NOx- How Low is Achievable with Oilheating Combustion Systems?

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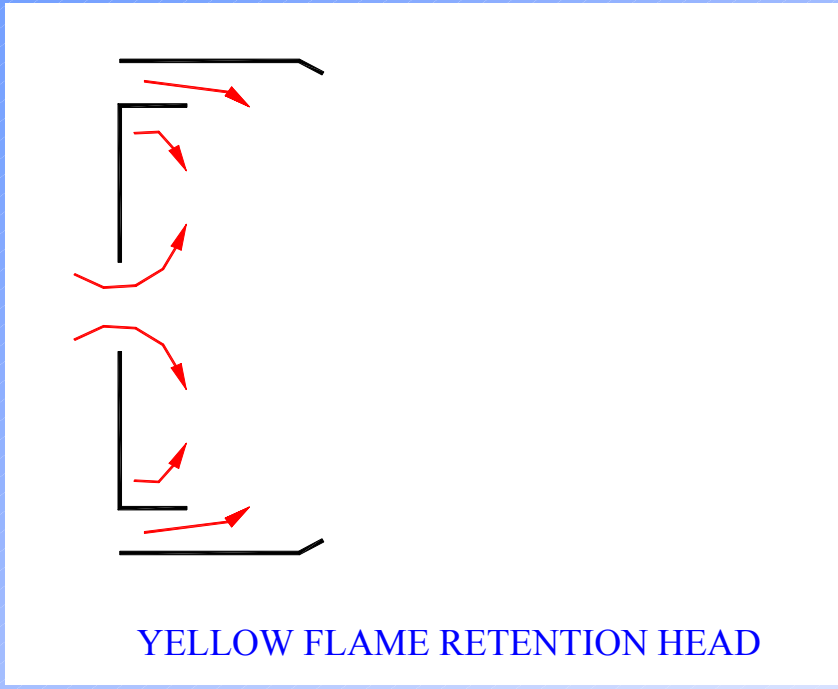
BROOKHAVEN NATIONAL LABORATORY

Conventional Yellow Flame



Range: 75 to 180 ppm Average 110 ppm

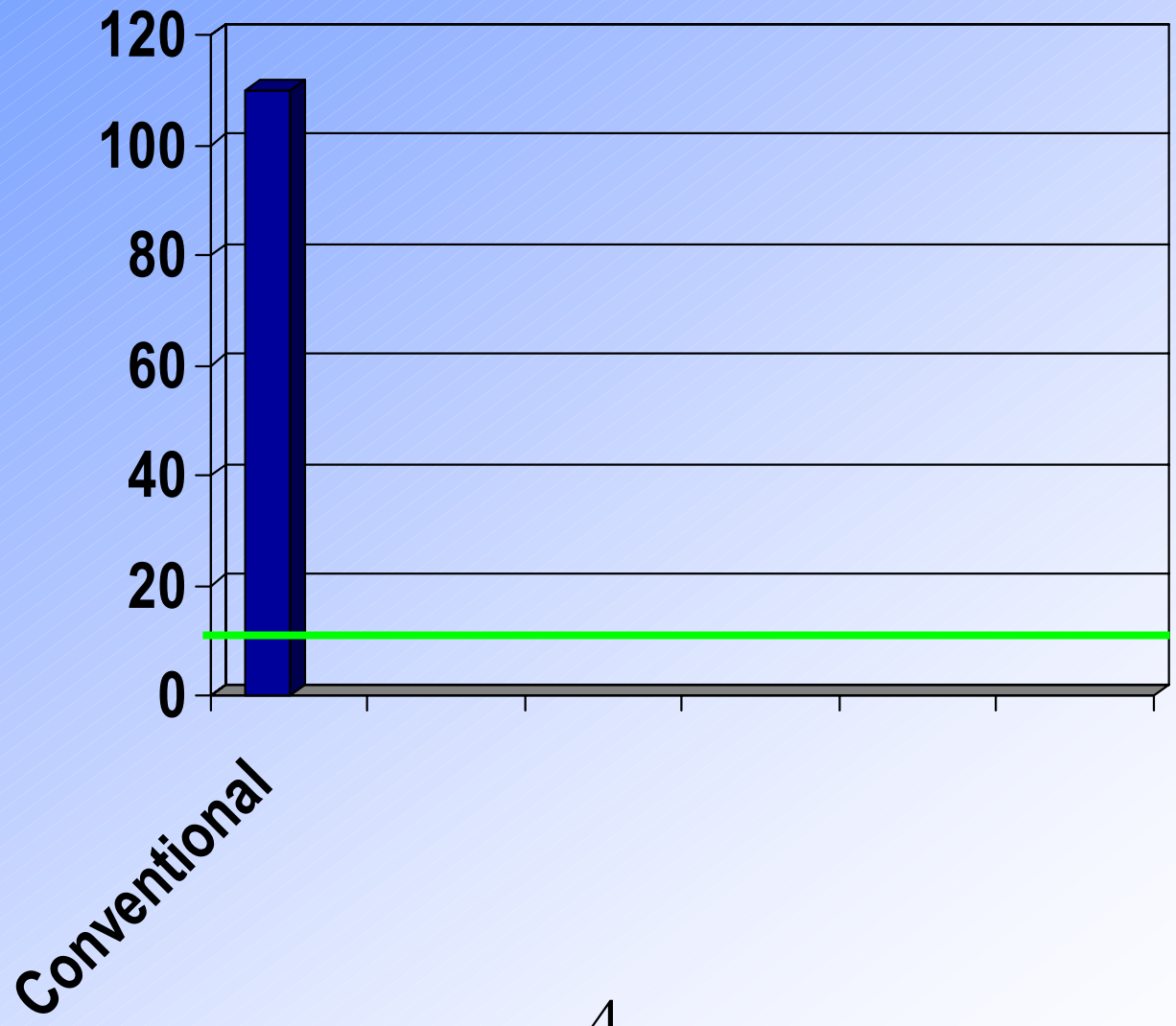
Objectives

Short Term – 50 to 60 ppm

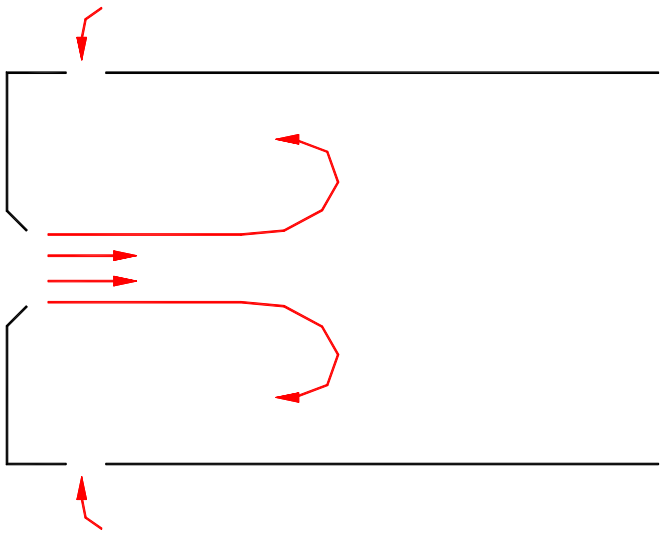
Long Term – 20 ppm with improved fuel

BNL Goal – 10 ppm technical feasibility

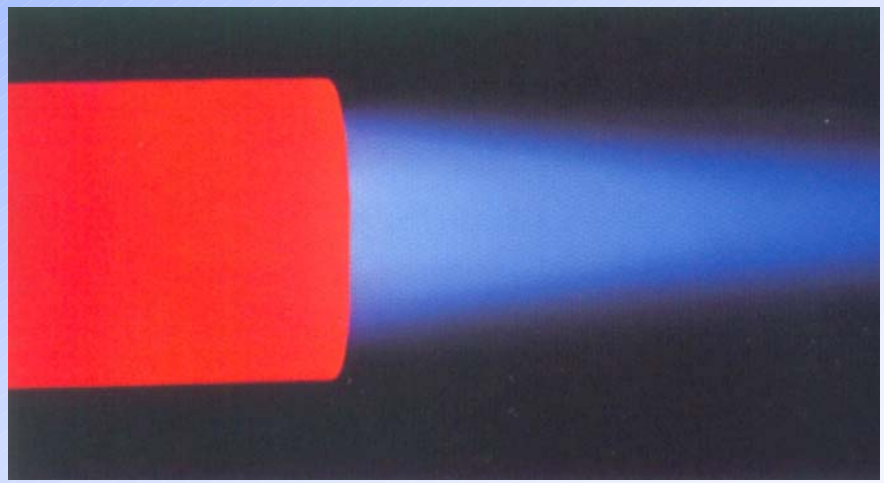
Comparison Chart



Low NOx

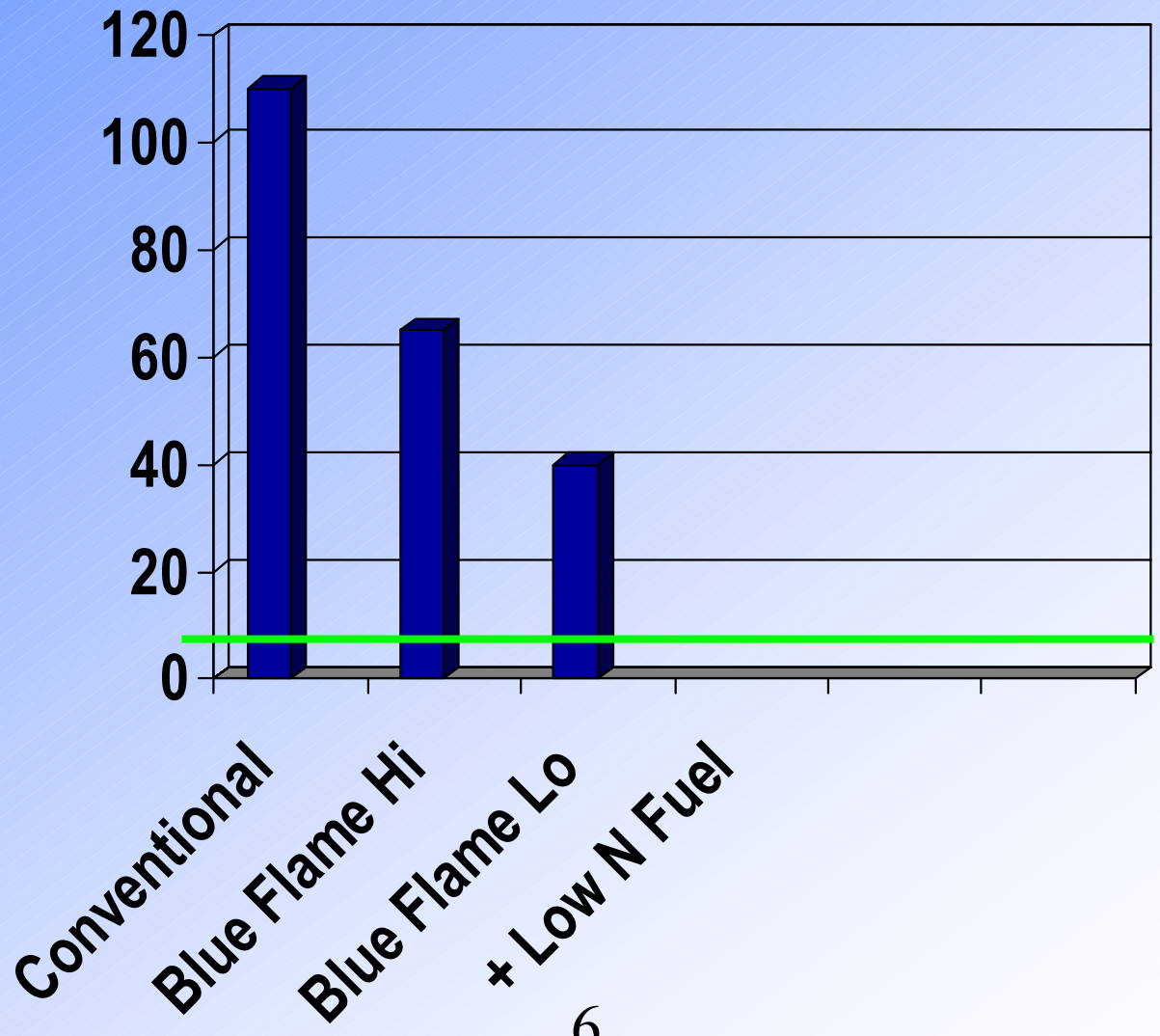


BLUE FLAME RECIRCULATING



Range: 40 to 60 ppm

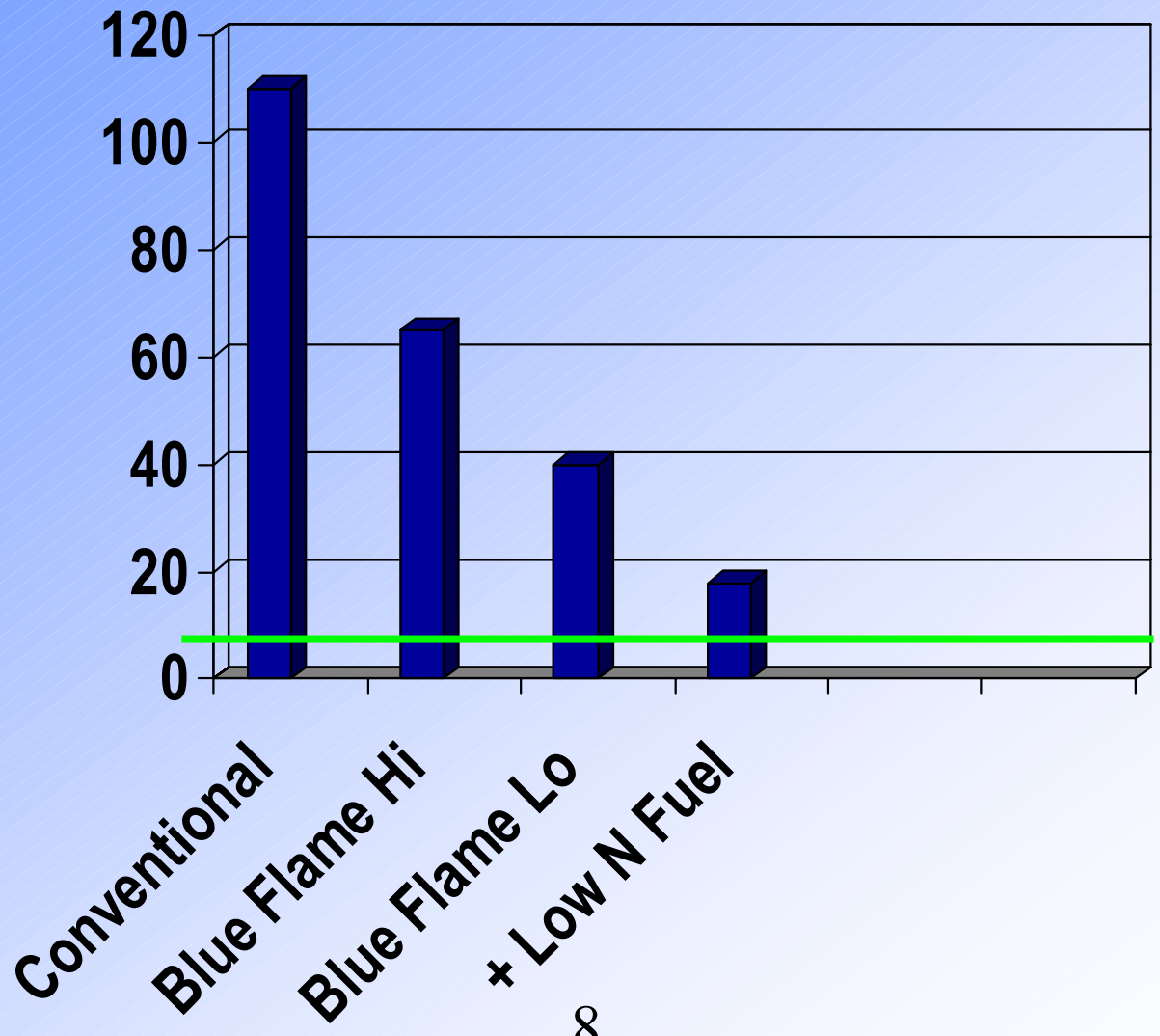
Comparison Chart



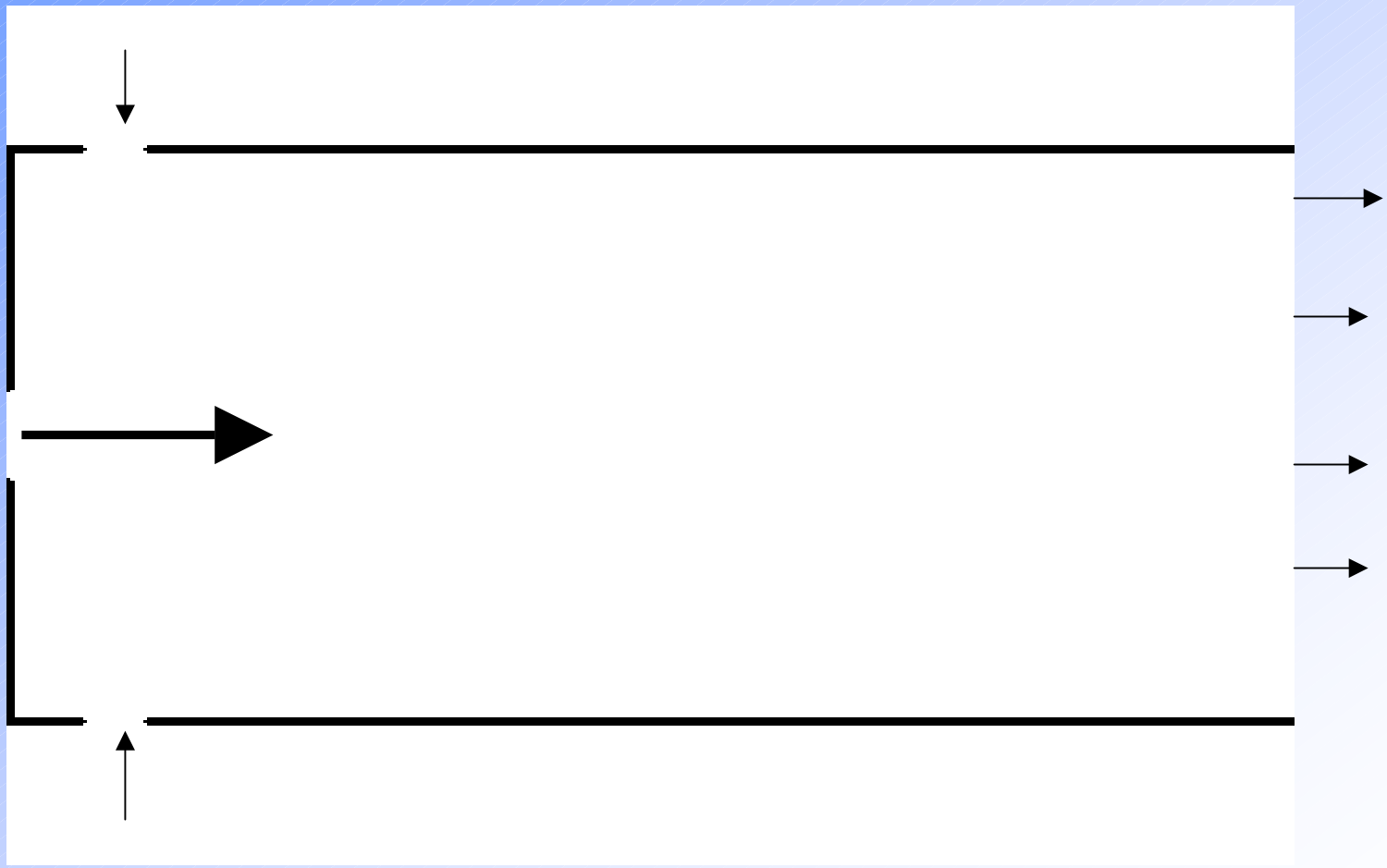
Fuel Nitrogen Content

- Not commonly measured in the U.S.
- Typical value 150 ppm by weight
- Contributes roughly 23 ppm
- Low S fuel tends to be low N

Comparison Chart



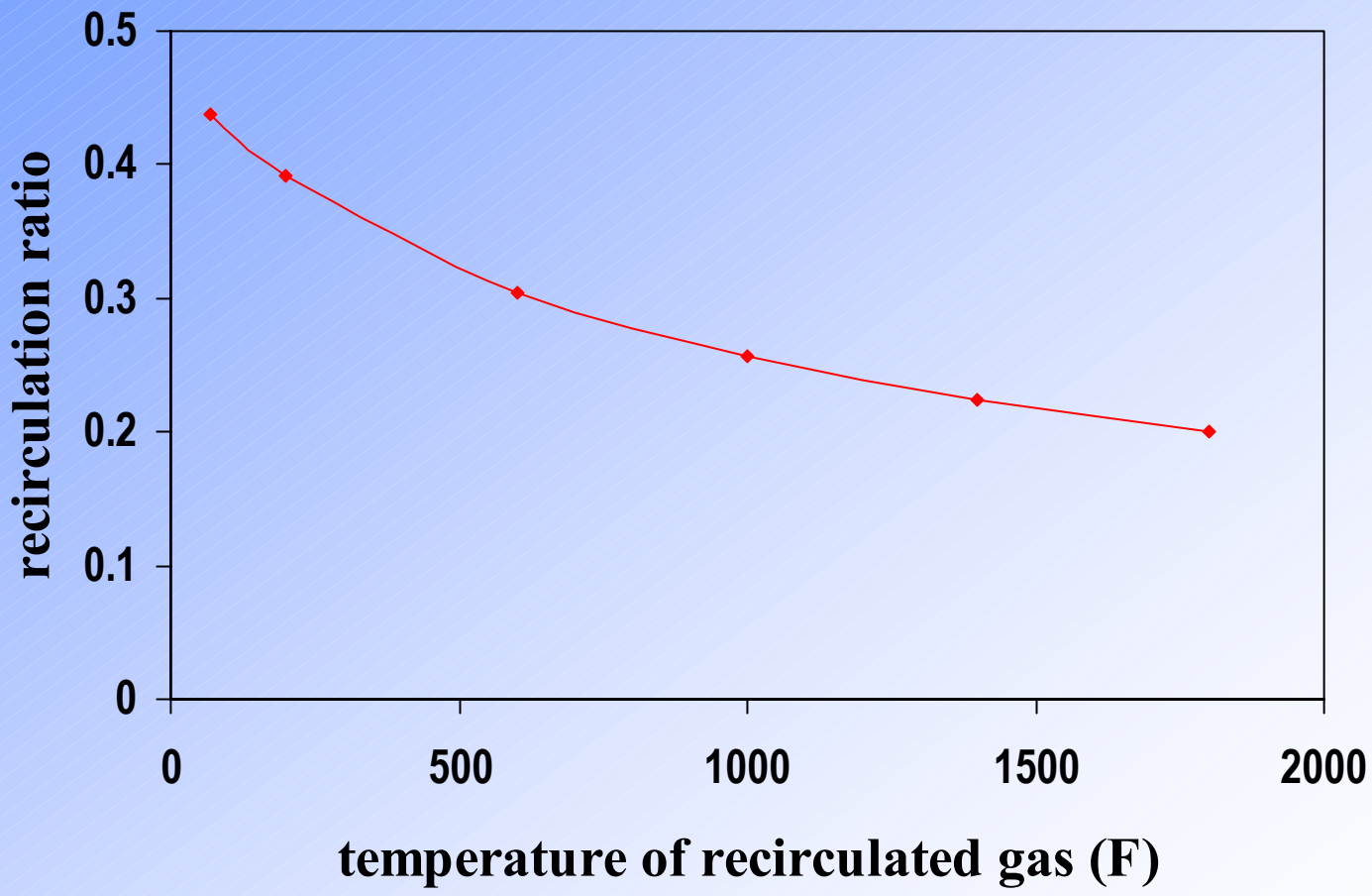
Increasing Internal Recirculation



Internal Recirculation

- Internal recirculation driven by inlet air velocity
- Amount of recirculation controlled by recirc slot area
- At startup, under cold conditions, gas density is high and recirculation rate is high.

Effect of cold start



Forcing High Recirculation Rates

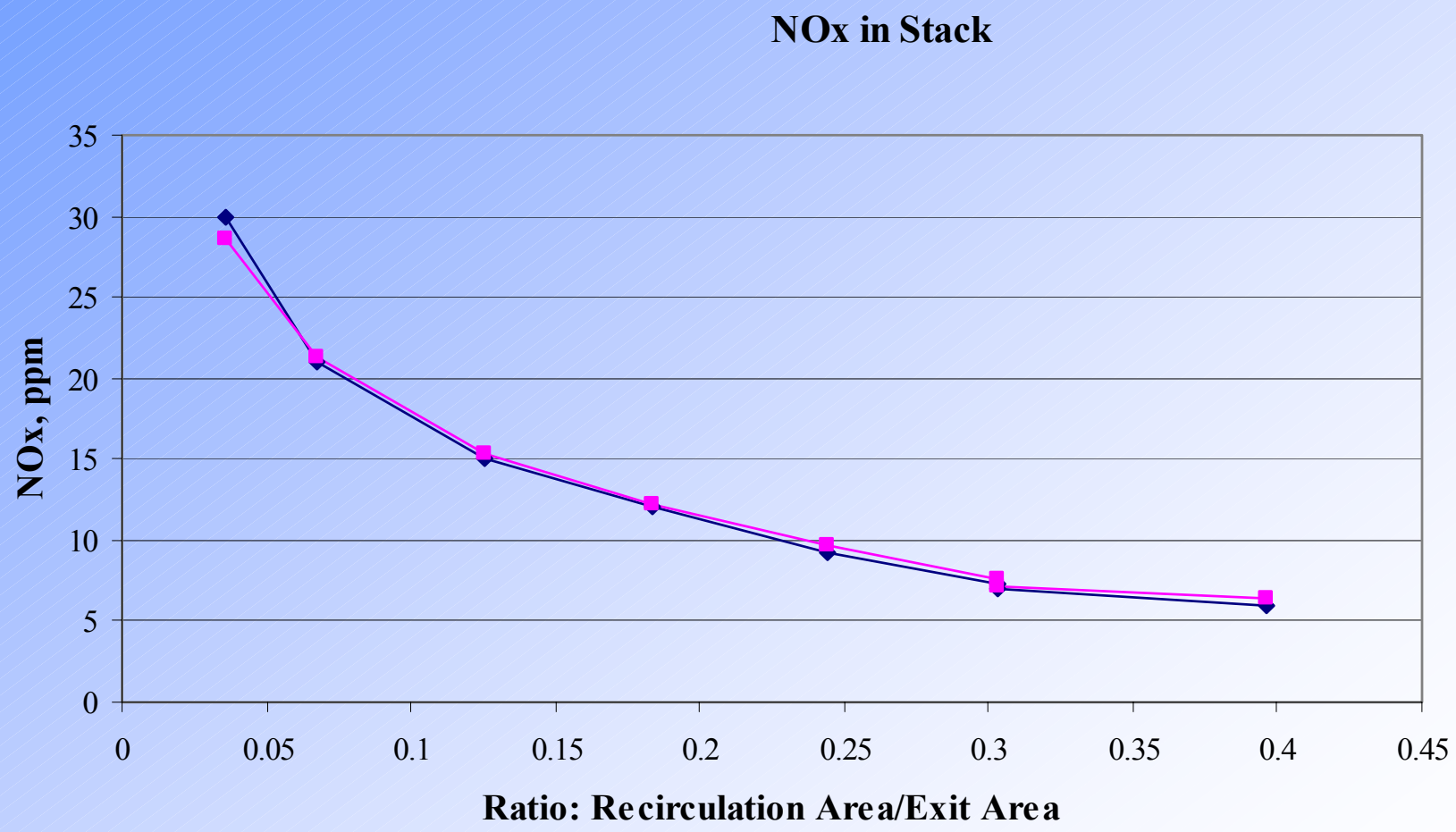
For test purposes

Manually adjusting recirc area for high recirulation rates <u>after</u> burner has lit and stabilized

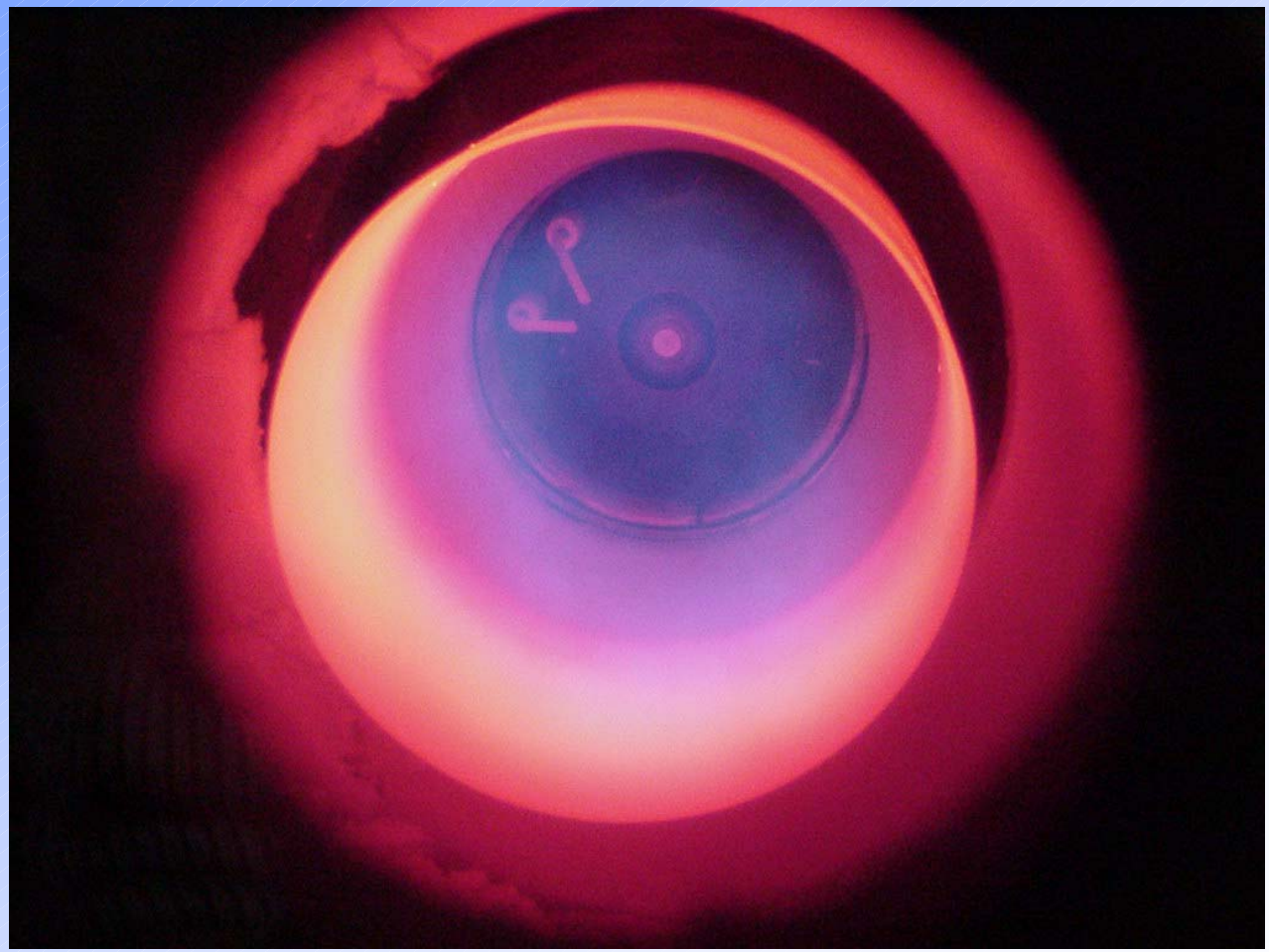
Low Recirc Area

High Recirc Area

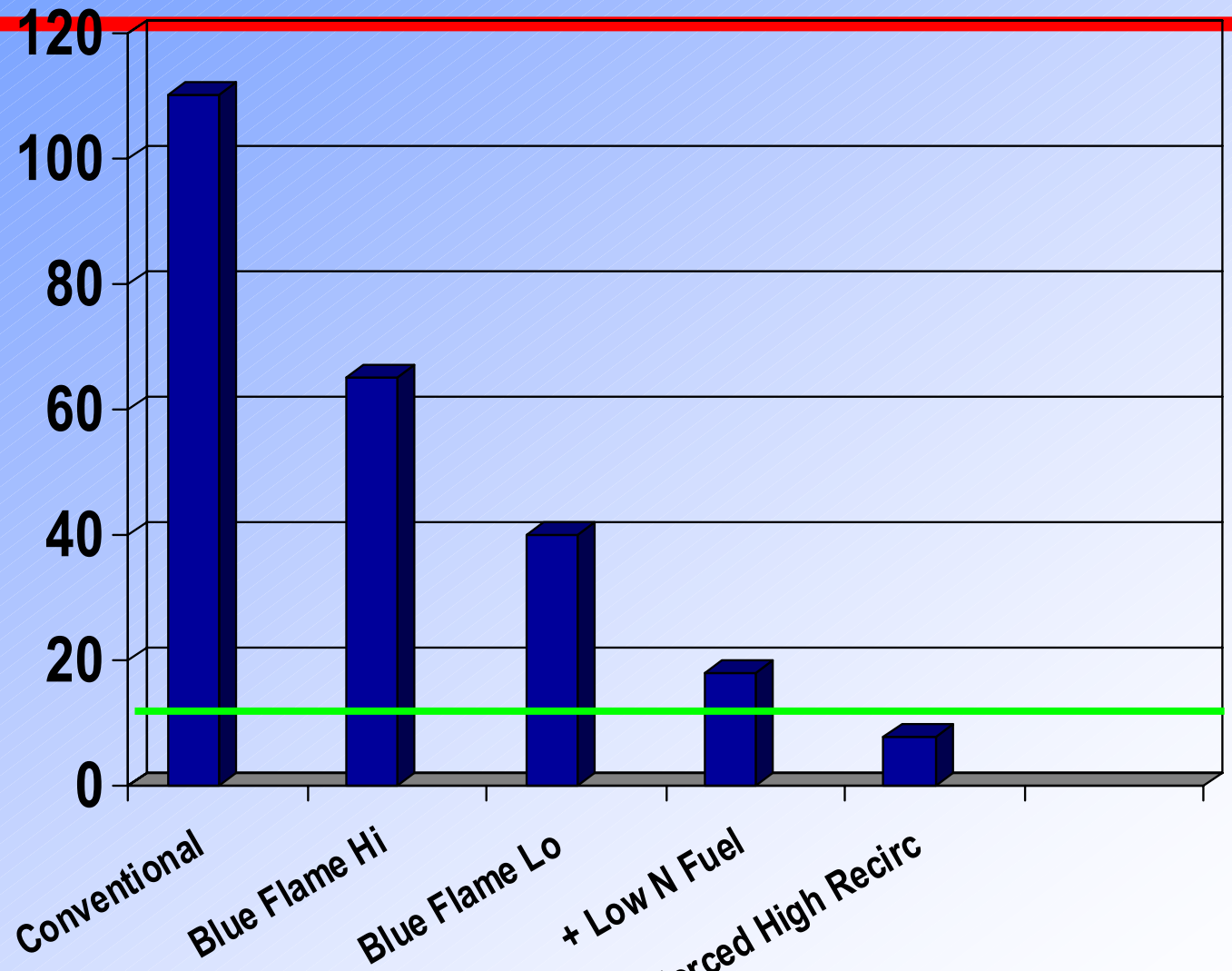
Forcing High Recirculation Rates



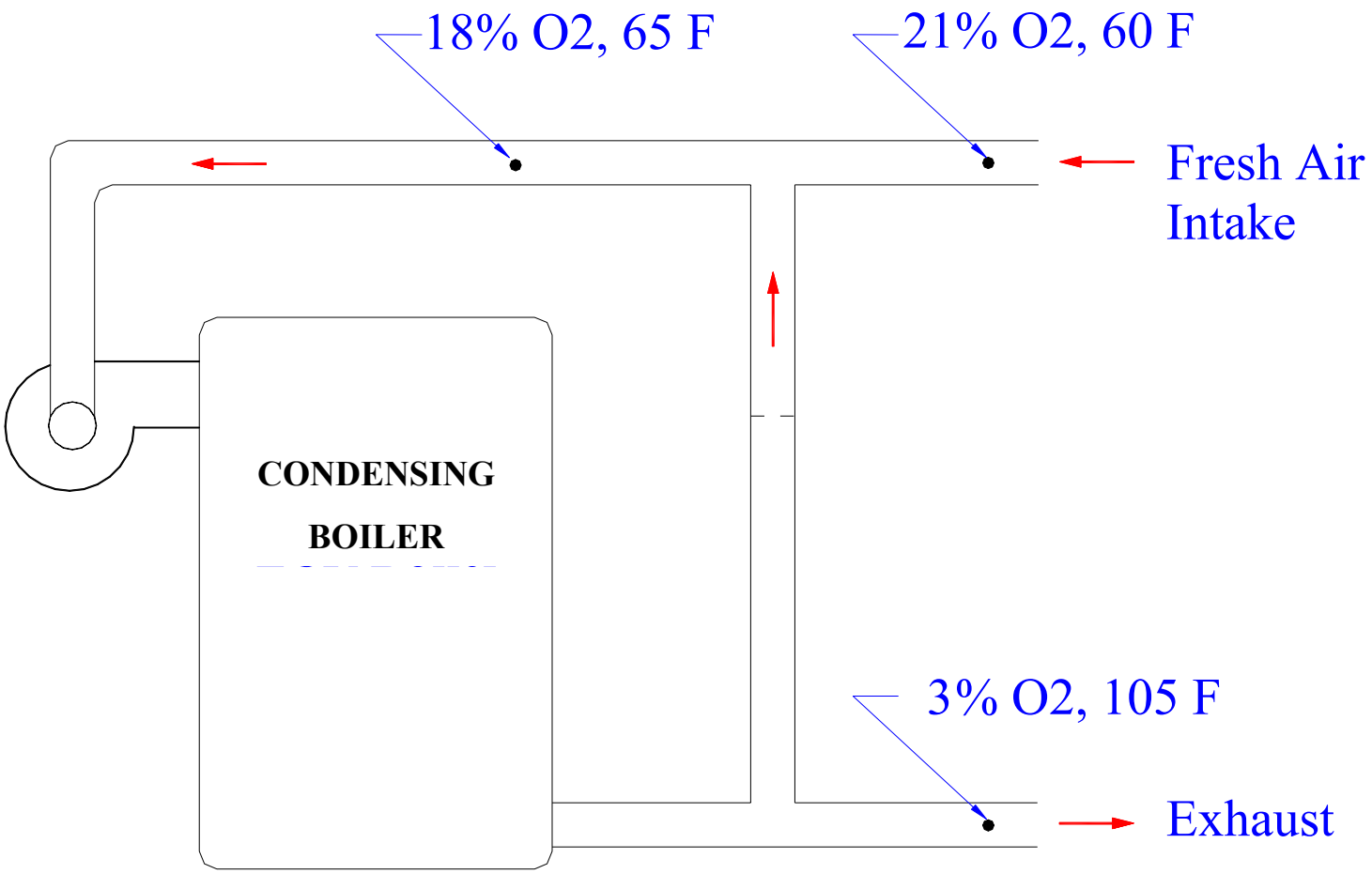
High Recirculation Rate Photo



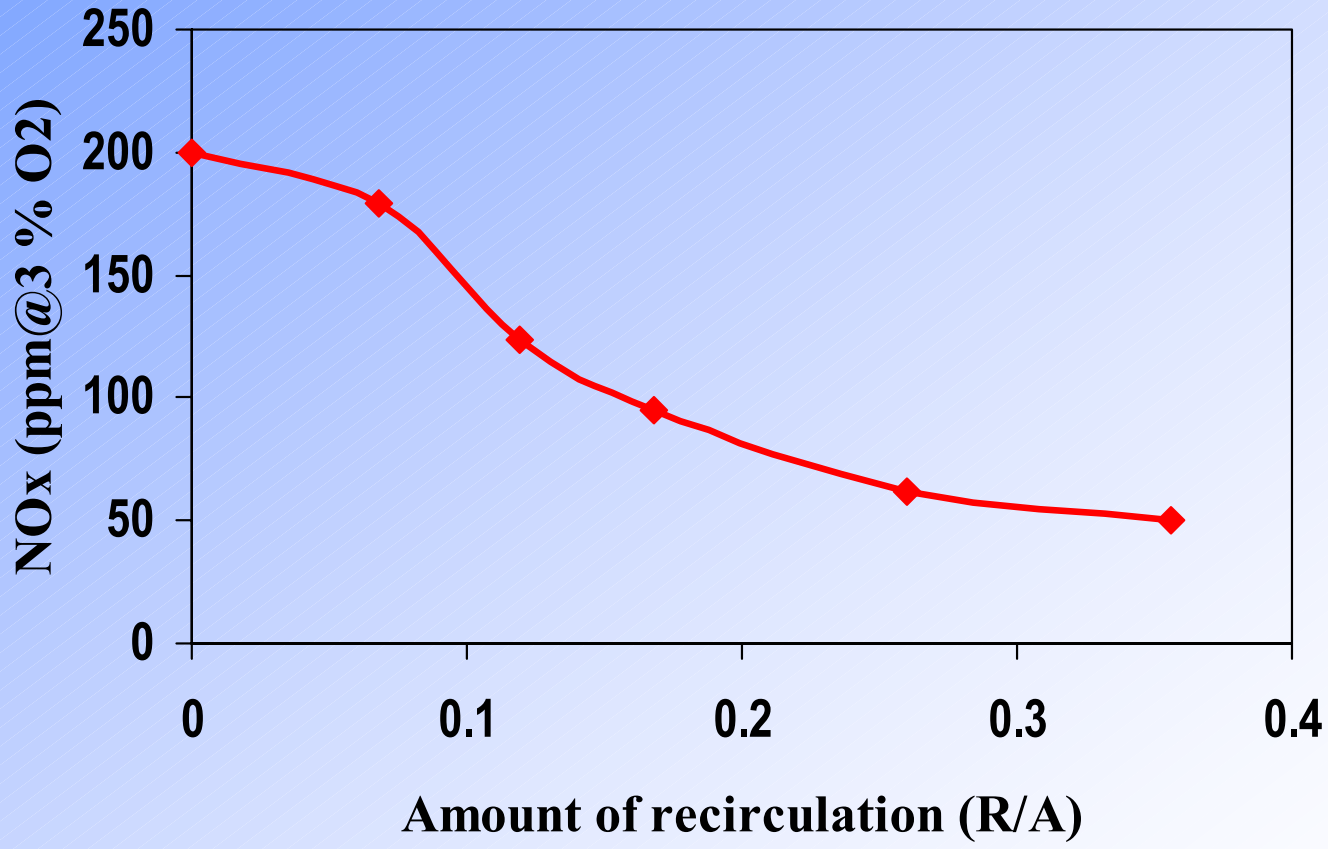
Comparison Chart



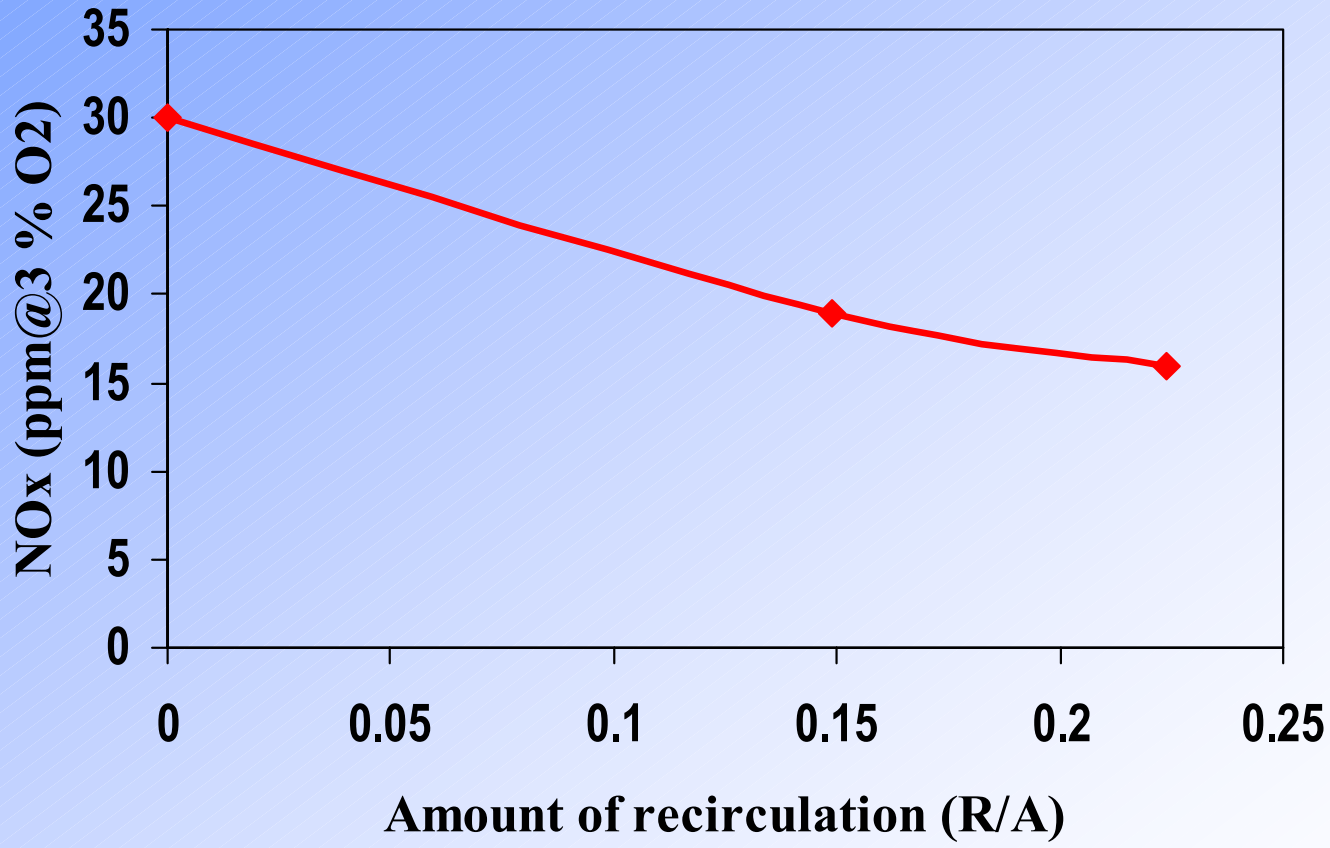
Exhaust Gas Recirculation



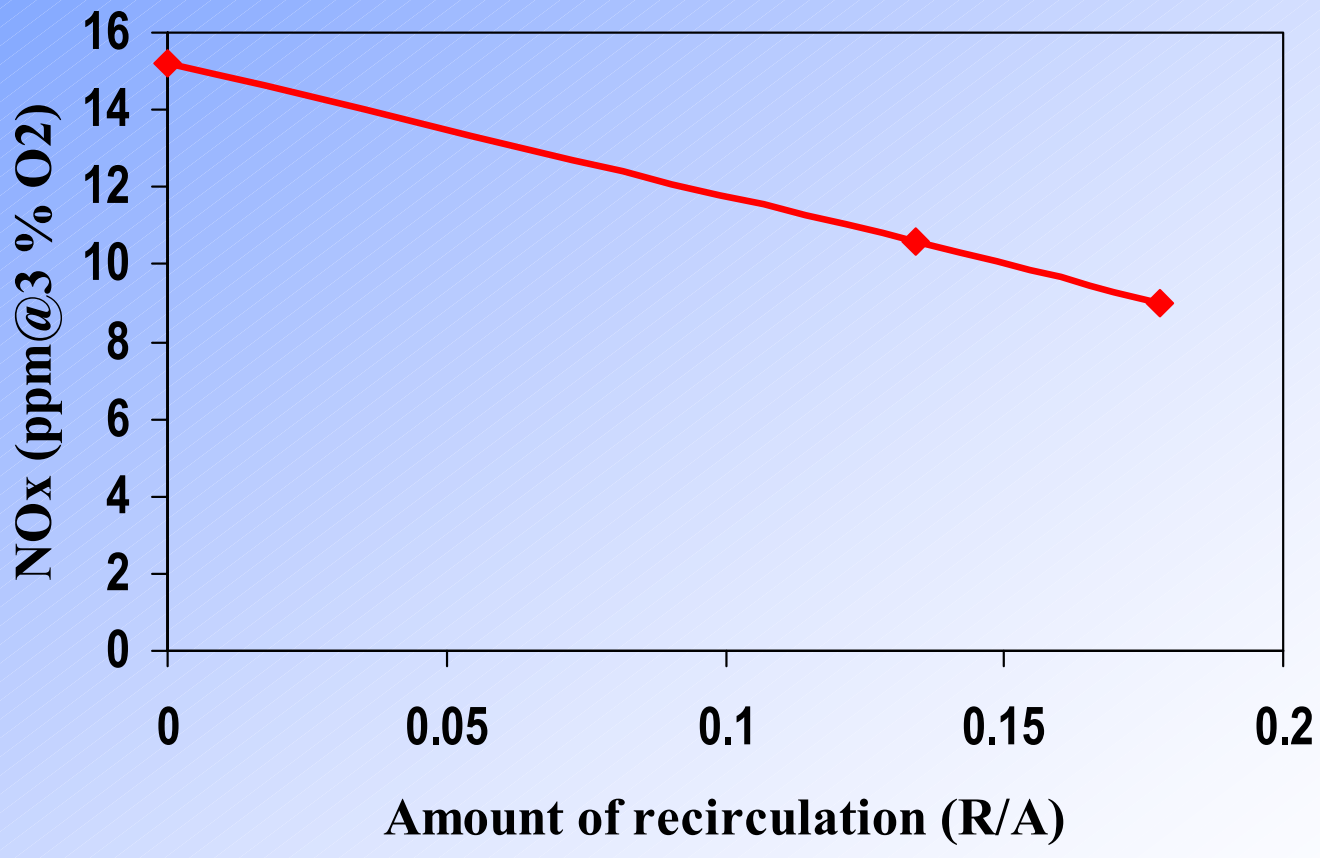
EGR – Yellow Flame Burner



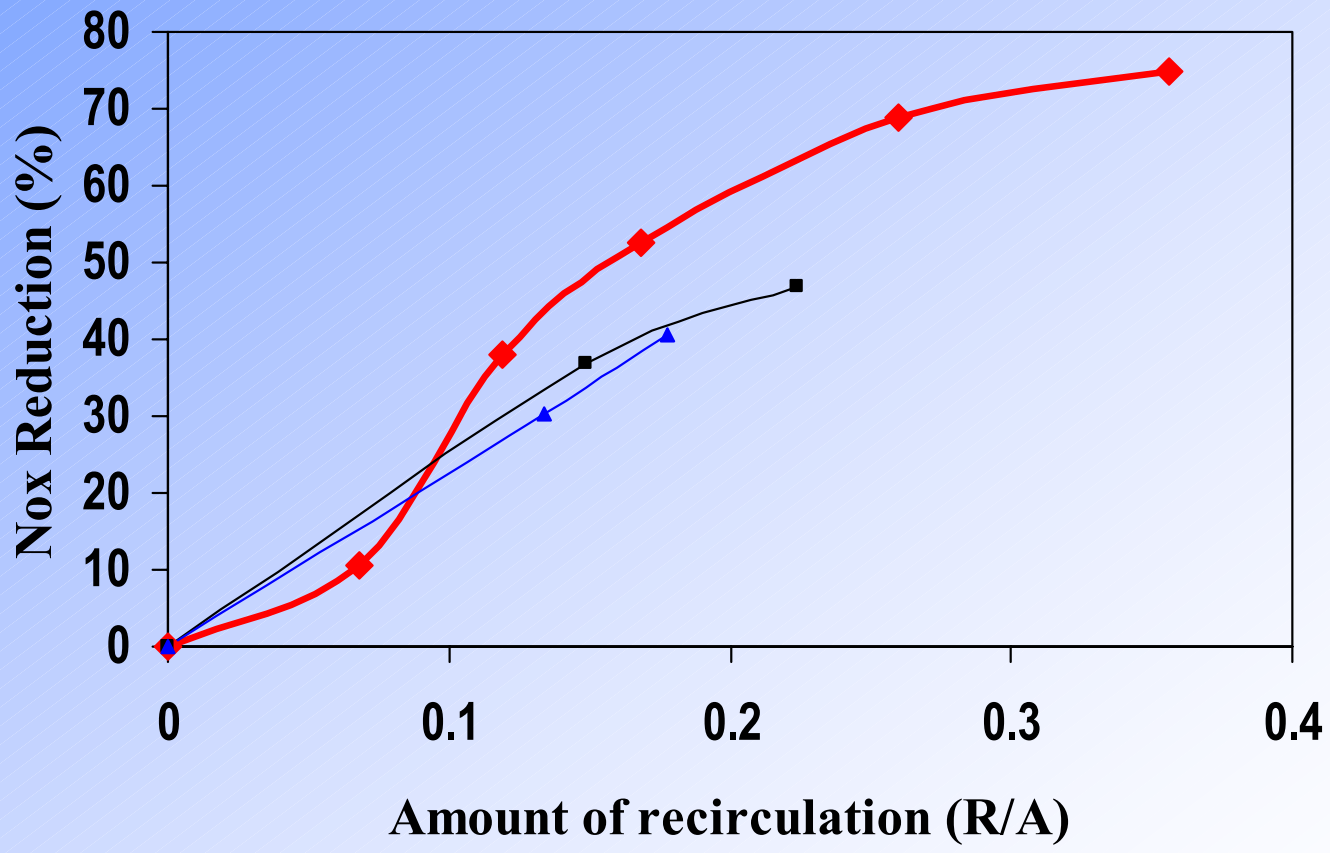
EGR – Blue Flame, low CGR



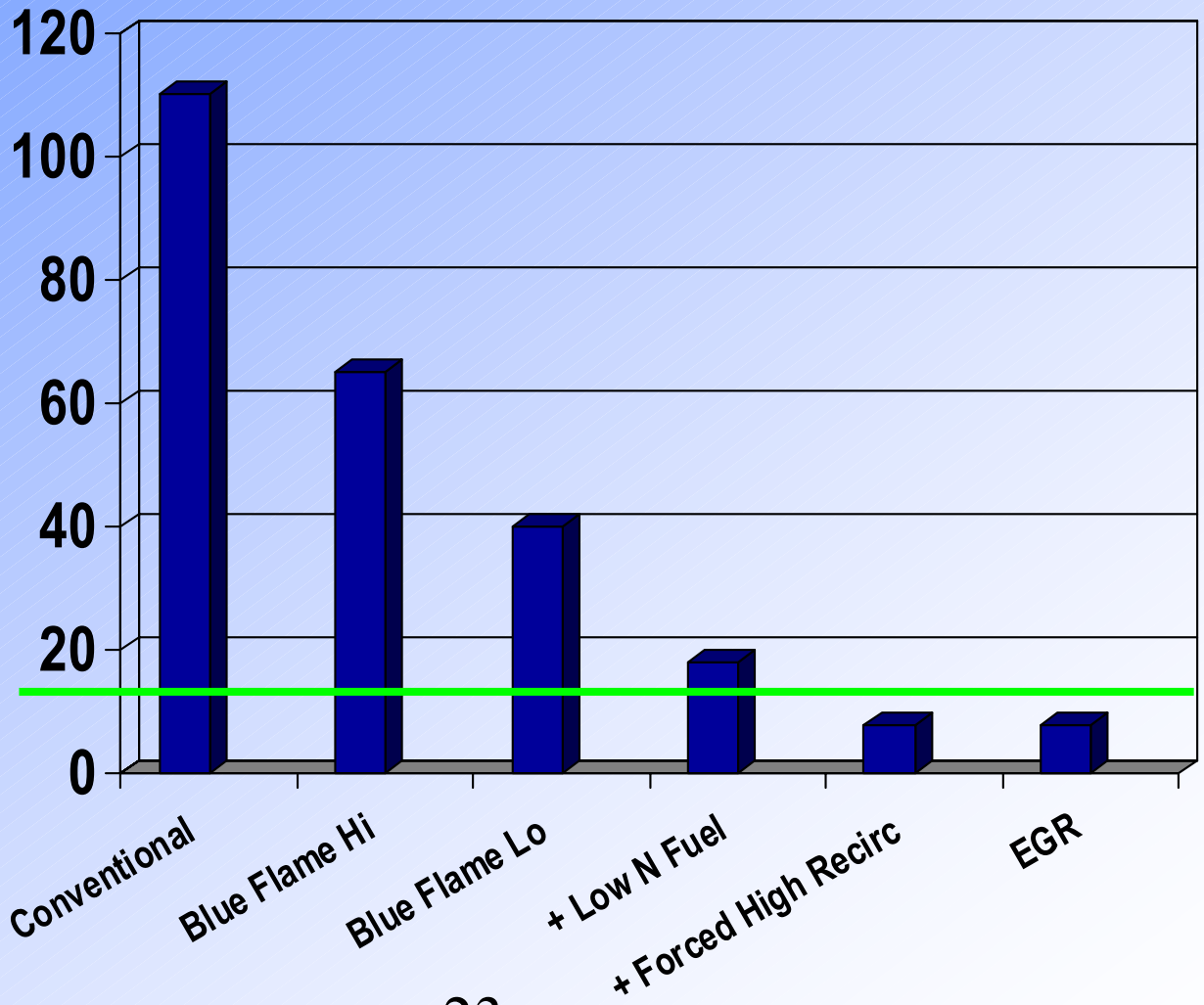
EGR – Blue Flame, moderate CGR



EGR – Comparison of 3 Cases

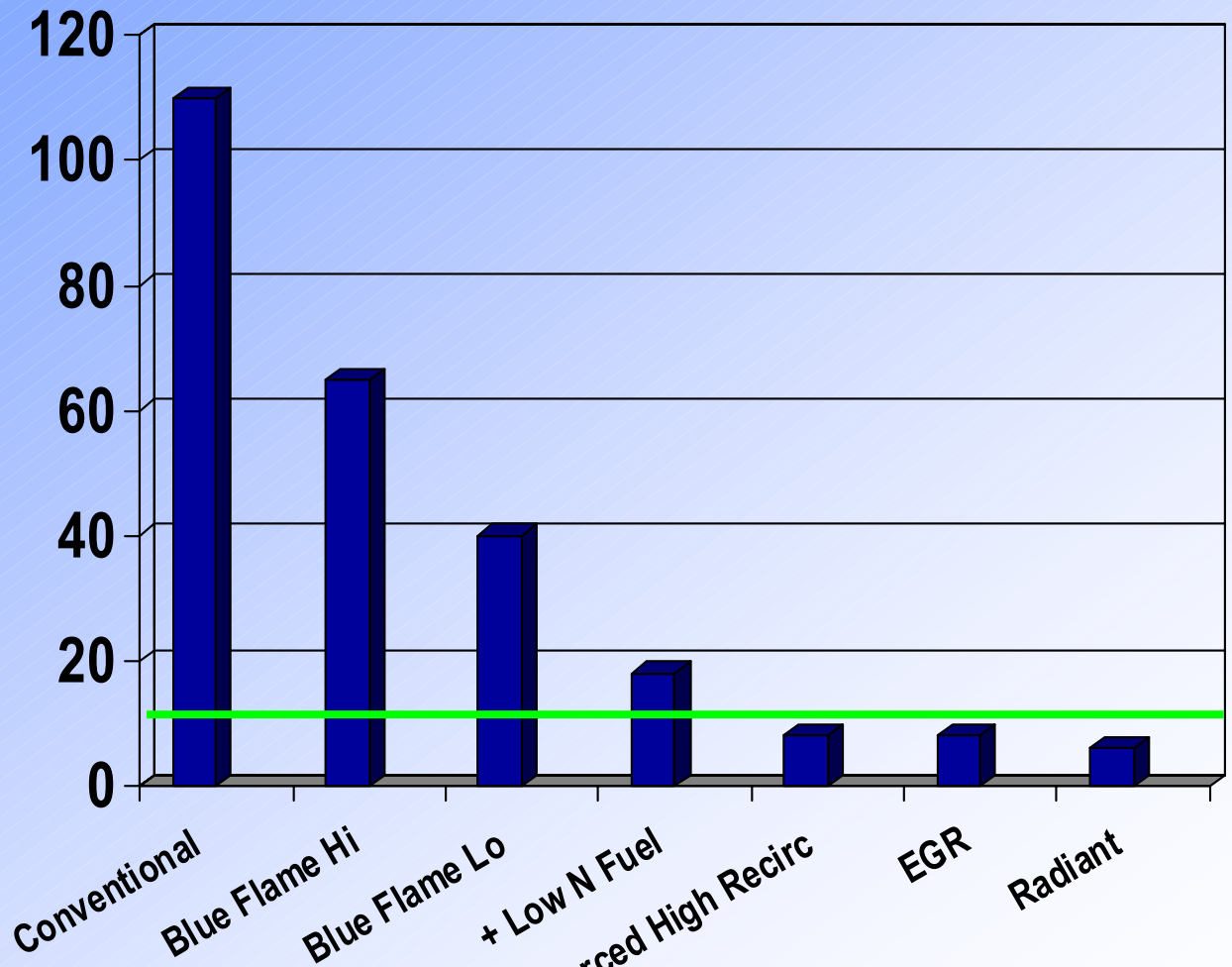


Comparison Chart

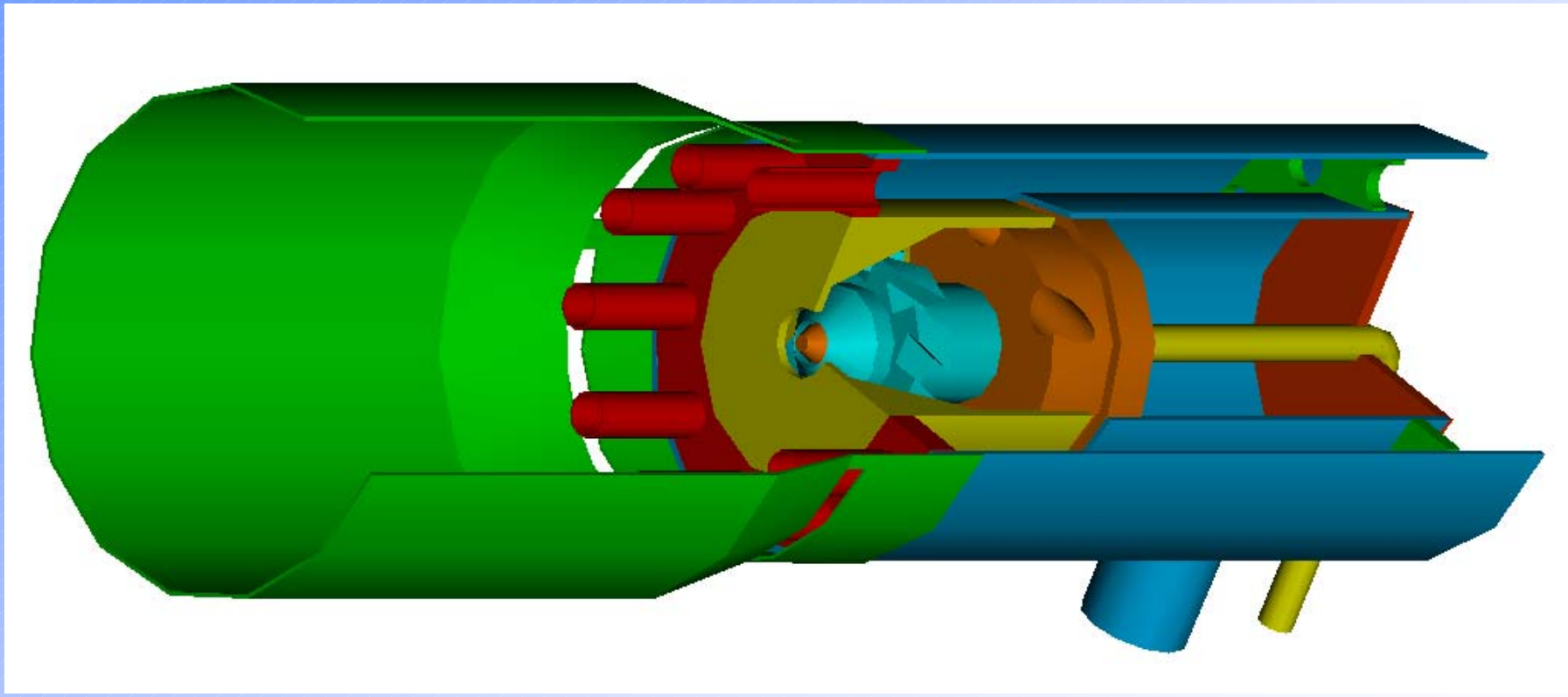


Vaporized Fuel / Radiant Burner

Comparison Chart



Advanced Head Designs



Conclusions

- NOx emissions under 10 ppm are technically achievable
- Increasing gas recirculation to achieve sub 10 ppm will require special startup provision
- Low CGR at start / high CGR run
- Only CGR at start and add EGR after warmed up
- Vaporized oil / radiant burner possible but most complex
- Advancing head designs may provide alternative options