Diesels 2007
Promise & Problems

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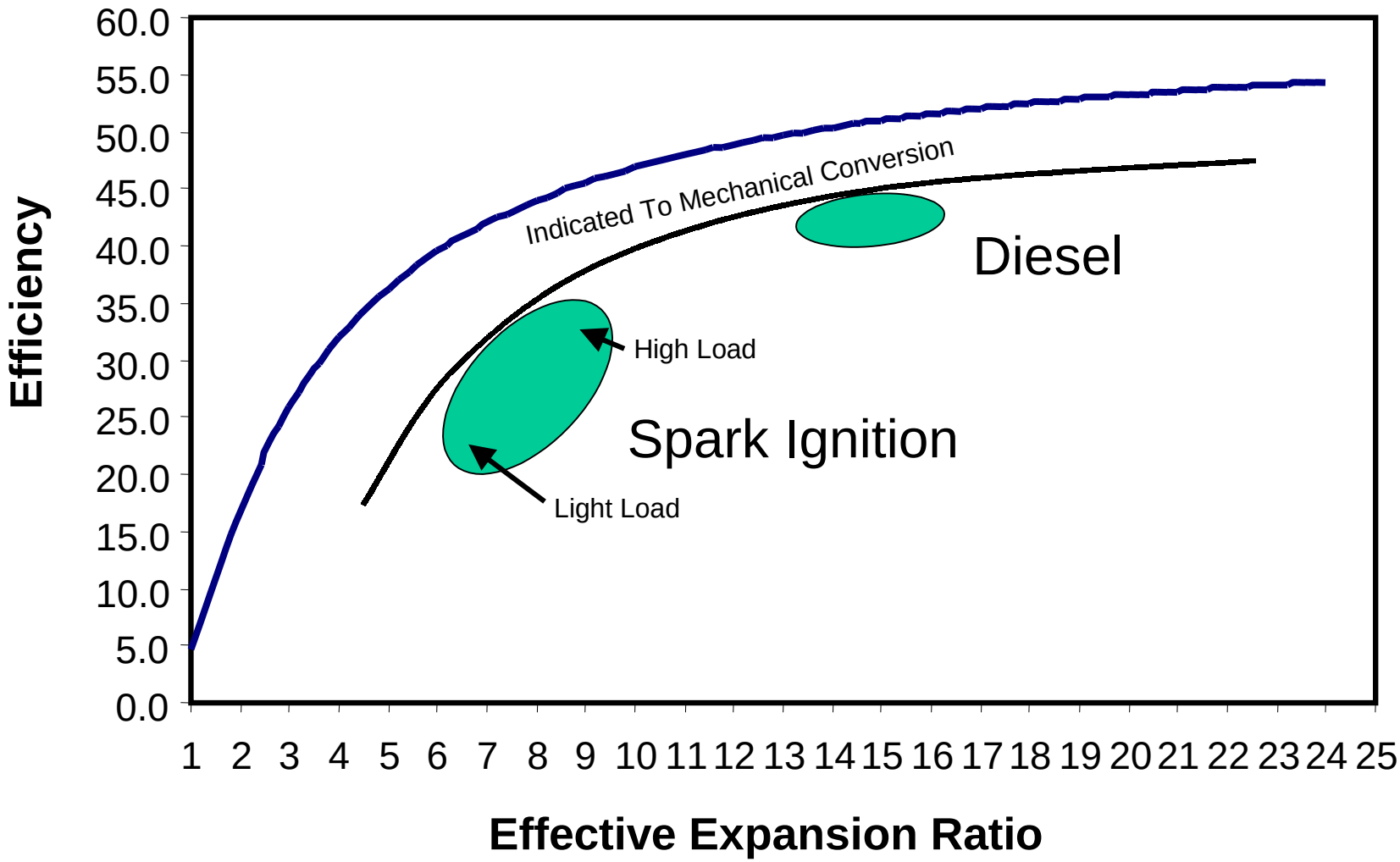
Outline

- Why Diesels – Economics
- Emissions Progress And Issues
- NOx
  - Potential And Issues
- Particulate
- Conclusions

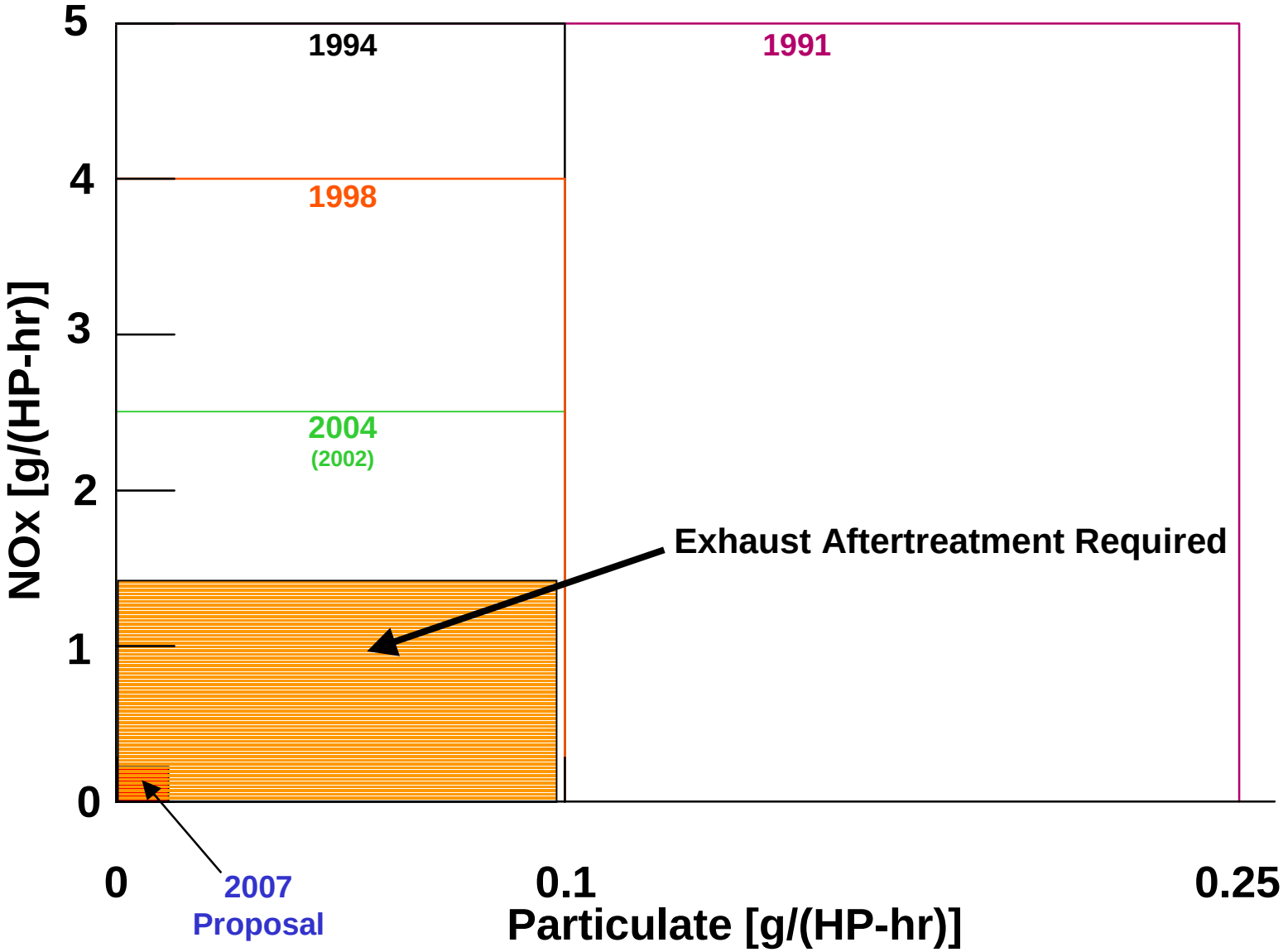
Closed Cycle Efficiency vs. Effective Expansion Ratio



Must Have High Expansion Ratio Power Plants

- Spark Ignition Expansion Ratio Too Low
  - Poor Efficiency
- Heavy Duty Operation Demands Overall Lean Combustion
  - Materials Not Available To Tolerate Temperatures Created By High Load Stoichiometric Combustion
- Choices Depend on Use and Payback
  - Light Duty
  - Heavy Duty
- Diesel Provides High Expansion Ratios
  - Lower Operating Cost
  - Lower CO2 Emissions

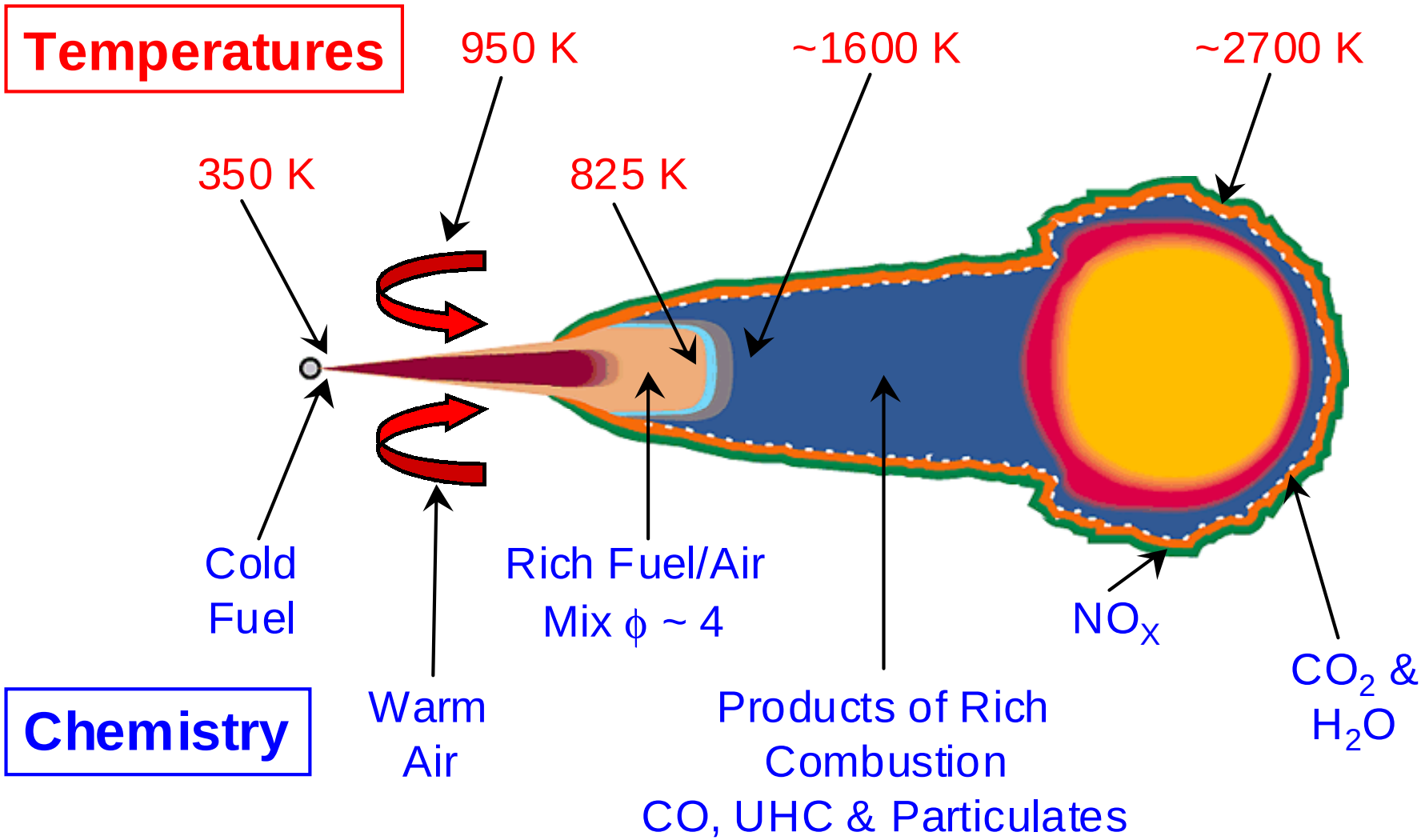
Evolution of Engine Emission Control



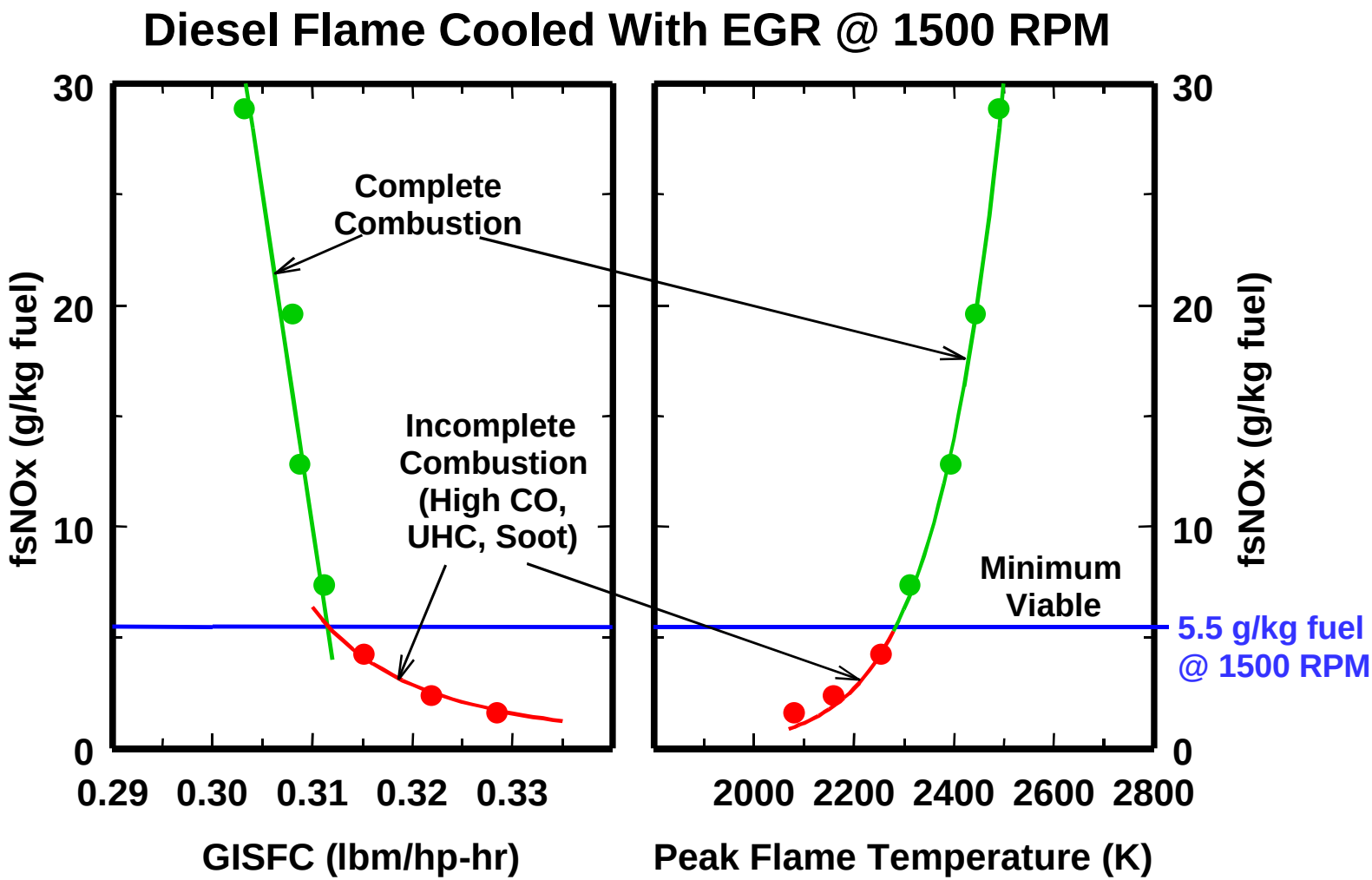
Types Of Compression Ignition Combustion

- **Normal Diffusion Flame Combustion**
  - **NOx Levels Limited By Diffusion Flame Temperature Limits**
    - **NOx: 5.5 gm/ Kg-fuel @ 1500RPM, 2.25 gm/Kg-fuel @ 3000 RPM**
- **Premixed Compression Ignition**
  - **HCCI**
    - **Fuel Mixed to Lean F/A Locally**
    - **Hard To Manage And Control**
    - **Used to Modest Power Levels Only**
    - **NOx Levels Can Be Very Low**
  - **Early Injection at Light Load**
    - **Fuel Injection Completed Before Ignition**
    - **Initial Combustion Rich F/A Locally**
    - **Intermediate NOx Levels Attainable**
    - **Works at Low Load Only – Only Beneficial in Light Duty Applications**

Summary - Overall Picture



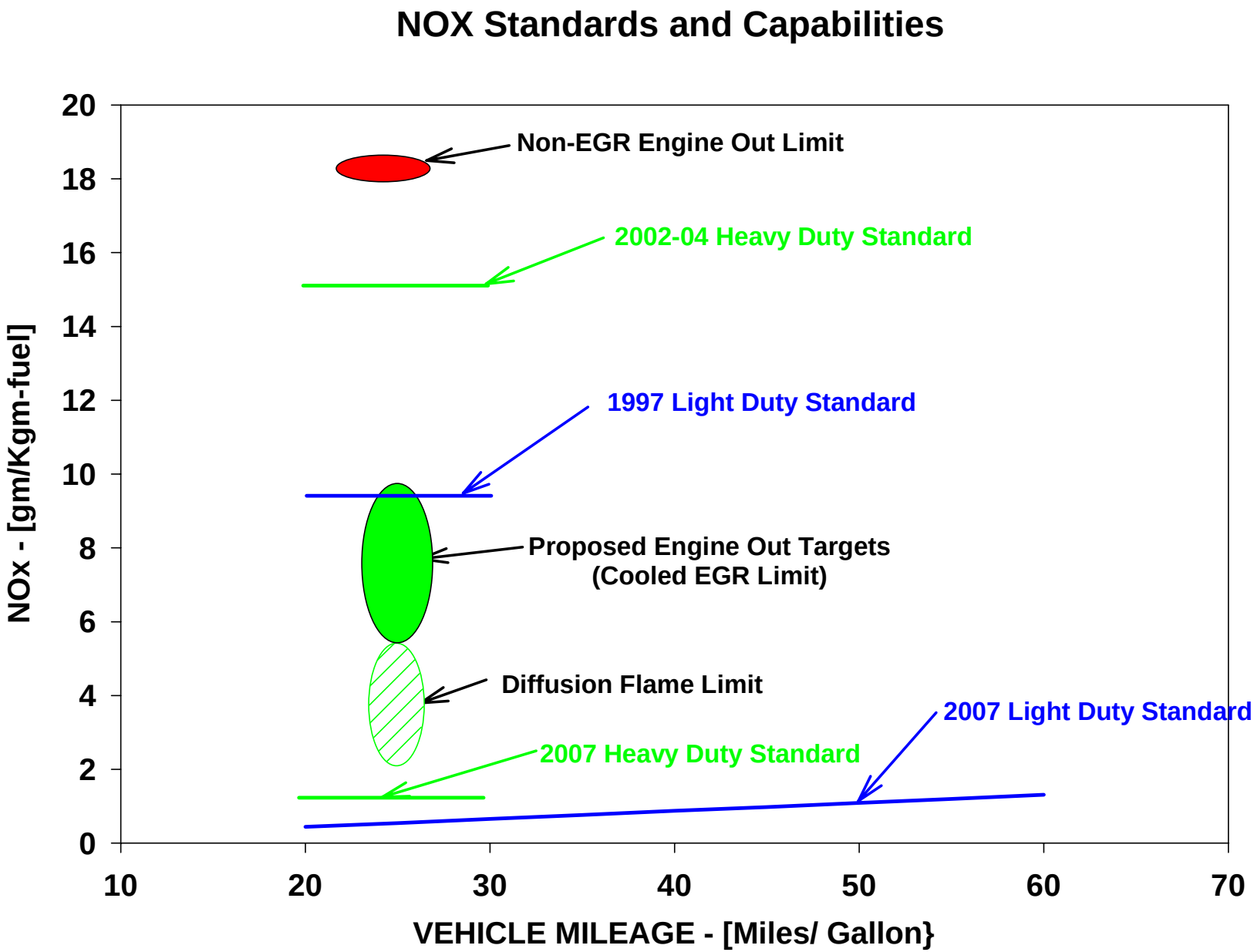
Limits of Diesel Engine Combustion



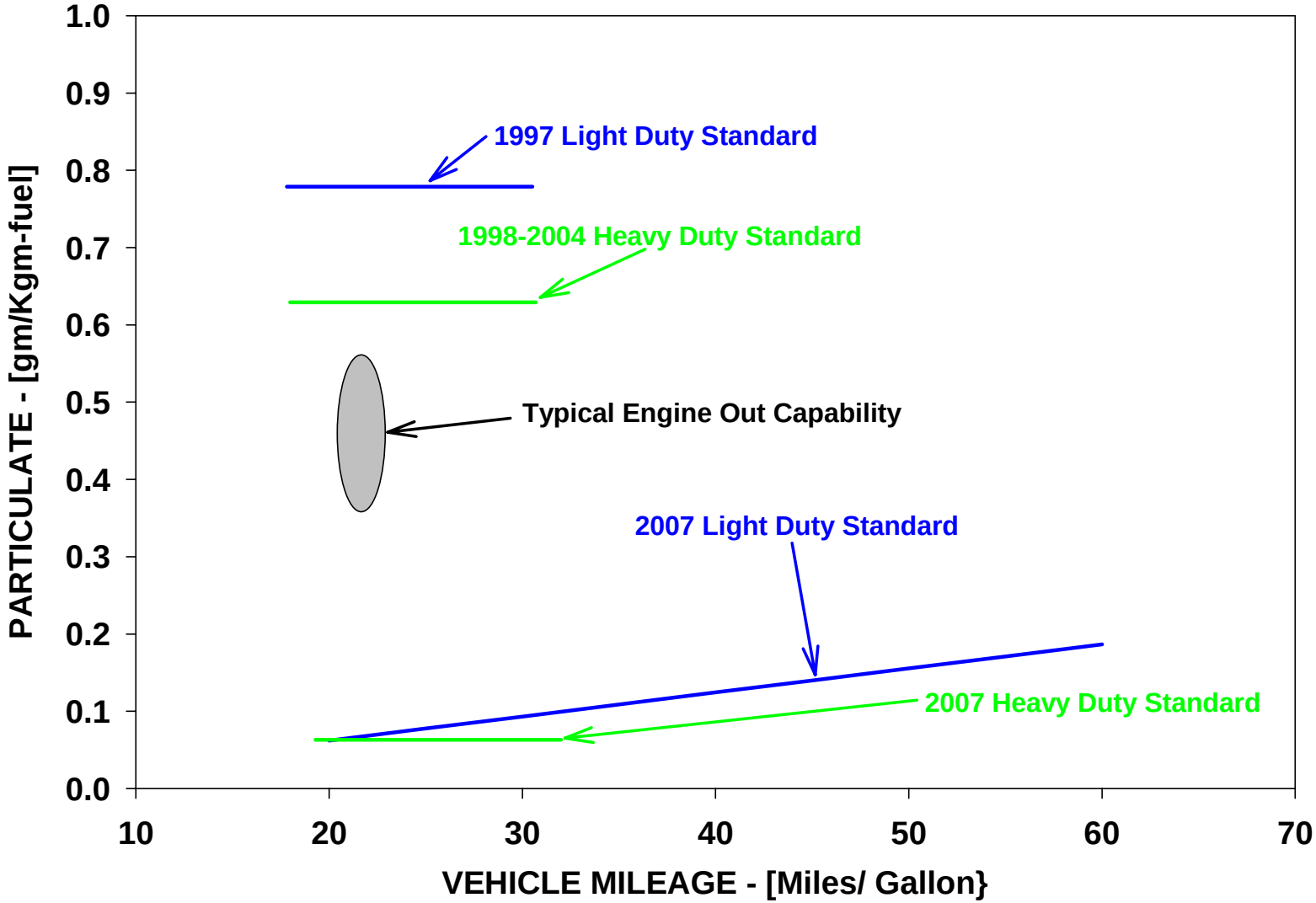
SAE 2000-01-1177

Managing a Series of Linked Chemical Processing Plants

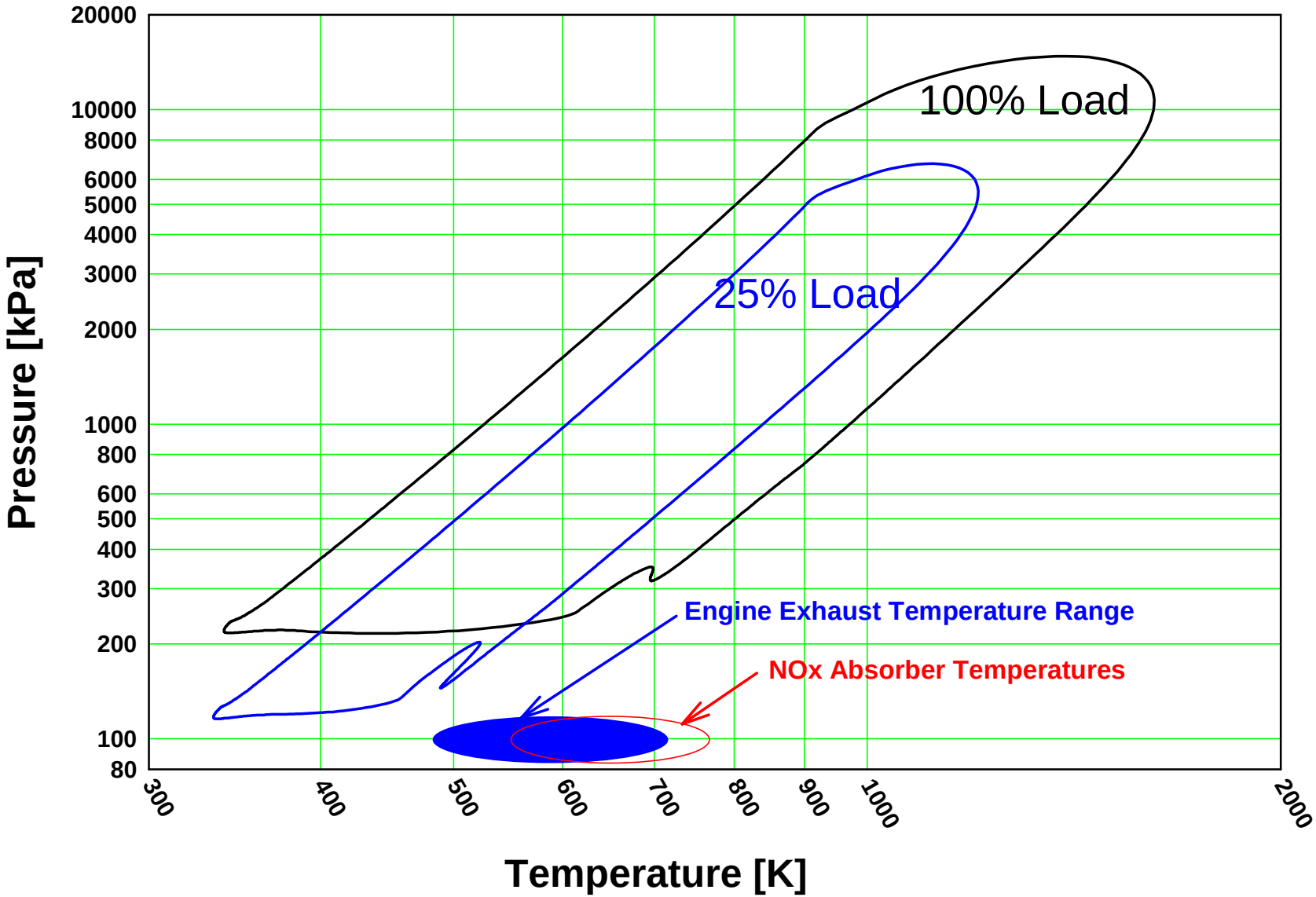
- In-cylinder Combustion
  - Managed To Limit NOx And Particulate Emissions
- NOx Aftertreatment
  - Temperature an HC Concentration Managed on a Second by Second Basis
  - Absorption or Reduction of NOx
  - Removal of Trapped Sulfur
- Particulate Aftertreatment
  - Oxidation of Trapped Particulates Before Self Destructive Accumulation Takes Place


NOX Standards and Capabilities
Non-EGR Engine Out Limit
2002-04 Heavy Duty Standard
1997 Light Duty Standard
Proposed Engine Out Targets
(Cooled EGR Limit)
Diffusion Flame Limit
2007 Light Duty Standard
2007 Heavy Duty Standard
NOx - [gm/Kgm-fuel]
VEHICLE MILEAGE - [Miles/ Gallon}
0
2
4
6
8
10
12
14
16
18
20
10
20
30
40
50
60
70

PARTICULATE Standards and Capabilities



Temperature Management Required



Conclusions

- Diesel Fuel Economy and Engine Durability Is Essential for Transport
  - No Present Alternatives for Heavy Duty Applications
- Promising Work Underway On Emissions Improvement
- Actively Managed Aftertreatment Technology Will Be Required
  - Duty Cycles Required Need Definition
  - Integrated Active Control Systems Need To Be Developed
    - Particulate Oxidation (Medium Time Constant)
    - NOx Adsorber Activation (Short Time Constant)
    - Desulfurization (Medium Time Constant)
- NOx and Particulate Emissions Standards for 2007 Will Be Difficult to Meet On Schedule
  - New Technology required
  - New Industrial Relationships Required
  - New Infrastructure