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July 30, 2003

FINAL REPORT
SONIC LIQUID LEVEL GAUGE DEVELOPMENT & DEMONSTRATION PROJECT
(PERC DOCKET #10314)

PREPARED FOR THE PROPANE EDUCATION & RESEARCH COUNCIL

By: Mr. Jared Meyer

I. Executive Summary

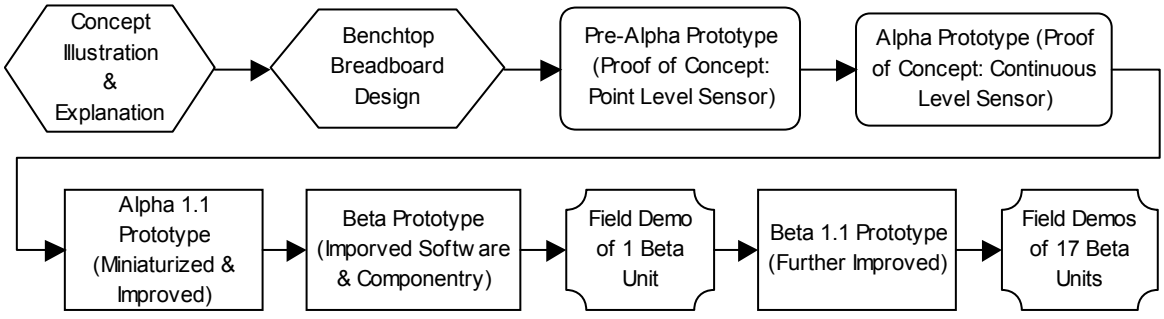
The October 7, 2002 interim report indicated that Adept Science & Technologies, LLC (ASCENT) successfully completed the design, assembly, and lab tests of a Beta 1.0 prototype. This process is outlined in Figure 1. This prototype was tested in the field on a 1,000-gallon LPG tank for 90+ days. The Beta 1.0 demonstration was a success.

From data gathered during the Beta 1.0 demonstration, ASCENT developed the Beta 1.1 prototype (includes upgraded hardware and software). 17 Beta 1.1 units were assembled and field deployed. Due to issues unrelated to the functionality of the level detection devices, 3 units are still wrapping up their 90-day field demonstration.

The completed Beta 1.1 demonstrations were a success. Minor refinements and upgrades to the Beta 1.1 prototype are warranted prior to commercialization. One of the objects of the multi-unit demonstration was to define and outline the next improvements to be made to the device.

The $156K PERC grant covered about 1/3 of the cost to bring the level detection device to its current state. ADEPT and ASCENT thank PERC as well as the U.S. LPG industry for the help to conduct the above work, and for their valuable input.

Figure 1: Level Sensor Development Flow Chart



II. Background

Starting from a technology licensed from the Los Alamos National Laboratory (which did not yield the expected results), Adept Science & Technologies LLC (ASCENT) developed new art (patent pending) that can continuously, non-invasively and non-

intrusively detect liquid level in stationary horizontal LPG tanks. This technology improves the accuracy, the safety, and the environmental friendliness of LPG level detection while lowering LPG industry operating costs. In May 2000, a market assessment survey was distributed among NPGA Research and Development members to determine the first target market for which to develop a level detection device. In June 2000, the collected surveys indicated that, by a slim margin, domestic tanks (~125 – 1,000 gal.) were top priority for such development. From the onset of this project, the focus was to design a level detection device for the 125 – 1,000 gal. LPG tank market. There are said to be about 7.5 (±1) million such tanks in United States alone.

III. Beta 1.0 Demonstration

18 Beta prototypes were assembled and field-tested. An initial demo of the Beta 1.0 prototype was conducted on a 1,000-gallon tank in Los Alamos, NM (Pictures 1 and 2). The device was connected to a telemetry device to prove that such data transmission was viable. The 90-day field trial was a success.

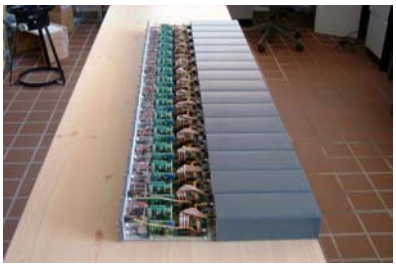
Picture 1: Installed Beta 1.0 Prototype with Telemetry Device

Picture 2: Beta 1.0 Prototype Installation Closeup

IV. Beta 1.1 Demonstrations

The Beta 1.0 field tests indicated the need for minor software and hardware improvements. Modifications were made to facilitate field installation, to raise liquid level detection accuracy and reliability, and to lower power consumption. The first Beta 1.1 prototype was installed near Albuquerque, NM. After a month of successful tests 16 more prototypes were assembled (Pictures 3 and 4).

Picture 3: Beta 1.1 Prototypes



Picture 4: Beta 1.1 Prototypes

A data collection log, an installation guide, an operations guide and a troubleshooting guide were designed and printed (see Appendix 1). These documents were included in each installation kit (along with a pre-programmed prototype.) In February and March 2003, such packages were sent to each demo site. (Pictures 5 and 6 show two Beta 1.1 installations.)

Picture 5: Installed Beta 1.1 Prototype

Picture 6: Installed Beta 1.1 Prototype

The Beta 1.1 prototype development effort was successful. It proved that this device's design is on the right track, and it prioritized what improvements are next to be made.

The most common problem encountered in these field tests was the drying of the coupling gel (used to facilitate the interface between the sensor head and the LPG tank's surface.) The field solution was to remove the sensor, add more gel, and reattach the sensor. The sensor heads were assembled with magnets to ease attachment and removal from the tank. The drying of the gel was not experienced during the Beta 1.0 field trial because this particular sensor head was epoxied to the tank. Prior to deploying the Beta 1.1 demonstration units, it was decided to use the gel since removing epoxied sensor assemblies from tanks may have resulted in destruction of the sensor head and/or paint removal from the tank surface.

All the collected prototypes were bench tested. Bench testing consisted of two (2) steps: (a) electronics package tests; and (b) sensor heads tests. All the Beta 1.1 electronic packages passed the bench tests. There were two (2) sensor heads that failed the bench tests. Post failure analysis revealed that the transducer material had detached from the frequency conducting surface. Several possible solutions will be tested in the current redesign process of the sensor heads.

This technology was also demonstrated at the PERC booth at the April 2003 NPGA Southeastern Convention (Pictures 7 and 8).

Picture 7: PERC Booth

Picture 8: Beta 1.1 Prototype Demonstration Setup

V. Conclusions and Follow-on Activities

- The Beta 1.1 devices performed up to design expectations. As far as level detection is concerned (software and hardware component performance), the Beta 1.1 demonstration was a success.
- The installation instructions must be made even clearer and simpler.
- Continued hardware and software upgrades towards reliability, reduced power consumption, and miniaturization are warranted.
- A user interface where one can walk up to any tank and key in the tank dimensions prior to installation (rather than having a pre-programmed unit for a specific location) is to be incorporated in the upgraded electronic package.
- Sparta, NJ field tests indicated that this level detection method is not yet sophisticated enough for fuel metering purposes.
- Sensor head assembly design is to be upgraded.
- A temperature sensor is to be incorporated in the sensor head assembly.
- Further work is indicated to find a better method to permanently attach the sensor head assembly to the LPG tank (protocol for such work has been defined, and bench testing is underway).

Technologies developed so far are “new art.” A first patent application was submitted.

ASCENT continues to communicate with potential licensee's/sub-licensee's of its continuous liquid level detection technologies. Once a promising licensee is ready for the next step, ASCENT and ADEPT may return to PERC for further grant requests.

VI. Appendices

Appendix 1:

(a) Beta 1.1 Prototype Data Collection Log *(Confidential)*
(b) Beta 1.1 Prototype Installation Guide *(Confidential)*
(c) Beta 1.1 Prototype Operation Guide *(Confidential)*
(d) Beta 1.1 Prototype Troubleshooting Guide *(Confidential)*

Appendix 2: Beta 1.X Prototype Bench Test Log

Appendix 3: Beta 1.X Prototype Sensor Assembly Bench Test Log

APPENDIX 1: BETA 1.1 DEMO SITE USER GUIDE

APPENDIX 2: BETA 1.X PROTOTYPE BENCH TEST LOG

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

File:Beta1-1 bench test.doc

BETA 1.X PROTOTYPE BENCH TEST LOG									
Device ID	Output Calibration Check		Test Tank Diam = 3dm, Wall Thickness = 2.5mm (software Idle_blevdg)						Pass?
			Test #1 (level = 20%)		Test #2 (level = 50%)		Test #3 (level = 80%)		
	Gain=1 Out = 600mV	Gain=20 Out = 12 V	Level	Serial comm.	Level	Serial comm.	Level	Serial comm.	
B1.0-1I	N/A[1]	N/A[1]	20%	L020	50%	L050	81%	L081	✓
B1.1-1I									
B1.1-2E	600 mV	12 V	20%	L020	50%	L050	81%	L081	✓
B1.1-3E									
B1.1-4E	600 mV	12 V	20%	L020	50%	L050	81%	L081	✓
B1.1-5E	600 mV	12 V	20%	L020	50%	L050	80%	L080	✓
B1.1-6E	600 mV	12 V	20%	L020	50%	L050	80%	L080	✓
B1.1-7I	600 mV	12 V	20%	L020	50%	L050	80%	L080	✓
B1.1-8I	600 mV	12 V	20%	L020	50%	L050	80%	L080	✓
B1.1-9I	600 mV	12 V	20%	L020	50%	L050	81%	L081	✓
B1.1-10I	600 mV	12 V	20%	L020	50%	L050	80%	L080	✓
B1.1-11E	600 mV	12 V	20%	L020	50%	L050	80%	L080	✓
B1.1-12E	600 mV	12 V	20%	L020	50%	L050	80%	L080	✓
B1.1-13E									
B1.1-14I	600 mV	12 V	20%	L020	50%	L050	80%	L080	✓
B1.1-15I	600 mV	12 V	20%	L020	50%	L050	80%	L080	✓
B1.1-16I	600 mV	12 V	20%	L020	50%	L050	80%	L080	✓
B1.1-17I	600 mV	12 V	20%	L020	50%	L050	80%	L080	✓

[1] Does not have digitally controlled gain amplifier.

APPENDIX 3: BETA 1.X PROTOTYPE SENSOR ASSEMBLY BENCH TEST LOG

ADEPT SCIENCE & TECHNOLOGIES, LLC

51 Rover Boulevard, Los Alamos, NM 87544 USA Telephone: (505) 672-0002 Fax (505) 672-0003

File:Sensor bench test.doc

BETA PROTOTYPE SENSOR ASSEMBLY BENCH TEST LOG						
Sensor ID	**Tank Temp.**	**Test #1**	**Test #2**	**Test #3**	**Mech. Gauge**	**Pass?**
#4	82 °F (28 °C)	33%	33%	33%	31%	✓
S1						
S2	82 °F (28 °C)	33%	33%	33%	31%	✓
S3						
S4	82 °F (28 °C)	33%	33%	33%	31%	✓
S5	82 °F (28 °C)	ERROR	ERROR	ERROR	31%	NO
S6	82 °F (28 °C)	33%	33%	33%	31%	✓
S7	82 °F (28 °C)	33%	33%	33%	31%	✓
S8	82 °F (28 °C)	33%	33%	33%	31%	✓
S9	82 °F (28 °C)	33%	33%	33%	31%	✓
S10	82 °F (28 °C)	33%	33%	33%	31%	✓
S11	82 °F (28 °C)	33%	33%	33%	31%	✓
S12	82 °F (28 °C)	33%	33%	33%	31%	✓
S13						
S14	82 °F (28 °C)	33%	33%	33%	31%	✓
S15	82 °F (28 °C)	33%	33%	33%	31%	✓
S16	82 °F (28 °C)	ERROR	ERROR	ERROR	31%	NO
S17	82 °F (28 °C)	33%	33%	33%	31%	✓