

California Air Resources Board



Tire Pressure Regulation to Reduce Climate Change Emissions

**Public Workshop
October 8, 2008**

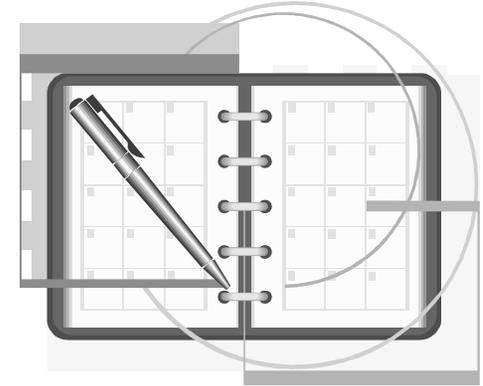
Air Resources Board



California Environmental Protection Agency

Agenda

- Introduction
- Background
- Overview
- Regulatory Concepts
 - Check and Inflate
 - Inflation Pressure Loss Rate (IPLR)
 - Alternatives Considered
- Emission Inventory
- Emission Benefits
- Regulatory Costs
- Cost-Effectiveness
- Enforcement
- Outreach
- Timeline



Background

- Global Warming Solutions Act (AB32)
- Reports/Stakeholder Input/Meetings
 - California Inspection and Maintenance Review Committee (IMRC)
 - National Highway Traffic Safety Administration (NHTSA)
 - California Integrated Waste Management Board (CIWMB)



Background

- Reports/Stakeholder Input/Meetings (continued)
 - ExxonMobil Chemical
 - Inflation Pressure Retention Effects On Tire Rolling Resistance, Vehicle Fuel Economy and CO2 Emissions
 - 10th Worldwide Tire Survey: Replacement Tires
 - Survey conducted by the Rubber Manufacturer's Association
 - Two workgroup meetings held in March and June 2008



Overview

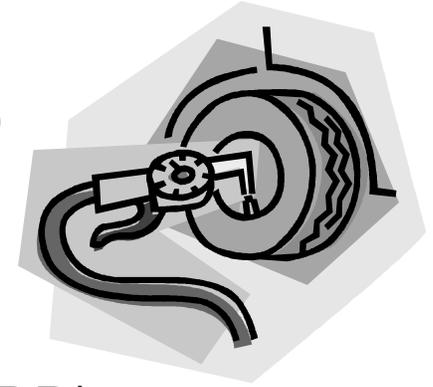
Regulatory Assumptions

- Proposed regulations will reduce CO₂ emissions by reducing fuel consumption
- Properly inflated tires helps reduce fuel consumption by reducing rolling resistance



Regulatory Concepts

Check and Inflate



Requirements

- Will require Automotive Repair Dealers (ARD) to perform a tire check and inflate service as part of every maintenance or repair service

- Example of ARD's affected:
 - oil change facilities, dealerships, independent garages, smog check stations, tire facilities

- Example of ARD's not affected:
 - Collision & Auto-body shops, auto paint shops, auto glass repair businesses



Regulatory Concepts

Check and Inflate

Concerns to date

- Liability
 - Tire Guide/Yearbook
 - Tire gauge standard
 - Properly inflated tires provide optimal safety benefits

- Exemptions will not be provided

- Costs

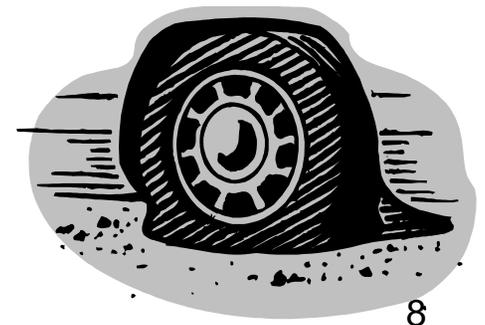


Regulatory Concepts

Inflation Pressure Loss Rate

Requirements

- Will require tire manufacturers to reduce Inflation Pressure Loss Rates (IPLR) for passenger cars and light-duty and medium-duty vehicle tires sold in California.
- IPLR performance standard will be based on cost-effectiveness and technical feasibility



Regulatory Concepts

Inflation Pressure Loss Rate

Assumptions

- IPLR → Improves Rolling Resistance → Improves Fuel Efficiency

- One of the world's leading automakers
 - 2.5% loss/month or better IPLR Standard
 - OE tires worldwide

- ASTM F1112-06 “Standard Test Method for Static Testing of Tubeless Pneumatic Tires for Rate of Loss of Inflation Pressure”
 - Used to measure IPL rate (% per month)
 - Auto and Tire Industry involved in developing test
 - Already used by many tire manufacturers



Regulatory Concepts

Inflation Pressure Loss Rate

Concerns

- Testing Procedure
 - Certification

 - Length of Testing

 - Inflation medium used for testing
 - “Dry Air” vs. “Shop Air”
 - “Dry Air” used to standardize test



Regulatory Concepts Alternatives Considered



Nitrogen

- Provides Pressure Retention Benefits
- Cost-Effectiveness
 - ~\$416 million initial capital investment
(\$6,500 x 44,000 ARD's+20,000 gas stations)
 - ~\$92 to \$161 million initial cost to consumer

Tire Pressure Monitoring Systems (TPMS)

- Limited Aftermarket Equipment
- Designed to improve safety not fuel efficiency
- Estimated ~\$5.4 billion initial capital cost to consumer (\$257 x ~21 million vehicles w/out TPMS)

Emissions Inventory (Without Regulation)



Assumptions

- Automobiles a major source of CO₂ emissions

- CO₂ production from automobiles is directly proportional to fuel consumed
 - One gallon of gasoline consumed produces ~19.4 lbs of CO₂

- Approximately 23 million registered light and medium-duty vehicles in California



Emissions Inventory (Without Regulation)

- Utilized ARB's Emission FACtors Model (EMFAC2007)
- EMFAC2007:
 - Latest computer model that can estimate California emission rates for on-road mobile sources for years 1970 to 2040
 - Reflects ARB's current understanding of vehicle travel and emissions generated



Emissions Inventory (Without Regulation)



- EMFAC2007 utilized to forecast:
 - Passenger cars/light-duty vehicles population
 - < 5750 lbs. GVWR (Toyota Camry)
 - Medium-duty vehicle population
 - 5751 – 8500 lbs. GVWR (Ford Expedition)
 - Annual Fuel Consumption
 - Annual CO₂ Emissions

- Projected for years 2010 to 2020
 - Increase in emissions due to forecasted increase in vehicle population and miles traveled



Emissions Inventory (Without Regulation)

- In 2010:

| | Number of Vehicles | Fuel Consumption (gallons/year) | CO2 Emissions (MMT/year) |
|----------------------|--------------------|---------------------------------|--------------------------|
| Light-Duty Autos | 13,551,100 | 7.2 billion | 63.1 |
| Light-Duty Trucks 1 | 2,956,830 | 1.9 billion | 17.0 |
| Light-Duty Trucks 2 | 5,622,180 | 4.0 billion | 35.1 |
| Medium-Duty Vehicles | 2,468,110 | 2.5 billion | 21.8 |
| Total | 24,598,220 | 15.6 billion | 137.0 |

- In 2020:

| | Number of Vehicles | Fuel Consumption (gallons/year) | CO2 Emissions (MMT/year) |
|----------------------|--------------------|---------------------------------|--------------------------|
| Light-Duty Autos | 15,695,300 | 8.0 billion | 71.3 |
| Light-Duty Trucks 1 | 3,480,900 | 2.3 billion | 20.3 |
| Light-Duty Trucks 2 | 6,644,750 | 4.6 billion | 40.3 |
| Medium-Duty Vehicles | 2,953,680 | 2.8 billion | 24.6 |
| Total | 28,774,630 | 17.7 billion | 156.5 |

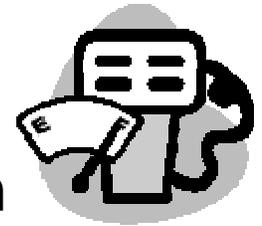


Emission Benefits

Check and Inflate

Overview

- Emission reduction based on the potential fuel savings with the implementation of proposed regulation
- Fuel savings:
 - Difference between gas consumption without regulation and gas consumption with regulation



Emission Benefits

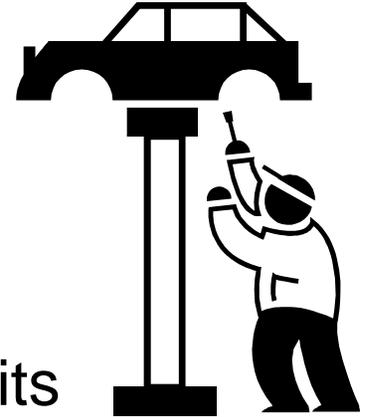
Check and Inflate

- NHTSA Tire Pressure Study, vehicles with under-inflated tire (average of all 4 tires)
 - 54% of Passenger Cars
 - 62% of Light/Medium-Duty Trucks
- Passenger
 - 20% Severely (≥ 6 psi under-inflation)
 - Average 8.7 psi under-inflation
 - 34% Moderately (>1 psi and <6 psi)
 - Average 2.9 psi under-inflation
- Light/Medium-Duty Trucks
 - 26% Severely under-inflated
 - Average 8.5 psi under-inflation
 - 36% Moderately under-inflated
 - Average 3.0 psi under-inflation



Emission Benefits

Check and Inflate



Assumptions

- Vehicle maintenance patterns, shop visits
 - Estimated 3 times per year

- Outreach & monthly reminders for tire check and inflate:
 - At least one time during the year

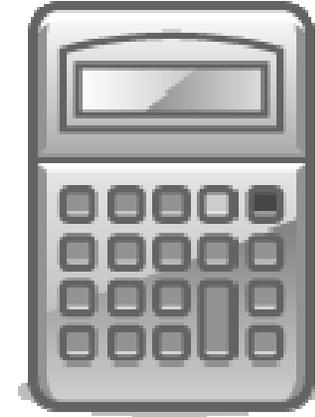
- On average, tires lose one psi per month

- Fuel efficiency is reduced one percent for every three psi of under-inflation (average of all four tires)



Emission Benefits

Check and Inflate



- Fuel Savings Equation
= $FGC - FGC/(1+IFE)$

FGC = Forecasted Gasoline Consumption
(from EMFAC2007)

“1” = represents fuel efficiency w/out the proposed regulation

IFE = Increase in Fuel Efficiency w/proposed regulation (expressed as a decimal)

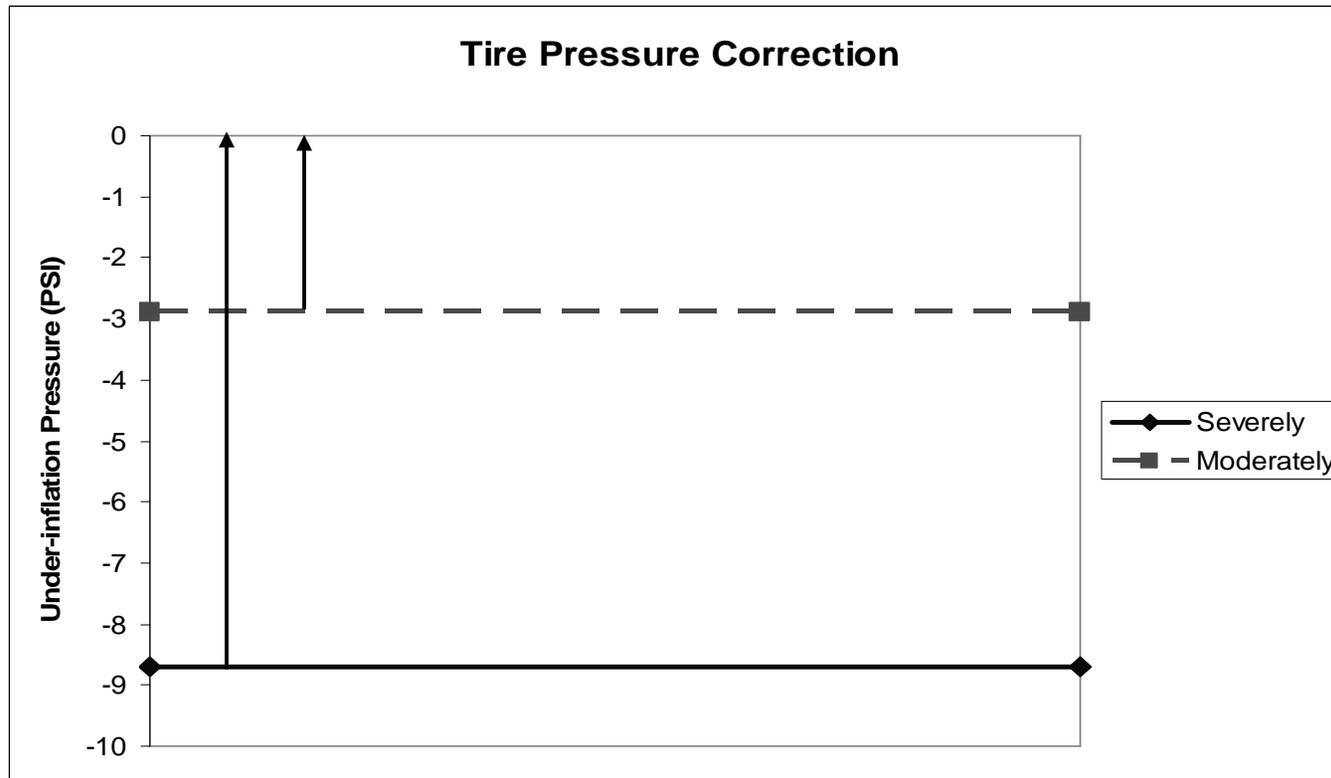


Emission Benefits

Check and Inflate

Passenger cars example:

- 20% severely under-inflated average 8.7 psi
- 34% moderately under-inflated average 2.9 psi



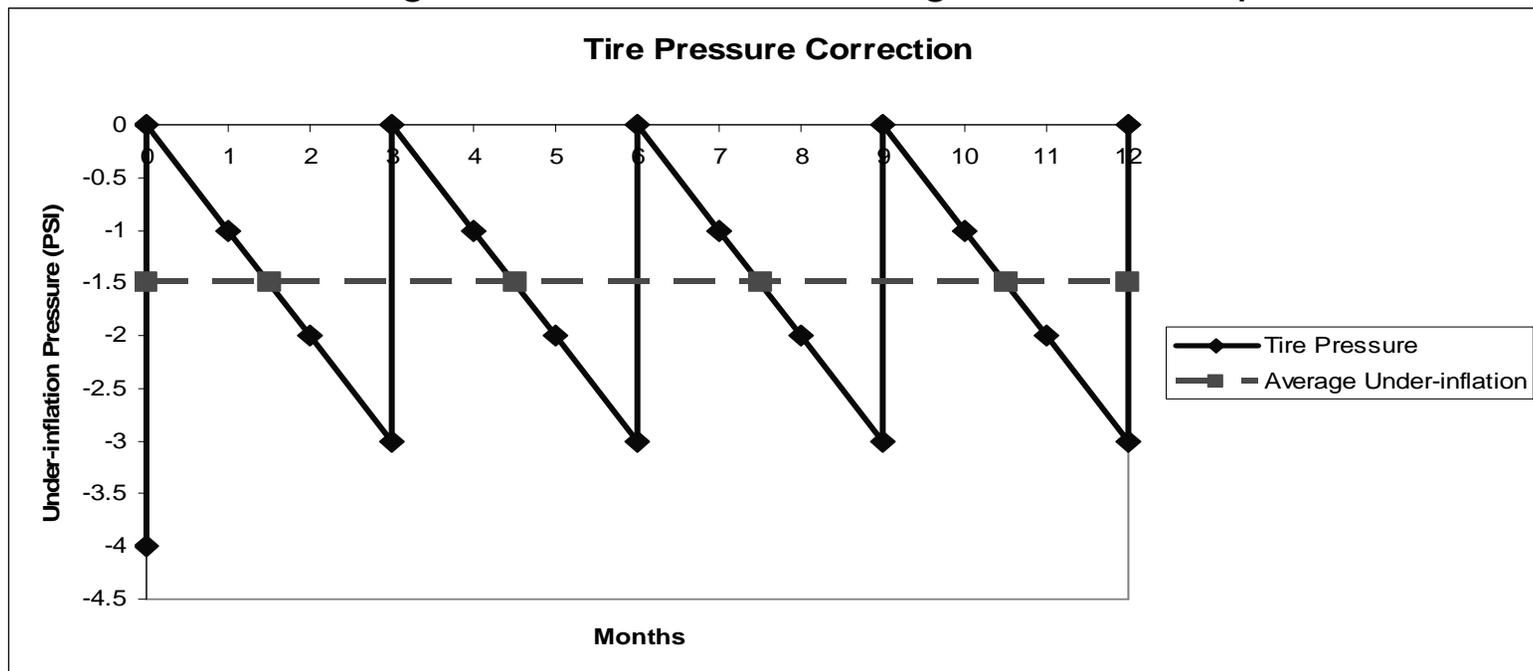
Emission Benefits

Check and Inflate

2011-2020 Tire Pressure Correction:

(Quarterly re-inflation interval)

- Expected tire pressure air loss and re-inflation interval with regulation after initial correction in 2010
- 54% Average under-inflation with regulation = 1.5 psi



Emission Benefits

Check and Inflate

- Fuel Savings Equation
= $FGC - FGC/(1+IFE)$



Passenger cars example:

For year 2010 (initial correction)

- Fuel efficiency is reduced 1% for every 3 psi of under-inflation
- 20% severely under-inflated average 8.7 psi
 $8.7 \div 3 = 2.9 \rightarrow (IFE = 2.9\%)$
- Calculation methodology applied to passenger car and light/medium-duty truck under-inflation data



Emission Benefits

Check and Inflate

- Fuel savings
- Emission reduction
 - ~19.4 lbs of CO₂ produced for every gallon of gasoline consumed
 - Converted to Million Metric Tons (MMT) CO₂

| Year | Average Annual Fuel Savings (Gallons/year) | Average Annual CO ₂ Emission Reduction (MMT/year) |
|-------------|--|--|
| 2010 - 2020 | ~ 63 million | ~ 0.56 |



Emission Benefits

Inflation Pressure Loss Rate

- Staff studied tire composition, air permeability, and tire inner liners
- Tire inner liner
 - function is to retain compressed air
 - designed for low air and low moisture permeability
 - allows tires to be tubeless
- Researched inner liner formulations of major tire manufacturers
 - Public patents
 - Existing tire studies



Emission Benefits

Inflation Pressure Loss Rate

Example tire inner liner formulation

| Ingredients | (phr) |
|--------------------------|---------------|
| Halobutyl Rubber | 60 |
| Natural Rubber | 40 |
| Carbon Black | 60 |
| Calcium Carbonate | 40 |
| Processing Oil | 16 |
| Stearic Acid | 1 |
| Vulcanizing Agent | 1.25 |
| Zinc Oxide | 3 |
| Magnesium Oxide | 0.25 |
| Accelerators | 1.25 |
| Total Ingredients | 222.75 |
| % Rubber | 44.9% |
| % Halobutyl | 26.9% |
| % Filler | 44.9% |

} Rubber (Synthetic and Natural)

} Filler material

- Analyzed 15 tire inner liner formulations
- Modification of formulations can improve (decrease) IPLR



Emission Benefits

Inflation Pressure Loss Rate

- Techniques to improve IPLR at the manufacturing level
 - Increase thickness of tire inner liner
 - Increase halobutyl rubber percentage
 - Increase filler material percentage
 - Addition of recycled rubber powders
- Major advantage is no new or additional equipment required by tire manufacturers



Emission Benefits

Inflation Pressure Loss Rate

- Increase thickness of tire inner liner
 - Advantages:
 - No new materials required
 - Formula unchanged
 - Disadvantages:
 - Increase in cost due to more material
 - Increase in tire inner liner weight



Emission Benefits

Inflation Pressure Loss Rate

- Increase halobutyl rubber percentage

- ExxonMobil Chemical Study:
 - Increase of 20 phr halobutyl rubber with corresponding decrease in natural rubber can lower IPLR 0.5 to 0.6%
 - Advantages:
 - No new materials required
 - Overall tire inner liner weight same
 - Disadvantages:
 - Increase in cost due to higher halobutyl rubber cost



Emission Benefits

Inflation Pressure Loss Rate

- Increase filler material (Carbon Black, Silica, Clay, Talc, Calcium Carbonate)
 - Filler material provides more barriers to permeating air
 - Advantages:
 - No new materials required
 - Filler material inexpensive
 - May decrease formulation cost
 - Disadvantages:
 - Too much filler may require more oils
 - Oils increase permeation rate



Emission Benefits

Inflation Pressure Loss Rate

- Addition of Recycled Rubber Powder
- Malcolm Pirnie, Inc. 2007 study:
 - Addition of Engineered Rubber Powder decreased air permeability
- Lehigh Technologies presentation in June 2008
 - Akron Rubber Development Laboratory air loss test showed a 19 percent decrease in air loss/month



Emission Benefits

Inflation Pressure Loss Rate

- Addition of Recycled Rubber Powder
 - Advantages:
 - Utilizes existing formulas
 - Promotes recycling of scrap tires
 - Disadvantages:
 - May increase cost for additional material



Emission Benefits

Inflation Pressure Loss Rate

- Emission benefits additional to Check and Inflate benefits
- Benefits result of tires losing air at a slower rate than the assumed 1 psi loss per month
- Estimated for IPLR = 1.5%, 2.0%, 2.5%

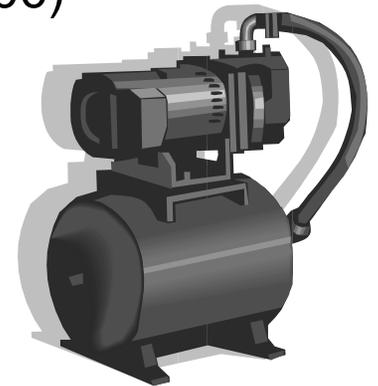
| IPLR Performance Standard | 2020 Annual Fuel Savings (Gallons/year) | 2020 Annual CO ₂ Emission Reduction (MMT/year) |
|---------------------------|---|---|
| 1.5% | ~ 46 million | ~ 0.41 |
| 2.0% | ~ 32 million | ~ 0.28 |
| 2.5% | ~ 18 million | ~ 0.16 |



Regulatory Costs

Check and Inflate

- Capital Costs
 - Air compressors w/5 year service life (\$400-500)
 - Air tools and hoses (\$50-70)
 - ANSI Commercial Grade “B” gauges (\$10-25)
 - Tire Guide/Yearbook (\$20-80)
- Maintenance Costs
 - Annual compressor maintenance (\$40)
 - Annual repair/replacement of air tools and hoses (\$50-70)
- Labor Costs
 - Labor for check and inflate procedure
 - Estimated \$2 per vehicle based on five minutes labor



Regulatory Costs

Check and Inflate

- Capital and Maintenance costs
 - 2,000 to 2,100 test-only smog check facilities
 - Average annual cost of ~\$500 per facility
 - Total annual cost for all ARDs
 - Average annual cost of ~\$2 million
- Labor costs
 - Estimated ~25 to 29 million passenger cars, light-duty vehicles subject to regulation
 - Staff estimates a vehicle will visit an ARD about 3 times per year
 - 5 minutes to check/inflate, ~\$2 per vehicle
 - Average annual costs of ~\$178 million per year



Regulatory Costs

Check and Inflate

- Fuel Savings
 - Average annual fuel savings of ~ 63 million gallons of gasoline
 - Average annual savings of ~ \$213 million

- Total Average Annual Cost
 - Capital, Maintenance, and Labor Cost
 - Average annual cost of ~ \$180 million

- Net Average Annual Savings of \$33 million

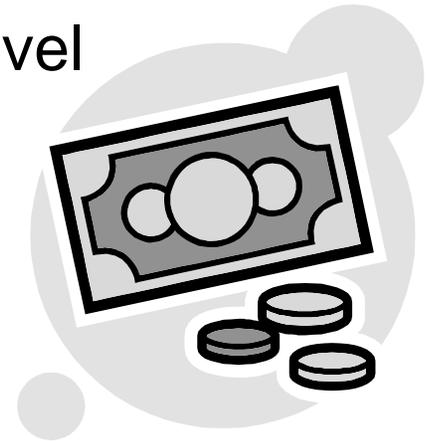
- Costs are in 2007 equivalent expenditure dollars



Regulatory Costs

Inflation Pressure Loss Rate

- Estimated costs resulting from techniques to decrease IPLR at the manufacturing level
- Determine cost of each tire inner liner formulation
- Determine cost of individual ingredients
 - Individual ingredient changes results in changes in overall tire inner liner cost



Regulatory Costs

Inflation Pressure Loss Rate

Example tire inner liner formulation

| Ingredients | (phr) |
|--------------------------|---------------|
| Halobutyl Rubber | 60 |
| Natural Rubber | 40 |
| Carbon Black | 60 |
| Calcium Carbonate | 40 |
| Processing Oil | 16 |
| Stearic Acid | 1 |
| Vulcanizing Agent | 1.25 |
| Zinc Oxide | 3 |
| Magnesium Oxide | 0.25 |
| Accelerators | 1.25 |
| Total Ingredients | 222.75 |
| % Rubber | 44.9% |
| % Halobutyl | 26.9% |
| % Filler | 44.9% |

- Average tire inner liner weight
 - 1.85 pounds passenger tire
 - 3.5 pounds light truck tire
- Based on parts per hundred rubber (phr)
- Rubber to equal 100 phr
- Ingredients based on 100 phr
 - 3% Zinc Oxide = 3 phr
- Weight percentage of halobutyl rubber:

$$60 \div 222.75 = 0.269 \text{ (26.9\%)}$$
- Weight of halobutyl rubber

$$0.269 \times 1.85 = 0.50 \text{ lbs}$$



Regulatory Costs

Inflation Pressure Loss Rate

- Estimated cost of tire inner liner
 - (Ingredient weight) X (Ingredient cost per pound)
 - Ingredient cost obtained from distributors and manufacturers. List price.
 - Sum all ingredient costs
 - Average inner liner cost
 - Passenger car tire = \$2.53
 - Light/medium-duty truck tire = \$4.78



Regulatory Costs

Inflation Pressure Loss Rate

- Increasing inner liner thickness
 - Cost increase due to additional material
 - Passenger car tire = \$0.25 to \$0.63 (M)
 - Passenger car tire = \$1.25 to \$3.15 (R)

- Increasing Halobutyl Rubber +20 phr
 - Cost increase due higher material cost
 - Cost offset due to less Natural Rubber
 - Passenger car tire = \$0.11 (M)
 - Passenger car tire = \$0.55 (R)

(M) Manufacturing Level

(R) Retail Level



Regulatory Costs

Inflation Pressure Loss Rate

- Increasing filler material
 - Lack of information regarding filler content and IPLR reduction
 - Estimated reduction in formulation cost

- Addition of Recycled Rubber Powder
 - 5 to 10% loading
 - Cost increase due additional material
 - Passenger car tire = \$0.09 to \$0.19 (M)
 - Passenger car tire = \$0.45 to \$0.95 (R)

(M) Manufacturing Level

(R) Retail Level



Regulatory Costs

Inflation Pressure Loss Rate

- Summary of IPLR Reduction Techniques

| Technique | Advantages | Disadvantages | Cost/Tire Manufacturing | Cost/Tire Retail |
|--|---|---|---|---|
| Increase Inner Liner (Example: 10%-25%) | No new materials or equipment | Increased cost, weight reduction elsewhere | \$0.25 to \$0.63 (P) \$0.48 to \$1.20 (LT) | \$1.25 to \$3.15 (P) \$2.40 to \$6.00 (LT) |
| Increase Halobutyl 20 phr | No new materials or equipment | Increased cost | \$0.11 (P) \$0.20 (LT) | \$0.55 (P) \$1.00 (LT) |
| Increase Fillers | No new materials or equipment. Decreased cost. | Decreased processability | Estimated < Halobutyl Costs | Estimated < Halobutyl Costs |
| Addition of ERP rubber | No new equipment | New material. Increased cost. More testing. | \$0.09 to \$0.19 (P) \$0.18 to \$0.35 (LT) | \$0.45 to \$0.95 (P) \$0.90 to \$1.75 (LT) |



Regulatory Costs

Inflation Pressure Loss Rate

- Assumptions
 - 20% of vehicles will replace tires annually
 - Tires are replaced approximately every 4 to 5 years

- Estimated Cost
 - Based on IPLR: 2.5% → 1.5%
 - Cost per tire:
 - ~\$4 to \$7 per passenger car tire
 - ~\$7 to \$14 per light/medium-duty truck tire

 - 2020 Average Annual Cost
 - \$28 million to \$55 million



Regulatory Costs

Inflation Pressure Loss Rate

- Fuel Savings (2020)
 - Average annual fuel savings:
 - ~ 18 to 46 million gallons of gasoline
 - Average annual savings range:
 - ~ \$65 to \$168 million

- Total Average Annual Cost (2020)
 - ~ \$28 to \$55 million

- Net Average Annual Savings
 - ~ \$37 to \$113 million

- Costs are in 2007 equivalent expenditure dollars



Cost-Effectiveness

Check and Inflate

- Expressed in terms of costs (dollars) per unit of emissions reduced (tons)
- Cost-effectiveness

| Emissions | Average Annual Costs 2010 - 2020 | Average Annual Emissions Reduction 2010 – 2020 | Total CO ₂ Cost- Effectiveness |
|-----------------|-------------------------------------|--|---|
| CO ₂ | ~ \$180 million | ~ 0.56 MMT | ~ \$292/ton |



Cost-Effectiveness

Inflation Pressure Loss Rate

- Expressed in terms of costs (dollars) per unit of emissions reduced (tons)
- Cost-effectiveness

| IPLR | Average Annual Costs 2020 | Average Annual Emissions Reduction 2020 | Total CO ₂ Cost- Effectiveness |
|------|------------------------------|---|---|
| 1.5% | ~ \$55 million | ~ 0.41 MMT | ~ \$122/ton |
| 2.0% | ~ \$41 million | ~ 0.28 MMT | ~ \$132/ton |
| 2.5% | ~ \$28 million | ~ 0.16 MMT | ~ \$158/ton |



Enforcement

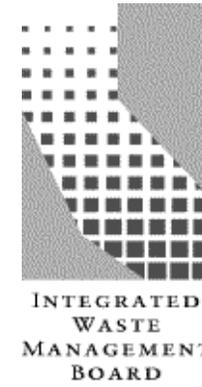
- Check and Inflate Regulation
 - ARB will enforce Regulation
 - Regular audits through State Agency partnerships
 - Automobile Repair Dealers will be responsible for non-compliance

- Inflation Pressure Loss Rate Regulation
 - Manufacturer self-certification
 - Test method ASTM F1112-06
 - Random testing of tires bought from retail facilities



Outreach Coordination

- California State Fair
 - 13,000 Fair Booth Visitors
 - Handed out 3,000 tire gauges
 - Collected 1,100 email addresses for check and inflate monthly email reminder list serve
 - Outreach Partnerships
 - Integrated Waste Management Board
 - Rubber Manufacturers Association
 - Future Outreach



Timeline

- Research and Outreach - Ongoing
- Additional Workshops – TBD
- Staff Report Draft Regulation –
January 2009
- Board Consideration – March 2009



Action Items

Future Meetings/Contact Info

- Action Items
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