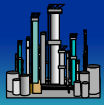


Alternative Octane Boosters and the Impact on Vehicle Emissions and Public Health



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 Board Chairman, International Council
 on Clean Transportation

What is Gasoline?

- Blend of Various Hydrocarbons Derived From Refining of Crude Oil
- An Excellent Energy Carrier
- Some Components are Toxic and Combustion By-Products Are Air Pollutants
- Certain Additives Can Improve Its Performance

Gasoline Blendstock Qualities

Example Properties of Gasoline Blending Components

Blending Component	RVP psi	Arom. %	Benz. %	Olef. %	Sulfur ppm	T50 degF	T90 degF	RON
Reformate	6	71	3	0	small	279	339	98
Alkylate	7	0	0	0	small	227	244	100
Butane	60	0	0	0	small	31	31	94
FCC Light	12	7	1	42	60	141	224	91
FCC Heavy	1	40	0	13	300	274	339	89
Light Straight Run	12	3	2	0	10	161	192	75
Hydrocracked Light	13	1	1	0	small	140	181	81
Isomerate	15	0	0	0	small	176	176	86
Coker Light	12	1	1	43	1800	109	164	78
Polymer Gasoline	9	0	0	100	small	170	334	97
MTBE	8	0	0	0	0	131	131	110
Ethanol	18	0	0	0	small	173	173	115

Gasoline is Made by Blending Many Components To Produce A Fuel With Acceptable Quality Considering Vehicle Performance and Emissions

Selected EU Fuel Quality Requirements

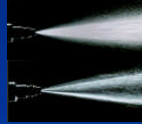
Requirement	1996 (Euro 2)	2000 (Euro 3)	2005 (Euro 4)	2009 (Euro 5)
Gasoline				
Vapour Pressure (Summer) max kPa		60	60	?
Benzene max Vol %		1	1	?
Aromatics max Vol %		42	35	?
Sulphur max ppm	500	150	50/10	10
Diesel				
Cetane Number min	48	51	51	?
Density max kg/m ³		845	845	?
Polycyclic Aromatics max Mass %		11	11	?
Sulphur max ppm	500	350	50/10	10

Some Properties of Motor Fuels Can Be Improved By Additives

- Deposit forming tendencies
- Octane and cetane quality
- Low temperature handling and filterability
- Stability
- Lubricity
- Conductivity
- Corrosivity
- Combustion products - Emissions

Types of Additives Used in Fuels

- Additives used to improve quality or performance



- Detergents
- Lubricity additives
- Antifoam additives
- Demulsifiers
- Friction modifiers
- Combustion modifiers



Additives Have Been Used To Raise Octane – What is Octane?

- o Octane Number represents how much the fuel can be compressed before it spontaneously ignites.
- o RON (Research Octane Number) is determined in a single cylinder variable compression ratio engine that operates at 600 rpm with a 65.6 °C inlet air temperature at standard barometric pressure.
- o MON (Motor Octane Number) is determined at engine speed of 900 rpm and 148.9 °C inlet air temperature.
- o Higher Octane is Desirable Because
 - o Avoids engine knocking
 - o Allows higher compression ratio, increased power & efficiency
- o Optimal Octane Reflects A Balance of Vehicle & Refinery Efficiencies – Most Vehicle Do Not Need Very High Octane

Octane Can Be Enhanced By

- Blending in High Octane Components Such As Reformate, Alkylate
- Adding Oxygenates
- Adding Metallic Additives (Pb, MMT, Ferrocene)

Criteria For Selecting Octane Enhancers

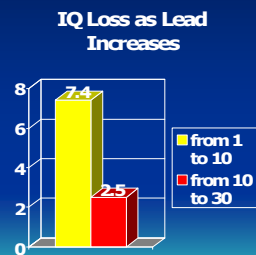
- Cost to Refiner
- Cost to Society
 - Impact on Air Quality/Health
 - Impact on Vehicle Pollution Controls

We Have Lots of Experience With Metallic Additives; Mostly Very Bad The Experience With Lead

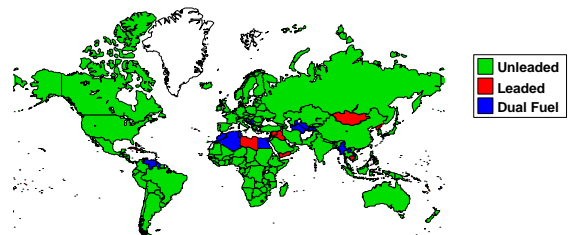
- Lowest Cost Octane Booster
- But Serious Health Impacts
 - Warning Signals Ignored or Suppressed for Over 50 Years
 - Still Marketed Today In Spite of Conclusive Proof of Toxicity to Children
- Destructive of Vehicle Pollution Controls

Effects Are Subtle & It Has Taken Many Years of Study to Show Large Impacts Occur at Very Low Lead Levels

- New England Journal of Medicine (4/17/2003)
- 172 children tested at 6, 12, 18, 24, 36, 48, 60 months
- Corrected for confounding variables
- 101 children never above 10µg/dl
- Blood lead significantly associated with I/Q



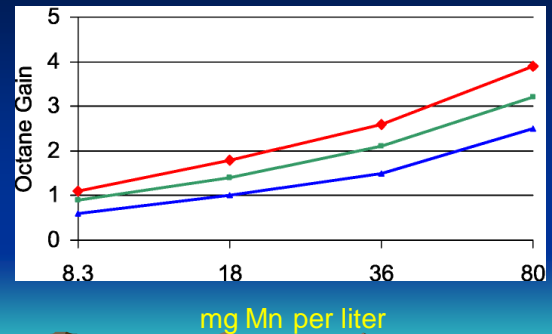
Gasoline Lead Levels End of 2006



The Same Company That Gave Us Lead Has Come Up With A New Gift MMT

- Lowest cost lead alternative, octane response less than lead.
- 10-20% of the MMT derived manganese from the fuel is emitted from the tailpipe- the majority remains within the engine, catalyst and exhaust system
- Most major auto-makers recommend against using MMT, advising that any damage caused by MMT not covered by the warranty
- Because of Growing Concerns Regarding Adverse Health Effects of Manganese & Possible Damage to Advanced Pollution Controls, Very little MMT is Used in OECD Countries and it is Banned in India & Brazil

Typical MMT Octane Response



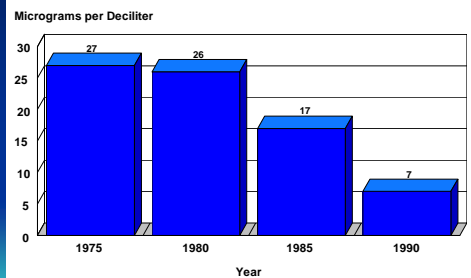
Source: PCFV Draft Octane Report

While Some Manganese is Emitted from MMT Fueled Vehicles, the Producer* Claims:

- Manganese is actually an essential nutrient for humans and is only a health concern at very highly elevated levels.
- MMT® use results in a very minor contribution of manganese to the environment because the treat rate is very low (typically 10 to 40 ppm manganese; equivalent to one or two drops in five liters of fuel) and the inorganic manganese emission compounds are already naturally abundant in the environment (because manganese is the 12th most common element in the earth's crust.)
- Numerous risk assessments, including those conducted in Canada, Australia and South Africa since 2001, have repeatedly concluded that the use of MMT® as a fuel additive at the levels mentioned does not represent an additional health risk, even to specific sensitive subpopulations.

*MMT is Produced by the Same Company (Afton) that Produces Lead

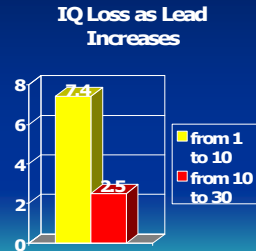
Blood Lead Levels Considered Elevated



Lesson: The More We Know, The Greater The Concern!

Study Indicates Largest Impact at Very Low Lead Levels

- New England Journal of Medicine (4/17/2003)
- 172 children tested at 6, 12, 18, 24, 36, 48, 60 months
- Corrected for confounding variables
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Health Effects Institute Statement (December 2005)

- There is a large body of evidence that
 - under certain circumstances, manganese can accumulate in the brain,
 - chronic exposure can cause irreversible neurotoxic damage over a lifetime of exposure,
 - manganese may cause neurobehavioral effects at relatively low doses, and
 - these effects follow inhalation of manganese-containing particles.

HEI's Comments on the Afton Rebuttal

Health Concerns With MMT Lead to the Brescia Declaration

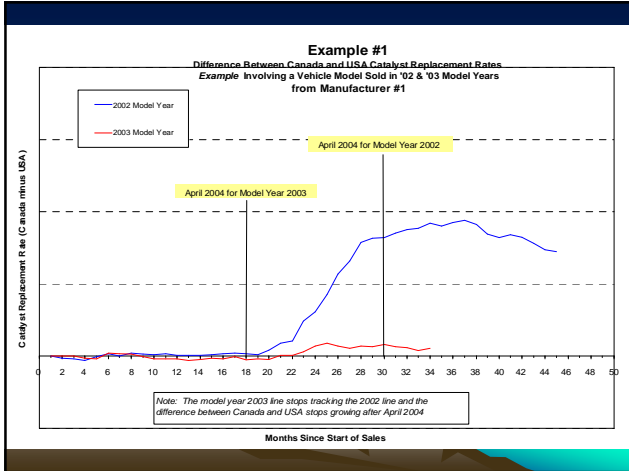
- Scientific Committee on Neurotoxicology and Psychophysiology and the Scientific Committee on the Toxicology of Metals of the International Commission on Occupational Health (ICOH) convened an International Workshop; Scientists and physicians from 27 nations participated.
- **Conclusions:**
 - Exposures of pregnant women and young children to manganese need to be reduced to prevent subclinical neurotoxicity.
 - In children, evidence from two recent epidemiological studies suggests that exposure to manganese in early life causes subclinical developmental neurotoxicity.
 - The addition of organic manganese compounds to gasoline should be halted immediately in all nations.
 - New data raise grave concerns about the likelihood that addition of manganese to gasoline could cause widespread developmental toxicity similar to that caused by the worldwide addition of tetraalkyllead to gasoline.

Experience with MMT China: Blocked catalytic converter



Not A Scientific Study But A Cause For Concern

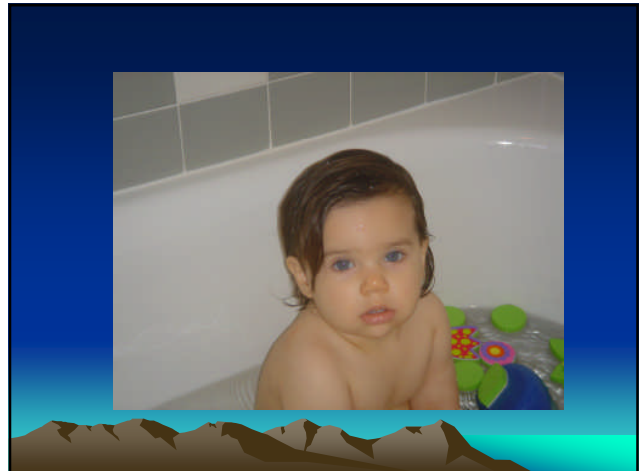
Source: Schindler, VW



ICCT Conclusions Regarding MMT

(ICCT) is unable to conclude that the use of MMT will not result in direct adverse health impacts nor that emissions of CO, HC and NOx from catalyst equipped cars will not increase. In 1996, the Administrator of the EPA stated, "the American public should not be used as a laboratory to test the safety of MMT". The ICCT believes this statement to be true for the citizens of every country. Consistent with the precautionary principle, the ICCT recommends that countries delay any use of MMT in gasoline at this time, pending the outcome of ongoing health-based studies and further review of the vehicle impacts.

Copies of the ICCT Report Available at
<http://www.ICCT.org>

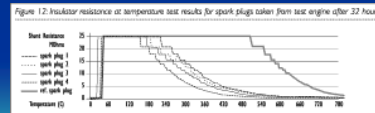


Ferrocene

- Another Metallic Additive – such as Lead and Manganese
- Vehicle Manufacturers Raise Similar Concerns Regarding Damage to Controls (see WWFC)
- Negative Indications Regarding Health Concerns As Well

Ferrocene – Vehicle Industry Concerns

- Iron Oxide Deposits on Spark Plugs, Catalysts
- Spark Plug Misfire Can Cause Thermal Damage to Catalyst



Ferrocene – Health Effects Studies

- Very Few Studies of Ferrocene Directly But Some Studies of Iron Oxide, the Combustion Product of Ferrocene
- 13 Week Inhalation Study in Mice and Rats
 - Lower Weight in Females
 - Cellular degeneration in nose, larynx, trachea, lung, and liver of both species which suggests that ferrous iron is released inside the cells and causes formation of OH radicals that react with cellular components (DNA)

Conclusions Regarding Ferrocene

- Strongly Recommend Against Using Ferrocene Until & Unless More Health Studies Conducted **AND** They Do Not Show Adverse Effects

So! What To Do?

How Have Europe, the US, Canada and Japan Produced the Cleanest Gasoline in the World Without LEAD or MMT or FERROCENE?

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Octane Replacement Options

- o **Refinery Processing**
 - o **Reforming** – Increase severity, moderate cost, increased benzene/aromatics, loss of volume, overall net producer of hydrogen
 - o **Isomerization** - moderate cost, lower octane addition than reforming, volatility impact, reduced benzene, requires small amount of hydrogen
 - o **Alkylation** - higher cost, favorable benzene/aromatics dilution, high motor octane contribution to gasoline pool
- o **High Octane Blend Purchases**
 - o **MTBE** – High octane, low volatility, no sulfur, benzene or aromatics, widely traded on international market. Moderate to high cost
 - o **Ethanol** – High octane, no sulfur, benzene or aromatics, high volatility, higher cost.
 - o **Other ethers (ETBE, TAME)** - High octane, low volatility, no sulphur, benzene or aromatics, Moderate to high cost

Oxygenates - Octane Numbers

	RON	MON	AKI
MTBE	118	101	110
ETBE	118	102	110
TAME	109	99	104
Ethanol	130	96	113

Pearls of Wisdom From My Grandmother

- An ounce of Prevention is Worth A Pound of Cure
- Better Safe than Sorry
- Look Before You Leap

- The Precautionary Principle
- If an action or policy might cause severe harm to the public, in the absence of a scientific consensus that harm would not ensue, the burden of proof falls on those who would advocate taking the action.

Based on the Precautionary Principle

No Metallic Additives such as Lead, MMT or Ferrocene Should Be Used Until and Unless Proven Safe by the Supplier of the Additive; This Seems Highly Unlikely

Do Not Use the Children of Your Country to Carry Out the Next Experiment!



Merry Christmas and Happy Holidays to All

