

# **Gas Appliance Modulating Controls Technology**

**ASGE Technical Conference**

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**Honeywell**



# Gas Appliance Modulating Controls

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- **Why modulate?**
- **Modulation range**
- **CO<sub>2</sub> curve**
- **Factors Impacting Modulation**
- **Gas Appliance Modulating Controls Technology**
  - Gas modulation only
  - Gas / Air control
- **Application Considerations**
- **Application Problems**
- **Advanced Systems**



# Why Modulate?

- **Load matching**

- **Comfort**

- ◆ Heat demand / heat loss
      - Equipment sized for coldest days – cycles the rest of the time
    - ◆ Reduction in fan speed / air noise

- **Multiple processes one burner**

- ◆ Combi Appliance
      - Central heat
      - Water heating

- **Increased system efficiency**

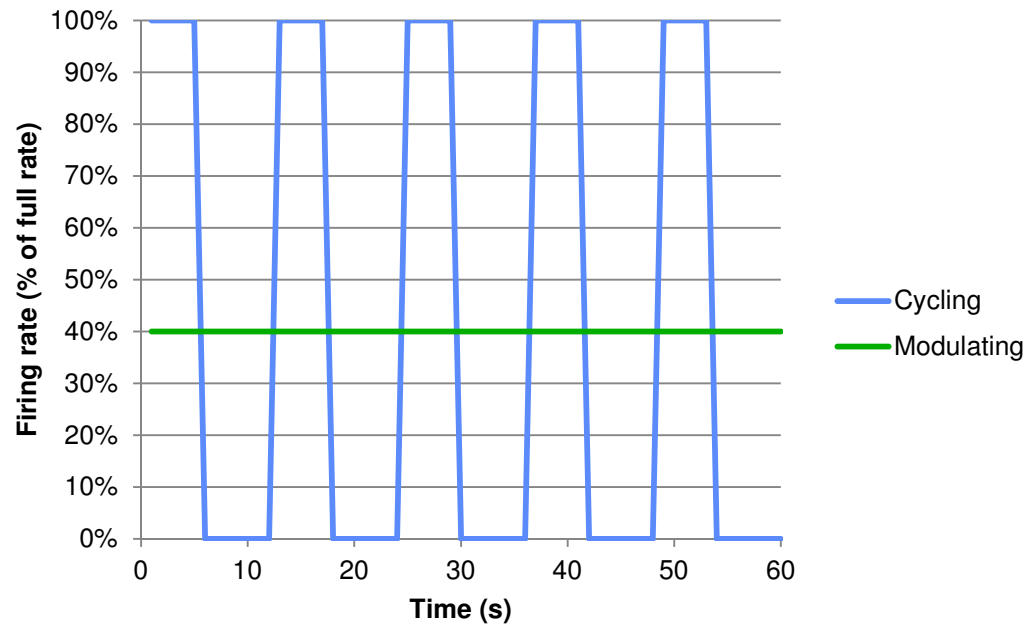
- **Air/fuel linkage**

- ◆ Heat exchanger performance
      - Efficiency gains at low fire – Hx sized for max input
      - Energy savings – Hx efficiency and cycling losses
    - ◆ Reduction in combustion products emissions



# Why Modulate?

- **Increased system reliability**
  - **Reduction in burner cycles**
    - ◆ Reduce burner short cycling
    - ◆ Less thermal stress on system





# Modulation Range

- **How much turndown?**

- **2:1**

- ◆ 50% of full rate
    - ◆ 25% of full rate gas pressure

- **2.5:1**

- ◆ 40% full rate
    - ◆ 16% of full rate gas pressure

- **5:1**

- ◆ 20% full rate
    - ◆ 4% of full rate gas pressure

- **10:1**

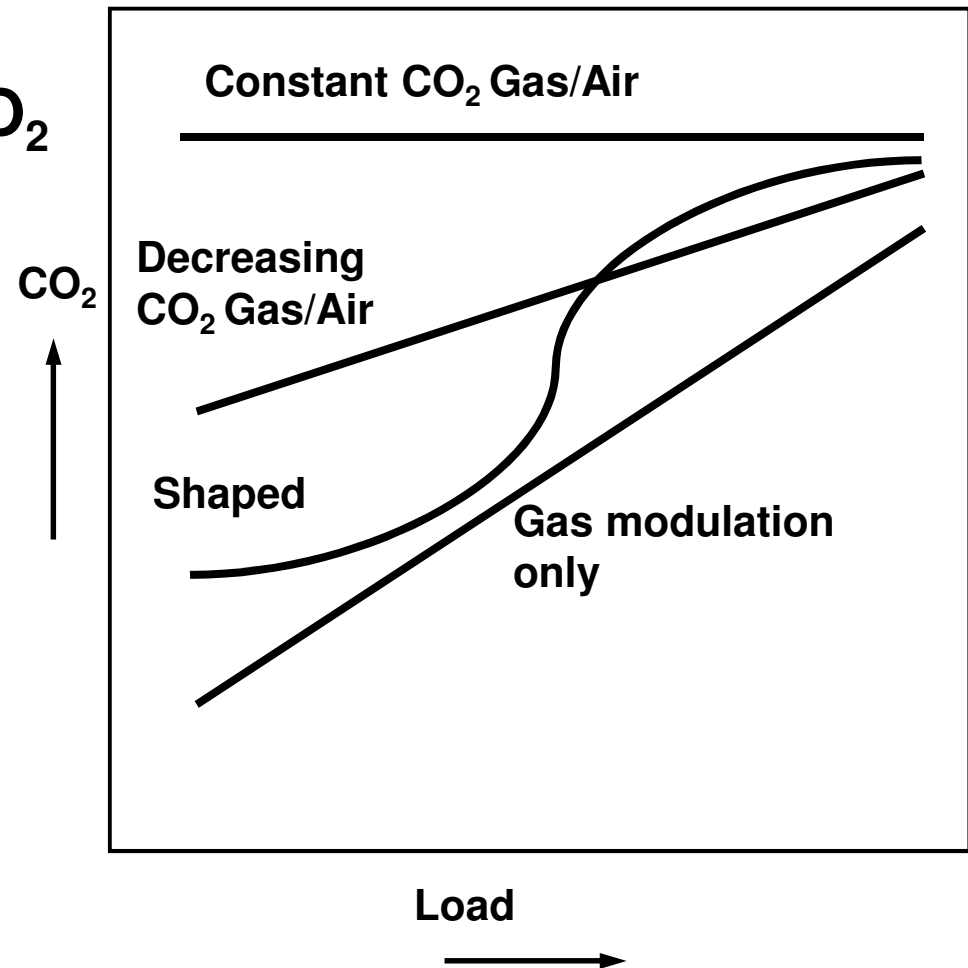
- ◆ 10% full rate
    - ◆ 1% of full rate gas pressure



# CO<sub>2</sub> Curve

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- Constant CO<sub>2</sub>
- Increasing/Decreasing CO<sub>2</sub>
- Gas modulation only
- Shaped





# Modulation Range

- **Considerations**
  - **Customer demand / expectations**
    - ◆ Comfort
    - ◆ Performance
  - **System Cost**
  - **Process**
    - ◆ Air heating
    - ◆ Water heating
      - Central heat
      - Hot water
  - **Installation**
    - ◆ Complexity of commissioning
    - ◆ Field support
    - ◆ Tools required



# Factors Impacting Modulation

- **System components**

- **Fuel supply**

- ◆ Pressure

- 4"WC
      - 7"WC
      - 14"WC

- ◆ Quality

- Consistent
      - Varying

- **Burner Type**

- ◆ Atmospheric

- Minimum gas pressure
      - Maximum gas pressure

- ◆ Premix

- Operating range input
      - Operating range CO<sub>2</sub>



# Factors Impacting Modulation

- **System components**
  - **Heat Exchanger**
    - ◆ Condensing
    - ◆ Non condensing
    - ◆ Bimodal
  - **Fan**
    - ◆ AC
    - ◆ DC
    - ◆ Variable speed control
  - **Gas Valve**
    - ◆ Minimum outlet pressure
    - ◆ Maximum supply pressure
    - ◆ Regulation range
    - ◆ Flow capacity
    - ◆ Accuracy



# Factors Impacting Modulation

- **System components**

- **System Controls**

- ◆ Thermostats
      - On – off
      - Communicating
    - ◆ Sensors
      - Supply temperature
      - Return temperature
      - Flue temperature
    - ◆ Flame safety
    - ◆ Ignition
    - ◆ Fan control
      - On/off
      - Modulating
    - ◆ Valve control
      - On/off
      - Modulating



# Factors Impacting Modulation

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- **Regulations**
  - Local requirements
  - Agency approvals



# Gas Appliance Modulating Controls Types

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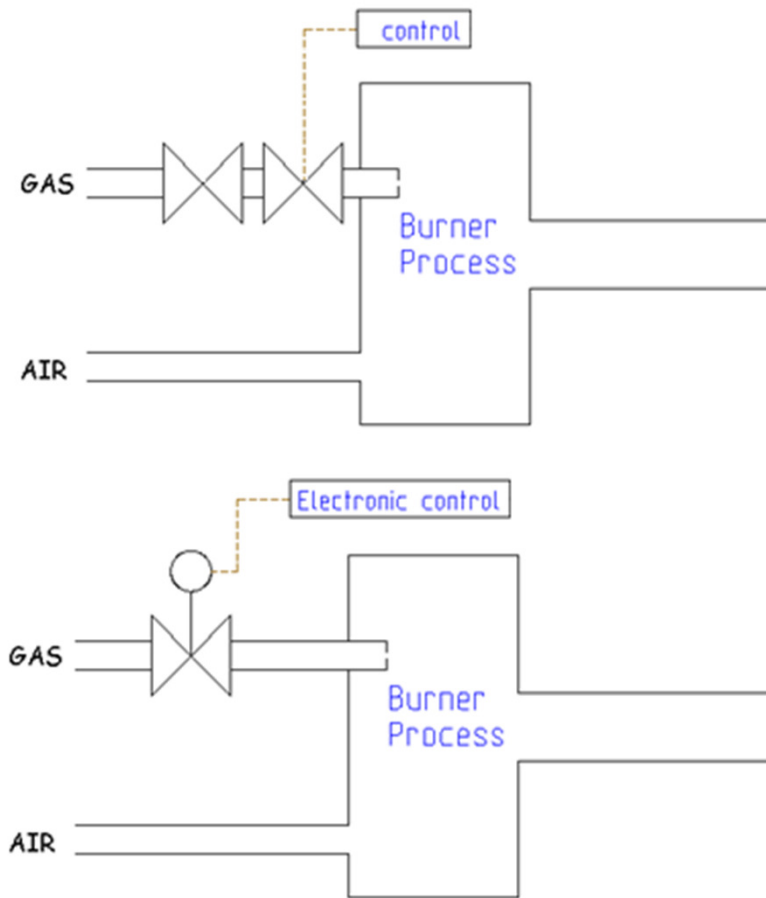
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- **Gas modulation only**
  - Flow control valve
  - Modulating regulator
- **Gas/Air control**
  - Feedback Gas/Air control
  - Feed forward Gas/Air control



# Gas only Modulation

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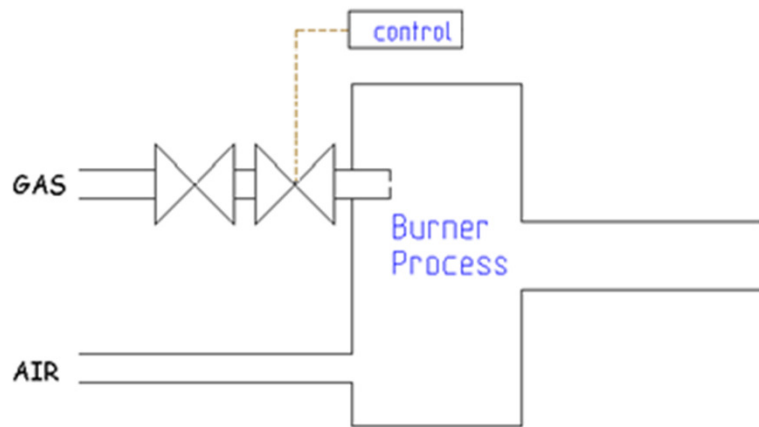




# Gas Only Modulation

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- **Flow control valve**
  - Constant gas pressure
  - Adjust orifice/throttle

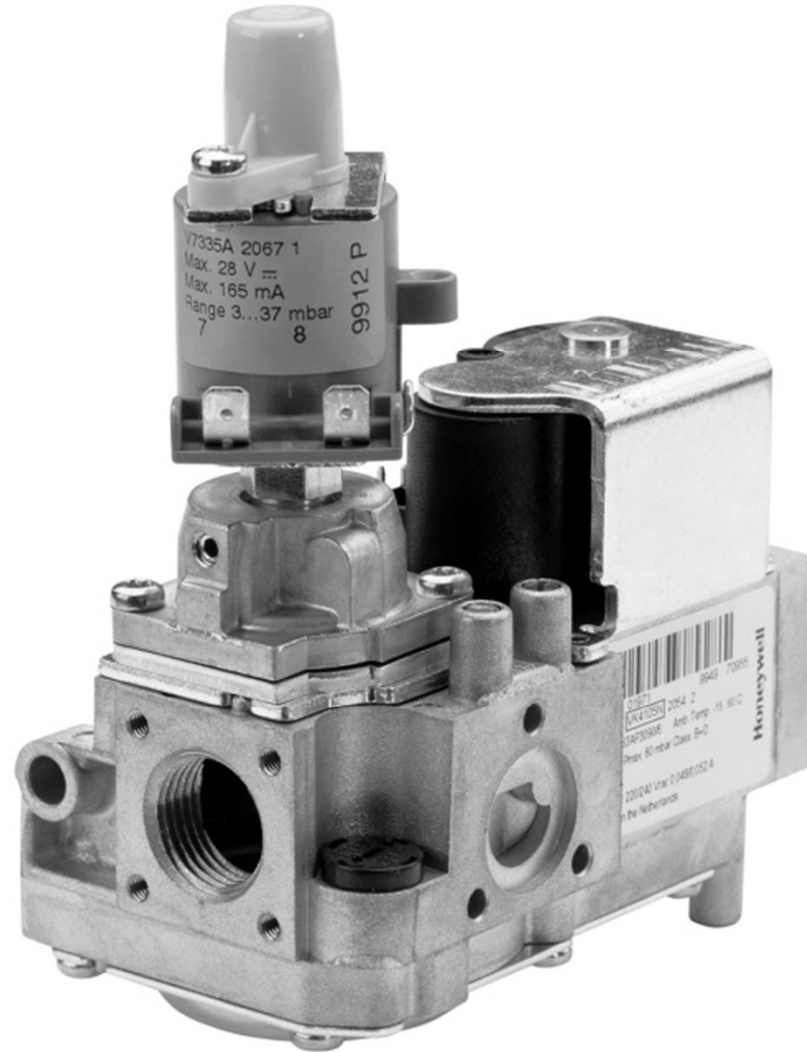
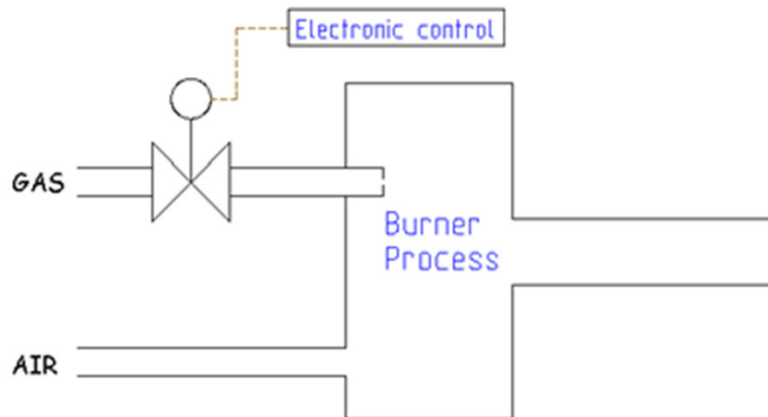




# Gas Only Modulation

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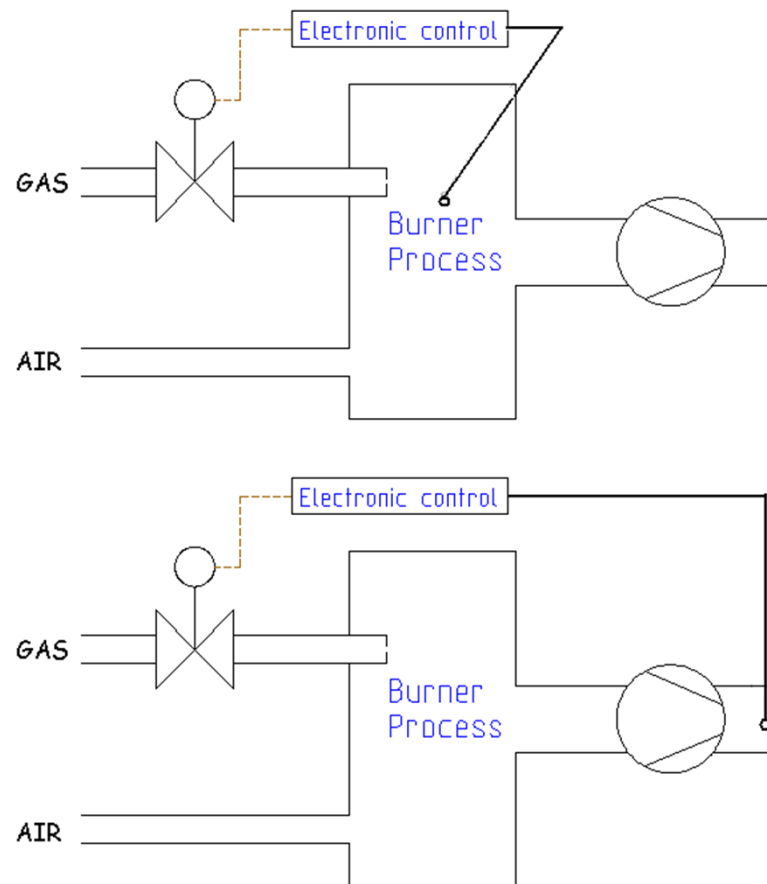
- **Modulating regulator**
  - Adjust gas pressure
  - Constant orifice/throttle





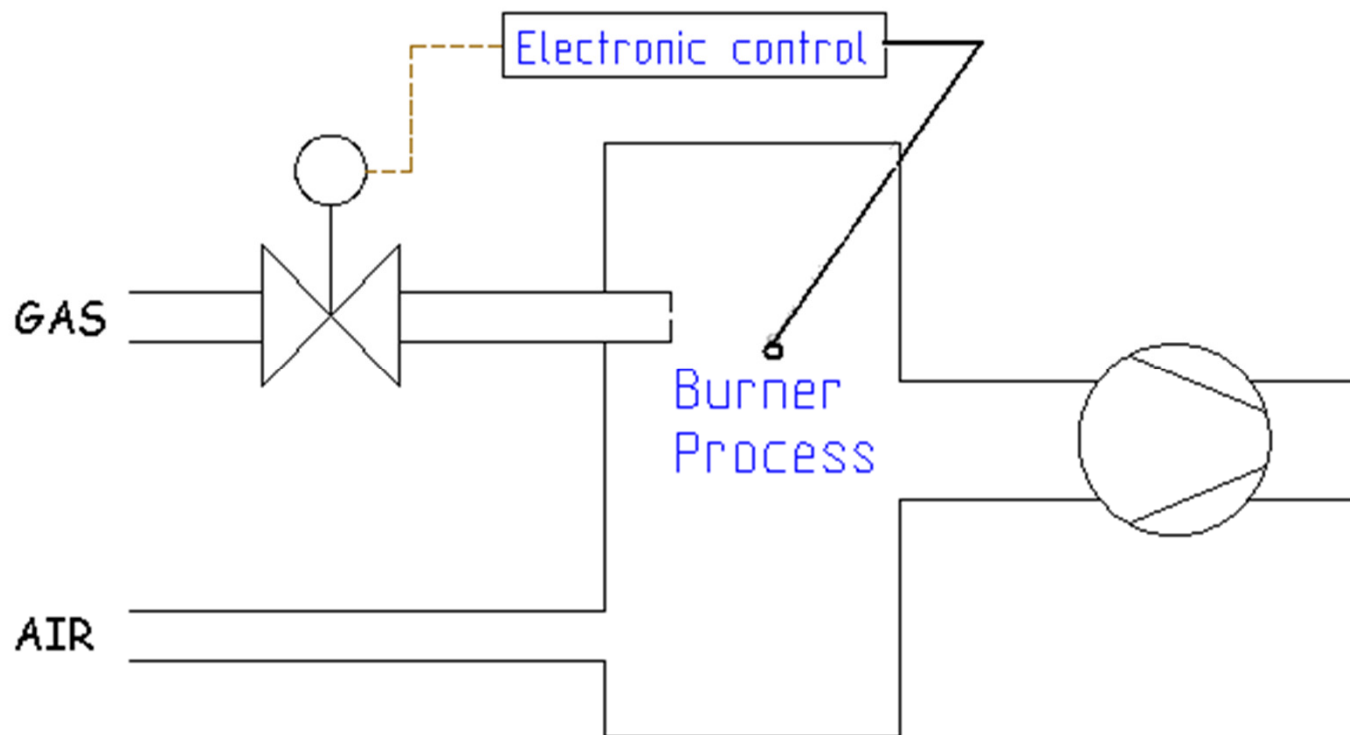
# Feedback Gas/Air Control

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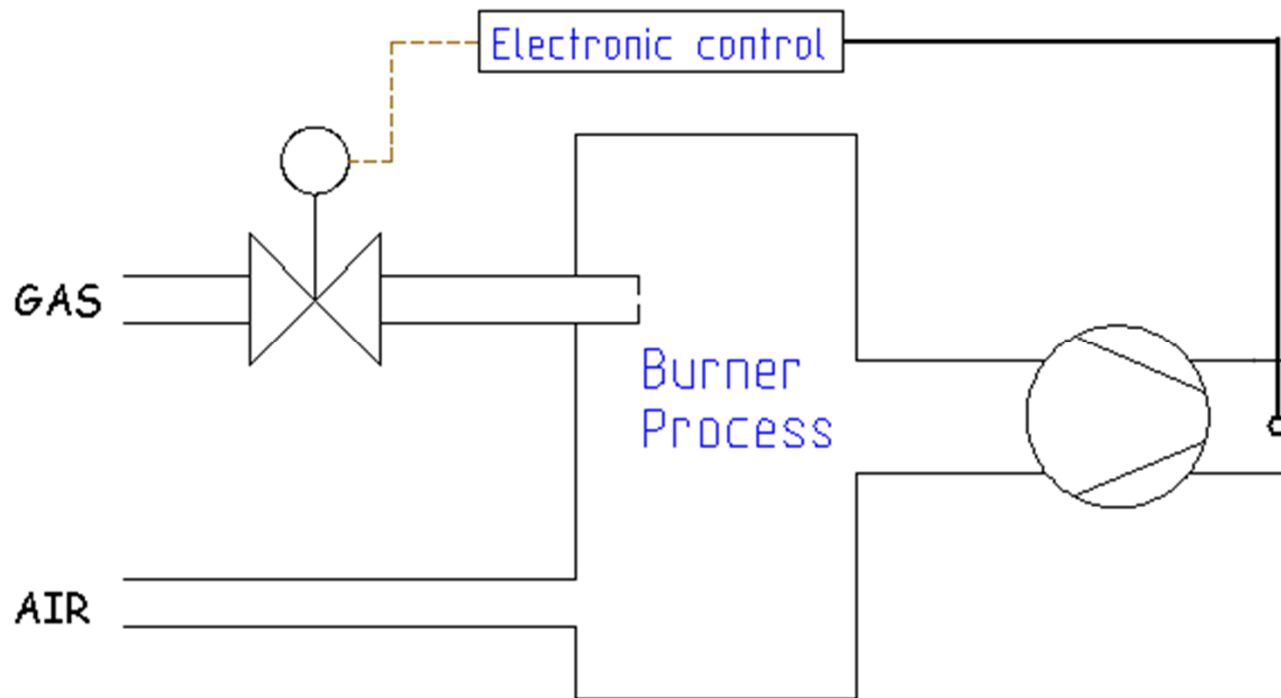
# Burner Process Feedback





# Combustion Product Feedback

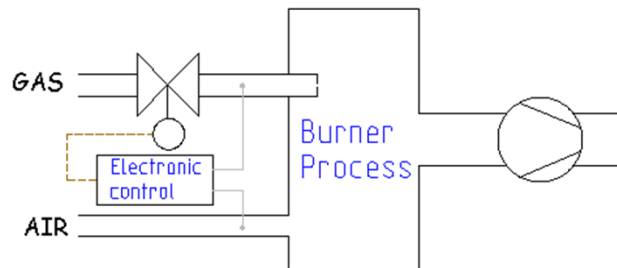
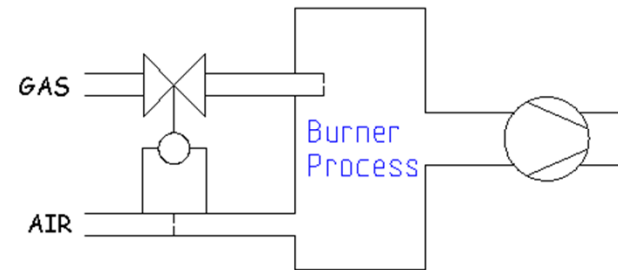
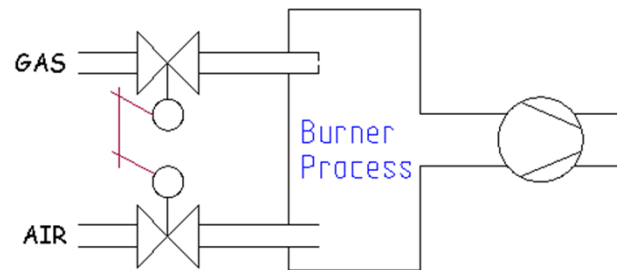
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# Feed forward Gas/Air Control

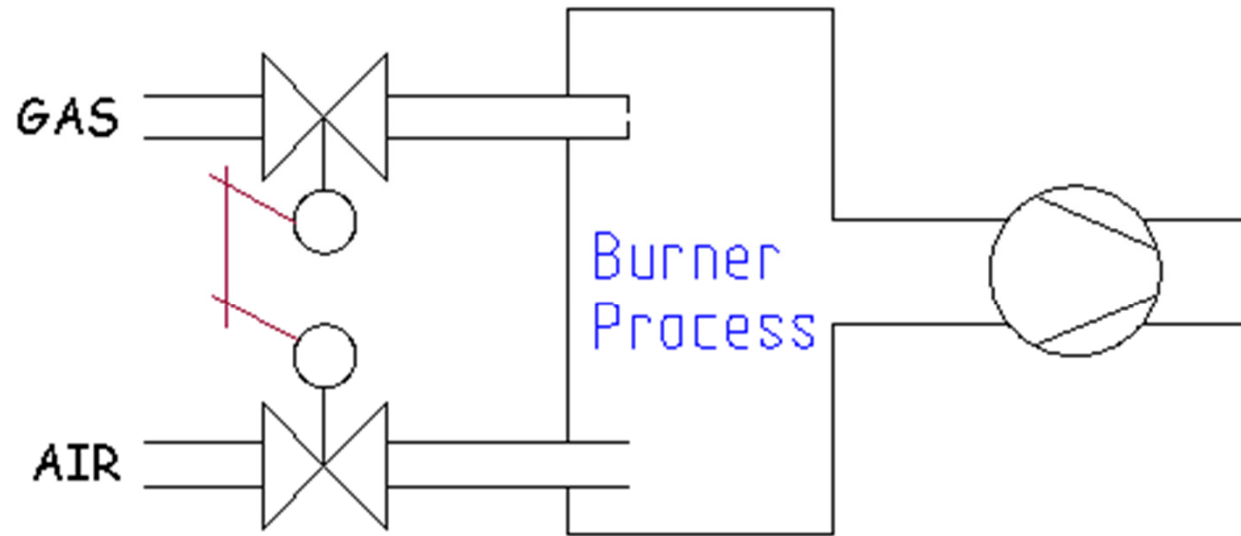
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# Mechanical Linkage Gas/Air Control

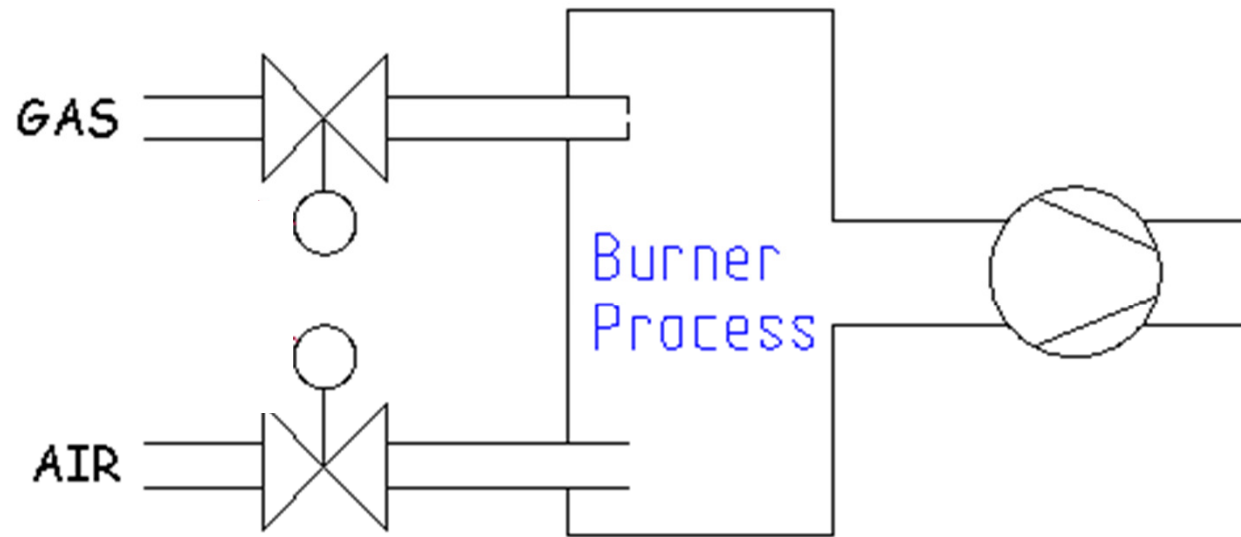
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# Motor Linkage Gas/Air Control

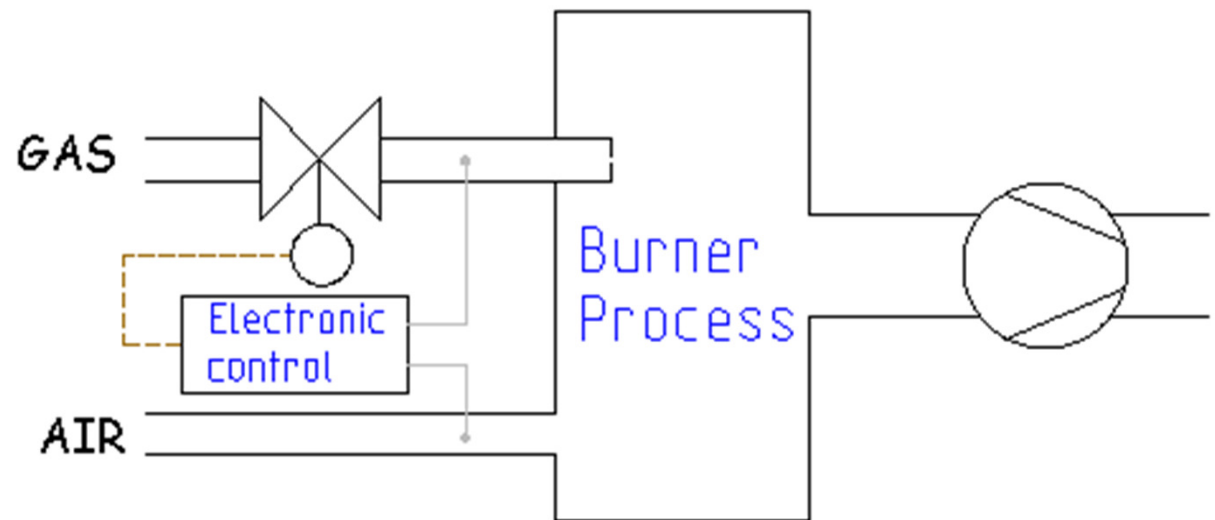
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# Mass flow Gas/Air Control

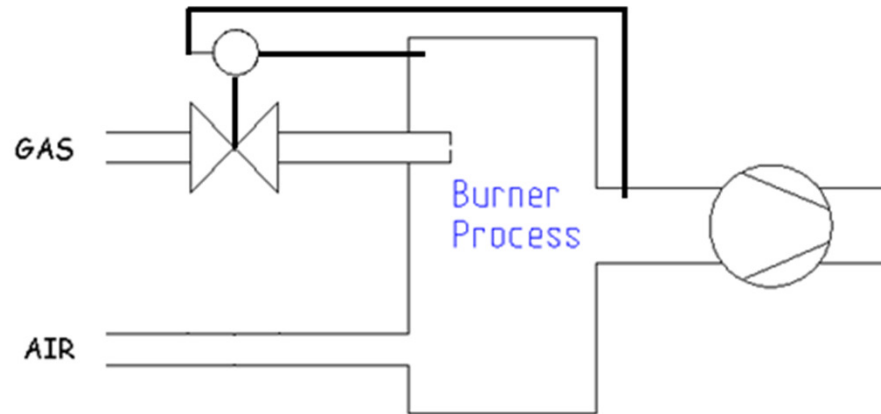
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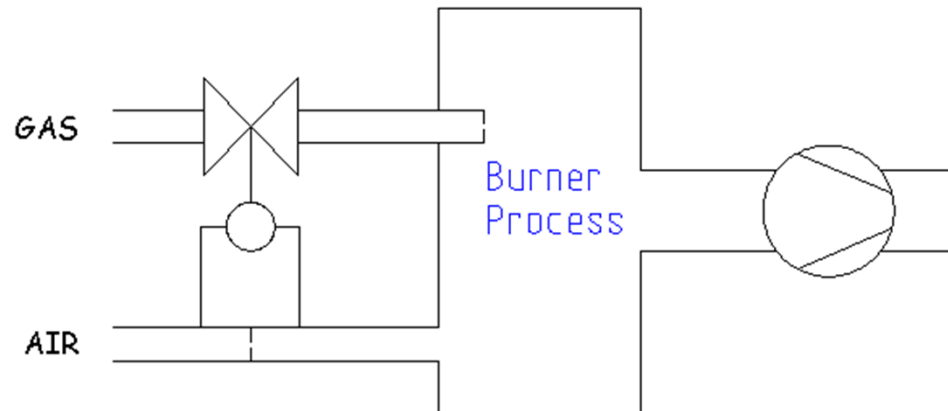


# Pneumatic Gas/Air Control

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**Amplified Gas/Air – Furnace Application**



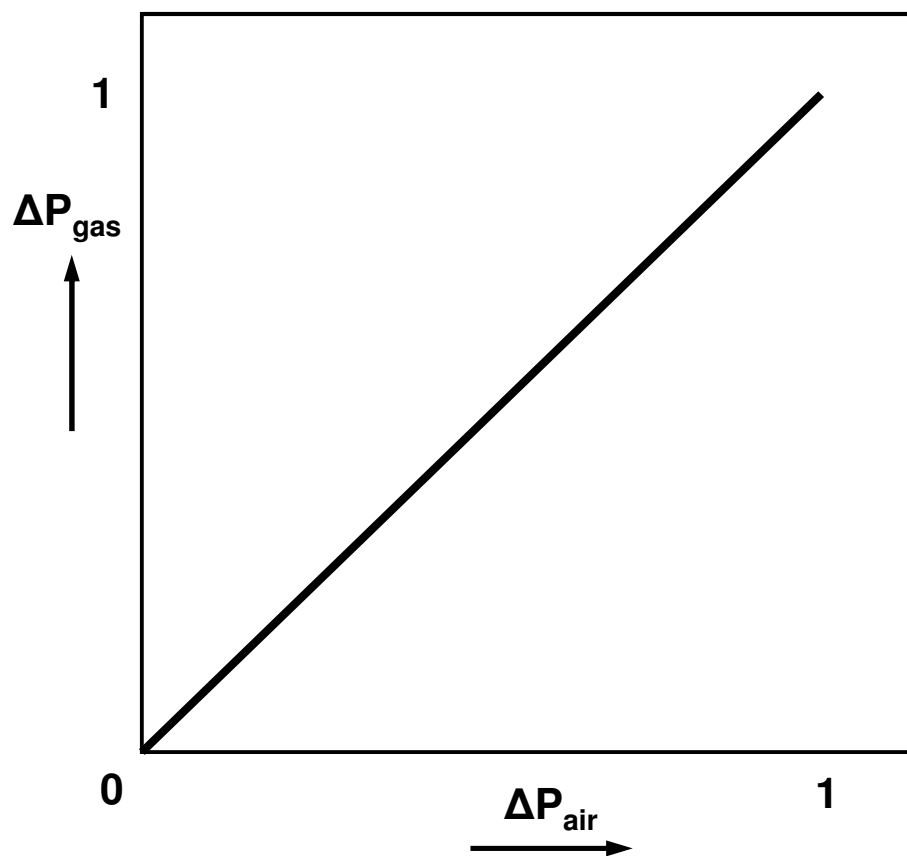
**1:1 Gas/Air – Boiler / Water Heater Application**



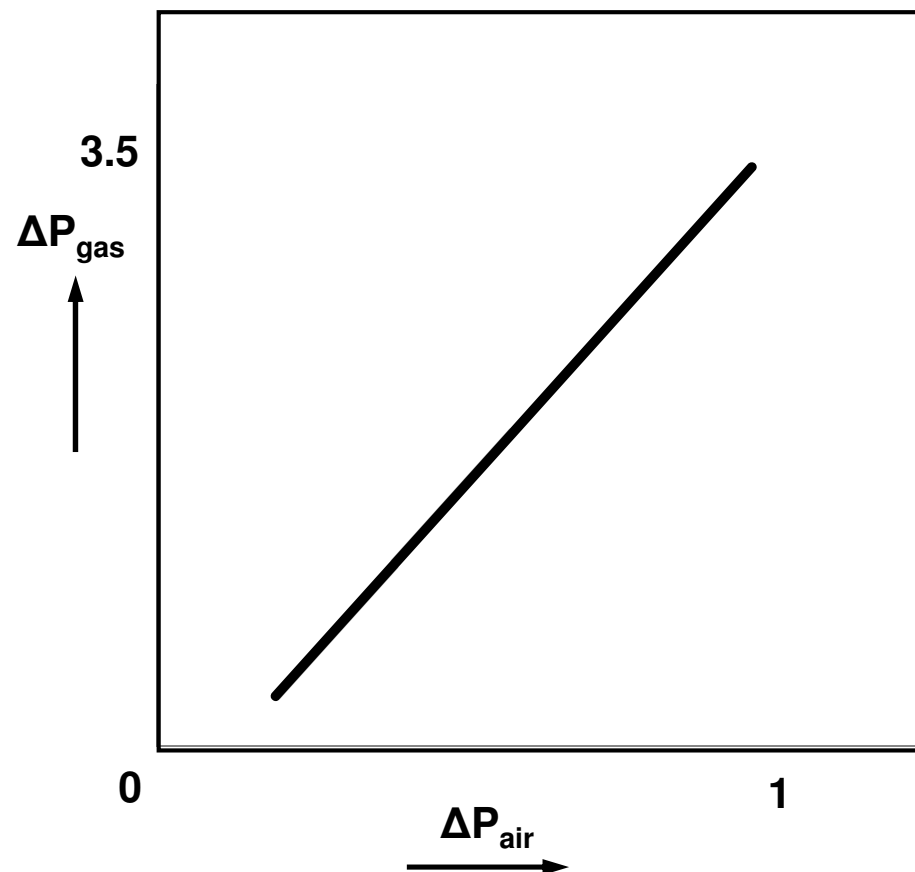
# Pneumatic Gas/Air Control

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- 1:1



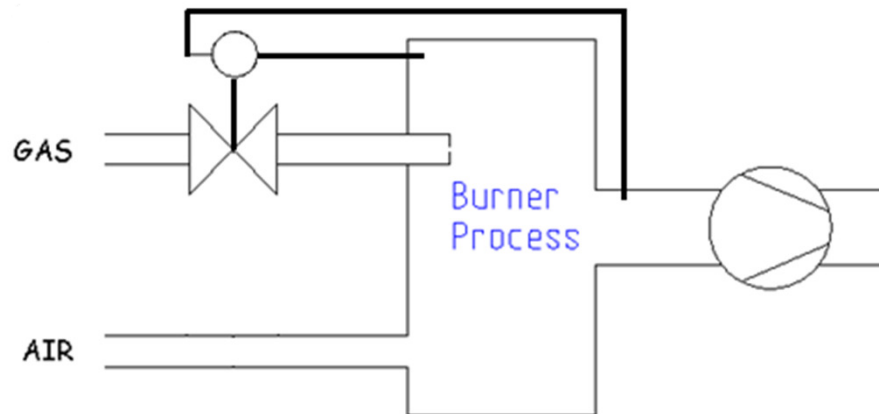
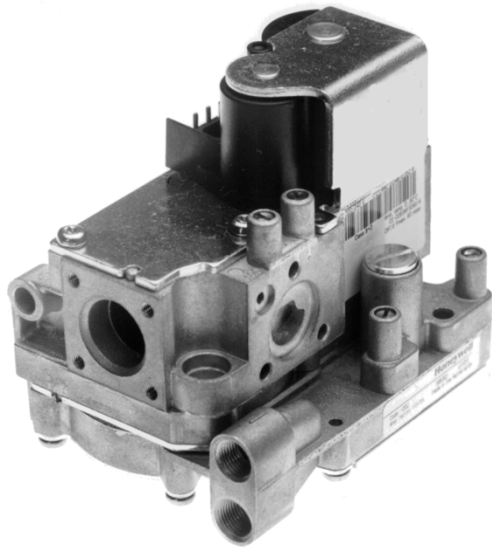
- Amplified





# Amplified Gas/Air Control

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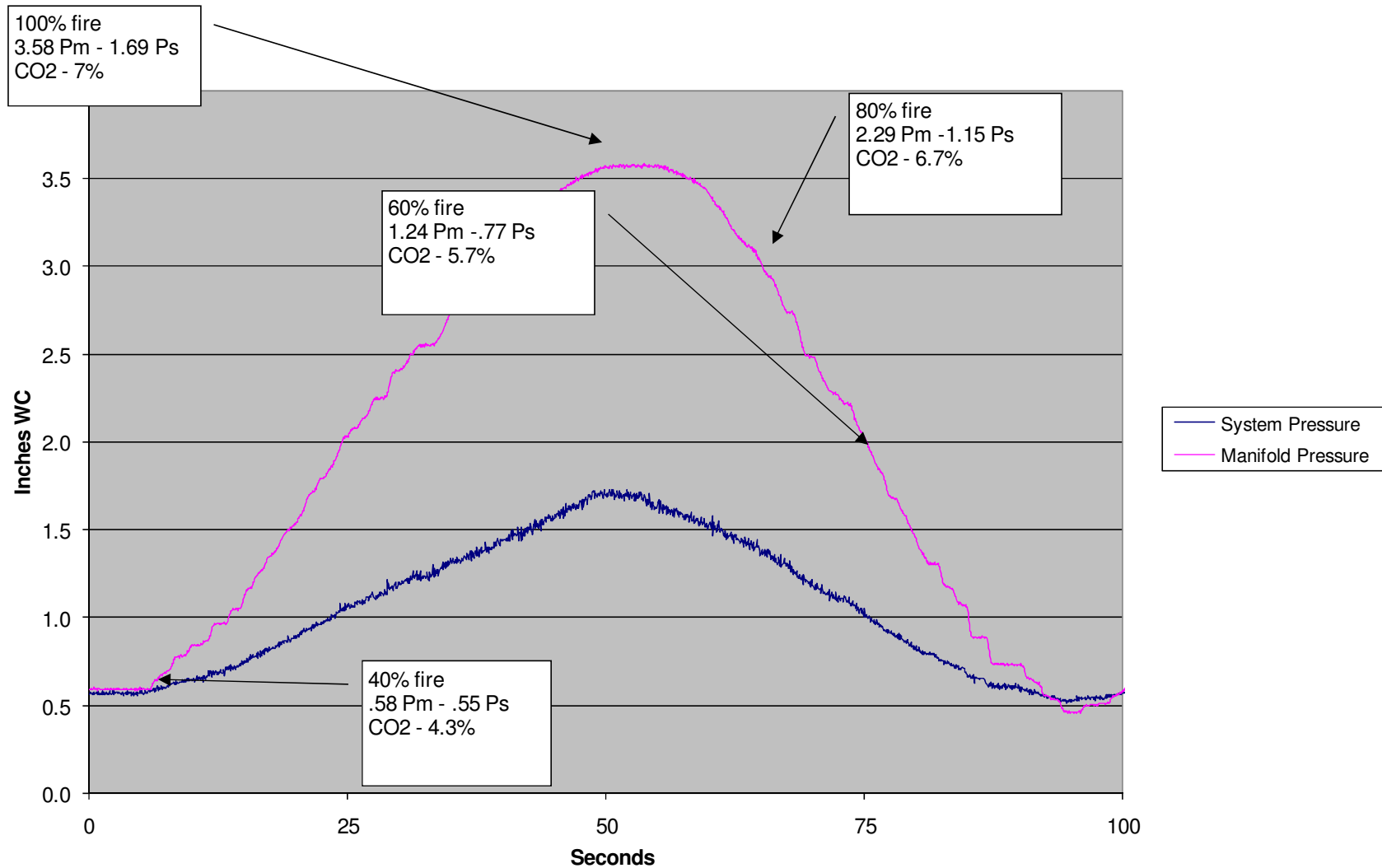


**Amplified Gas/Air**



# Typical Amplified Gas/Air Modulating Performance

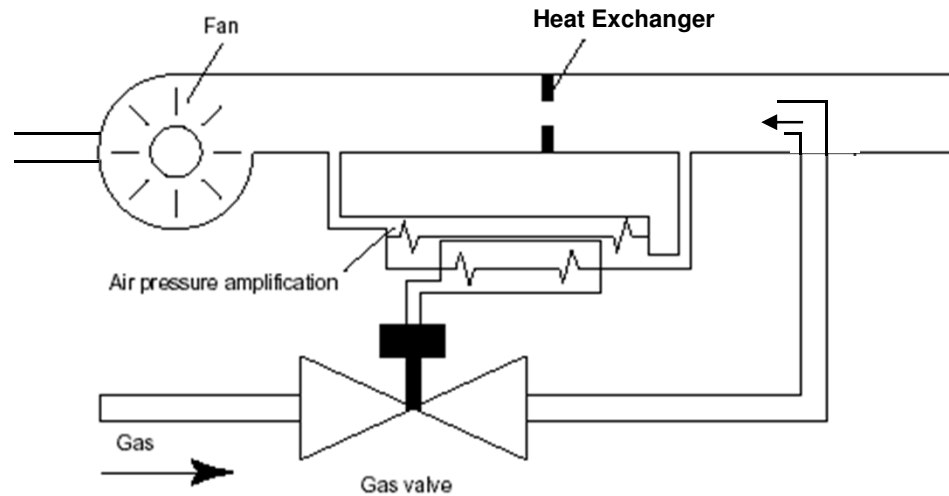
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# Amplified Gas/Air

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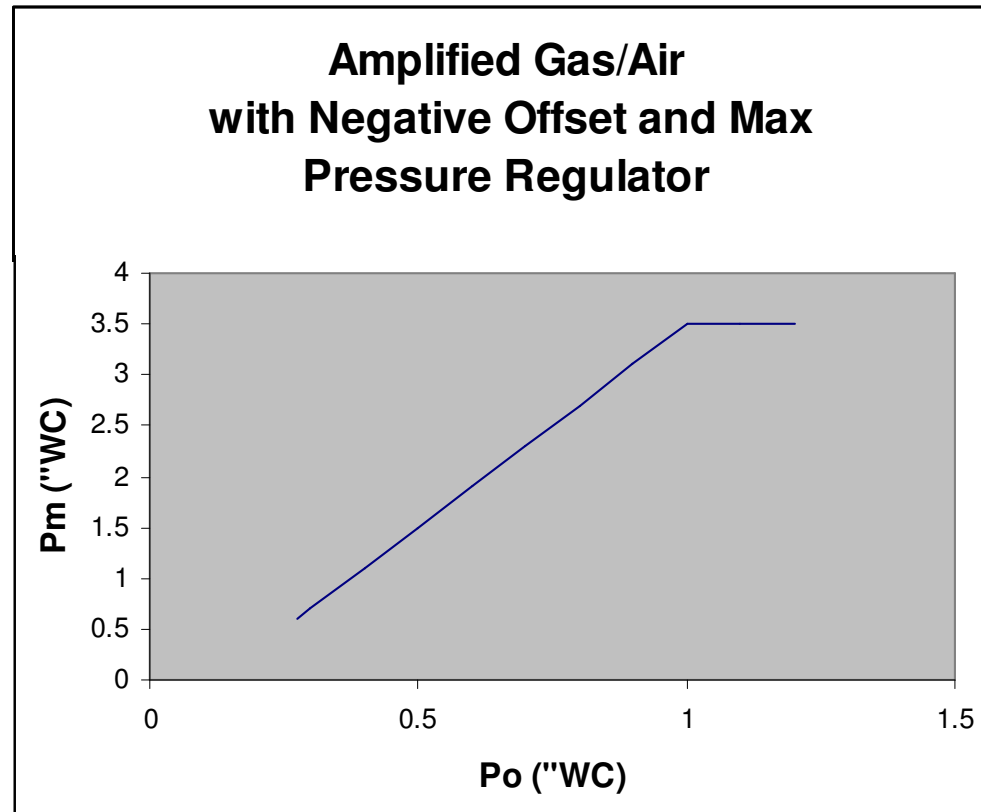


- Gas (manifold) pressure is linked to combustion air pressure through a servo regulator system
- System pressure is amplified to obtain “normal” manifold pressures.



# Amplified Gas/Air

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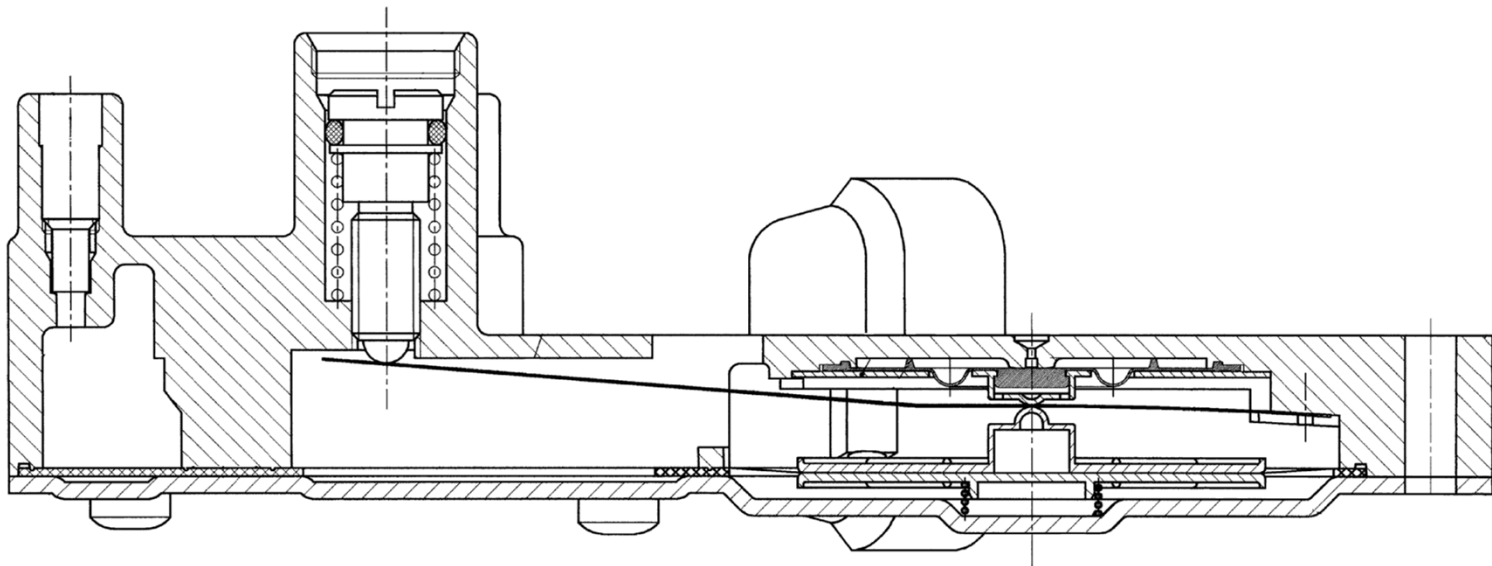


- Manifold pressure is driven by pressure drop across heat exchanger (pressure signal normally applied to pressure switch)
- Simple solution for staging and modulation



# Gas/Air Amplifier

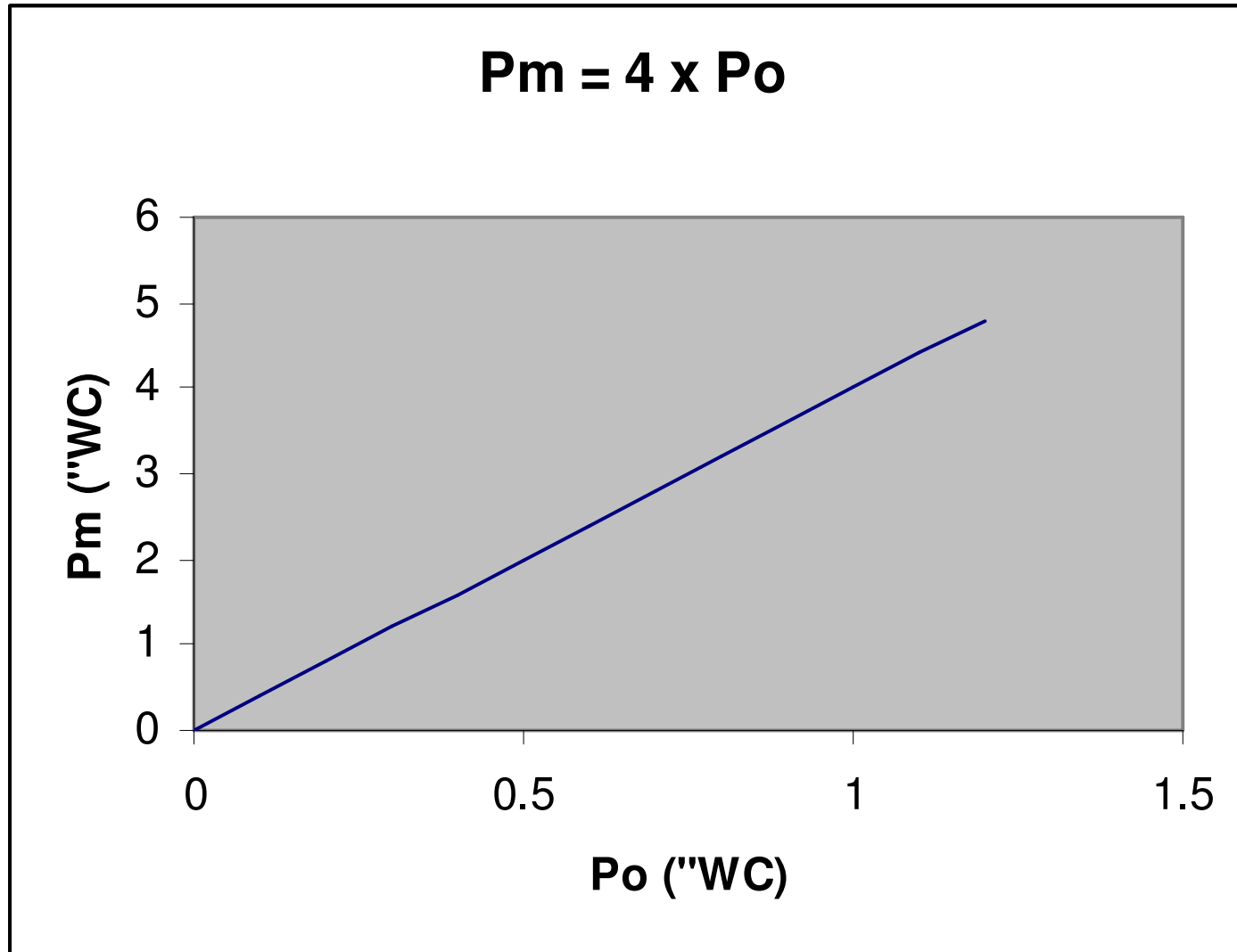
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# Amplified Gas/Air with 4 amplifier

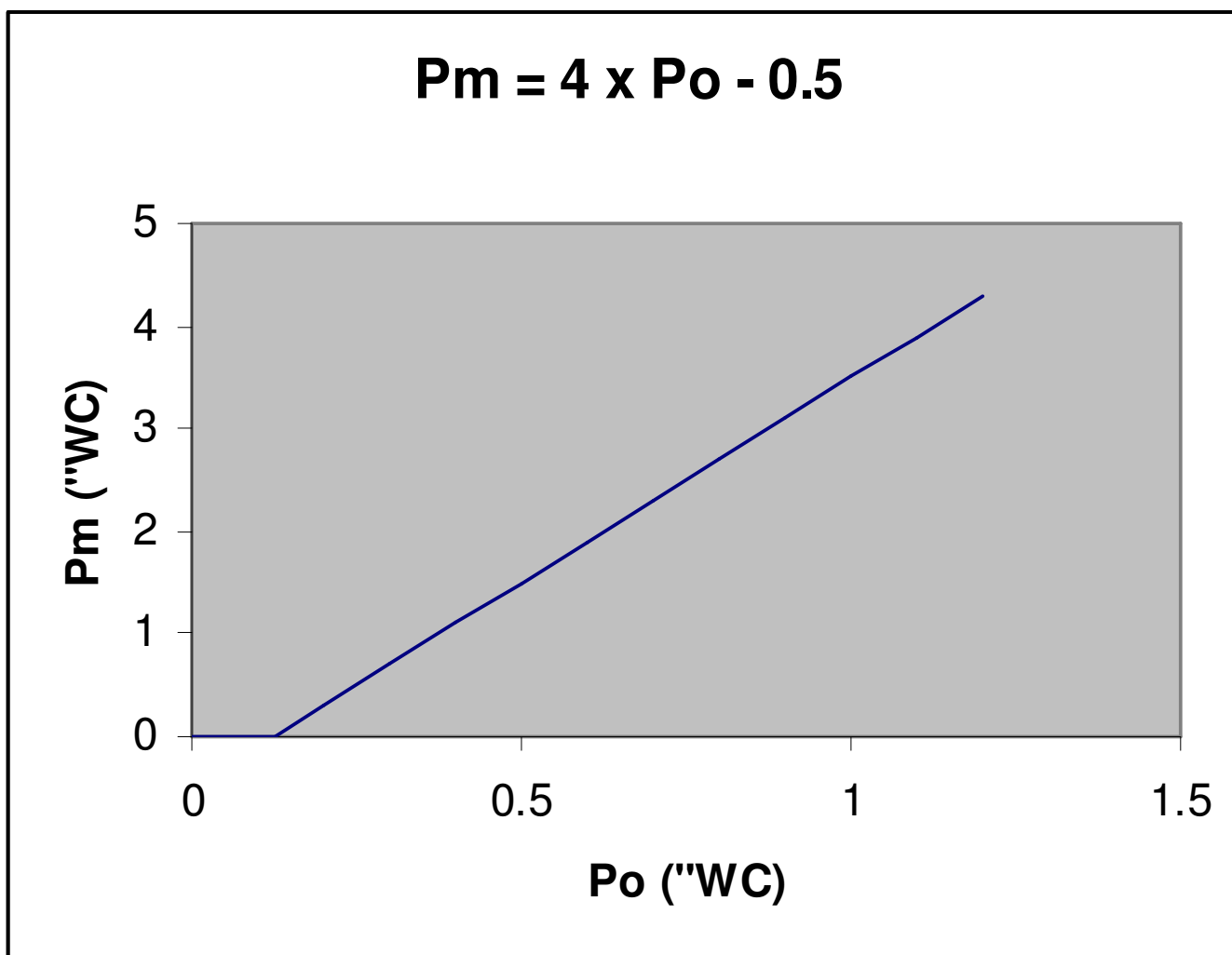
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# Amplified Gas/Air with 4 amplifier and -.5 Offset

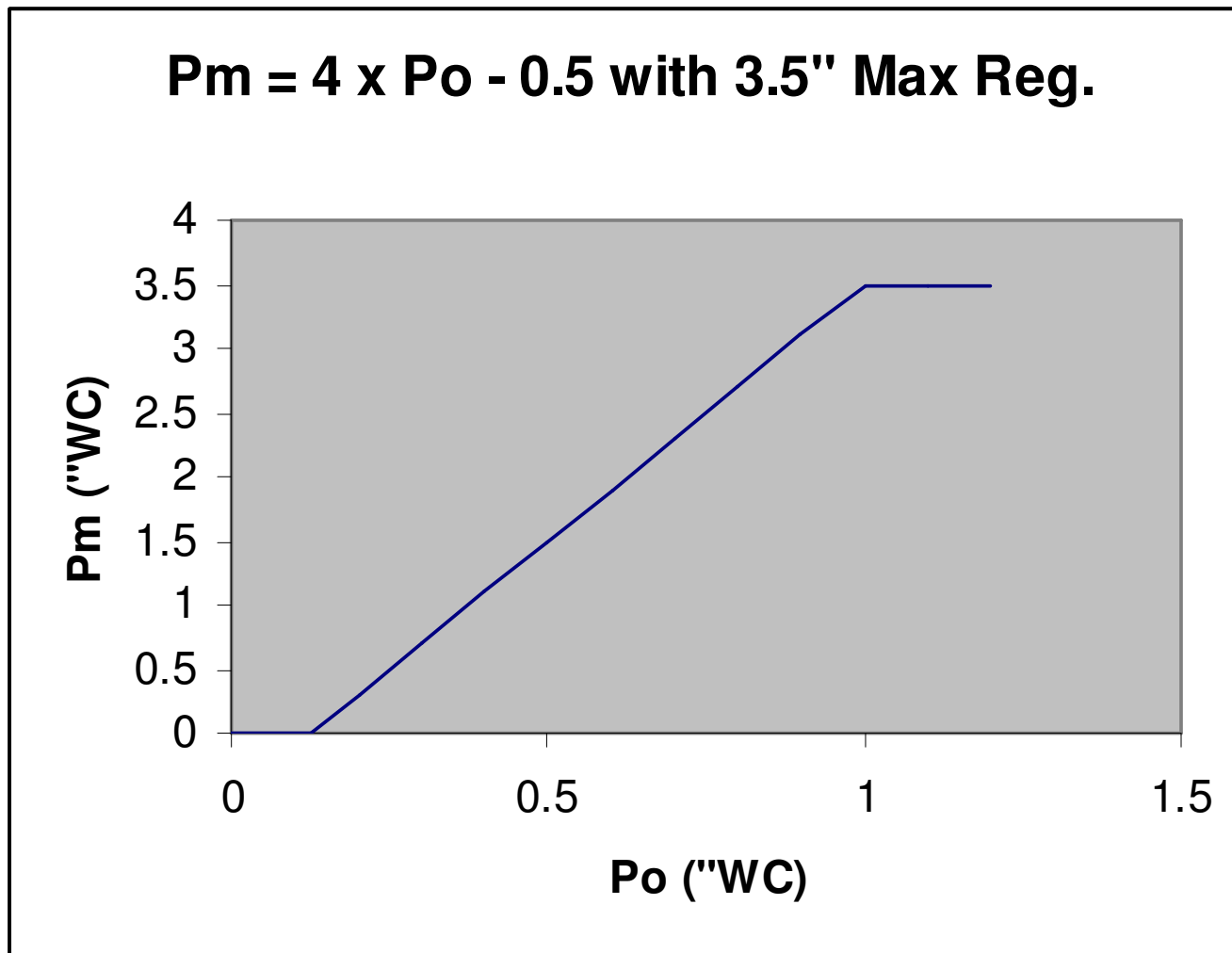
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# Valve with 4 amplifier, -.5 Offset and 3.5 Max Reg.

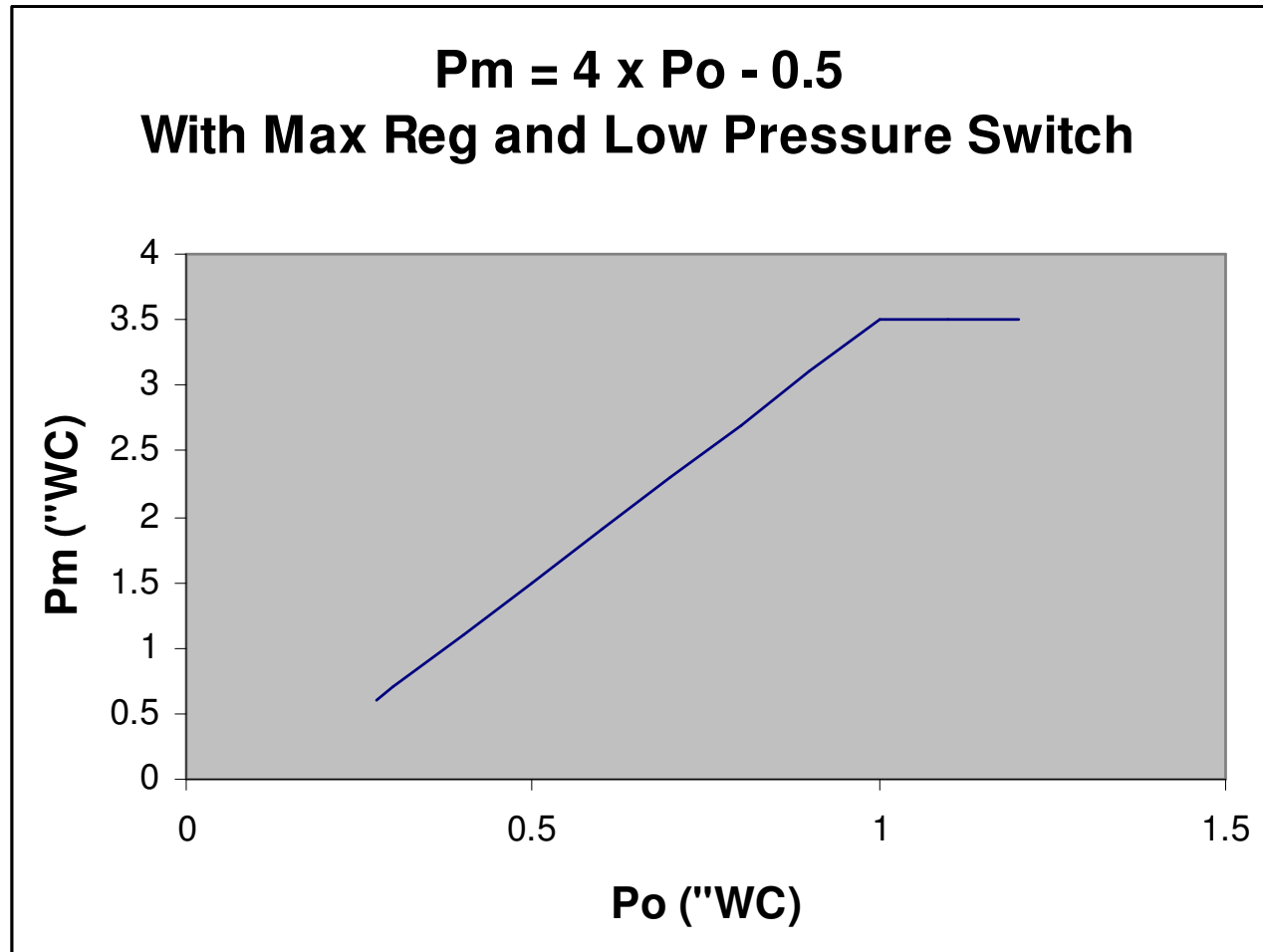
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# System with Low Pressure Switch

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# Amplified Gas/Air Benefits

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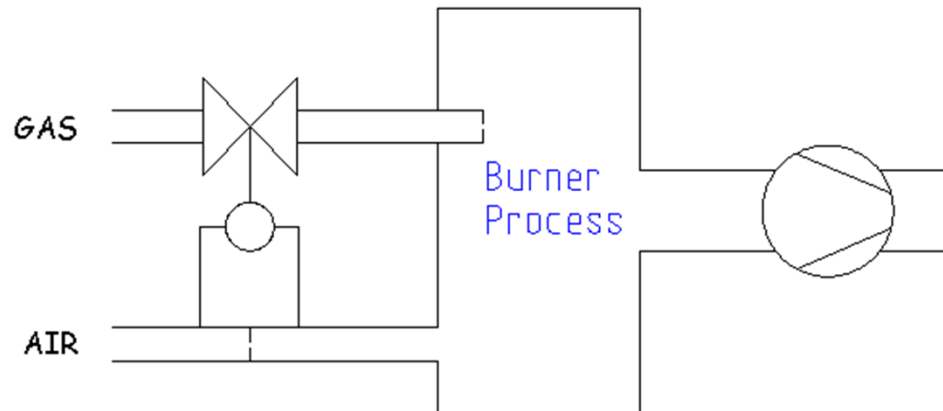
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- **Pneumatic linking of gas and air.**
- **Easy staging and modulation.**
- **Compatible with inshot burners.**
- **Compatible with existing Furnace Heat Exchangers**
- **Compatible with existing Inducers.**
- **Simple application in existing Central Furnaces**
- **Simple field replacement.**



# 1:1 Gas/Air Control

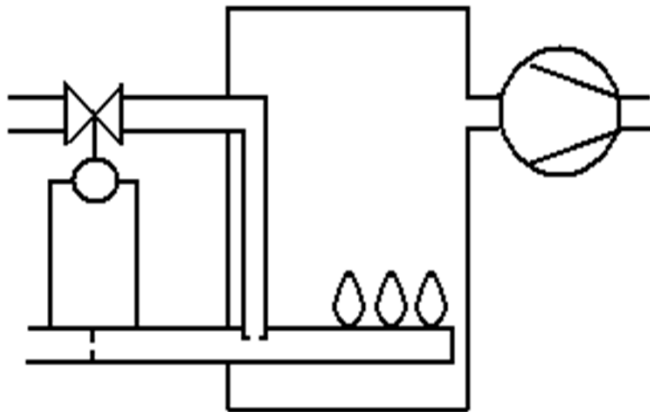
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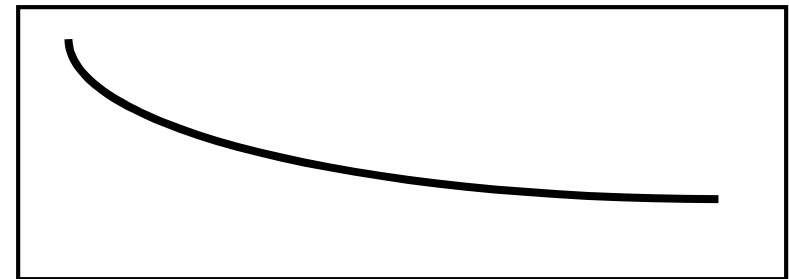


# 1:1 Gas/Air Control with Premix Burner

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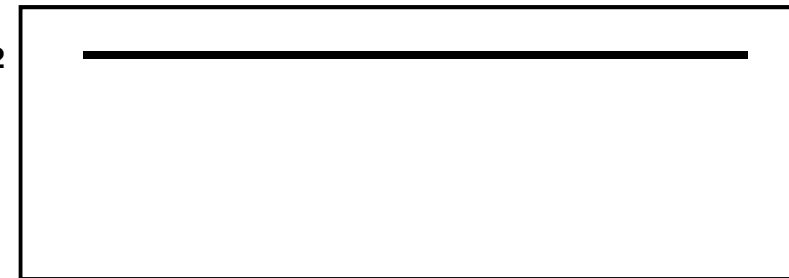
Eff.



Load



CO<sub>2</sub>



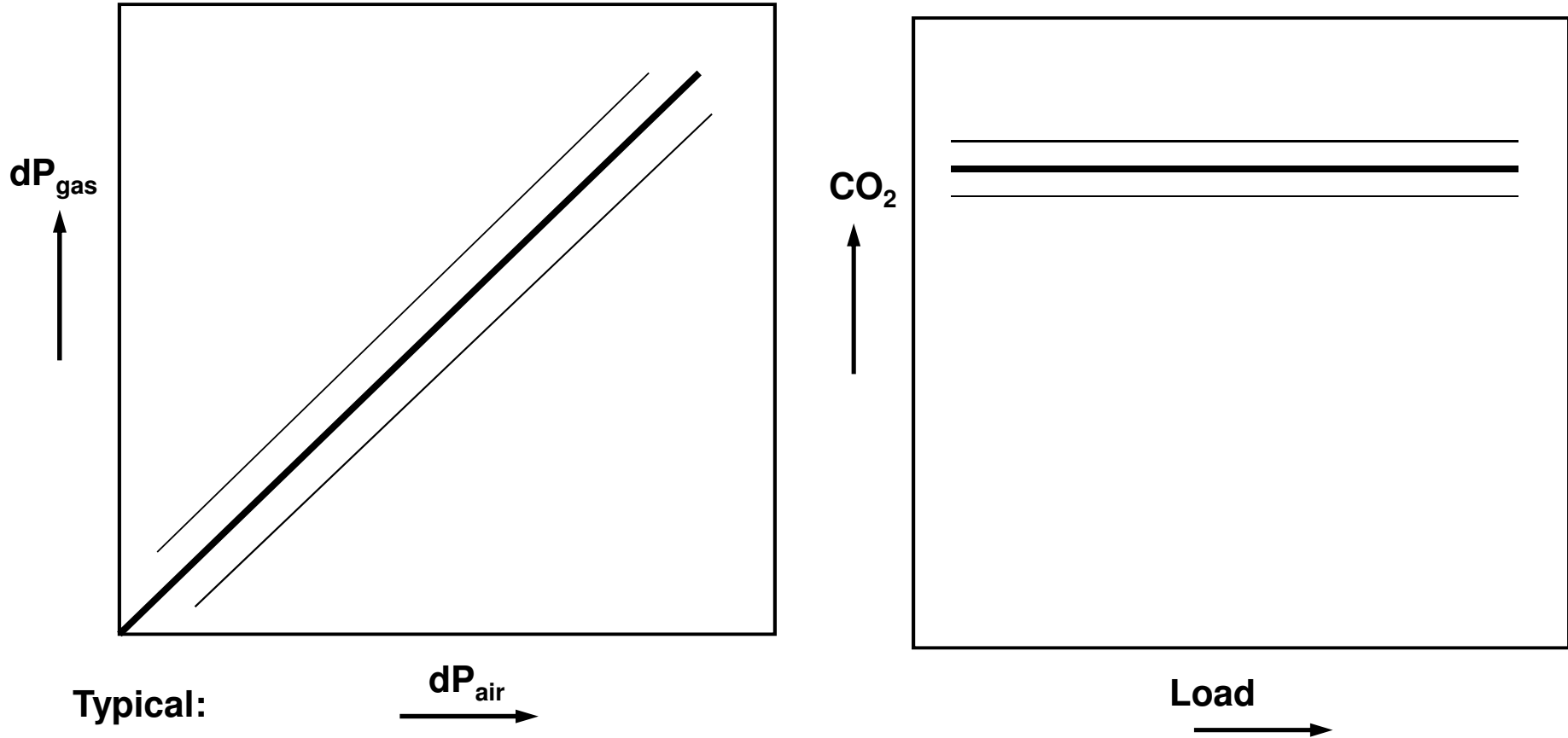
Load





# Gas/air control of premix burner

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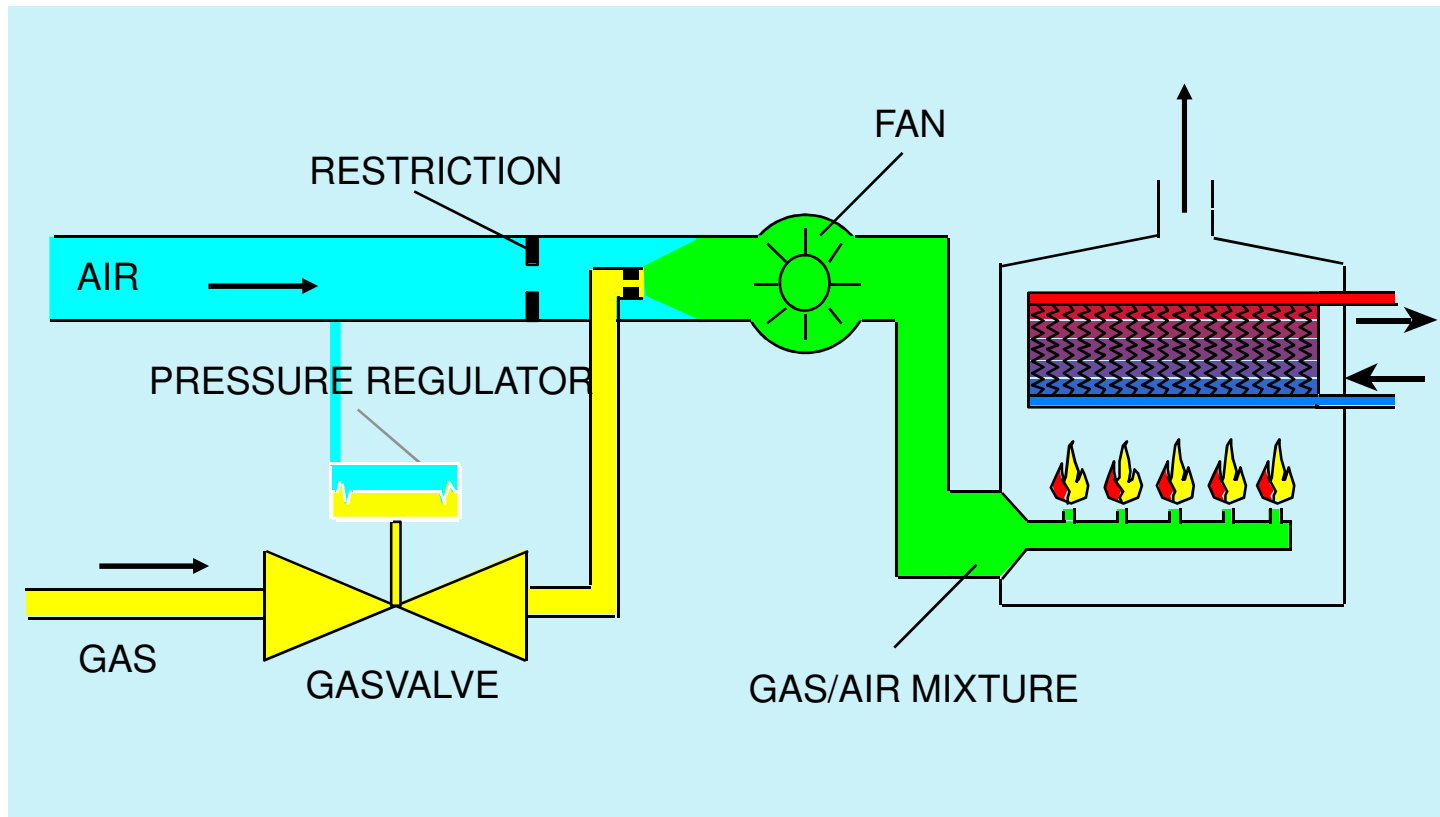
Typical:

- Tolerances on burner pressure tight, especially at low pressures
- Modulation graph through zero
- Limitation of max. burner pressure by gas valve not possible



# 1:1 Gas/air

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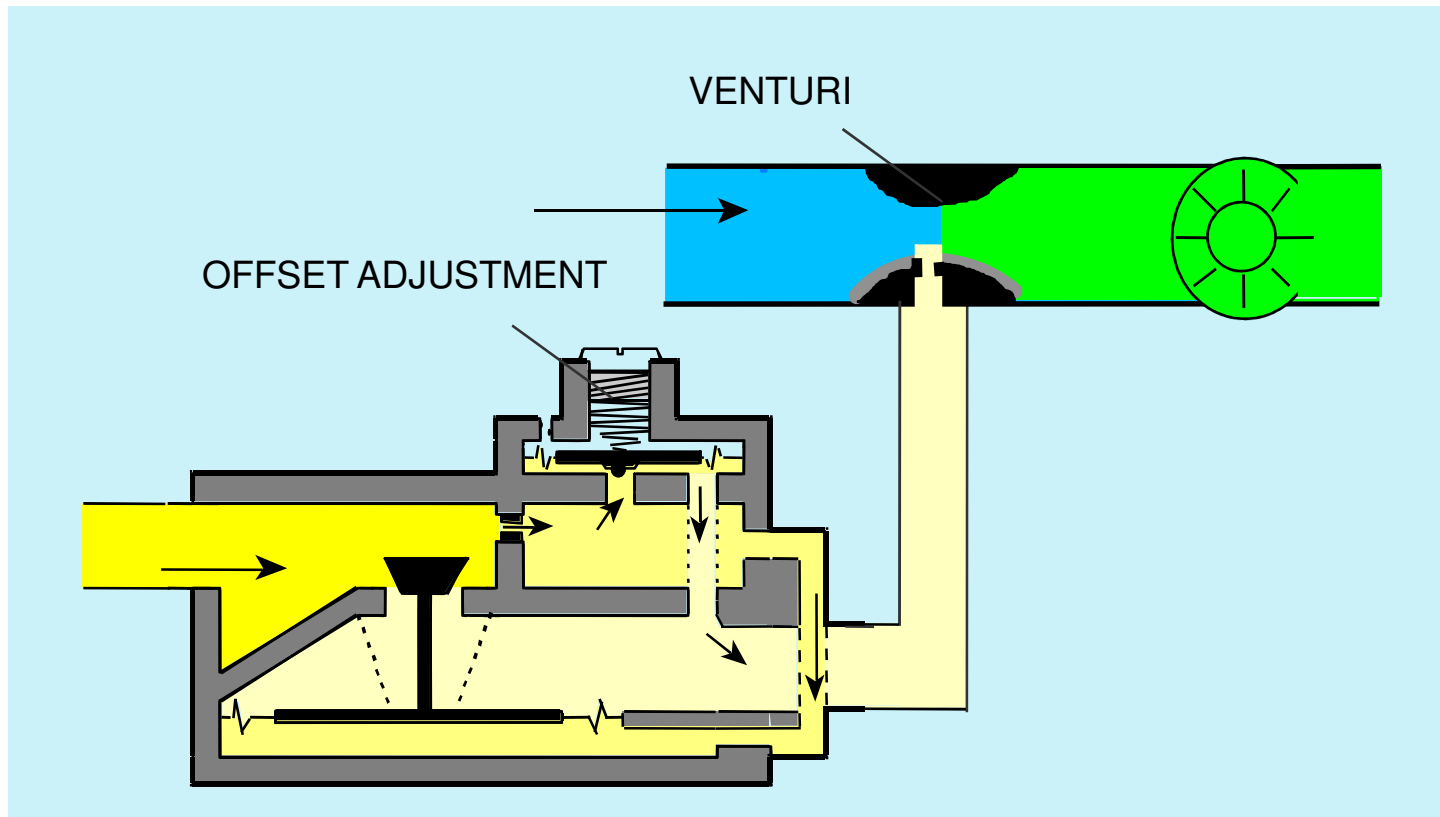
# Venturi

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$\Delta P_{air} = \text{HIGH AIR} - \text{LOW AIR}$

LOW AIR can be measured on gas pressure tap if gas valve is closed

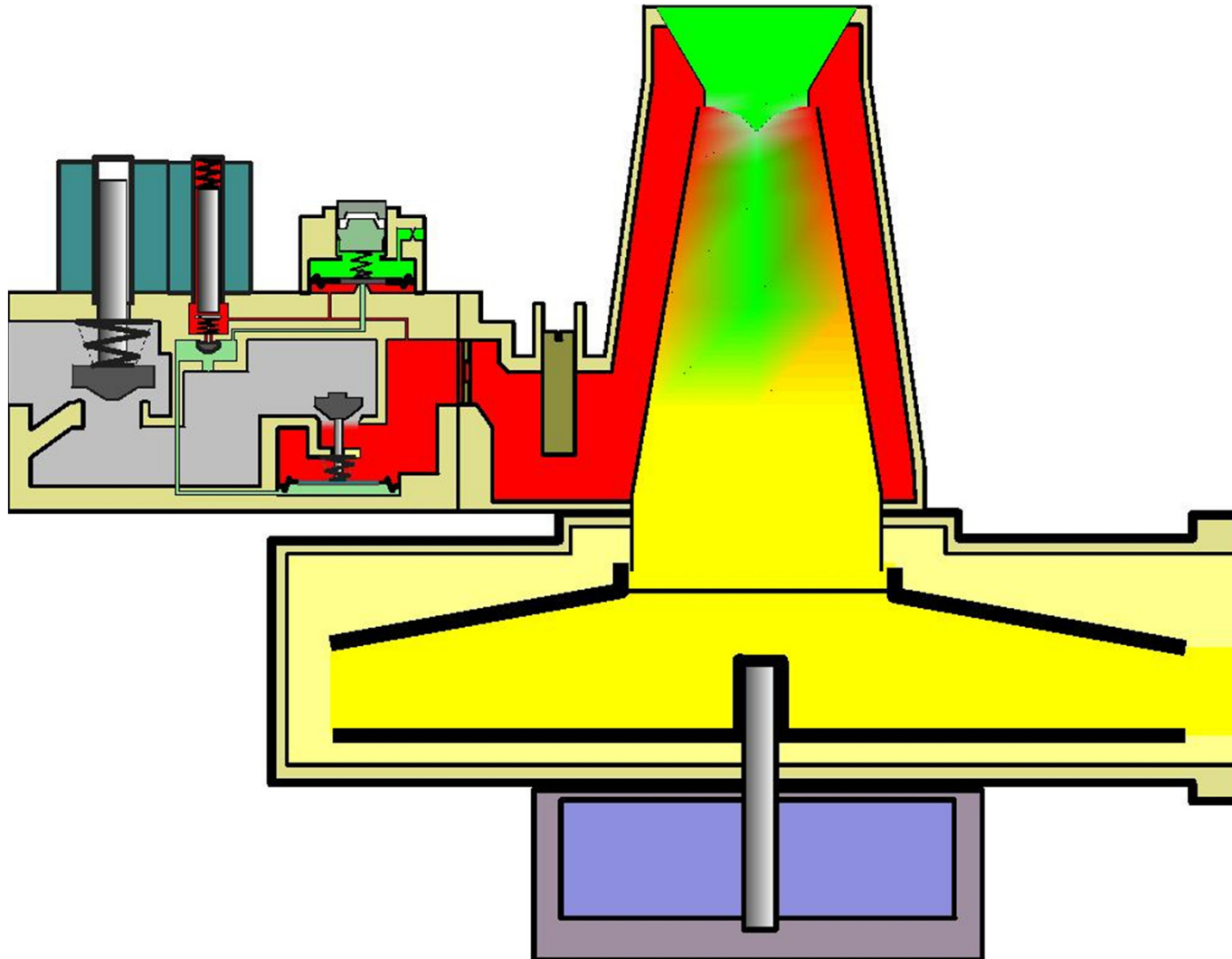
$\Delta P_{gas} = \text{GAS PRESSURE} - \text{REFERENCE PRESSURE (= LOW AIR)}$





# 1:1 with a Venturi

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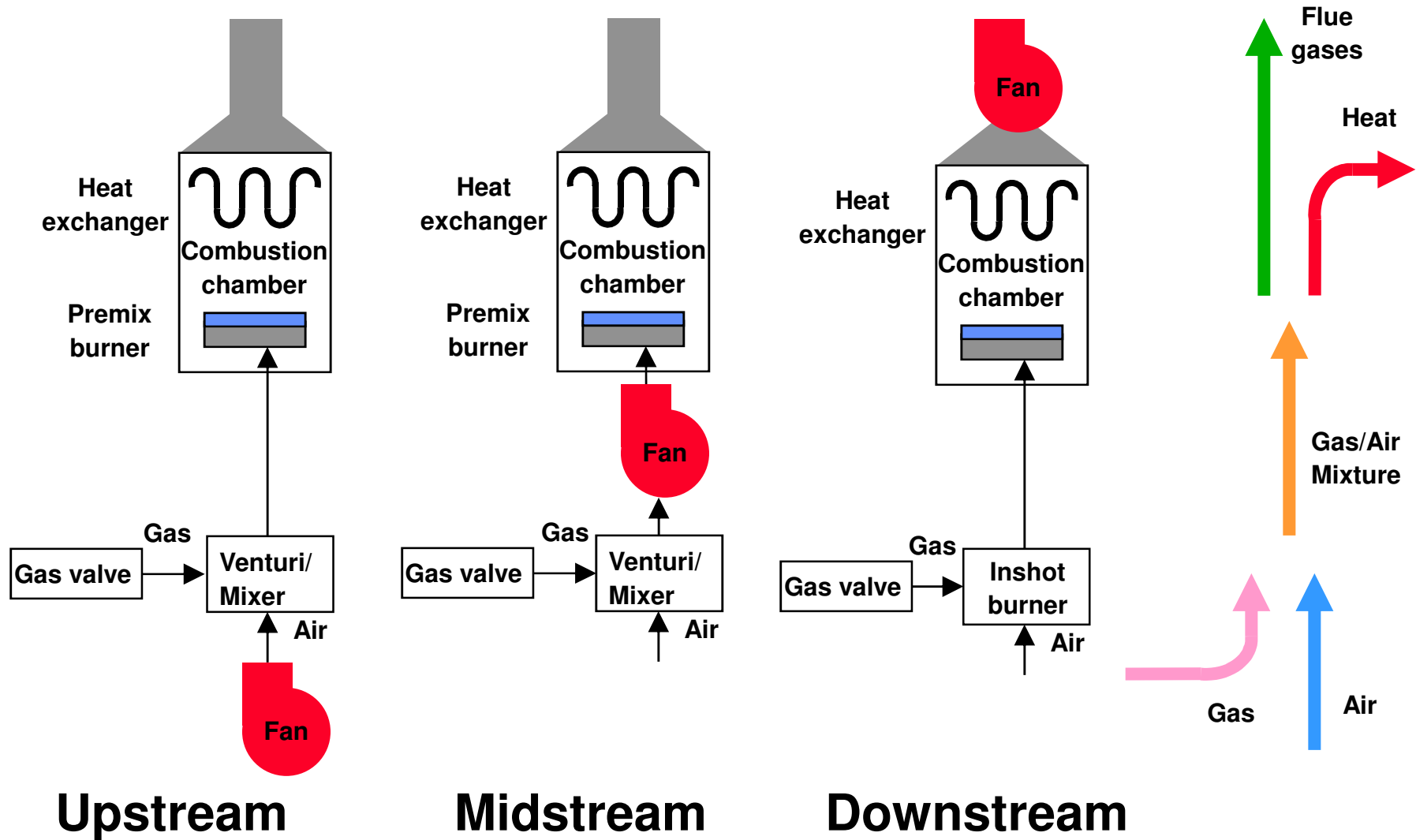
# 1:1 Gas/Air Benefits

- Optimization of efficiency
- Modulation with premix burner
- Increased reliability
- Reduction of combustion products emissions
- Omission of air pressure switch



# Fan position for Pneumatic Gas/Air

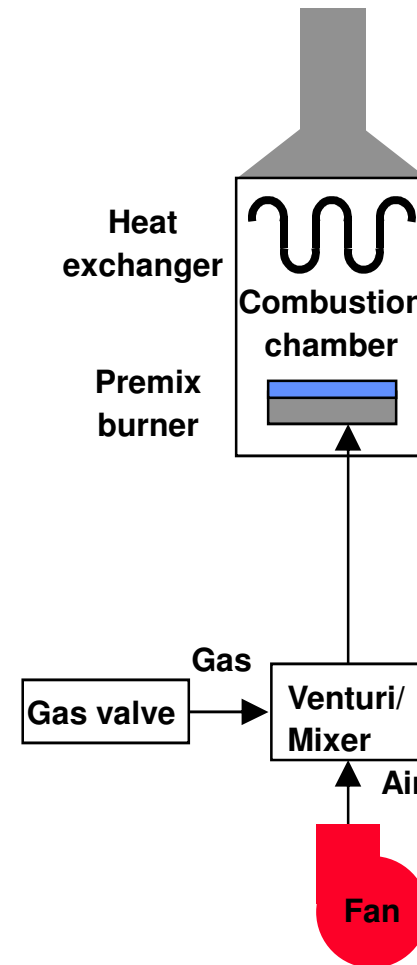
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# Upstream Fan - 1:1 Gas/Air

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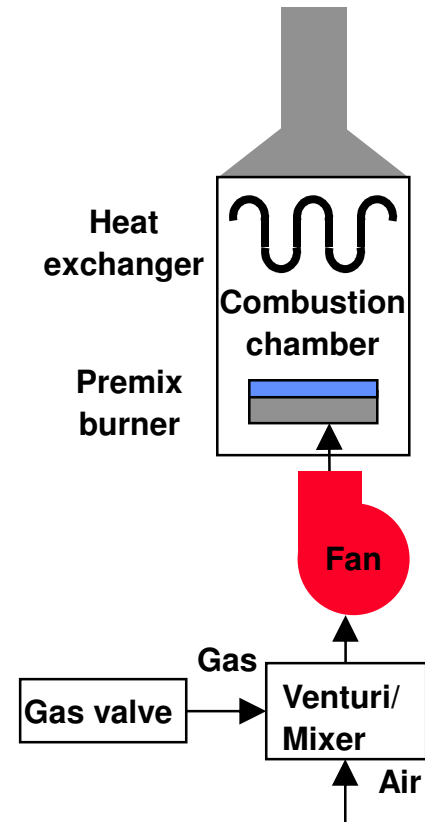


Upstream



# Midstream Fan - 1:1 Gas Air

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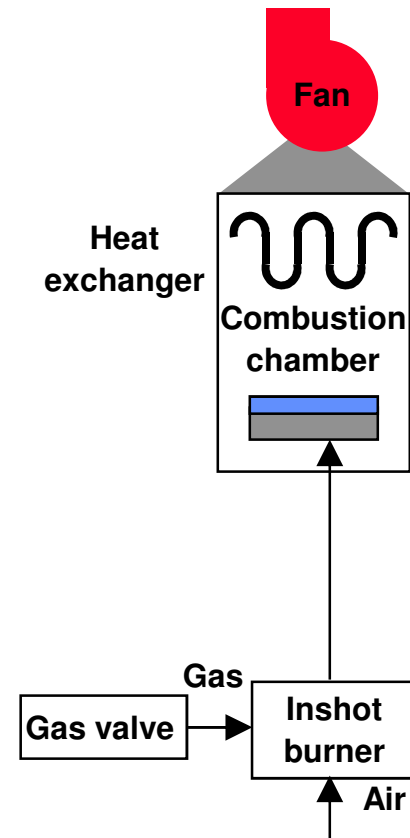
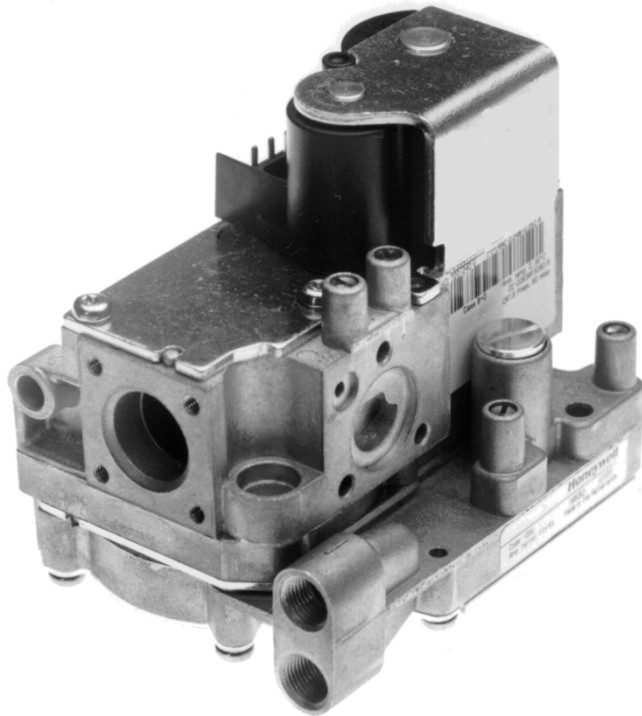


Midstream



# Downstream Fan - Amplified Gas Air

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**Downstream**



# Application Considerations

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- **Fan performance**
- **Regulator accuracy**
- **Valve capacity**
- **Gas quality tolerances**
- **LP (oscillation)**
- **Noise production**



# Application Procedure

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- **Determination of nominal CO<sub>2</sub>**
- **Determination of control settings:**
  - **Offset**
  - **Orifice / throttle**
- **Measurement of static performance with gas/air control**



# Application Procedure

- **Accuracy tests:**
  - **Tapping**
  - **Ambient temperature**
  - **Inlet pressure**
  - **Hysteresis**
- **Accuracy tests: performance at gas valve tolerances**
- **Ignition performance tests**
- **Determination of optimum start input rate**
- **Step response test**



# Application Problems

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- Ignition problems
- Insufficient input rate (air pressure too low)
- Minimum gas pressure too low (measure delta P!)
- Deviations from ideal CO<sub>2</sub> characteristic



# Ignition Problems

- **Causes**

- insufficient mixing of gas and air
- incorrect CO<sub>2</sub>-%
- Moisture
- igniter position not correct
- sensitive burner

- **Remedies:**

- improved mixing
- ignition at different input rate
- hot surface ignition or intermittent pilot
- optimize igniter position
- increased spark energy



# Maximize pressures

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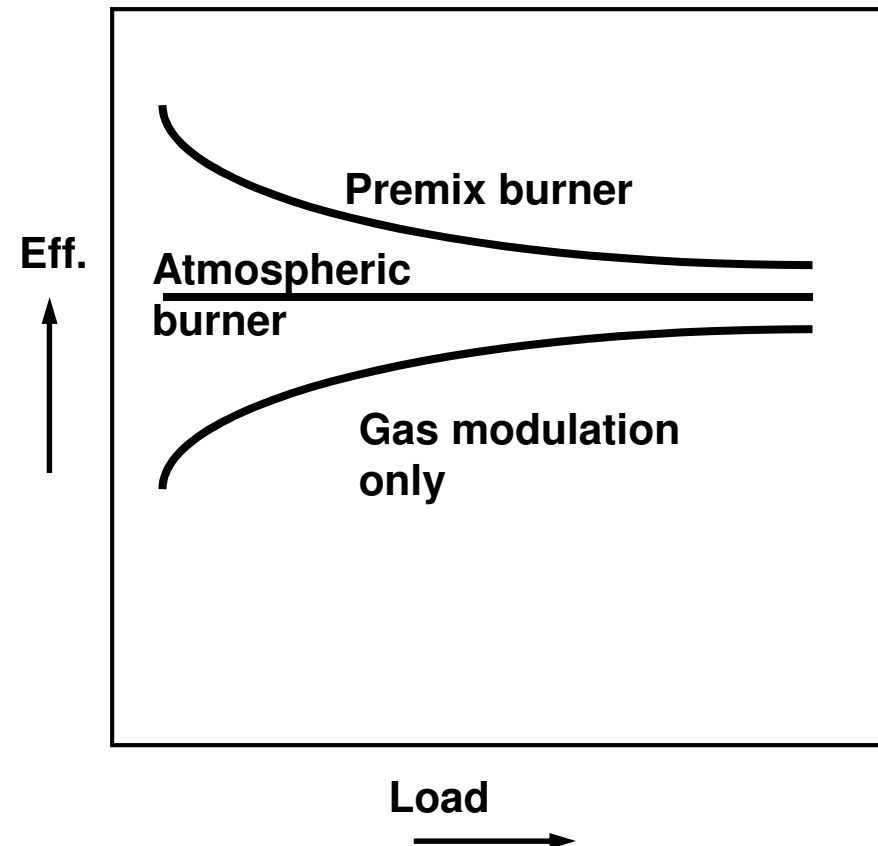
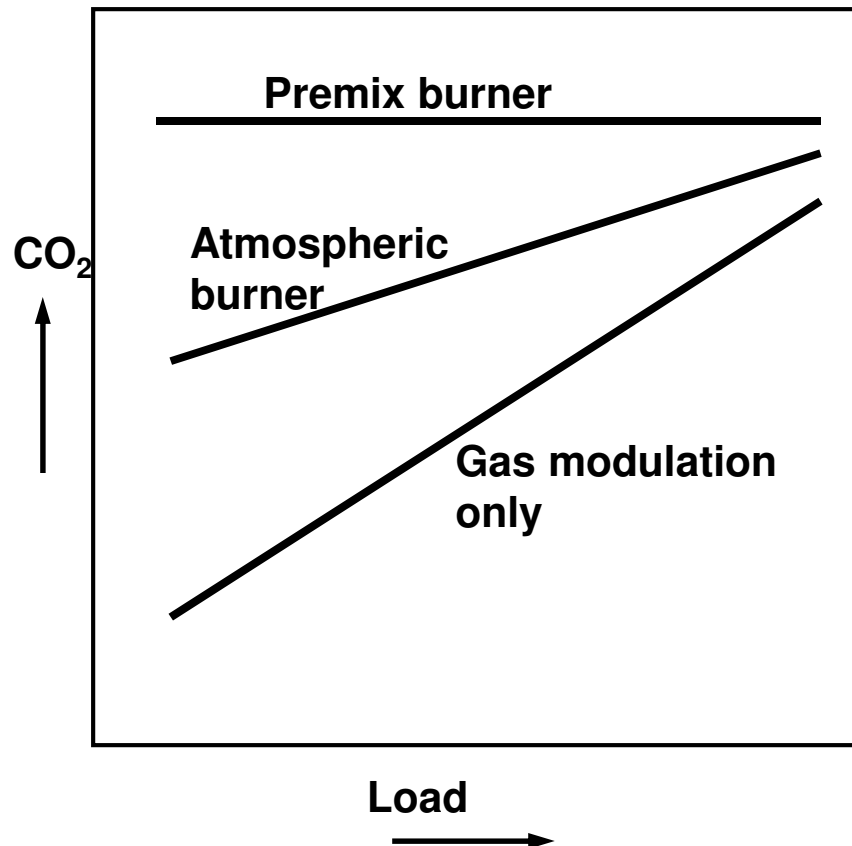
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- **Air signal is never too high !**
- **Reasons:**
  - effect on regulation accuracy
  - effect on mixing conditions (CO emission)
  - effect on modulation band (minimum point is fixed)
  - lower fan speed possible (noise reduction)



# Which System is Required?

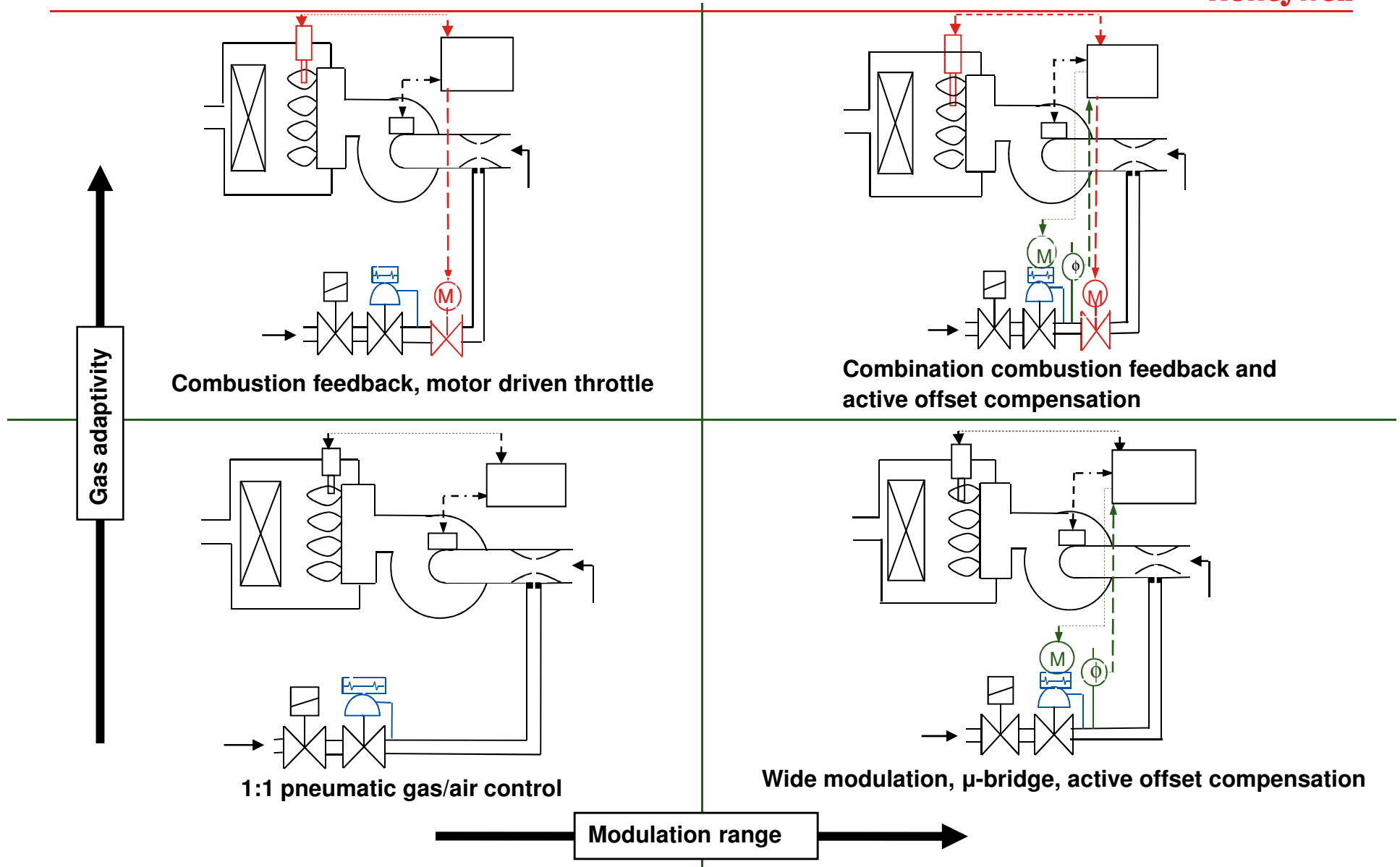
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# Advanced Systems

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# Conclusion

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- **Thank you!**
- **Questions?**