Innovation Φ Development Φ Enterprise Φ Action Φ Service

IDEAS Competition
Cover Sheet

Project Name: Gasoline Storage-Tank Leak Detection

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Project Summary (100- 150 words):

The goal of this project is to reduce the environmental impact of leaking gasoline storage tanks by making continuous testing of the monitor wells around the tanks possible at low cost. This new technology will enable tank owners in developing countries to catch leaks earlier and limit environmental damage. This low cost approach will be attractive to a cost sensitive industry that is reluctant to pay for expensive testing that does not contribute directly to profits.

The proposed solution replaces unaffordable electronic detection equipment, or tedious manual water sampling and testing with a simple, inherently safe, mechanical system. If gasoline is detected in the well, a window in the well cover changes from green to red. The well can be monitored visually without unbolting the cover. This will make it practical for the tank owners to check the wells for contamination much more often than they currently do. The early detection of gasoline leaking into the ground water will help minimize the environmental and health impact to the local community.

Gasoline Storage-Tank Leak Detection

Problem Statement

Petroleum storage tanks are found all over the world at refineries, storage depots and gas stations. When gasoline leaks out of these tanks, it can contaminate ground water causing serious health and environmental problems for the surrounding community.

It is expensive to replace or inspect these tanks regularly, so leaks are detected using monitor wells in the ground surrounding the tank. These monitor wells must be checked on a regular basis if a leak is to be detected before it becomes a serious problem for the surrounding community.

In many developing countries the laws require monitor wells, but it is not required that they be checked regularly for contamination. The existing electronic monitoring equipment is prohibitively expensive, and it is unlikely that electronic systems will be required in developing countries because the expense is too high. What is needed is a low cost way to test the existing monitor wells that is either cost competitive with the expected liability costs of polluting, or inexpensive enough for lawmakers to require that they be used.

Communities to be Served

In the 1990s the United States mandated electronic detectors in monitor wells to alert tank owners of gasoline leaking into the ground water. The detectors and central control station cost $20,000. For developing nations, this is simply not affordable. Instead, the monitor wells are tested manually, if at all. The well is opened and a sample is drawn and tested for contamination. This process costs ~$100 per month. These tests are not actually done on a regular basis because the tests usually come up negative, and are perceived to be a waste of money. However, an unchecked leaking tank can cause extensive environmental damage. This is especially true in poor regions or islands that depend on local well water. By developing a low cost monitoring system, it should be possible to reduce the environmental and community health problems caused by contaminated ground water despite the cost sensitivity of this industry.

Proposed Solution

Described below is a low-cost device called the ChemicalFuse that continually tests the monitor wells around a storage tank. It is a simple mechanical system with no electronics, so there are no spark or explosion hazards. These devices will be available for $100 apiece, and will clearly indicate if a well has been contaminated and if further testing is required.

The device, shown below, consists of a chemical fuse, invented and patented by Robert Bridges of MassTech Inc., and a signaling device that was invented by the MIT team submitting this application. The fuse works on the principle that gasoline will melt polystyrene. A long polystyrene tube runs the length of the well. Any gasoline in the ground water will melt the tube and cause it to break. A weight at the bottom of the tube will be released, and a metal cable attached to the weight will pull on the signal device. The signal device has a green flag that is visible in a window in the well cover if the well is uncontaminated. If the fuse has melted, releasing the weight, the green flag is pulled out of view exposing a red portion of the signal device. Red showing through the window indicates that the fuse has broken, and the well should be tested for contamination.

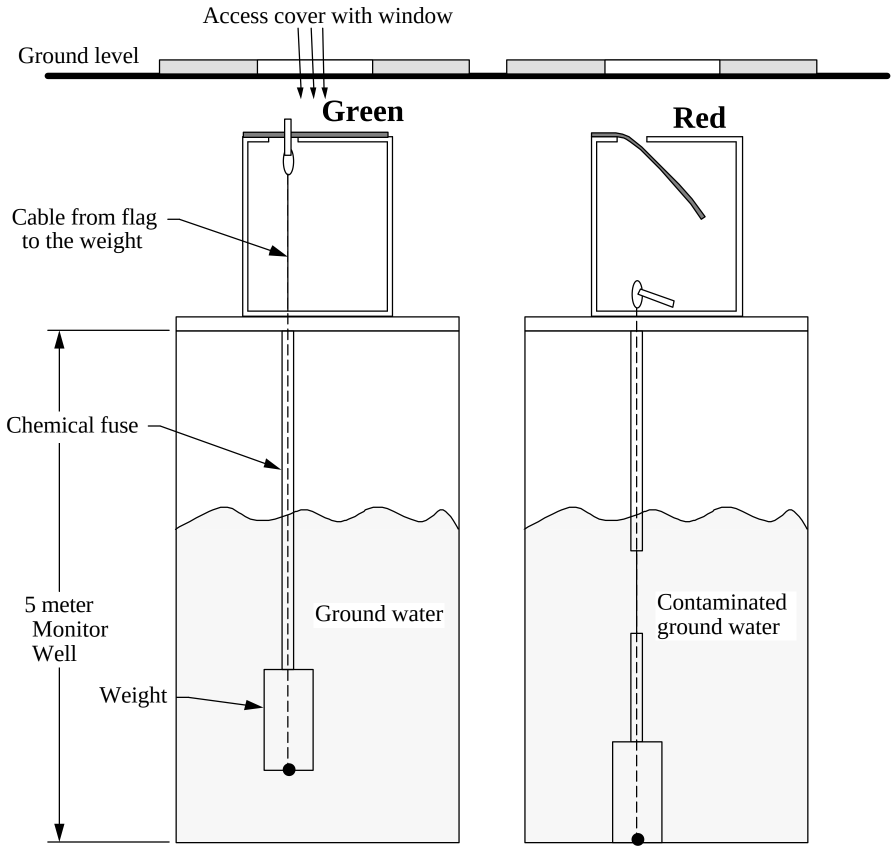

Figure 1 Monitoring system schematic

The system is designed to minimize parts count and complexity. The materials are readily available in developing nations in the event that they need to be manufactured locally to reduce shipping costs and tariffs. At this stage the parts for the signaling part of the device will be produced in the United States.

Some of the major advantages of this testing device over existing systems are as follows:

- It is a passive system – No testing action by the tank owner is required. Simply looking into the observation window is enough to see if there is contamination.
- Continuous well monitoring – The system will detect contamination whenever it is present. It does not depend on monthly or yearly test sampling.
- Explosion proof – Since this is a completely mechanical system, there is no danger that a loose electrical connection will create a spark, and set fire to a leaking tank. Other systems go to great length and expense to work at low voltages and within contained housings to minimize this risk.
- Low cost – This system is inherently very inexpensive due to its simplicity and low parts count.

Implementation

Work to date

Implementation of the ChemicalFuse is well underway.

- An independent testing laboratory has tested the fuse technology, and they found that a small quantity of gasoline (or a variety of other petroleum products) mixed into a column of water caused the fuse to break in 5-12 minutes.[1]

- A series of prototypes of the fuse with the signaling device were made and presented to Esso, in Puerto Rico. Based on their feedback, the design was modified to increase visibility, chemical resistance and ease of assembly. The improved device is shown in Figure 1.

- A short production run of 200 devices was made to send out as samples to companies and sales representatives. These samples have been shown to potential customers in Columbia, Brazil, Australia, Malaysia, The Philippines, Singapore, Hong Kong, Italy, England, Mexico and several Caribbean Islands. These samples are mounted on a cast aluminum base that attaches to the top of a 4" diameter well, and has a polycarbonate dome lid. The dome lid is tagged with a tamper evident seal, so that if the lid is removed, the seal is disturbed and can not be replaced.

[1] The test report is available upon request.

It was then discovered that there is a significant market for a device that can be used in a smaller 2" diameter monitor well. A second batch of 200 prototypes was manufactured, with the help of the IDEAS contest materials grant. These devices fit on the smaller well, and are covered by a short glass jar instead of the polycarbonate lid. They are less expensive, and will be offered as a lower cost option than the larger ones, which are easier to see, and more solidly built.

The first big sales breakthrough occurred in mid-March with the first order to place the ChemicalFuse around a new Esso storage tank being built in Puerto Rico and a second tank in the Caymans. The significance of this sale is hard to overstate. In an established industry such as the petroleum industry, no one wants to be the first to try a new technology. It is far safer to simply NOT try it. The feedback on the device so far is that "it is a great idea, but no one else uses it, so why should I?" This first sale enables us to say "as used by Esso" in the sales pitch, which will imply to the other companies that they are missing out on something that Esso already knows about. It is a strong validation and endorsement of the technology to be bought by one of the major companies in the industry.

The ChemicalFuse version being purchased by Esso is slightly different than that shown in Figure 1. It is configured to run horizontally in the monitor pipes that are placed underneath the storage tank as shown in Figure 2. A large advantage of this system over manual testing is that the threshold for contamination detection is much lower. In the case of manual testing, the monitor pipe must fill with enough gasoline that it spills out the end of the pipe, into the catch cup. The ChemicalFuse detects the presence of gasoline anywhere in the monitor pipe.

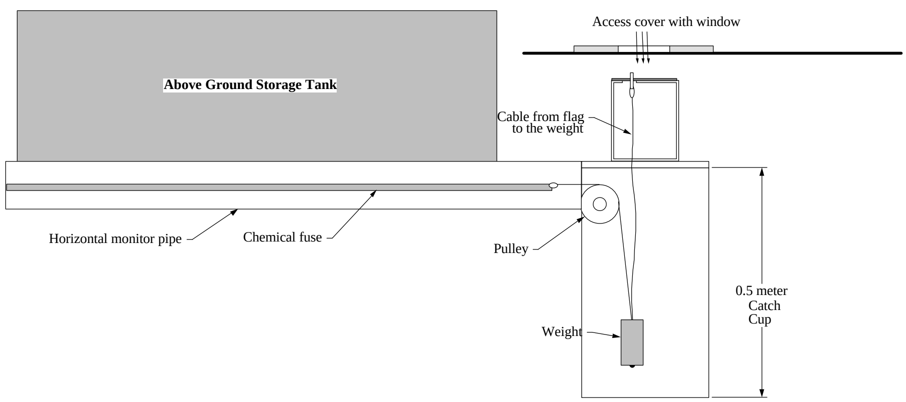

Figure 2: ChemicalFuse version for Esso

To summarize the product development to date, there are now three products in the product line. The first is the ChemicalFuse for a 4" well, the next is for a 2" well, and the third is for a horizontal installation. A purchase order from Esso for the horizontal version has been received.

The Team

Andrew Heafitz has received his bachelor's and master's degrees from the MIT Mechanical engineering department, specializing in product design. He also has three years of experience as a product design consult at Arthur D. Little, and four more doing electric vehicle design at Solectria. These jobs have given him extensive product design experience in a variety of fields, experience with design for low cost, design for assembly and limited production runs.

Carl Dietrich has a Bachelor of Science from MIT in Aeronautics and Astronautics, and is currently a doctoral candidate in the same department. He has extensive hands-on experience with machine design, has won four design competitions, and was recognized as one of sixteen MIT aero/astro alumni who have shown "extraordinary accomplishment early in their careers".

The team has developed the signaling portion of the ChemicalFuse system, and will be responsible for delivering production quantities once orders are received, as well as designing variations on the concept as new applications require.

Partners and Support Network

The MIT team invented the low-cost signaling device, and is working with Robert Bridges, who has a patent on the chemical fuse technology and MassTech[2] which is a tank testing company based in Australia. They have approximately 100 employees based in 14 different countries, and they have two major products. The first is a tank testing service using a mass measuring technology that can detect leakages down to 80 ml per hour. (For reference, the EPA sets 190 ml/hr as a detection threshold.) Their other product is Red One, which statistically monitors the tank to make sure that the inflow and outflow are equal, and nothing is leaving through unknown paths.

The ChemicalFuse technology is being introduced to the MassTech network by Bruce Heafitz, MassTech's South American franchise owner. MassTech is a good place to start distribution because they do not currently have a method for directly and continuously monitoring tanks for leaks, such as the ChemicalFuse. They also have an established customer base that can be leveraged for initial sales. There are two possible business models for this new product. The first is to sell the ChemicalFuse system to companies so that they can install them and monitor for leaks. The second is that MassTech could provide a service contract where they come by and check the ChemicalFuse once a month, and replace it

[2] Further information about MassTech can be found at http://www.masstech.com.au

once a year. The second method is more profitable to MassTech, but they are pursuing both avenues at this time.

MassTech has demonstrated the fuse and signaling device to major South American oil companies such as Esso, Shell, Texaco and Repsol. Prototype samples have also been shown in Columbia, Brazil, Australia, Malaysia, The Philippines, Singapore, Hong Kong, Italy, England, Mexico and several Caribbean Islands.

Implementation Plan

At this point, 200 prototype signaling-devices designed for 4" wells have been completed, and are being used as sales tools. Another batch of 200 prototypes designed for smaller 2" wells have also been delivered. The first sale of 12 units has been made to Esso, for use in Puerto Rico and the Cayman Islands. The next goal is to start volume sales to customers. Companies such as Shell Oil have said that they could use as many as 50,000 of these devices, however, they have not yet ordered any. It is expected that a lead customer would order 1,000 to 5,000 to start. MassTech representatives are demonstrating the system to international oil companies, regional oil companies, as well as companies in other industries such as terminalling (storage tanks pipelines, and transportation of petroleum products). The system is also being shown to companies that repair, replace and retrofit old storage tanks with double walled tanks. (The ChemicalFuse can be installed in the interstitial space between the tank walls.) There are also industry conventions which present sales opportunities, or the Petroleum Equipment Institute could offer this as an option that is sold with gasoline dispensers to gas stations.

Once a customer or customers orders a sizable quantity of systems, we will ramp up production immediately. The venders who will make the various parts have been identified, and they have made some of the prototypes, so we have a high level of confidence that starting up the manufacturing phase will go smoothly. The quotes that we have for quantities of 10,000 – 20,000 indicate that the signaling portion can be made for $5.00 which is the target price. The vendor being used for the green printed, die cut signal flag is ScreenPrint Dow in Wilmington, Massachusetts. The sheet metal fabricator is Fabco, and they also assemble the devices using pop rivets. The backup fabrication plan uses hand cut and drilled green shim stock from McMaster Carr for the flag material, and Maplewood Engineering for the sheet metal work and pop rivet assembly. This backup plan is only practical for quantities up to 1,000 units. The lead-time for the backup manufacturing plan is shorter (3 weeks instead of 6 weeks), but the flag quality is lower, and the sheet metal price is higher.

Challenges

At this point, the biggest challenge is finding initial customers to install the ChemicalFuse system. This should be helped by the recent lead order by Esso. MassTech is approaching this challenge by presenting the system to as many potential customers as possible, through as many different channels as possible. However, at this point, it will just take time for the first orders to gel.

Once there is an initial major order, the next challenge will be building the units quickly enough to meet the order. It is expected that a substantial order could be for as many as 50,000 units per year. The vendors selected for the prototyping stage are all capable of these volumes, but it will be important to make a realistic delivery plan when the order comes in.

Schedule and Budget

The schedule is shown in Figure 3. It shows the prototype work that has been done to date. The length of the sales efforts by MassTech until the first major sale is the least well-known item in the schedule. It is then assumed that a couple of modest sized orders will come in a few months apart, but that really depends on outside factors.

In quantities of over 10,000 units, the signaling device will cost $4 to make and will be sold for $5. The profit from these sales will make the product self sustaining, and will pay for the MIT team to manage the production of this part of the system. For lower quantities, the cost per unit will be higher. The money to pay for development, tooling and any difference between the product cost and the $5 sale price will have to come from other sources including MassTech R&D funding, IDEAS contest funding, and out of the pockets of the MIT team members.

The budget shown in Figure 4 assumes that there are two orders, for 1000 units and 5000 units respectively in the next year. The signaling devices will be sold to MassTech for $5 each for incorporation into the rest of the testing system. The rest of the money needed to balance the budget is made up from other sources as mentioned above. Once larger quantities are ordered, the production costs will go down enough that the signaling devices should be a self supporting product at $5 each.

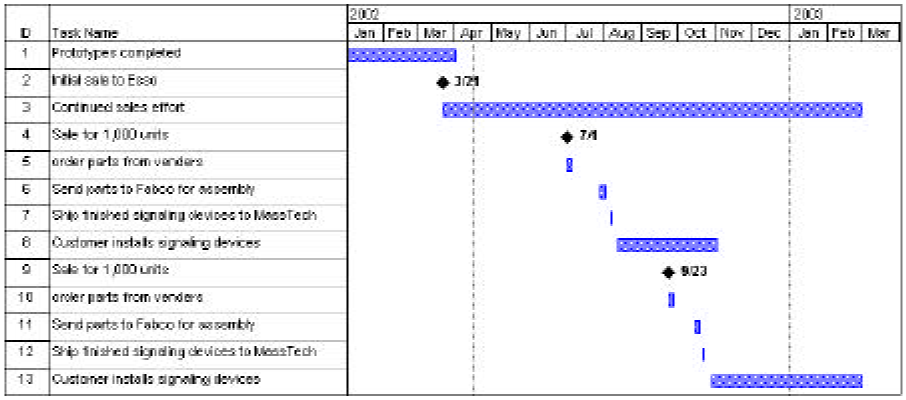

Figure 3: Project Schedule

Expenditures		hours
Continued adaptation of prototype to new applications		
parts	$ 500	
labor	$ 2,313	50
Prototype runs to produce sales demos of new devices	$ 2,000	
Tooling for production signaling devices	$ 1,300	
Parts cost for first production run (1000 units @ $7 each)	$ 7,000	
Parts cost for second production run (5000 units @ $5 each)	$ 25,000	
Planning and coordination of first production run	$ 1,850	40
Planning and coordination of second production run	$ 1,850	40
Shipping	$ 400	
Total expenditures	**$ 42,213**	

Inflows	
Sales of first production run at $5 each	$ 5,000
Sales of second production run at $5 each	$ 25,000
IDEAS material grant, prize money, and other funding	**$ 12,213**
Total inflow	$ 42,213

Figure 4: Budget

Impact
Currently, the EPA defines a detectable leak as one that leaks over 190 ml/hr. The testing that they require must be able to detect a leak of this size or larger. The EPA is a very influential environmental agency; so many other countries adopt the EPA standards for themselves. MassTech's tank testing can detect leak rates almost 3X lower than the EPA threshold. The ChemicalFuse is another tool in the leak detection tool kit. If it can be shown that smaller leaks can be detected sooner, it is possible that the EPA would mandate a lower detection threshold. This would have a resonating impact around the world as other governments implemented similar limits based on the EPA's recommendations.

From a business standpoint alone, it is bad to let your product leak away. A gas station must sell 30 liters of gasoline to make up for 1 liter lost into the ground. Of course from an environmental standpoint, these leaks can be devastating. Gasoline contamination on the order of parts per million is enough to make water undrinkable. The leakage also makes the land around the tank unusable for residential use. In Brazil, the national petroleum company, Petrobraz, paid $175 million over 2 years in penalties for leaks that contaminated drinking water and ruined beaches around Rio de Janeiro. Locally, a leaking gas tank can run a company out of business because of the liability and damage to their reputation.

The impact of widespread use of the ChemicalFuse signal device would be earlier detection of petroleum leaks all over the world and a reduction in the associated pollution and environmental damage. While the ChemicalFuse will be marketed as a tool to help the petroleum industry, the real beneficiaries will be all the people who live near gasoline storage tanks.

Conclusion
The leak detection system described here can reduce the environmental impact of leaking storage tanks by making continuous monitor well testing financially attractive for petroleum companies. The resulting reduction in environmental damage from successfully detected leaks will help people in neighboring communities who may not even be aware of the dangerous contaminates that are allowed to leak into their ground water.