BIODIESEL TIER I HEALTH EFFECTS

Steve Howell, MARC-IV
Chris Sharp, SwRI
Joe Jobe, National Biodiesel Board

2002 TRU Workshop
Detroit, Michigan
October 2002

OVERVIEW

→PROGRAM DESCRIPTION

- ♣TEST ENGINES
- ♣TEST FUELS
- ♣ TEST PROCEDURES

→REGULATED EMISSIONS

- ♣ HC, CO, NO_x, PARTICULATES

→TOXIC AND REACTIVE HC EMISSIONS

- ♣ SPECIATED HYDROCARBONS (C_1 - C_{22})
- ♣ POLYCYCLIC AROMATIC HYDROCARBONS (PAH)

Tier 1 Speciation Papers

- SAE 2000-01-1967
- SAE 2000-01-1968

TEST ENGINES

→ 1997 CUMMINS N14
- 14L, INLINE-6 CYLINDER
- ELECTRONIC UNIT INJECTORS
- 370 HP @ 1800 RPM

→ 1997 DETROIT DIESEL SERIES 50 COACH
- 8.5L, INLINE-4 CYLINDER
- ELECTRONIC UNIT INJECTORS
- 275 HP @ 2100 RPM
- CATALYST

→ 1995 CUMMINS B5.9
- 5.9L, INLINE-6 CYLINDER
- BOSCH MECHANICAL INLINE FUEL PUMP
- 160 HP @ 2500 RPM
- CATALYST

NATIONAL BIODIESEL BOARD

TEST FUELS

- BASE DIESEL FUEL (2D) - LOW-SULFUR 2D DIESEL FUEL BLENDED TO MEET 211(b) TEST SPECIFICATIONS

- NEAT BIODIESEL FUEL (B100) - 100% METHYL ESTER MEETING NBB AND DRAFT ASTM SPECIFICATIONS

- BLENDED FUEL (B20) - 20% BIODIESEL IN THE BASE DIESEL FUEL BY VOLUME

TEST FUEL PROPERTIES

	2-D	B100	B20
CETANE NUMBER	43.3	51.2	46.0
SPECIFIC GRAVITY	0.856	0.886	0.862
SULFUR, WT%	0.048	0.000	0.037
OXYGEN, WT%	0.0	11.0	2.1
HEAT OF COMB., BTU/LB	18290	16004	17764
VISCOSITY, cSt	2.8	4.1	2.9

TEST PROCEDURES

- EXHAUST EMISSIONS EVALUATED OVER THE HEAVY-DUTY TRANSIENT FTP (COLD AND HOT START)
- EVALUATED WITH AND WITHOUT CATALYST IF ONE WAS PRESENT
- TRIPLICATE TEST DAYS FOR N14 ON NEAT FUELS
- SINGLE TEST DAYS FOR ALL OTHER ENGINES (EXCEPT NEAT BIODIESEL DUPLICATE RUNS)

REGULATED EMISSIONS

HC, CO, NO_x, PARTICULATES

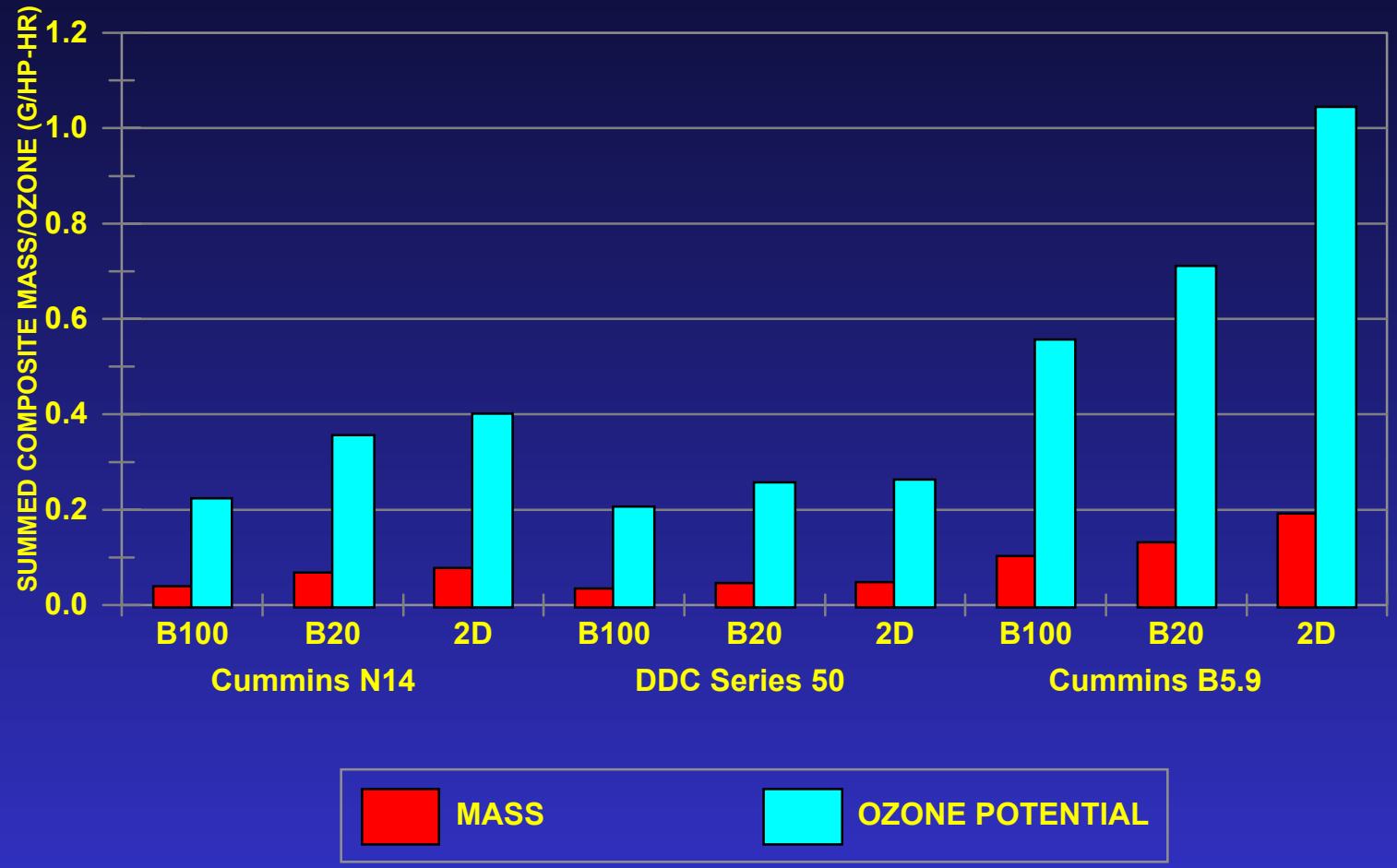
CONCLUSIONS
BIODIESEL AND REGULATED EMISSIONS

POLLUTANT	B100 vs 2D	B20 vs 2D
HC	-80% to -90%	-20% to -30%
CO	-40%	-10% to -20%
PM	-30% to -50%	-5% to -15%
PM w/ Catalyst	-50% to -60%	-10% to -22%
NOx	+12% (+4% B5.9)	+4% (+2% B5.9)

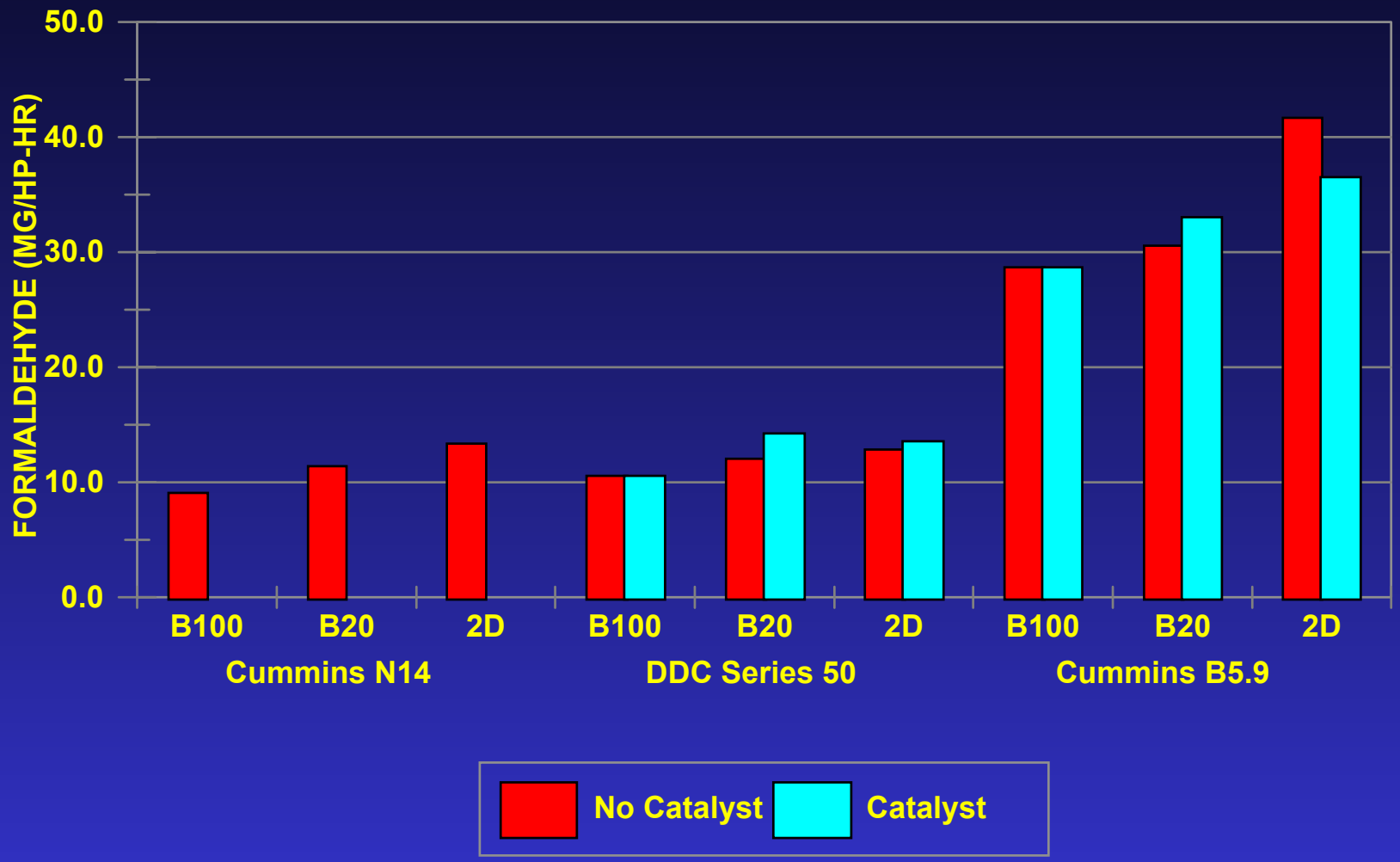
TOXIC AND REACTIVE HYDROCARBONS

SPECIATED HYDROCARBONS
PAH/NPAH

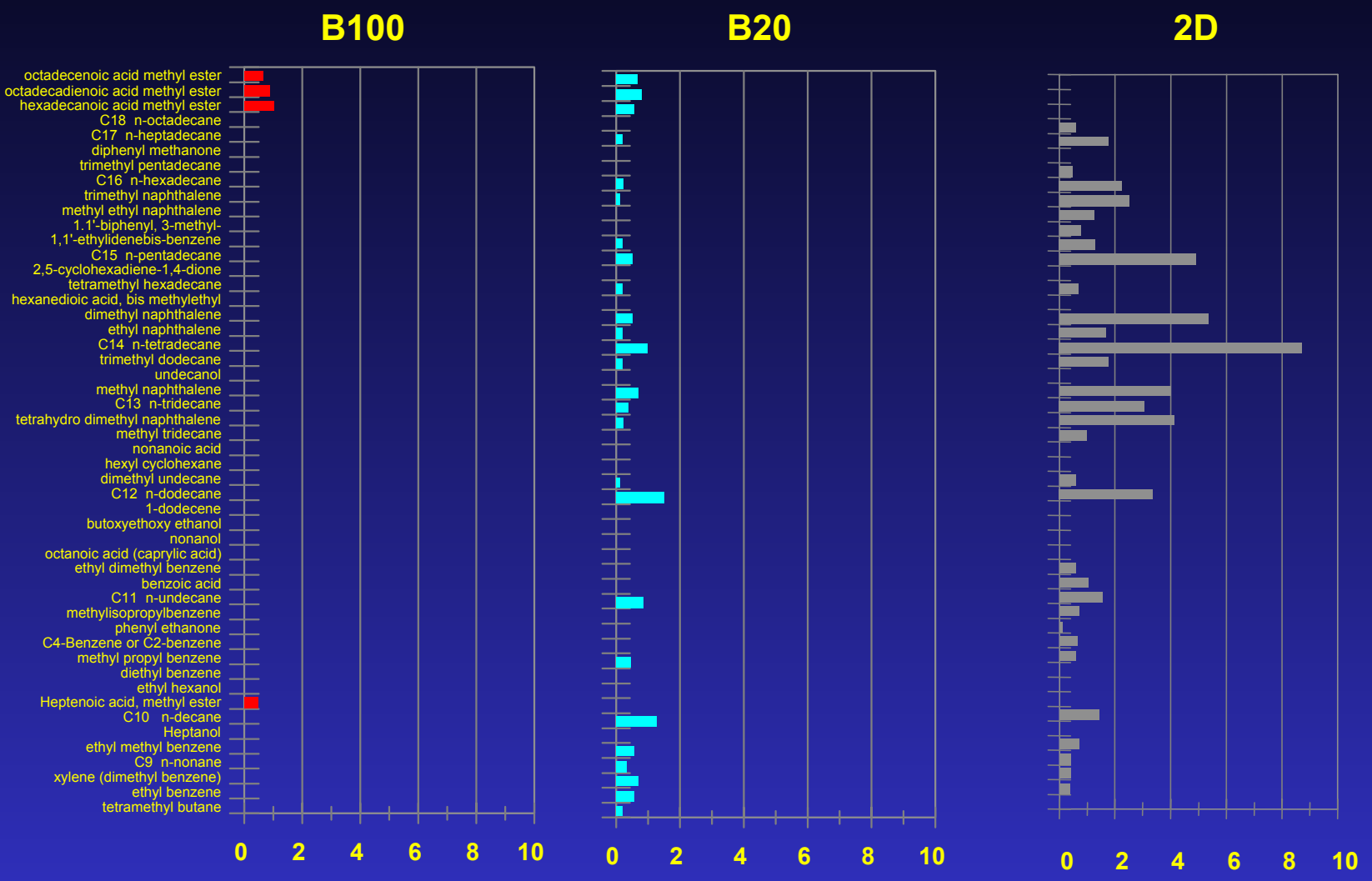
C_1 TO C_{12} SPECIATION
TOTAL MASS AND OZONE POTENTIAL



FORMALDEHYDE EMISSIONS



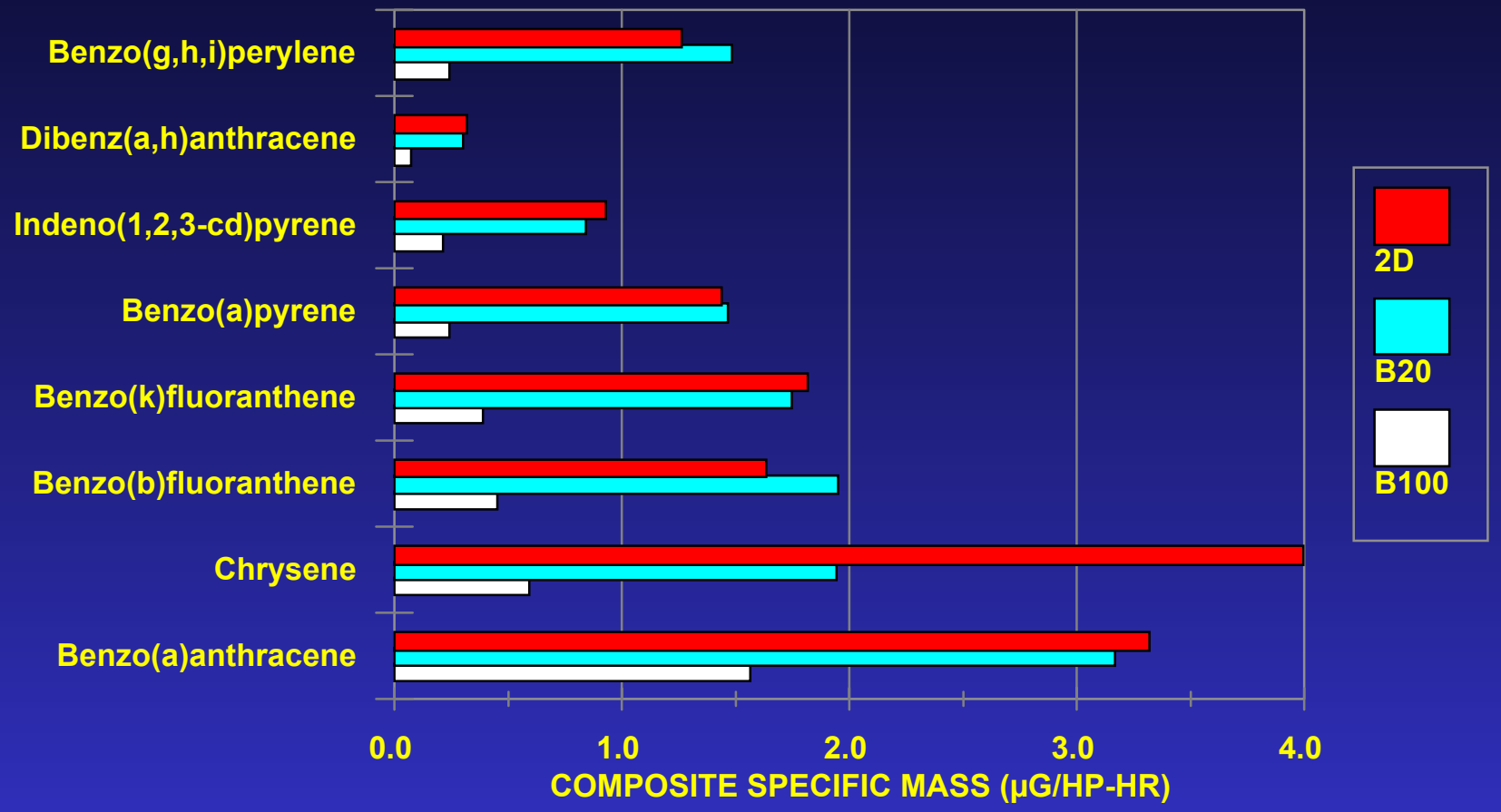
HEAVY HC SPECIATION - CUMMINS N14 ENGINE



RELATIVE EMISSION RATE (MG/HP-HR)

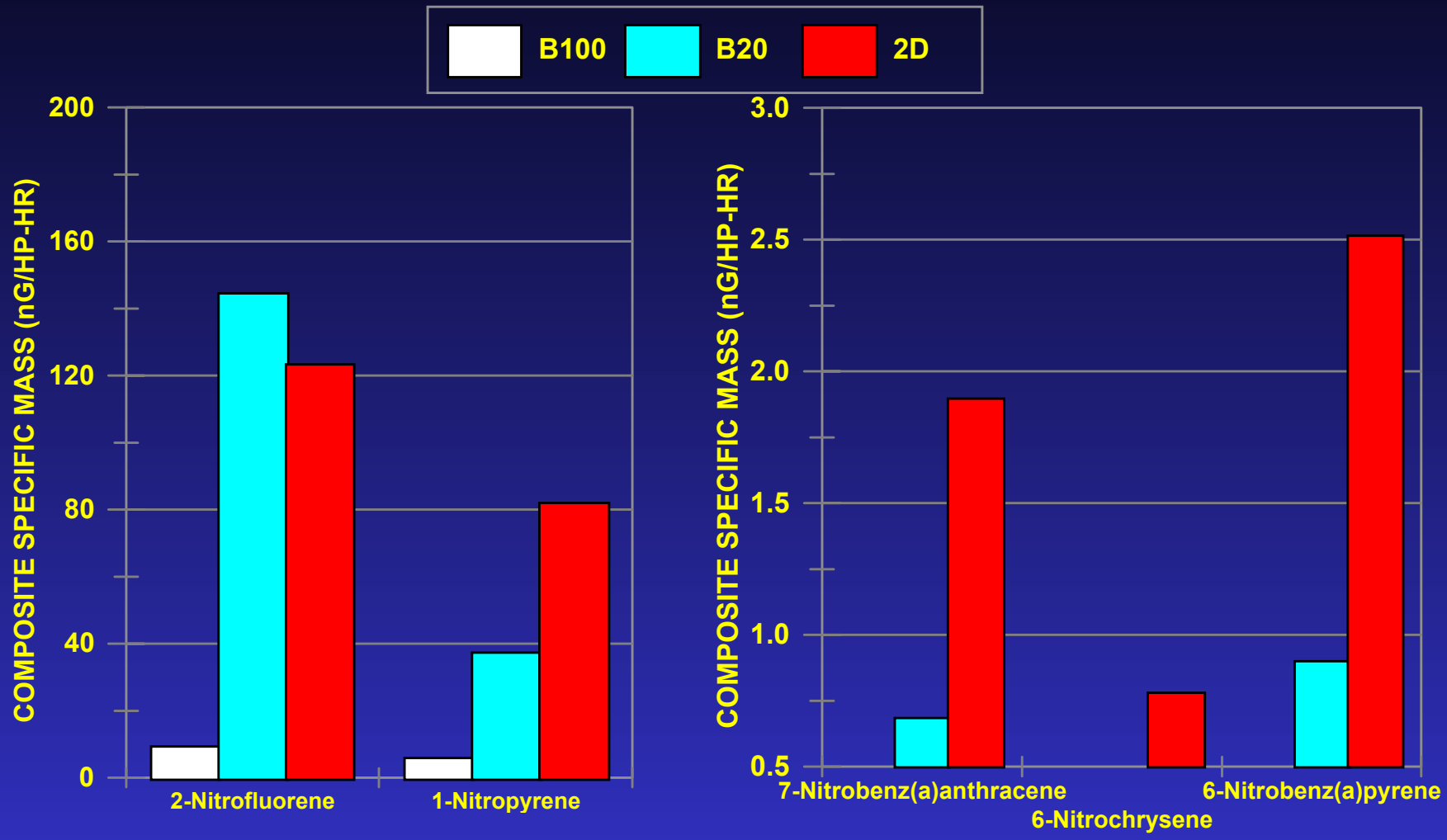
NATIONAL BIODIESEL BOARD

PAH EMISSIONS - CUMMINS N14 ENGINE



Note: 2D & B100 values are 3 repetitions, B20 is one repeat

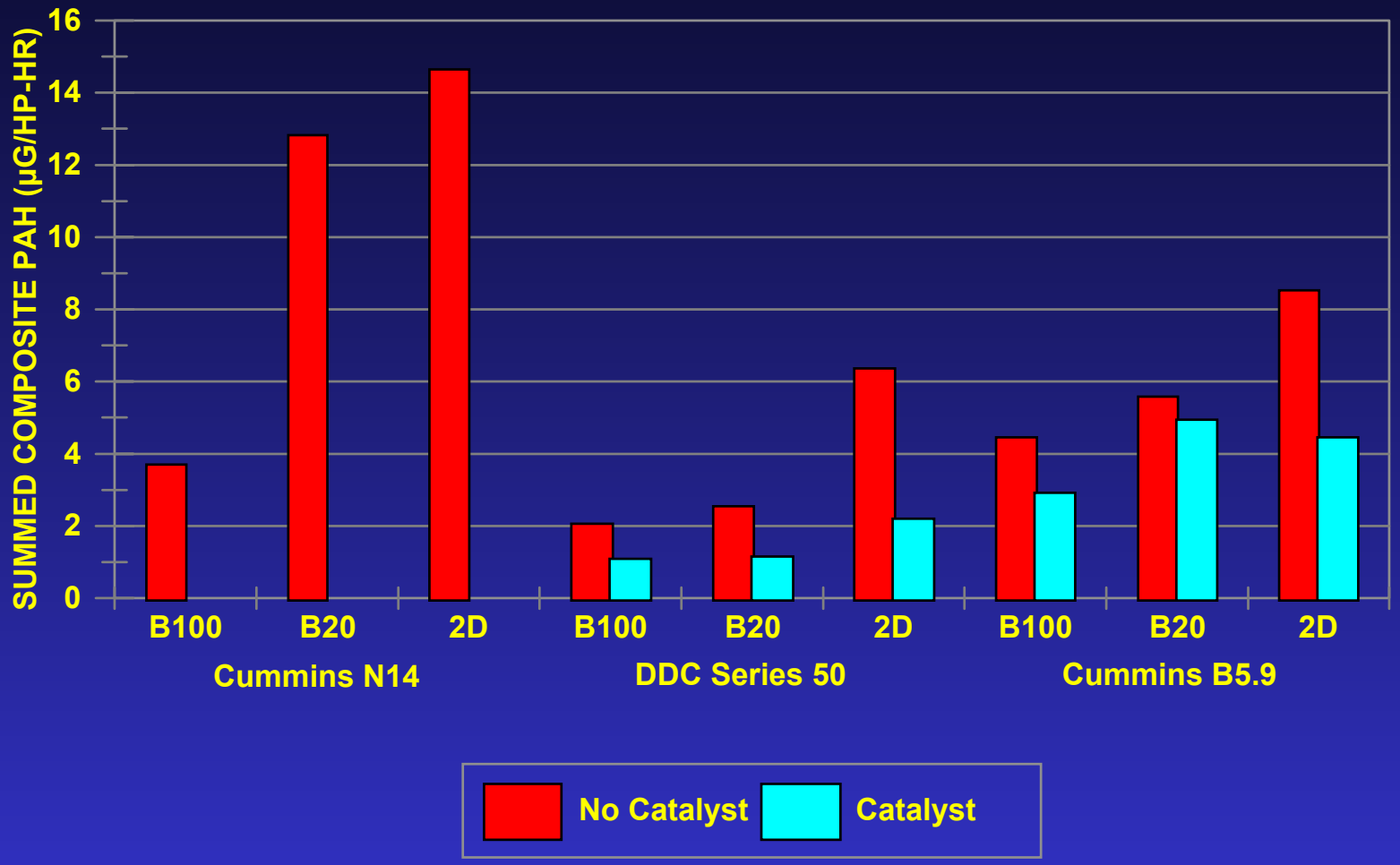
NPAH EMISSIONS - CUMMINS N14 ENGINE



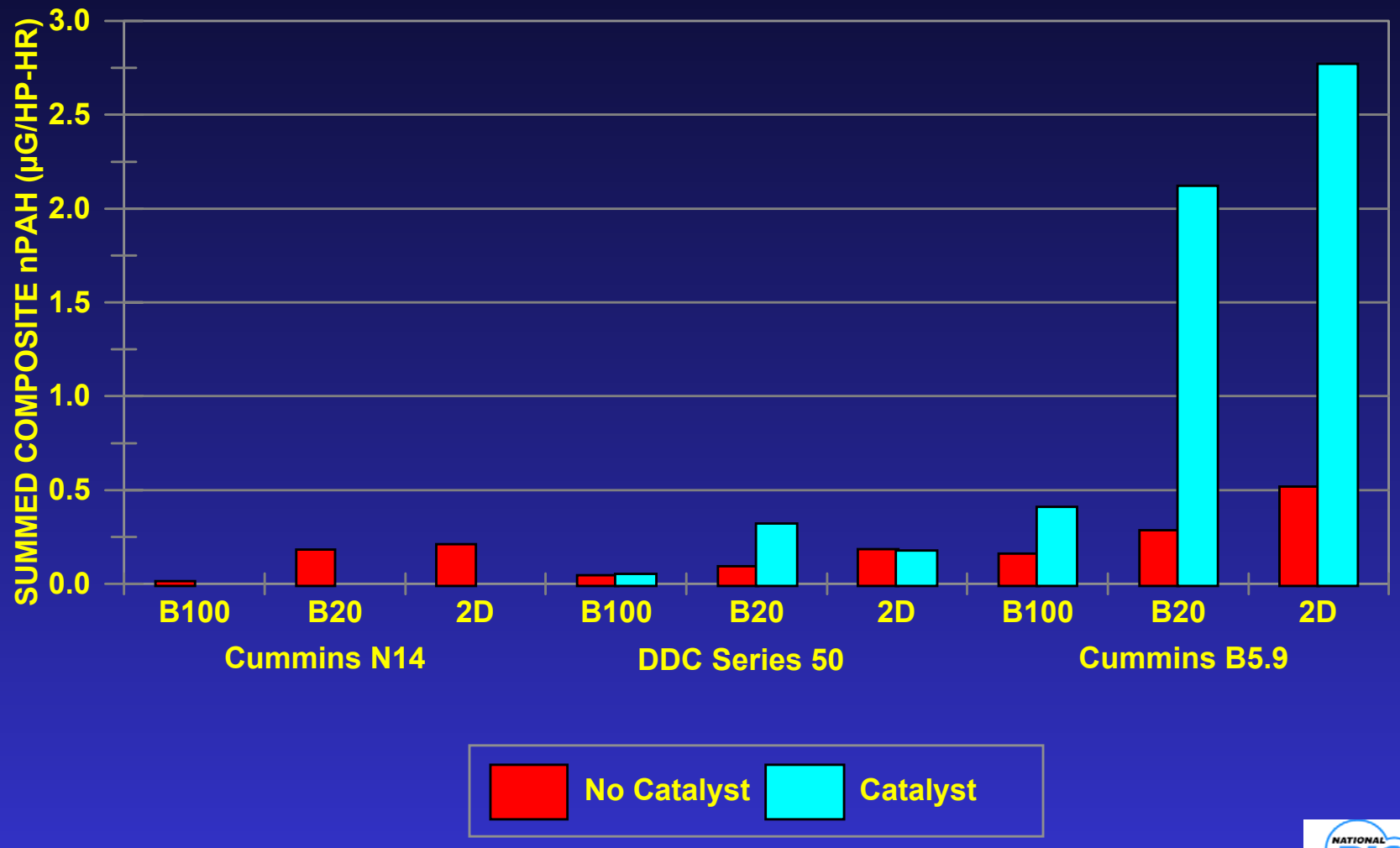
Note: 2D & B100 values are 3 repetitions, B20 is one repeat

NATIONAL BIODIESEL BOARD

PAH EMISSIONS SUMMARY
ALL ENGINES



NPAH EMISSIONS SUMMARY
ALL ENGINES



CONCLUSIONS

→ BIODIESEL REDUCED EMISSIONS OF HC, CO, AND PARTICULATES

→ BIODIESEL INCREASED NOx SLIGHTLY

CONCLUSIONS (CONT'D)

→ BIODIESEL REDUCED EMISSIONS OF TOXIC AND REACTIVE HYDROCARBON SPECIES

→ BIODIESEL REDUCED PAH AND NPAH EMISSIONS

→ BLENDING BIODIESEL AND DIESEL FUEL DID NOT GENERATE ANY UNEXPECTED NEW HC SPECIES