GM C/K PICKUP TRUCK FUEL TANK RETROFIT EVALUATION PHASE 1

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PREFACE

The work described in this report was performed at the request of Mr. Kennerly Digges, an agent for the Automotive Safety Research Institute. This report constitutes a partial deliverable for the Alternative Gas Tank Systems for the GMC C/K Pickup project, and outlines the general activities conducted during the initial evaluation of alternative fuel systems.

The opinions expressed herein are those of Biokinetics and Associates Ltd. and do not necessarily reflect those of the client.

TABLE OF CONTENTS

LIST OF FIGURES

1. INTRODUCTION

A fuel system retrofit program is being considered for the 1973 to 1987 General Motors C/K Pickup truck to improve system integrity. The truck model years in question have the fuel tank mounted between the vehicle frame rails and exterior body. It has been shown that when this vehicle is struck in the side by another vehicle, the fuel tank is susceptible to damage [Ref. 1]. The damage, in one form or another, may lead to fuel leakage and the increase the potential for post-crash fires.

A retrofit program is under evaluation to determine if an alternative fuel tank and/or location could provide increased crashworthiness of the fuel system. There are currently many different retrofit options including the installation of stronger gas tanks or moving the tanks to safer locations between the vehicle frame rails.

Each of the suggested retrofit options needs to be evaluated for feasibility including cost, materials, installation and safety. Additionally, those options that are shown to be reasonable need to be properly tested. A work plan for a full-scale test program has been developed in conjunction with this effort, as described in Biokinetics Report No. P99-33, Workplan for Full Scale Impact Test of Alternative Fuel Tank Systems for GM C/K Pickup Trucks.

2. RETROFIT ACTIVITIES

The purpose of the following activities was to evaluate the vehicle with its existing fuel tank system, assess the space available for a different tank, research alternative fuel systems and generate several retrofit options. In addition, a literature review was conducted to better understand the crash hazards and the feasibility of similar vehicles passing the same test [Ref. 1-5].

2.1 VEHICLE PURCHASE

For the purpose of evaluating the space available for a retrofit fuel system, an exemplar pickup truck was purchased. The vehicle is a 1986 GMC C/K 2500 pickup with two-wheel drive and a 350 cu. in. engine with a single exhaust. The body consists of a regular cab and a long 8-foot box. This particular model is equipped with a dual fuel tank system with a switching valve below the cab. The fuel tanks are mounted on both sides of the truck, outside the frame rail.

To better evaluate the vehicle, the truck box and the driver's side fuel tank were removed. Given the age of this vehicle and exposure to winter driving conditions, the frame shows little sign of rust and corrosion. The state of the subsequent vehicles will need to be a consideration during crash testing.

2.2 FUEL TANK SUPPLIERS

Fuel tank suppliers were identified to provide information on replacement and auxiliary tanks, speciality tanks, steel, aluminium and plastic tanks.

For practical purposes, the suppliers that were contacted are based in North America though some of these do have many world wide manufacturing facilities. It was found that there are similar companies representing all the major world regions.

A list of fuel tank suppliers that were researched or contacted is included in Appendix A. Estimated tank costs and associated installation costs are presented in Appendix B.

2.3 FUEL TANK PURCHASES

Based on available space, a search of the fuel tank suppliers was conducted to identify possible replacement tanks. Fuel tanks from several makes and models of vehicles were purchased from different suppliers for evaluation. These tanks were physically placed within the vehicle to assess the space available beneath

the truck for alternatives to the current tank. The tanks are detailed in later sections.

3. RETROFIT EVALUATION

Based on vehicle configuration, available fuel tanks and safety issues, several retrofit ideas were generated and are described below. It is assumed that the existing fuel system will be removed regardless of the type of the retrofit system to address uncertainties with tank integrity.

3.1 TANK RELOCATION

The objective of relocating the tank is to install an alternative tank into a more protected compartment. The main frame rails of the C/K Pickup could provide impact protection if the tank was placed between these rails. Considering the space between the rails, there are two alternatives for tank placement, centre mounted beside the drive shaft and on the underside of the box, aft of the drive axle.

The preference would be to utilize an existing fuel tank, possibly from another vehicle make or model. If another tank was used, from Ford for example, the sending unit for the fuel gauge that is fitted to that tank would not be compatible with the electronics of the GMC pickup. It is possible, however, to correct this with minor modifications by the sending unit manufacturer.

3.1.1 CENTRE MOUNTED - ALONGSIDE DRIVE SHAFT

The first option is to relocate the tank inboard from its current position to occupy the space between the chassis rail and right of the drive shaft. Currently, the space is empty with the exception of the dual tank switch under the cab, which would be removed during the retrofit. With a newly designed mounting bracket, a tank could be installed using off-the-shelf mounting straps. Fuel lines would require minimal modification and the fuel filler hoses could be routed to accommodate the access locations on the left (post 1981) or right side (pre 1981).

Photo 1: Centre and Side Mounted Tank

After considering many makes and models, a standard tank from an '83-84 Ford Ranger could be used with the filling tube on either the right or left-hand side. For large production quantities, having a custom tank designed and manufactured could maximize fuel capacity and simplify installation.

There are concerns with this option due to vehicle variations. Vehicles built after 1981 have the fuel filler door on the left side of the box, requiring a longer fill hose that would be more cumbersome to route. The hose would have to travel over the exhaust and drive shaft, occupying the space between the box and the rail. Fuel may pool in such a long, horizontal tube increasing the risk of compromising the fuel system integrity.

For those vehicles with a dual exhaust, such as the truck with 454 cu. in. engine, the right side exhaust would have to be re-routed along the left side of the vehicle to allow the tank to be fitted. Additional re-routing may be required to accommodate the transfer case on a four-wheel-drive truck.

3.1.2 REAR MOUNTED - AFT DRIVE AXLE

The second option is to relocate the tank at the rear of the truck, beneath the box, in place of the spare tire. This tank would be positioned between the chassis rails, the rear bumper and the drive axle. Aero Enterprise, a fuel tank manufacturer, can supply 25-30 gallon auxiliary tanks that are designed to fit in this space on the Chevy Pickup. This tank comes as a complete kit, including hardware, mounting brackets and filler tubes.

Photo 2: Aero Tank Kit

This kit is designed to have the tank mounted to the underside of the truck box using two carriage bolts. This may be insufficient due to the condition of the box on these older trucks. It would be preferable to mount this tank directly to the frame rails and, with minor modifications, this could be achieved using existing tabs on this tank. The second issue is that the filler hose travels into and is accessed from the open wheel well. The cap and tube are more susceptible to damage as they are completely unprotected.

As this kit does not currently satisfy all the safety concerns, a custom designed kit may be an alternative. It was found that a fuel tank from a '84 Ford Bronco II could fit in the same location as the above tank. A system could be developed to securely fasten this tank in place and the filler system could be safely routed to an opening in the truck box.

Photo 3: Rear Tanks

Crashworthiness, however, remains a concern with this option. Although this new position is away from the side impact location in question, it may now be susceptible to rear impacts and further safety studies would be required. A second concern is the loss of the

spare tire and, if required the relocation of this tire to somewhere else in the vehicle.

3.2 Fuel Cell (Bladder)

A fuel cell is a gas tank alternative consisting of a rubberized fabric bladder inside a steel container. This type of tank is both impact resistant and non-exploding and is normally used for racing applications. For consideration in the C/K Pickup, Aero Tec Laboratories (ATL) Inc. was contacted for information.

The first option was to purchase a standard size fuel cell. For this type of application, ATL offers several different capacity tanks, each with different outside dimensions, with prices ranging from $450-1100 US. Designed for racing, these tanks tend to be very compact and thus do not fit the physical requirements of the pickup truck.

Photo 4: Fuel Cell

This led to the second option, purchasing a custom designed fuel cell. Based on the current models, ATL can build fuel cells to custom specifications including size and fitting requirements. The fittings were specified such that the fuel line fittings and the sending unit for the fuel gauge are compatible with the GM system. In addition, a specialized filler hole can be added that includes a flapper valve, preventing fuel from leaking in the event that the filler hose or cap is damaged in the impact.

The last option was to have a bladder, like those used in the fuel cells, installed inside the existing fuel tank. Normally reserved for vintage racing cars, this is not a common practice. The fuel bladders are hand-made from flat stock and can not accommodate rounded corners or stepped heights. Internal baffles and edges in the fuel tank need to be removed to eliminate abrasions. ATL first requires an evaluation of the existing tank to determine whether it will accept a fuel bladder. Considering these concerns and the current tank, this option is not recommended for the C/K Pickup.

It is important to note that ATL builds all of the above fuel bladders to meet FIA FT-3 specifications that recommend a maximum bladder life span of five years. Information for the rationale behind the five-year life span is not readily available. Fuel cells are often returned for service or maintenance and ATL technicians have seen operational bladders, without significant deterioration, as old as 15 years.

3.3 PLASTIC TANK

According to the manufacturers, plastic tanks out-perform steel tanks in durability, permeation and crashworthiness. Made from 1/4-inch thick polyethylene, these tanks never rust and have no welds or seams to fail or leak. Plastic tanks are readily available that match the shapes and dimensions of the stock tank. Provided that the plastic tank can withstand the impact requirements in the current location, this would be a retrofit with minimum vehicle alterations.

Photo 5: Plastic Tank

It is of interest to note the changes in the tank-mounting brackets, which were purchased to assess the re-assembly of a plastic tank into the existing location. The original brackets have a welded nut requiring the mounting bolt to be pointed towards the tank, a recognized hazard. The replacement brackets, purchased from a GM dealer, have not included this welded nut which allows the bolt to be inserted from the other side and point away from the tank. This minor change will reduce the likelihood that the bolt will tear the tank. Changes like this, as described in the next retrofit option, could be used in conjunction with a plastic tank to increase the overall crashworthiness of a fuel tank remaining in the current location.

3.4 TANK PROTECTION

As an alternative to a different tank, it may be possible to modify the area around the existing fuel tank to improve the overall crashworthiness. After examining the tank and common failure modes [Ref. 1], several items were identified as being possible hazards to the tank. These included sharp edges on the tank mounting brackets and protruding bolts for mounting of the brake line. If these items can be removed or made blunt, the likelihood of the tank being punctured in an impact could be greatly reduced.

There may be other items that could affect integrity of the tank that have yet to be identified. For example, a running board is a common accessory to a pickup truck that poses a clear danger of impacting and damaging the existing tank. If the tank is to remain in this location, further study could be conducted to eliminate additional hazards.

Additionally, the existing mounting brackets could be replaced with a stronger system. It is suggested that a new system be constructed that would increase the number of brackets from two to at least three and the brackets would enclose the entire tank instead of simply supporting the underside. These new brackets would also be joined with cross members. This would essentially create a cage

around the gas tank strong enough to transmit the impact forces directly to the frame of the truck and away from the tank itself.

Finally, it is recommended that the tank be replaced during this installation because of the likely corrosion of existing tanks. If this were the case, these modifications could be implemented in conjunction with the installation of a plastic tank.

3.5 BOX TANK

This alternative is the second to employ an existing auxiliary fuel tank. A common truck accessory is a toolbox that fits in the front of the truck box, immediately behind the cab. Auxiliary Truck Accessories manufactures such a toolbox that also incorporates a 40-gallon auxiliary fuel tank with all the necessary conversion hardware. These tanks are equipped with a roll over valve to reduce the likelihood of fuel leakage. While this fuel tank would be further away from the point of a side impact, the crashworthiness of such a device is unknown. In addition, consumers would lose considerable space in their truck bed.

4. RETROFIT COMPARISON

A subjective comparison of the retrofit options, based on the advantages and disadvantages of each, is presented in Table 1. Each system has been given a rating out of three (1-best, 3-worst) in each categories. Each category has been listed according to importance and is weighted with a multiplier such that the maximum score on the least critical criteria equals the lowest score on the most critical.

Crashworthiness of Fuel System - This is an estimation of post-crash integrity of the fuel tank and filler / pickup system based on type and location of fuel tank.

Availability of Tank and Peripheral Components - This column rates the overall availability of the system. Of-the-shelf components receive a better score than items that are specifically designed and built.

Cost of Complete Retrofit - This rates the estimated cost (See Appendix B) of the retrofit as follows: Under $600 - 1, Between $600 and $1200 - 2, Over $1200 - 3.

Ease of Installation - This rates the ease of installation, given that a complete kit has been supplied to a qualified technician. For example, options requiring modifications to the truck body or exhaust system would score poorly.

Impact on Functionality - This category penalizes the retrofit options that limit the functionality of the vehicle, e.g. a tank that occupies space in the truck box.

Table 1: Retrofit Comparison

Categories / Options	Crashworthiness of Fuel System	Availability of Tank and Components	Cost for Complete Retrofit	Ease of Installation	Impact on Functionality	Total (Weighted)	Ranking
	Weighting Factor						
	3	2.5	2	1.5	1		
Tank, centre mounted	1	1	2	3	1	15	1
Tank, rear mounted	2	1	1	2	2	15.5	2
Plastic Tank, side mounted	3	1	1	1	1	16	3
Tank Protection	2	2	2	2	1	19	4
Fuel Cell, side mounted	1	3	3	2	1	20.5	5
Tank / Toolbox, box mounted	2	1	3	2	3	20.5	6

The tank relocations scored very well in this comparison based largely on the increased crashworthiness and availability of components. The plastic tank, although possibly stronger than the existing tank, is still susceptible to damage if it is to remain in the current location. The tank protection had average scores across all categories and thus ranked near the middle of the field. Finally, both the fuel cell and box-mounted tank have good crashworthiness but the high cost of the retrofit scored very poorly.

All of the retrofit options will require a fuel filler system. There is a safety concern that the hose between the filler cap and the gas tank could be damaged during an impact allowing fuel to leak directly from the filler hole on the tank. This is an issue for not only this particular pickup, but for most vehicles, regardless of the location of the fuel tank itself. A system, such as a flapper valve, installed at the gas tank opening, could prevent such leakage and should be evaluated for each available retrofit option. Both the fuel cell and the truck box tank employ such a device.

5. SUMMARY AND RECOMMENDATIONS

An exemplar GMC C/K Pickup truck was purchased to evaluate the current fuel tank location and the available space for relocation. Several suppliers of fuel tanks were identified and contacted to assess the available options of standard and specialized tanks. Sample models were purchased and evaluated with the available space on the vehicle. Following this, a variety of retrofit alternatives were developed.

Each retrofit alternative was discussed to assess their advantages and disadvantages and it was then possible to rate each alternative in a variety of categories. It was found that mounting an alternative tank between the frame rail and the drive shaft was the optimal solution. This tank, along with some of the other retrofit options, will be tested during the next phase of this program.

6. REFERENCES

Ref. 1: Arndt, Mark W., “Failure Modes of General Motors C\K Light Truck Outboard Frame, Side-Mounted Fuel Containment System”, Arndt & Associates, Ltd., Tempe, Arizona, March 24, 1994.

Ref. 2: "Engineering Analysis Report and Initial Decision that the Subject Vehicles Contain a Safety-Related Defect", October 17, 1994.

Ref. 3: “FM Pickup Truck Defect Investigation Corrosion and Fuel Tank Integrity”, Office of Defects Investigation, National Highway Traffic, Safety Administration, October 18, 1994.

Ref. 4: Hubele, Norma F., “A Critical Review of the Reports in the Public File (Aug. 1992 - Nov. 1993) Submitted by GM and NHTSA on Recorded Accident Data of Pickup Trucks with Side-Mounted Gas Tanks”, Refrac Systems, Phoenix, Arizona, March 24, 1994.

APPENDIX A FUEL TANK SUPPLIERS

The following is a list of fuel tank suppliers.

Fuel Tank Suppliers		
Name	Contact Information	Description
Aero Enterprise	1780 Pomona Road Corona, California 91720 Tel: 909-737-7878 Fax: 909-737-8226 Toll Free: 800-783-4826 www.aerotanks.com	- Specializes in manufacturing auxiliary and replacement gas tanks - Builds custom fuel tanks to specifications or to fit vehicles not in inventory - Provides mounting hardware as well as installation
Aero Tec Laboratories Inc.	Spear Road Industrial Park Ramsey, NJ 07446-1251 USA Tel: 201-825-1400 Fax: 201-825-1962 Toll Free: 800-526-5330 www.atlfuelcells.com	- Impact resistant, non-exploding tank with a rubberized fabric bladder inside a metal container - Offers several models with ranges of strength and size
Auxiliary Truck Accessories	13211 Bee Street Dallas, Texas 75243 Toll Free: 800-809-8265 www.rpm-tank.com	- Manufactures tank / toolbox combos that fit in the bed of the truck - Builds replacement tanks, both either standard or custom sizes, in either aluminium or plastic
Dynafab Corporation	4711 Winfield Houston, Texas 77039 Tel: 281-590-5467 Fax: 281-590-9255 www.dynafab.com	- Offers several models of steel or aluminium gas tanks in a range of sizes as well as mounting hardware - Will build custom tanks
MTS Company, L.C.	1365 Kane Street Debuque, Iowa 52001 Tel: 319-557-9577 Toll Free: 800-522-1622	- Manufactures polyethylene replacement fuel tanks for light trucks

Fuel Tank Suppliers		
Name	Contact Information	Description
	www.mtscompany.com	
Plastic Omnium Industries Inc.	2610 Bond Street Rochester Hills, Michigan 48309 Tel: 248-853-0088 Fax: 248-853-6973 www.plasticomnium.com	- Leading automotive equipment manufacturer for exterior components and fuel systems - World-wide facilities
Spectra Premium Industries Inc.	1421 Ampère Street Boucherville, Québec Canada J4B 5Z5 Tel: 450-641-3090 Fax: 450-641-3866 Toll Free: 1-800-577-9486 www.spectrapremium.com	- Manufactures over 465 models of replacement fuel tanks for domestic and import vehicles
Textron Automotive Company	Windsor Tel: 519-974-6656 www.tac.textron.com	- Independent supplier of plastic fuel tank systems for cars and light trucks - World-wide facilities
Walbro Corporation	1227 Centre Road, P.O. Box 215257 Auburn Hills, Michigan 48326 Tel: 248-377-1800 Fax: 248-377-1660 web.walbro.com	- Manufactures plastic fuel tanks for many automotive companies - World-wide facilities

APPENDIX B FUEL SYSTEM PRICES

The table below shows the price estimation for each retrofit option based on a high volume retrofit program and may not be representative of the cost of modifications required during the testing program. All prices are in US dollars and exclude taxes.

Option	Tank	Filler, etc	Sending Unit	Brackets	Labour	Total
Tank, centre mounted	$120	$100	$140	$150	$250	$760
Tank, Rear mounted, kit	$400	-	-	-	$200	$600
Fuel Cell, side mounted	$1,080	$50	-	$150	$100	$1380
Plastic Tank, side mounted	$145	$50	-	$130	$100	$425
Tank Protection	$145	$50	-	$250	$200	$645
Tank/Toolbox, box mounted, kit	$1,020	-	-	-	$290	$1310
Tank, box mounted, kit	$775	-	-	-	$290	$1065

Notes:

1. Labour rates are estimated at $50US per hour.
2. Labour rates for the kits include the installation by the manufacturer plus $60 for the removal of the existing tank.
3. Installation cost for Tank, centre mounted may require an additional $300 in labour to re-route the exhaust system, depending on the specific truck.