fixed setpoint of 50% RH with 10% TR

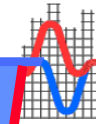
q **Supply Fan Control**

- | Two position control based on a time schedule or hi/lo zone temp

q **Return Fan Control**

- | Two position control based on a time schedule

Single Zone Reheat w/ Humidity Control & Min/Max OA



m **Limits/Conditions**

q **Max OA & RA Dampers**

- | **Airflow**
- | **High Limit of 65 F. with 2 F. differential**

q **Min OA Damper**

- | **Airflow**
- | **Bypass minimum OA when unoccupied**

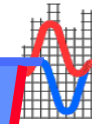
q **CHW Coil - None**

q **Reheat Coil - None**

q **Humidifier**

- | **Fan Proof**
- | **Discharge Humidity less than 85% RH**

Single Zone Reheat w/ Humidity Control & Min/Max OA



m **Limits/Conditions (cont.)**

q **Supply Fan Control**

- | Air Flow w/ Latch
- | Return Fan w/Latch

q **Return Fan Control**

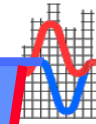
- | Air Flow w/ Latch
- | Supply Fan w/Latch

m **Measured Variables**

q **Max OA & RA Dampers**

- | Mixed air temperature
- | Outside air temperature
- | Zone temperature
- | Airflow

Single Zone Reheat w/ Humidity Control & Min/Max OA



m Measured Variables (cont.)

q Min OA Damper

- | Airflow
- | Time

q CHW Coil

- | Space Temperature
- | Space Humidity

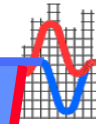
q Reheat Coil

- | Space Temperature

q Humidifier

- | Space Humidity
- | Discharge Humidity
- | Airflow

Single Zone Reheat w/ Humidity Control & Min/Max OA



m Measured Variables (cont.)

q Supply & Return Fan Control

- | Time
- | Airflow

m Communication

q Max OA & RA Dampers

- | Zone Control Loop
- | Supply Fan

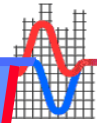
q Min OA Damper

- | Supply Fan

q CHW Coil - None

q Reheat Coil - Zone, via the thermodynamics of the system

Single Zone Reheat w/ Humidity Control & Min/Max OA



m **Communication (cont.)**

q **Humidifier**

| **Fan**

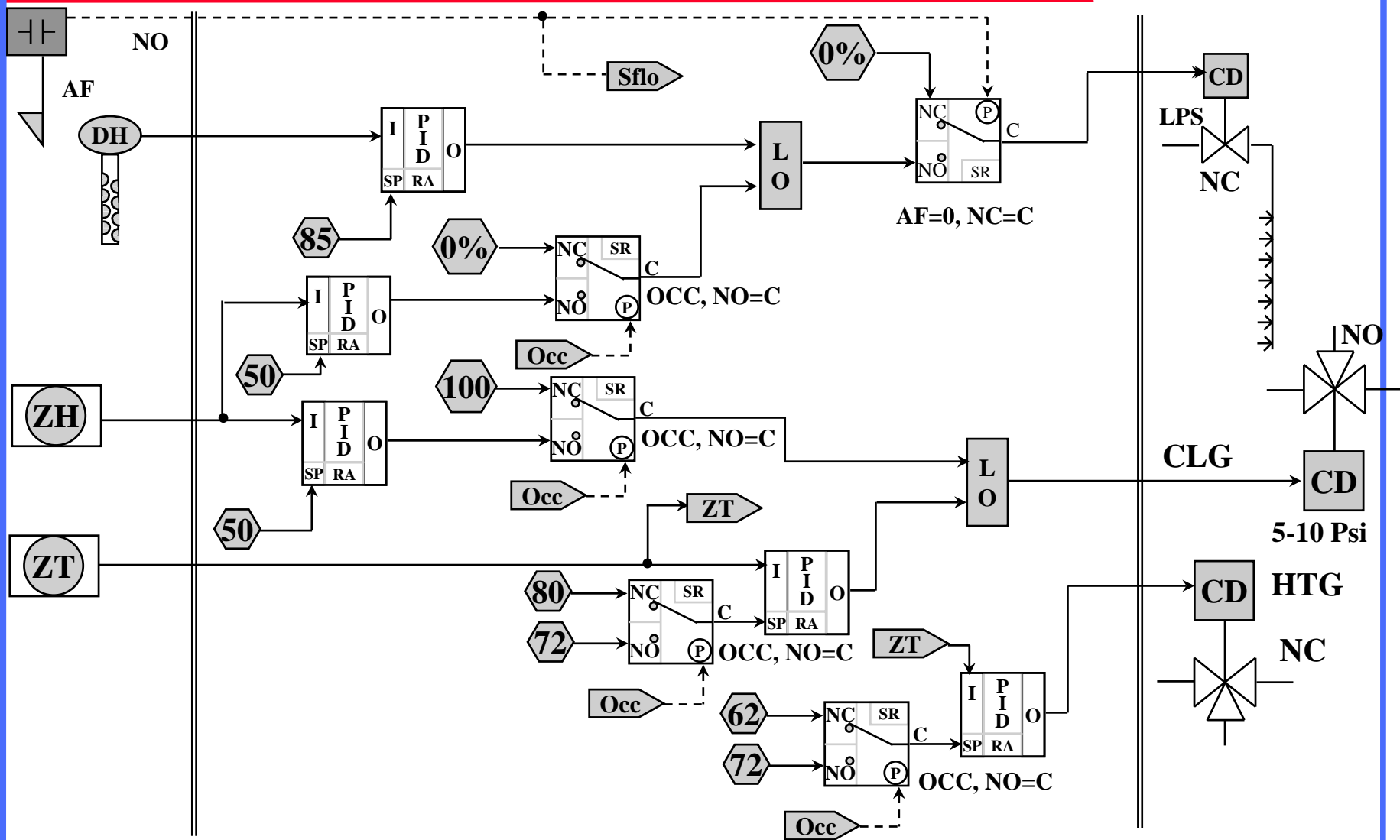
q **Supply Fan**

| **Return Fan**

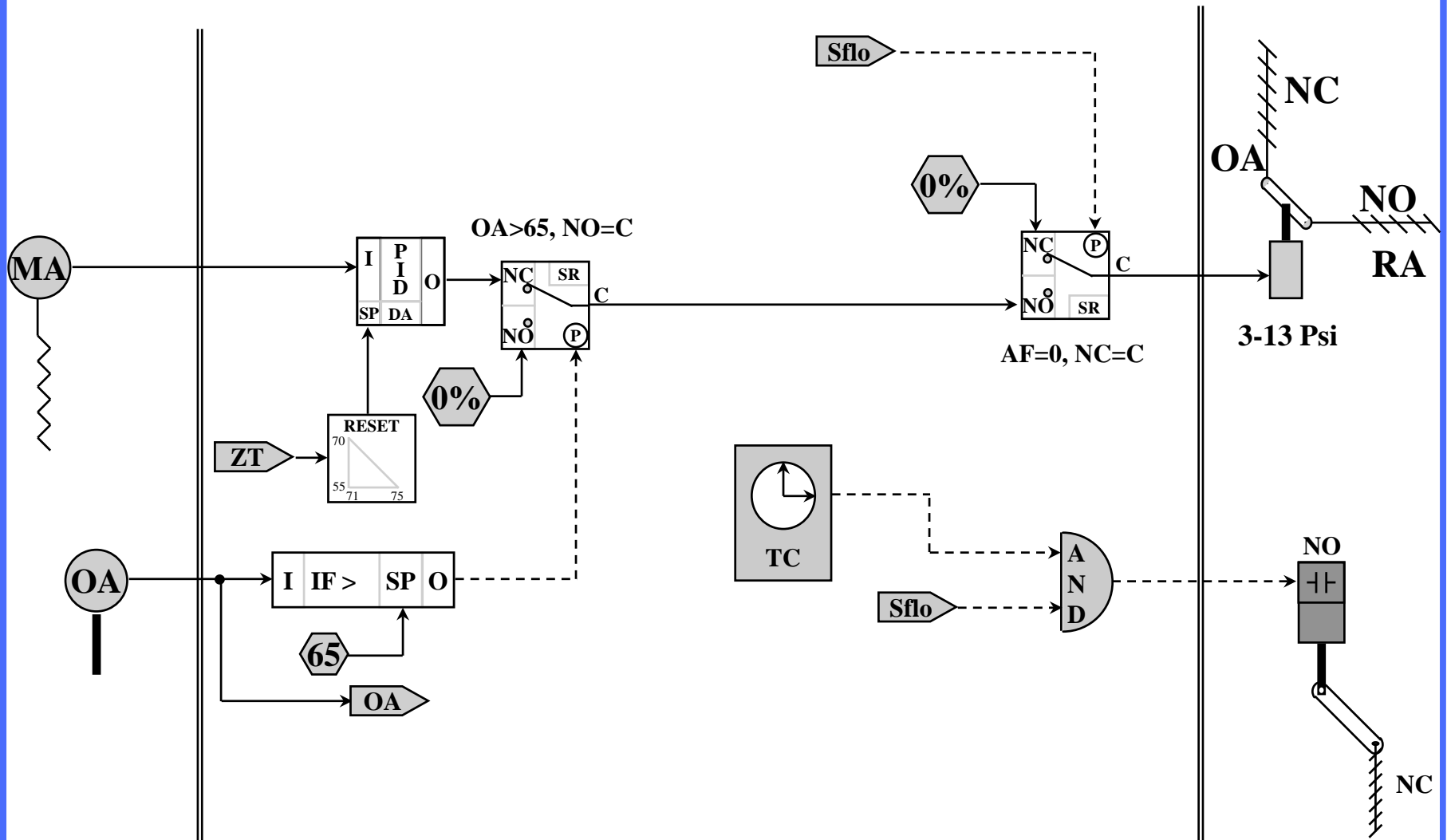
q **Return Fan**

| **Supply Fan**

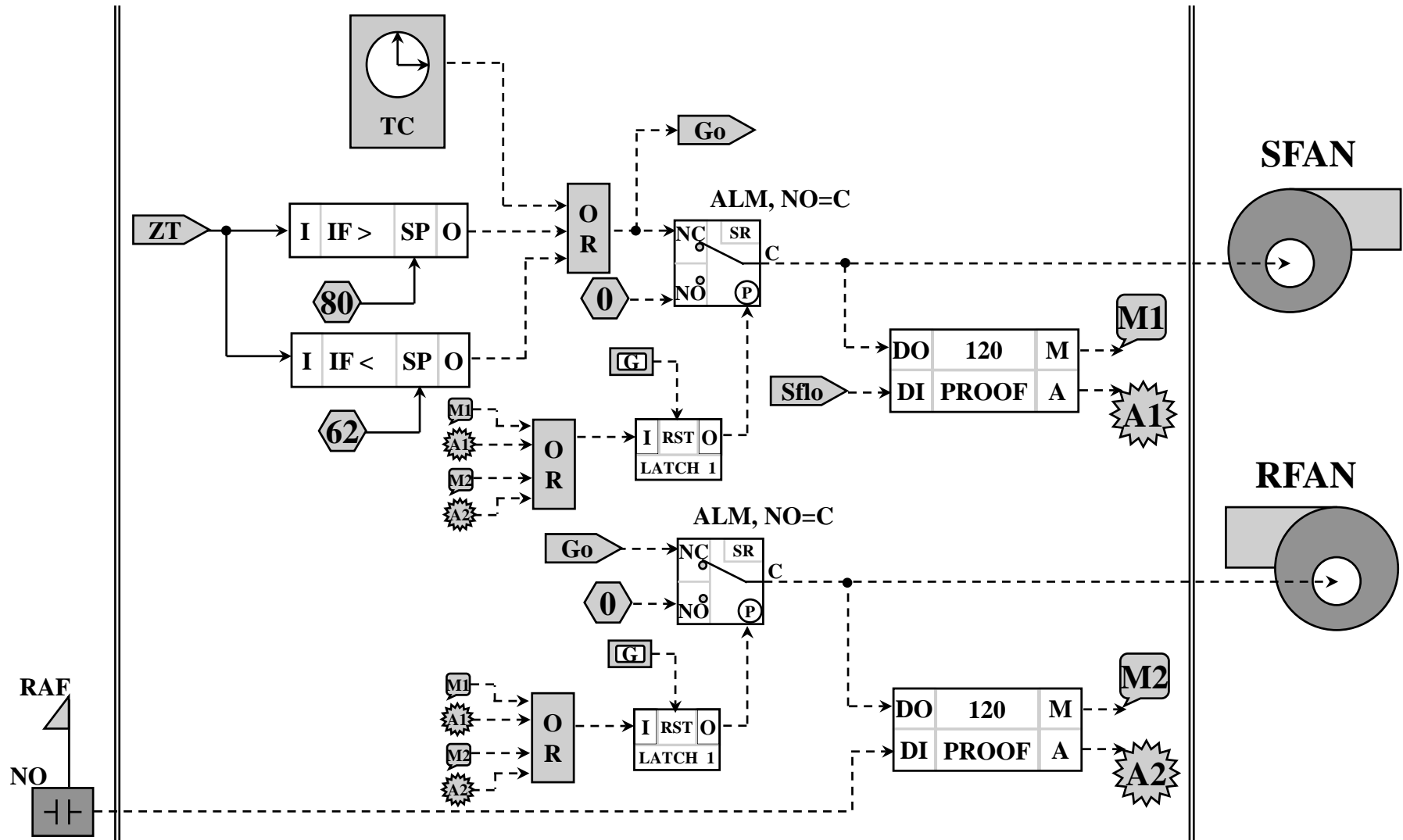
Control Logic (AHU section)



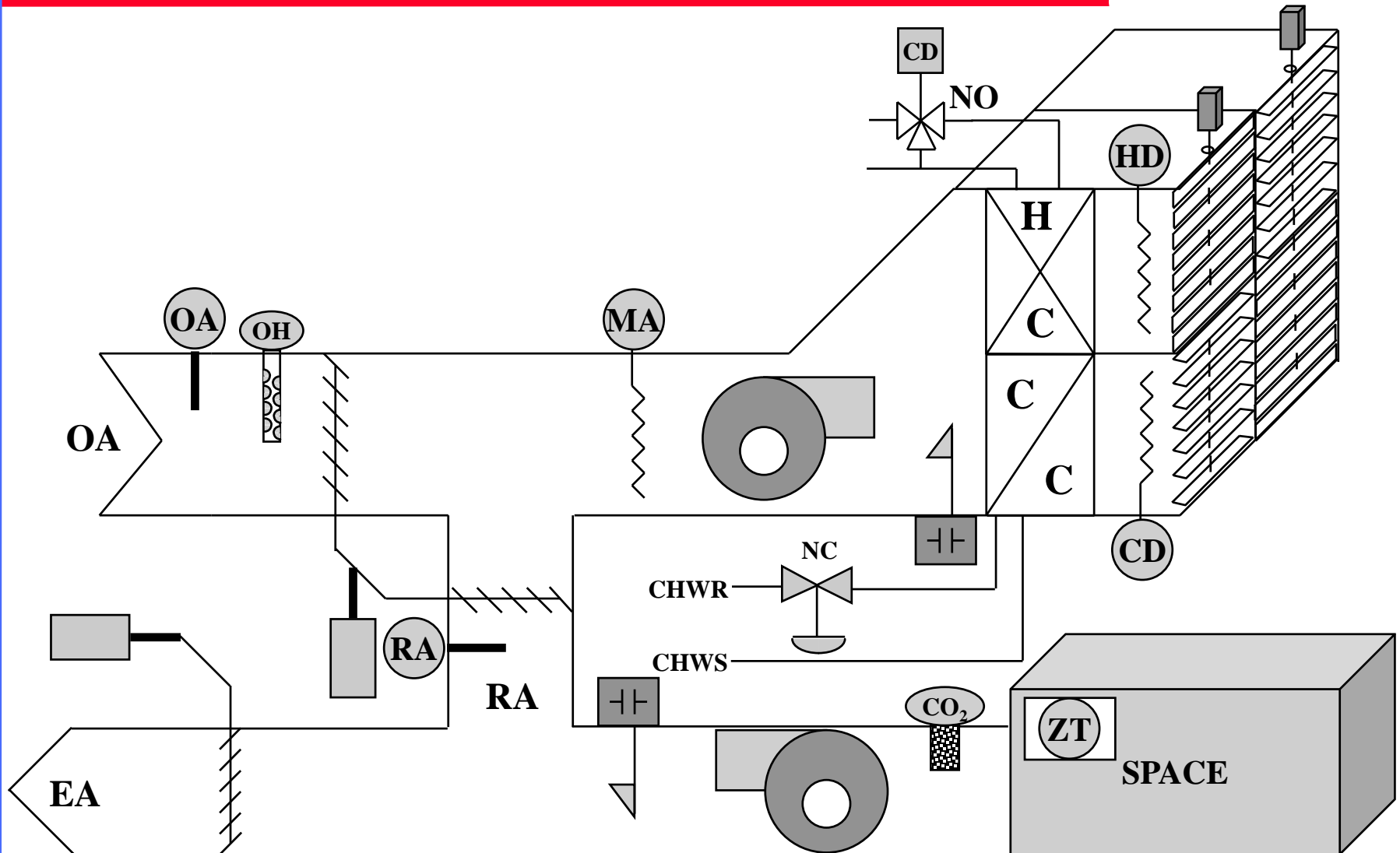
Control Logic (mixing section)



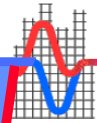
Control Logic (fan section)



Multizone Systems



Multizone System



m Subsystems

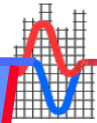
- q Mixed Air
- q Hot Deck
- q Cold Deck
- q Zone Dampers
- q Supply Fan
- q Return Fan

The Control Logic



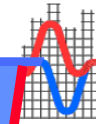
- ❑ The mixed air dampers shall modulate to control a mixed air temperature SP 2 F. below the cold deck discharge SP. The OA dampers will close on fan shut down. The OA dampers shall maintain Minimum OA when the building is occupied. The OA dampers shall maintain minimum (occ.) or bypass minimum (unocc.) when the OA temperature exceeds RA temperature (2 F. differential) or when the OA enthalpy is greater than 28 Btu/# (0.5 Btu/# differential). Minimum position shall be reset based on RA CO₂ according to a reset schedule.
- ❑ The hot water valve shall modulate to control a hot deck SP which is reset based on the coldest zone temperature according to the reset schedule. Valve shall open on loss of air flow.
- ❑ The chilled water valve shall modulate to control a cold deck SP which is reset based on the warmest zone temperature according to the reset schedule.

The Control Logic



- **The supply fan runs based on a time schedule. During unoccupied periods, fans will run when the coldest zone space temperature drops below 60 F. or the warmest zone temperature rises above 85 F (with 3 F. differential) . The fan shall de-energize and latch off on a “proof” alarm or message from either fan.**
- **The return fan runs when the supply fan runs. The fan shall de-energize and latch off on a “proof” alarm or message from either fan.**

Multizone System



m The Process

q Mixed Air Dampers

- | Proportional Control of OA/RA Dampers, variable set point
- | Variable setpoint 2 F. less than Cold Deck SP with 6 F. TR

q Hot Deck

- | Proportional Control of HW valve, variable setpoint
- | Variable SP based on coldest zone with TR=10 F.
- | Reset Schedule

Coldest ZT	HDSP
70	110
75	75

q Cold Deck

- | Proportional Control of CHW valve, variable setpoint
- | Variable SP based on warmest zone with TR=8 F.
- | Reset Schedule

Warmest ZT	CDSP
72	65
76	55

q Supply Fan Control

- | Two position control based on a time schedule or hi/lo zone temp

q Return Fan Control

- | Two position control based on a time schedule

Multizone System



m Limits/Conditions

q Mixed Air Dampers

- | Airflow
- | High Limit when $OAT > RAT$ with 2 F. differential, or OA enthalpy $> 28 \text{ Btu/\#}$ with 0.5 Btu/# differential
- | Bypass minimum OA when unoccupied
- | Minimum OA reset based on CO_2
- | Reset Schedule

CO_2	MinOA	Control Signal
800	1,000	5%
1,000	4,000	20%

q Hot Deck

- | Full Heating on loss of air flow

q Cold Deck - None

q Supply Fan Control

- | Air Flow w/ Latch
- | Return Fan w/Latch

q Return Fan Control

- | Air Flow w/ Latch
- | Supply Fan w/Latch

Multizone System



m Measured Variables

q Mixed Air Dampers

- | Mixed air temperature
- | Outside air temperature
- | Cold Deck SP
- | Airflow
- | Time
- | CO₂

q Hot Deck

- | Zone temperature
- | Hot Deck Discharge temperature
- | Airflow

q Cold Deck

- | Zone temperature
- | Cold Deck Discharge temperature

q Supply & Return Fan Control

- | Time
- | Airflow

Multizone System



m **Communication**

q **Mixed Air Dampers**

- | **Cold Deck**
- | **Fan Control**

q **Hot Deck**

- | **Zone**
- | **Fan**

q **Cold Deck**

- | **Zone**

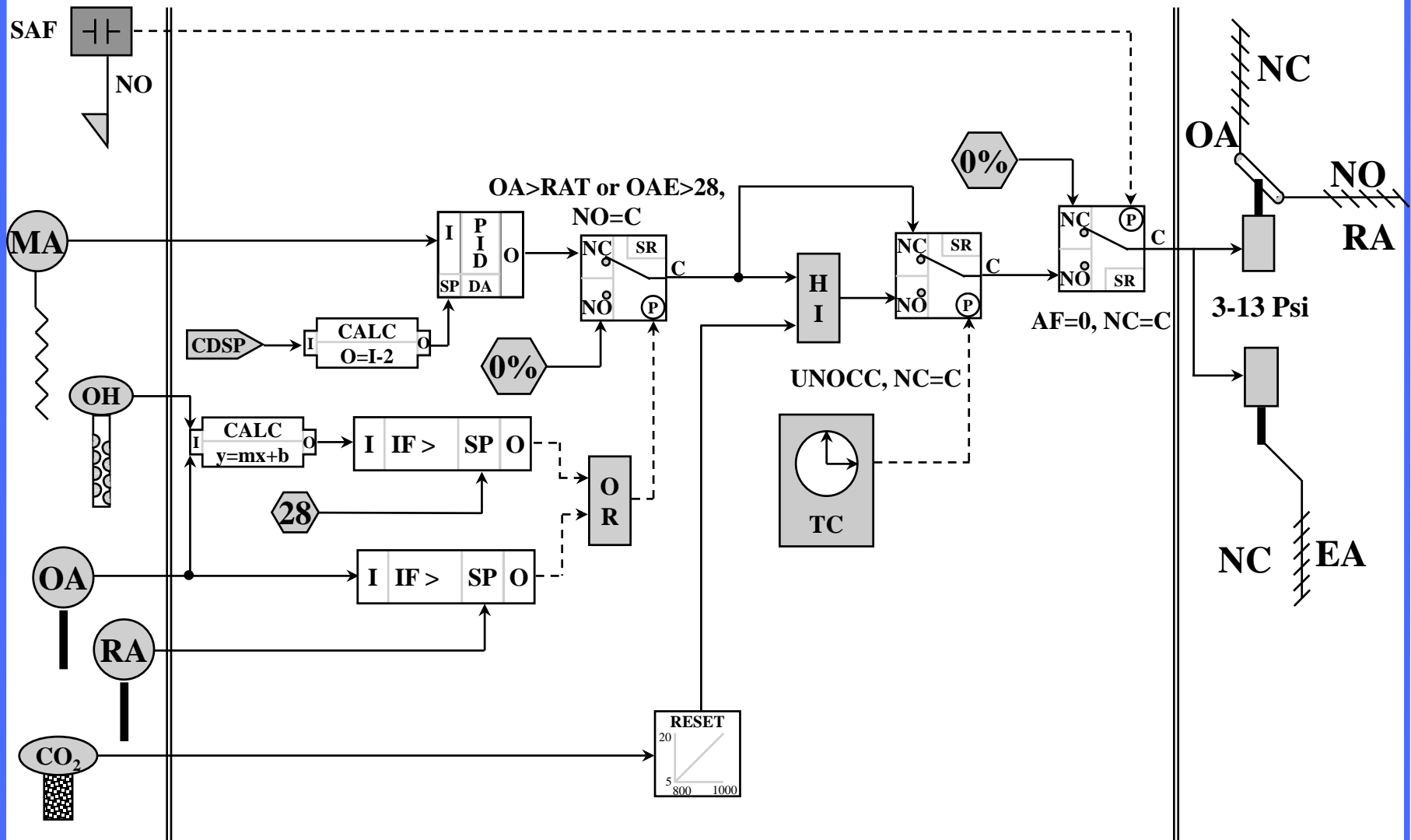
q **Supply Fan**

- | **Return Fan**

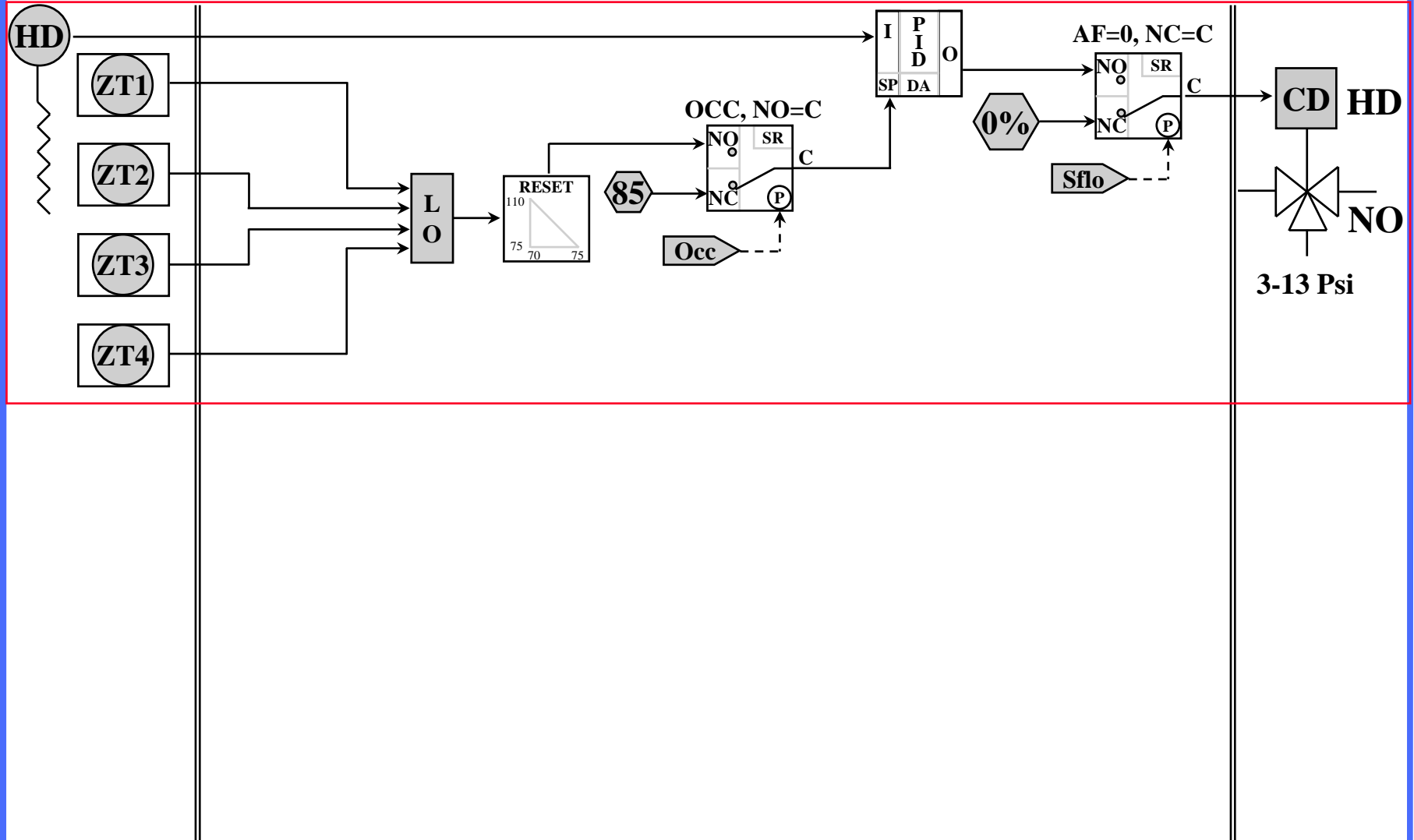
q **Return Fan**

- | **Supply Fan**

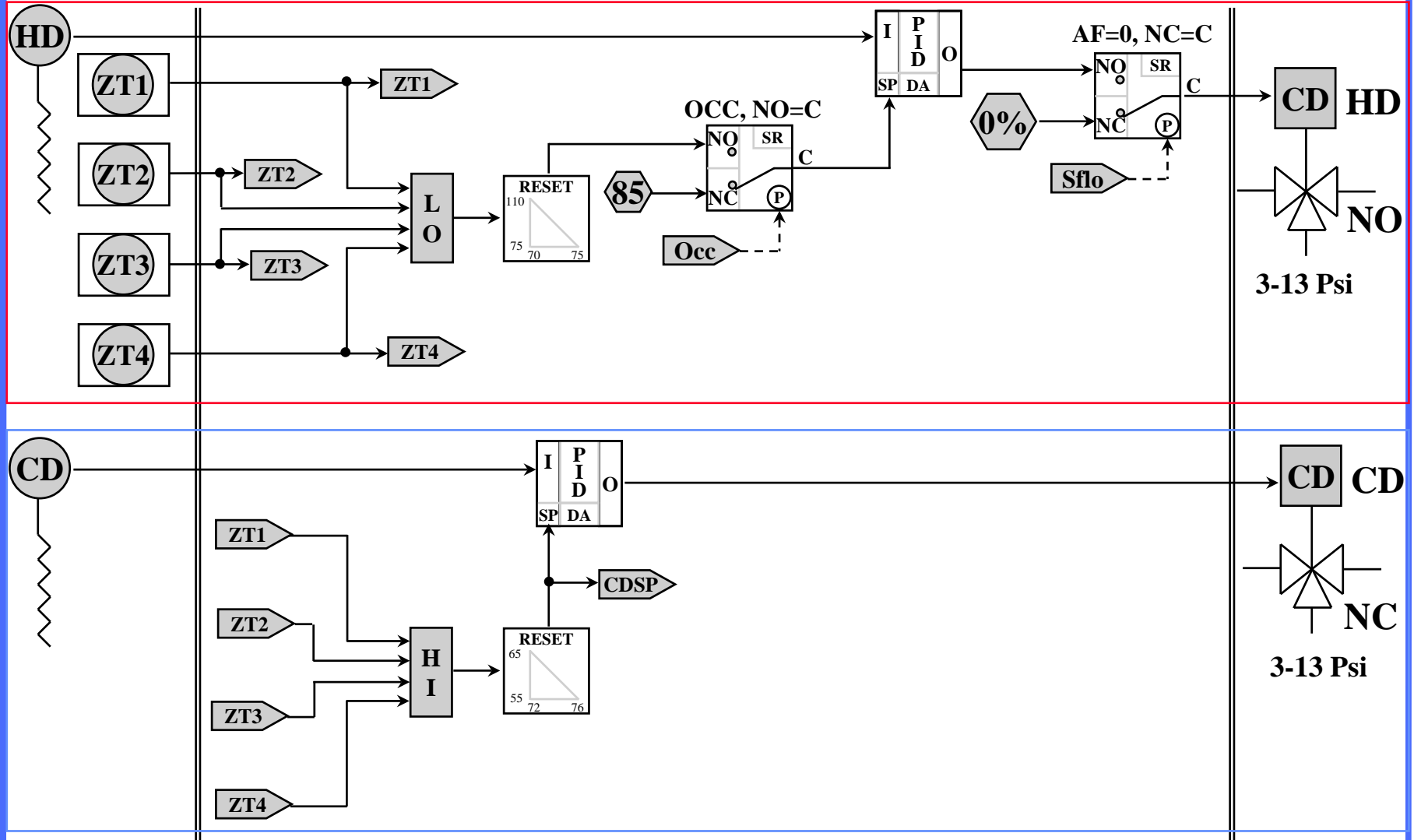
Logic Diagram (mixed air)



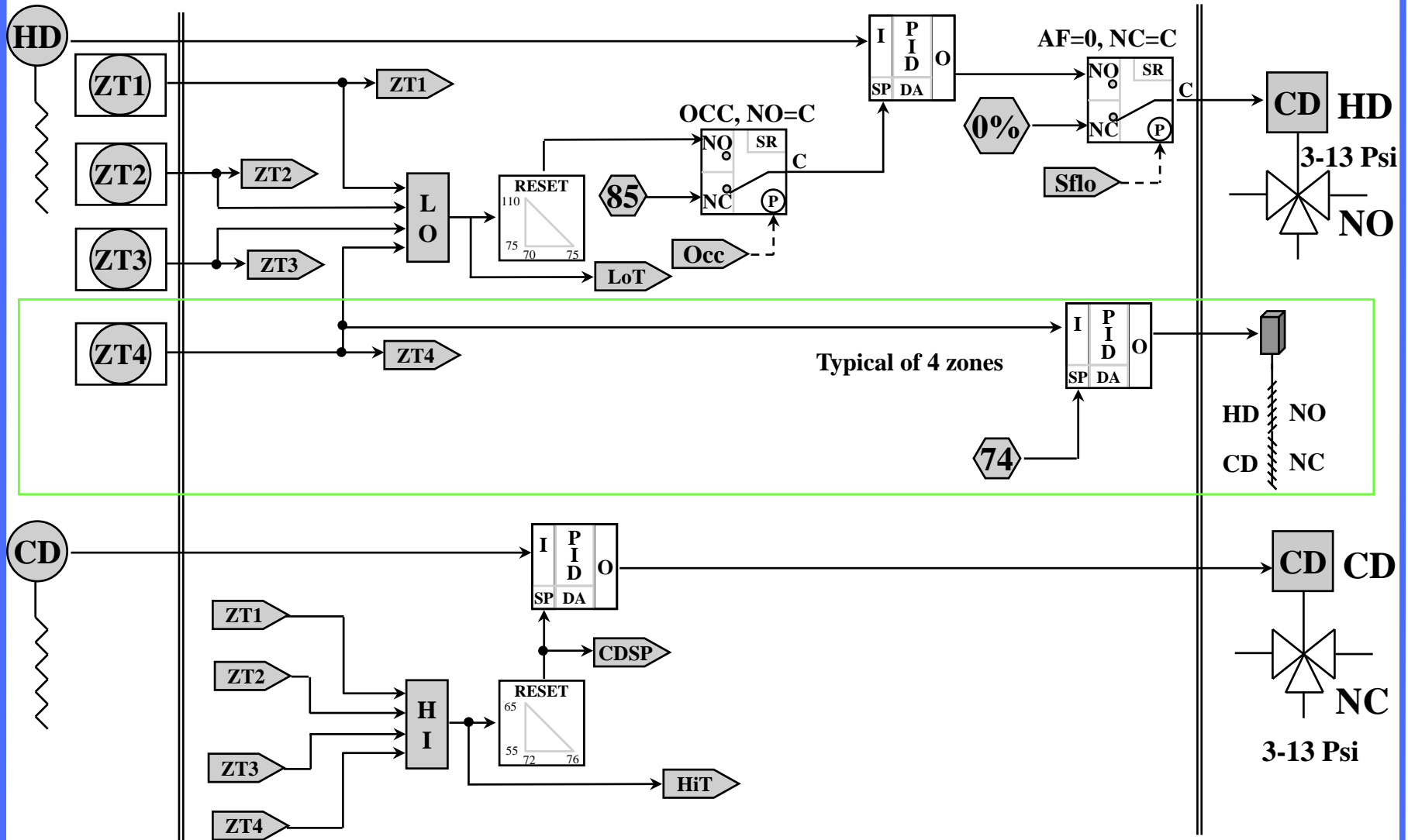
Multizone Logic Diagram (hot deck)



Multizone Logic Diagram (cold deck)



Multizone Logic Diagram (zone control)



Multizone Logic Diagram (fan control)

