ADEPT SCIENCE & TECHNOLOGIES, LLC
51 Rover Boulevard, Los Alamos, NM 87544 USA Telephone: (505) 672-0002 Fax: (505) 672-0003

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October 6, 2006

Final Report to PERC

Docket Number:	**11653**
Project Title:	**Acoustic Stop-Fill Instrument for LP Gas Tanks**
Grantee:	Adept Science & Technologies, LLC (ASCENT)
Report Period:	**FINAL REPORT**
Contact:	Jared Meyer, (310) 441-4404, jmeyer@adeptscience.net

1.0 Executive Summary

VIA Metropolitan Transit (VIA) initiated ASCENT's work on a non-invasive stop-fill instrument to be used on their LP Gas powered vehicles. One objective of this work is to provide redundancy to the overfill protection device (OPD). This is achieved with an ultrasonic sensor that is placed at the ~80% full level on the outside of the bus' fuel tank.

This PERC project helped advance ASCENT's technology in three specific areas: (a) electronic packaging, (b) electronic design, and (c) sensor assembly design. Prior to this PERC funded project, ASCENT demonstrated an alpha prototype at VIA in 2004.

The project started in mid-July 2005. Initially, a system that would be active during the bus refueling process was to be developed. When the liquid reached the desired level and was sensed by the Maximus™ instrument, the sensor would signal via radio frequency to shut off the LP Gas dispenser. Meanwhile, VIA's staff communicated a more immediate need that could be met by a slight modification of the work-in-progress. This technology shift and project goals modification was proposed to PERC by ASCENT on December 5, 2006. PERC accepted a modified work schedule in light of a revised Texas Railroad Commission ruling (in September 2005) that allows LP Gas fleet operators to keep outage gauges shut while refilling tanks as long as: (1) the tanks are equipped with OPDs; (2) there is documented periodic verification of the OPDs; and (3) and OPDs are replaced every two years. The modified project was to develop a tool to reliably verify OPD performance <u>post-fill</u>. This instrument is now called the Maximus™ Overfill Diagnostic Instrument (ODI).

During the project, prototypes were: (a) bench tested at ASCENT's facilities in Los Alamos, NM; (b) field tested in New Mexico; and (c) tested at VIA.

2.0 Introduction

The LP Gas industry was previously limited to invasive methods to determine when to stop filling LP Gas tanks. The use of outage gauges (AKA fixed liquid level gauges or "spitter valves") is the commonly accepted method to decide when the max fill level is reached. Leaving these gauges open during refilling (a common practice) brings about safety risks, loss of product, undesirable emissions, and liability exposure. When looking at an individual fill, the LP Gas loss is not significant. However, on a national scale, with thousands of fills per day, these losses are estimated at ~2 trillion BTUs/yr (LP Gas + anhydrous ammonia).

The Maximus™ instrument will limit and eventually eliminate the practice of opening the fixed liquid level gauge while refueling tanks equipped with OPDs. The refueling technician will gain the confidence that the tank was not overfilled. For instance, on a vehicle, in the event a tank is overfilled because of a failed OPD, the refueler will receive immediate indication from the ODI and the vehicle can be tagged to replace the defective OPD.

The overfill diagnostic instrument is to be first used on fleet vehicles, although handheld instruments can be used by inspectors or maintenance personnel to spot check OPD functionality. Two embodiments of the instrument can be used to verify OPD functionality for LP Gas fleet vehicles: (1) permanently installed sensor assembly using the dual channel Maximus™ technology (two point level detecting sensors are installed above and below the OPD shut-off line); and (2) removable handheld sensor assembly using the single channel Maximus™ technology (single sensor assembly is moved on the outside surface of the tank like a stud-finder to locate liquid level post-fill). Both keep overfilled tanks from getting out in the field by quickly diagnosing defective OPDs. This non-invasive method saves fuel (money), enhances safety, and does not pollute.

The Maximus™ instrument utilizes a proprietary acoustic method to non-invasively detect liquid or gas inside an LP Gas tank (where the sensor is positioned). Thus, after a fill, the Maximus™ can tell the refilling technician if the OPD worked properly.

3.0 Technology Description

The Maximus™ instrument draws from a patent licensed from a Los Alamos National Laboratory scientist. This core technology, complemented by additional ASCENT intellectual property (in new science as well as in proprietary hardware and software), constitutes the Maximus™ instrument know-how.

The instrument has two sub-systems: (1) an electronics assembly; and (2) a sensor assembly. The electronics generate sound waves and process received signals. The sensor assembly is placed on the outside of the tank. Within each sensor assembly, there are two transducer elements [one transmits (sends) the sound wave; the other receives the response signal].

The electronics generate an inaudible sound which, through the transducers, resonates in the tank wall. The tank wall responses are monitored. There is a distinct difference in the received signal between when there is liquid or vapor phase LP Gas (inside the tank) at the point where the sensor is placed.

The dual channel Maximus™ instrument uses two points of level detection (Fig. 1). When used for OPD verification, the two transducer assemblies are labeled “TOP Sensor” and “BOTTOM Sensor.” They are positioned to straddle the level at which the OPD is supposed to shut-off the incoming fuel flow (e.g. 80% full). The desired distances above and below the OPD shut-off level must be confirmed by the tank manufacturer or the OPD installer (OPD is often installed by the tank manufacturer). In this project, the LP Gas tank manufacturer is Sleegers Engineering Inc (Sleegers). Sleegers provided ASCENT the necessary information for the VIA tanks.

Two LEDs on the instrument are used to indicate OPD functionality. Both LEDs will glow green if two conditions are satisfied: (1) top sensor is above the liquid level; and (2) bottom sensor is below the liquid level. If the tank is overfilled, the top sensor LED will be red because it detected liquid at that point. Similarly, if the tank is underfilled, the bottom sensor LED will glow red because no liquid is detected at that point.

The single channel Maximus™ is used for single point level detection (Fig. 2).

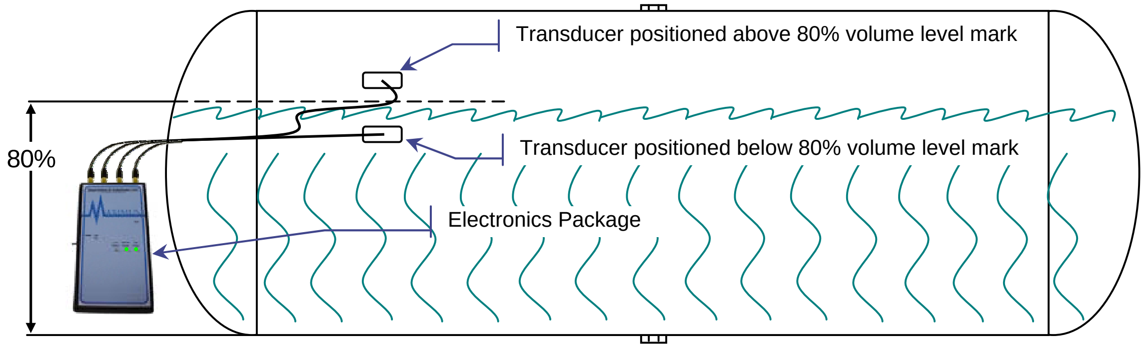


Figure 1: LP Gas Tank Schematic with Maximus™ Dual Channel Technology

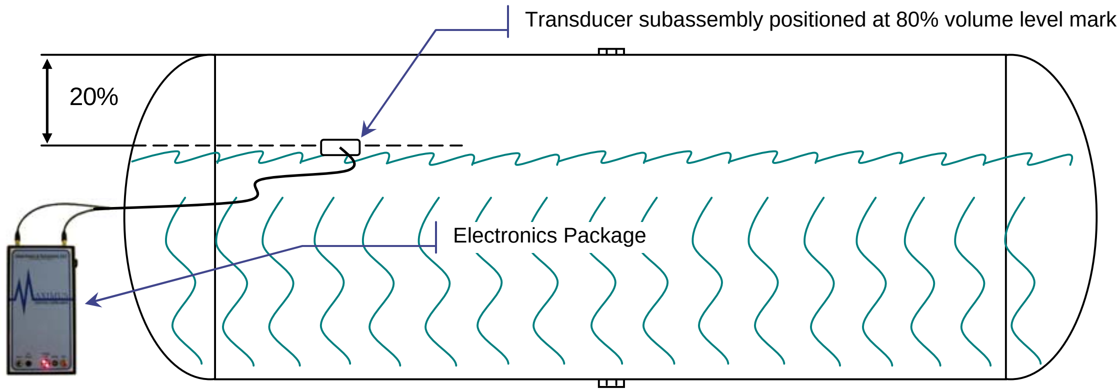
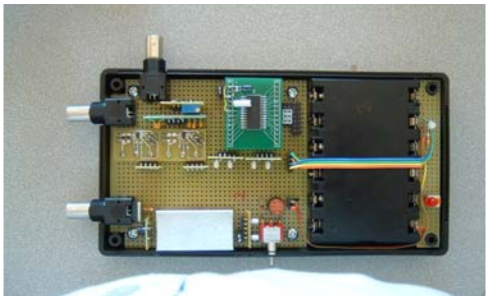


Figure 2: LP Gas Tank Schematic with Maximus™ Single Channel Technology

4.0 Prototype Developments and Technology Advances

ASCENT first built and field tested single and dual channel alpha prototypes (see Pictures 1 and 2). These alpha prototypes used an ultra-low power microcontroller (an upgrade from the proof-of-concept prototype). The alpha prototypes required revised software for embedded systems control, data acquisition, and data reporting. The same prototype was used to incorporate an additional ultrasonic technique, as well as to test the two sensor system communication and multiplexing processes. The alpha prototypes are modular, which means they have a mother board that was constructed from perf-board and wiring. The individual modules were discrete electronics (e.g. amplifier, receiver, gain controller, etc.) populated on ASCENT-made printed circuit boards (PCBs).


Picture 1: Single Channel Alpha Prototype


Picture 2: Dual Channel Alpha Prototype

The next step was to design a single channel beta prototype (Picture 3 below). Rather than modular (like the alpha prototype), the beta prototype parts are surface mounted onto a single PCB. This is done to lower cost, reduce power use, increase durability, incorporate radio frequency transmission, and, ultimately, move one step closer to a readily manufacturable product. A one-off beta prototype was built and tested. Several issues were raised in these tests (validating the importance of a one-off prototype):

(1) A key portion of the circuit was not wired to be shut down when the microcontroller goes to sleep (temporarily powers down);
(2) The radio frequency transmitter should be surface mounted, rather than pin connected (to enhance durability); and
(3) Some parts must be re-positioned for the dual sensor design.

The final stage of electronics development in this project was to convert the dual channel alpha (modular) prototype into a dual channel beta (single PCB) prototype (Picture 4).


Picture 3: Single Channel Beta Prototype


Picture 4: Dual Channel BetaPrototype

5.0 Sensor Assembly

ASCENT developed its own design as there were no concentric transducers on the market that were cost-effective for this project. Also, the most promising off-the-shelf concentric transducer was not in the required frequency range. The transducer design affects both the needed driving voltage and the received signal quality and strength. The new ASCENT design yielded increased signal quality and strength, and reduced cost, which made permanently attaching sensors to the tank a viable option.

Pictures 5 and 6 show a commercially available concentric transducer. Pictures 7 and 8 show a concentric transducer made by ASCENT.

Picture 5: Commercially Available Transducer (17.77 mm ∅)

Picture 6: Commercially Available Transducer (Top View)

Picture 7: ASCENT Transducer (17.07 mm ∅)

Picture 8: ASCENT Transd. (Top View)

To test signal strength and quality, a frequency sweep was conducted on a glass bottle with a 160 mm (6.3") external diameter. Each transducer was individually tested using a fixed peak to peak driving voltage in the first test, and twice the driving voltage in the second test. The results are shown in Figures 3-6.

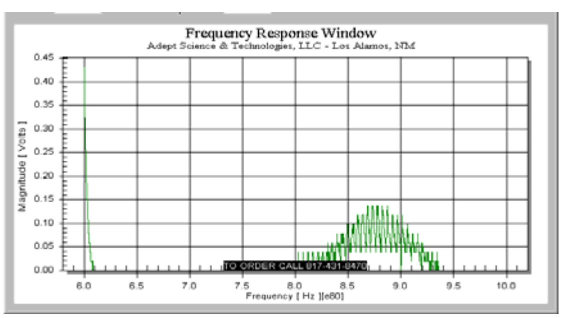


Figure 3: Commercially Available Transducer's Frequency Response (Driving Voltage a)

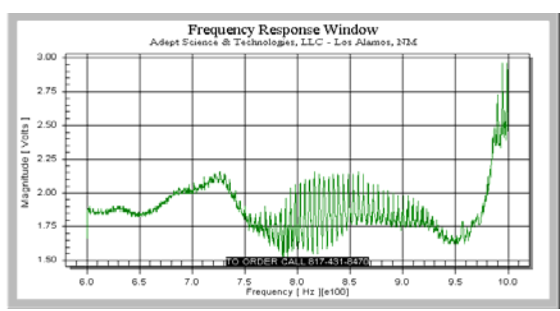


Figure 4: ASCENT's Frequency Response (Driving Voltage a)

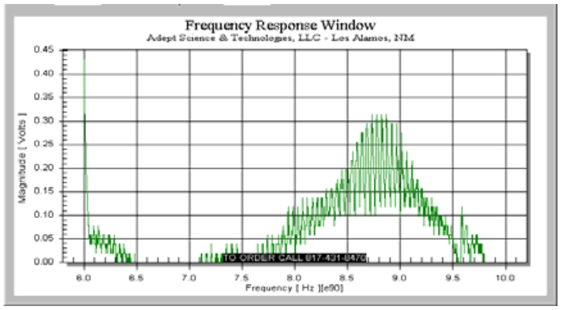


Figure 5: Commercially Available Transducer's Frequency Response (Driving Voltage 2a)

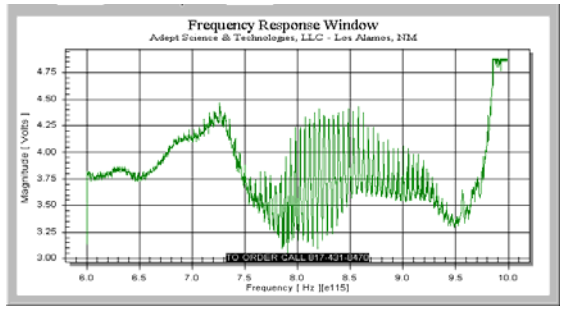


Figure 6: ASCENT's Frequency Response (Driving Voltage 2a)

ASCENT's transducer provided a higher resolution signal and greater signal strength vs. the commercially available transducer (note the net voltage at the maximum consecutive peak to trough section of the graph). The ASCENT-made transducer's received signal is 8 to 10 times larger than that of the commercially available transducer. (The y-axis scale in Figures 2 and 4 of the commercially available transducer is 18 to 23% of the y-axis in ASCENT's graphs. This gives the false impression that magnitude of the received signal from the commercially available transducer is close to that of ASCENT's transducer.)

ASCENT's efforts to find an outside contractor to manufacture the 120 transducer subassemblies required by this project were not successful. One vendor's bid was far above ASCENT's budget. Another vendor's lead time was too long. A third reported technical difficulties to make the desired product. This protracted search and negotiation period delayed the eventual in-house manufacturing of these transducers. The finished product transducers can be seen in Pictures 9 and 10.

Picture 9: ASCENT Transducers (end product)

Picture 10: ASCENT Transducers (closeup)

6.0 Test Rig

The same model tanks as those used at VIA were bought (from Sleegers) and mounted in a specially designed test rig (see Pictures 11 to 13). This helped simulate in the lab various field conditions likely to be seen by the tanks.

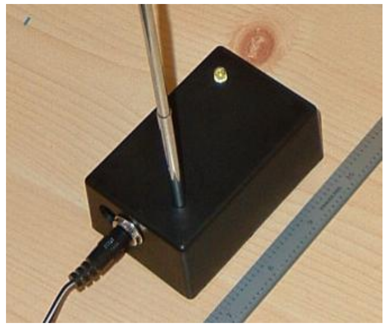
Picture 11: Test Rig Side View

Picture 12: Test Rig Front View

Picture 13: Dual Sensor Alpha Prototype Tests Using Lab Test Rig

7.0 RF Communication

Prior to the project scope modification, fully integrating the Maximus™ into the dispensers at VIA's new fueling station seemed to be the most likely scenario for the Maximus™ to be effective. The thought was that automating the process would eliminate overshooting, eliminate user error, and increase overall safety. It turned out that the distance between the dispensing pump and the buses' fill ports is so short that hardwiring the communication link was an option. Regardless, ASCENT prepared for the possibility that the Maximus™-dispensing pump link could not be hardwired. ASCENT integrated a radio frequency (RF) transmitter into the beta prototype. This transmitter communicates with a separate ASCENT-made receiver module (Picture 14).



Picture 14: Proof-of-Concept RF Receiver Module

The RF link was no longer needed when the projected shifted to the OPD verification path.

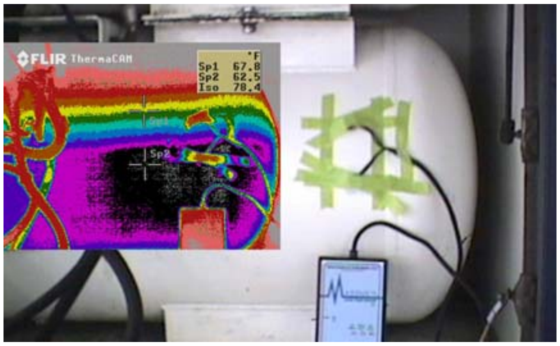
8.0 Data Collection – March 2006

The first field data collection effort was conducted in March 2006. Tests were conducted at VIA to:

- o Confirm the final Maximus™ system design;
- o Finalize logistics for the 20-bus installation; and
- o Determine where (liquid height-wise) the OPDs typically stop the filling process.

These Maximus™ dual channel system tests were successful. VIA graciously set aside bus #729 for extensive testing. All modes of instrument operation were tested by moving the two transducers subassemblies above and below the liquid level. The Maximus™ instrument functionality was verified by infrared camera photos showing that the ASCENT transducers were straddling the liquid level (Pictures 15 and 16). To create a temperature differential for the infrared camera to work, a small amount of LP Gas was vented to cool the liquid in the tank.

Picture 15: Setting up Infrared Camera at VIA



Picture 16: Infrared Camera Picture Overlaid with Actual Photo of Maximus™ Instrument Temporary Installation

Subsequently, data was collected from six buses during VIA's nightly fast-fill operation (Table 1). The tanks were tested with the Maximus™ instrument when the OPD stopped the flow during refueling. The arc length was measured (using a tailor's measuring tape) from the top weld of the tank to the point on the side of the tank where the Maximus™ instrument detected the LP Gas liquid level (Picture 17). A single channel Maximus™ unit was used to non-invasively detect the liquid level by moving the magnetized sensor head assembly up and down the surface of the tank shell along the vertical axis.

Picture 17: Measuring the Maximus™ Detected Liquid Level after Refueling

Table 1: Data Collected March 2006 at VIA

Measurements of Arc Length from Top Weld on Tank to Line Where the Liquid Level was Detected by Maximus™ Point Sensor			
Bus #	Side Tank	Lower Rear Tank	Upper Rear Tank
665	Did not fill tank	11.5"	OPD did not stop filling process
683*	9.5" (95% full)*	11.25" (0% full)*	11.75" (80% full)*
708	9.5" **	11.5"	OPD did not stop filling process
712	10.375"	11.5"	11.5"
725	10.0"	11.25"	11.25"
729	10.5"	OPD did not stop filling process	11.75"

Sleegers advised that the OPD's in their tanks are positioned to operate at the 78% full level to allow for an extra safety margin. Sleegers provided tank drawings for their 18" and 20" tanks that showed the 78% arc lengths (Figure 7). Reportedly, the OPD's are accurate within ±6%. The data collected to date has shown that permanently mounted transducers at the 70% and 85% full lines is how to proceed (Table 2).

Table 2. Arc Lengths for Specific Volume Percents on VIA's LP Gas Bus Tanks

Tank Diameter	70%	78% Level	85%
18" (Side Tank)	11.3"	10.0"	8.6"
20" (Rear Tank)	12.5"	11.2"	9.5"

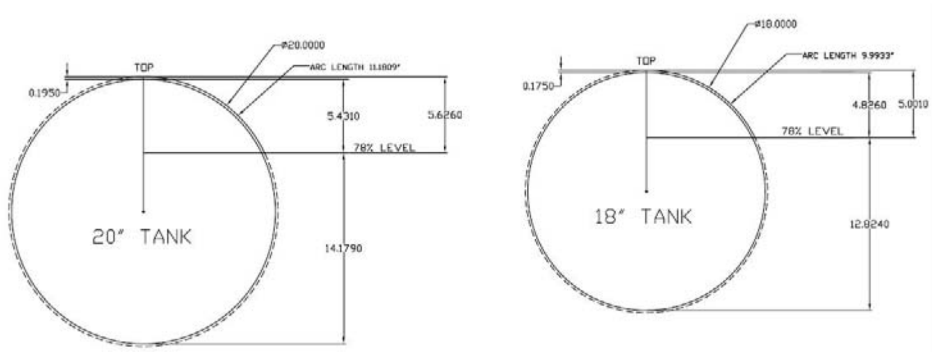


Figure 7: Sleegers' LP Gas Tank Cross Sectional Views Showing Arc Lengths for 78% Full Position

3 out of 17 refuelings on the tested bus tanks were not stopped by the OPDs. The refueler turned off the pump after noticing a mostly liquid cloud of LP Gas streaming from the tank's outage gauge. Then, when the outage gauge indicated that liquid has reached its bottom opening, the refueler added up to five more gallons to see if the OPD would trigger. If it did not trigger, then it was concluded that the OPD required further investigation to see if it failed.

Possible causes for such undesirable outcomes include:

- defective OPD;
- OPD is positioned inside the tank higher than it should be;
- outage gauge is positioned lower than it should be; or
- combinations of the above.

Although the fixed liquid level gauge provided some indication of OPD performance, it cannot reliably verify that the OPD is functioning properly. In the case where the fixed liquid level gauge emits liquid before the OPD engages, it does not necessarily mean that the OPD has failed. The OPD may still perform within its operating tolerances (+/-6%), except no one would know one way or the other because most refueling technicians stop the dispensing pump when liquid emits from the fixed liquid level gauge. The intended use of the Maximus™ Overfill Diagnostic Instrument is to diagnose if an OPD is working properly after the tank has be refilled.

9.0 Data Collection – June 2006

In the same manner as in March 2006, 81 onboard tanks were investigated in June 2006. The collected data (Table 3) confirmed the suspicions on two of the three suspect tanks documented in the March 2006 tests. Following these tests, six of the 69 filled tanks investigated (~9%) were flagged for OPD replacement. Unlike the March 2006 tests, the arc length was measured for every tank, regardless of whether or not the OPD stopped before the outage gauge indicated liquid. This was to determine if the measured error margin exceeded the OPD's shut-off valve tolerance (i.e. whether or not OPD failed).

Table 3. Summary of Data Collected June 2006 at VIA

Test Summary	
# of Buses	28
# of Tanks Measured	81
# of Tanks Filled	69
% Total OPD Failures	7%
% OPD Function post Outage	12%

These tests reaffirmed the previous conclusion that the transducers should be permanently installed at the 70% and 85% full lines to consistently straddle the level where the OPD operates. It also confirmed the need for such an instrument.

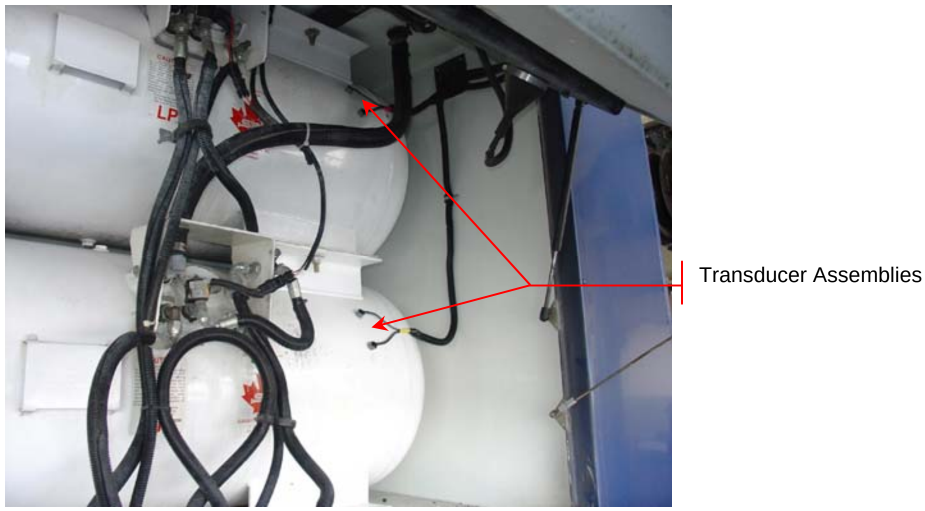
10.0 Final Installation & Test

In August 2006, ASCENT engineers permanently attached sonic sensors to the outside of the bus tanks at 70% and 85% full (straddling above and below the 80% fill level) on 20 buses. To install the transducers on 20 buses, ASCENT manufactured 120 sensors and associated cabling (20 buses x 3 tanks/bus x 1 coax wire pair/tank = 60 coax wire pairs). The sensors were paired up and the coax wires were pre-cut at lengths prescribed by VIA's maintenance foreman. The wires were routed to a junction box on the right side of the bus. The color-coded wires were stripped and soldered to a 24-pin connector that plugs into the circuit board in the junction box. The junction box consists of a connector receptacle (where the quick-release connector on the Maximus™ instrument plugs in) and a 3-position switch (Picture 18). The switch allows the refueling technician to switch between tanks.

Picture 18: Junction Boxes with Quick-release Connector + 3-Position Switch

Six (6) Maximus™ instruments were built for VIA (each instrument can be handheld or suspended from a fixture on the filling station ceiling).

In August 2006, ASCENT installed all the transducer assemblies on the 20 buses' tanks (Picture 19). One VIA electronic technician was trained on the Maximus™ system wiring installation. At the same time, one refueling technician was trained how to use the Maximus™ electronics (Picture 20). Subsequent to this visit, the user guides and installation manuals for the Maximus™ ODIs were drafted and sent to VIA for review and comment.



Picture 19: Permanently Installed Transducer on Two Rear LP Gas Bus Tanks

Picture 20: Technician Using the Maximus™ Instrument after Refueling the LP Gas Bus Tanks

11.0 Deliverables Completed

<u>Task</u> <u>Description</u>

1. Modify hardware & software of pre-alpha prototypes based on Sept. field tests.
2. Modify sensor head sub-assembly.

3. Test and collect data at several field sites (pilot test).
4. Select suitable RF technology
5. Analyze results.
6. Modify hardware & software of pre-alpha prototypes for two-sensor design (alpha 1) prototype.
7. Validate RF technology selection.
8. Modify sensor head sub-assembly (alpha 2 prototype).
9. Bench test & field test alpha 2 prototypes at ASCENT.
10. Analyze results.
11. Integrate RF technology with alpha 2 prototype.
12. Further test & collect data at VIA.
13. Analyze results.
14. Interim report.
15. Design & build first beta (pre-manufacture) prototypes.
16. Bench test beta prototypes.
17. Test final system design (with connectors) at VIA.
18. Build remaining beta prototypes.
19. Build transducer subassemblies for 20 VIA buses.
20. Install transducers on VIA's buses.
21. Demonstrate Maximus™ instrument operation.
22. Report project results.

12.0 Budget

Task #	Description	Budget	Funds spent	Funds Remaining	% Funds Remaining	% Work Remaining
1-5	Interim Report	$117,515	$21,000	$96,515	82%	84%
6-14	Interim Report	$117,515	$20,700	$75,815	65%	57%
15-16	Bench Test Prototypes	$117,515	$30,815	$45,000	38%	25%
17	Test Fully Integrated System	$117,515	$30,000	$15,000	13%	16%
20-22	Final Report	$117,515	$15,000	$0		
	Balance		**$117,515**	**$0**	**13%**	**16%**

13.0 Work Outside the Project Scope

Additional work was essential for this PERC project to be a success. A critical element for VIA to use the Maximus™ instrument is to ensure that it complies with industrial safety standards. ASCENT took the instrument through UL 913 testing [Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations] with a nationally recognized testing laboratory. This certification process was completed on July 31, 2006 (see Appendix 2 for approval letter).

ASCENT will shortly apply with a nationally certified testing laboratory to certify the Maximus™ dual channel electronics under UL 913. Such approval is anticipated in November 2006.

ASCENT also worked with Railroad Commission of Texas (RRC) to make sure the instruments satisfy the state's regulatory requirements. RRC was provided with all the collected OPD performance data, Maximus™ instrument use information, an end-product demonstration, and a presentation at their headquarters in Austin, TX. A follow-up show-and-tell demonstration is scheduled for RRC's October 2006 LP Gas inspector conference.

In August 2006, ASCENT engineers met with a RRC inspector to demonstrate the fully installed Maximus™ overfill diagnostic system. An important clarification was made to the RRC just prior to this visit. There was concern that the Maximus™ instrument was attempting to replace the function of an OPD. Such undertaking is not part of this work. This would require satisfying the equivalency requirements in NFPA 58.[2]

ASCENT asserts that the Maximus™ Overfill Diagnostic Instrument is not meant to be used as a fill monitoring device in lieu of the fixed liquid level gauge or the OPD (i.e. the instrument is a point sensor that is used post-fill, not used continuously during the fill). It is a diagnostic instrument only. There are no perceived equivalency issues involved that would restrict its use.

14.0 Conclusion

The PERC funded project to advance the Maximus™ technology was a success. The project deliverables have been met. The Maximus™ Overfill Diagnostic Instrument can be readily used as an effective means to verify OPD functionality.

Several items for consideration prior to full scale commercialization include: optimization of transducer assembly manufacturing and work to reduce junction box production costs.

ASCENT graciously thanks PERC for this funding opportunity, with special consideration to its R&D Director, Mr. Greg Kerr. ASCENT also thanks VIA (specifically Messrs. Gary Glasscock, Doug Peck, and Michael Sarro) for providing the test sites and for being exceptionally accommodating. ASCENT also wishes to thank Messrs. Joe Adams and Sean McAllister of Sleegers for their continued support.

Appendix 1: Data Collected June 2006 at VIA (part 1 of 1)

Data Collection Log: June 12-13 Monitoring of LP Gas Bus Refilling							
		Before Outage Gauge	After Outage Gauge		Maximus™ Reading		
Bus #	Tank	OPD Shut-off	OPD Shut-off	Volume before Stop-fill (gal)	Arc Length* to Liquid (in)	Variance from 78%** full (in)	Comments
114	Side	Yes	N/A		11.25	-	Trolley - Sleegers 18x30
114	Rear	Full	N/A		10.75	-	Trolley - Sleegers 18x30
663	Side	Yes	N/A		10.50	0.51	Outage gauge not working
663	Lower	Yes	N/A		11.00	-0.18	
663	Upper	Yes	N/A		11.25	0.07	
665	Side	Full	N/A		10.25	0.26	
665	Lower	Full	N/A		11.00	-0.18	
665	Upper	No	?	?	11.00	-0.18	
669	Side	Yes	N/A		9.50	-0.49	
669	Lower	No	No	>10	7.50	-3.68	Operator shut-off required
669	Upper	No	Yes	?	9.00	-2.18	
680	Side	Yes	N/A		9.25	-0.74	Outage gauge not working
680	Lower	Yes	N/A		11.25	0.07	
680	Upper	No	No	>8	7.75	-3.43	Operator shut-off required
683	Side	Yes	N/A		10.25	0.26	
683	Lower	No	Yes	2	10.75	-0.43	
683	Upper	No	Yes	?	12.00	0.82	Shut-off, then restarted and allowed to fill until OPD triggered - Outage gauge not working
684	Side	Yes	N/A		10.75	0.76	
684	Lower	Yes	N/A		11.00	-0.18	
684	Upper	Yes	N/A		11.25	0.07	
686	Side	Yes	N/A		10.50	0.51	
686	Lower	No	Yes	2	10.75	-0.43	
686	Upper	Yes	N/A		11.00	-0.18	
690	Side	Yes	N/A		10.00	0.01	
690	Lower	Yes	N/A		11.25	0.07	
690	Upper	Yes	N/A		12.25	1.07	
692	Side	Yes	N/A		10.50	0.51	
692	Lower	Yes	N/A		11.25	0.07	
692	Upper	Yes	N/A		11.50	0.32	
693	Side	Yes	N/A		10.75	0.76	
693	Lower	Yes	N/A		10.50	-0.68	
693	Upper	Yes	N/A		10.50	-0.68	
696	Side	Yes	N/A		11.00	1.01	
696	Lower	Yes	N/A		11.00	-0.18	
696	Upper	Yes	N/A		11.50	0.32	
699	Side	Yes	N/A		10.00	0.01	
699	Lower	No	Yes	0.5	11.50	0.32	
699	Upper	Yes	N/A		12.00	0.82	
700	Side	Yes	N/A		10.25	0.26	
700	Lower	Yes	N/A		12.00	0.82	
700	Upper	Yes	N/A		11.50	0.32	
701	Side	Full	N/A		11.00	1.01	
701	Lower	Full	N/A		11.00	-0.18	
701	Upper	Full	N/A		11.50	0.32	
708	Side	Yes	N/A		10.25	0.26	
708	Lower	Full	N/A		11.50	0.32	
708	Upper	Full	N/A		12.25	1.07	
711	Side	Yes	N/A		9.50	-0.49	
711	Lower	No	Yes	2	10.75	-0.43	
711	Upper	Yes	N/A		11.25	0.07	
713	Side	Yes	N/A		?	-	Questionable data
713	Lower	Yes	N/A		11.50	0.32	
713	Upper	Yes	N/A		?	-	Questionable data
715	Side	Full	N/A		10.25	0.26	

Data Collected June 2006 at VIA (part 2 of 2)

		Before Outage Gauge	After Outage Gauge		Maximus™ Reading		
Bus #	Tank	OPD Shut-off	OPD Shut-off	Volume before Stop-fill (gal)	Arc Length* to Liquid (in)	Variance from 78%** full (in)	Comments
715	Lower	Full	N/A		11.25	0.07	
715	Upper	Yes	N/A		11.25	0.07	
716	Side	Yes	N/A		9.50	-0.49	
716	Lower	Yes	N/A		11.25	0.07	
716	Upper	Yes	N/A		11.50	0.32	
719	Side	Yes	N/A		10.00	0.01	
719	Lower	Full	N/A		12.50		
719	Upper	Full	N/A		11.75		
720	Side	Yes	N/A		10.25	0.26	
720	Lower	Full	N/A		11.25	0.07	
720	Upper	No	Yes	?	11.25	0.07	
721	Side	Yes	N/A		10.25	0.26	
721	Lower	Yes	N/A		11.50	0.32	
721	Upper	Yes	N/A		11.25	0.07	
724	Side	Yes	N/A		9.75	-0.24	
724	Lower	Yes	N/A		11.25	0.07	
724	Upper	Yes	N/A		10.25	-0.93	
726	Side	Yes	N/A		10.00	0.01	
726	Lower	No	No	>4	10.50	-0.68	Fill rate slowed towards end of fill. Stopped manually.
726	Upper	Yes	N/A		11.25	0.07	
727	Side	Yes	N/A		10.25	0.26	
727	Lower	Full	N/A		11.00	-0.18	
727	Upper	Yes	N/A		11.50	0.32	
729	Side	No	No	>5	9.00	-0.99	Operator shut-off required
729	Lower	No	No	>5	9.00	-2.18	Operator shut-off required
729	Upper	Yes	N/A		12.00	0.82	
947	Side	Yes	N/A		10.50	0.51	
947	Lower	No	Yes	0.5	10.25	-0.93	
947	Upper	Yes	N/A		10.50	-0.68	

Test Summary	
# of Buses	28
# of Tanks Measured	81
# of Tanks Filled	69
% Total OPD Failures	9%
% OPD Function post Outage	12%

Legend	
Cell Color	Description
Gray	Tank not filled - bus had ~0 hours
White	Filling process stopped by OPD
Yellow	Issues during filling
Red	OPD did not stop filling process

*Arc length was measured from tank's top weld to where the Maximus™ Sonic Point Sensor detected liquid level on the shell of the tank.
**Sleegers Engineering Inc.'s arc lengths for 78% liquid level on 20" (rear) and 18" (side) diameter tanks are 11.18" and 9.99" respectively.

Appendix 2

MET Laboratories, Inc. Safety Certification - EMI - Telecom - Environmental Simulation - NEBS
914 WEST PATAPSCO AVENUE • BALTIMORE, MARYLAND 21230-3432 • PHONE (410) 354-3300 • FAX (410) 354-3313

July 31, 2006

Mr. Jared Meyer
Adept Sciences & Technologies, LLC
51 Rover Blvd.
Los Alamos, NM 87544 U.S.A.

Subject: Maximus™ Overfill Diagnostic Instrument
MET Project 18501
Safety Standards: • UL913, Sixth Edition, Revised 8/8/02: Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations

Dear Mr. Meyer:

Congratulations on successfully completing the MET Certification process for the aforementioned product. Adept Sciences & Technologies may begin to apply the MET Mark on the above stated product at this time in accordance with the MET Mark Utilization Agreement. The reports covering the above stated product will be forthcoming.

Follow-Up inspections will be conducted to assure the Certified product is identical to the product evaluated.

Thank you for the opportunity to perform this service for Adept Sciences & Technologies. We look forward to future opportunities with your company.

Reviewed by:

Rick Cooper
Director of Laboratory Operations,
Safety Laboratory

Sincerely,
MET LABORATORIES, INC.

Cedric Valiente
Technical Manager
Senior Project Engineer,
Safety Laboratory