New England Interstate Water Pollution Control Commission

Boott Mills South
100 Foot of John Street
Lowell, Massachusetts
01852-1124

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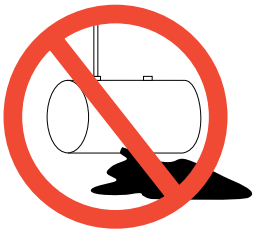


A Report On Federal & State Programs To Control Leaking Underground Storage Tanks

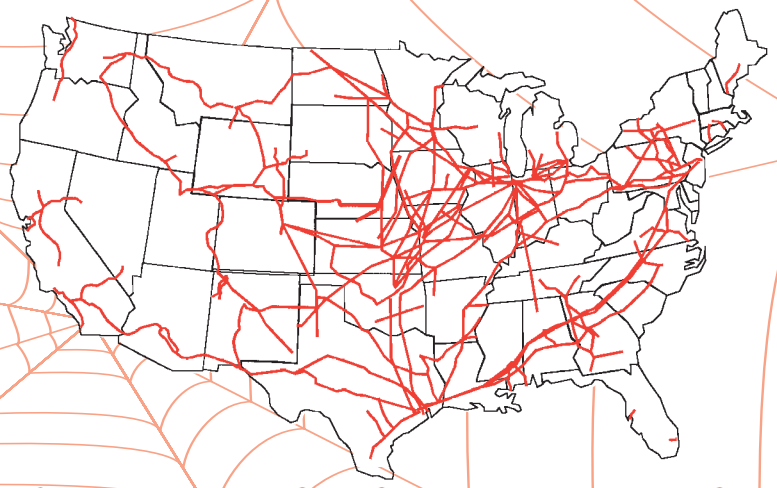
Oh What a Tangled Web!

Gasoline Oxygenates, Petroleum Distribution Networks, and Detections in Groundwater at LUST Sites

by Michael Martinson

Over the past several years, groundwater analyses at leaking underground storage tank (LUST) sites across the U.S. have detected various ether oxygenates, including MtBE, from releases of gasoline, fuel oil, and other petroleum products. Interestingly, many of these oxygenate detections occur in state locations where the use of ether-oxygenated or reformulated gasoline (RFG) has never been mandated for clean air requirements. South Carolina, for example, has never required the use of oxygenated gasoline, yet MtBE has been found at 72 percent of all LUST release sites and at 85 percent of all corrective action releases (Shrader 2002).

So what's going on here? Certainly the use of oxygenates for all purposes, including octane boost, RFG, or oxyfuel, all contribute to the "cross-contamination" issue. However, the U.S. pipeline distribution system and its operations also offer plausible explanations for the widespread detections and occurrences of gasoline oxygenates in LUST site groundwater. Let's take a look at this tangled and perplexing system.



U.S. REFINED PRODUCT PIPELINE NETWORK

Petroleum Shipments in the U.S.

Data for 2001 indicate that approximately 19.5 million barrels (819 million gallons) per day of petroleum products are consumed in the U.S. (Trench, 2001). Approximately two-thirds of the petroleum shipped in the U.S. travels via oil pipelines. The balance of the distribution methods includes barge trucking, railroad, and waterborne shipments.

■ *continued on page 2*

Inside

■ Tangled Web *from page 1*

The interregional flows of crude and refined petroleum are built upon a national infrastructure of pipelines designed to move oil and refined products from the producing regions to the consuming regions (Pennwell, 2002). According to the Association of Oil Pipe Lines' data (AOPL, March 2000), in 1998, the total network for crude and refined petroleum products constituted over 200,500 miles of pipeline. Crude oil and gathering lines account for 114,000 miles; product lines make up another 86,500 miles.

PADDS

Five regions, referred to as "Petroleum Administration for Defense Districts" (PADDs), were delineated during World War II to facilitate the pipeline transmission of refined products. Up until World War II, domestic distribution relied primarily on tanker shipments, but the disruption of wartime shipments created a need for the development of long-distance, large-diameter pipelines. The logistical hubs of the PADDs serve as gateways for regional supplies of petroleum products.

Allegro Energy Group's December 2001 document, *How Pipelines Make the Oil Market Work – Their Networks, Operation and Regulation,* explains how the transmission of petroleum products through the oil market's pipeline infrastructure helps balance the oil market—moving oil from producing regions to consuming regions. The regional PADDs are summarized as follows.

- **East Coast (PADD 1)** has little or no crude oil production, some refining capacity, and one of the highest PADD demands for refined products.
- **Midwest (PADD 2**) is the source of approximately 10 percent of the region's crude oil needs. The balance of crude oil is obtained from outside the region (i.e., Canada, the Gulf Coast region, foreign crude imports). While the Midwest refining capacity meets most of the needs of the region, refined supplies are also supplemented with shipments from other regions, most notably the Gulf Coast.
- **Gulf Coast (PADD 3)** provides the U.S. with the largest regional production of crude oil (55%) and refined products (47%). In terms of interregional PADD trading of crude and refined petroleum, this region provides 90 percent of the crude and 80 percent of the refined petroleum that is shared among all PADDs. Refined products are primarily shipped to the East Coast; a smaller portion is shipped to the Midwest.
- **Rocky Mountain (PADD 4)** obtains crude oil from local production and supplements refinery inputs with Canadian crude. Geographic limitations of distances and topography create an inadequate infrastructure that relies on interregional trading to maintain supply and demand balances, despite its being the lowest petroleum-consuming PADD region in the U.S.
- **West Coast (PADD 5)** is a region that is mostly separate from the other PADDs in the U.S. Alaska supplies approximately 55 percent of the crude oil inputs to the refineries;

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Ellen Frye, *Editor*
Ricki Pappo, *Layout*
Marcel Moreau, *Technical Advisor*
Patricia Ellis, Ph.D., *Technical Advisor*
Ronald Poltak, *NEIWPCC Executive Director*
Lynn DePont, *EPA Project Officer*

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NEIWPCC
Boott Mills South, 100 Foot of John Street
Lowell, MA 01852-1124
Telephone: (978) 323-7929
Fax: (978) 323-7919
lustline@neiwpcc.org

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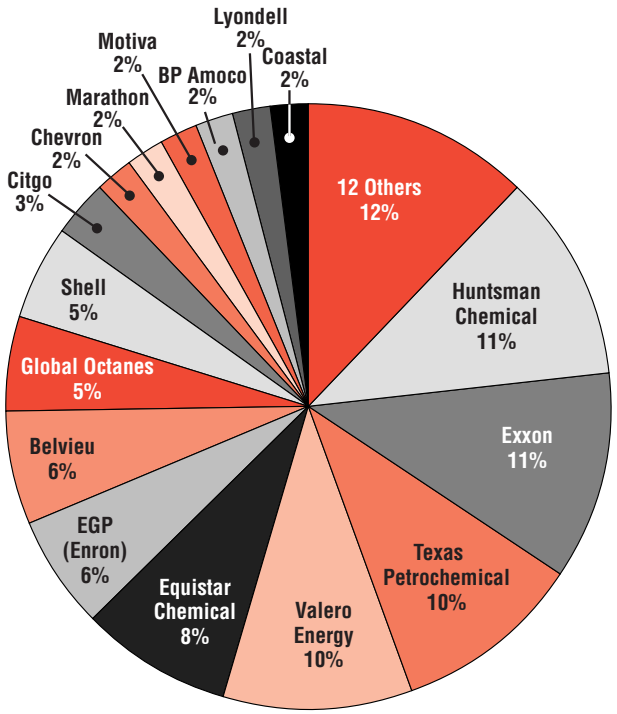
Figure 1

U.S. PRODUCERS OF MtBE
(1999)



Source: ChemExpo 2000 Chemical Profile MtBE.

the balance of the oil production takes place in California. Almost all of the refining capacity is met from California state refineries that produce unique product specifications.

The manufacturers of MtBE and other ether oxygenates are numerous. (See Figure 1.) In 1999, MtBE oxygenate supplies were produced from at least 28 U.S. suppliers (ChemExpo Chemical Profile, 2000). In 1998, approximately 25 percent of the MtBE used in the U.S. was from imports (Oak Ridge National Laboratories, 2000).

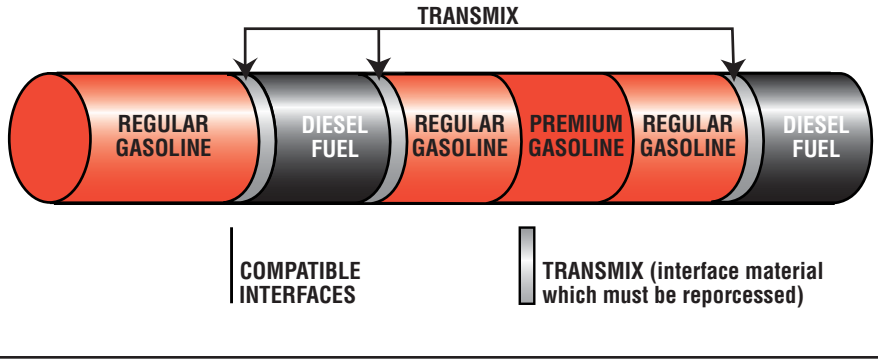
The produced oxygenated gasoline products vary in their oxygenates content, depending on clean air mandates, use as octane boosters in the gasoline, and other factors associated with supply and demand. MtBE is combined with refined gasoline per shipping specifications for shipment to ultimate distribution points.

As oxygenated gasoline enters the refined products distribution network of pipelines, it enters a system encompassing various geographies, numerous manufacturers, and gasoline products with varying MtBE and other oxygenate contents. These all contribute to a national complex of widespread MtBE distribution, both intended and unintended. In addition, the refined petroleum product passes through many of the more than 2,500 pipeline terminals, starting at the point of production, during the pipeline transmission process to its final distribution point (Penn Well, 2002).

In Maine, a state where oxygenate-containing RFG use is not required, there is considerable variability in MtBE content in gasoline. The Maine Department of Environmental Protection (DEP) monitors and reports annually on levels of MtBE in shipments of gasoline to storage terminals that have a throughput of more than 20,000 gallons of gasoline per day in the state. Terminals in Maine reporting data were owned by Gulf, Irving, Mobil, Motiva, and Webber. Although the goal for Maine has been to eliminate MtBE from gasoline this has, so far, been next to impossible. The average level of MtBE in gasoline for 2002 was 2.44 percent (by volume) in gasoline, ranging from 0 to 14.53 percent MtBE (Maine DEP, 2003). Shipments with 11 percent or higher are most likely loads of RFG that have ended up in Maine, one way or another, when they shouldn't have.

Figure 2

TYPICAL SEQUENCE OF PETROLEUM PRODUCTS FLOW THROUGH A PIPELINE



Residual Refined Product Mixing During Distribution

Another contribution to the nationwide distribution of MtBE and other oxygenates, even to locations that do not use or need them, is the mixing of residual petroleum products within the pipelines, terminal storage tanks, bulk shipments in barges, and final distribution to retail sites via tanker trucks. Even fuel oil supplies have been found to have significant MtBE and other oxygenate concentrations due to residual volumes of oxygenated gasoline mixing with fuel oil shipments in pipelines, barges, and tanker trucks.

In pipeline transmission operations, it is common practice to ship different petroleum products or grades of the same product in sequence through a pipeline, with each product or "batch" distinct from the preceding or following (Allegro, 2001). Transmix interface materials are used to separate refined petroleum products (e.g., fuel oil or diesel fuels separated with a transmix from gasoline shipments). (See Figure 2.) However, the various grades of gasoline products are not typically separated during pipeline transmission. The mixing of gasoline grades and their respective varying oxygenate concentrations can result in the inadvertent distribution of residual

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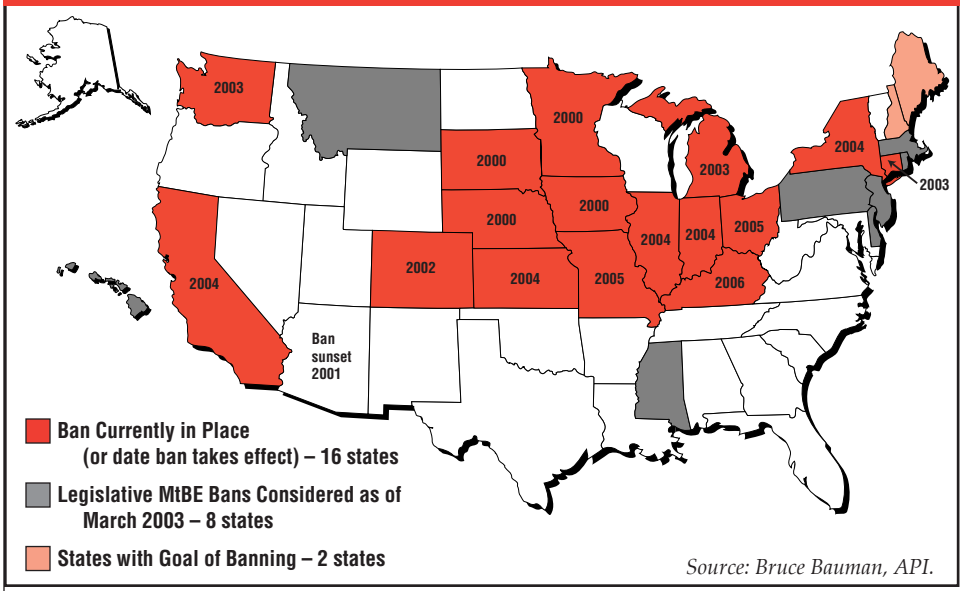
Figure 3

STATE MtBE BANS
March 2003



Source: Bruce Bauman, API.

■ **Tangled Web** *from page 3*

refined products containing ether oxygenates such as MtBE.

Can We Predict Detections of Ether Oxygenates at LUST Sites?

Unintended MtBE and oxygenate distribution to states is plausible, if not likely, given the complexities in MtBE and other oxygenates production, refined product composition, pipeline and terminal network operations, and final distribution of the refined products to the retail distributor. The refined product pipeline network works with the supply and demand from the PADDs network to cause an unpredictable distribution of oxygenate-containing petroleum products.

When pipeline networks move refined products from refining centers through states that do not require the use of oxygenated gasoline, the supplied refined products tapped by states along the transmission process are not necessarily formulated to meet individual state bans on the use of MtBE as a gasoline oxygenate. (See map of state MtBE bans, Figure 3.) Thus, LUST releases of gasoline products anywhere in the U.S. have a good chance of containing some level of MtBE or other ether oxygenates due to the complex nature of refined petroleum distribution networks and their operations. ■

Michael Martinson is with Delta Environmental Consultants, Inc. and Inogen Environmental Alliance. He can be reached at mmartinson@deltaenv.com.

He wishes to thank to the following contributors to this article:
• *Association of Oil Pipe Lines (AOPL)* – http://www.aopl.org. *AOPL Contact: Michele F. Joy* – mjoy@aopl.org
• *Bruce Bauman – American Petroleum Institute* – bauman@api.org
• *Carl Varteresian, AIG Consultants, Inc.* – carl.varteresian@AIG.com
• *Cheryl J. Trench – Allegro Energy Consultants-* ctrench@rcn.com

References

ChemExpo Chemical Profile: MTBE , 2000 December 2002 revision found at: *http://www.the-innovation-group.com/ChemProfiles/MTBE.htm*

Davis, Stacy C., 2000. *Transportation Energy Data Book,* Edition 20, prepared for Office of Transportation Technologies, U.S. Department of Energy under Contract No. DE-AC05-00OR22725, Oak Ridge National Laboratories, October 2000.

Maine Department of Environmental Protection Bureau of Air Quality. February 2003. 2002 Maine Fuels Report. *http://www.maine.gov/dep/air/mobile/fuelsrpt2002.pdf*

PennWell MAPSearch, , 2003. Petroleum distribution infrastructure maps and data found at: *http://www.mapsearch.com/digital_products.cfm*

Shrader, Art , South Carolina-DHEC, 2002. Personal communication.

Trench, Cheryl J., 2001.*How Pipelines Make the Oil Market Work – Their Networks, Operation and Regulation,* A Memorandum Prepared for the Association of Oil Pipe Lines and the American Petroleum Institute's Pipeline Committee, Allegro Energy Group, December 2001.