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IMPLEMENTATION OF ALTERNATIVE BIO-BASED FUELS IN AVIATION: THE CLEAN AIRPORTS PROGRAM

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ABSTRACT

The Renewable Aviation Fuels Development Center at Baylor University in Waco, Texas, was designated, in March 1996, by the US Department of Energy (US DOE) as the national coordinator of the Clean Airports Program. This program, a spin-off of the Clean Cities Program, was initiated to increase the use of alternative fuels in aviation.

There are two major fuels used in aviation today, the current piston engine aviation gasoline, and the current turbine engine fuel. The environmental impact of each of these fuels is significant. Aviation Gasoline (100LL), currently used in the General Aviation piston engine fleet, contributes 100% of the emissions containing lead in the USA today. In the case of the turbine engine fuel (Jet fuel), there are two major environmental impacts to be considered: the local, in the vicinity of the airports, and the global impact on climate change.

The Clean Airports Program was established to promote the use of clean burning fuels in order to achieve and maintain clean air at and in the vicinities of airports through the use of alternative fuel-powered air and ground transportation vehicles.

Keywords: renewable, alternative aviation fuels, clean airports, turbine, jet fuel, pollution

BACKGROUND

Local, state and national governmental entities, along with many private individuals and companies are currently engaged in the effort to improve the quality of the air while at the same time reducing the United States' dependence on imported petroleum.

Several federal, state and local laws and ordinances have been enacted to address the problem, but the use of petroleum-based fuels continues to degrade the quality of the air, representing a health hazard for the population and endangering the environment. Furthermore, we continue to import higher percentages of petroleum, therefore increasing our economic and political vulnerability by becoming more dependent for our oil supplies on politically unstable nations.

Airports are major centers of transportation and commercial activities and consequently areas of massive fuel combustion. Recognizing the fact that airports, while being essential to the economic development of a community, are also major sources of pollution, the Department of Energy's/Baylor University's Clean Airports Program is targeting airports to encourage and facilitate the conversion of aircraft, ground support vehicles, and airport's equipment to clean burning alternative fuels. This new initiative is called the Clean Airports Program. This program is based on the Department of Energy's successful Clean Cities Program.

With the knowledge and experience gained at RAFDC in developing ethanol as an aviation fuel, air as well as ground transportation vehicles are now capable of efficient, safe, clean and economical operations. The use of alternative, clean, domestically produced fuels in aviation is a significant step toward clean air and energy independence.

WHY CLEAN AIRPORTS

The aviation community is confronted today with a great challenge: working to ameliorate a major cause of environmental and health concern. Fuel combustion at airports, in their vicinities and in the higher levels of the atmosphere is increasingly becoming a threat to human health and to the environment. There are two major fuel related issues in question: pollution from jet fuel use (commercial and military aircraft), and the phase-out of leaded aviation gasoline (general aviation).

Pollution from jet fuel use

Jet fuel, used by commercial and military aviation worldwide, is a cause of concern on two different levels: local pollution at airports and in their vicinities, and global impact on climate chance.

Local Pollution at Airports. Ground level ozone is formed when oxides of nitrogen (NOx) and volatile organic compounds (VOCs) react in the presence of sunlight. Ozone is the most serious air pollution problem in the United States. Children under the age of 13, adults over 65 and people with respiratory illnesses are the most susceptible to being affected by high levels of ozone. Approximately 62 million people in these categories live in areas designated as ozone non attainment areas (American Lung Association, 1993). These are regions which violate existing federal ambient air quality standards. In addition to posing health problems, high levels of ozone cause several billions of dollars of damage annually. Ozone also causes extensive damage in the industrial sector by accelerating the aging process in various materials.

An example of the seriousness of the problem caused by aircraft emissions is the contribution of pollution from the New York City's airports. According to a study conducted in 1994, Kennedy airport was found to be the single largest contributor of NOx and the second largest contributor of VOCs. LaGuardia Airport was the fourth largest contributor of NOx and third largest contributor of VOCs (FAA, 1993). Airline passenger miles are growing twice as fast as ground vehicle miles, consequently, airlines will contribute increasingly larger percentages of pollution (Gordon, 1991).

Ozone pollution is targeted by the Clean Air Act Amendments (CAAA) of 1990 which established health based standards for NOx, VOCs, ozone and other pollutants. Areas that fail to meet these standards are required to develop State Implementation Plans (SIPs). SIPs are plans to reduce emissions within the non attainment areas to attain compliance with the regulations. Ozone SIPs attempt to reduce VOCs and NOx emissions one source at a time. As part of an ozone SIP, power plants, industries, commercial activities, and private car owners can be asked by the state to reduce emissions.

It is peculiar, therefore, that aircraft emissions at even the largest airports are not yet regulated by the SIP process. Since 30 of the busiest airports are in ozone non-attainment areas, some sort of regulatory action is bound to be enacted.

Global impact on climate change. Measurements of air quality at heights between 9 and 12 km. in the North Atlantic flying corridor, were made by the German Research Department for Air & Space Travel (DLR). NOx, Ozone, CO_2, Water Vapor, and other air traffic emission products were analyzed. The data collected proved that emissions of air traffic cause great concentrations of air pollutants in traffic corridors. The following remarks are excerpts from an article published in Germany on this study (Von Stamm, 1995).

"Jet aircraft emissions are so dangerous because they are emitted directly into the upper atmosphere. In the troposphere, where the mixing and weather phenomena take place, rain washes pollutants out in a short time (days or weeks). In the tropopause, the effects of exhaust gases increase because of lower temperatures. The stratosphere, which is above the tropopause, is even more sensitive because of the lack of vertical movement, the pollutants have more residence time and accumulate in the traffic corridors. In those corridors, 44% of the fuel is burned and 5% of NOx is emitted. At higher altitudes of the stratosphere, at lower temperatures, nitrous oxide (NO) destroys the ozone layer, which should protect life on Earth from UV-B-radiation. Furthermore, sulfur dioxide and the soot particles magnify the destructive power of the ozone-killer Chlorine, which is set free from fluoro-chloro-hydrocarbons in the stratosphere."

"The effect on the climate of an airline flight to Brazil (for a single person) is equal to 4.5 times that of a land vehicle for an entire year. A flight to Rio, for a single passenger, is therefore as harmful as 4 and a half years of driving by car; while a domestic flight equals the harmfulness of one passenger's year total traffic by car, bus and rail."

"In the next 10 years the worldwide number of airline passengers will double. Passengers flying on Pacific routes will quadruple while 15,000 more aircraft will be flying around the globe. If one takes into account the expected rate of growth in air traffic and the catastrophic effects of jet emissions in sensitive climate zones, then the air polluting potential of air traffic will rise in ten years from the supposed current 3.9% of total pollution to almost 50%."

"Despite the introduction of more modern and cleaner jet engines, the load of pollutants caused by air traffic will increase rather than decrease in the future as a result of the enormous rate of growth of the industry."

RAFDC is initiating a research program to test blends of Jet fuel with Biodiesel and ETBE. The purpose of the program is to clean up fuel's emissions. Accordingly, emission testing will be an important part of the project. The best performing blends will then be used in one of the two engines of RAFDC's King Air, an aircraft fully instrumented to perform airborne air pollution monitoring.

Phase-out of Leaded Aviation Gasoline

The phase-out of tetraethyl lead from motor fuel in the U.S., as mandated by the Clean Air Act, is a cause of great concern to the aviation industry. The industry standard is a 100 octane, leaded fuel known as 100 LL (low lead). Since the phase out of lead from the rest of the motor fuel, Avgas is the only remaining leaded fuel in the United States. Although a temporary informal waiver has been granted by the Environmental Protection Agency (EPA) to general aviation, EPA and the California Air Resources Board have considered regulating the use of this fuel in order to eliminate hazardous air pollutants.

The Federal Aviation Administration, aircraft manufacturers, engine manufacturers, professional aviation organization and the oil industry are attempting to develop an alternative to the leaded aviation gasoline (AVGAS) used in today's piston engine aircraft. Following are some of the economic and regulatory reasons, urging the development of an unleaded aviation fuel:

- To avoid lead contamination, fuel suppliers are not able to transport leaded fuels in either pipelines or tankers used to carry unleaded fuels.
- In the future, used oil from engines using leaded gas will likely be classified as toxic waste.
- The Montreal Protocol requires elimination of all use of ethyl-di-bromide by 1998. This lead scavenger is necessary in any engine using lead additives.
- According to the most current public information, existing alternate octane boosters cannot achieve the standard 100 octane. A substandard octane fuel, now under consideration, could not be used in certain aircraft engines which consume almost 1/2 of the fuel used today.
- Increased use of alkylates in the new reformulated gasolines for automobiles will cause the price to increase and could result in supply shortages for their use in Avgas production.

- Piston aviation engines emissions are not yet regulated. Volatile organic compounds and nitrogen oxides are being investigated by the EPA.

Many attempts have been made to develop an acceptable gasoline-based replacement fuel. Difficulties in producing such a fuel that satisfies both technical and economic guidelines are due to the high octane requirements, high costs of its constituents and environmental considerations.

A program at the Renewable Aviation Fuels Development Center (RAFDC) at Baylor University has proven, in the course of seventeen years of research and development, that 100% denatured ethanol has all the desired technical characteristics to replace 100 LL Avgas (Shauck and Zanin, 1992).

Ethanol is a high octane alternative fuel that can be easily adopted for use in small aircraft. Engines can be modified to use ethanol with relatively minor adjustments. Not only are there numerous performance advantages with ethanol, including smoother operation, increased power, and superior resistance to knocking, but it also enjoys a relative cost advantage compared to Avgas. In addition, since ethanol burns cleaner than petroleum-based fuels, there are also significant environmental benefits.

All of the aircraft modified to use ethanol are for all practical purposes flexible fuel aircraft, since they can burn either ethanol, ETBE, gasoline, or any mixture of these fuels.

Ethanol is currently being demonstrated on a widescale basis, and has received FAA certification for use in two series of aircraft engines and in the most popular training aircraft in the world, the Cessna 152 (Shauck and Zanin, 1997).

CLEAN AIRPORTS IMPLEMENTATION

The goal of this program is to implement the use of alternative, clean fuels at airports by providing a refueling facility for alternative fuels. To apply for designation as a clean airport, it will be necessary to enlist stakeholders to coordinate and oversee the program, to draft and sign a Memorandum of Understanding (MOU) among them, and to appoint a Clean Airport Coordinator. If the criteria are not met at the time of designation, commitments have to be made to develop a program and the facilities in a timely manner. In brief, the criteria are the following (a Clean Airports Program brochure produced by the U.S. DOE is available to the public to further clarify details):

General Aviation Airports

- Appoint a clean airport coordinator
- Form a stakeholder committee
- Develop a program plan

The program plan will include a schedule to fulfill the following goals:

- The airport will serve as home base for at least one alternatively fueled aircraft
- The airport will have refueling infrastructure for at least one type of alternative fueled aircraft
- The airport will use alternative fuels in at least some of its ground vehicles
- Establish a public awareness campaign about alternative fuels (such as a display or an education program or a demonstration program)

The Clean Airports Program establishes local partnerships among a particular group of stakeholders, including fixed base operators university aviation programs, and flying clubs, which are committed to operating aircraft on alternative fuels. Clean Airports partners work directly with local businesses and governments to shepherd them through the goal setting, coalition-building, and commitments process necessary to establish the foundations for an alternative fuels airport.

Commercial Airports

- Appoint a clean airports coordinator
- Form a stakeholder committee
- Develop a program plan

The program plan will include a schedule to fulfill the following goals:

- Develop assessment of current environmental impact of airport
- Develop a set of appropriate environmental goals and the means of realizing these goals
- Establish a public awareness program about the environmental conditions at the airport and the ongoing efforts to improve them

A prominently displayed exhibit in the main terminal of a commercial airport will fulfill this last requirement. Alternative fuel suppliers will provide information on their products and their implementation at the airport. RAFDC would provide information and exhibit material concerning the environmental impact of aircraft fuels, emissions, and possible measures to improve it. Pamphlets and a newsletter will be develop for this exhibit.

RAFDC's Suggested Future Courses of Action:

- Form alliances that include major metropolitan airports and general aviation airports where appropriate (example: Will Rogers-Wiley Post-C. E. Page, airports in the Oklahoma City area under a single airport authority)

- Develop criteria for certification of a clean airport coordinator (suggestions: short courses by distance learning offered on regular basis, periodically scheduled teleconferences to exchange and update information)
- Yearly conference (including workshops and clean airport coordinator certification-- possibly, this year, held in conjunction with the 2nd International Conference on Alternative Aviation Fuels at Baylor University, November 6-8)
- Establish a nationwide Newsletter to report progress and share information
- Clean airports can become the base for an airborne air pollution monitoring operation (providing an environmental service for the whole metropolitan area while monitoring transport of air pollutants for the whole region)
- Joint recognition of the program from the FAA, EPA and DOE.

CLEAN AIRPORTS DESIGNATIONS AND FUTURE IMPLEMENTATION

Texas State Technical College (TSTC) airport in Waco, Texas, was the nation's first Clean Airport to be designated in June 1996. This is the airport housing RAFDC's facilities. There is an ethanol fueling site and four aircraft powered by ethanol at this airport. An education/demonstration program has been in place for many years.

The second airport designated in August 1996 was the Morgantown Municipal Airport in Morgantown, West Virginia. The Mechanical and Aerospace Engineering Departments at West Virginia University (WVU) have converted a Cessna 150 to use ethanol as its fuel. A refueling site and an educational exhibit on the project are in place.

In April 1997, McGregor Municipal Airport in McGregor, Texas, was the first non-controlled airport to be designated as Clean Airport. There is a 1000 gallon underground tank dedicated to ethanol. One ethanol powered Pitts Special, an acrobatic aircraft, is based at the airport as well as electrical carts and alternative fuel powered airport equipment .

Another airport, Tea airport in Sioux Falls, South Dakota, is ready to be designated. It has a refueling site in place and six aircraft converted to use ethanol. These aircraft have been involved in demonstration flights around the U.S.

The next airports to be designated, in June 1997, are Will Rogers International Airport and its two satellite airports, Wiley Post and C.E. Page, in Oklahoma City.

Many other airports around the country are interested in the designation. RAFDC is continuously receiving requests for information on the designation procedures.

The program is still new and open to suggestions. A session dedicated to the Clean Airports Program will be held at the 2nd International Conference on Alternative Aviation Fuels on November 6-8, 1997 at Baylor University in Waco, Texas.

By joining the Clean Airports Program, airports could make a significant contribution to the nation's efforts to diversify U.S. fuel consumption patterns and improve air quality by increasing the use of alternative fuels.

CONCLUSION

The United States spends more than $50 billion each year to import oil, accounting for more than fourty percent of the trade deficit. Ninety-seven percent of our total transportation energy comes from oil. Furthermore, U.S. oil consumption is growing while production levels are declining. At this time, the U.S. is over fifty percent dependent on imported oil.

Moreover, transportation use is the single largest (eighty percent) contributor to air pollution in many cities. According to the American Lung Association, approximately $50 billion is spent each year on health care as a direct result of air pollution.

Airports are major contributors to pollution. The problem facing the aviation industry today is similar to the one the automobile industry had to face approximately 10 years ago: the engines had been cleaned up as much as possible, the only remaining method of improving emissions had to be the reformulation of the fuel.

The aviation industry must develop and implement strategies to deal with its environmental impact in its own self interest, as opposed to resisting change and dealing with drastic regulatory action.

By introducing and encouraging the use of alternative fuels in aircraft and at airports, the U.S. Department of Energy/Baylor University Clean Airports Program actively reduces the nation's energy security burden, improves the environment, and provides new economic opportunities for our country.

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