Alternative Fuels Guidebook

Properties, Storage, Dispensing, and Vehicle Facility Modifications

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Preface

I have been fortunate to be involved with alternative fuels for vehicles over the past 20 years. During that time, alternative fuels have evolved from experiments conducted in research laboratories to use by the public. I have personally been involved with vehicle modification to use alternative fuels, and more recently, design and installation of alternative fuel refueling facilities and modification of existing garages for safe storage and maintenance of alternative fuel vehicles. This experience includes underground and above-ground methanol refueling systems, compressed natural gas refueling systems, the Maryland Mass Transit Administration liquefied natural gas transit bus refueling system, and the Greater Richmond Transit Company electric bus recharging facility. The information herein includes the fundamentals that I have found to be essential to understanding the physical and chemical properties of alternative fuels and how they impact refueling system design and modifications of existing garages for safety purposes. As such, it is a combination of reference and general guide for engineers and fleet managers whose job is to implement alternative fuel vehicles.

R.L. Bechtold
April 1997
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Introduction

The term "alternative fuel" has been used to describe any fuel suggested for use in transportation vehicles other than gasoline or diesel fuel. In many ways, the current situation regarding fuels for transportation vehicles resembles the time in the early 1900s when vehicle buyers could choose among internal-combustion, steam, or electric vehicles. During this period, there were great debates about which fuels were best—even Henry Ford envisioned many of today’s concerns about fuel availability and the environment by investigating the use of ethanol as a renewable, home-grown fuel whose production would benefit agriculture. The wide availability of inexpensive gasoline as a by-product of kerosene refining (for lighting purposes) was surely a large factor in the subsequent success of the internal-combustion engine in transportation vehicles. Both steam and electric vehicles had characteristics much desired by consumers at the time such as low noise and good driveability. However, drawbacks such as lengthy start-up time and complexity of operation (steam vehicles) and short driving range (electrics) conspired to limit their appeal. With the advent of the electric starter, internal-combustion-engine vehicles achieved a combination of economy, range, and ease of use that steam and electric vehicles could not match. From the demise of steam and electric vehicles, internal-combustion vehicles using gasoline and diesel fuel have enjoyed virtually complete dominance of the market. Ongoing development over time has resulted in very durable and reliable vehicles that are safe and less damaging to the environment than ever before.

The original impetus for development of alternative fuels to gasoline and diesel fuel was the realization that the oil-producing nations that held the majority of the world’s reserves had the power\(^1\) to dictate the price and availability of what

\(^1\) The extent and completeness of this power is a topic of much debate, but there is no disagreement that the potential exists for much greater use of monopolistic powers if coordinated efforts by oil-producing nations are applied.
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had become a truly international commodity. The U.S., several European countries, and Japan have led the development of alternative fuels because they have become dependent on oil imports to satisfy their transportation vehicle fuel needs. Today, the U.S. highway transportation sector is essentially totally dependent on petroleum fuels, making transportation very vulnerable to oil shortages and sudden price increases. The U.S. now uses more petroleum fuels in light-duty vehicles than all of its domestic oil production. Growth in light-duty vehicle fuel consumption is projected to be 0.8% through the year 2015, and for heavy-duty vehicles the fuel consumption growth rate is projected to be 1.3%. At the same time, growth in net oil imports is projected to be 1.9%, which predicts an ever-widening gap between petroleum consumption and domestic production.2 Other petroleum-using sectors of the U.S. such as industry and utilities have made provisions to switch to fuels other than oil, while the transportation sector has not. It is this dependence on petroleum fuels that is prodding the use of alternative fuels in transportation.

Through experimentation with alternative fuels, it soon became clear that alternative fuels had inherent environmental advantages as well. Each alternative fuel has some characteristic that gives it an environmental advantage over petroleum fuels. Most are less damaging to the environment if spilled, and, in general, the emissions from alternative fuels are less reactive. This results in reduced amounts of ozone being produced with the benefit of improved air quality. In the 1980s there was less concern about energy security in the U.S., but the environmental advantages of alternative fuels kept interest high. In the 1990s the pendulum has swung back to the energy security value of alternative fuels. U.S. dependence on foreign oil, particularly for transportation, has assumed a steady increase approaching levels in the past when oil shortages or price shocks have occurred. Another reason interest in alternative fuels has again centered on energy security is because emission control technology combined with cleaner petroleum fuels such as reformulated gasoline and “clean diesel” has resulted in emission levels low enough to significantly depreciate the emissions benefits of alternative fuels.

Introduction

The initial work on alternative fuels focused on which one was best from the viewpoint of technical feasibility, production capability, and cost. That question was never answered with certainty and, in the interim, development of alternative fuel vehicle technology has proceeded in parallel. Technical feasibility is no longer questioned, and the focus now has shifted more toward which alternative fuels can be produced at a competitive cost. Cost is calculated in terms not only of fuel price, but vehicle price and operating characteristics, and the expense of developing a national fuel distribution infrastructure. In addition, new issues such as public awareness and training of vehicle maintenance personnel have arisen as the use of alternative fuel vehicles spreads. Professions only peripherally aware of vehicle technology, such as professional engineers that must design vehicle storage and maintenance facilities, will need to become familiar with the physical characteristics and safe handling practices of alternative fuels. Building code and standards-setting organizations are slowly gaining the necessary information to address alternative fuels, though the process for change of codes and standards is a thorough one that takes many years to complete.

Alternative fuel vehicles will likely become more prevalent throughout the U.S. as a result of the passage and implementation of the Energy Policy Act of 1992, known as EPACT. EPACT requires the Federal government, state governments, and companies producing alternative fuels (fuel providers) to purchase alternative fuel vehicles as part of their new vehicle acquisitions. The Federal government has to date acquired approximately 15,000 alternative fuel vehicles, and the regulations for state and fuel providers to begin to acquire alternative fuel vehicles went into effect on March 16, 1996. EPACT also includes provisions for requiring private and local fleets to purchase alternative fuel vehicles if it is determined that the petroleum displacement caused by Federal, state, and fuel provider alternative fuel vehicles is insufficient to meet the petroleum displacement goals of EPACT (if enacted, this mandate would take effect in 2002). The U.S. Energy Information Administration estimates that within ten years, annual sales of alternative fuel vehicles could exceed one million per year because of state mandates in addition to EPACT and from market-driven sales of alternative fuels.

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fuel vehicles. These alternative fuel vehicles will create substantial demand for new fuel storage and dispensing facilities, and for modifications of existing facilities.

The objective of this book is to inform engineers and other interested parties about alternative fuels. It is directed at the professionals whose responsibilities require a working knowledge of alternative fuels, and who need a ready reference to inform and guide them in making decisions in their work. It concentrates on alternative fuels, their properties, characteristics, materials compatibility, and safe handling practices. It does not attempt to include the vehicle technology for using alternative fuels, nor their efficiency and emissions characteristics. These are changing very rapidly and are therefore not conducive for inclusion in a text meant to have more lasting content.

The alternative fuels included in this book are those which are considered the most likely candidates for use in internal-combustion engines and future energy conversion devices such as fuel cells. The alcohols (methanol and ethanol), natural gas (compressed and liquefied), LP gas, vegetable oils, and hydrogen are all covered in their entirety. Electricity is included only in terms of facility modifications for recharging and storing electric vehicles since the means for distributing electricity is not affected by its use in electric vehicles. Dimethyl ether (DME) is a promising alternative fuel for diesel engines made from natural gas, with physical properties similar to LP gas. Very little work has been done to define the production processes, typical composition data of DME from such plants, and storage and dispensing requirements for DME (though they are likely to be very similar to those for LP gas). At present, it is too early to provide guidance about how DME should be stored and dispensed.

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