AN ASSESSMENT OF THE HEALTH EFFECTS OF REFORMULATED GASOLINE IN MAINE

Presented to:
Governor Angus S. King Jr.
Clean Air Stakeholders Conference
The Joint Standing Committee on Natural Resources,
Maine State Legislature

Presented by:
Task Force on Health Effects of Reformulated Gas

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EXECUTIVE SUMMARY

The Clean Air Act Amendments of 1990 (CAAA) require a 15% reduction of volatile organic compounds (VOCs). These organic compounds are formed from incomplete organic combustion. The automobile is a major source of VOCs, and one of the components of ground level ozone. Ground level ozone is produced by nitrogen dioxide, VOCs, and sunlight. Furthermore, the CAAA also requires the reduction of air toxics emitted from the tailpipe. Air toxics, as defined by the CAAA, are benzene, butadiene, formaldehyde, acetaldehyde and polycyclic organic matter. The Petroleum Industry, in cooperation with the U.S. Environmental Protection Agency (EPA) and several natural resources and conservation groups, specifically developed 11% methyl tertiary butyl ether (MTBE) reformulated gas (RFG) and other oxygenated fuels to meet the requirements of the CAAA.

The State of Maine elected to use 11% MTBE RFG as a means of achieving part of the federally required 15% reduction in Maine VOCs. Initiation of the RFG program was to begin no later than January 1, 1995.

In the state of Maine, health complaints began to be registered during January and February of 1995. The symptoms reported were of a nonspecific nature which included: dizziness, lightheadedness and respiratory symptoms. After an organized effort to ban the use of RFG in Maine was initiated, the Bureau of Health, began receiving unsolicited health surveys from York County. These health surveys were distributed by an organization called "Oxy Busters". Subsequently, the Bureau of Health received 48 of these surveys which reported complaints linked to RFG such as: odor, headaches, breathing problems, sneezing and other concerns. These surveys have been tabulated and analyzed. This report is included in the appendix. In response to published newspaper reports the Bureau also received several letters and numerous telephone calls describing health problems. To date, the vast majority of complaints have originated in York County.

This report has been written to provide not only an overview and evaluation of the specific health concerns that have been linked to RFG, but also to place those concerns specifically in the Maine context. To do this, it was necessary to consider the health effects of gasoline without 11% MTBE, and the health effects of other air toxins in Maine and the nation.

As this report was prepared, the Task Force was acutely aware of the fact that some important information would not become available until after the report has been submitted to the Governor and Legislature. It is important that this report be considered in light of the pressure to develop an appropriate plan for reducing air toxins in Maine, and the Legislature's need to act on legislation addressing RFG use in Maine.

In addition, the introduction of MTBE RFG, during the late fall and early winter, occurred at a time when exposure to other factors which have adverse health impacts, such as influenza, indoor air toxins and even weather (severe cold, dry air) would be maximized. Headaches, skin irritation and respiratory problems, such as sneezing and shortness of breath, are all increased during this season.

The health problems experienced by Maine people and attributed to RFG, are very similar to concerns raised by citizens in other parts of the county. The investigation of health effects in Alaska appears to be inconclusive and has not been confirmed by similar studies done in New Jersey and New York. The Wisconsin study of MTBE Health Effects is complete, but is under scientific review (confidential).

The presence of MTBE in groundwater was raised as a significant environmental health and contamination issue by persons questioning the use of MTBE RFG in Maine. Review of the available literature, evaluation of in-state sources of information, and discussions with other states, particularly the state of Colorado, confirms the fact that MTBE has been found in groundwater in Maine, as well as across the nation.

MTBE has been detected in Maine groundwater for about a decade, and occasionally in drinking water, at levels which exceeded the current Maine health-based standard of 50 parts per billion (ppb). At the present time MTBE in Maine drinking water does not pose a significant health hazard. Furthermore contamination levels should be decreasing with continued progress toward correcting the leaking underground storage tank problem. However, because the unsubstantiated possibility of significant airborne contamination of ground water by MTBE has been raised, increased surveillance for MTBE in Maine groundwater is recommended.

The Health Effects Task Force identified a sufficient quantity of available high quality research information to recommend against banning MTBE RFG because both regular gasoline and ozone represent significant public health hazards and environmental risk to Maine residents. In fact the use of MTBE RFG in Maine, in combination with Stage II vapor recovery mechanisms at service stations, could be expected to achieve some positive health impacts.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

- From a health effects perspective, MTBE RFG appears to represent a reasonable alternative to regular gasoline with a modest potential for long term positive health impacts.
- Acute health effects experienced by Maine people and attributed to MTBE RFG appear to be primarily odor related with the smell serving as a direct irritant or a trigger for effects; however, a population subset with a specific sensitivity to MTBE RFG cannot be ruled out at this time.
- The absence of stage II vapor recovery mechanisms in Maine is likely to have contributed to the complaints of adverse health effects registered by Maine people.
- Air sampling data for gasoline vapors and combustion products in Maine is quite limited. In addition, most EPA data available is based on modeling which may not accurately reflect conditions in Maine. A basic surveillance program is needed to confirm and quantify anticipated reductions in air toxins as well as demonstrate that the exposure of Maine people to these toxins is below EPA established reference levels.

Recommendations:

- The use of MTBE RFG should not be banned in Maine as this time.
- The State of Maine should await results of Wisconsin MTBE Health Study to determine if a rigorous scientific assessment of health effects experienced by Maine people is warranted.
- A professional education program both for Maine residents as well as Maine's medical community should be developed to raise awareness of the adverse health effects of ozone and air toxins as well as specifically addressing those concerns that have been raised about MTBE RFG.
- Maine people who have experienced adverse health effects associated with MTBE RFG should consider obtaining gasoline at service stations where gasoline can be pumped for the customer, and generally minimizing exposure to all forms of petroleum products.
- Stage II vapor recovery at service stations would be an excellent way to minimize gasoline vapors generally, and MTBE vapors specifically. This system should result in a substantial reduction in exposure to toxic gasoline vapors, and should be initiated as soon as possible.
- Additional air sampling for gasoline components should be done at service stations, traffic areas, and other outdoor selected sites as well as in the interiors of passenger vehicles. This effort should include formaldehyde which may be increased by use of MTBE RFG. The assumption that this contribution is not significant relative to other sources should be confirmed.

- Additional study is needed of MTBE's health effects in combination with other toxins, such as benzene and toluene.

- Evaluation of gasoline use in Maine should be closely followed to confirm the EPA estimates of only 2-3% mileage loss due to RFG. Obviously if these estimates are not confirmed, and mileage loss is greater than expected, the anticipated positive benefits could be reduced.

- Surveillance for MTBE in Maine groundwater should increase to assure the identification of on-going changes and confirm sources of contamination.

INTRODUCTION

On March 29, 1995, Governor King announced the formation of two Task Forces to look into concerns which arose following the introduction of 11% methyl tertiary butyl ether (MTBE) reformulated gas (RFG) in the state of Maine. **The primary goal of the Maine RFG Health Effects Task Force was to develop a readable summary of the issue, which would be accessible to legislators, Maine citizens, as well as to the Governor and the Clean Air Stakeholders Conference (CASC).** These Task Forces were to make results available to the Governor, the CASC, and the Legislature's Joint Standing Committee on Natural Resources.

Governor King designated Dr. Lani Graham, Director, Maine Bureau of Health, Department of Human Services, as the Chair for the Health Effects Task Force, with membership to be invited by the Chair. The Task Force was asked to report on health effects associated with RFG after making a survey of existing literature and medical studies, evaluating the reported health problems of Maine people due to exposure to RFG, and considering the use of RFG in Maine.

Due to the extremely short-time line for the preparation of this report, it was decided to limit the membership of the Task Force to Maine residents with high levels of credibility and expertise. The Task Force was staffed by professionals from both the Maine Department of Human Services (DHS) and the Maine Department of Environmental Protection (DEP). Offers of assistance and support came from membership of the CASC, the Maine Petroleum Association, ARCO Chemical Company, and the Federal Environmental Protection agency (EPA).

The first meeting of the Task Force was held April the 7th. Prior to meeting, a significant amount of material on RFG and its health effects, along with Maine citizen concerns, was given to the task force. In addition, an extensive list of sources of information was provided for Task Force members who were encouraged to independently contact representatives of ARCO Chemical Company, Environmental Protection Agency, concerned citizens, or any of the other sources of information. A list of the literature reviewed, the persons contacted, and other documents examined, is provided in the Reference Section and the Appendix.

This report has been written to provide not only an overview and evaluation of the specific health concerns that have been linked to RFG, but also to place those concerns specifically in context in Maine. To do this, it was necessary to consider the health effects of gasoline without 11% MTBE, and other air toxins in Maine and the nation.

As this report was prepared, the Task Force was acutely aware of the fact that some important information would not become available until after the report had been submitted to the Governor and Legislature. It is important that this report be considered in light of the pressure to develop an appropriate plan for reducing air toxins in Maine, and the Legislature's need to act on legislation addressing RFG use in Maine.

OVERVIEW AND CONTEXT
PROBLEM STATEMENT

The Clean Air Act Amendments of 1990 (CAAA) require a 15% reduction of volatile organic compounds (VOCs). These organic compounds are formed from incomplete organic combustion. The automobile is a major source of VOCs, and one of the components of ground level ozone. Ground level ozone is produced by nitrogen dioxide, VOCs, ultraviolet and sunlight. Furthermore, the CAAA also requires the reduction of air toxics emitted from the tailpipe. Air toxics, as defined by the CAAA, are benzene, butadiene, formaldehyde, acetaldehyde and polycyclic organic matter. The Petroleum Industry, in cooperation with the U.S. EPA and several natural resources and conservation groups, specifically developed 11% MTBE RFG and other oxygenated fuels to meet the requirements of the CAAA.

Reformulated gasoline (RFG) is gasoline that has an increased "chemical" oxygen content. RFG contains 2% oxygen by weight which enables the fuel to burn cleaner, thus reducing VOCs, carbon monoxide and some of the air toxics. The chemical oxygen content is achieved by the addition of methyl tertiary butyl ether (MTBE). MTBE also replaces some of the benzene and other aromatic compounds which are present in gasoline. The RFG currently in use in the state of Maine contains 11% MTBE. Gasoline which contains 2.7% oxygen, or 15% MTBE, is referred to as oxygenated fuel; oxygenated fuels are required for use during the winter season only. Areas of the country that are not in attainment with the federal Carbon Monoxide Air Quality Standard are required to use oxygenated fuels.

The State of Maine elected to use 11% MTBE RFG as a means of achieving part of the federally required 15% reduction in Maine VOCs. Initiation of the RFG program was to begin no later than January 1, 1995. By this date, all gasoline retailers in the following southern Maine counties were required to sell RFG: Androscoggin, Cumberland, Hancock, Kennebec, Knox, Lincoln, Sagadahoc, Waldo, and York.

Health Complaints And The Use Of RFG:

Maine is not the first state to use RFG or oxygenated fuels. In the winter of 1988, Colorado began using oxygenated fuel (15% MTBE) to reduce carbon monoxide levels. It was not until November 1992, when the state of Alaska began using oxygenated fuels, that health complaints from MTBE exposure became a major focus. The Alaska Department of Health established a "hotline" and encouraged citizens to report any adverse health effects. By the third week in November 1992, more than 150 people had reported symptoms including headache, dizziness, and nausea. Similar complaints were also reported in New Jersey and Montana after these states began using oxygenated and reformulated fuels. However, not all states or cities using these fuels received widespread complaints. Most recently, the state of Wisconsin received numerous complaints from the Milwaukee area, and a MTBE RFG Health Effects Study has just been completed in that state. However, a similar program was simultaneously undertaken in Chicago with almost no health concerns raised.

In the state of Maine, health complaints began to be registered during January and February of 1995. The symptoms reported were of a nonspecific nature which included: dizziness, lightheadedness, and respiratory symptoms. After an organized effort to ban the use of RFG in Maine was initiated, the Bureau of Health, began receiving unsolicited health surveys from York County. These health surveys were distributed by an organization named "Oxy Busters".

Subsequently, the Bureau of Health received 48 of these surveys which reported complaints linked to RFG such as: odor, headaches, breathing problems, sneezing and other concerns.

The survey symptom reports have been tabulated and analyzed. This report is provided in the Appendix. In response to published newspaper reports the Bureau also received several letters describing health problems. To date, almost all complaints have originated in York County.

At present, there is no conclusive epidemiological or clinical evidence to link the use of RFG in Maine with serious health effects. While there is no doubt that Maine people have experienced some health problems, in association with the introduction of 11% MTBE RFG in Maine, this occurred at a time when considerable national media attention was focused on health problems attributed to this additive, making an assessment of Maine people's health problems extremely difficult. One demonstration of this difficulty is provided by the fact that complaints of health effects began after January 1995 while most, if not all, service stations in southern Maine began distributing 11% MTBE RFG to their customers in early December 1994. Furthermore, the introduction of MTBE RFG, during the late fall and early winter, occurred at a time when exposures to other factors which have adverse health impacts, such as influenza, indoor air toxins and even weather (severe cold, dry air) are at their peak. Headaches, skin irritation and respiratory problems, such as sneezing and shortness of breath, are all increased during winter.

The health problems experienced by Maine people and attributed to RFG, are very similar to concerns raised by citizens in other parts of the county. The investigation of health effects in Alaska appears to be inconclusive and has not been confirmed by similar studies done in New Jersey and New York. The Wisconsin study of MTBE Health Effects is complete, but is under scientific review (confidential).

MAJOR SOURCES OF OUTDOOR AIR POLLUTION IN MAINE

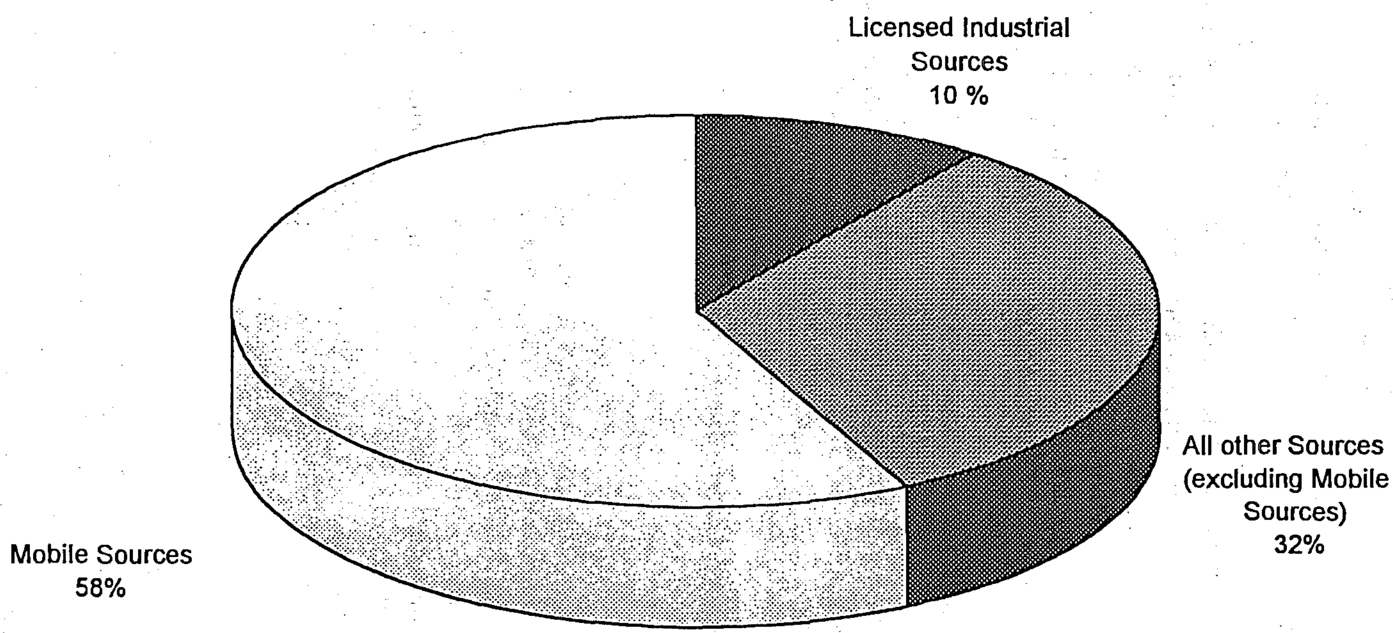
Background

Volatile Organic Compounds (VOCs) are one of the three major constituents to ozone formation. As Shown in Figure 1, VOCs are emitted from a large variety of source types. Ozone itself is formed when VOCs and Nitrogen Oxides (No_x) react in the presence of ultraviolet sunlight. A general misconception about ozone is that it is all transported from "out-of-state". This is not true. While some ozone is transported from elsewhere, a larger amount is also formed within our borders. This is true because VOCs cannot be transported for very long distances due to their relatively short half-lives in the atmosphere. The purpose of RFG is to reduce these "local lived precursors" which are significant contributors to ozone formation.

What Is Being Done.

Controls on large industries and businesses that emit air toxins (point sources) have long been thought to be the "cure-all" for our pollution problems. As shown in Figure 1., point sources' controls are not as effective as believed. Mobile source emissions of VOCs account for almost 60% of all the VOCs emitted in the Maine counties with the most serious air pollution problems while only 10% can be attributed to point sources.

MAINE 1990 BASE YEAR VOC EMISSIONS
MODERATE PLANNING AREA
York, Cumberland, Sagadahoc, Androscoggin Kennebec, Knox, and Lincoln Counties



Mobile Sources - Automobiles, Trucks
Licensed Industrial Sources - Large businesses and mills
All Other Sources - small businesses, (such as gasoline stations), forest fires and other

OTHER BENEFITS OF USING RFG

According to the federal Environmental Protection Agency (EPA), using RFG will reduce ozone "precursors" (VOCs) from automobiles by at least 15%. Additionally, specific pollutants will be reduced as follows:

Pollutant	Reduction Levels
No_x	3 percent
Benzene	33 percent
Total Toxics	24 percent
CO	13 percent
Sulfur oxides (So_x)	11 percent
Particulate matter (PM_{10})	9 percent
CO_2	3-4 percent

HEALTH EFFECTS OF AIR TOXINS: OZONE

Ozone is produced by a chemical reaction of nitrogen oxides and hydrocarbons with ultraviolet sunlight. Both nitrogen oxides and hydrocarbons are in auto exhaust. Ozone is the main chemical in the pollution mixture called "smog". In the body, ozone triggers irritation and inflammation of mucus membranes. This leads to the many acute health effects of ozone, which include eye, nose and throat irritation, cough and, with higher or prolonged exposures, tracheal burning, increased secretions, susceptibility to infection, and decreased lung function.

The federal standard for ozone was increased from 0.08 ppm in 1986 to the current federal limit of 0.12 ppm. The Maine standard remained 0.08 ppm. Research has demonstrated that health effects occurred at levels below the current federal standard. Groups of people more susceptible to ozone include children, adults while exercising outdoors, the elderly, and people with chronic respiratory conditions. Hospitalizations and emergency room visits due to respiratory conditions have been shown to increase during high ozone periods. High ozone days have been correlated with increased use of asthma medications. While conclusive data on chronic health effects of ozone are not yet available, there is preliminary published evidence that development of lung function in children from high ozone areas does not occur as quickly, or reach as high a value as children who live in low ozone areas. Adults may lose lung function faster in high ozone areas. Over the last decade, it has become increasingly clear that high ozone levels have many adverse health consequences on large population groups in Maine and elsewhere. Therefore, an effective plan to reduce ozone levels is needed to reduce these serious health consequences in Maine as well as across the nation.

HEALTH EFFECTS OF AIR TOXINS: CARBON MONOXIDE

Carbon monoxide (CO) is a well-studied toxin, whose adverse health effects increase with increasing exposure. Carbon monoxide when inhaled is rapidly taken up by the lungs and absorbed into the blood where it binds tightly to hemoglobin, thereby displacing oxygen. The net effect is a decrease in oxygen in the blood. Persons with heart disease, anemia and pregnant women, are particularly susceptible to its effects. It can cause shortness of breath, nausea, confusion, seizures, coma, and even death.

In fleet studies by the EPA and others, CO has been shown to markedly decrease in tailpipe emissions when RFG is used as a replacement for regular unleaded gasoline. A number of scientific studies have found significant decreases in CO in areas with RFG programs.

HEALTH EFFECTS OF AIR TOXINS: PARTICULATES

In a recent large study of over 550,000 people in 150 cities in the US during a 9 year period, increased particulate air pollution (soot particles less than 10 microns in diameter, or PM-10) was found to increase mortality from cardiopulmonary disease and lung cancer by 15 percent. This study controlled for the effects of smoking, education, diesel exhaust, occupational chemicals and several other variables. Particulates are emerging as a greater mortality risk than ozone air pollution.

General Toxicity:

Gasoline is a complex chemical mixture containing more than 250 hydrocarbons in addition to small amounts of additives and blending agents. Conventional gasoline and some of its constituents are known health hazards. Small amounts aspirated in the lungs can cause severe pulmonary injury. Toxicity associated with inhalation of gasoline vapors is typically found at high exposure levels, however, exposure to lower levels over long periods of time can produce similar results. The toxic effects observed for gasoline are also observed for the individual components. For example, acute neurotoxicity has been associated with gasoline as well as the individual aromatic components of gasoline. Table 1 provides a general summarization of the toxic responses associated with gasoline and some of its components. Gasoline toxicity must be considered both from the stand point fumes ("evaporative emissions") and exhaust emissions ("combustion emissions").

Some of the most notable toxic components include: benzene, toluene and xylene which are referred to as aromatic compounds. A typical gasoline contains 25-30% by volume aromatic compounds. These components are usually singled out because of their toxic nature. The aromatic compounds are easily absorbed into the blood upon inhalation and have a high rate of skin absorption. This is important as people are exposed to gasoline through various sources, and exposure can occur through either inhalation, contact with skin or ingestion, with inhalation being the most common.

Table 1. Inhalation Hazards Associated with Gasoline and it's Aromatic Components.

Component	Acute Exposure Toxicity	Long Term Exposure Toxicity
Gasoline Mixture	central nervous system: headache, dizziness eye and respiratory irritation (1000 ppm)	pulmonary effects renal effects blood forming organs neurologic effects
Benzene	central nervous system: headache, dizziness, tremors delirium (300 ppm)	Leukemia aplastic anemia developmental effects
Toluene	central nervous system: headache, dizziness, confusion, fatigue (100 ppm)	neurological effects
Xylenes	respiratory: nose and throat irritation (200 ppm) gastrointestinal: nausea, stomach discomfort	developmental effects

Exhaust ("combustion emissions") emissions of regular unleaded gasoline are affected by engine operation, environmental conditions and fuel composition. In typical regular unleaded gasoline, 99+% of exhaust is a combination of nitrogen, carbon dioxide and water. The remainder are pollutants, about 50+% as unburned hydrocarbons, including aromatics like benzene (Sawyer, Schuetzle). These are C5+ hydrocarbons (5 or more carbon atoms per molecule). The rest are products of combustion which include hundreds of smaller hydrocarbons produced from breaking covalent bonds in the parent chemicals in gasoline. Examples include formaldehyde, hexane, methane, carbon monoxide and nitrogen oxides.

Formaldehyde is a carcinogen. The highest human exposures to formaldehyde occur in indoor air from building materials, which has been estimated to be approximately 90% of the yearly exposure. Although tailpipe formaldehyde emissions may be increased slightly through use of RFG (0-13%), amounts produced during fuel combustion in outdoor air are not considered to be significant relative to other sources.

HEALTH EFFECTS OF REGULAR GASOLINE: MAINE EXPERIENCE

During 1991 and 1992, air toxics monitoring was conducted by the Maine Department of Environmental Protection (DEP) in three towns with process paper mills (Woodland/Baileyville, Westbrook, and Rumford), one tannery town (Berwick), two coastal towns (Kennebunk and Jonesport), and at the top of Mt. Agamenticus. Monitoring results were evaluated by the Department of Human Services for evidence of potential health risks posed by concentrations of the hazardous air pollutants detected. Air pollutants identified at each location were evaluated both individually and in combination for potential to: 1) significantly increase one's lifetime risk of cancer (for carcinogens), and 2) to cause adverse health effects other than cancer (all compounds).

Sampling results indicated that levels of certain compounds raised long term health risk concerns. Initial observations showed that health based guidelines were exceeded by four chlorinated hydrocarbons (chloroform, carbon tetrachloride, trichloroethylene, and tetrachloroethylene) and two petroleum hydrocarbons (benzene, and 1,3-butadiene). At two locations, a legally enforceable standard for total hydrocarbons (a complex mixture of hydrocarbons) was exceeded (Zeeman).

The most likely source of these toxins was automobile exhausts. Of importance was the fact that benzene and 1,3-butadiene could not have been "imported" due to their short half-lives in the atmosphere. A health recommendation made was to "continue efforts to limit fuel related emissions (including benzene and butadiene) by adopting stringent requirements on automobile emissions" (Zeeman).

KNOWN HEALTH EFFECTS OF RFG MTBE AND ITS COMBUSTION PRODUCTS

RFG (discussed previously) can have up to 16% MTBE added to enhance octane and improve the combustion of gasoline. Adding MTBE decreases tailpipe emissions of carbon monoxide, benzene, toluene, and VOCs. MTBE and tertiary butyl alcohol (TBA) are increased and formaldehyde may be increased. Therefore, an analysis of the potentially increased risk of MTBE in RFG must consider MTBE and its degradation and metabolite by- products. At this time there is no data on the toxicity of MTBE in combination with the other constituents in gasoline (i.e., mixtures).

MTBE is a liquid with a pungent sweetish ether-like smell and has many of the properties of ethers. The smell of MTBE is more easily detected in RFG compared to regular gasoline. At anesthetic doses, it causes drowsiness, depressed respiratory rate, and eventually coma. Acute effects are rapidly reversible, due to rapid exhalation of at least 50% of a typical MTBE dose, with greater proportions exhaled as the dose of MTBE increases. Medically, large doses of pure MTBE are used for gallstone dissolution therapy; 90% of a typical MTBE dose is excreted by the lungs or kidneys within 2 hours after treatment with MTBE infused into the gallbladder. A small amount is distributed into body fat, which is metabolized over several hours and excreted as TBA. Formaldehyde was undetectable in the blood or urine in studies of patients receiving MTBE for gallstone therapy (Leuschner). There are no controlled trials that verify whether MTBE causes allergic symptoms, but, similar to regular gasoline, it is likely to cause drying of the skin.

Chronic effects of MTBE: There is no human data available. At doses thousands of times greater than a typical refueling exposure, studies of rats and mice are reflective of the ether-like effect of MTBE. In animal studies, liver weight gains are most likely resulting from increased amounts of the alcohol TBA produced as a metabolic product. Alcohols are frequently hepatotoxic; this is true of TBA, which is found in trace amounts in acute exposures. More information on chronic exposures is needed.

POTENTIAL HEALTH EFFECTS OF ALTERNATIVES TO MTBE

Alternatives to MTBE as oxygenated fuel additives include more energy-efficient ETBE (ethyl tertiary butyl ether). At this time ETBE's health effects have not been studied enough to either recommend or discourage its use. As of 1993 TAME, (tertiary amyl methyl ether) has only limited available information in rats showing increased mortality at high doses, but not neurotoxicity. Methanol is a well-studied toxin at relatively low concentrations in humans, with a TLV (threshold limit value) of 200 ppm, and measure and effects on concentration and memory at 192 ppm. It is teratogenic in mice at concentrations of 26,000 ppm. In humans, it causes headache, dizziness, intoxication, seizures, vomiting, blindness, coma and death at increasing levels. Much of the toxic effect of methanol result from its metabolism to formaldehyde, which is further metabolized and becomes formic acid. Survivors of acute severe methanol ingestion can develop permanent Parkinson-like motor abnormalities. Ethanol is well known with a closely defined toxicity profile in humans. Like other possible gasoline additives, it has acute and chronic neurotoxic effects, including intoxication, amnesia and dementia, causes fetal alcohol syndrome and has been shown to cause liver tumors. Symptoms from inhalation of ethanol in humans occur at doses of >5000 ppm, and result mostly in irritation (coughing, eye and nose irritation).

CARCINOGENESIS OF MTBE VS. UNLEADED GASOLINE

There is no data on human cancer risk from MTBE. There is data available on rats and mice (Burleigh-Flayer and Chun). In male and female rats exposed to up to 28,800 mg/m3 (8000 ppm), (human equivalent dose 1430 ppm) 6-8hours/day for several weeks showed an increased incidence of hepatic adenomas and/or carcinomas. No increase in cancer risk was detected in the lower exposure groups.

Male rats showed an increased incidence of kidney tumors at the highest dose. These studies have been criticized for lack of controls comparing MTBE to gasoline. Anesthetic effects of MTBE probably contributed to excess mortality in the high dose animals. Testicular tumors were increased in male rats exposed to mid and high doses of MTBE. Data on lymphoreticular malignancies in animals is not yet published.

MTBE was not found to be mutagenic (i.e., did not cause chromosomal damage) in any test except a mouse lymphoma test. Of the combustion/metabolic products of MTBE, formaldehyde and TBA, formaldehyde is a weak mutagen and a "probable human carcinogen", EPA. TBA has not been shown to be mutagenic or to cause a significant increase in tumors. Extrapolating these potential risks to humans is difficult because of interspecies variability, and the poor predictive value of the small number of animals in the studies.

Summary Of Cancer Risk Of Reformulated Gas Vs. Regular Unleaded Gasoline:

1. There are no direct estimates available of human cancer risk from MTBE; estimates of risk from animal studies extrapolated to humans suggest the risk to be small. Further study is clearly needed; however, the available data is reassuring that MTBE probably does not increase cancer risk of RFG compared to regular unleaded gasoline.

2. Compared to the overall risk of regular unleaded gasoline, the net effect of adding MTBE (a low potency potential carcinogen) to gasoline, (with several higher potency known carcinogens) should reduce the concentration of and therefore exposure to the higher potency carcinogens. However, no animal data is available to test this hypothesis.

3. The cancer risk of RFG should be less than regular unleaded gasoline as a result of more complete burning of fuel components, particularly carcinogenic aromatic hydrocarbons.

4. Cancer was seen at increased frequency in the kidney and liver in animals exposed to 8000 ppm of MTBE for several hours per day for weeks. When compared to human exposures to MTBE of <1 ppm for 4 minutes once a week during refueling, this would seem to be a very small increased risk to a low potency potential carcinogen. More study in higher exposure populations (for example, service station population) is needed.

5. Comparison of the overall risk of cancer incidence caused by cigarette smoking versus cancer risk from all air pollution is approximately 10 to 1 (Pope). Since the net effect of RFG would be to decrease air pollution, the relative risk of cancer from air pollution should theoretically decrease over time.

REVIEW OF THE LITERATURE: MTBE RFG

The general toxicity of MTBE in animals is summarized below:

Acute Inhalation Studies

Inhalation studies designed to measure the relative toxicity of MTBE to rats revealed an LC50, of 33,370 ppm for 4 hours. Thus, it took an exposure of 33,370 ppm MTBE for 4 hours before 50% of the exposed rats died; the 10 minute LC50 in mice was 180,000 ppm. Acute inhalation of 19,621 ppm of MTBE produced tearing in rats after 3 minutes of exposure; after 4 hours of exposure, rats exhibited neurological effects including incoordination, ataxia (loss of control for voluntarily movements), and prostration (ARCO, 1980). Exposures up to 8,000 ppm for 0.5 and 1.5 hours produced ataxia and drowsiness (Bioresearch Labs, 1990). In mice, one hour exposures of MTBE ranging from 84-8,400 ppm resulted in mild to severe sensory irritation which was concentration dependent (Tepper et al., 1993).

Sub-Acute and Subchronic Inhalation Toxicity:

Exposure of rats and mice to 50,000-80,000 ppm MTBE (5-10 min./day, 5 days/wk for 30 days) caused no mortality (Snamprogetti, 1980). Likewise, exposure of rats and mice to concentrations up to 8,000 ppm (6 hrs./day, 5 days/week for 4 or 5 weeks) caused no mortality (Chun and Kintigh, 1993). Rats exposed to concentrations of either 1,000 or 3,000 ppm MTBE for 9 days had a high incidence of chronic inflammation of the nasal mucosa and trachea. No histological or microscopic changes indicative of inflammation MTBE exposure on nasal or tracheal tissue was observed (Biodynamics, 1981). Furthermore, rats exposed intermittently for 13 days or 13 weeks to 8,000 ppm had no microscopic lesions in lung tissue (Dodd and Kintigh, 1989).

In a 13 week rat study, 4,000 ppm MTBE exposure caused ataxia and 8,000 ppm caused daily hypoactivity and ataxia after exposure for 6 hrs./day (Dodd and Kintigh, 1989). In a 90 day study, rats were exposed to 0, 800, 4,000, 8,000 ppm MTBE, 6 hours/week. Hypoactivity, ataxia and changes in liver and kidney weights were observed at exposures greater than 800 ppm, but no gross pathological lesions were observed (Bushy Run, 1989).

Chronic Inhalation Studies:

Chronic inhalation studies on the effects of MTBE exposure were conducted in male rats. After 24 months (lifetime for the rat) of exposure to 3,000 or 8,000 ppm, statistically significant increases in mortality and a decreased mean survival time were observed. Animals in the 8,000 ppm exposure group were sacrificed earlier than 24 months due to excess mortality. Rats that were exposed to 400 ppm for 24 months had a slight increase in mortality and a statistically significant decrease in mean survival time. In these animals, the primary cause of death was progressive nephropathy (kidney disease) (Chun et al., 1992). It was speculated that the mechanism of renal toxicity observed in this study may be specific for the male rat, and may not be relevant to humans (EPA IRIS, 1995).

In mice exposed for 18 months to MTBE at 8,000 ppm a significant increase in mortality and decrease in mean survival time was observed due to uropathy (urinary tract disorder) (Burleigh-Flayer et al. 1992).

Carcinogenicity

Rats were exposed to concentrations of MTBE of 400, 3,000 and 8,000 ppm for 6 hours/day, 5 days/week for 24 months. A statistically significant increase in kidney tumors was observed for the 3,000 ppm group (8 out of 50 rats), but only 3 out of 50 rats exposed to the 8,000 ppm were found to have kidney tumors. Production of tumors did not appear to be related to the dose received in this study. Moreover, kidney tumors may have been related to a mechanism of renal toxicity specific to the male rat, and is not associated with human responses. A dose-related increase in testicular tumors was observed at the 3,000 and 8,000 ppm groups. However, the incidence of testicular tumors in rats is historically high. Tumor incidences of rats exposed to MTBE in this study were not different from historical controls (Chun et al. 1992).

In another study, mice were exposed to MTBE concentrations of 400, 3,000 and 8,000 ppm for 6 hours/day, 5 days/week, for 18 months. Both males and females in the 8,000 ppm group had higher incidence of liver tumors; however, as with testicular tumors in male rats, the liver tumors in the mice were within historical control values (Burleigh-Flayer et al. 1992).

Genotoxicity

MTBE has been tested for mutagenicity (ability to cause mutations in genetic material). MTBE has tested positive in only one out of eight different tests performed. MTBE tested positive in the mouse lymphoma assay. Positive results were attributed to the formation of formaldehyde from MTBE metabolism; formaldehyde has been shown to be mutagenic in other genotoxic assays.

Dermal Toxicity

It appears that sensitization to MTBE occurs only when directly applied to the skin. No irritation or lesions have been noted in short and long-term vapor studies using concentrations of 8,000 ppm or less to rats and mice. Application of 0.5 ml of liquid MTBE to the skin of rabbits caused slight to severe redness, blanching, thickening of the epidermis or localized necrosis. In dermal sensitization tests in guinea pigs, local irritation resulted after injection of 0.5 ml of 1% MTBE under the skin (ARCO, 1980).

INTERPRETATION

Data from the chronic animal inhalation studies has revealed that the no observable adverse effects level (NOAEL), or the dose at which no toxic effects are observed after long-term exposure is 403 ppm. From the NOAEL certain safety factors were applied when extrapolating the animal dose to the human dose. The adjusted human dose which is considered to be protective of human health when continuously exposed over a lifetime is thought to be 0.84 ppm (Iris, 1995).

HUMAN CLINICAL TRIALS

Human respondents to MTBE exposure have been evaluated in controlled laboratory situations which are intended to reproduce environmentally relevant exposures to MTBE. The American Petroleum Institute has measured mean MTBE breathing zone concentrations at less than 1.0 ppm at stations with stage II vapor recovery systems and 2.6 ppm without stage II systems. Similar monitoring results were obtained by the state of Wisconsin during a recent study.

Two controlled exposure chamber studies have been recently conducted to investigate the incidence of symptoms that may be attributed to MTBE exposure. A study performed by EPA exposed 37 healthy nonsmoking individuals for 1 hour to 1.4 ppm of pure MTBE and evaluated the symptoms that were first reported in Alaska. Specifically, the symptoms evaluated were behavioral effects, upper airway and eye inflammation. No differences in symptoms of headache or nasal irritation from MTBE exposure were reported compared to breathing clean air. Likewise, no differences were found in a comparison of indicators of nasal and ocular inflammation between clean air and MTBE.

A similar study, (Cain et al. 1993), exposed healthy individuals to 1.7 ppm of MTBE. Controls were exposed to a mixture of volatile organic compounds (no MTBE) and clean air. Results were similar to those reported by EPA with no differences the comparison groups.

The accumulation of MTBE in the body was also evaluated in a few of the volunteers. Blood concentrations of MTBE rose rapidly upon inhalation. Two individuals in the EPA study had blood concentrations of 8.2 and 14.1 micrograms/liter, but the half -lives were short (the time for MTBE to leave the blood was fast). At 7 hours following the exposure, the blood concentrations were down to 0.2 and 0.6 micrograms/liter respectively. TBA (tertiary butyl alcohol) a metabolite of MTBE has a longer half-life and is a better indicator of exposure to MTBE. These two studies did not correlate MTBE blood levels to any health symptoms.

In another study conducted by the Swedish National Institute of Occupational Health, 10 healthy males were exposed to 5, 25, and 50 ppm MTBE for 2 hours during light physical exercise. Subjects were examined for eye and pulmonary irritation.. This study reported slight or no acute effects from MTBE exposures (Nihlen et al., abstract).

Dermal Effects

No reports of skin rash or dryness have been reported in any of the human clinical studies from vapor exposure.

REVIEW OF THE LITERATURE: EPIDEMIOLOGIC STUDIES

EPIDEMIOLOGIC STUDIES

After receiving numerous complaints concerning oxygenated fuels (15% MTBE) an epidemiologic investigation was conducted in Fairbanks Alaska. A case was defined as a person who, since October 14, 1992, reported increased frequency of headaches or two or more symptoms (cough, burning of the throat or nose, eye irritation, nausea or vomiting, dizziness or poor awareness). Three different groups were interviewed: taxi drivers (high exposure group), commuting health care workers (moderate exposure) and students (low exposure). Taxi drivers were found to have a statistically higher prevalence of reported symptoms.

In follow-up to the epidemiologic study conducted in Fairbanks, an exposure study was conducted in an attempt to correlate exposure levels with reported symptoms. Subjects were evaluated for MTBE exposure by blood analysis in December 1992 (phase I), during the oxygenated fuels program in February 1993 (phase II), and after the program was suspended. Comparison groups consisted of subjects who spent a significant amount of each work day in a motor vehicle or were employed as mechanics (occupational group), and the nonoccupational exposure group consisted of commuters. A statistically significant difference was observed between phase I and II of the study. Thus, blood MTBE levels were lower for both exposure groups after the program was suspended compared to when oxygenated fuels were being used. Furthermore, there was a decrease in self-reported symptoms attributed to MTBE exposure in phase II compared to phase I (Moolenaar, 1994).

STAMFORD, CT AND ALBANY, NY STUDIES

The above studies have been criticized for lack of proper controls. Specifically, control subjects should be selected from a city that was not using oxygenated fuels. The Centers for Disease Control conducted another epidemiologic study to compare the prevalence of symptoms in an area using MTBE-supplemented reformulated gasoline but which had not received widespread media exposure and which had no evidence of widespread consumer complaints (Stamford, CT) with an area not using reformulated gasoline (CDC 1993a and b).

In Stamford, subjects were recruited into exposure groups of car repair or gasoline sales, professional driver, other (persons spending most of their time around traffic), or commuters. Blood was drawn from 44 of the 221 participants and analyzed for MTBE and TBA. The median concentration of MTBE in the blood of gasoline service station attendants was 15.19 micrograms/L, car repair median was 1.73 micrograms/L, and commuter was 0.12 micrograms/L.

Median TBA concentrations were > 75, 15.17, and 2.06 micrograms/L respectively. Persons in the highest quartile of blood MTBE concentrations (>2.4 micrograms/L) were more likely to have reported one or more key symptoms compared to those in the lower three quartiles although the differences were not statistically significant.

In Albany, exposure groups were again selected: auto mechanics and gas station attendants; police; garage workers; and students and office workers. A total of 38 blood samples were drawn from these subjects. Subjects from the first exposure group had a median blood MTBE concentration of 0.42 micrograms/L, group 2 had 0.08 micrograms/L, and in group 3 it was not detected. (CDC 1993b)

Very few differences were noticeable among the groups in the Albany and Stamford studies. Among gas station attendants, the prevalence of all symptoms was indistinguishable except for an increased prevalence of burning nose/throat (15% versus 6% in Albany). Similarly, comparison of the prevalence of symptoms in commuters in Stamford with students in Albany found no significant differences. Among individuals spending considerable amounts of time around traffic (police, garage workers, etc.) Stamford residents were more likely to attribute their cough to gasoline exposure (42%) than Albany residents (15%).

NEW JERSEY STUDY

Two epidemiologic studies were conducted by the Environmental and Occupational Sciences Institute (Mohr et al. 1994). In all, 237 employees from the State Departments of Transportation and Treasury were surveyed. Comparisons were made between northern New Jersey, where MTBE-oxygenated fuel was in use, and southern New Jersey which was not using MTBE-oxygenated fuel. Locations were monitored to determine the concentration of MTBE in the ambient air.

Overall, the garages in the northern part of the state had higher concentrations of MTBE than those in the southern part of the state. Exposure groups selected were: gas station attendants pumping gas for more than 5 hours/day; mechanics working on cars for more than 4 hours/day; persons spending greater that 25 hours/week driving; persons with highest personal exposure to MTBE (6-22 mg/cubic meter as determined by personal 24 hour sampling apparatus); and persons having lowest exposure (1-3 mg/cubic meter). Reported symptoms in these groups by different regions of the state were not significantly different and no adverse health effects were clearly attributable to MTBE exposure in the garage workers.

SENSITIVE EXPOSURE GROUPS

Subjects who were classified as having multiple chemical sensitivity (MCS) or chronic fatigue syndrome (CFS) were studied with respect to MTBE exposure. Questions focused on both situations where MTBE exposure would be most prevalent (gas stations, etc.) and where MTBE exposure would be low (shopping malls). Both groups reported symptoms believed to be associated with MTBE exposure, but symptoms were reported in all situations. Thus, MTBE symptoms were not specifically associated with MCS or with situations where MTBE was most often found (Fiedler, et al. 1994).

MTBE AND GROUNDWATER: NATIONALLY AND IN MAINE

Maine was one of the first states to test for MTBE in water shortly after its introduction as a gasoline additive. The discovery of MTBE in groundwater has been associated with leaking underground storage tanks. However, since MTBE has physical properties which enable it to move rapidly in water and soil, it often is the first contaminant to be identified when a leaking underground tank is found, it has become a reliable marker of this contamination. The question of possible of air contamination of groundwater by MTBE has been raised by a U.S. Geological Survey sampling program of thirty surface sample sites in Denver, Colorado. MTBE was found at 80% of the sample sites. Unfortunately, this limited experience cannot be used to draw any useful conclusions for Maine but it does suggest the need for more surveillance and monitoring in Maine.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

- From a health effects perspective, MTBE RFG appears to represent a reasonable alternative to regular gasoline with a modest potential for long term positive health impacts.
- Acute health effects experienced by Maine people and attributed to MTBE RFG appear to be primarily odor related with the smell serving as a direct irritant or a trigger for effects; however, a population subset with a specific sensitivity to MTBE RFG cannot be ruled out at this time.
- The absence of stage II vapor recovery mechanisms in Maine is likely to have contributed to the complaints of adverse health effects registered by Maine people.
- Air sampling data for gasoline vapors and combustion products in Maine is quite limited. In addition, most EPA data available is based on modeling which may not accurately reflect conditions in Maine. A basic surveillance program is needed to confirm and quantify anticipated reductions in air toxins as well as demonstrate that the exposure of Maine people to these toxins is below EPA established reference levels.

Recommendations:

- The use of MTBE RFG should not be banned in Maine as this time.
- The State of Maine should await results of Wisconsin MTBE Health Study to determine if a rigorous scientific assessment of health effects experienced by Maine people is warranted.
- A professional education program both for Maine residents as well as Maine's medical community should be developed to raise awareness of the adverse health effects of ozone and air toxins as well as specifically addressing those concerns that have been raised about MTBE RFG.
- Maine people who have experienced adverse health effects associated with MTBE RFG should consider obtaining gasoline at service stations where gasoline can be pumped for the customer, and generally minimizing exposure to all forms of petroleum products.
- Stage II vapor recovery at service stations would be an excellent way to minimize gasoline vapors generally, and MTBE vapors specifically. This system should result in a substantial reduction in exposure to toxic gasoline vapors, and should be initiated as soon as possible.
- Additional air sampling for gasoline components should be done at service stations, traffic areas, and other outdoor selected sites as well as in the interiors of passenger vehicles. This effort should include formaldehyde which may be increased by use of MTBE RFG. The assumption that this contribution is not significant relative to other sources should be confirmed.

- Additional study is needed of MTBE's health effects in combination with other toxins, such as benzene and toluene.

- Evaluation of gasoline use in Maine should be closely followed to confirm the EPA estimates of only 2-3% mileage loss due to RFG. Obviously if these estimates are not confirmed, and mileage loss is greater than expected, the anticipated positive benefits could be reduced.

- Surveillance for MTBE in Maine groundwater should increase to assure the identification of on-going changes and confirm sources of contamination.

GLOSSARY:

MTBE: Methyl Tertiary Butyl Ether
ETBE: Ethyl Tertiary Butyl Ether
TAME: Tertiary Amyl Methyl Ether
ppm: parts per million
TLV: Threshold Limit Value (for exposure to a chemical)
EPA: Environmental Protection Agency
OFA: Oxygenated Fuels Association
API: American Petroleum Institute
TBA: Tertiary Butyl Alcohol
NO(A)EL: No Observed (Adverse) Effects Level
TDI: Tolerable Daily Intake
VOC: Volatile Organic Hydrocarbon
ED10: Effective Dose at which cancer risk is increased by 10%
ACGIH: American Conference of Governmental Industrial Hygienists

REFERENCE VALUES:

Blood levels of MTBE measured in human studies 15 - 75 ug/l
Range of exposure concentrations in humans to MTBE epidemiological trials: 0.8-1.7 ppm
Doses of MTBE in humans undergoing gallstone dissolution with MTBE: 0.01g/kg-0.2g/kg
Estimates of MTBE exposure at gas pump during refueling: < 1 ppm for 4 minutes
Estimates of MTBE exposure during commuting (inside car): < 0.03 ppm
Estimates of MTBE exposure at intersections and street canyons: < 2 ppm
Odor threshold for MTBE: 0.3 ppm
Odor threshold for MTBE in RFG: 0.6 ppm
conversion factor: 1 ppm = 3.5 mg/kg MTBE
ACGIH TLV for MTBE: 40 ppm
US EPA reference concentration (Rfc) estimate of inhalation dose to which a person may be exposed to over a lifetime without adverse health effects 0.84 ppm
US EPA estimate of year round annual exposure of an individual living in an area with year round RFG: 0.03 ppm
Drinking water threshold: 50 ppb
Sweden's TLV for MTBE: 50 ppm
Canada's TDI for MTBE: 30,000 nanograms per kg body weight per day, based on extrapolations from rat studies of NOAEL 797 ppm
Canada's estimated daily intake of MTBE at ambient concentrations: 0.67 nanograms per kg body weight per day (a 45,000 fold difference)
NOEL for MTBE: 400 ppm, based on extrapolation from rat studies.
ED10 for MTBE hepatic adenoma: 500 mg/kg/d.
ED10 for MTBE male rat kidney tumors: 20 mg/kg/d (lifetime equivalent dose of 1400 ppm annually)
For comparison, ED10 for 80 other clean air act hazardous pollutants range from 0.0000015 mg/kg/d (most potent) to 80 mg/kg/d (least potent)
NOAEL for benzene 10 ppm; TLV for benzene 1 ppm

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APPENDIX

Contents

REPORT OF RESPONSES

FROM HEALTH EFFECTS SURVEY OF OXYGENATED FUEL USERS

SENT TO MAINE DEPARTMENT OF HUMAN SERVICES

MARCH -- APRIL, 1995

DATA SUMMARIZED AND EVALUATED BY:

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BUREAU OF HEALTH
DEPARTMENT OF HUMAN SERVICES

APRIL, 1995

BACKGROUND

During March - April, 1995, the Environmental Toxicology Program received 48 reports from consumers in Southern Maine who identified themselves as users of Reformulated Gasoline (RFG). The reports consisted of a health effects survey which listed 21 symptoms. Additional information provided in reports included; occupation, age, smoking, and driving status (see Page 39, Health Effects Questionnaire).

METHODS

Information from all the health surveys received were entered into EpiInfo, Version 5. Data analysis consisted of summarizing the responses of the information provided.

RESULTS

Tables 1 - 5 describe the group of persons who sent the health surveys to the Environmental Toxicology Program. A total of 48 responses was received; they were evenly divided among males and females. Towns most frequently reported as the addresses of the respondents were Sanford, Springvale, and Shapleigh; all towns are located in York County. Approximately 19% of the respondents identified themselves as smokers. Occupations varied from college student to homemaker to retired person; the most prevalent occupation was retired person; the respondents were rather evenly divided between blue and white collar workers. However, as a group, the male respondents were older than the female respondents with median age at 45 years old compared to 40 years old respectively. There were no health complaint surveys submitted by persons who might be described as having occupational exposure, such as service station attendants.

Table 6 presents a summary of the symptoms respondents reported. Only 2 respondents (1 male, 1 female) reported having none of the 21 symptoms listed. The most prevalent symptoms listed were complaints of odor (77.1 %), followed by headache (56.3%) and feeling sick (47.9%). The least prevalent symptoms were chills (6.3%), rashes (10.4%), and pulmonary difficulties (10.4%). When separated by gender, the most prevalent symptoms generally remained the same among males and females.

DISCUSSION

Because respondents were self selected in reporting these symptoms, this survey cannot be considered a representative evaluation of the human health effects of MTBE in Maine. Despite this limitation, the results clearly demonstrate the existence of a human response to an exposure to RFG containing methyl tertiary butyl ether (MTBE) among the consumers submitting the Oxygenated Fuel Health Effects Surveys, but there is no comparison with symptoms for regular gasoline exposure. Another study (Albany) suggests there is no significant difference in symptomology between those exposed and those not exposed to MTBE. Only two (4.1%) of the respondents indicated no symptoms; while the most prevalent symptom, complaints of odor, were identified by almost 80% of all respondents. The second most prevalent symptom reported was headaches which were identified by almost 60% of respondents. However, there was no control group of persons pumping regular gasoline or persons with no exposure for comparison.

The most prevalent symptom identified by respondents is consistent with what is known about the physical properties of MTBE RFG. It has been shown that the threshold for detecting MTBE by smell in the air occurs at much lower levels than various blends of gasoline without MTBE. This occurs because MTBE is an ether compound which consumers can find to have a distinctive, or offensive odor. This odor, associated with MTBE may serve as a trigger for certain sensitive individuals and result in the experiences described, such as "headaches", "feeling sick", "sneezing", "sinus problems", etc.

The question is whether a more representative and complete evaluation of the health effects experienced by Maine people and attributed to MTBE RFG is necessary should not be decided until the Wisconsin Health Effects Study has been released and evaluated for relevance to Maine. In the interim, remedies for this situation should involve reductions in exposure to MTBE RFG. Consumers might choose to frequent full-service filling stations in which attendants pump gas and additional vapor controls may be added to existing filling station equipment.

TABLE 1

TOWNS LISTED BY RESPONDENTS AS ADDRESSES.

TOWN	NUMBER	PERCENT
Acton	4	8.3 %
Alfred	5	10.6 %
East Lebanon	1	2.1 %
Kennebunk	1	2.1 %
Lebanon	1	2.1 %
North Shapleigh	2	4.3 %
Saco	1	2.1%
Sanford	12	25.5 %
Shapleigh	6	12.8 %
Springvale	10	20.8 %
Waterboro	1	2.1 %
Wells	2	4.3 %
West Newfield	1	2.1 %
York	1	2.1 %
TOTAL	48	100 %

TABLE 2

SMOKERS AND NON-SMOKERS AMONG RESPONDENTS.

SMOKERS	NUMBER	PERCENT
Yes	9	18.8 %
No	39	81.3 %

TABLE 3

GENDER OF RESPONDENTS.

GENDER	NUMBER	PERCENT
Male	24	50 %
Female	24	50 %

TABLE 4

OCCUPATIONS REPORTED BY RESPONDENTS.

OCCUPATION	NUMBER	PERCENT
Carpenter	1	2.08 %
Certified Nurses' Aide	4	8.32 %
College Student	1	2.08 %
Cook	1	2.08 %
Crane Operator	1	2.08 %
Homemaker	2	4.16 %
Housekeeping	2	4.16 %
Laborer	3	6.25 %
Management	3	6.25 %
Nurse	5	10.41 %
Nursing Home Therapist	3	6.25 %
Office	3	6.25 %
Retired	8	16.67 %
Sales Rep.	1	2.08 %
Self Employed	1	2.08 %
Social Worker	2	4.16 %
Technician	1	2.08 %
None Listed	6	12.5 %
TOTAL	48	100 %

TABLE 5

AGES OF RESPONDENTS BY GENDER

AGE	TOTAL		MALE		FEMALE	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
18 - 30	7	15.6	2	8.7	5	22.7
31 - 40	10	22.2	4	17.4	6	27.3
41- 50	12	26.7	6	26.1	6	27.3
51-64	9	20.0	6	26.1	3	13.6
over 65	7	15.6	5	21.7	2	9.1

TABLE 6

SUMMARY OF RESPONSES FROM
HEALTH EFFECTS SURVEY OF
OXYGENATED FUEL USERS
SENT TO
MAINE DEPARTMENT OF HUMAN SERVICES
MARCH -- APRIL, 1995

	TOTAL POPULATION		MALES		FEMALES	
SYMPTOMS	# POSITIVE	%	# POS.	%	# POS.	%
Any symptom	46	95.8	23	95.8	23	95.8
Anxiety	6	12.5	5	20.8	1	4.2
Breathing problems	12	25.0	5	20.8	7	29.2
Bronchitis	6	12.5	3	12.5	3	12.5
Chills	3	6.3	0	0.0	3	12.5
Complaints of odor	37	77.1	19	79.2	18	75.0
Depression	7	14.6	6	25.0	1	4.2
Ear/nose/throat complaints	21	43.8	10	41.7	11	45.8
Fatigue	19	39.6	10	41.7	9	37.5
Feeling sick	23	47.9	13	54.2	10	41.7
Headache	27	56.3	14	58.3	13	54.2
Rashes	5	10.4	4	16.7	1	4.2
Inc. Secr. of tears/saliva/mucus	10	20.8	5	20.8	5	20.8
Insomnia	8	16.7	5	20.8	3	12.5
Irritability	13	27.1	10	41.7	3	12.5
Lightheadedness	18	35.4	10	41.7	8	34.8
Pulmonary difficulties	5	10.4	4	16.7	1	4.2
Shortness of breath	14	29.2	9	37.5	5	20.8
Sinus problems	19	39.6	7	29.2	12	50.0
Sneezing problems	21	43.8	13	54.2	8	33.3
Sore throat/cough	10	20.8	4	16.7	6	25.0
Trouble sleeping	19	39.6	10	41.7	9	37.5
SAMPLE SIZE	**48**	**100.0**	**24**	**50.0**	**24**	**50.0**

SEND TO:

Assistant State Toxicologist
Div. of Disease Control
SHS11, 157 Capitol Street
Augusta, Maine 04330

OXYGENATED FUEL SURVEY: HEALTH EFFECTS

Professor M.A. Mehlman
7 Bouvant Drive
Princeton, NJ 08540
Fax: 609-683-0838

Name

Addres

Occupation ______________

Do you smoke? Yes / No

Do you drive? Yes / No

Age

SYMPTOMS

1. Anxiety — Yes / No
2. Breathing problems — Yes / No
3. Bronchitis — Yes / No
4. Chills — Yes / No
5. Complaints of odor — Yes / No
6. Depression — Yes / No
7. Ear/nose/throat complaints — Yes / No
8. Fatigue — Yes / No
9. Feeling sick — Yes / No
10. Headache — Yes / No
11. Rashes — Yes / No
12. Increased secretion of tears/saliva/mucus — Yes / No
13. Insomnia — Yes / No
14. Irritability — Yes / No
15. Lightheadedness — Yes / No
16. Pulmonary difficulties — Yes / No
17. Shortness of breath — Yes / No
18. Sinus problems — Yes / No
19. Sneezing problems — Yes / No
20. Sore throat/cough — Yes / No
21. Trouble sleeping — Yes / No
22. Do you get less mileage per gallon? — 0-10% / 10-20% / 20-30%

Please describe any other illnesses you may experience.

In Cooperation with Mr. Barry Grossman (President of OXY-BUSTERS of NJ): 609-275-7080

Personal Contacts by Task Force Members:

U.S. Environmental Protection Agency:
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