Fuel Tanks

Nowadays, 90% of the worldwide vehicles work with fossil fuels. Use of fossil fuels contributes to the

greenhouse effect and, to increase the pollution worldwide. Hydrogen has been suggested as a possible alternative to fossil fuels. However, the use

of hydrogen as fuel implies using, different fuel tanks. Due to its lower energy density, hydrogen requires fuel tanks with larger volume than conventional fuels,

for an equivalent amount of energy released. The larger tanks modify the external geometry of the vehicle and therefore the aerodynamics are also different. The aim

of this project is to carry out an experimental and Computational Fluid Dynamics (CFD) analysis of an Airbus A320 and a tanker truck for which

the geometries have been modified accounting for the larger hydrogen fuel tanks needed. Then, the aerodynamic performances of the modified vehicles are compared with the

reference conventional A320 and tanker truck. The software used in this analysis is ANSYS Fluent. As in other CFD analysis, the procedure we followed consisted of

these steps: generation of the geometry, meshing, definition of the boundary conditions and the physics of the problem, solving, processing of the

results. Firstly, the A320 and tanker truck fuel tank modelling have been done in order to stock up the same quantity of fuel as before and to keep an

equivalent energy. The modelling process has been performed thinking about the worst possible aerodynamics case. Furthermore, the control volume dimensions have

been chosen, that is, the fluid field domain around the target body. Dimensions of the control volume have to be sufficiently big in order to not disrupt the

simulation. ANSYS Meshing allowed us to do the mesh. We have tried that cells were refined as much as possible into the interest zones. The mesh quality parameters

have been considered to ensure that the simulation is reliable. For the Airbus A320 study, two simulations have been carried out, the first one without

any modification and the second one considering the implementation of hydrogen as fuel. For the tanker truck study, three simulations have been carried out, the

first one without any modification, the second one considering that is constituted by one single hydrogen tank and the last one considering that is constituted by

two hydrogen tanks in order to improve the manoeuvrability. The idea is to compare the simulations to better understand what is happening in each

vehicle. It has been seen that the modified A320 presents an increase on drag and lift forces. To be able to overcome this increase on drag, extra

fuel will be burnt. Furthermore, because of the implementation of the hydrogen tank, the aircrafts structure weights more than before. However, as

hydrogen is now the fuel and it weighs less than Jet A, the total weight of the aircraft is reduced. In this way, we do not need to fly with any AOA higher than the

actual one because the current lift is able to compensate the weight of the aircraft. Pitifully, hydrogen is so expensive at present day, and its implementation would be

very expensive for airlines. Regarding the tanker truck modifications, the tanker truck constituted by two hydrogen tanks presents the higher

increase on drag. However, is not too much larger than the one single hydrogen tank tanker truck. Because of the higher manoeuvrability, it is

thought that it would be the best option. We printed 3D models of the A320 studied geometries and tested them in a wind tunnel to measure experimentally the

aerodynamic performances and compare them with the results of the CFD simulations. From this analysis, appears that there are many external factors that affect the

experiment. However, it has been seen that the modified aircraft presents more drag because of the new fuel tank and the efficiency also diminishes.

Four selected plastic fuel tanks and containers were subjected to preliminary evaluation tests related to boating safety and the results compared to

those obtained on a metal fuel tank. The preliminary tests were: receiving inspection; proof/rupture; flame; static electricity; impact drop shock;

permeability/fuel weight loss; sunshine; and vibration. The tests were designed to simulate the most severe conditions which the containers might

encounter in typical recreational boating usage. Test results are tabulated. (P.P.-PL). Study of Thermal Insulation for Airborne Liquid Hydrogen Fuel

Tanks
A Subject Bibliography from Highway Safety Literature
Fuel Tank Systems
Portable Marine Fuel Tanks, UL 1185

Automobile Fuel Tanks, a Subject Bibliography from Highway Safety Literature

Fuel Tanks, Fuel Tank Filler Pipes

Twenty-Three by twenty foot (lay flat)

pieces of tubular fabric was coated with polyurethane and fabricated into two 7500-gallon fuel tanks. The tanks were shipped to Arizona for filling and exposure testing. (Author).
This report summarizes activity performed in support of the FAA's

Fuel Containment research program. A review was made of previously performed pretest analysis and longitudinal test results for a double-wall cylindrical auxiliary fuel tank. A review was made of the Auxiliary Fuel System Installation Advisory Circular.

Available data from recent, pertinent transport category airplane accidents and full-scale crash test results were discussed for their relevance to the Fuel Containment research effort. The fuel tank/airframe installation was defined for the next series of

longitudinal- and vertical-impact tests. The outline of a proposed semiempirical procedure was developed. The procedure's potential would be for use in evaluating fuselage- auxiliary fuel tank installations under dynamic loading

utilizing available and pending test data.
Underground Heating Oil and Motor Fuel Tanks Exempt from Regulation Under B029 I of the Resource Conservation and Reco
(Fuel Tanks and Foam).

Steering Control Rearward Displacement
Electrostatic Hazards of Urethane Packed Fuel Tanks
Automobile Fuel Tanks
Rotary Balance Data for an F-15 Model with Fuel Tanks for an Angle-

of-attack Range of 80 to 900
Standard for Fuel Tanks, Fuel Tank Filler Pipes, and Fuel Tank Connections-passenger CarsFuel Tanks, Fuel Tank Filler Pipes and Fuel Tank Connections-passenger Cars; Comments of General Motors Corporation on Proposed Motor

Vehicle Safety StandardFord Pinto Fuel TanksABDO

The purpose of this project was to develop a Raman-based method for detecting oxygen and nitrogen in empty fuel tanks. The need for such a method comes from the potential danger of allowing explosive oxygen-

fuel mixtures to accumulate in empty airplane fuel tanks. An explosion resulting from such a mixture is believed to have caused the Flight TWA 800 disaster in 1996. Recently, (e.g., February 17,2004 press release) the FAA announced its intentions to make fuel tank inerting mandatory.

One potential solution to this problem is to use an inert gas such as nitrogen to flood the empty fue1 tanks in order to reduce the concentration of oxygen.
Chen, Peter C. Glenn Research Center
Guidance for Residential Underground Fuel Tanks Releases

1956-1958
Conventional Fuel Tank Blunt Impact Tests
A Study of the Flammability of Commercial Transport Airplane Wing Fuel Tanks
Analysis of the Effect of Large Fuel Tanks on Aerodynamic Performances

of Heavy Trucks and Large Aircraft
Standard for Fuel Tanks, Fuel Tank Filler Pipes, and Fuel Tank Connections-passenger Cars
"The Fire Safety Team of the Airport and Aircraft Safety Research and

Development Division performed tests at the Federal Aviation Administration (FAA) William J. Hughes Technical Center using the environmental

chamber and the air induction facility (wind tunnel) to examine individual effects that contribute to commercial transport wing fuel tank flammability.

Additionally, previously acquired wing tank flammability measurements taken during flight tests were compared with the results from the FAA

Fuel Air Ratio Calculator in an effort to see if the calculations agreed with existing flight test data. The results of the scale fuel tank testing

in the environmental chamber showed that (1) fuel height in the tank had little or no effect on the flammability, (2) increasing the amount of heat on the top surface

and a higher ambient temperature caused increased flammability, and (3) lower fuel flash point increased flammability greatly. Wind tunnel tests

conducted with a section of a Boeing 727 wing tank showed that, under dynamic airflow conditions, change in ullage temperature was the primary mechanism

affecting ullage flammability, not fuel temperature, as observed in environmental chamber tests. Other wind tunnel tests showed that the angle of attack of the

fuel tank played little role in reducing fuel tank flammability, but that a cross-venting condition of the fuel tank would lead to a very rapid decrease in

hydrocarbon concentration. An input temperature algorithm could be used with the FAA Fuel Air Ratio Calculator to significantly improve

predictions of wing tank ullage flammability, based on tests that showed in-flight changes of ullage flammability in a wing tank are driven largely by the

ullage temperature. This is very different from what had been shown with a center wing fuel tank, in which fuel temperature continues to be the main driver of

flammability even during flight."--Report documentation page. An experiment investigation has been been carried out to determine the primary

factors that have contributed to recent aircraft electrostatically induced ground refueling fire incidents. It was found that the explosion

suppression open pore polyurethane fuel tank foams along with the charging characteristics of the JP-4 fuel resulted in charge accumulation and

electrostatic spark discharging. The polyurethane foams accumulated charge due to their highly resistive nature (blue, 10 to the 15th power ohm-

cm; red, 10 to the 14th power ohm-cm; yellow, to to the 14th opwer ohm-cm; and orange, 10 to the 13th power ohm-cm). The fuel flow rate and velocity entering the

tank and impinging on the open pore polyurethane foam directly affected te magnitude of the charge separation which was occurring. The number of

refuelings that had taken place also was a critical factor due to its effect on charge accumulation/discharge frequency levels. The last major variable

investigated was pro-static (Gulf-178) and conductivity improving (shell ASA-3) fuel additives. The Gulf-178 additive dramatically increased the levels of

charge separation and accumulation taking place along with a reversal in the polarity of charge. The Shell ASA-3 fuel additive eliminated the aircraft

ground refueling electrostatic discharge hazard decreasing the level of charge accumulation.

The Public's Stake in Our Oil-gas Conservation

Laws
CT Department of Environmental Protection Underground Storage Tank Program Fact Sheet
Fuel Tanks, Fuel Tank Filler Pipes and Fuel

Tank Connections- passenger Cars; Comments of General Motors Corporation on Proposed Motor Vehicle Safety Standard Test and Analysis

Results
Windshield Mounting : Fuel Tanks, Fuel Tank Filler Pipes
Fuel Containment of Auxillary Fuel Tanks

The U.S. Environmental Protection

Agency (EPA) was introduced on December 2, 1970 by President Richard Nixon. The agency is charged with protecting human health and the environment, by writing and enforcing regulations based on laws passed by Congress. The EPA's struggle to protect health

and the environment is seen through each of its official publications. These publications outline new policies, detail problems with enforcing laws, document the need for new legislation, and describe new tactics to use to solve these issues.

This collection of publications ranges from historic documents to reports released in the new millennium, and features works like: Bicycle for a Better Environment, Health Effects of Increasing Sulfur Oxides Emissions Draft, and Women and Environmental Health.

Twelve containers, proposed for shipping/storage of external fuel tanks, were subjected to outdoor storage environmental tests. The external fuel tanks were totally encapsulated in 2.0 p.c.f. rigid polyurethane foam. Opening of container was accomplished by

using a tear wire prepositioned on the fuel tank prior to total encapsulation. From the results obtained it was concluded that the rigid polyurethane foam gives adequate protection to external fuel tanks during unprotected storage and rough handling for a period of 3

years. Also, a tear wire opening of the container at an angle down from the center line of the external fuel tank will provide a good closure without the use of a sealant.

Raman-Based Oxygen and Nitrogen Sensor for Monitoring Empty Airplane Fuel Tanks

Purging, Cleaning, and Coating
Interior Ferrous and Terne Sheet
Vehicle Fuel Tanks
The Design of Fuel Tanks
Fall Hazards While Installing
Underground Fuel Tanks at
Company XYZ
Foam-in-Place, External Fuel Tanks

Occupant Crash Protection

The Director of Research, Air Ministy, in aiming at securing the design of a thoroughly safe and reliable fuel tank for service and commercial purposes, is desirous of bringing to notice

that it is proposed to hold a competition on the lines laid down and governed by a set of rules and regulations.
This project aims at defining better solutions to substitute PbSn `terne' coated steel sheets

for metallic fuel tanks referring to the current context, i.e. the forthcoming alcoholcontaining fuels. In this way we have studied the properties and carried out feasibility investigations of different types

of coated steel sheets: existing materials, also not conventionally utilised for fuel tanks or already considered for these applications, but that need to be tested with alcohol-containing fuels and/or

optimised with respect to the transformation properties; new coatings. The results of these studies consist of an assessment for several types of coated steel sheets of the following properties: stamping (by friction,

powdering, hydroforming tests); assembling (weldability and solderability with various techniques); fuel resistance, to.different fuel blend compositions with tests recommended by carmakers'

specifications and on laboratory prototype (stamped and welded) tanks. On the basis of the results of these evaluations, the transformation properties of different coatings, mainly hot dip aluminised and galvannealed

steel sheets, have been better defined for this application and two kinds of organic coated steel have been selected for manufacturing fuel tank prototypes: hot dip aluminised steel sheet with a new organic

coating (film thickness 8 µm) consisting of an epoxy resin containing aluminium powder; galvannealed steel sheets with a thin (1 µm) organic coating, a material that was developed in the course of a previous ECSC

research project (7210-MB/407). Both these materials have been evaluated with success as full-scale fuel tanks have been stamped and welded under industrial conditions with the fuel tanks'

maker. Finally, an important contribution of this research to the knowledge of materials for this application, is a detailed and updated survey of patents related to coatings for fuel tanks. Seamless Collapsible Fuel Tanks

Rotary balance data for an F-15 model with conformal fuel tanks for an angle-of-attack range of 8 deg to 90 deg
Coated Steel Strip for Fuel Tanks
Report to Congress
A Benefit Analysis for Nitrogen

Inerting of Aircraft Fuel Tanks Against Ground Fire Explosion Recommendations to Improve the Cleanup Process for California's Leaking Underground Fuel Tanks (LUFTs)

This book examines the scope of the Ford Pinto Fuel Tanks disaster, its causes, and how people can keep a similar disaster from happening again. Aligned to Common Core Standards and correlated to state standards. The International Cabin Safety

Research Technical Group's Survivable Accidents Database was used to identify past worldwide transport aircraft accidents and extract detailed data for those accidents where explosion was an issue in the survivability of the occupants. Each of

these accidents was analysed in depth to assess the number of lives and injuries that might be saved if the fuel tanks were protected with nitrogen inerting systems. The objective of this analysis was to assess the potential benefits, in terms of reducing fatalities

and injuries, resulting from three methods of aircraft fuel tank inerting. The methods analyzed were ground nitrogen inerting in centre fuel tank only, ground nitrogen inerting in all fuel tanks, and onboard nitrogen inerting in all fuel tanks. Thirteen

accidents to transport category aircraft were identified during the period from 1966 to 1995 that may have involved a fuel tank' explosion. A mathematical technique was used to model each accident scenario and a Monte Carlo simulation was used to assess a high,

median, and low value for the total achievable benefits.

Final Report

Fundamentals of Noncuring Sealants for Aircraft Fuel Tanks

Small Craft - Permanently Installed Fuel Systems and Fixed Fuel Tanks

Fuel Tanks Taken for Personal Use
Control and Accountability of Mobile Fuel Tanks in the New York State Department of Transportation
"Abstract: The Federal Railroad Administration's Office of

Research and Development is conducting research into fuel tank crashworthiness. A series of impact tests are planned to measure fuel tank deformation under two types of dynamic loading conditions - blunt and raking impacts. This paper

describes the results of the first set of blunt impact tests for two retired EMD F-40 locomotive fuel tanks, Tank 232 and Tank 202. On October 8, 2013 and October 9, 2013, the FRA performed impact tests on two conventional passenger locomotive fuel tanks

at the Transportation Technology Center (TTC) in Pueblo, Colorado. Each fuel tank was emptied of fluid and mounted on a crash wall with the bottom surface exposed. A rail cart modified with a "rigid" indenter was released to impact the center of the bottom

of each fuel tank at about 6 mph. A center-impact on Tank 232 was chosen to impact between two baffles. A center-impact on Tank 202 was chosen to impact on a baffle. In the first test, Tank 232 was impacted by the indenter at 4.5 mph. The maximum residual

indentation on the bottom of the tank measured approximately 5 inches. The tank deformed across the middle longitudinal span of the tank forming a diamond-shaped indention. In the second test, Tank 202 was impacted by the indenter at 6.2 mph. The

maximum residual indentation on the bottom of the tank measured approximately 1.5 inches. The bottom of the tank deformed with an "X" shape spanning out from the location of square indenter at the center of the tank. Post-test autopsies

revealed the deformation of the interior structures, i.e. baffles and attachments. There was no damage to the baffles in Tank 232. Deformation to the interior structure of Tank 202 was limited to the baffle directly beneath the impact location, which folded in

the area near the impact location. Material coupons were cut and tensile testing performed to determine the properties of the materials used in each tank. Prior to the test, computer models were developed from measurements taken on the test

articles. Material properties were estimated based on Brinell hardness measurements. Computer analyses were conducted to determine the conditions for the test, i.e. instrumentation, location of impact, target impact speeds and

to predict the deformation behavior of the tank. Post-test, the resulting stress-strain relationships for the bottom sheets and baffles of both tanks were used to update the finite element models of the two tanks. The models were also updated to

reflect the actual geometry of the tanks as confirmed by measurements of the tank interiors. The results of the finite element (FE) models run at the test conditions with the updated tank details are compared with the results from the test itself.

Specifically, the deformation progression and the residual dent depth are compared between the tests and the models. In accidents, fuel tanks are subjected to dynamic loading, often including a blunt or raking impact from various

components of the rolling stock or trackbed. Current design practice requires that fuel tanks have minimum properties adequate to sustain a prescribed set of static load conditions. Current research is intended to increase understanding of the

impact response of fuel tanks under dynamic loading."
The need for efficient space utilization in military aircraft has led to the use of wing and fuselage cavities as fuel tanks. Of the three methods of sealing these cavities (filleting, faying,

and channel), channel sealants are the least understood and have the most contrast between behavior and requirements. Potential failure mechanisms were identified against the thermal, chemical, and physical aspects of the fuel tank

environment. Thermal degradation, low temperature embrittlement, thermal expansion, and viscosity reduction were mechanisms associated with the -54 C to +177 C temperature range. Hydrolysis, oxidation, closed system

reversion, and crosslinking were associated with the chemical aspect. Fuel swelling of the sealant, extraction by fuel, system pressure, vibration, shear, and adhesion/cohesion were associated with the physical aspect. Selected polymers with a

wide variety of formulating ingredients were evaluated as channel sealants in laboratory-sized test apparatus to confirm the suspected failure mechanisms. The results have been digested as engineering principles that govern the

behavior of channel sealants. Application of these principles resulted in some immediate benefits and a basis for long range sealant development.

Ford Pinto Fuel Tanks

Competition for Safety Fuel Tanks

Steering Control Rearward Displacement Windshield Mounting
Windshield Mounting : Fuel Tanks
Fuel Tank Filler Pipes and Fuel Tank Connectors
Impact Tests of Flexible Nonmetallic Aircraft Fuel Tanks

Installed in Two Categories of Simulated Wing Structures

No Ghost Towns, No Empty Fuel Tanks

Fall-related construction deaths have consistently exceeded the national fatalities by almost three

times the national rate. Employees at Company XYZ were routinely exposed to fall hazards while installing underground fuel tanks without effective fall protection solutions. The introduction of this work

provides background information and statistics to this little studied fall protection hazard. This study has three main goals: 1. Collect and assess data about the fall hazards that typically exist with underground fuel tank

installations. 2. Determine the extent of employee knowledge of fall protection regulations at Company XYZ. 3. Develop effective fall protection solutions for employees exposed to fall hazards while installing

underground fuel tanks at Company XYZ. The literature review discusses studies the broad range of regulatory requirements and consensus standards relevant to this topic. Quantitative and qualitative

research was conducted with surveys for exposed workers and supervisors, and interviews with industry subject matter experts. This research was compiled, summarized and discussed in the results section. Effective solutions

are presented in the conclusion, with the use of ladders as the ultimate resolution. Ladder use proves to be the most cost effective, efficient, and feasible solution, including the added benefit of little training required for

the employees.
Report
Portable Plastic Fuel Tanks
Flexible Pipes, Flexible Fuel Tanks and Self-sealing Fuel Tank Coverings for Aircraft