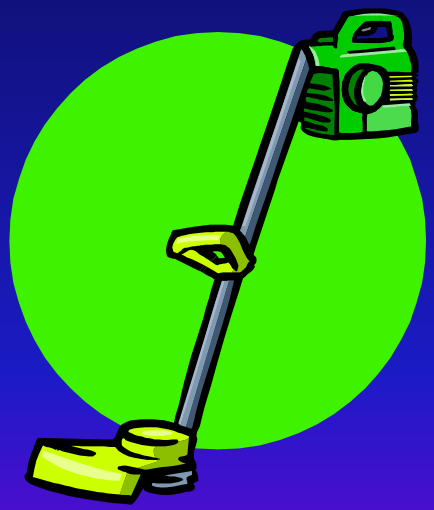
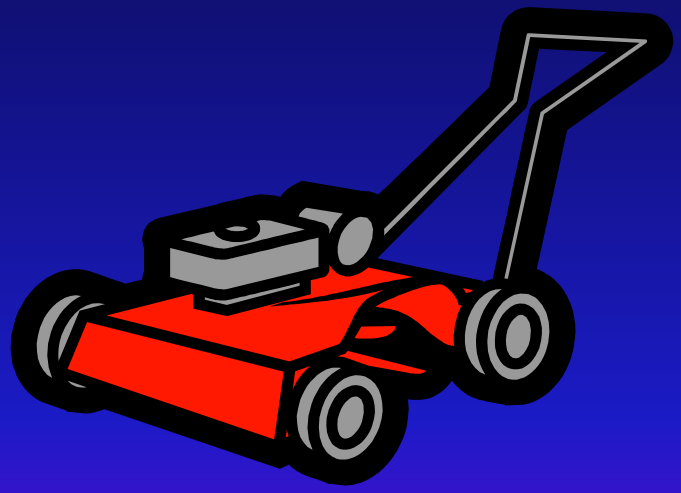
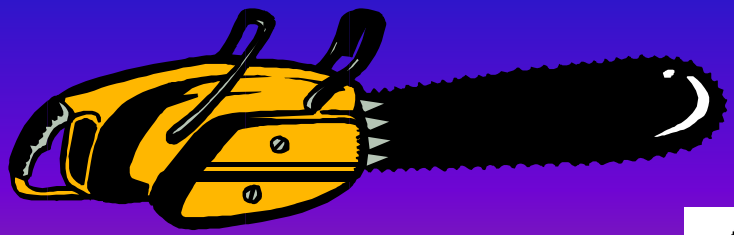
Control Measure to Reduce Emissions from Small Off-Road Engines (SORE)

Mobile Source Control Division
Monitoring and Laboratory Division
California Air Resources Board

September 25, 2003
Board Hearing







California Environmental Protection Agency
Air Resources Board

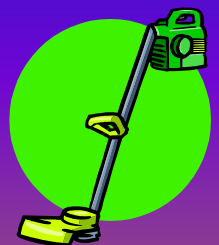
Outline

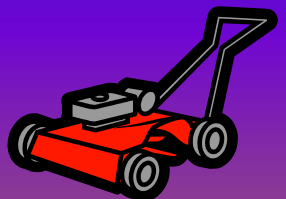
- Background
- Proposed Exhaust Emission Standards
- Proposed Evaporative Emission Standards
- Environmental Benefits
- Economic Impacts
- Conclusion

Small Off-Road Engines and Equipment (SORE)

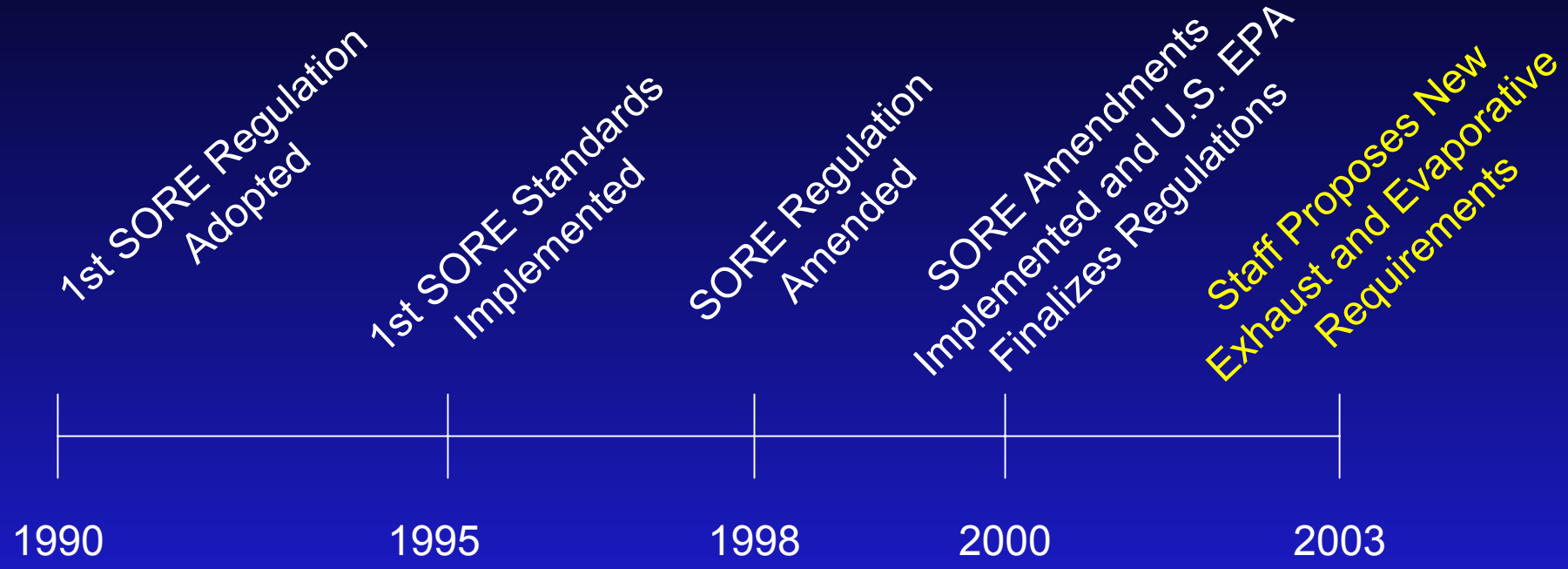
- Engines ≤ 19 kW
- Two and four-stroke engines
- Lawn and garden and small industrial equipment
- Preempt: farm and construction equipment < 175hp

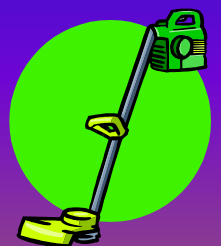
Examples of SORE Equipment

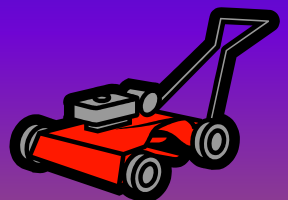




History

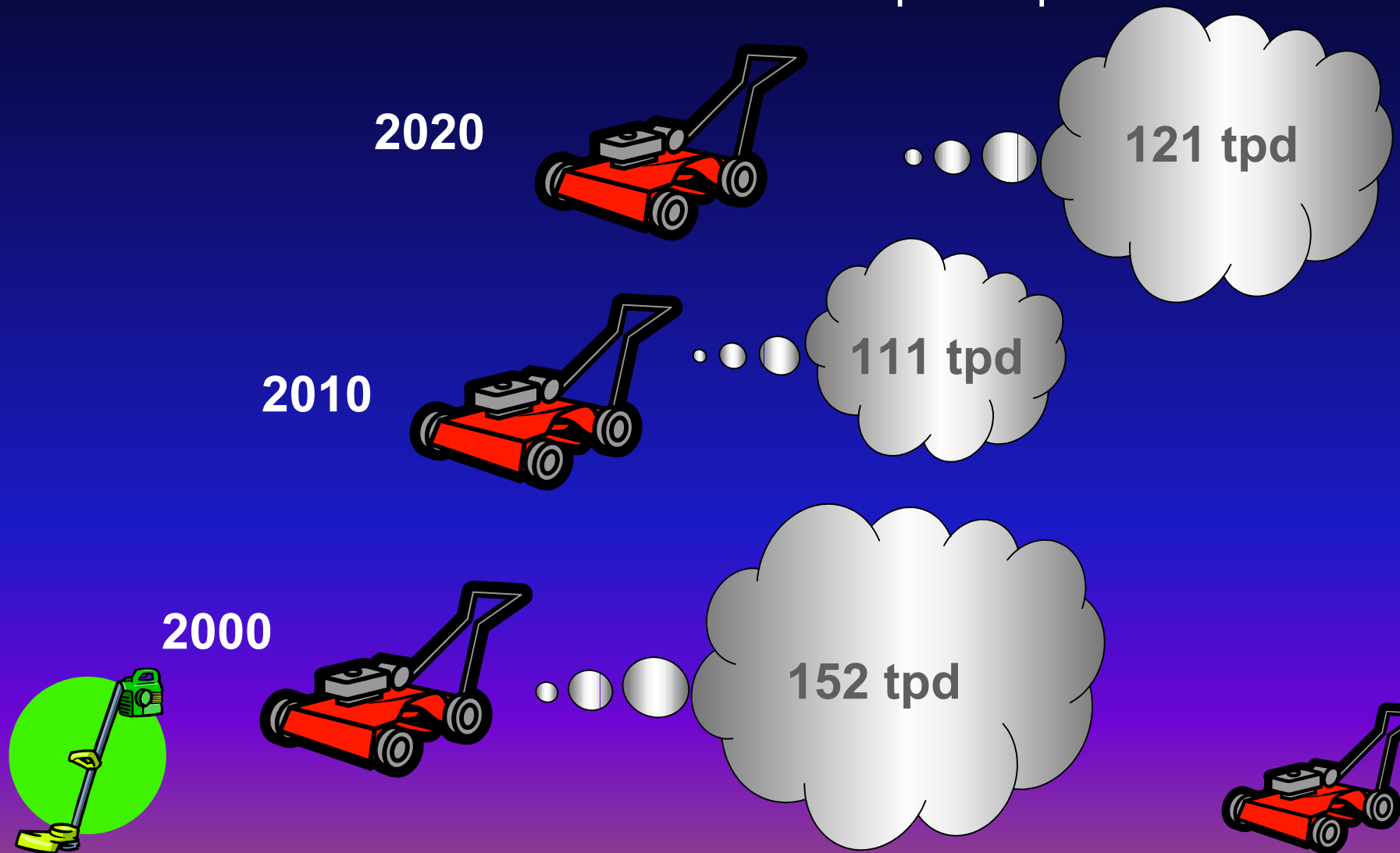

1st SORE Regulation Adopted
1st SORE Standards Implemented
SORE Regulation Amended
SORE Amendments Implemented and U.S. EPA Finalizes Regulations
Staff Proposes New Exhaust and Evaporative Requirements
1990
1995
1998
2000
2003





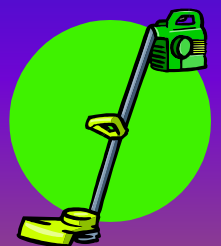
Need for Regulation

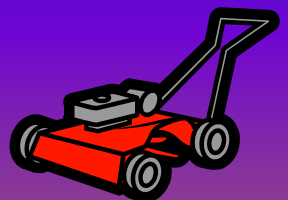
Exhaust and Evaporative Emissions Statewide
HC+NOx Baseline - Nonpreempt



New SIP Commitments

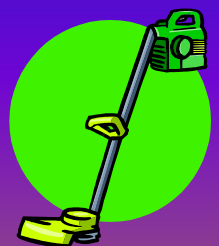
- Includes two SORE measures
  - SMALL OFF-RD-1
  - SMALL OFF-RD-2
- Staff's proposal designed to accomplish goals of both measures





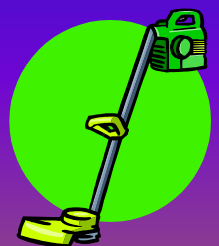
Proposed 2005 Handheld Standards Tier 3

- Align with most stringent U.S. EPA HC+NOx standard for engines < 50 cc
  - 50 g/kW-hr
  - 30% reduction from current standard



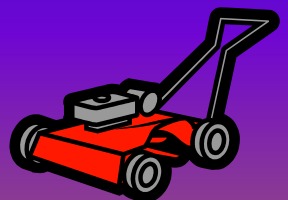
Handheld - Exhaust
Tier 3 Levels Already Met By Some

- Currently 25 CA engine families certified to levels below proposed Tier 3
- Includes all types of handheld equipment
- Technologies
  - Four-stroke
  - Two-stroke with a catalyst
  - Stratified scavenging
  - Two-stroke/four-stroke hybrid
  - Electric equipment



Proposed 2007/8 Nonhandheld Standards Tier 3

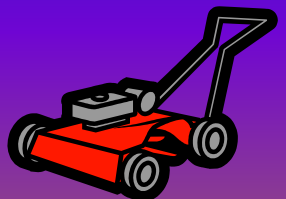
- Staff's Original Proposal
  - >80 - <225cc: 8.0 g/kW-hr, 2007+ MY
  - 225cc and above: 6.0 g/kW-hr, 2008+ MY
- Alternative Proposal
  - >80 - <225cc: 10.0 g/kW-hr, 2007+ MY
  - 225cc and above: 8.0 g/kW-hr, 2008+ MY
- Standards based on the use of a catalytic converter



Catalyst Test Program to Show Technical Feasibility

- Three-way catalyst
- Secondary air injection
- Some enleanment of A/F

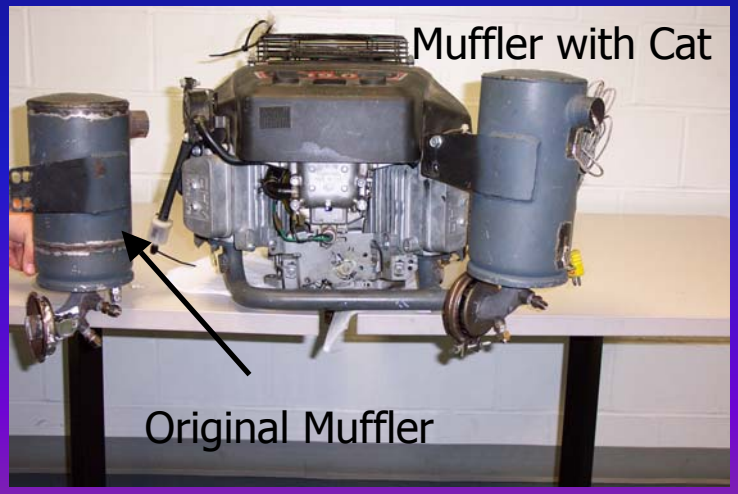
Engine	Power (kW)	Application
B&S #1	4.8	WBM
B&S#2	4.8	WBM
Tecumseh	4.8	WBM
Honda #1	4.1	WBM
Kawasaki	14.2	Riding Mower
Honda #2	8.2	Generator



Catalyst Pictures

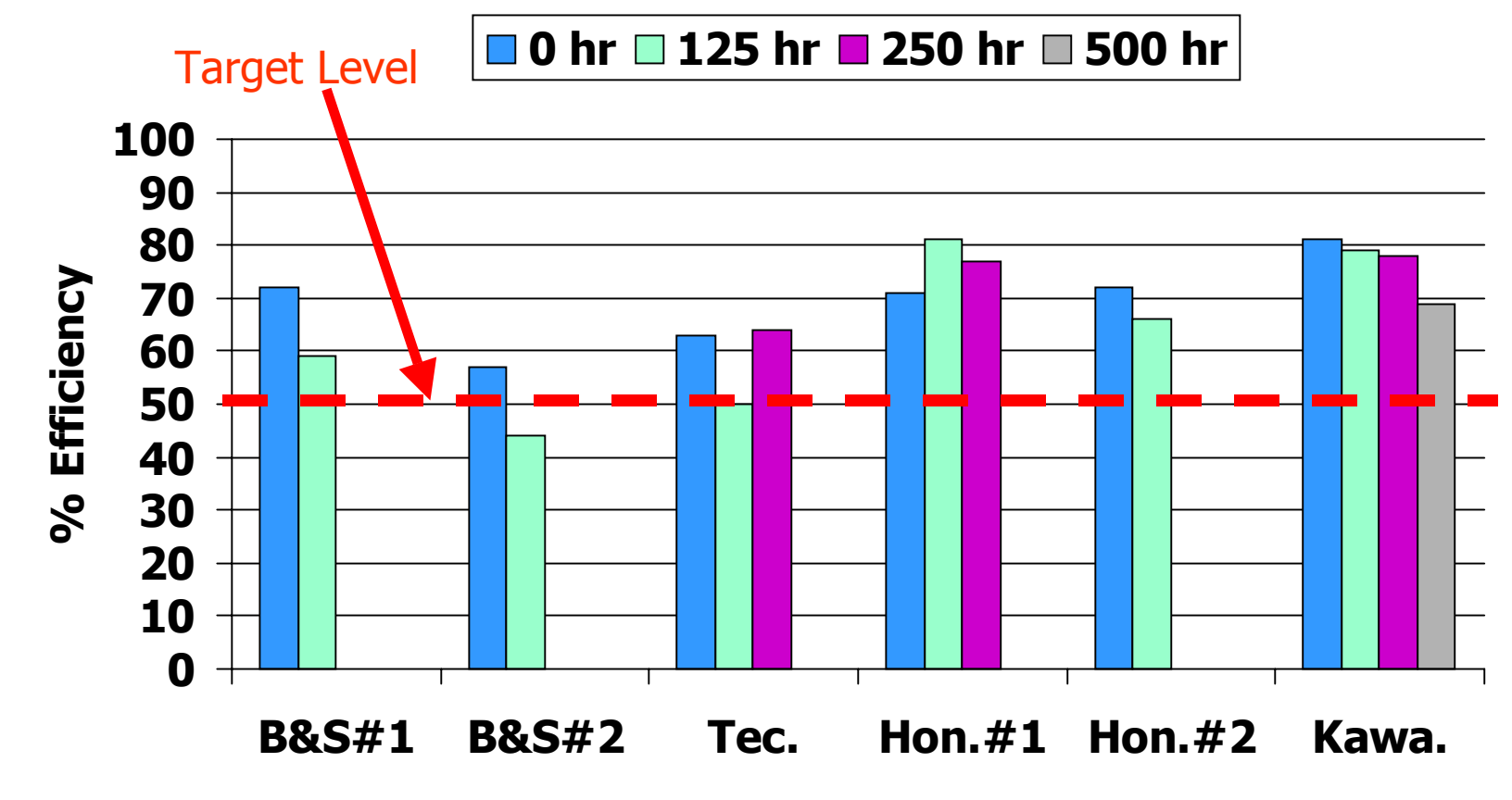
B&S #2

Honda #2



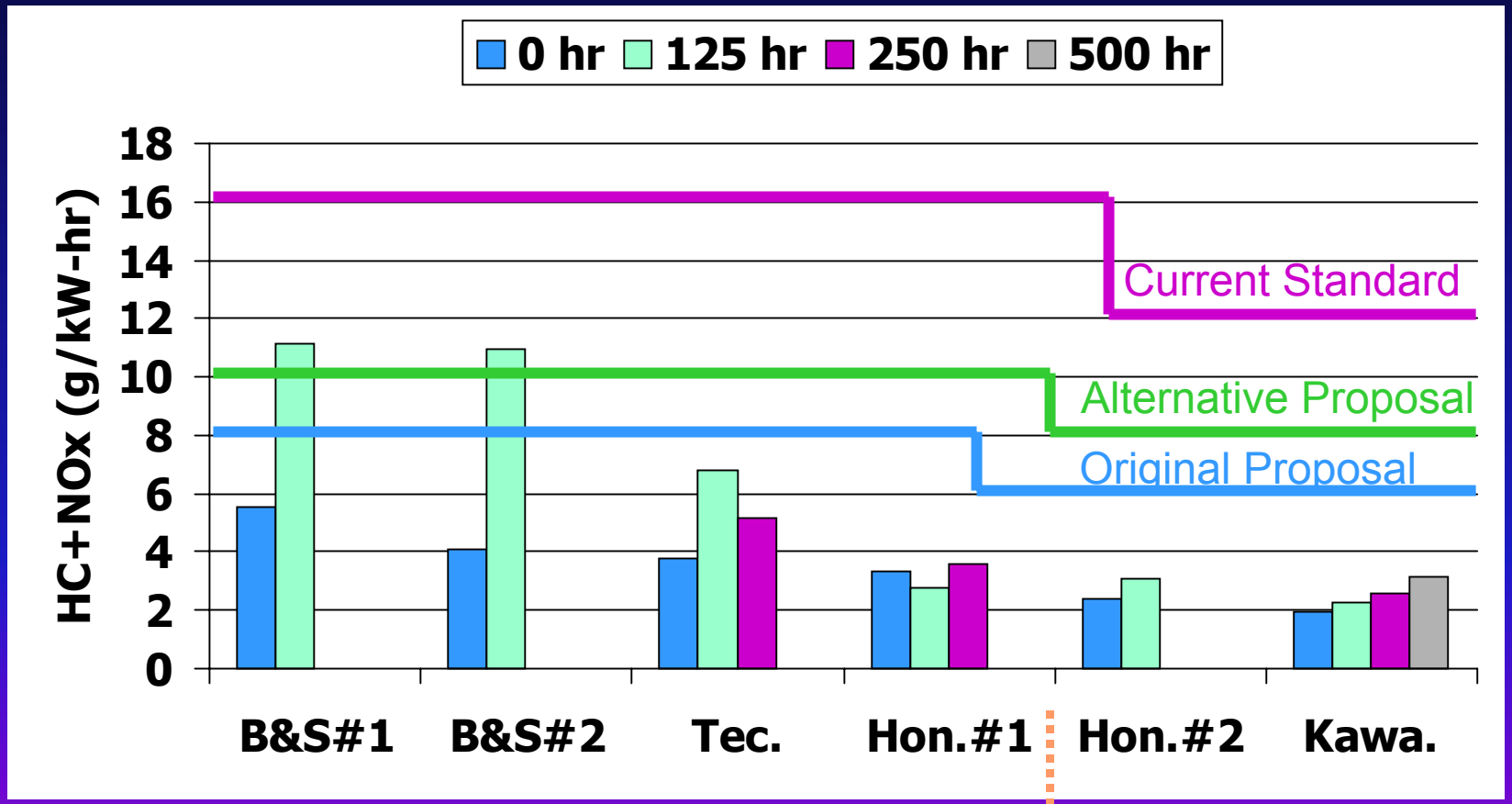
Kawasaki

Catalyst Efficiency



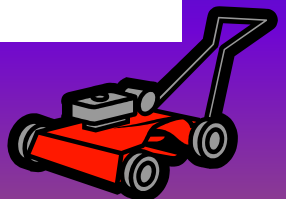
Exhaust Levels Achieved

Developed Engine Emissions

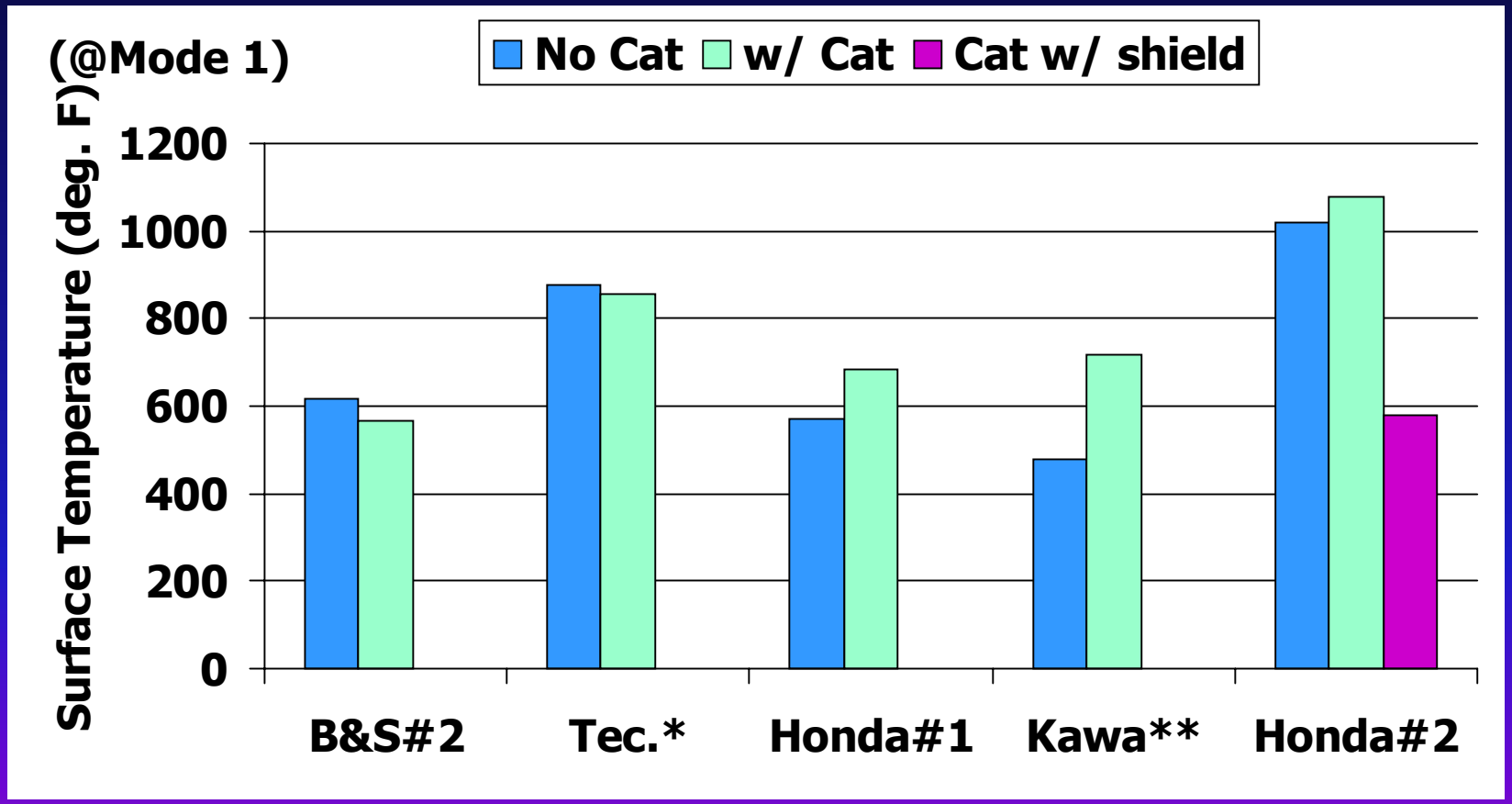


>80 cc - <225cc

≥225cc



Muffler Surface Temperatures



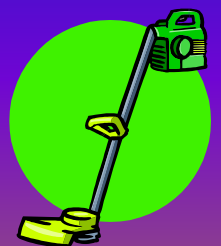
* At 250 hours

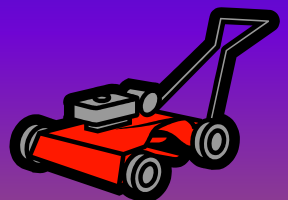
** At 125 hours

Summary of Proposed Tier 3 Standards

Size (cc)	MY	HC+NOx Standard (g/kW-hr)
< 50	2005+	50
≥50 - ≤80	2005+	72
>80 - <225	2007+	8/10*
≥ 225	2008+	6/8*

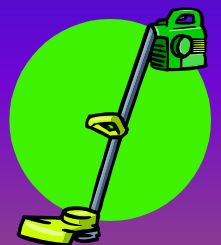
* Alternative Standards

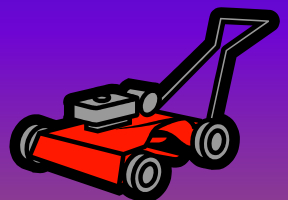




"Blue Sky" Engine Standards

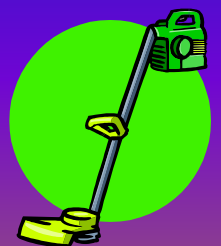
- Voluntary
- HC+NOx levels 50% of Tier 3 standard
- Provides opportunity for clean label and incentives
- Includes zero-emission engine eligibility

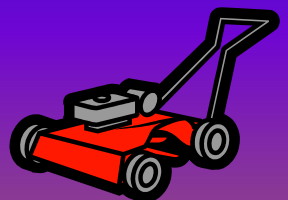




Additional Changes to Exhaust Regulations

- Alignment with U.S. EPA
  - < 25 hp vs. ≤19 kW
  - 1000 hour durability option
  - Test procedures
- Handheld limit raised to 80cc

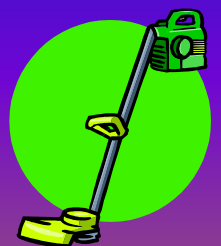


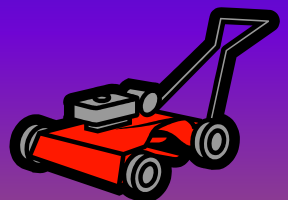


Additional Changes to Exhaust Regulations

- Warranty Defects Reporting
  - Voluntary/Ordered Recall
  - Included in Exhaust and Evaporative Program

- Additional text to clarify use of cooling fans during testing





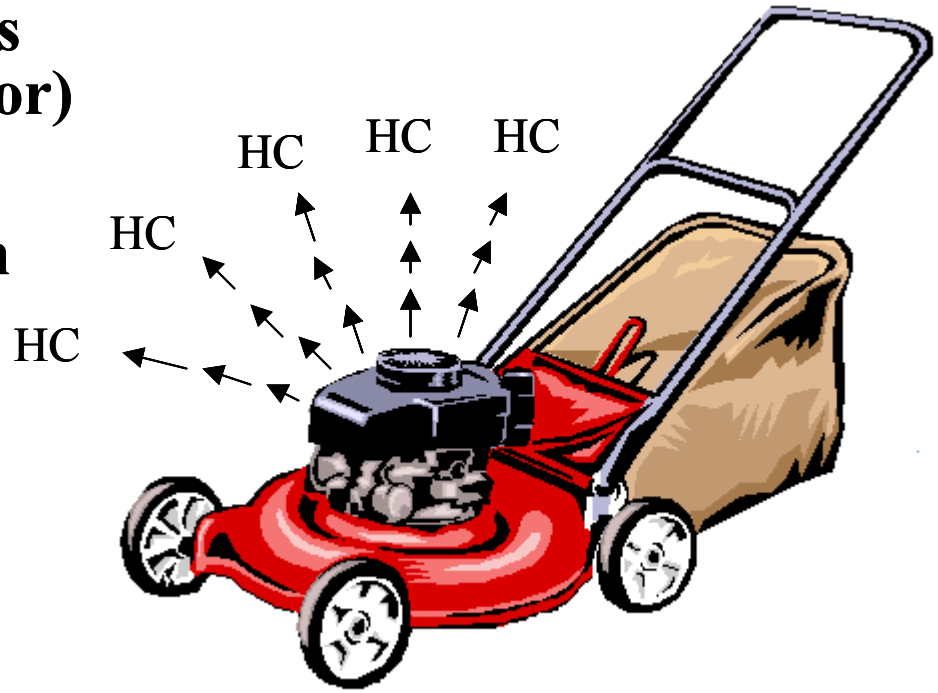
Sources of SORE Evaporative Emissions

Fuel Tank Permeation

Vented Emissions (Tank & Carburetor)

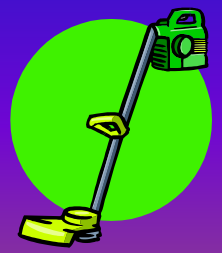
Fuel Line Permeation

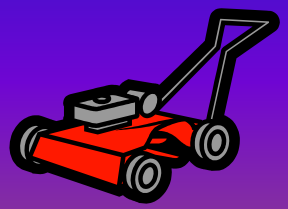
Fuel Connectors



Overview

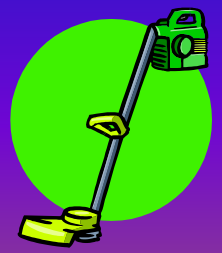
- Evaporative Emission Control Elements
- Control Technology and Test Data
- Industry Issues
- Nonhandheld Alternatives
- Comparison of Alternatives
- Overall Cost Effectiveness
- Conclusions

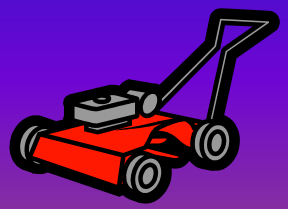




Evaporative Emission Control Elements

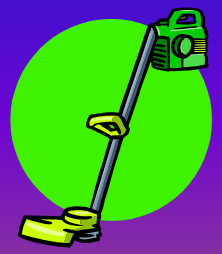
- Handheld standards
- Nonhandheld standards
- Certification





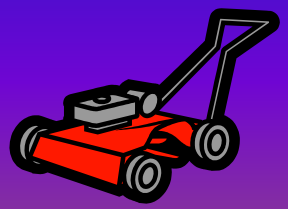
Handheld Standard

SORE Equipment Category	Effective Date Model Year	Permeation Standard Grams ROG/m^2/day	Diurnal Standard Grams HC/day
≤ 80 cc	2007	2.0	None



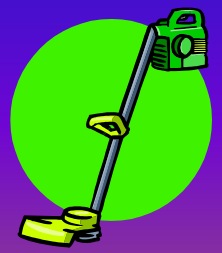
Nonhandheld Standards

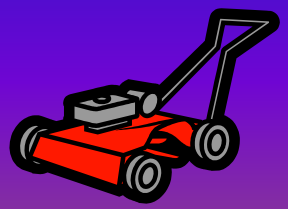
SORE Equipment Category	Effective Date Model Year	Permeation Standard Grams ROG/m^2/day	Diurnal Standard Grams HC/day
Walk-Behind Mowers > 80 cc - < 225 cc	2007	None	1.0
> 80 cc - < 225 cc Excluding Walk-Behind Mowers	2007	None	0.21 * Tank Volume (gal.) + 0.95
≥ 225 cc	2008	None	2.0



Certification

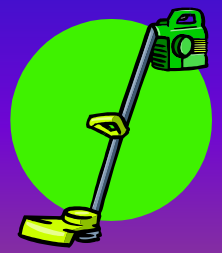
- Requires certification of evaporative families
- Handheld tanks
  - Tested per TP-901
  - Certified per CP-901
- Nonhandheld equipment
  - Tested per TP-902
  - Certified per CP-902

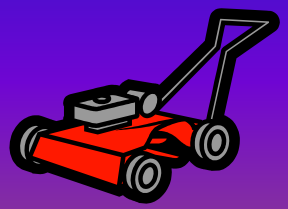




Permeation Control Technologies

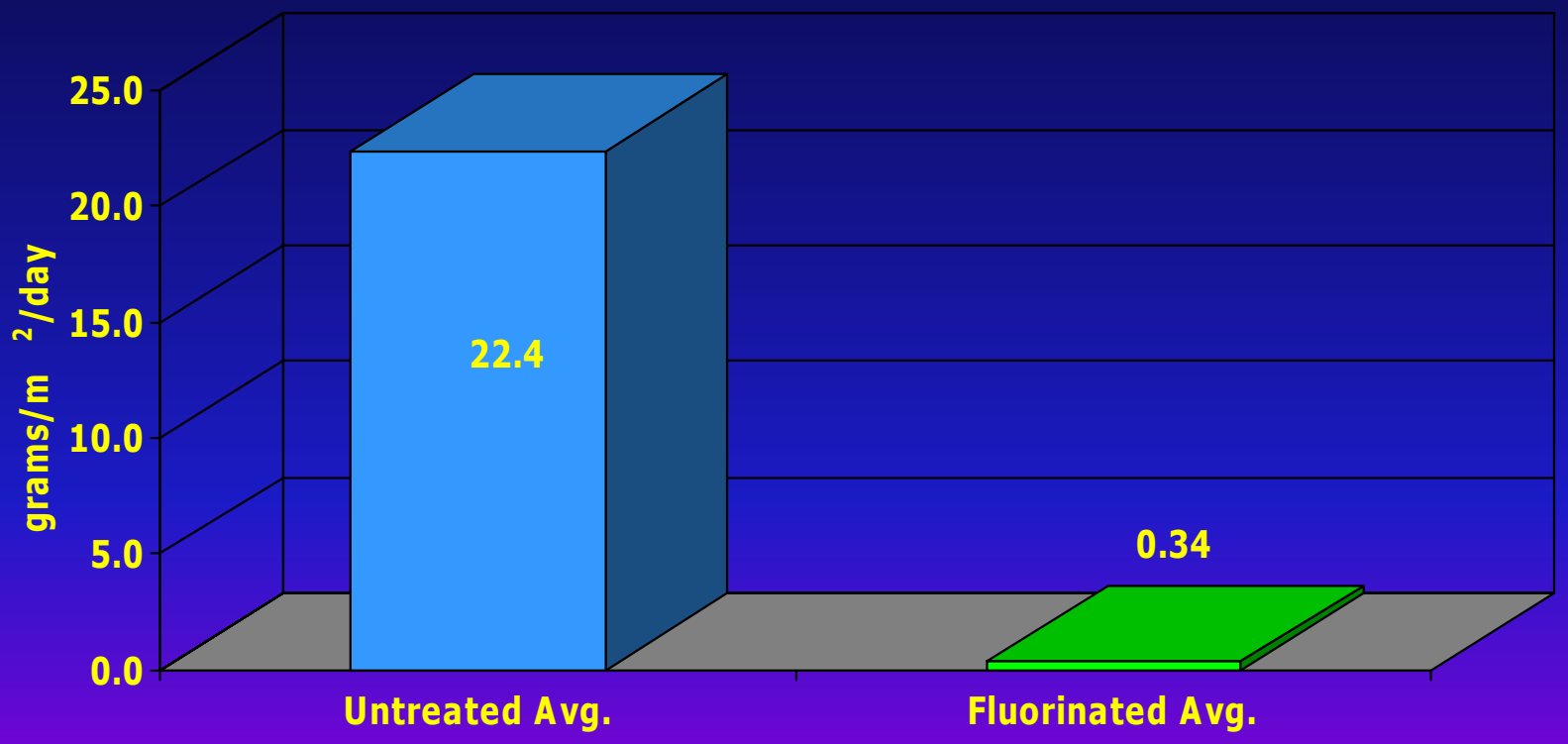
- Tanks
  - Metal and coextruded tanks, nylon tanks, and barrier treatments
- Connectors, Gaskets, and Hoses
  - Thermoplastic materials, Viton®, and Teflon®





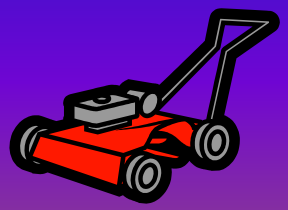
ARB Permeation Test Data

Untreated HDPE Tanks vs. Optimized Fluorinated Tanks



Diurnal Emission Control Technologies

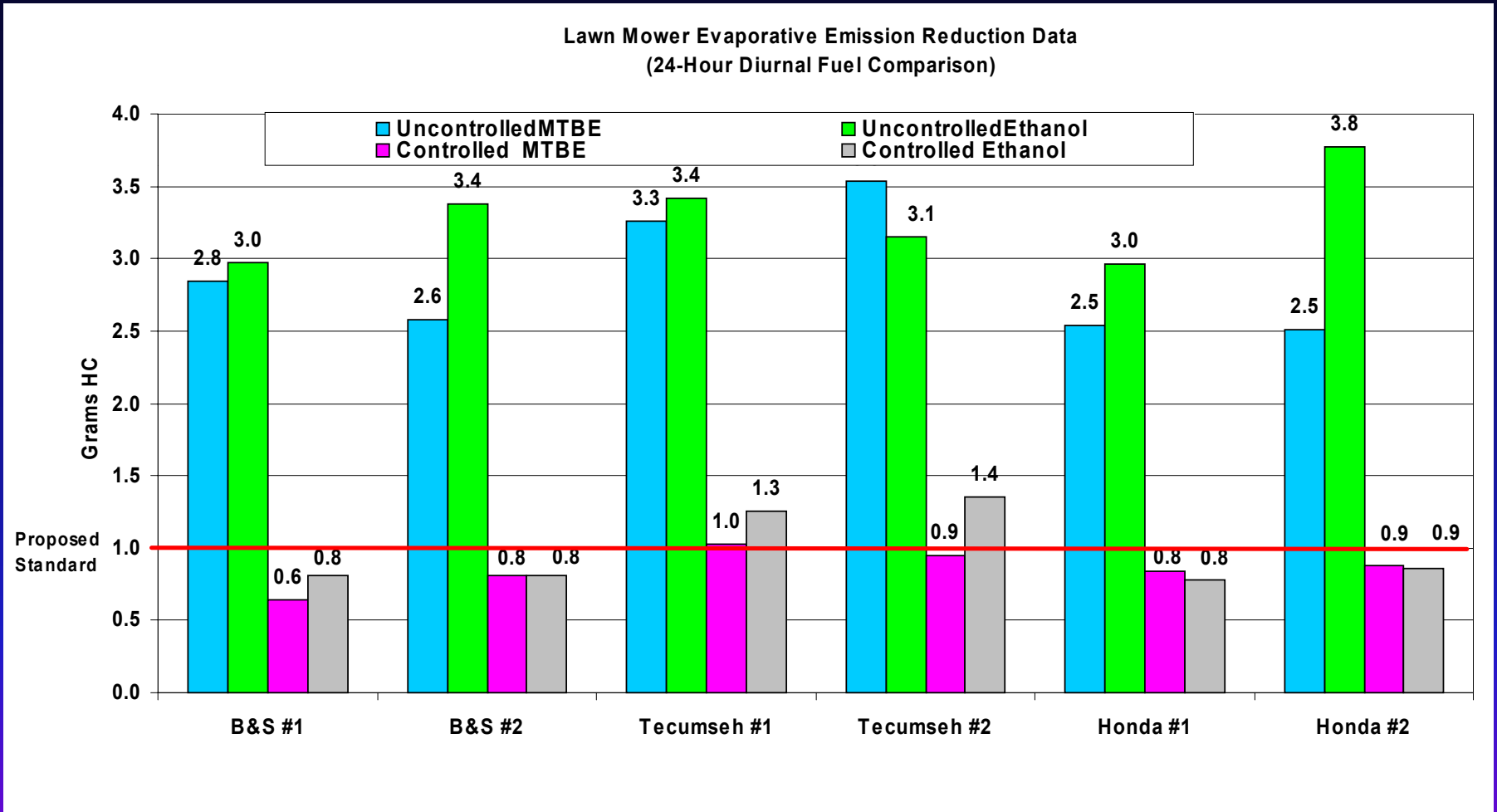
- Sealed systems
- Carbon canister systems
- Hybrid sealed systems



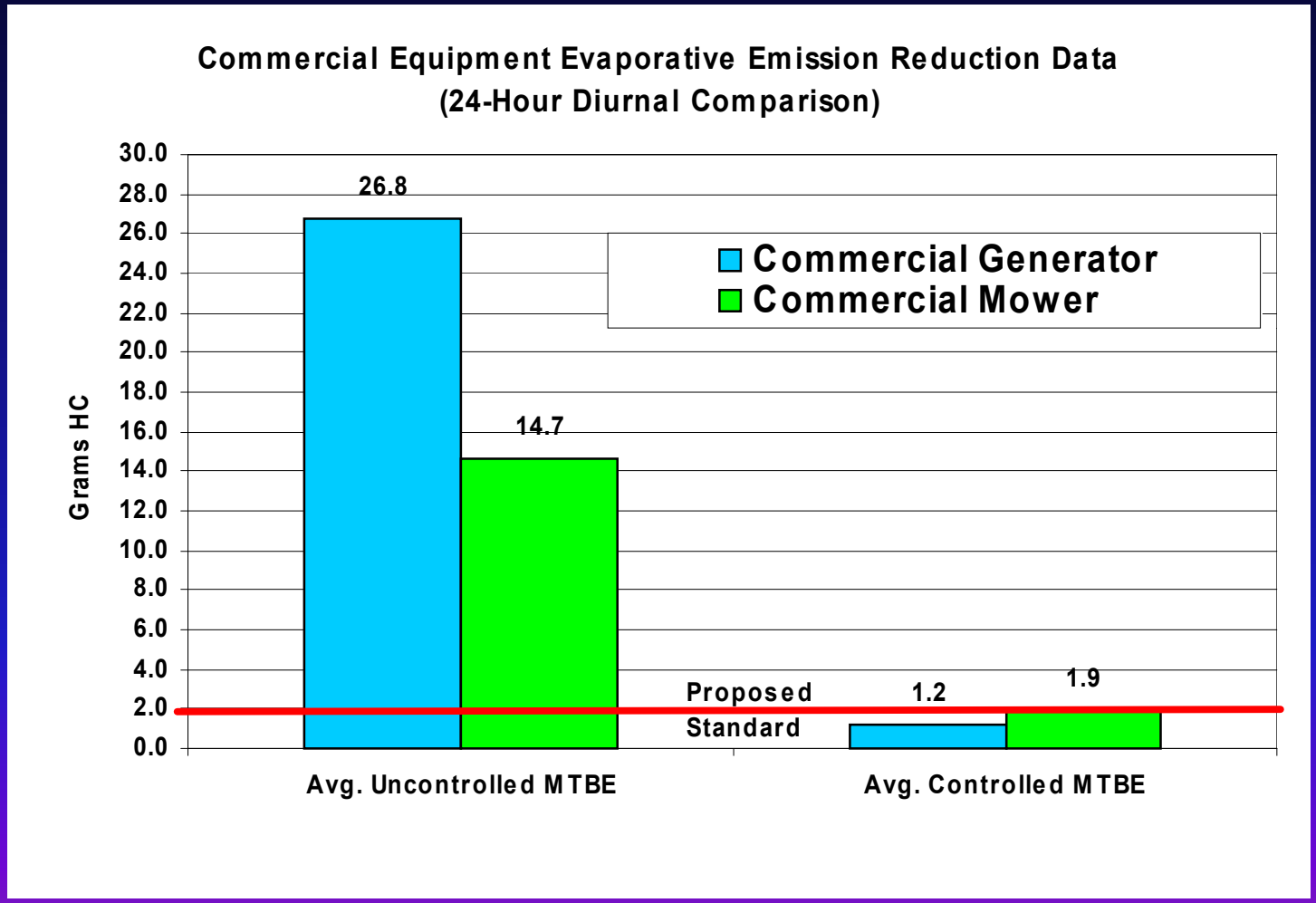
Diurnal Emission Control Technologies
ARB Feasibility Testing

- ARB tested prototype equipment
- Six mowers configured with:
  - sealed systems,
  - fluorinated HDPE tanks
  - low permeation fuel lines
- A generator and commercial mower configured with:
  - carbon canisters
  - metal tanks
  - low permeation fuel lines

ARB Test Results for Sealed Systems

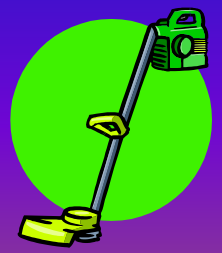


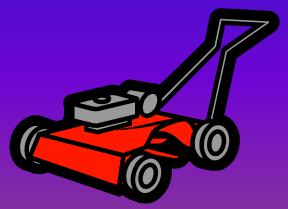
ARB Test Results for Canister Systems



Additional Changes to the Evaporative Proposal

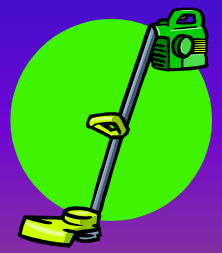
- Adjust canister working capacity in TP-902
- Require small volume manufacturers to submit a letter of conformance

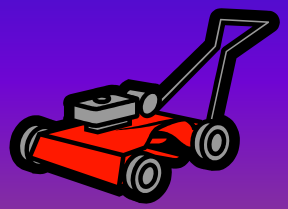




Industry Issues

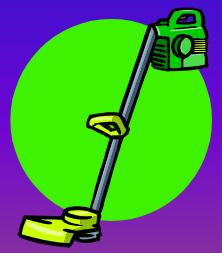
- Standards too stringent
  - Exhaust
  - Evap.
- Proposal lacks flexibility
- Costs too high

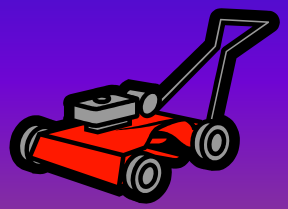




Alternatives Suggested by Industry

- Alternatives presented by Briggs & Stratton, EMA/OPEI, and Honda
- Staff evaluated alternatives
- Alternatives 1 and 2 developed from industry proposals

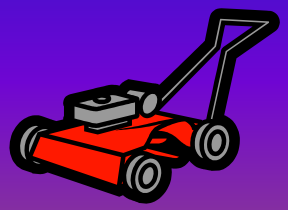




Nonhandheld Alternatives

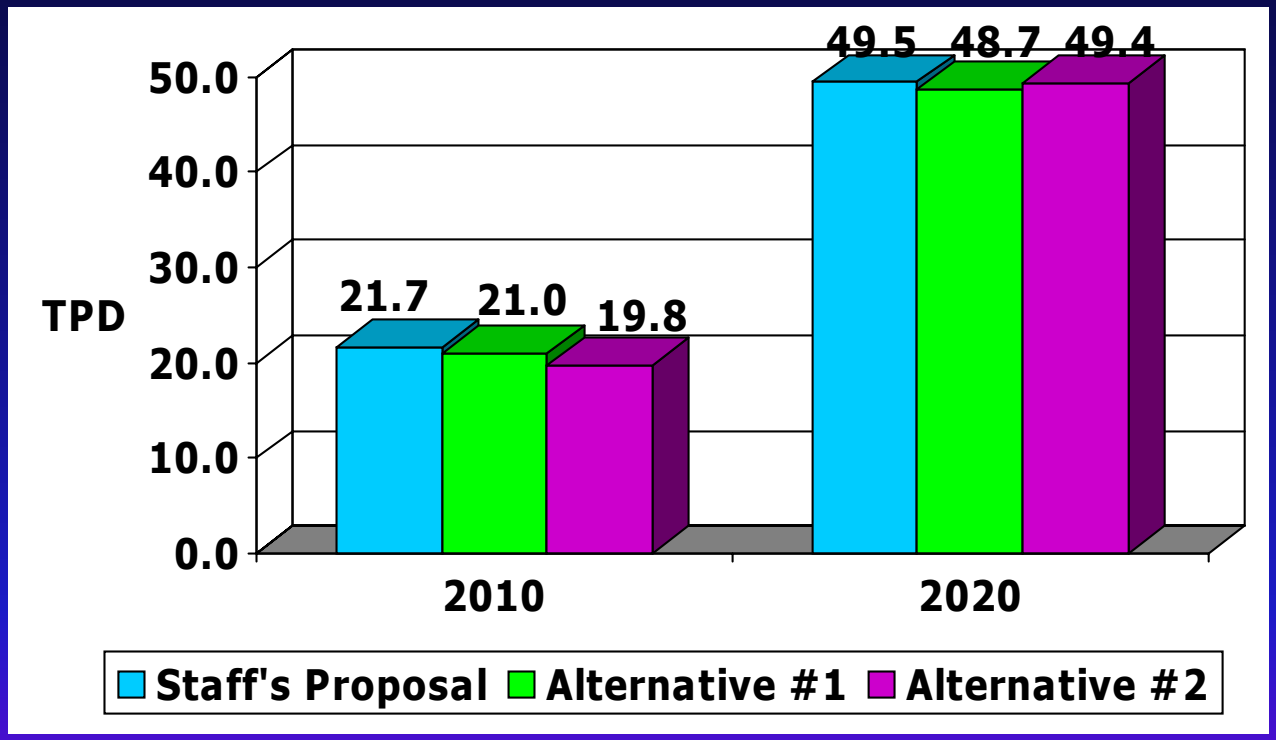
Alternative 1 and 2 would:

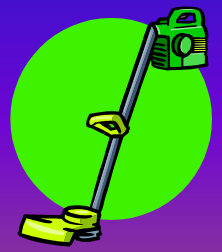
- Provide nearly same emission reductions
  - Greater evaporative emission reductions
  - Less exhaust emission reductions
- Provide flexibility for compliance
- Reduce costs
- Meet SIP commitments

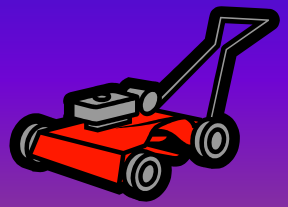


Overall Emission Reductions

Statewide Comparison of the Alternatives
(Annual Average Tons Per Day for Nonpreempt Equipment)

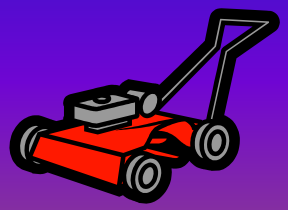






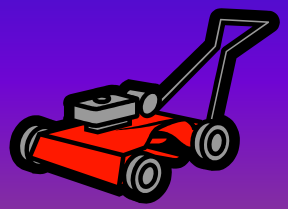
1st Alternative - Major Elements

- Achieves additional evaporative emission reductions (running loss)
- Requires testing of complete engines
- Implements low permeation hoses one year early
- Allows fleet averaging



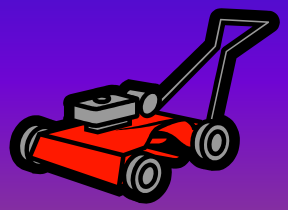
1st Alternative - Nonhandheld Standards

Effective Date Model Year	Engine Displacement	Fuel Hose Permeation Standard Grams ROG/m2/day	Diurnal Standard Grams HC/day
2006	> 80 cc	15	None
2007 and 2008	> 80 cc - < 225 cc	15	1.2 + 0.21*tank vol. (gal)
2009 WBMs	> 80 cc - < 225 cc	15	1.0
2009 Non-WBMs	> 80 cc - < 225 cc	15	0.95 + 0.21* tank vol. (gal)
2008	≥ 225 cc	15	1.2 + 0.21* tank vol. (gal)



2nd Alternative - Major Elements

- Achieves additional evaporative emission reductions (running loss)
- Requires testing of Class I walk-behind mowers (WBMs)
- Implements low permeation fuel hoses two years early
- Reduces compliance testing (design standards)



2nd Alternative - Nonhandheld Standards

Class I Engines, > 80 cc - < 225 cc

Walk-Behind Mowers

Effective Date Model Year	Fuel Hose Permeation Standard Grams ROG/m2/day	Diurnal Standard Grams HC/day
2005	15	None
2007 thru 2011	15	1.3
2012	15	1.0

Non Walk-Behind Mowers

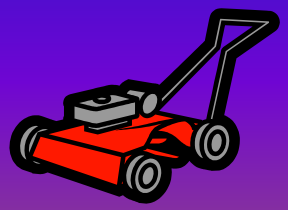
Effective Date Model Year	Fuel Hose Permeation Standard Grams ROG/m2/day	Fuel Tank Permeation Standard Grams ROG/m2/day	Carbon Canister or Equivalent Butane Working Capacity Grams HC/Liter Tank Vol.
2005	15	None	None
2007 thru 2011	15	2.5	Per TP-902
2012	15	1.0	Per TP-902

2nd Alternative - Nonhandheld Standards

Class II Engines, ≥ 225 cc

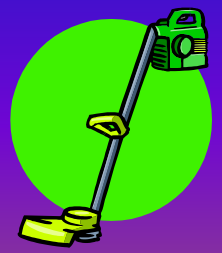
Effective Date Model Year	Fuel Hose Permeation Standard Grams ROG/m^2/day	Fuel Tank Permeation Standard Grams ROG/m^2/day	Carbon Canister or Equivalent Butane Working Capacity Grams HC/Liter Tank Vol.
2005	15	None	None
2008[1]	15	3.0	Per TP-902
2010[2]	15	None	Per TP-902
2013[1]	15	1.0	Per TP-902

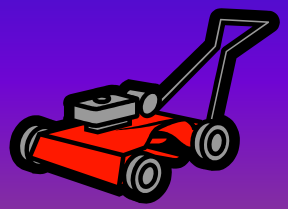
[1] First year of implementation 90% of production volume must be compliant increasing to 100% the following year.
[2] Applies to small volume manufacturers.



Overall Cost Effectiveness

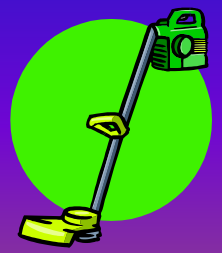
- Handheld Equipment - $1.71 to $6.21 per pound of HC reduced
- Nonhandheld Equipment – $0.20 - $4.30 per pound of HC+NOx

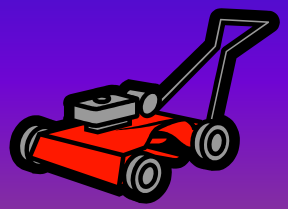




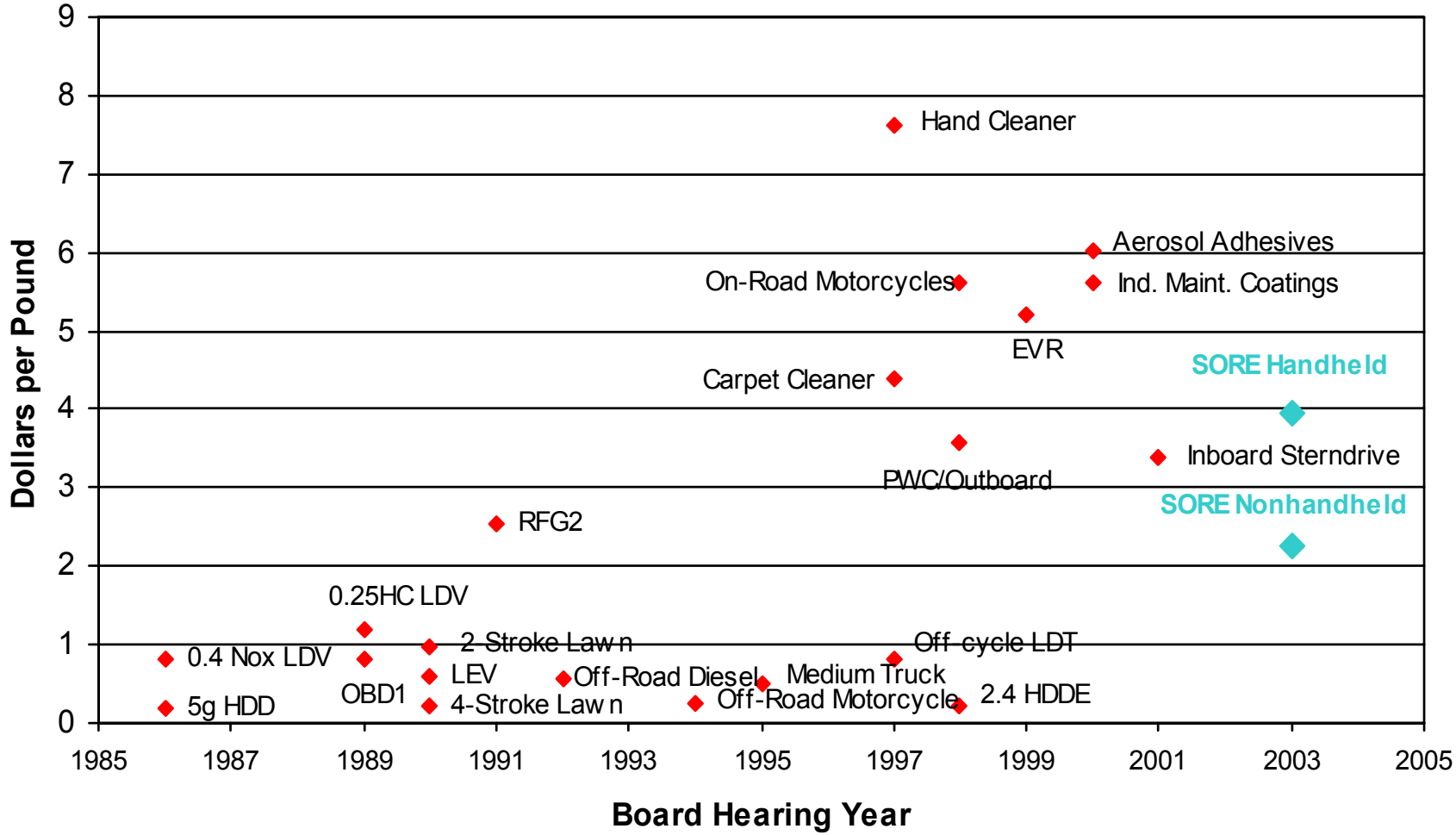
Estimated Retail Price Increase

- Handheld Equipment - $2.16 to $4.84
- Nonhandheld Equipment - $37 to $179



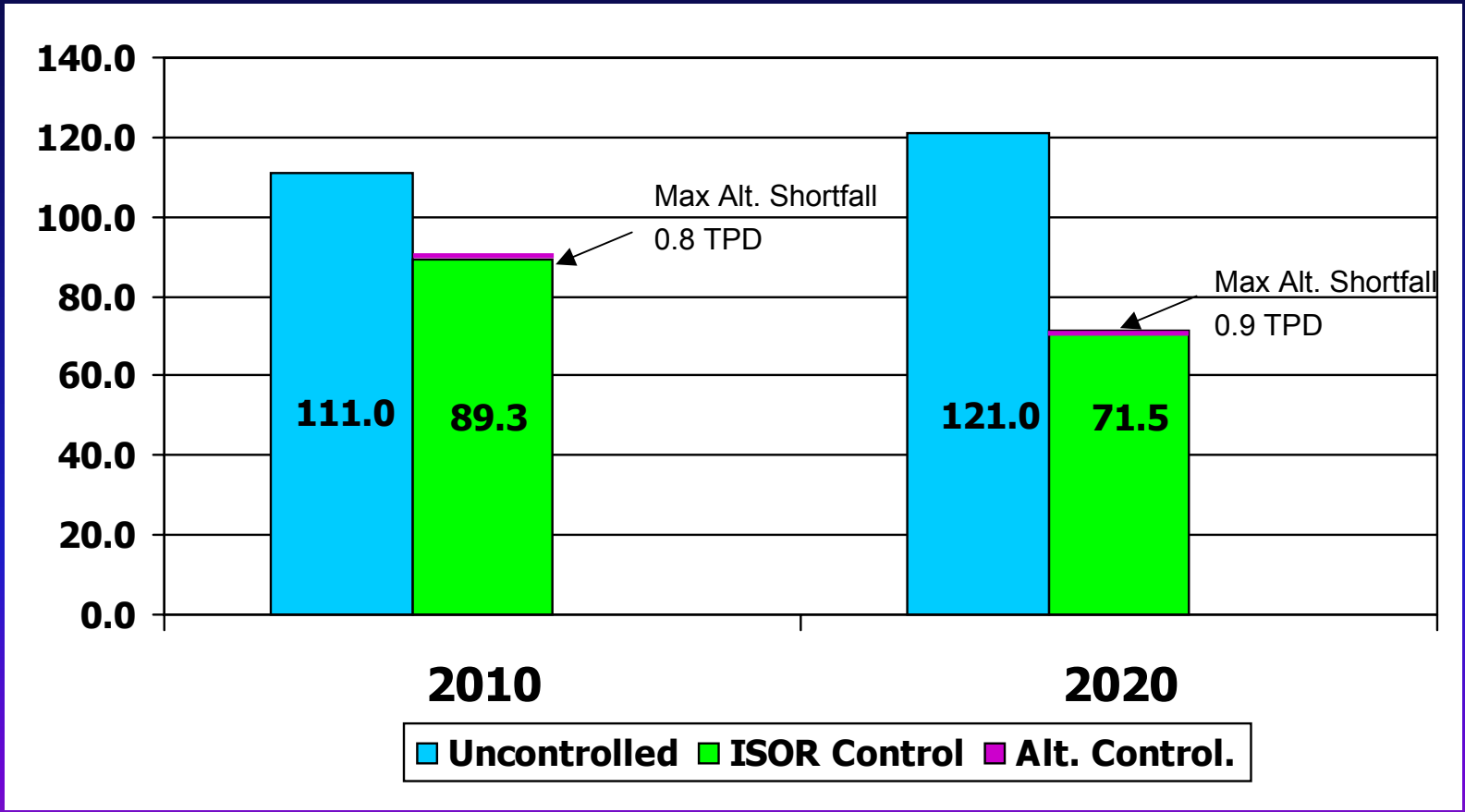


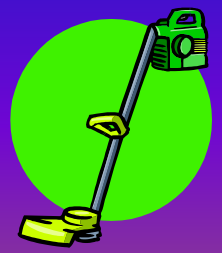
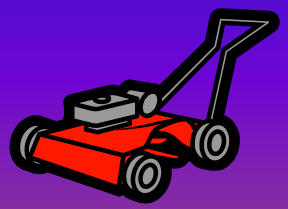
Cost Effectiveness of Major Regulations



Comparison of Controlled Emissions

(Annual Average Tons Per Day for Nonpreempt Equipment)



Conclusions

- Proposal and alternatives provide significant emission reductions
- Proposed controls are cost effective
- Standards are attainable with existing technologies
- Staff recommends Board adoption including alternatives