THE CHEMISTRY OF REBURNING

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DONALD STOOKEY
COMPACT MEMBRANE SYSTEMS

DISCUSS

- EMISSIONS STANDARDS
- FUEL AND NON-FUEL NITROGEN
- EQUILIBRIUM
- NO CONTROL TECHNOLOGIES
- ECONOMICS
- CONSTRAINTS

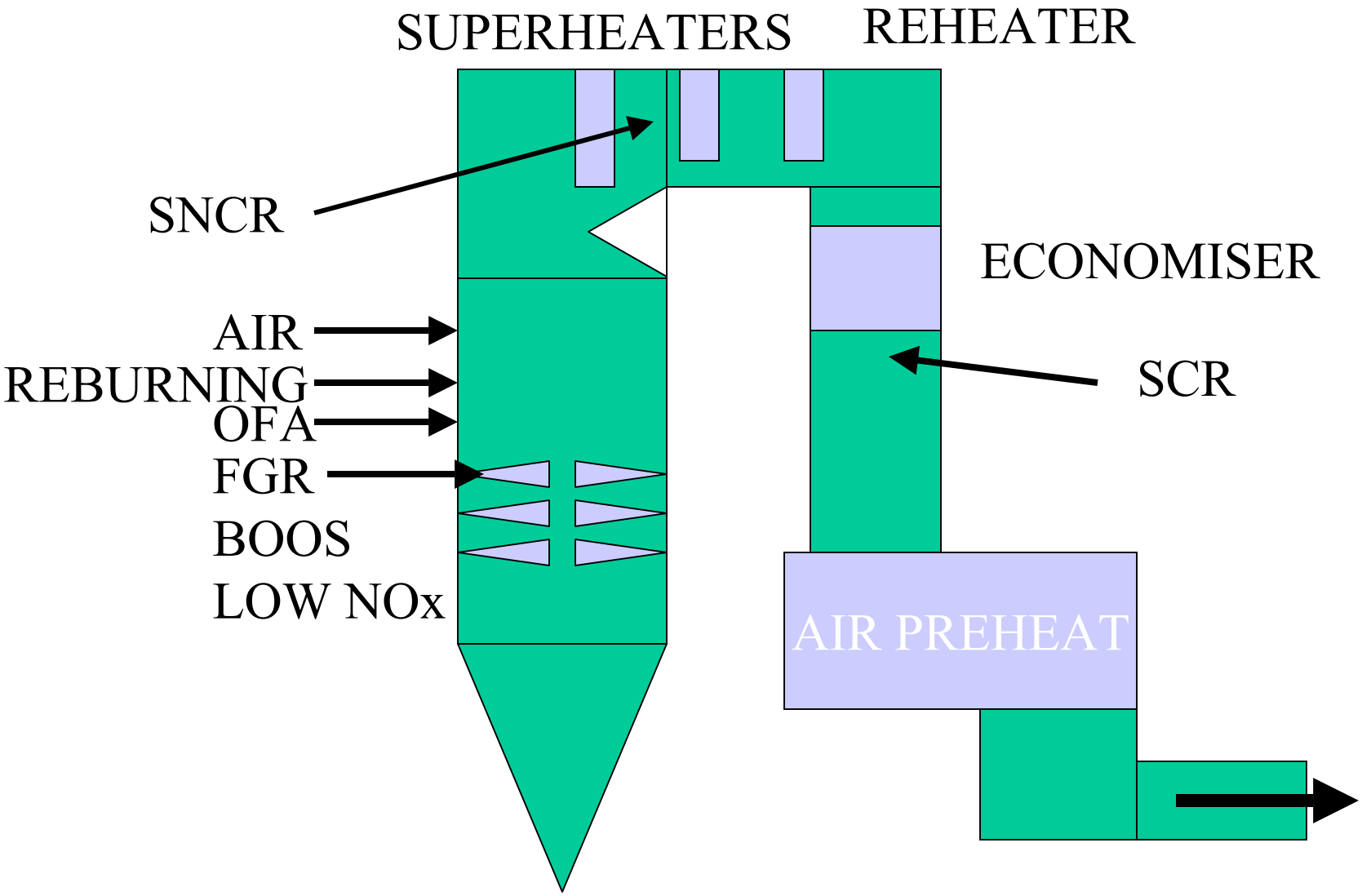
CONCLUSIONS FROM 4 STUDIES

- REBURNING DEMONSTRATION AT 120 CYCLONE AT NILES, OH (ESA)
- TESTING NH3 AT 10 MBTU/HR, AT EMRO, TAIWAN
- LABORATORY TESTING NH3 AT UCI (EMRO)
- INDUSTRIAL DEMONSTRATION NH3 AT UCLA (ESA ENGINEERING)

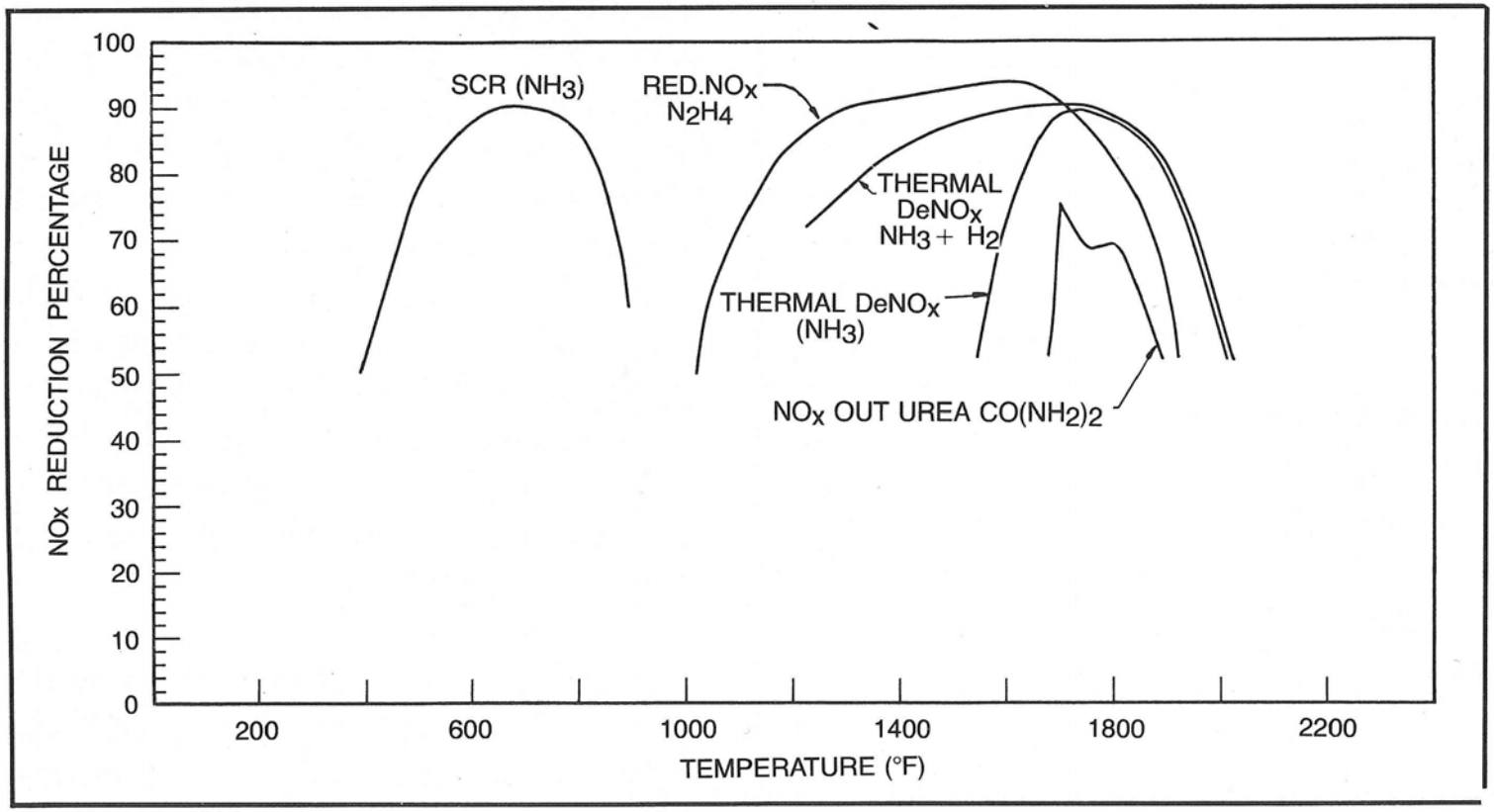
EMISSION STANDARDS

- NEW EPA 0.15 LB NO2/MBTU ~108 PPM (d, 3% O2)
- NO PEL~TWA 25 PPM
  - NO+O2=NO2+O
- NO2 PEL TWA 5 PPM
  - NO2+hv=NO+O
  - O+O2+M=O3+M
  - PEROXYACETYL NITRATE
- O3 PEL TWA 200 ug/m3~0.155 PPM
  - NEW~0.09 PPM

NOx CONTROL

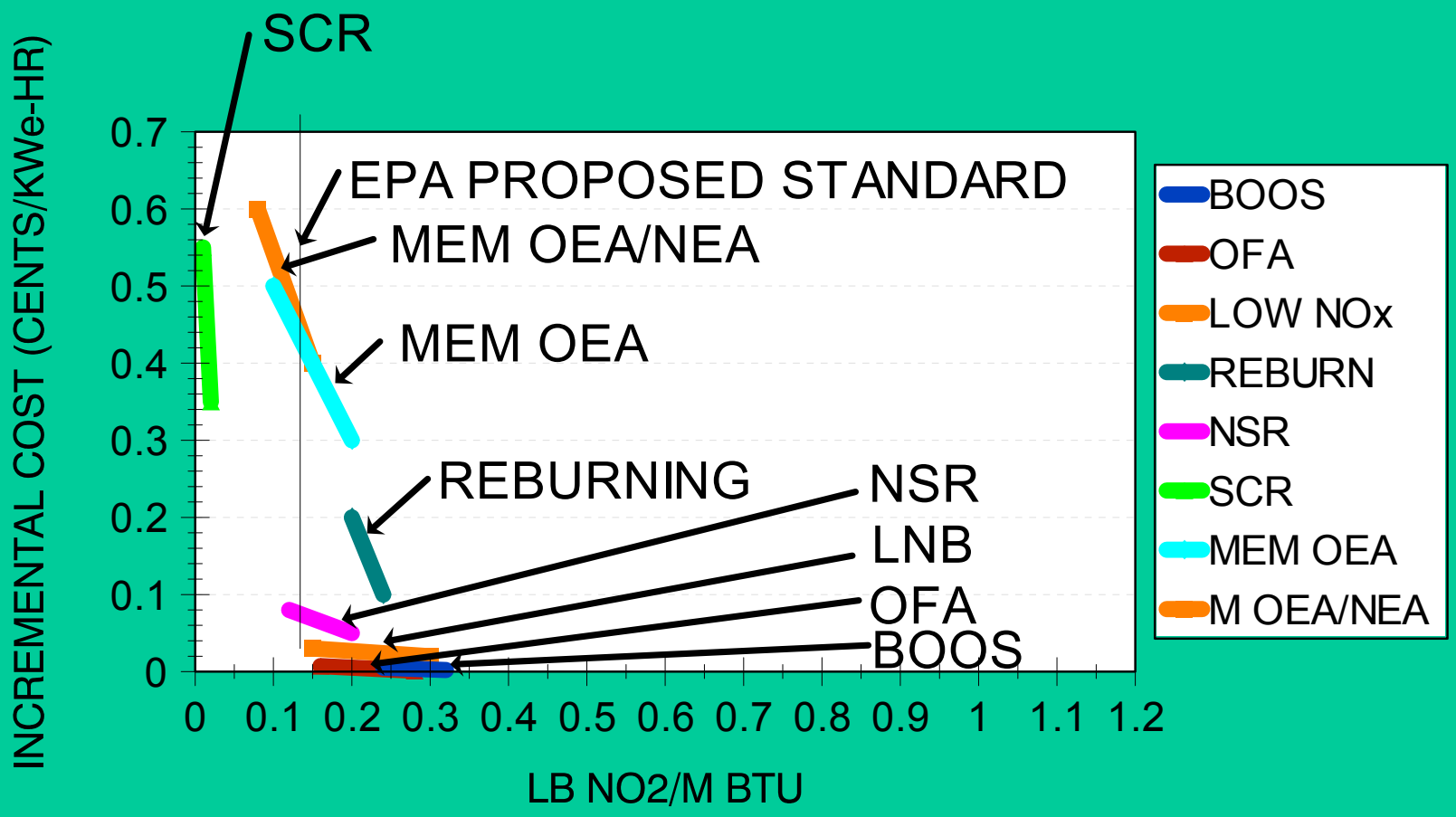

SUPERHEATERS
REHEATER
SNCR
ECONOMISER
AIR
REBURNING
OFA
FGR
BOOS
LOW NOx
SCR
AIR PREHEAT

NOx % CONTROL


100
90
80
70
60
50
40
30
20
10
0
NOx REDUCTION PERCENTAGE
SCR (NH3)
RED.NOx
N2H4
THERMAL
DeNOx
NH3 + H2
THERMAL DeNOx
(NH3)
NOx OUT UREA CO(NH2)2
200
600
1000
1400
1800
2200
TEMPERATURE (°F)

COST OF REMOVING NOx

LB NOx/MBTU, CENTS/KWe-HR



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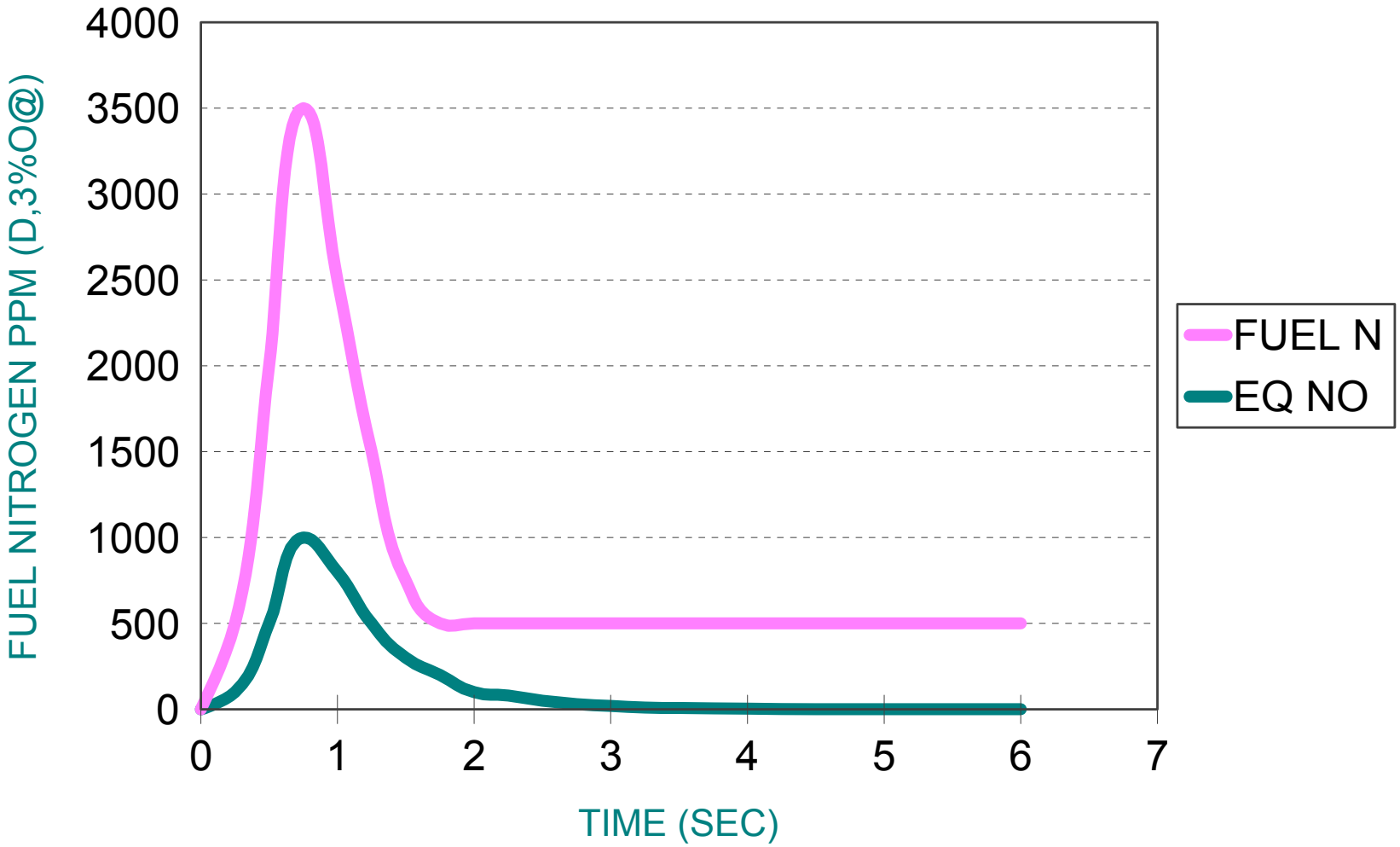
FLAME N LEVELS

PPM(D, 3 % O2)



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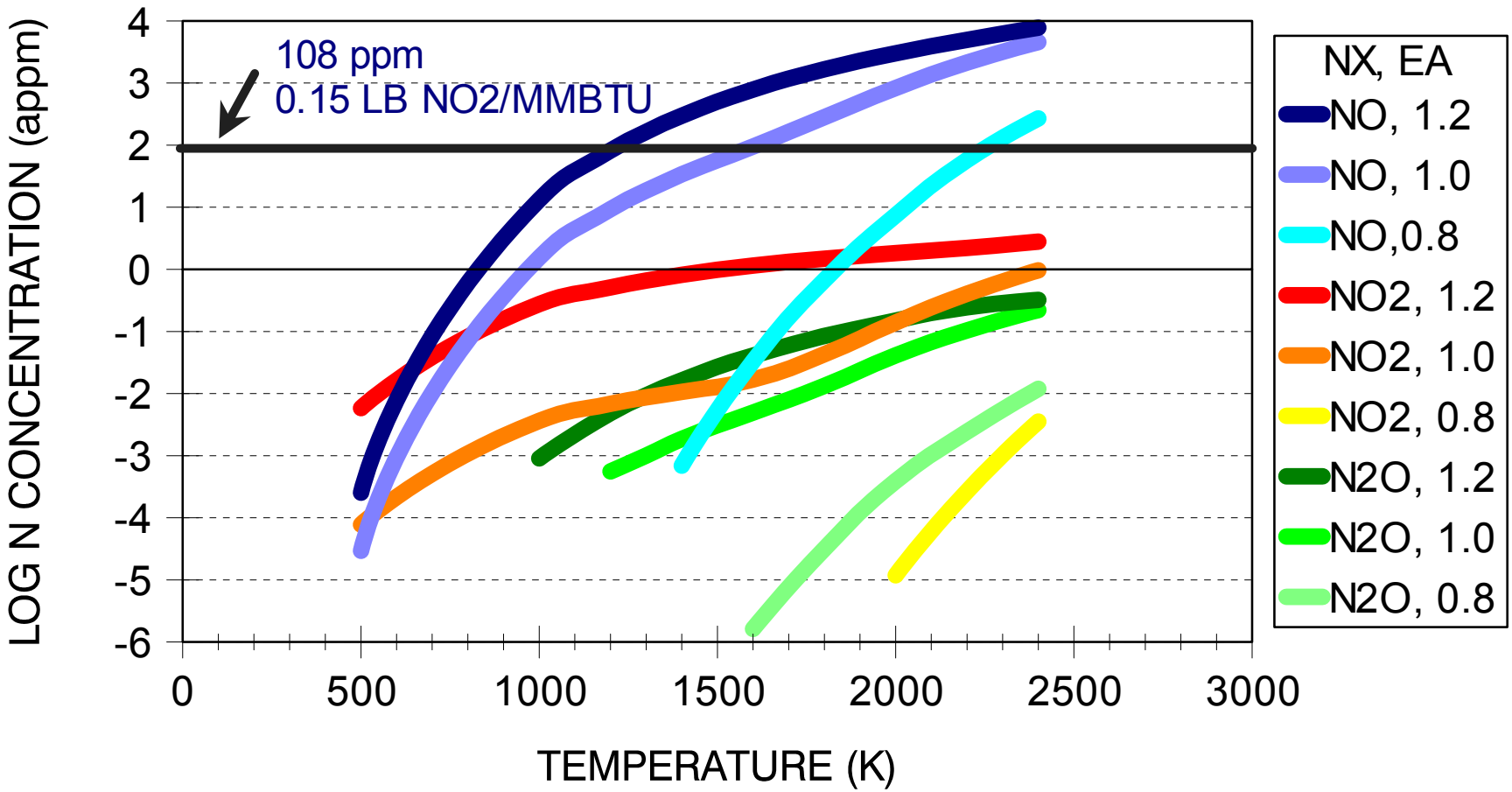
EQUILIBRIUM N COMPOUNDS

PITT 8 COAL



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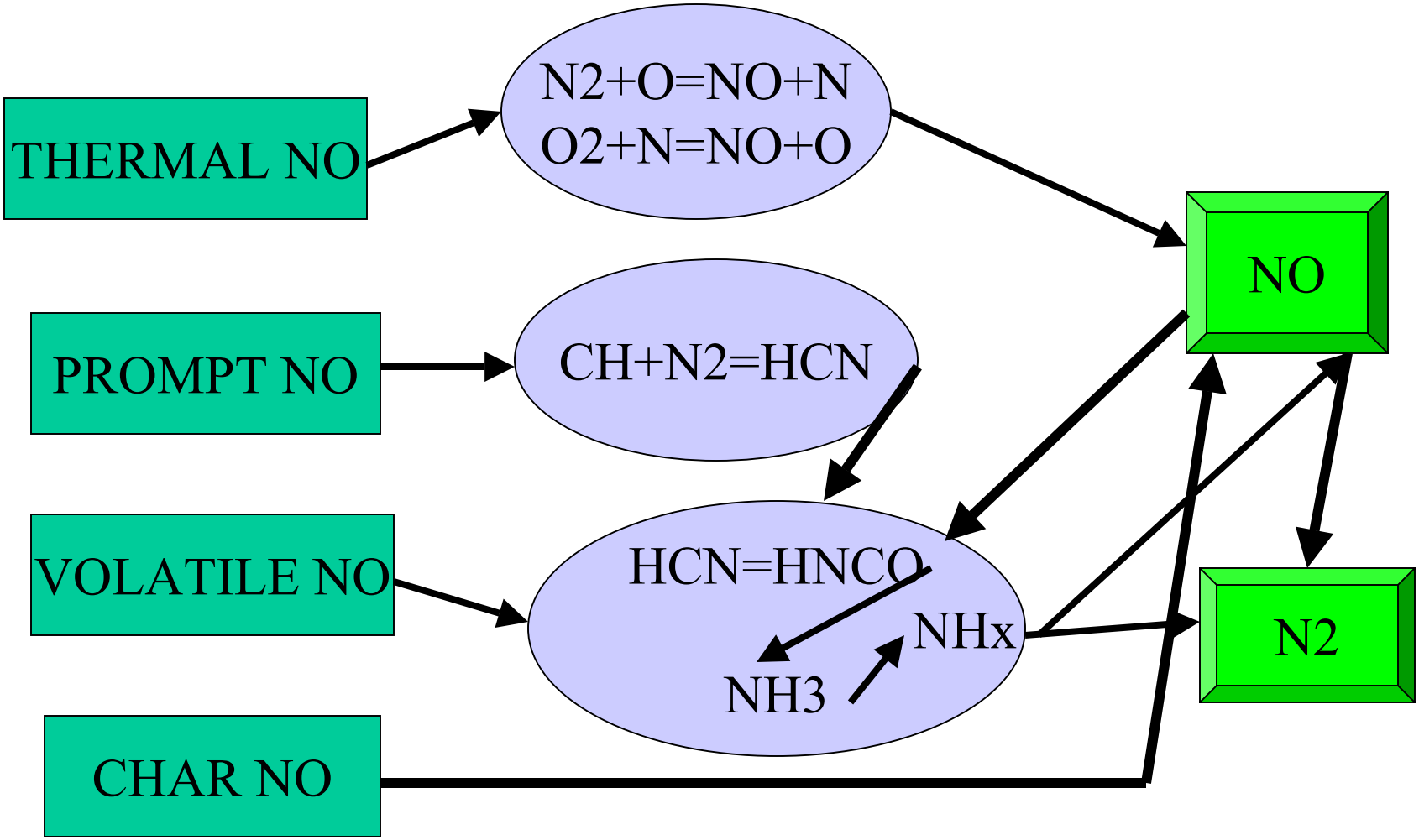
FUEL NITROGEN

- N COMPOUNDS IN EXCESS OF EQUILBRIUM
  - NEED ACTIVE REACTIONS TO REDUCE TO N2
  - N2 FAVORED BY HIGH TEMPERATURE RICH ATMOSPHERES
- THERMAL NO
  - N2 FAVORED BY LOW TEMPERATURE RICH ATMOSPHERES

NO REDUCTION REQUIREMENTS

- LOW EQUILIBRIUM NOx CONCENTRATION
- ACTIVE REDUCTION REACTIONS
  - TEMPERATURE
  - CATALYST
- SINGLE N COMPOUND
  - NH3/UREA
  - HCN
- MIXING

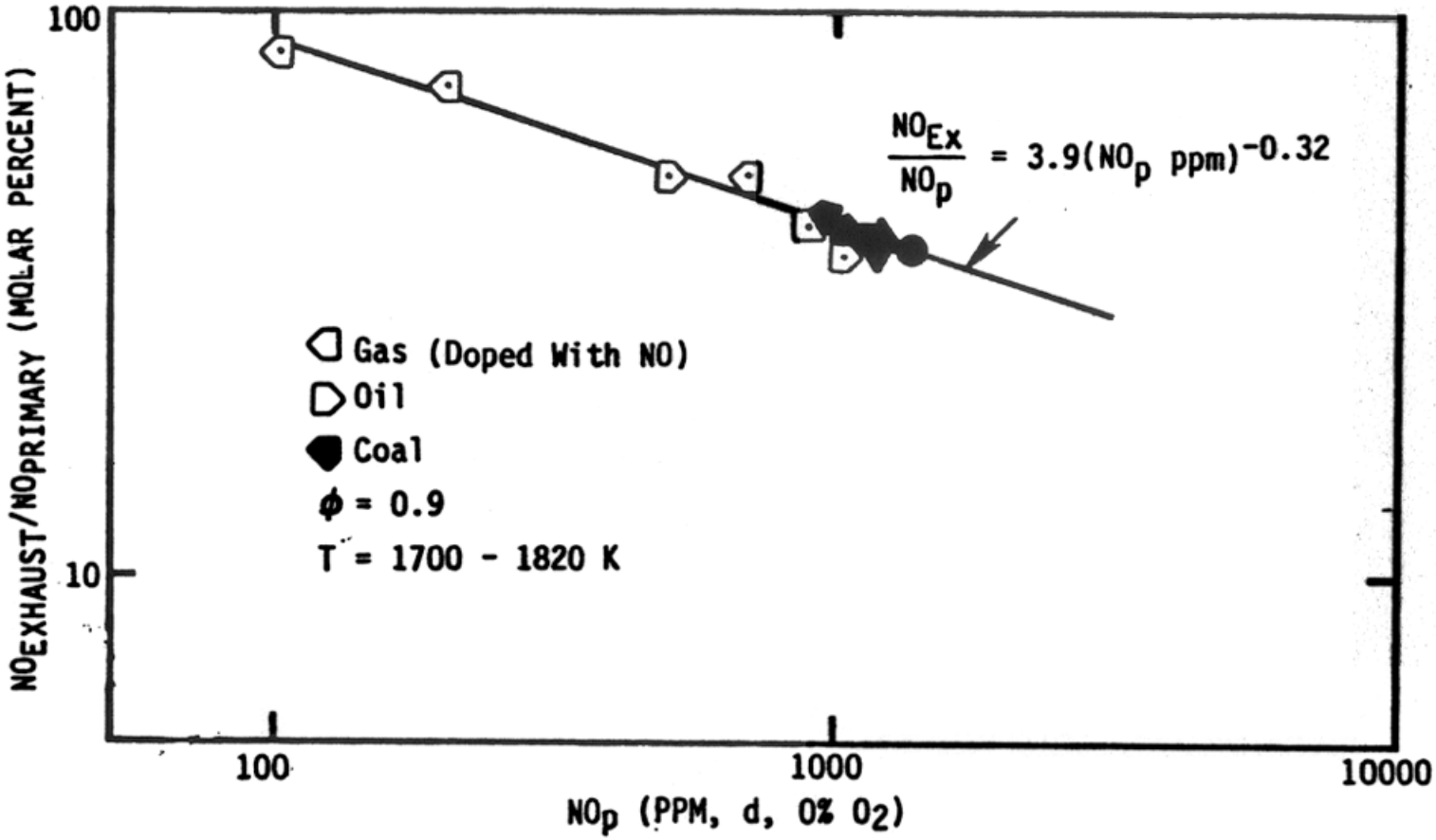
NOx PRODUCE/REDUCE



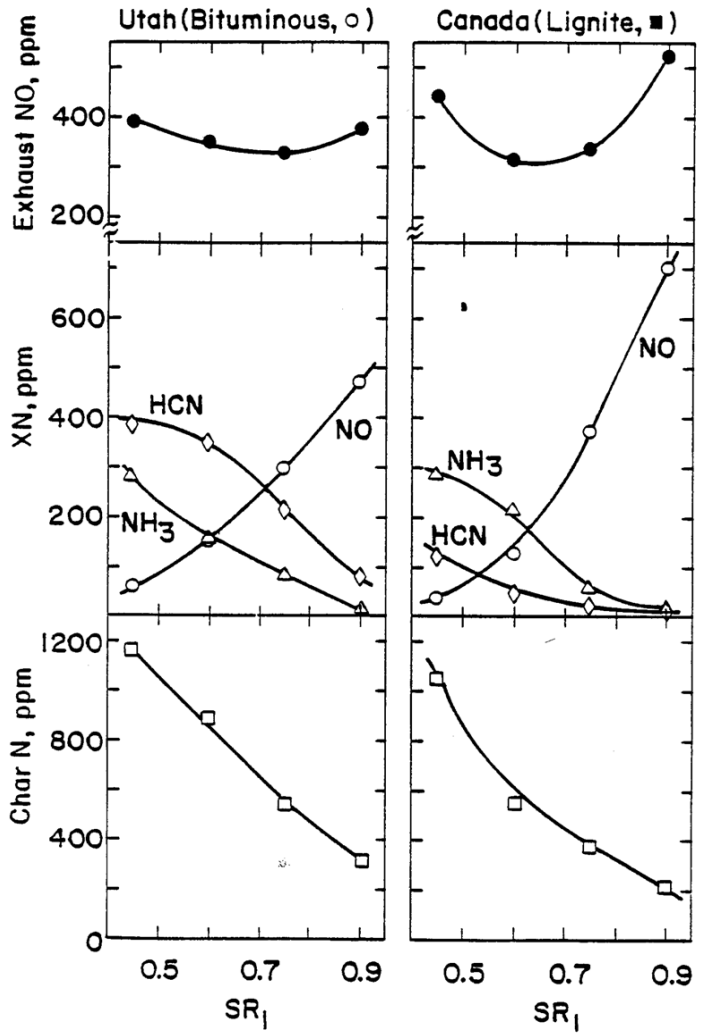
REBURNING POTENTIAL PROBLEMS

- LIMITED REDUCTION > 0.15 LB NO2/MBTU
- ACTIVE TEMPERATURE WINDOW
- TWO WATER WALL PENETRATIONS
- MIXING
- UNBURNED MATERIAL/SOOT
- CORROSION

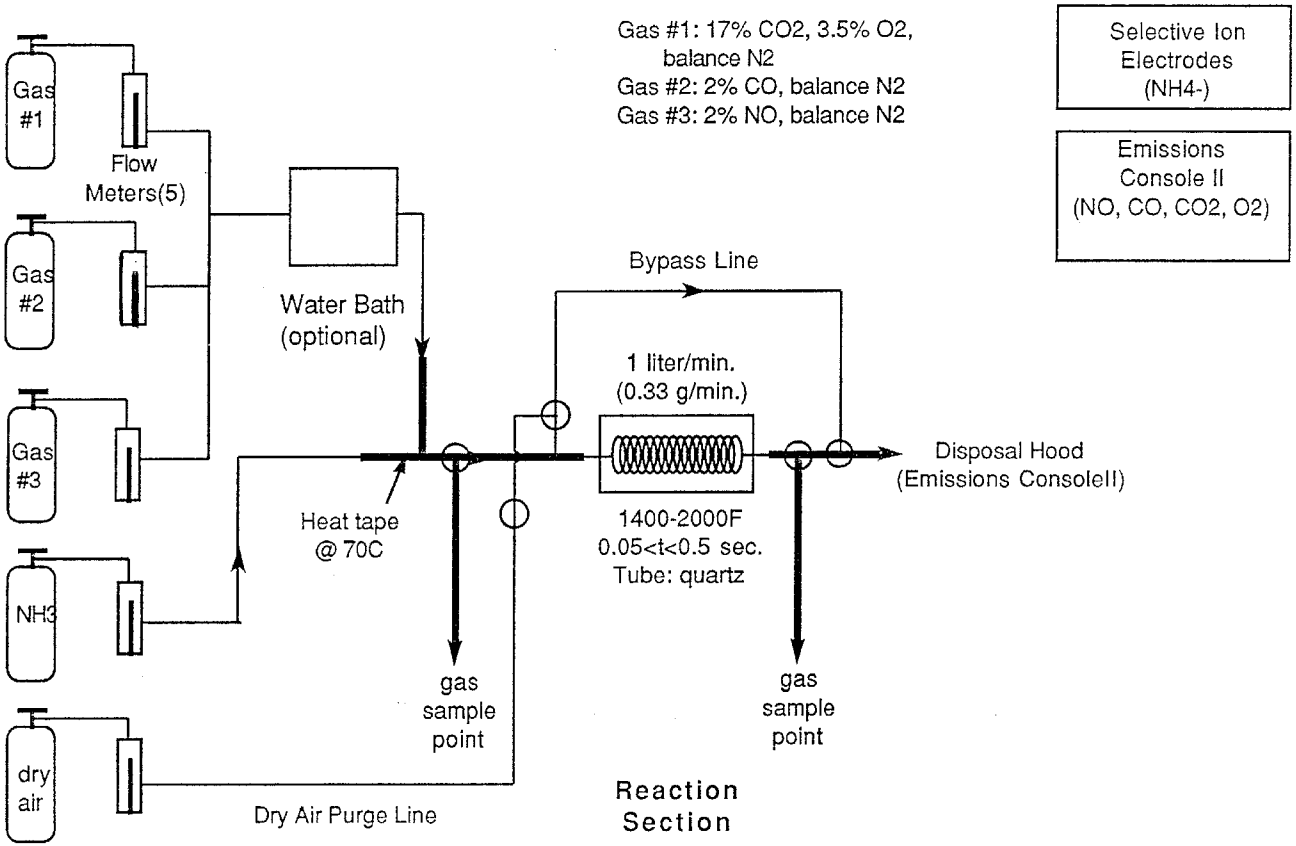
NOx REDUCTION BY REBURNING



REBURNING N COMPOUND CONCENTRATION

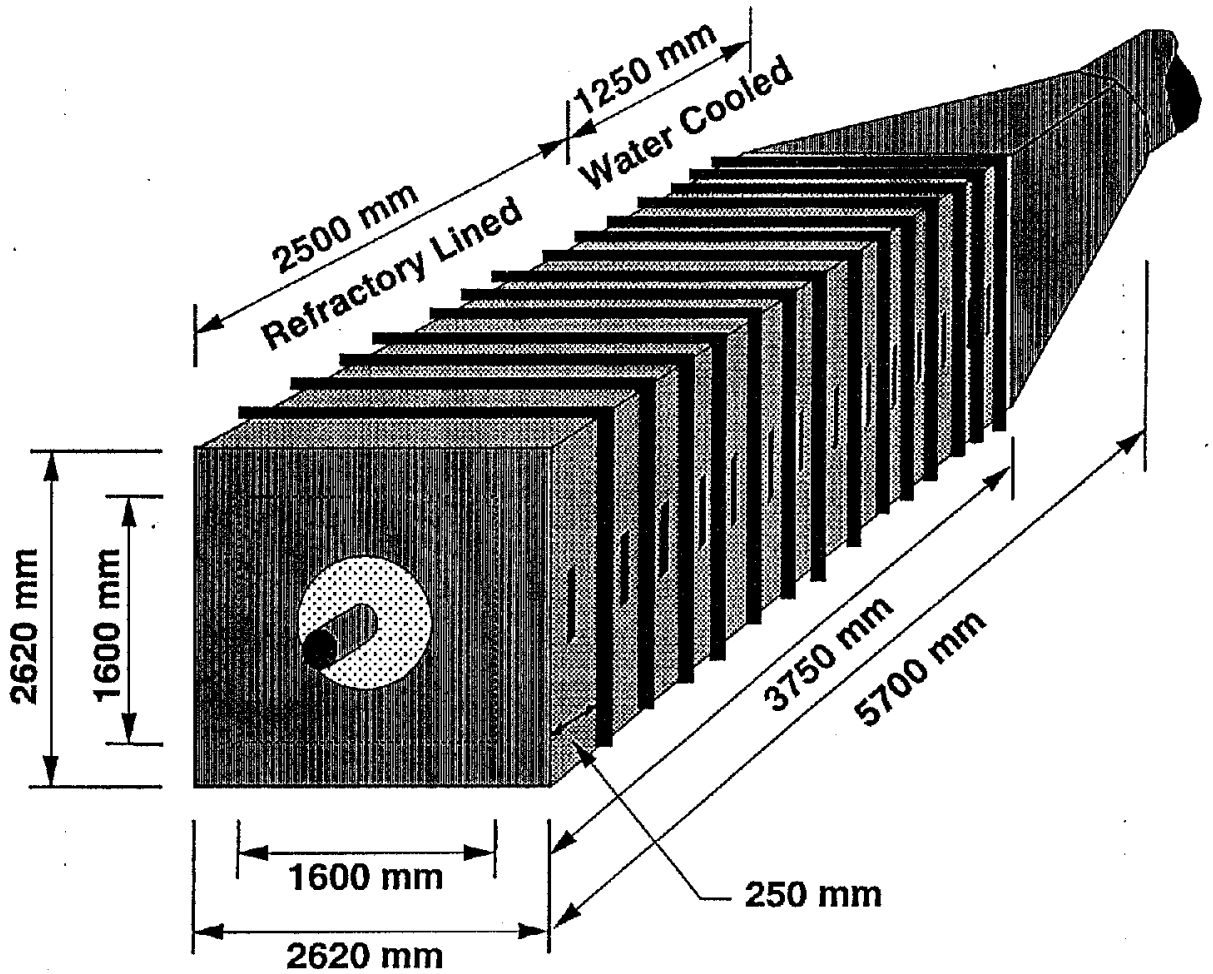


UCI LABORATORY RIG

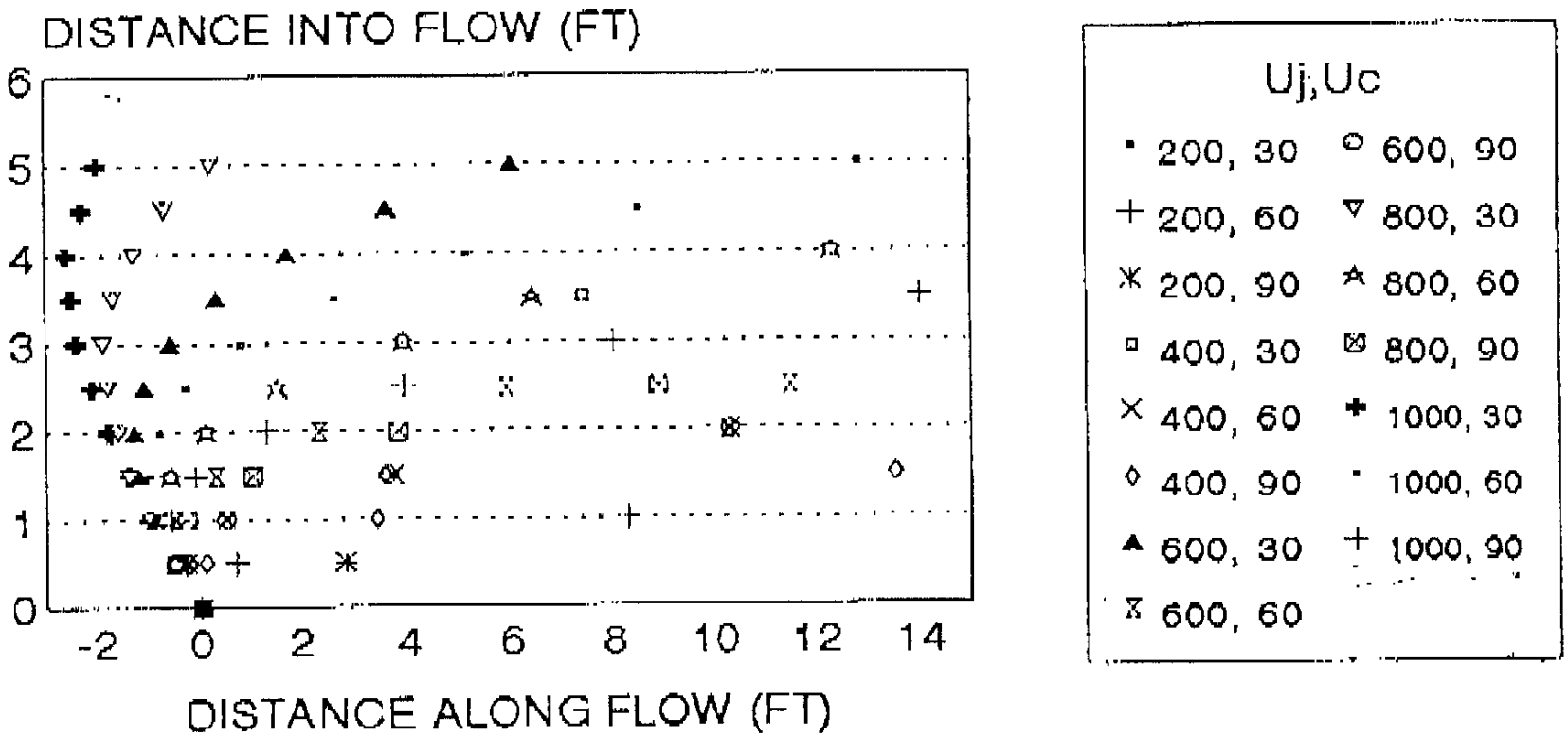


t = residence time

E & RL FURNACE


1250 mm
Water Cooled
2500 mm
Refractory Lined
2620 mm
1600 mm
3750 mm
5700 mm
1600 mm
2620 mm
250 mm

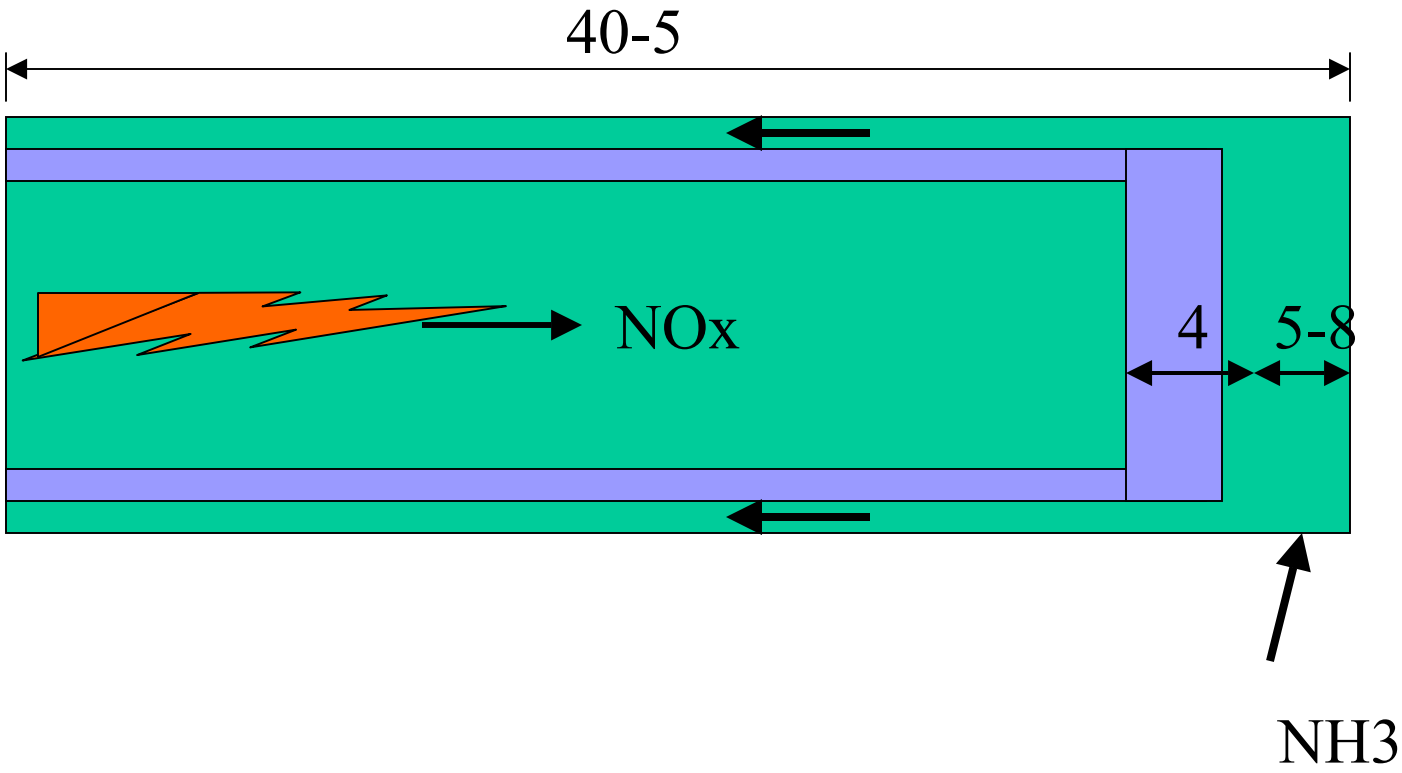
INJECTION



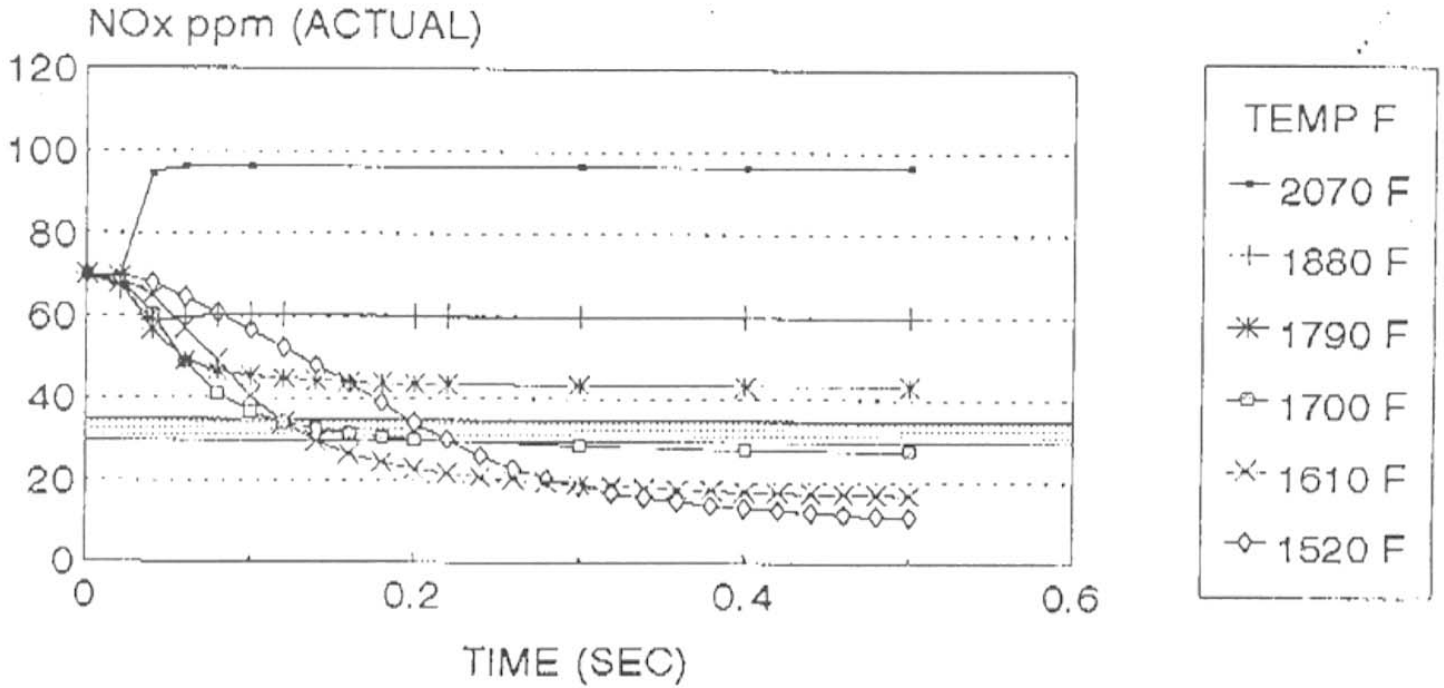
45 DEG INTO FLOW
INJECT 260 F
CROSS 1700F

160,000 LB/HR UCLA BOILER

SINGLE BURNER, NG 224, OIL 218 MBTU/HR

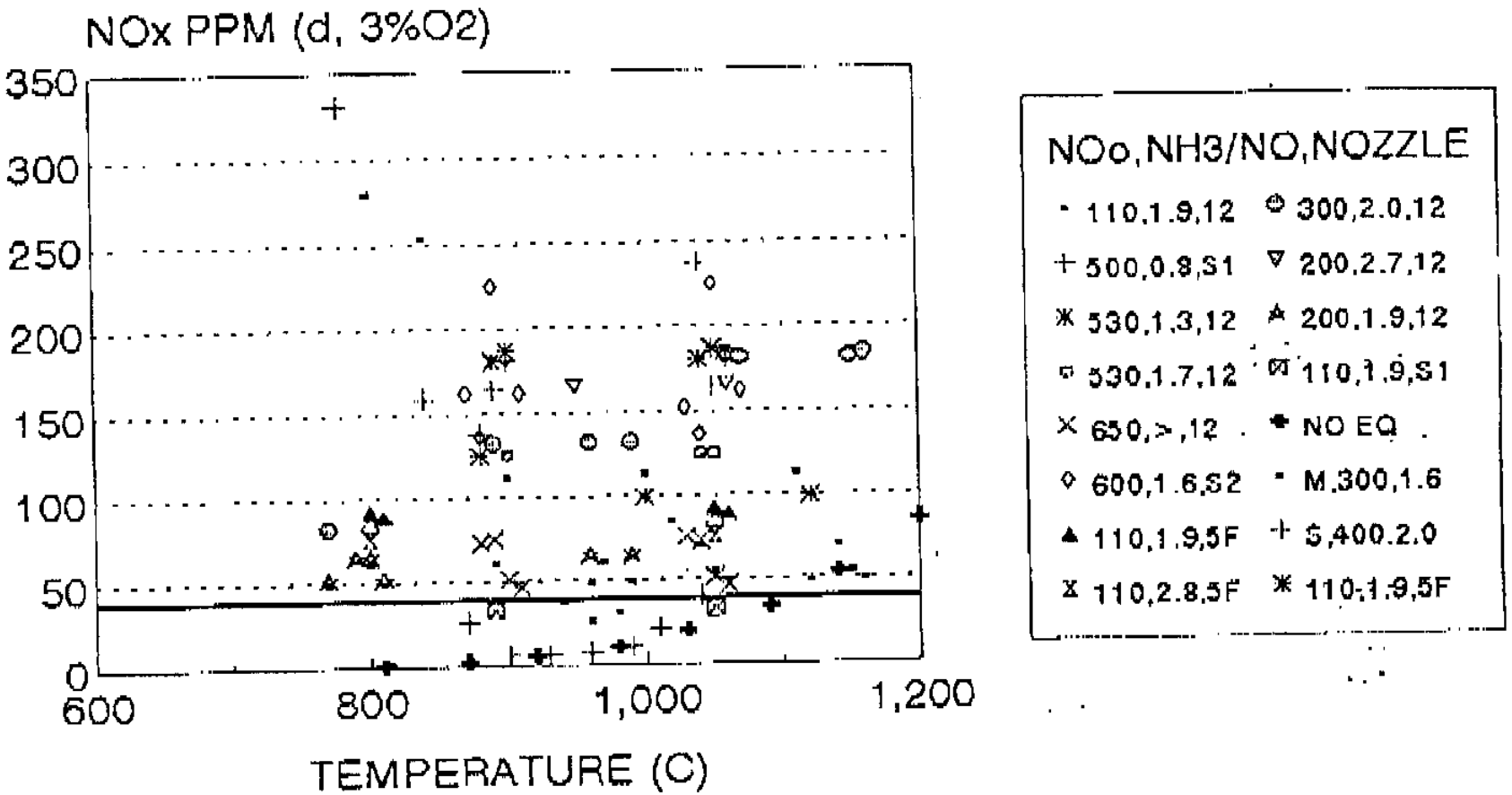


KINETIC CALCULATIONS

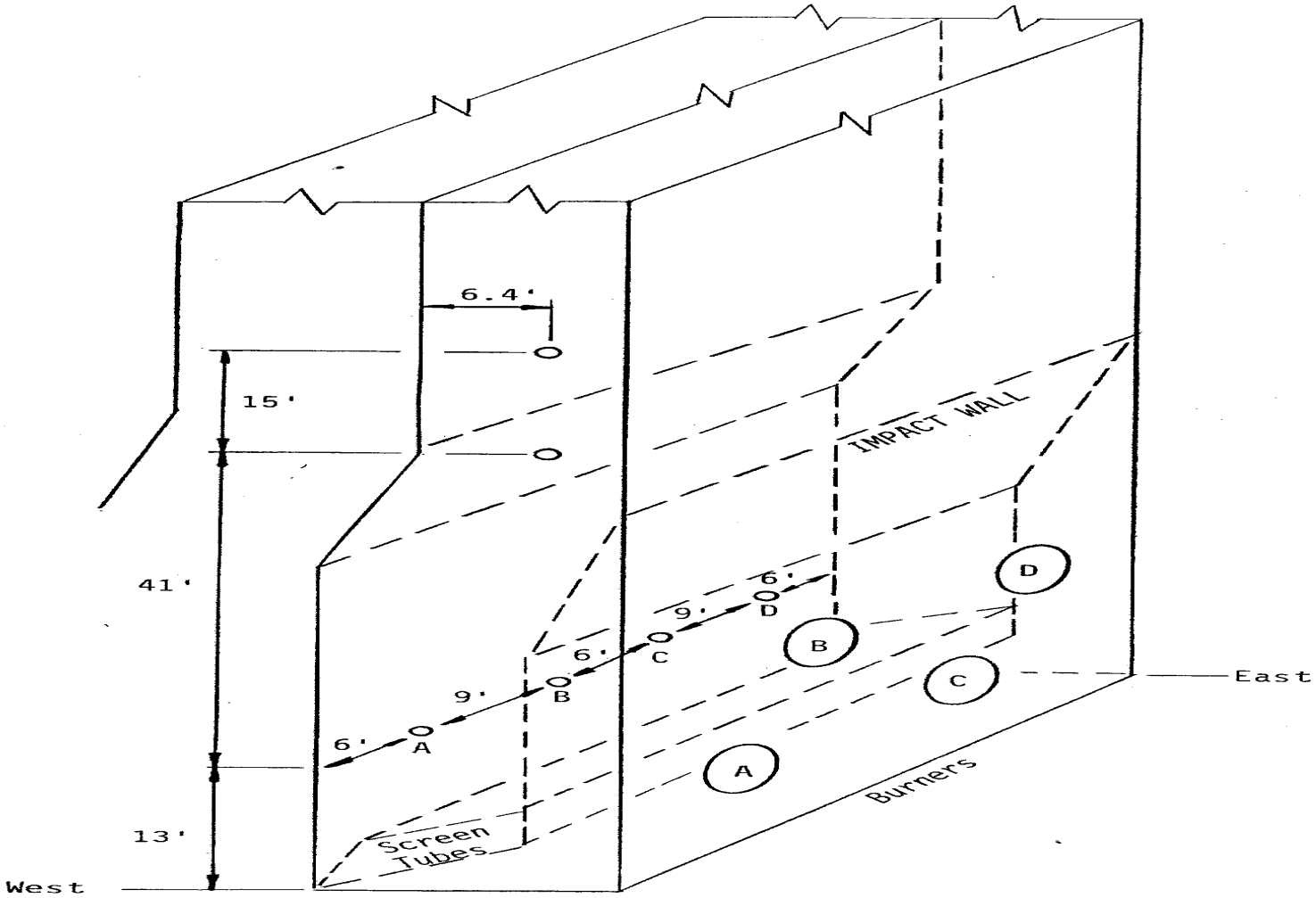


MILLER BOWMAN MECHANISM
3.5 % O2
CO int=30 ppm (ACTUAL)

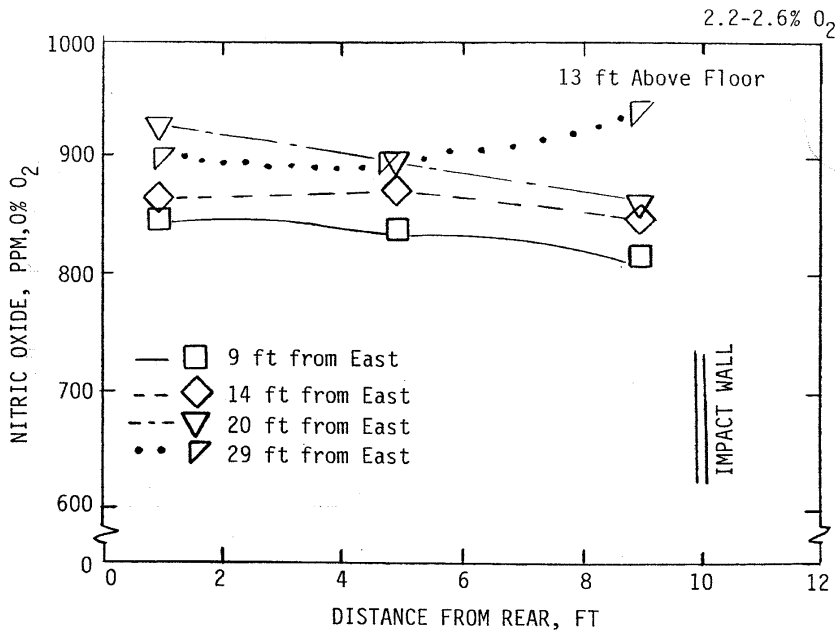
NOx REDUCTION

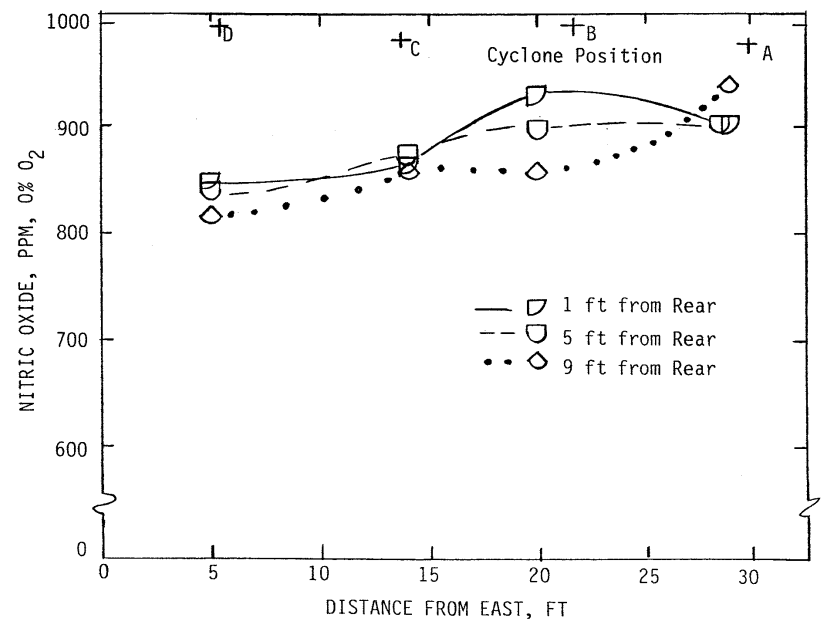


120 MWe NILES CYCLONE

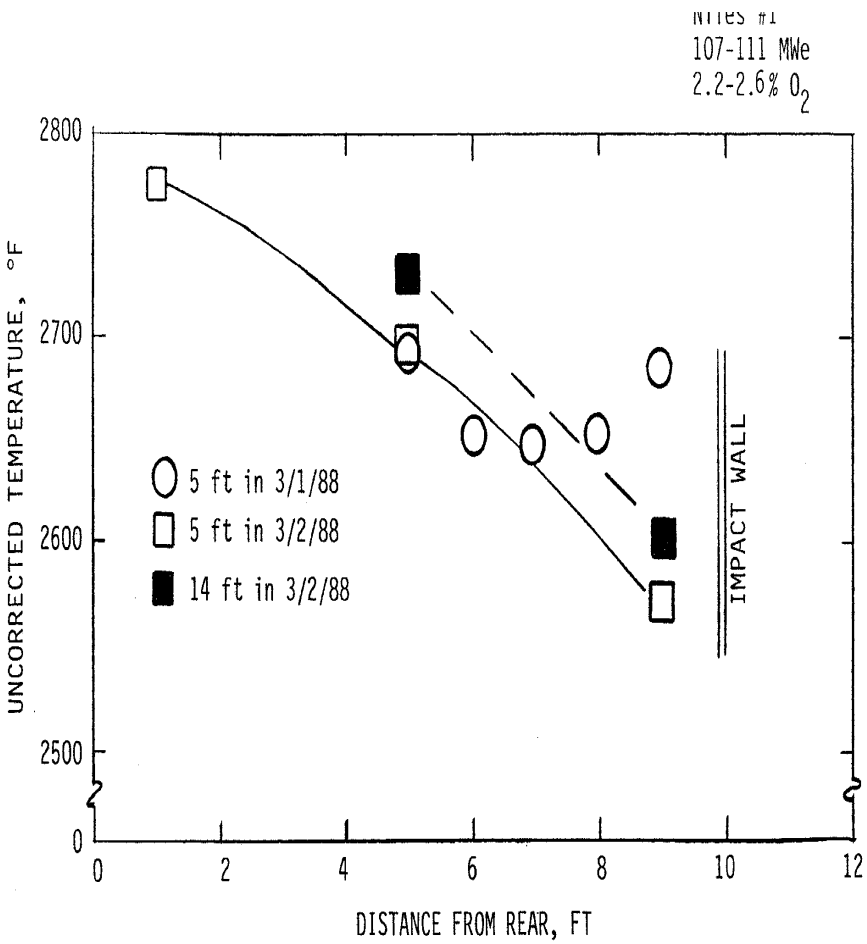


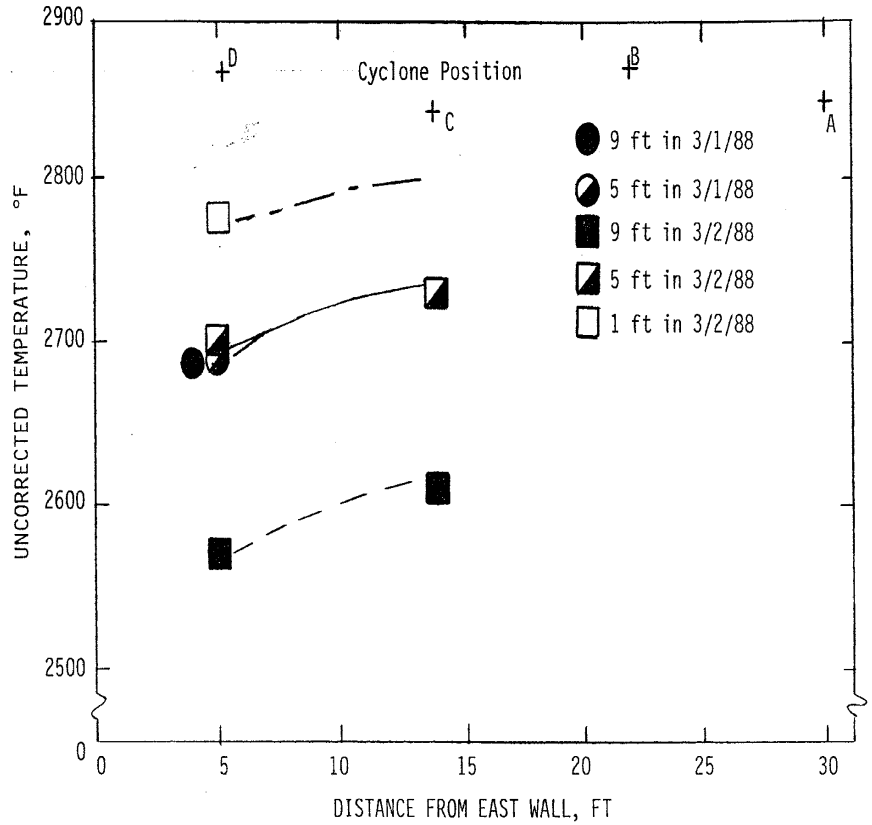
NOx PROFILES, 800-900 PPM REBURNING~450 PPM



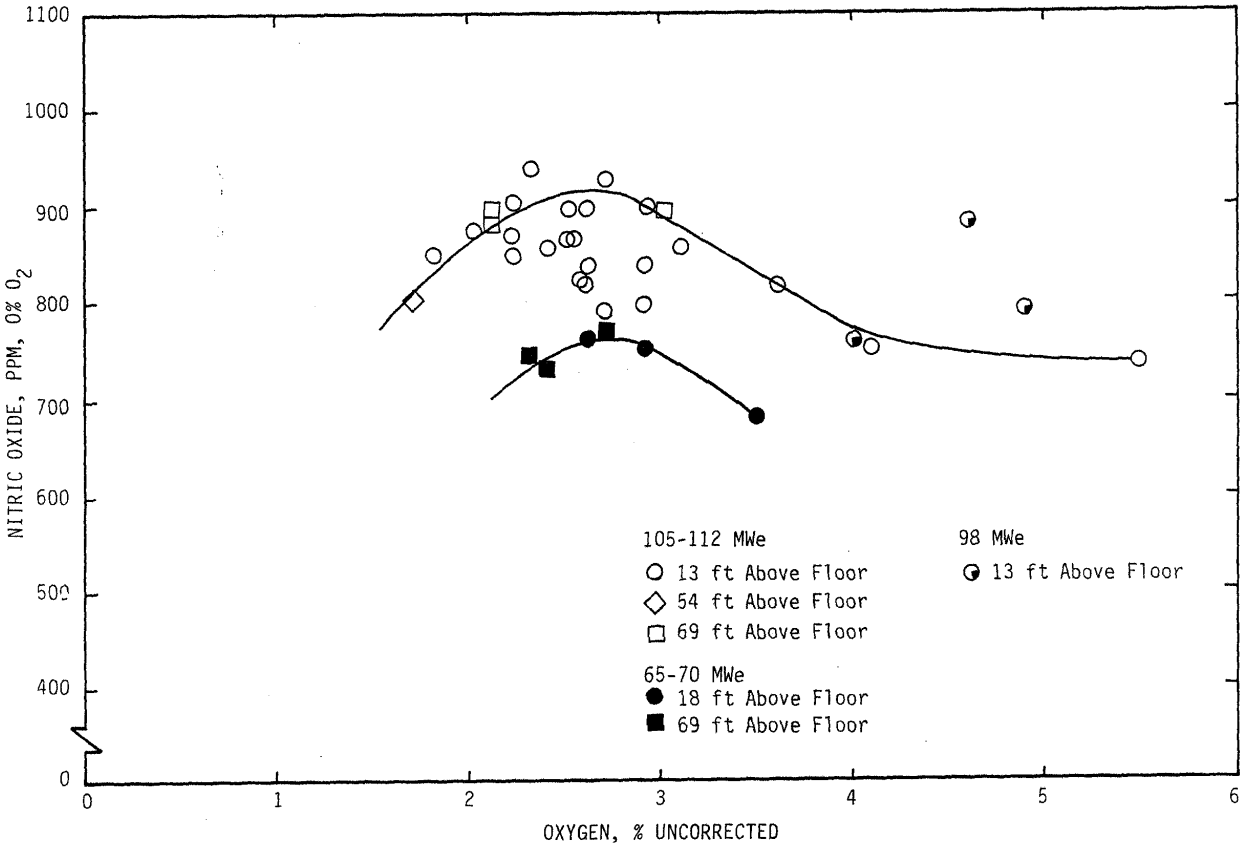


TEMPERATURE PROFILES, 2600-2800 F (1426-1538 C)



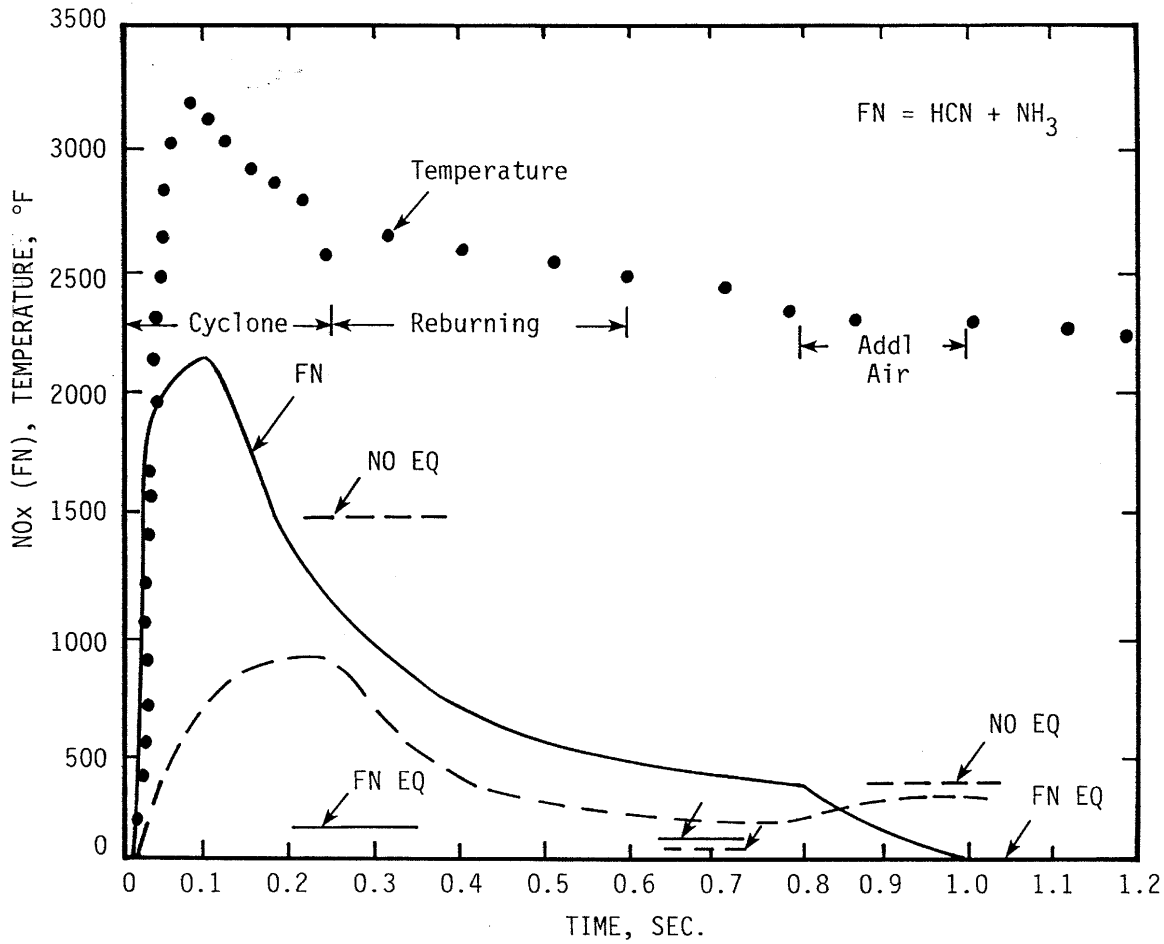


NO=f(MWe, O2)

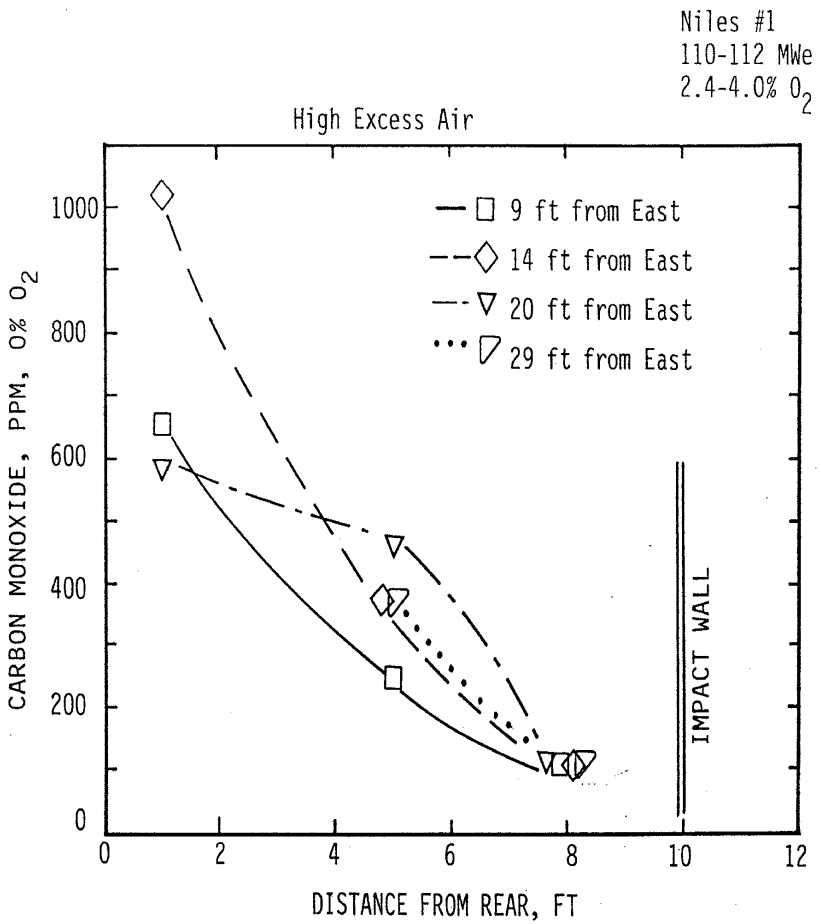


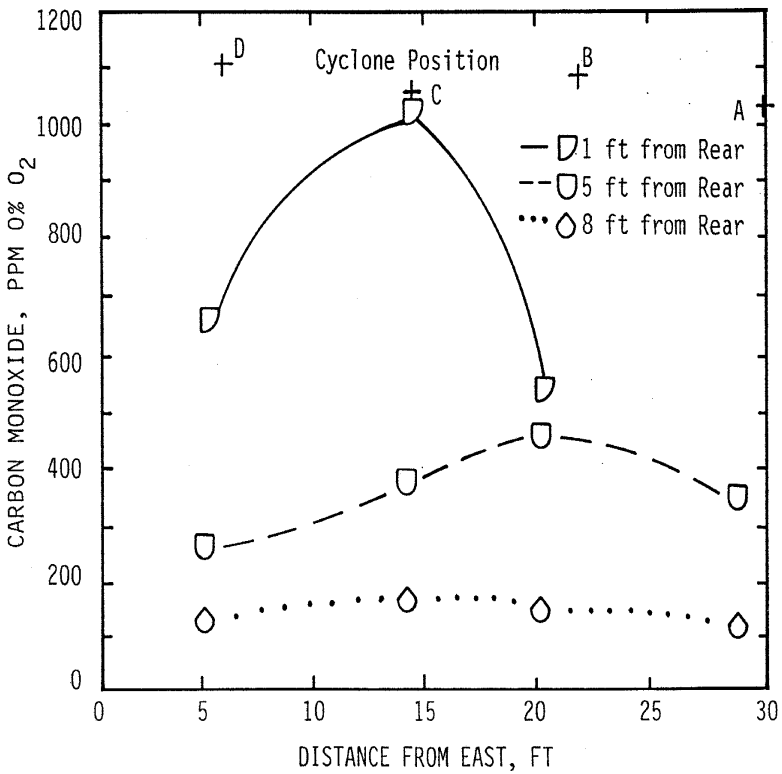
Relationship Between Oxygen and Nitric Oxide

NO REDUCTION BY REBURNING



CO PROFILES
100-3000 PPM, FEG<50 PPM





CONCLUSIONS

- REBURNING MODEST REDUCTION IN NOx TO~100 PPM
- MODERATE COSTS~0.2 cents/kWe-HR
- RELATED TO OTHER REDUCTION TECHNIQUES: CONTROLLED
  - EQUIIBRIUM
  - KINETICS~T, t, AND C_i
- CYCLONE 900-450 PPM (d, 0% O2)

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