Review of Automatic Tank Gauging for BP Oil New Zealand Limited

A thesis presented to fulfil the requirements of a Masters in Technology

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EXECUTIVE SUMMARY

The project was undertaken for the Commercial Division of BP Oil New Zealand Ltd (BPONZ) to investigate and evaluate the future of automatic tank gauging. The Division has over 100 customer refuelling facilities around New Zealand. Fuel monitoring and management of these facilities, mainly Truckstops, is very difficult as most of the sites are unmanned.

Automatic tank gauging systems are used to remotely measurement fuel volumes at petroleum storage facilities. The Commercial Division of BPONZ, in 1993, had approximately 100 of these systems installed at sites. They were turned off in 1994 due to their unreliability and inaccuracies.

The investigation required the trial of two tank gauge systems from Compac Industries Limited and Fuelquip Services Limited. Compac was the supplier of the first gauges installed in 1993. Other investigating issues involved in the project include financial, environmental and current BPONZ procedures and systems that dealt with fuel monitoring and management.

The main conclusion from the study is that BPONZ should not invest further capital into automatic tank gauging at its Truckstop network for at least three years. The main reason is the large capital investment required to have the existing gauges upgraded or new gauges installed. However, the study showed that automatic tank gauging is a very complete package that can deal with stock monitoring and management of unmanned sites. The accuracy of the systems proved to be higher than that of current reconciliation methods and the previous technology. This is the reason that tank gauging should not be ruled out indefinitely in the future.

Recommendations for the future include:

- developing a pump calibration program for all consignment sites.
- annually up-dating the Commercial Environmental Program.

- re-investigate tank gauging in three to five years if current systems are not improved or if new legislation requires tighter control of wetstock management or environmental protection.
- investigate the option of accurate meters on tanker outlets and have drivers record the manual tote of pumps when delivering fuel to a site.

INTRODUCTION

BP Oil New Zealand Ltd (BPONZ) has been in the New Zealand petroleum market since 1946. The company is the retail market leader within New Zealand, as of January 1998, and is always striving to keep ahead of the other three major oil companies, Shell, Caltex and Mobil. In doing so, BPONZ has to constantly invest capital into cost saving technology to sustain the small hold the company has on the market and be competitive.

One such technology investment is the remote measurement of petroleum fuel levels in Underground and Aboveground Storage Tanks (USTs and ASTs). These tanks are situated at retail (Service Stations) and commercial (Truckstops) sites around New Zealand. The tanks range in size from 20,000 to 50,000 Litres holding capacity.

The remote measurement of fuel levels in the Oil Industry is known as automatic tank gauging. Automatic tank gauging is important to BPONZ Commercial as the division has many remote unmanned sites and regular, manual dipping of the sites is uneconomical for stock control. Tank gauging is the most practical way of managing the fuel stocks at these sites, but whether it is the most feasible way is one of the questions that prompted this thesis.

The focus of the thesis was to bring together existing information and knowledge to evaluate the tank gauging systems in place within the Commercial Division of BPONZ. The project came about as a result of inaccurate and unreliable readings from the existing tank gauging systems that were introduced in 1993 and 1994.

Two outside companies, Compac Industries Limited and Fuelquip Services Limited were involved in the project, each providing a different type of automatic tank gauge. Their equipment was set up at company locations around the country as trial sites. BPONZ Commercial has had Compac tank gauging installed in Truckstops since 1993 and an upgrade took place for the trials. The aim of the trial sites was to monitor the gauging equipment for accuracy and reliability.

The thesis is set out in four main sections, Background, Suitability of Tank Gauging, Results and Discussion, and Conclusion and Recommendations. The Background section sets the platform for the thesis and includes profiles of the companies involved in the project, brief history of tank gauging and a description of tank gauging and related issues. The next section "Suitability of Tank Gauging" deals with the two automatic tank gauge systems and the experimental trials used to examine the accuracy and reliability of each system. The thesis then continues with the section on Results and Discussion. This section brings together the findings of the experiments and discusses relative information like financial and environmental issues. The final section in the thesis, Conclusion and Recommendations will conclude the major findings and present recommendations to BPONZ for future investigations and projects.

BACKGROUND

Company Profiles

BP Oil New Zealand Limited

The company's initial contact with the New Zealand petroleum market was back in 1946 when the Anglo-Iranian oil company (later renamed BP) set up in New Zealand to sell BP products. In 1972, BP and Europa Oil (New Zealand's only native oil company at the time) combined with BP acquiring the marketing and refining interests of Europa and later re-imaging all sites to conform with BP international signage.

BPONZ employs around 1600 people and is one of New Zealand's largest companies. It provides a wide range of petroleum products, from oils and lubricants to motor-spirits and aviation fuels. The product range is marketed to both the public and private sectors. The company is the market leader in petroleum products sold through service stations in New Zealand and holds approximately a third of the market share.

BPONZ commitment to all of its customers can be reflected in the company's mission statement "BP is committed to providing quality service and quality products which meet both internal and external customer requirements at all times"[1]. The company also has a high level of commitment to the environment. The Health, Safety and Environmental (HSE) goal is simple "have no accidents, do no harm to people and do no damage to the environment"[1].

Compac Industries Limited

Compac Industries Ltd commenced business back in 1983, focusing on the petrochemical industry. The company is privately owned with its Head Office in Auckland, New Zealand and Branch Offices in Sydney and Melbourne, Australia. Trained Sales and Service Agents cover New Zealand, Australia and many other countries around the world like South Africa and Sweden.

The company's product line ranges from specialist meters for LPG and CNG to fuel pumps and leak detection systems. The manufacturing plant is located on the same premises as their Head Office in Auckland. Compac manufactures products for hazardous areas, therefore independent standards authorities carry out approval and testing.

Compac is accredited with the ISO 9001 standard, which recognises the company's commitment to quality and service.

Research and Development is a continuing process at Compac and consists of two divisions, Electronic and Mechanical. Mr S Cowdell's (Compac Account Manager) facsimile dated the 31 July 1997 stated that the company recognised the importance of Research and Development and was committed to reinvesting ten percent of its turnover back into the company for future development.

Fuelquip Services Limited

Fuelquip Services Ltd is New Zealand's leading supplier of equipment and services to the petroleum and related industries. It is a privately owned company that sees the ownership equally divided between three of the management team. The company's head office is located in Wellington with two regional offices in Auckland and Christchurch.

The company employs over 200 staff, with 120 service vehicles operating out of 17 service and workshop bases throughout the North and South Island of New Zealand. Mills-Tui Ltd, situated in Rotorua is a wholly-owned subsidiary of Fuelquip specialising in the manufacture of fire appliances and airport fire rescue vehicles.

The company's commitment to providing quality and service to its customers through its staff lead Fuelquip to initiate a total quality management program in 1989. This laid the foundation for the company's progress towards formal accreditation of the Quality Assurance Standard ISO 9002 (NZS 9002). The basic focus of Fuelquip's philosophy is quality and this can be reiterated with one of the company's principles "The quality and reliability of Fuelquip's products and services are the concern of every employee. Quality starts with the design or plan and continues through all facets of manufacture, service or construction. It also includes the quality that comes from the skill, accuracy and accumulated knowledge of the person doing the task. Every person is therefore responsible for the work they have been allocated, and to carry it out within planned estimates and at the required quality level. Consequently a "do it right first time" approach is the key to quality workmanship, cost reduction, productivity and customer satisfaction."[2].

Fuelquip is a member of the Petroleum Equipment Institute (PEI) based in America and the Institute of Petroleum in the United Kingdom. This allows the company to stay in-touch with the latest technologies on the petroleum marketplace.

Legislation Governing the Monitoring of Underground Storage Tanks

There are many Acts, Regulations and Codes of Practice oil companies have to abide by when constructing and managing a site with underground petroleum storage systems. This section will highlight the legislation that governs monitoring of underground petroleum storage systems and therefore automatic tank gauges.

The Resource Management Act (1991) has a major bearing on company operations, especially when dealing with underground storage tanks and the surrounding environment. Part II Section 5 of the Act states that "the purpose of the Act is to promote the sustainable management of natural and physical resources"[3]. Sustainable management concentrates on the use, development and protection of the country's resources for the well-being of the community while "avoiding, remedying, or mitigating any adverse effects of activities on the environment"[3]. This section of the Act is important to BPONZ as it endeavours to avoid leakage from tanks and, in the event of a leak, remedy the effect on the environment as fast as possible. Large fines of up to $200,000 and clean-up can be imposed on companies that neglect to abide by the Act. Waiuku transport company Knight and Dickey Ltd was fined $4000 and had to spend more than $200,000 to clean up a diesel spill caused by a leaking underground tank. The fine was imposed because the company had failed to operate appropriate stock control procedures (Franklin County News [Pukekohe], 26 August 1997). Due to the large costs, BPONZ makes a conscious and dedicated effort to manage, monitor and assess all of its petroleum storage facilities.

The Code of Practice for the Design, Installation and Operation of Underground Petroleum Storage Systems states that "Every storage site operator must establish and operate a sound system of stock reconciliation that will identify any losses as they occur. It must be updated regularly, at least daily on busy sites, and no less frequently than fill-to-fill or monthly, whichever is the less, on any other site"[4]. The foundation of a good stock reconciliation system is the recording of measured actual stock at the beginning of each period, record of fuel deliveries into the tanks, the sales during the period, calculated book stock and the actual measured stock at the end of the period.

Differences between the book and actual stock at the end of the period is the recorded loss or gain.

The Dangerous Goods (Class 3 - Flammable Liquids) Regulation 1985, Part 49, Means of Determining Capacity of Tank states that "Approved means of accurately determining the capacity of every tank for storage of dangerous goods of Class 3 and the quantity of dangerous goods in it shall either be fitted to the tank or kept readily available,..."[5]. This is one of the reasons why dipsticks are usually located within a tank. Tank gauging coincides with this code as the measuring device is attached to the tank and the volumes can be read from the site controller.

When dealing with sites that are remotely located, tank gauging is the most feasible solution to retrieving the information that is required for the above code and regulation. This conclusion is based solely on the ease of retrieving the data from automatic tank gauges verses the difficulty of obtaining the data through regular visits to the sites to manually dip the tanks. Costs were not examined in this conclusion. With reference to the Code of Practice, tank gauging is able to aid the operator with opening and closing stock, total sales (as the controller communicates to the pump communications) and fuel deliveries. From this information, book stock and the loss/gain calculations can be performed instantly by the controller software.

Determining the capacity of a tank on site by an operator or a tanker driver is easily achieved by taking the reading off the display of the site controller. This takes away the need and time (approximately five minutes for several tanks) spent by a person to manually dip the tanks.

Current BPONZ Procedures

Refuelling of an Underground Storage Tank

This section will discuss the process that BPONZ undertakes to refuel an underground storage tank at retail and commercial sites.

The first step in the process is to know when to refuel a site and the types and quantity of fuel to be delivered. These tasks are performed by the dispatch planners located in Auckland (covering the North Island) and Christchurch (covering the South Island). The Terminals and Distribution Manual states that "The principle requirements are to ensure that:

product is available in sufficient quantity to meet demand;

vehicles are deployed in the most efficient manner;

deliveries are made as near to the time agreed with the customer as practicable;

the appropriate sized vehicle is scheduled to best suit the customer's order and delivery constraints"[6]. These requirements should meet the customer's agreed distribution service level agreement with dispatch.

The dispatch planners use a program called the Order Prediction System (OPS). This system utilises dip and sales information from the last two deliveries to the site in question too predict the theoretical date and quantity of when the next fuel-drop should be made.

If a certain site is not on the OPS (an example is a company that buys the fuel in bulk), then the operator of the site has the responsibility to contact the appropriate dispatch office to request an order for a fuel delivery. All BPONZ Commercial Truckstop sites are on consignment, meaning the fuel in the UST is owned by BPONZ and the customers purchase the fuel from the site. Dispatch in New Zealand, has a service agreement with BPONZ Commercial to supply fuel to its Truckstops.

Once the theoretical dates and quantities are generated, the planners can then group the orders into location, and date. From the groupings, the planners are able to shuffle the orders around to maximise the efficiency and effectiveness of the tanker fleet and drivers. The most efficient trip plan for a truck would be to make one full tanker delivery at a site. This cuts down on revisits to the site and takes away the time of having to make another delivery at a site to unload the remaining fuel in the tanker. Unfortunately UST's range in size from 20,000 to 50,000 litre holding capacity and large tankers have a capacity up to 38,000L for diesel. This size range makes it difficult for the planners to get maximum efficiency while trying to avoid dry tanks, therefore tanks are normally refilled when they are in the 10,000L to 20,000L range. Plans should be generated up to at least the end of the first shift of the next planning day. When the plans are finalised, they are entered into the network system and the appropriate Terminal offices receive the plans.

Each tanker driver receives their trip plan for their shift from the Terminal office via an On-board Vehicle Computer (OVC). The OVC is a portable computer that carries the trip plan and delivery records. The drivers load their tankers according to the plan.

The first step by a driver when they arrive at a site is to notify and verify with the customer (if site is open) that a fuel delivery is to be made. Before any product can be unloaded from the tanker, the driver, by law, must dip the customer's tank to ensure it can accommodate the planned delivery. This dip figure is entered into the OVC. The driver can unload the fuel when he/she is confident that the delivery will be contained within the UST. The driver, once again, dips the customer's tanks to confirm that all of the product has been delivered. This figure is also entered into the OVC for future reference by the customer and the planners. The customer receipt is printed using the OVC and a printer located in the truck cab. The driver then continues on with their planned shift.

At the end of a driver's shift, the OVC is connected into the computer network at the Terminal office. The information that has been obtained from the driver is up-loaded into the BPONZ network and distributed to the appropriate users (e.g. Dispatch).

Stock Control Of BPONZ Truckstops

Stock control (reconciliation's) plays a major role in any consumer oriented industry. The oil industry is aware of the consequences if an incident should occur and the company at fault does not have up-to-date stock control records. This sub-section will outline the process that BPONZ use to perform stock control of its fuel at Truckstops.

At present, the reconciliation's are calculated on a monthly basis. The author beliefs that the time between these reconciliation's is to long and a more appropriate length would be ever two weeks. The reasoning behind this is that it could take three months (three reconciliation's) before a slow constant leak is found or even investigated. The person studying the reports would have to see a constant loss pattern in the reconciliation of a Truckstop before they start investigating the reason for the losses.

The majority of the information for the reconciliation's come through the BPONZ computer system. The only information that is entered manually into the report is the tanker driver dips and this takes on average one person four hours ever reconciliation. The dip readings required are the first and last for the month. BPONZ have to use the tanker driver dips as there is no one on site to take a dip. The driver dips come from the OVC information which was down-loaded into the BPONZ computer system and printed off. Unfortunately, this information has yet to be tied automatically into the reconciliation reporting program.

Sales for the period and the amount of fuel deliveries are also required for the reconciling of stock. The sales are gathered each night (midnight close-off) by a modem link to each individual Truckstop. The computer gathers the customer transactions for the day. The fuel delivery information comes from the dispatch system.

Stock control reporting of a site is calculated by taking the first dip of the month, adding the amount of fuel delivered to the site, subtracting the sales and then weighing this figure against the dip at the end of the month. The difference between the figures is the loss/gain of fuel for the month.

The major inaccuracy with this reporting is the difference between the times of the dips and the sales information. The last dip for the month could be taken in the morning with the sales for the day recorded at midnight. This leaves numerous hours between the two for fuel transactions (sales) that the driver dip is unable to take into account. The other inaccuracies is that of the dipstick and the person taking the readings.

Brief History - Automatic Tank Gauging

Level measurement of petroleum products has been around as long as the products have been for sale. The measurement of products may have been crude with accuracy's of +5% in the 1860s. In 1866, oil producers agreed to give buyers an allowance of 2 gal for every 40 gal gauged, to cover spillage, evaporation, and measurement errors. In other words, for every 40 gal of crude oil purchased, the buyer received 42 gal (This is the origin of the 42-gal barrel)[7]. This indicates that the producers of oil were well aware of the need of a measuring system to compensate for errors in the transfer of oil to the customer.

Automatic tank gauging came into the market of the petroleum industry in the 1950's with the development of the servo gauge. The gauge was pushed into the market as a need for tighter control and monitoring of liquid stock in storage. The focus of control was on the bulk storage facilities, whilst the monitoring of underground storage systems at Service Stations and Truckstops came at a later date. Unfortunately, the instrumentation of the 1950's did not have an accuracy of less than 1-2%.

The more widely used tank gauge in the 1960's was the float and tape gauge (similar to Compac Industries tank gauge). The gauges had a resolution of about 1/16 inch. The accuracy unfortunately was in the range of 1/4 to 1/8 inch. This was due to the mechanical friction between the transmitter encoder and the tape and hysteresis when the level changed from one directional movement to the other (i.e. increasing to decreasing).

The seventies saw the introduction of new technology to the gauging market in the form of ultrasonic gauges. Unfortunately, they were released into the market ten years too soon as the technology had not been totally developed and the accuracy of the gauge was lacking. Further technological developments in the gauge saw it come back to the market in the late eighties with an accurate, but expensive package.

Hydrostatic and magnetostrictive tank gauges were developed in the seventies and eighties. Both devices had fewer moving parts than their rival tank gauges, and this was seem as an advantage in the harsh confinements of a petroleum tank. Magnetostrictive uses a time-of flight principle to measure liquid level and hydrostatic uses density and mass readings to calculate the approximate liquid level. Mr Roland Piccone, who has been in the tank gauging industry since 1961 stated in his book that "Accuracy is not a strong feature when Hydrostatic tank gauging is used as a liquid level measuring device..." [8]. Mr Piccone's reasoning behind this statement was the fact that the gauges use mass and density calculations, and this was ideal for products transferred by weight like liquefied petroleum gas (LPG), but not accurate enough for liquid level control.

Today, sees most, if not all of the above mentioned tank gauges still in the market. There are many more out there to, each with its advantage over its competitors. They vary in accuracy, cost of purchase, installation and maintenance and moving parts.

Alternative Methods to Automatic Tank Gauging Tasks

Manual Dipping

The only alternative to automatic tank gauging when fuel volumes are required, is the physical measurement of the fuel within the UST. The Code of Practice for the Operation of Underground Petroleum Storage Systems (UPSS) stipulates that "the measurement of product quantity in each tank be taken at least daily on a busy site, and before and after each fuel delivery to the site. Less active sites require monthly dips or dips when a delivery is made, whichever is sooner"[4]. On BPONZ Commercial Truckstop sites, the measurement of product quantity is conducted by the tanker driver when making a delivery.

Each individual petroleum tank should have its own dipstick that has been calibrated to the tank's shape. The dipsticks are normally located within a dip tube in the tank. The process for dipping a tank requires the stick to be removed from the tank, checking the product level and then wiping the stick dry around the level. The next steps in the process are taken from the Code of Practice for the Design, Installation, and Operation of Underground Petroleum Storage Systems. The steps required are to "Lower the stick slowly and carefully into the dip tube. Do not plunge it in as this may create a surge in the dip tube. Pause when the stick is within 50mm of the bottom of the tank to allow any surge to die down, then slowly lower the stick until it just touches the bottom of the tank and withdraw it immediately. Read the liquid level and record it in a notebook. Wipe the stick dry at and around liquid level and repeat the measurement. Check that it agrees with the record quantity. If it does not agree, repeat the dip until a consistent result (within 1 to 2mm on the stick) is achieved."[4]. This is the process set down by the industry for the tanker drivers to follow when delivering fuel to a site.

Some tank dipsticks are hard to read due to the surrounding environment and the condition of the dipsticks themselves. If a tank's dipstick is hard to read, then a small amount of product finding paste can be spread around the face of the stick at the approximate product level. This will create a clear cut product line when the stick is dipped.

Statistical Inventory Reconciliation Analysis (SIRA™)

Manual tank dipping is the only alternative to automatic tank gauging when product levels within a tank are required, but level readings are not the only function of an automatic tank gauge. The automatic tank gauge has the ability to detect possible leaks from the tank by monitoring fuel levels constantly over a period of time. This monitoring occurs when the site has a "quiet" period and no sales occur.

An alternative to the leak detection offered by automatic tank gauging is Statistical Inventory Reconciliation Analysis (SIRA™). SIRA™ is a computerised statistical package offered by specialised companies in the petroleum industry to monitor underground storage systems. The packages are able to offer valued information on the condition of the underground storage system. Statistical reports produced have the potential to identify different types of losses. These losses may indicate a leakage, discrepancies in deliveries, dispenser errors, effects of temperature, theft and dip measurement errors. All of these reports can be generated from the normal reconciling data that is gathered by manned sites.

The more consecutive daily data that is made available to SIRA™ companies, the greater the chance of accurately detecting a leak. The package utilises daily sales, deliveries and dip information; therefore, it can be run in conjunction with tank gauging. Unfortunately, the package requires thirty days of data for reports to be generated and an initial three to six month start-up phase before consistent information on the status of tanks is produced.

Monitoring and Observation Wells

Monitoring and observation wells are used to assist in the conformation of a suspected leak at sites with underground petroleum storage tanks. A monitoring well, when installed at a distance from the UPSS is able to monitor the spread of hydrocarbons through the ground should a leak occur. Observation wells detect the presents of hydrocarbons in the ground, indicating the possibility of a leak.

Important Aspects of Automatic Tank Gauging

General

Tank gauging equipment does not measure volume, as many people believe, it actually measures the height of the liquid within a tank. The height is obtained using a precise form of measuring device. The height is the basis for computing the volumetric quantity of the liquid. The site controller uses strapping tables to convert reference height markings of a cylindrical tank into volumetric readings.

Automatic tank gauging will require a small amount of supervision from a network computer administrator. Their responsibility will be to monitor all the sites. With little supervision, the tank gauging is ideal for unmanned sites. Constant monitoring of the stock on-site is easily accessible by taking the readings from the digital display of the site controller.

It is the author's belief that automatic tank gauging can best be described as a continuous stock control monitoring system. From the continual monitoring of the product level in a tank and the communication link with the pump controller, the tank gauge is able to provide assistance with stock control (reconciliations), environmental monitoring and other site issues like low stock warnings and alarms.

Stock control is an important function within the oil industry. Reconciliations are performed weekly, or monthly, depending on site volume throughput to 'balance the books' and highlight any anomalies at a site such as product loss. Reconciliations of Truckstops currently use the dipstick level reading before a tanker fueldrop and the pump sales figures that come from the Fuelcard (swipe card used to purchase fuel at unmanned sites) transactions to balance the book stock against the physical stock. This method of reconciliation is dependent on tanker deliveries; therefore, reconciliations can only be performed after a delivery and cannot be performed accurately for a fixed period (eg. 20th of each month, or midnight each Sunday). Automatic tank gauging is able to perform reconciliations over any fixed period of time. The system takes a 'snap-shot' of the tank levels, pump totals and recorded fueldrops to produce a report.

Leaks from underground storage tanks are difficult to detect and can take months to discover due to the nature of the leak. Some types of tank gauges have the ability to alert the user to a possible leak through their continuous monitoring of product levels. When the underground storage system is not in use and the system is set in leak detection mode, a tank leak test can be conducted. The accuracy of the test is usually related to the period of time the equipment is in the leak detection mode. This test will take in the range of 2-6 hours, depending on the type of equipment. A fuel sale will normally cause the equipment to terminate the leak test.

Most manufacturers of tank gauges follow the United States Environmental Protection Agency (EPA) standards. These standards describe the minimum factors leak detection equipment need to possess before they can pass the EPA criteria. The main standard manufacturers follow is the EPA standard for detecting a leak. The EPA states that the equipment must meet the performance standard of detecting a leak of 0.2 USgph (0.76 lph) with a probability of a detection of at least 95% and a probability of a false alarm of no more than 5%[9]. Certain laboratories around the world conduct the EPA tests on behalf of the manufacturers. Unfortunately, the tank gauging is not tested over the total capacity of tank and the environment is controlled.

Reports and Alarms

Reports and alarms produced by the tank gauge systems portray a picture of the status of a site. The software manipulates the height and temperature data received from the probe and produces informative end user reports. Reports can be used to inspect and control the petroleum fuel stock (known as wetstock) requirements and environment. Software is typically Windows™ based with development towards Local Area Network for the larger company.

The main types of reports available are:

- Sales (Reconciliation) - This report gives a breakdown of the volume in the tank(s) and the sales that pass through the pump(s). It can range from an hour-by-hour report to a daily or monthly report depending on the software.
- Fueldrop (Deliveries) – This is able to give the level within a tank before and after a fueldrop was made, and the amount of fuel that was delivered. Sales during the fueldrop are also included.
- Leak Report - The report is able to give indications of whether a leak is occurring within a storage tank. Expansion of fuel from temperature differences can affect the viability of the leak report and further investigation is generally required.
- History Event - All events that have occurred at a site are listed in this report. This report can include alarms, reports generated and filling of tanks. The date, time and a reference number are normally associated with each event in the report.
- Site - Each site that is on the system has its own site report. Information contained in this report includes site name, address, contact and polling number. Other details can include number of tanks and pumps and the type of fuel within each tank.

Alarms are one the most important function of the tank gauging. They are the first sign that a site may have a problem. The alarms are set through the software using variables, for example, a product low alarm can be set at any level, 2000 Litres or 10,000 Litres. When an alarm is triggered, the central controller on site will report the condition via modem to the main computer. The dialling in of non-critical alarms can be delayed, saving the company high telephone expenses. The most common types of alarms are:

- Product low and high alarms
- Dry tank alarm - Product stock out
- Overfill alarm - Amount of product exceeds tank volume
- Cocktail alarm – A mixture of fuel types in a tank which occurs when a driver enters a delivery to one tank into the site controller and then actually delivers the product to another tank.
- High Leak alarm
- Theft alarm - Product loss with no pump sales.
- High water alarm

- Site tamper alarm - Someone is accessing the site controller.
- Power failure - No power to the site controller.

Alarms that are sent to the main computer will normally be accentuated by bold text and/or a flashing window on the computer screen to indicate the importance of the alarm. The site controller also has the ability to activate a local audible alarm.

Calibration of the Tank Gauges

This is one of, if not the, most important aspects of commissioning a tank gauge within an underground tank. The calibration of the gauge to the tank will determine future level measurements in relation to a reference measurement set at the time of commissioning.

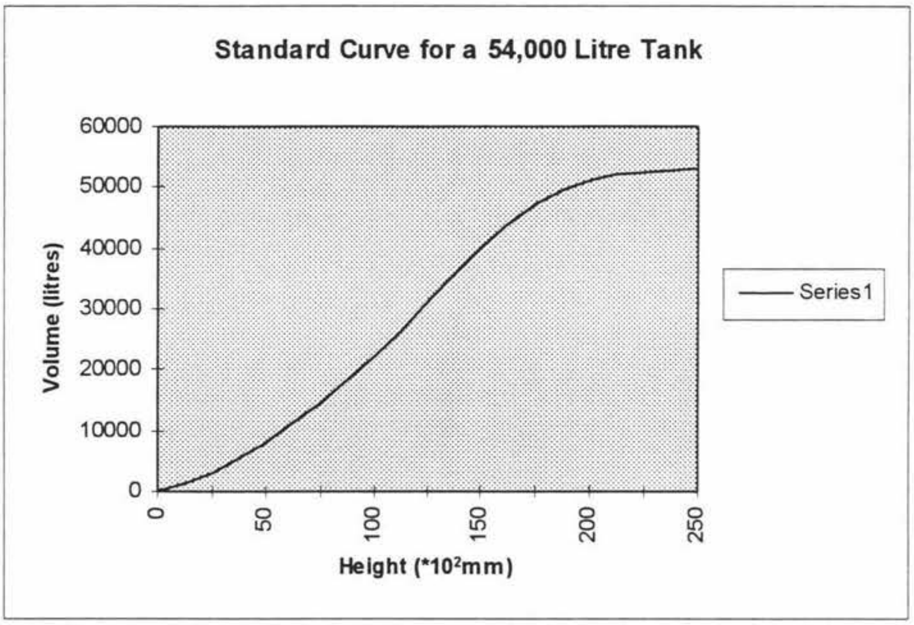
There are four calibration methods available for commissioning tank gauging.

1. Strapping table
2. Standard curve
3. Auto calibration
4. Flood fill

The strapping table (also known as the calibration table) for a tank shows the capacities, or volumes in a tank corresponding to various liquid levels measured from a reference point[8]. The strapping table information is normally gathered from the tank's dipstick. Each dipstick is unique to the tank shape and size.

A standard curve can be generated for a tank by taking the main parameters of the tank. These main parameters are diameter and length. Figure 1 illustrates the standard curve when plotted on a graph. Unfortunately, tanks placed underground tend to distort in shape (bow outwards on the bottom) from the surrounding environment and the amount of fuel within the tank. This will cause an error in the standard curve for the tank.

Fig. 1 Example of a Standard Curve



The third method of calibrating a tank gauge is to leave the gauge to automatically monitor the fuel level over a period of time in normal use. The gauge will create its own strapping table from the monitoring. This is achieved by entering a reference height-volume level in the gauge controller, and leaving the gauge to monitor sales through the pump against movements of fuel within the tank. To create a full strapping table the tank needs to be filled to its maximum and left to empty before refilling the tank and repeating the process. This method will give the true tank shape but does; however, rely on the accuracy of the pump meters and amount of fuel used to fill the tank. It is therefore imperative that pump meters be calibrated on a regular basis.

The final method of calibration is flood filling. Flood filling requires the tank to be full. A master meter is connected to the pump and the site controller. The fuel is then pumped out of the tank, while being measured through the master meter. The information is gathered in the site controller and a curve can be generated.

Automatic tank gauge systems that have the ability to utilise all calibrating methods give the customer the opportunity to compare the curves and decide on the 'best fit' curve. Certain types of tank gauging software also allow the user to manually adjust the tank curves for a refined shape. This may be used if abnormalities are occurring in the tank shape.