Title: SYSTEMS AND METHODS FOR CENTRAL CONTROL, MONITORING, AND RECONCILIATION OF LIQUID PRODUCT

Abstract: Embodiments of the present invention extend to methods, systems and computer program products for a liquid product book to physical reconciliation process that can be initiated and performed on a virtual real-time basis, regardless of ongoing sales transactions. Further, the present invention is configured to measure and compensate for temperature variances at every point of physical measurement in order to appropriately reconcile book and physical inventory. In addition, the present invention provides for an automated way to request, determine, and monitor the delivery of liquid product to a distribution facility in order to prevent shortages, unauthorized drops, theft, etc.

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SYSTEMS AND METHODS FOR CENTRAL CONTROL, MONITORING, AND RECONCILIATION OF LIQUID PRODUCT

BACKGROUND OF THE INVENTION

1. The Field of the Invention

Embodiments of the present invention extend to methods, systems and computer program products associated with the delivery, tracking, and reconciliation of liquid product inventory. More particularly, embodiments of the present invention provide for a liquid product book inventory to physical inventory reconciliation process that can be initiated and performed on a virtual real-time basis, regardless of ongoing sales transactions. Further, embodiments of the present invention are configured to measure and compensate for temperature variances at every point of physical measurement in order to appropriately reconcile book and physical inventory. In addition, embodiments of the present invention provide for an automated way to request, determine, and monitor the delivery of liquid product to a distribution facility in order to prevent shortages, unauthorized drops, theft, etc.

2. Background and Related Art

Both retail and wholesale liquid product distribution facilities (e.g., gas stations, oil refiners, etc.) are located throughout the nation and other parts of the world. Typically, the liquid product is stored in bulk storage containers or tanks, which may be located above, below, or partially below ground. Each tank may store various petroleum and other liquid products (e.g., gasoline, diesel, kerosene, etc.) to be dispensed through pump dispensers at various retail facilities (e.g., automobile service stations, trucking terminals, automobile rental outlets, and other similar operations). The liquid product is generally delivered to such retail facilities by a gravity drop from a compartment in a wheeled transport such as a fuel delivery truck. These delivery trucks are in turn loaded for delivery from tank systems located at wholesale distribution centers, which may also receive deliveries of product from, e.g., a pipeline spur, delivery trucks, a barge, rail car, or other similar means. The amount of the load is typically reported in a bill-of-lading, which is issued to the retail facility at the time of the drop.

In larger facilities, there may be multiple tanks containing the same or similar liquid product. In fact, tanks containing like or similar product may be manifolded together, allowing them to function as one larger tank. For example more
than one tank containing LS #2 Diesel fuel may be plumbed to a common trunk line connecting to multiple fueling dispensers. Additionally, multiple tanks could be plumbed together with a siphon line allowing for the cross flow of product between the tanks. For instance, tanks with premium fuel may be manifolds together with regular fuel tanks, wherein mid-grade fuels are a cross flow of these two types of fuel. For purposes of book inventory to physical inventory reconciliation, the multiple tanks that are plumbed together can be treated as one tank, since it is not always feasible to assign a sales transaction to any one of the tanks individually.

Regardless of the type of tanks, these distribution outlets (both wholesale and retail facilities) are tightly governed by Federal and state laws that require tank systems to have leak detection. One available leak detection processes is known as Statistical Inventory Reconciliation (SIR), which analyzes inventory, delivery, and dispensing data collected over a period of time to determine whether or not a tank system is leaking. Each operating day, the owner of the facility should measure the product level using a gauge stick or other tank level monitor (e.g., an Automatic Tank Gauge (ATG)). The owner is also required to keep complete records of all withdrawals from the tank and all deliveries to the tank. After data has been collected for the period of time required by the SIR, the data may be provided to the SIR vendor or entered into the owners own SIR program. The SIR system then uses sophisticated computer software to conduct a statistical analysis of the data to determine whether or not the tanks may be leaking. The program may then provide the owner with a test report of the analysis results with one of three possible bottom-line responses: pass, fail, or inconclusive.

Although current SIR systems are useful in detecting leaks and are approved by various governmental agencies (e.g., the Environmental Protection Agency EPA), they also have several shortcomings. For example, in order to use such SIR processes, measurements must take place in a static environment. In particular, no liquid product should be delivered to or dispensed from the tanks during the tank volume measuring process. For small retail facilities that typically have idle times (e.g., during early morning hours), this may not be a big burden. For larger operating facilities that have continual activity (e.g., popular truck fueling stations), however, such required inactivity of the dispensers causes a great burden on the
owner and is a big inconvenience for customers who must wait while the measurements are taking place.

Another problem with such SIR systems is they cannot provide real-time monitoring of the delivery of liquid product for accurate inventory. Frequently, there may be overages and shortages in the delivery of the liquid product as opposed to what gets reported in the bill-of-lading. These delivery inconsistencies may be caused by any number of things, for example, inaccurate metering at the rack where the fuel is dispensed into the delivery truck, inconsistencies in the delivery truck’s tank not allowing all of the fuel to drop, a bad release valve on the delivery truck, temperature changes from the rack to the tank where it’s delivered, and even theft. Regardless of the reason for the inconsistency, as mentioned above because these SIR systems typically require data taken over a large period of time (e.g., a month), they cannot immediately identify overages or shortages in deliveries by taking instant reconciliations before and after a delivery. Nevertheless, even if they could do a real-time reconciliation, because they cannot operate in a dynamic environment, they cannot give on-demand reconciliation when pumps are active. Accordingly, in order to use SIR for determining delivery shortages, deliveries would need to be made during idle times, which could be difficult, if not impossible, to schedule.

A related problem with current SIR systems is that, because they cannot do real-time monitoring of the change in volume within a tank, they cannot immediately determine if liquid product is being dropped into an unauthorized tank or if the level of water within the tank is too high. An unauthorized drop, however, can have serious consequences. For example, if the wrong petroleum product is unknowingly dropped into an improper tank, extreme damage may occur to vehicles fueled with the improper product. In addition, during a drop, the sediment at the bottom of the tank may be disturbed causing the level of water within the tank to rise dramatically. Such a rise in water volume, however, can also be siphoned into the dispensing system, causing those vehicles fueling during the surge to get water instead of fuel.

One solution to such problems would be to manually monitor the drop through, e.g., an ATG. This rudimentary solution, however, has several downfalls. For example, often times a drop cannot be anticipated; and therefore one might not even know when an unauthorized drop has occurred. In addition, by the time it is determined that the unauthorized drop is occurring or that the level of water in the
tank is rising to dangerous levels, it may take several minutes to run out and stop the unauthorized or dangerous drop, while the damage has already occurred.

Another problem with SIR reports is that they don’t take into account temperature differences at every physical point in the distribution process. When the liquid product is initially loaded into the delivery vehicle, it is at a first temperature that can be reported in the bill-of-lading. Depending on a myriad of factors, however, the temperature of the liquid product can change dramatically during the distribution process. For example, the temperature of the liquid product may change depending on the temperature difference where the delivery truck was loaded and where the drop was made, the time of day, whether the tank is above or below ground, etc. These temperature differences, however, can have an enormous effect of the measured volume of the liquid product and can be the cause of error in the SIR system.

SUMMARY OF THE EMBODIMENTS

Embodiments of the present inventions overcome these problems by providing various methods, systems, computer program products and devices. In one configuration, the present invention can include systems and methods for the central control and monitoring of product delivery based on anticipation of delivery through a request and authorization of product drop process. Prior to delivery of a product, the driver requests and receives authorization from a centralized service, such as a corporate based Centralized Inventory Management system, or CIM, sending authorization data to the driver and/or the retail facility to receive the liquid product.

The driver can provide the CIM with information on a bill-of-lading. The driver can also provide additional information such as the supplier, the fuel source where the product was loaded, the carrier, driver’s information, etc. In some embodiments, the driver can provide all of this information electronically using a portable computing device carried by the driver or located in the truck to wirelessly communicate this data between the terminal, the CIM, and/or the retail facility. The CIM can authorize delivery following a series of appropriate interactions between the fuel source, the CIM, the carrier, the driver and the retail facility where the delivery or drop will occur. As part of the anticipation of a drop, the specific tank to receive the product can be identified and flagged. That particular tank, as well as all other tanks at the retail facility, can be monitored to determine in real-time if the drop occurs at the
proper tank. Further, monitoring of water content can occur to prevent delivery of the water to the customer through the dispenser.

In one configuration, disclosed are systems, methods, and computer program products for the central control and monitoring of a delivery of liquid product. The system can include a centralized inventory management system that can monitor and control the delivery of the liquid product by a carrier, to at least one retail facility. The method can include receiving at the centralized inventory management system a request from the carrier for instructions relating to delivery of liquid product. Based on data monitored by the centralized inventory management system, the method can include determining a type and volume of liquid product needed in one retail facility selected from a plurality of retail facilities and then posting an order providing instructions to the carrier regarding liquid product needed in the selected retail facility.

In another configuration, disclosed are methods, systems, and computer program products to prevent a delivery vehicle from making an unauthorized delivery of liquid product to a liquid product storage tank at a retail facility. The method can include a retail system and/or a centralized inventory management system monitoring one or more tanks at the retail facility for liquid product delivery by the carrier. A retail system and/or the centralized inventory management system monitors the delivery, the method can include identifying delivery of liquid product to an unauthorized tank and then automatically terminating delivery of the liquid product by interrupting delivery of the liquid product into the unauthorized tank.

The system to prevent a delivery vehicle from delivering liquid product to an unauthorized storage tank can include a centralized inventory management system connected to at least one a computer in the retail facility. The system also can include at least one sensor located in each storage tank at the retail facility, the at least one sensor can be electronically connected to the centralized inventory management system and can perform a real-time measurement of the amount of liquid product in each of the storage tanks. The centralized management system and/or the retail facility can activate a valve that can interrupt the flow of liquid product during a delivery. The centralized inventory management system can monitor the sensor in each of the storage tanks while liquid product is being delivered into any storage tank and can send a signal to the delivery vehicle to close the valve if the liquid product is
being delivered into an unauthorized tank or a level of water increases, thereby indicating that too much water is in or being deposited into the tank.

In another configuration, disclosed is a virtual real-time liquid product book to physical reconciliation process within a dynamic environment. The method can include receiving a request to perform a liquid product book to physical reconciliation process for one or more storage tanks. Once received, the method can include identifying the status of one or more liquid product dispensers corresponding to the one or more storage tanks. While the one or more liquid product dispensers are in an active state, the method can include taking a plurality of measurements within the one or more storage tanks and the one or more liquid product dispensers and, based on the plurality of measurements, automatically performing the liquid product book to physical reconciliation process.

In another example embodiment is disclosed a system, method, and computer program product for performing a virtual real-time liquid product book to physical volume reconciliation by rapidly accumulating data over a predetermined time period at a plurality of measurement devices and monitoring sale transactions during the predetermined time period. This embodiment comprises receiving a request to initiate a liquid product book to physical volume reconciliation process for one or more storage tanks. The request is received while one or more liquid product dispensers, corresponding to the one or more storage tanks, are in an active state. Thereafter, a plurality of measurement data from a plurality of measurement devices is collected over a predetermined period of time, wherein the plurality of measurement data is taken at rapid intervals over the predetermined period of time. Further, a time-stamp is assigned to each of the plurality of measurement data and sales transactions are monitored during the predetermined period of time. After the predetermined period of time, the plurality of measurement data and the monitored sales transactions are used to complete the liquid product book to physical volume reconciliation process.

In another configuration, disclosed are systems, methods, and computer program products to compensate for surface movement of liquid product within one or more tanks during a virtual real-time liquid product book to physical reconciliation process. The method can include filtering physical volume measurements within one or more tanks at a point in time by receiving a plurality of measurement data at a plurality of times, each measurement data representing a volume of liquid product
within the tank. With the plurality of measurement data, the method can include comparing each volume of liquid against at least one predetermined volume identified as being unreliable and generating a second set of measurement data by eliminating any measurement data from the plurality of measurement data that is identified as being unreliable. Using the second set of measurement data, the method can include determining a sample mean and a standard deviation for the second set of measurement data and then filtering the second set of measurement data to generate a third set of measurement data by eliminating any measurement data from the second set of measurement data that has a value plus or minus a predetermined number of the standard deviations from the standard mean for the second set of measurement data.

In another configuration, disclosed are methods, systems, and computer program products for monitoring and reporting liquid product dispenser transaction states for book to physical reconciliation purposes. This embodiment can provide real-time status of sales transactions in order to perform liquid product fuel reconciliation regardless of ongoing sales. The process can include receiving a request to perform the liquid product book to physical reconciliation for one or more of storage tanks. Once the request is received, a duration for accumulation of measurement data used for the reconciliation is identified. During the identified duration, the status of one or more dispensers that dispense liquid product from one or more storage tanks is monitored. Based on the status of the one or more dispensers, either a physical inventory or a book value is updated to appropriately determine the book to physical reconciliation.

In another configuration, disclosed are methods, systems, and computer program products for collecting and communicating temperature and volume data directly from a dispenser for use during a book to physical reconciliation process. The temperature and volume readings, such as data indicative of the measured temperature and volume of the liquid product, can be received directly from a dispenser by at least one of a retail system and a central inventory management system. The method can include collecting flow data indicative of a volume of a liquid product dispensed from the dispenser at a plurality of times during a defined time interval and collecting temperature data indicative of a temperature of the liquid product dispensed from the dispenser at the plurality of times during the defined
interval. Once collected, the temperature data and the flow data can be transmitted to at least one of a retail system and a centralized inventory management system.

In another configuration, disclosed is a device for collecting liquid product volume data at a dispenser. The dispenser can include a first totalizer that receives signals from a pulser. A second totalizer can be connected or linked in parallel with the first totalizer and can receive signals from the pulser. The dispenser further includes a data acquisition unit in signal communication with at least the second totalizer. The data acquisition unit receives data from the second totalizer that is indicative of a volume of the liquid product dispensed from the dispenser.

The method for collecting liquid product data at a dispenser can include receiving a plurality of pulses at a first totalizer within the dispenser. Upon receiving pulse data or signals from the first pulser at a second dedicated totalizer within the dispenser, the method can further include generating data indicative of a volume of liquid product flowing from the dispenser. Following generating the data, the method can include sending the data corresponding to the dedicated totalizer to at least one of a retail system and a centralized inventory management system.

In another configuration, disclosed are methods, systems, and computer program products for performing an on-demand book balance to physical balance reconciliation process for liquid product. The method can include receiving an indication that a delivery of product is about to occur at a retail facility. Based on the received indication, the system can automatically initiate a first book balance to physical balance reconciliation of one or more liquid product storage tanks at the retail facility prior to receiving a delivery of liquid product. This reconciliation can be performed while fuel is dispensed from the one or more storage tanks. Following completion of the first book balance to physical balance reconciliation, the method can include delivering an amount of liquid product as indicated on a delivery document. Upon receiving an indication that the amount of liquid product has been delivered, the method can include automatically performing a second book balance to physical balance reconciliation process to identify one or more discrepancies between the book amount of liquid product and a physical amount of liquid product actually delivered to the one or more storage tanks.

In another configuration, disclosed are methods, systems, and computer program products for performing temperature standardization of the volume of a
liquid product at one or more points of physical measurement. The system can include a plurality of volume measurement devices. At least one volume measurement device is located at each of (i) a fuel source located with a distributor, (ii) a storage tank at a retail facility, and (ii) a dispenser that delivers the liquid product to the consumer. Each volume measurement device measures a gross volume of the liquid product at, respectively, the distributor fuel source, the retail facility storage tank, and the dispenser and generates volume data indicative of the gross volume. The system also includes a plurality of temperature measurement devices. At least one temperature measurement device is located at each of (i) the distributor fuel source, (ii) the retail facility storage tank, and (iii) the dispenser. Each temperature measurement device measures a temperature of the liquid product at, respectively, the distributor fuel source, the retail facility storage tank, and the dispenser, and generates temperature data indicative of the temperature. A plurality of time-stamp systems can also be included in the system. In one embodiment, at least one time-stamp system is located at each of (i) the retail facility storage tank and (ii) the dispenser. Each time-stamp system allocates a time-stamp to each of the volume data and the temperature data generated at, respectively, the retail facility storage tank and the dispenser.

In another configuration, disclosed is a method of standardizing a volume of a liquid product across a fuel management system. The method can include measuring a gross volume and a temperature of the liquid product at each of a fuel source located at a distributor, a storage tank at a retail facility and a dispenser at the retail facility. Following measuring the gross volume and temperature, the method can include assigning a time-stamp to data indicative of the temperature and gross volume in the tank and at the dispenser. The method can also entail using the measurements of gross volume, temperature and each of the given time-stamps to reconcile gross to net volumes at a single point in time.

In another configuration, disclosed are methods, systems, and computer program products for balancing net inventory using a dynamic expansion coefficient of liquid product relative to the temperature changes with density. The method can include receiving an American Petroleum Institute (API) gravity report that includes a measurement of a specific gravity and a temperature of the liquid product reported at a fuel source. Utilizing the API gravity report, the method can include maintaining
correct densities of the liquid product by utilizing a plurality of expansion coefficients to dynamically convert a gross volume measurement to a net volume measurement for transactions of liquid product in a tank and at a dispenser in order to maintain a net perpetual book balance.

In another configuration, disclosed are methods, systems, and computer program products for measuring a physical volume of a liquid product in a manifold set of tanks. The method can include identifying three or more volume book balances of the volume of the liquid product in the manifold set of tanks at three or more reconciliation times. The amounts of the liquid product dispensed from the manifold set of tanks can be monitored and the physical volume of the liquid product in each tank of the manifold set of tanks measured at the three or more reconciliation times. With this data, variance data indicative of a difference between the physical volume and the three or more volume book balances can be calculated and data for use in determining the volume of the liquid product in the manifold set of tanks, based upon a measured height of the liquid product in the manifold set of tanks, can be generated. A relationship between three or more data points representative of the variance data can be generated and used to calibrate the manifold set of tanks.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to describe the manner in which the above-recited and other advantages and features of the invention can be obtained, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings. Understanding that these drawings depict only typical embodiments of the invention and are not therefore to be considered to be limiting of its scope, the invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

Figure 1 illustrates a general overview of a system for the delivery, tracking, and reconciliation of liquid product inventory according to one embodiment of the present invention;

Figure 2 illustrates a flowchart of one method of implementing example embodiments of the present invention;

Figure 3 illustrates a schematic representation of a dispenser at a liquid product retail facility in accordance with example embodiments;
Figure 4 illustrates a graph showing multiple volume measurements within a tank over a period of time;

Figure 5 illustrates a flowchart of one method of minimizing the effect of waves or ripples in the tank, according to one embodiment of the present invention;

Figure 6 illustrates a flowchart of a method for identifying sales that are active beyond the bounds of tank manifold readings using a late pump read rule in accordance with example embodiments;

Figure 7 illustrates a flowchart of another method for identifying sales that are active beyond the bounds of tank manifold readings using an early pump read rule in accordance with example embodiments;

Figure 8 illustrates a graphical representation of an exemplary volume vs. height graph usable in the tank calibration process of the present invention;

Figure 9 illustrates a graphical representation of an exemplary volume vs. variance graph usable in the tank calibration process of the present invention;

Figure 10 illustrates another graphical representation of an exemplary volume vs. height graph usable in the tank calibration process of the present invention;

Figure 11 illustrates another a graphical representation of an exemplary volume vs. variance graph usable in the tank calibration process of the present invention;

Figure 12 illustrates yet another a graphical representation of an exemplary volume vs. variance graph usable in the tank calibration process of the present invention; and

Figure 13 illustrates a schematic representation of a computer and associated systems within which various embodiments of the present invention can be implemented.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Embodiments of the present invention extend to methods, systems, and computer program products associated with the delivery, tracking, and reconciliation of liquid and non-liquid product inventory. The embodiments can include or use one or more special purpose or general-purpose computers, including various computer hardware, as discussed in greater detail below with respect to Figure 13.

Embodiments of the present invention generally relate to methods, systems, and computer program products for liquid product inventory reconciliation
between the physical measurements of the product stored in storage tanks when
compared to the amount of product sold (i.e., pumped out of the storage tanks) and the
amount of product delivered (i.e., pumped or otherwise delivered to the storage tank)
as recorded on the books of the retail facility and/or corporate offices; i.e., the book
balance or inventory. Additional embodiments of the present invention relate to
methods, systems, and computer program products for documenting and controlling
the flow of liquid product from a wholesale distribution storage unit to the retail
facility and, ultimately, to the individual consumer. Although the following
description of the embodiments of the present invention will typically refer to
petroleum fuels as the liquid product, the following embodiments are also applicable
to other liquid and non-liquid products for which reconciliation between the physical
product and the book balance is desired. Accordingly, the following discussion
referencing petroleum products or other specific products for reconciliation is used for
illustrative purposes only and it is not meant to limit or otherwise narrow the scope of
the present invention unless otherwise explicitly claimed.

Initially described herein is a system and method for the central control
and monitoring of product delivery placement based on an anticipation of delivery
through a request and authorization process. This load/delivery authorization process
provides for an aggregate procurement control with a centralized inventory
management system that is capable of identifying irregularities in a real-time manner
in order to immediately rectify such irregularities.

Following the discussion of this system, certain aspects of the retail facility
associated with the system will be described. In addition, descriptions of various
additional systems, methods, and computer program products related to the tracking
and reconciliation of liquid fuel inventory throughout the exemplary system will be
provided.

The following discussion will refer to both Figure 1 and Figure 2. Turning
now to Figure 1, schematically illustrated is a system 100 usable for the delivery,
tracking, and reconciliation of liquid and non-liquid product inventory. Generally, the
methods, systems, devices, and computer program products of the present invention
can track, monitor, and measure the temperature, volume, and/or density of the fuel at
numerous points within the system 100, and perform a reconciliation process using
the tracked, monitored, and measured temperatures, volumes, and/or densities. By
tracking these various temperatures, volumes, and/or densities measured data can be corrected or adjusted to bring measured volumes into net terms, i.e., adjusting for the change in temperature of the liquid product through the delivery process. This can minimize the effect that temperature change can have on variances in the reconciliation process.

Figure 2 illustrates one embodiment of a method 180 that implements one process for using system 100. The system illustratively represents the processes and methods for supplying a liquid product to a carrier from a fuel source or rack (i.e. a wholesale distribution storage unit), delivering the liquid product to a retail facility, and dispensing the liquid product into a consumer’s vehicle or other container.

In the system illustrated in Figure 1, a fuel source, referred to as a “rack” 105, contains a quantity of liquid product. The rack 105 includes or can be connected to a computerized system that communicates with a corporate based or centralized inventory management (CIM) system 120. The rack 105 can include a measurement system 106. Measurement system 106 can include devices to measure, by way of example and not limitation, a product temperature device 107 to measure liquid product temperature, a product dispensed volume device 108 to measure liquid product volume, and a product density device 109 to measure liquid product density. Each of these measurements can be communicated back to the CIM 120 using a variety of different communication techniques and technologies. For instance, wireless or wired connections, including combinations of the same, can be used to communicate the data between the measurement devise and the CIM 120. The wireless connection can include using any type of electromagnetic radiation to propagate data or signals between the measurement devise and the CIM 120. The connections can utilize the Internet, local area networks, wide area networks, and associated hardware and software to enable deliver of signals and/or data between the measurement devise and the CIM 120.

The CIM system 120, in turn, can be connected to one or more retail systems 130, located at one or more retail facilities or sites 128, which form part of a computer system used to operate or control a retail fuel center or any other facility that includes one or more product storage tanks 155. Each of the CIM system 120 and the retail system(s) 130 can include one or more computers capable of storing, transmitting and/or processing various types of data. Exemplary computers are
described in more detail with reference to Figure 13. The data transmitted and received by these computers can include any specific measurements of the various information used to form the inventive systems described herein. By way of example and not limitation, this information can include measurements of fuel volume, temperature, density, the time of the measurements, and any other type of information that can be useful to make the calculations described below.

In some embodiments, the CIM system 120 can be connected to dozens of individual retail systems 130, each having unique and time specific needs for fuel deliveries. The CIM system 120 is one example of a centralized station that can be used to monitor and control the movement of liquid product, as described in more detail below. Likewise, the CIM system 120 can be one example of a fuel management system used and described as part of the inventive systems and methods discussed below.

As illustrated in Figure 1, the retail system 130 can communicate with and optionally control various other components or devices that are located at the retail facility 128 where the retail system 130 is located. For instance, the retail facility 128 can include one or more tanks 155, only one being illustrated, to hold quantities of liquid product. These tanks 155 can receive fuel from the carrier 110 through a drop head 180 and deliver fuel to a dispenser 145, for delivery to a consumer of the retail facility 128, by way of a pickup tube 160.

To obtain accurate accounting of the quantities of fuel within the one or more tanks 155, various different sensors, meters, and systems can identify (i) the height of fuel within a tank, (ii) the temperature of fuel within a tank, (iii) the volume or flow rate of fuel out of the tank, (iv) the temperature of fuel flowing out of the tank, and (v) one or more time-stamps when measurements were taken and the data generated. Additionally, sensors, meters, and systems can be used to track other characteristics of properties or the fuel, including, but not limited to, the specific gravity of the fuel, the density of the fuel, etc.

In Figure 1, the volume of fuel within tanks 155 can be measured and tracked using a tank probe 175 that delivers signals or data representative of heights and temperatures of fuel 165 to a tank gauge console 135 and so to the retail system 130. The tank probe 175 can be or cooperate with a thermistor or thermistor probe that senses the temperature of the fuel, air, and water within the tank 155. The tank
gauge console 135, and optionally the tank probe 175 and/or the retail system 130, can include a time-stamp system 137 that can assign times to the signals and data. A clock is one example of a time-stamp system, but others are known to those skilled in the art.

It will be understood that one or more of the consoles, probes, and systems can be incorporated into a single device that performs the desired functions of the console, probe, and system. Furthermore, it will be understood that, with alternate technologies available, the volume can be determined through methods other than the sensing of the height of the fluid. In other embodiments, the probe 175 can also include device to measure the density of the product in the tank 155.

To aid in tracking the movement of fuel at the retail facility 128, sensors, meters, and systems are also provided at the dispenser 145. These sensors, meters, and systems track the flow and temperature of fuel as it is delivered from the dispenser 145 to a consumer of the retail facility 128. Readings or data 150 from the flow meter and the temperature sensor, i.e., thermocouple, can be delivered to a data acquisition unit 140 for storage and subsequent delivery to the retail system 130 as needed. Optionally, the data acquisition unit 140 can include another time-stamp system 137 that assigns time values to the data, or groups of data, generated by sensors, meters, and systems of the dispenser 145. Additional discussion of the sensors, meters, and systems, and the associated measurement data, will be described in greater detail hereinafter.

With continued reference to Figures 1 and 2, a driver or carrier 110 can request delivery instructions or a supply option to deliver to a branch or retail operator, such as the retail facility 128 associated with the retail system 130, as represented by block 202. The carrier 110 can request such an instruction from the CIM system 120 using a portable or other type of computing device having computer-executable instructions and/or computer-readable media, for example. Specific details concerning such a portable computing device are discussed below with reference to the computer of Figure 13.

The CIM system 120 can evaluate or monitor data and reference the most economical order feasible for a particular retail operator or branch, using a cost-minimizing, linearly constrained optimization processes that considers, among other things, the relative cost of delivered supply options, supply purchase fulfillment
obligations, and/or retail demand constraints. For example, because the CIM system 120 is capable of monitoring the needs of several retail systems 130, i.e., tracking the inventory at one or more retail systems 130, the CIM system 120 can determine those retail facilities 128 that are in greater need of fuel product relative to other retail facilities 128. In addition, the CIM system 120 can take other factors into consideration by monitoring other data, such as the geographical location of the carrier 110 relative to a rack 105 where the product can be loaded, as well as the relative geographic relationship between the carrier 110, the rack 105 and the retail facility and its associated retail system 130.

Upon taking these and other factors into consideration, and as part of the request represented by block 202, the CIM system 120 can post an order with an order number to the carrier 110 and to the referenced rack 105. The carrier 110 can then accept or reject the order, such as rejecting the order with a reason code indicative of the reason for the rejection. For instance, the carrier 110 can request the supply option from a computing device via, e.g., the Internet, and the CIM system 120 can post the order back to the driver and rack simultaneously via a similar automated computing network. Alternatively, the carrier 110 can reject the order by sending numerical, textual or other codes representative of the reason for the inability of the carrier 110 to accept the order. For instance, the carrier 110 can reject the order in the event that a truck may have developed a maintenance problem requiring immediate attention, so that the carrier 110 cannot make an immediate pick up. Other reasons can include, by way of example and not limitation, the supplier is out of fuel, the terminal is out of fuel, the terminal is below a minimum amount of fuel, the customer credit limit at the facility has been exceeded, the supplier allocation has been exceeded, there is insufficient time for the driver to make the delivery, or the driver or delivery vehicle are not authorized to receive deliveries at the facility.

Of course, accepting and rejecting the order can include an automated procedure performed through various mediums, e.g., wireless communications such as infrared, or radio frequency communication. Further, this type of communication can utilize hardwired direct connections. Accordingly, the use of the Internet for relaying information in this embodiment and subsequent embodiments is for illustrative purposes only and it is not meant to limit or otherwise narrow the scope of the present invention unless otherwise explicitly claimed. It should be noted that any
of the computer related communication processes described herein can utilize similar automated processes. Accordingly, although a particular automated process may or may not be referenced in the following examples and description, it should be understood that the methods, systems, and computer program products described herein can utilize any of the above described mediums and any other well known means to communicate and practice the various processes described herein.

In the system described above, it can be generally assumed that there are one or more computers at each of the rack 105, the carrier 110 and/or the driver, the CIM system 120, and the retail system 130, all of which have the capability to at least communicate with one or more of the disclosed systems using wired or wireless technologies, such as, but not limited to, Internet, wireless, infrared, RF communications, etc. Further, each of the components used to measure temperature, tank volume, flow rate, etc., time-stamp the data, and perform the reconciliation processes can utilize or include one or more computer components. General details concerning the types of computer or computer systems that can be used are discussed below with reference to Figure 13.

With continued reference to Figures 1 and 2, when the carrier 110 accepts (or possibly even rejects) the order, the CIM system 120 can update the status of the order and forward ordering details to the loading terminal or rack 105. In the event that the carrier 110 accepts the order, the carrier 110 can arrive at the loading terminal or rack 105, and reference the order with the order number previously received from the CIM system 120. The loading terminal or rack 105 references the order detail via the order number and authorizes constrained loading for the carrier 110 in accordance with the order detail received from the CIM system 120. The carrier 110 can then receive delivery of the product in a delivery vehicle, as represented by block 204 of Figure 2. Once the product is loaded into the delivery vehicle, a computer located at the rack 105 or loading terminal can forward an electronic transaction record (ETR) to the CIM system 120 such as, a corporate dispatch/central ordering system of the CIM system 120, thereby altering and updating the CIM system 120 with data indicative of the completion of the load.

At this time, the carrier 110 can receive a paper bill-of-lading (BOL) from the loading terminal or rack 105 that may subsequently be used to appropriately and accurately update the liquid product inventory book balance during the liquid product
reconciliation process. The paper BOL is required under Department of Transportation rules to be available for inspection in vehicles transporting commercial cargo on U.S. highways. It is understood that exemplary embodiments of the present invention do not require the use of paper during any phase of the operation. The embodiments of the present invention can be fully and completely automated, thus allowing for all information to be passed back and forth between the various entities completely electronically. The BOL information can be substantially similar to the information contained in the ETR, which can include some or all of the information discussed below in appropriate data fields. In some embodiments, the ETR can also be sent to the carrier 110, for automated forwarding to the retail system 130 upon arrival at the delivery site.

The BOL/ETR can include the route start and end time, a freight bill number and a truck and trailer(s) number(s) as appropriate. Further, the BOL can include the customer name and customer ID, the supplier name and supplier ID, the ship from name and ship to name and the ship to ID. Additionally, the BOL can include a date, a start and end time and/or a wait time. This BOL can also include the supplier BOL product name, product ID, the gross volume, the net volume as a function of temperature, the specific gravity of the product, and the density of the product. Moreover, the BOL can include the BOL volume unit of measure (UOM), the density UOM, the temperature and the temperature UOM, the product name and the product ID. Other information can also be included on the BOL as appropriate or desired.

Once a load of fuel is received, the carrier 110 can then transport the product in the delivery vehicle to the retail facility, as represented by block 206 in Figure 2. Upon arriving at the appropriate retail facility, the carrier 110 can request a delivery authorization 115 by sending load arrival information to the CIM system 120, which can then forward the information to the retail system 130, as represented by block 208 in Figure 2. Alternatively, the delivery authorization 115 can be sent directly to the retail system 130, which in turn forwards the information to the CIM system 120. In either case, at this stage, the driver can provide the retail system 130 with information from the BOL, e.g., the product type, density, temperature of the product at the rack 105, gross gallons, temperature corrected gallons, i.e., net gallons, etc. In some embodiments, this information can be provided by the driver 110 to the
retail system 130 or the CIM system 120 using automated systems, such as, but not limited to, wireless transmission of the ETR to one or both of the retail system 130 and the CIM system 120. Since the CIM system 120 has alerted the retail site and its associated retail system 130 that an inbound carrier is coming, the carrier 110 need only pull into the parking lot and electronically transmit the ETR data to the retail system 130. This saves a great deal of time over the current manual methods, and further decreases the chance of human error.

It should be noted that the ETR/BOL can also be used to generate various accounting reports and/or journal entries within the CIM system 120, the retail system 130, with the carrier 110, and/or with the fuel supplier who controls the rack 105. For example, when the driver delivers the load, an entry can be made reflecting an account payable to both the carrier 110 and the fuel supplier from the retail outlet. The carrier 110 can generate an entry reflecting an account payable to the driver and an account receivable from the retail outlet. The supplier can also generate an entry reflecting an account receivable from the retail outlet. The carrier 110 can also provide additional information on the BOL such as the supplier, the terminal where the product was loaded or the rack location 105, the carrier 110 or driver information, etc.

Upon appropriate interactions between one or more of the rack 105, the CIM system 120, the carrier 110, and the retail system 130 that is associated with the facility or retail operator where the delivery of fuel or “drop” 170 will occur, the CIM system 120 can grant authorization for the delivery. These interactions can include a number of different steps. For example, the retail system 130 can verify that the product type and product volume match the requirements for a storage tank 155 designated to receive the drop 170. If this is not the case, a different storage tank can be identified to receive the drop 170. The CIM system 120 can then reference the tank manifolds containing product matching the transaction record and indicate an appropriate tank 155 into which the carrier 110 is to make the drop 170. The driver can then proceed to the designated storage tank fill connection and begin making the various connections required to physically deliver the product from the delivery vehicle into the storage tank. However, the driver does not actually begin the delivery process until he receives specific authorization.
Prior to giving the authorization to begin the physical product delivery process, exemplary embodiments of the present invention provide for a process for reconciling the liquid product book balance and records at the CIM system 120 to the physical quantity of liquid at the retail facility 128 available for sale. As will be described in greater detail below, and unlike prior systems, this reconciliation process can be done in a virtual real-time system even during the dispensing of liquid product out of the tank 155 and/or other tanks at the retail facility 128. Of course, such reconciliation can also be done while the retail system 130 is static. It will also be understood that obtaining the measurement data can be performed in real-time, while the reconciliation process is performed in a virtual real-time. Accordingly, the use of the system as described herein in performing the reconciliation process at specific intervals is used for illustrative purpose only and is not meant to limit or otherwise narrow the scope of the present invention unless explicitly claimed.

In any event, some embodiments provide an inventory measuring probe 175 utilized to make the actual measurements of the height of the fuel in the tank, or in some embodiments, the actual volume in the tank. These height measurements can be converted to specific volume measurements, as discussed below in much greater detail. In some embodiments, tank probe 175 provides a measure of both the fuel level and the water level within the tank. In still other embodiments, probe 175 also provides a measurement of the specific gravity or the density of the fuel and/or the fuel temperature. In large volume facilities, this process can be repeated for every delivery that occurs during the day. Additionally, and as described in greater detail below, a snapshot of the fuel level in the tank can be taken on-demand. In any event, after performing the book to physical reconciliation, the system 100 can then post the transaction record to the driver for validation, whereupon the carrier 110 validates the transaction record and the CIM system 120 posts an authorization to the driver to drop the fuel, as represented by block 210 in Figure 2.

With this authorization, the carrier 110 then begins the delivery of the product into the designated tank(s) 155, as represented by block 212 in Figure 2. During product delivery, the CIM system 120 and the retail system 130 can monitor the flow rate of fuel into the tank 155 as the fuel passes from the delivery vehicle of the carrier 110, through linking piping, conduits, and manifolds, before the fuel is delivered into the tank 155. For example, the systems 120 and/or 130 can monitor the
drop to the tank 155 by specifically monitoring the fuel height in the designated storage tank 155, in order to insure that the appropriate liquid product is dropped or delivered into the appropriate tank 155. This can be a function of the flow rate from the dispensers relative to the height of product in the tank 155. More specifically, because the flow rate through the dispenser can be greater than the flow rate of the drop from the carrier 110 into the tank 155, this embodiment of the present invention can compensate and still recognize into which tank the carrier 110 is making the drop. If it is recognized that the carrier 110 is dropping in an unauthorized tank, then the appropriate action can be taken. For example, exemplary embodiments provide that as the CIM system 120 or the retail system 130, as the case may be, monitor the various tanks and identify that an unauthorized drop is occurring, the CIM system 120 can indicate an improper drop to the retail system 130. The retail system 130 can then initiate an alarm, or in some embodiments, a lock down of the delivery vehicle control valve 113 to interrupt the flow into the wrong tank. In other words, exemplary embodiments provide for the ability for a signal to be transmitted from the retail system 130 to the carrier 110 during an improper drop, which triggers a solenoid that will automatically shut down the fuel valve 113 in the truck and stop the drop in order to mitigate cross-contamination. The solenoid valve 113 can be initiated as its control module (not shown) communicates electronically via RF, WiFi, or other wireless methods to the CIM 120 or to the retail system 130. In some embodiments, the solenoid valve 113 can be opened automatically when the delivery authorization is granted and received by the carrier 110 delivering the load of fuel.

This same shut down process can be used when a sensor in the tank indicates to the retail system 130 that intermixing of fuels is occurring or about to occur. For instance, the system 130 can automatically or manually initiate a shutoff process that can prevent fuel intermixing, e.g., that prevents diesel fuel from being dropped into a gasoline storage tank, or vice versa.

In addition to monitoring fuel delivery, the sensors within each tank can monitor the height of water in each tank. Float heights of both the fuel and water floats can be monitored such that if the water content in the tank is too high, thereby causing a risk that liquid product being pumped out of the dispensers 145 contain a high water content, then the CIM system 120, (or the retail system 130 itself, as the case may be) can relay to the retail system 130 such information. The dispensers 145
can then also be shut down in a similar fashion as that of the carrier 110, to mitigate any damage to the customer’s vehicle. In yet other embodiments, if the drop process is stopped due to high water content, the retail system 130 can automatically begin draining some of the water from the tank 155. As water vapor routinely condenses inside the tank 155, this process is done on a periodic basis regardless of the drop schedule. In other words, as part of the anticipation of a drop, a specific tank to receive a product can be identified and flagged. That particular tank, as well as all other tanks at the facility, can be monitored to determine in real-time if the drop occurs at the proper tank.

Upon drop completion, the carrier 110 or driver can notify the CIM system 120, where upon the CIM system 120 updates its central book balance as per the loading transaction record received from the rack 105 and confirmed by the carrier 110. Thereafter, the CIM system 120 performs another book to physical reconciliation process, optionally accounting for volume differences due to temperature and density of the product.

Once reconciliation is complete, the CIM system 120 can then generate a real-time exception report of various types and post it to the appropriate users. In other words, exemplary embodiments provide for the reconciliation at the beginning and ending period of a delivery. This allows the system, among other things, to automatically determine if the full amount of the load (as indicated in the BOL and loading ETR) was delivered. If not, the driver and/or drop or retail system or facility can be immediately notified of the irregularity and the appropriate action can be taken.

For example, if the second reconciliation process indicates that the full amount of product has not been received, the various connections can be checked to ensure appropriate air ventilation into the delivery vehicle to effectuate emptying of the delivery vehicle. A visual inspection of the delivery vehicle can also be conducted to ensure that the entire load has been dropped. It is possible that the driver might verify that the load has been completely delivered into the tank, but the reconciliation balance still shows a shortage.

As can be appreciated, irregularities from the reported drop versus information provided in the BOL can occur for several reasons. For example, flaws in the truck design can cause fuel product to remain within the carrier 110. Further, the
irregularity can be an indication that the carrier 110 was shorted at the rack 105 during loading. Further still, the irregularity can be an indication of a faulty valve or that that tank or valve was not fully pressurized in order to open, allowing for the full drop of the liquid product. Additionally, the irregularity can be an indication of theft or other fraudulent activity, which can immediately be identified through exemplary embodiments. That is, because the book to physical reconciliation process is performed immediately before and after a drop, the CIM system 120 can notify the retail facility’s retail system 130, or vice versa, and the appropriate action can be taken depending upon the specific irregularity.

Through use of the system 100, and the reconciliation process usable with the system 100, irregularities in tracked data can be identified and investigated within a short period of time. This is in contrast to existing systems where irregularities cannot be identified for potentially many hours following delivery of the liquid product to the retail facility 128.

It will be understood that there are various other reasons for the system identifying variances or irregularities between actual measured data and data stored at the CIM system 120 that represents what the actual measured data should be. Table 1 below illustrates a list of some exemplary reasons, while other reasons for the variances can also occur.

<table>
<thead>
<tr>
<th>Category</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loading</td>
<td>Incorrect Volume Measurement</td>
</tr>
<tr>
<td></td>
<td>Incorrect Density Measurement</td>
</tr>
<tr>
<td></td>
<td>Incorrect Temperature Measurement</td>
</tr>
<tr>
<td></td>
<td>Wrong Product</td>
</tr>
<tr>
<td>Transporting</td>
<td>Temperature Change</td>
</tr>
<tr>
<td></td>
<td>Trailer Evaporation</td>
</tr>
<tr>
<td></td>
<td>Trailer Leak</td>
</tr>
<tr>
<td></td>
<td>Theft</td>
</tr>
<tr>
<td>Delivery</td>
<td>Delivery Evaporation</td>
</tr>
<tr>
<td></td>
<td>Equipment Leak</td>
</tr>
<tr>
<td></td>
<td>Product / Tank Mismatch</td>
</tr>
<tr>
<td></td>
<td>Trailer Retain</td>
</tr>
<tr>
<td>On Sight Storage</td>
<td>Incorrect Tank Calibration</td>
</tr>
<tr>
<td></td>
<td>Faulty Probe</td>
</tr>
<tr>
<td></td>
<td>Temperature Change</td>
</tr>
<tr>
<td></td>
<td>Tank Leak</td>
</tr>
<tr>
<td></td>
<td>Tank Evaporation</td>
</tr>
<tr>
<td></td>
<td>Theft</td>
</tr>
<tr>
<td>On Sight Plumbing:</td>
<td>Temperature Change</td>
</tr>
<tr>
<td>----------------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td></td>
<td>Plumbing Leak</td>
</tr>
<tr>
<td></td>
<td>Submersible Pump Leak</td>
</tr>
<tr>
<td>On Sight Dispensing</td>
<td>Temperature Change</td>
</tr>
<tr>
<td></td>
<td>Dispenser Leak</td>
</tr>
<tr>
<td></td>
<td>Dispenser Calibration</td>
</tr>
<tr>
<td></td>
<td>Pulser Tampering</td>
</tr>
<tr>
<td></td>
<td>Pump Test Override</td>
</tr>
</tbody>
</table>

**TABLE 1**

During the various reconciliation processes performed within the system 100, such as before and after a delivery, the CIM system 120 can isolate some of the variance categories from other categories, thereby allowing a more accurate determination of the correlation between variance and the true causes for that variance. For example, if a variance occurs during a time period in which no delivery has taken place, but fuel has been pumped, the process can rule out the “Loading”, “Transporting” and “Delivery” sections for variance, so the process can more accurately correlate the variance to the “On Site” sections.

Turning now to Figure 3, illustrated is one configuration of the dispenser 145 which delivers fuel to consumers of the retail facility 128 (Figure 1). The dispenser 145 can include an inlet conduit 214 that receives liquid product from the tank 155 (Figure 1). The inlet conduit 214 fluidly communicates with a meter 216 that is affected as the liquid fuel product passes along the inlet conduit 214 and out through an outlet conduit 218, which is in fluid communication with a dispensing nozzle 220. As is standard with most dispensers 145, a pulser 222 is provided that sends pulse signals to a dispenser volume indicator or totalizer 224 for determining and/or displaying a volume and price of fuel dispensed when the nozzle 220 is active.

The pulser 222 cooperates with a shaft (not shown) of the dispenser’s meter 216 and changes the mechanical rotational movement of the meter 216 into electrical pulses representative of the number of revolutions of the meter shaft. By counting the number of pulses in the totalizer 224, the quantity of fuel flowing through the nozzle 220 can be tracked. The signals from the pulser 222 can be used by the totalizer 224 to count accumulated pulses, which can be converted, in other dispenser electronics, to volume of fuel flowing through the nozzle 220.

Exemplary embodiments provide for the data acquisition unit 140 (also shown in Figure 1) to have a dedicated totalizer 226 and a control module 228 that
can be connected or linked in parallel to the totalizer 224. Optionally, the data acquisition unit 140, and the control module 228, can receive signals from the totalizer 226. Similar to the standard totalizer 224, the dedicated totalizer 226 receives pulses from the pulser 222 in order to determine the volume of liquid product pumped from the meter 216 through nozzle 220. In addition, the volume can also be adjusted by the temperature readings from a temperature module 230 that determines temperature with a temperature probe 232 disposed within either the inlet conduit 214, the meter 216, the outlet conduit 218 or the conduit extending from the pump meter 216 to the nozzle 220. The control module 228 within the data acquisition unit 140 can assign time-stamps to the gathered temperature and volume readings, and report this information to the retail facility point of sale (POS) 236 or the retail system 130 at the retail facility 128 (Figure 1), which will eventually be transmitted to the CIM system 120. This information can be transmitted via a wireless connection as shown by antenna 234. However, data can be transferred via a wire directly connected to the retailed facility point of sale 236. Alternatively, the data can be reported via the Internet to the CIM system 120. Of course, other ways of transmitting the data collected by the data acquisition unit 140 are also available. Any specific method for transmitting the data from the retail facility 130 directly to the CIM system 120 can be used. The above example is provided for illustrative purposes only, and is not meant to limit or otherwise narrow the scope of the present invention unless explicitly claimed.

As mentioned above, the control module 228 can time-stamp the temperature data and volume data in a number of different ways. For example, the control module 228 can include an actual time of day that can be updated via satellite or other means in order to keep the control module 228 accurately calibrated. In another embodiment, the control module 228 keeps time from the initiation of the reconciliation process as an offset from the time that has passed since the initiation of the reconciliation process. This offset can then be added to the reconciliation start time at the retail facility 128 (Figure 1), or the retail system 130, for ensuring that the time-stamp on the measurement data corresponds to the time-stamp at the retail system 130. This has the advantage of not having a continual need for updating the time on the control module 228. In addition, because the reconciliation process manipulates time-stamped volume readings from various times, if the clock within the
control module 228 is only slightly inaccurate, the methods and processes described herein adequately compensate for such inaccuracies. Nevertheless, any particular type of time-stamping can be used, and those described herein are for illustrative purposes only and are not meant to limit or otherwise narrow the scope of the present invention unless explicitly claimed.

As previously mentioned, the additional or dedicated totalizer 226 can be utilized for several different purposes. For example, readings from the additional totalizer 226 can be compared to volumes reported from the weights and measures certified dispenser firmware for determining an appropriate pulse to gallon conversion ratio. This conversion ratio can then be used during subsequent reconciliation processes for detecting such things as clearance in the meter 216 caused by normal wear and tear. Further, this conversion can also be monitored such that, if it deviates from some predetermined threshold, an exception can be raised and appropriate action taken. This second or dedicated totalizer 226 can also be used to determine other problems in the system 100 (Figure 1), such as theft, a bad totalizer 224, a bad pulser 222 and/or even a problem with the dedicated totalizer 226. The values read from the totalizer 226 during the reconciliation process even allow the CIM system 120 to determine historical flow rates achievable through each dispenser 145.

As would be recognized, the pulse to gallon conversion ratio can be calculated by taking the volume at the pump head, which the local governmental weights and measures department certifies as being accurate, referencing the totalized pulses that were measured through the dedicated totalizer 226, and dividing the totalized pulses from the dedicated totalizer 226 by the weights and measures certified gallon, to come up with the new pulse to gallon conversion ratio. This pulse to gallon conversion ratio can then be monitored such that, if it changes by more than a certain percentage (e.g., 5%), an exception report can be generated indicating such things as a problem with the pulser 222 not being consistent. In addition, this process of determining a pulse to gallon ratio in essence calibrates or allows calibration of each dedicated totalizer 226 upon completion of a sales transaction. In other words, this provides for an automated method to validate the totalizer 224, as a self-checking way to ensure that the volumes reported are accurate. In addition, this embodiment can provide an automated way to calibrate the dedicated totalizer 226.
It should be noted that, while Figure 3 shows the data acquisition unit 140 as being part of the dispenser 145, this is for the purpose of illustration only. In other embodiments, the data acquisition unit 140 can be physically located within the retail facility 128 (Figure 1). Alternately, the data acquisition units 140 for several different dispensers 145 can be located in the vicinity of the dispensers 145 or the retail facility 128.

Turning again to Figure 1, now that we have discussed the general features of the system 100, we will begin to discuss some additional methods, systems, and computer program products for using the system 100 to control, monitor, track, and reconcile the storage and delivery of fuel at various locations within the system 100. By so doing, the methods, processes, and other systems can be used to reconcile measured physical volumes of fuel within one or more tanks against book inventory or balances maintained at the CIM system 120 and/or the retail system 130.

As implied above, the system 100 can be used to perform on-demand or periodic reconciliation of a physically measured volume of a fuel product against the book balance or inventory. For example, the reconciliation process can be performed continually throughout the day at five minute increments or other incremental time period. This would allow for the immediate notification of deviations such as theft in order to identify the culprit and take the appropriate action. Alternatively, or in addition to the continual reconciliation processes, on demand reconciliation of the physically measured volume of a liquid product against the book balance or inventory can occur at any given time throughout the day, even when high volumes of product are being dispensed to customers. This provides for an accurate measure of all delivered and dispensed product, regardless of temperature variations throughout the system.

The reconciliation process generally entails tracking fuel flowing into and out of the various storage tanks within the system 100. Individual or groups of tanks can be monitored, and the volume and temperature of fuel within individual or groups of tanks can be reconciled against the stored book balance or inventory stored at the CIM system 120. To perform the reconciliation, data from the various tank gauges and the dispensers (e.g., fuel temperature, volumes, pending and completed transactions, etc.) can be rapidly gathered. The data can be individually time-stamped and then manipulated to a common time-stamp before being compared against data
representative of the book balance or inventory recorded at the CIM system 120. Any disparity between the data sets is considered as a variance. For accuracy, the physically measured data can be recorded in a rapid manner (e.g., in time intervals of less than 2 seconds). With a large data set, the accuracy of the reconciliation process is increased.

The book to physical reconciliation process is described as a virtual real-time process due to the fact that the rapid read of measurements do not simultaneously occur because of latencies within the system and other complications. Nevertheless, these readings, or data, for meters, temperatures of the liquid product, liquid product height in the tank, and other physical measurements, can be brought back to a single point in time for the book to physical reconciliation process.

Following hereinafter is a more detailed description of the reconciliation process and associated methods, systems and computer program products. The CIM system 120 can initiate the reconciliation process by initiating a reconciliation request to the retail system 130 at the appropriate retail facility 128. This request can entail delivering data to the retail system 130, the data including a number of data fields. The data fields associated with the request can include, but are not limited to, (i) retail facility ID, (ii) date and time of request, (iii) the reconciliation time period, i.e., the time period over which the data is to be accumulated, and (iv) tank and/or manifold ID’s, it being understood that single or multiple tanks can be associated with a tank manifold ID.

As can be recognized, the reconciliation time period can be either hard coded or it can be an adjustable time period. Further, the time period may be a default value if no value is set by the user. In any event, the longer the time period used to accumulate the data, the higher the confidence level and accuracy of the reconciliation or the physical measurements for the reconciliation process. Because this time duration can be dynamically adjusted and/or predetermined or hard coded within the system, any particular reference to how the duration for accumulating data is determined is used for illustrative purposes only and is not meant to limit or otherwise narrow the scope of the present invention.

Upon receiving the request, the retail system 130 (i) checks the status of the outstanding transactions at the one or more dispensers 145, (ii) generates a base time-stamp for the request, and (iii) initiates each measuring device to accumulate
data. The devices used to measure the data can include, but are not limited to, devices that provide liquid product flow through the dispensers, liquid volume level measurements, liquid product specific gravity or density, liquid product temperature at the tank, at the dispenser, etc., and dispenser sales measurements through meter readings and temperature readings 150. Data acquisition units 140 are utilized to rapidly collect or accumulate measurements and assign a time-stamp to each measurement as appropriate. This rapid read of measurement data from the measurement devices can be made more efficient by limiting the CPU processing power used by other devices in order to accumulate the maximum amount of data within the specified time period. For example, the reading of leak detecting sensors or optical sensors that detect if there is condensation or liquid somewhere there shouldn’t be, can be shut down during the rapid read process, in order to more fully utilize the CPU power of these probe interfaces. This allows the CPU to focus on rapidly reading physical measurement data, such as tank gauge height, dispenser readings or data, and temperature readings or data throughout the tank manifold system. In some embodiments, certain tank gauge probes can be singled out for reconciliation activity, allowing the tank gauge console 135 to further narrow the data collection interval.

As these data acquisition units 140 collect the measurement data from the various devices, the retail system 130 receives the measurement data. Either the data acquisition units 140 or the retail system 130 can assign precise time-stamps to each one. These time-stamps can then be sent along with sales status data to the CIM system 120. Generally, the data sent to the CIM system 120 can include, but is not limited to, general facility data, tank specific data and dispenser specific data. For instance, the general facility data can include, but is not limited to, the (i) retail facility ID, (ii) date and time that the data is sent, and (iii) ambient temperature. The tank specific data, can include, but is not limited to, (i) volume measurement, (ii) height measurement, (iii) temperature measurement, (iv) beginning date and time of the data accumulation, (v) tank/manifold ID, (vi) code identifying the fuel within the tank or set of manifolded tanks, (vii) tank number, (viii) water level, and (ix) density. The dispenser specific data can include, but is not limited to, (i) dispenser ID, (ii) average temperature of sale, (iii) fuel volume, (iv) closed sale or transaction information, including transaction time, invoice number, volume, temperature, and
tank(s) from which the fuel was dispensed. One or more of the above data can have an associated time-stamp that is set by the data acquisition unit 140, the measuring device itself, and/or the retail system 130.

One example of a sample data series according to this embodiment is shown in Table 2, below, where “N” – indicates the tank is not too turbulent to postpone concise volume determination; “O” references an open transaction; “C” refers to a complete transaction; “W” references water; “S” references a mathematically smoothed height determined by the tank gauge console 135, from a number of recent raw height readings; “F” references real-time raw height readings reported by tank gauge console 135; and “Temp” references temperature of fuel dispensed.

It should be noted that, while Table 2 shows some examples of the types of data that can be collected, such as a tank temperature reading, pump or dispenser dispensed volume, and tank volume, these readings are provided by way of example only. Many other types of data can be collected, over both very long (e.g. days) and very short (e.g. many readings per second) periods of time. Additionally, readings for a plurality of pumps or dispensers, tanks, delivery vehicles, etc. can be included when performing the reconciliation process.

<table>
<thead>
<tr>
<th>TABLE</th>
<th>TANK</th>
<th>TANK TEMPERATURE</th>
<th>TURBULANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>4</td>
<td>67.74</td>
<td>N</td>
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</table>

<table>
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<tr>
<th>TABLE</th>
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<th>READ_TIME</th>
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<th>TRAN_TYPE</th>
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<td>63 5.593</td>
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<td>76.52</td>
<td></td>
</tr>
</tbody>
</table>

TABLE 2
When the time-stamped data is forwarded to the CIM system 120, the CIM system 120 can then update the perpetual inventory book balance based off the virtual real-time sales reports and the dispenser(s) status. Further, the CIM system 120 can derive statistically smoothed physical readings at a single point in time and then reconcile book inventory with physical inventory, generate various exception reports, and post those reports to the appropriate users.

As mentioned above, the retail system 130 can initiate rapid data accumulation from numerous measuring devices. This rapid accumulation of data at various points in time has many advantages over existing systems and techniques. For example, the rapid accumulation of data can be used for the physical volume determination within the inventory tank at a point in time using the plurality of data measured during the time interval. In other words, in order to determine the amount of liquid product within a tank, the difference in volume meter readings is taken at rapid intervals. Due to an inherent attenuation wave motion of the surface of the liquid in the tank 155 after a drop of the product into the tank 155, it can be difficult to accurately determine the physical volume of the liquid within the tank. Additionally, the pickup tube 160 can vibrate when product flows through the dispenser 145, causing additional turbulence and again making it difficult to accurately determine the physical volume of the liquid within the tank 155.

The adverse affects of this wave motion on a typical reconciliation process can be overcome through the reconciliation process of the present invention. Turning to Figure 4, illustrated is a graph 240 that can be used to discuss one manner of canceling or compensating for the wave effects in the tank 155 (Figure 1). The graph 240 shows the measurements of tank volume 242 as a function of time 244. Various measurements for the volume are plotted on graph 240 as a plurality of data points 250. Figure 5 is a flowchart 260 that discusses specific steps for the manner or method of canceling or compensating for the wave effects.

As mentioned before, the data points 250 are accumulated very rapidly over time to produce a data sample. For example, 30-40 data points 250 can be measured for the fuel height in the tank 155 (Figure 1) every second. In still other embodiments, as many as 100 data readings can be taken every second. These data measurements can be forwarded to the CIM 120, as represented in block 262 of flowchart 260 in Figure 5. Each of these volume measurements can then be compared
to at least one predetermined volume, as represented in block 264. In essence, this method first filters out the rapidly accumulated data representative of liquid volumes and heights to eliminate various blips or spikes that are not representative of the possible. Thus, for example, unreliable data such as data indicating a predetermined volume that is more or less than a maximum tank volume or one or more other volumes of liquid identified as unreliable is filtered out.

For example, based upon the duration of the sample request, a deviation threshold below and above the "S" type of reading (as discussed above with respect to Table 2) and the deviation allowable above and below, can be determined by multiplying the standard threshold level by the number of seconds in the request. If one uses, for example, 100 gallons as the standard threshold level, and the reconciliation period is ten (10) seconds, then the threshold level would be 100 gallons times 10 seconds, or plus or minus 1000 gallons from that standard high reading. This 1000 gallon level is represented by lines 246 and 248 in Figure 4. Data readings 250 that fall above or below that 1000 gallon threshold are ignored as unreliable in the subsequent steps. Data that is identified as unreliable may be, for example, (A) a volume of liquid that is more than a maximum tank volume; (B) a volume of liquid that is less than a minimum tank volume; or (C) one or more other volumes of liquid that are identified as being unreliable. These threshold levels are used to identify what readings are obviously erroneous, which generates a secondary data set as represented by block 266 in Figure 5.

With the secondary data set, the CIM system 120 (Figure 1) can calculate a sample mean and a sample standard deviation for that filtered secondary data set, as represented by block 268. Once determined, the secondary data set can be filtered using the sample mean and sample standard deviation. For instance using this secondary data set, the CIM system 120 (Figure 1) can discard measurement data for the tank volume outside of so many standard deviations, thereby filtering the collected data set twice. For instance, the user can select X number of standard deviations and the CIM system 120 (Figure 1) discards any acquired data that is outside the X number of standard deviations. Thus, for example, any measurement data that has a value that is more or less than a predetermined number of standard deviations from the mean is eliminated. Therefore, any of the volume readings that are within plus or
minus X standard deviations are determined to be statistically acceptable, as represented by block 270 in Figure 5.

The remaining values can be included in a third data set sample for which a third data set sample mean and standard deviation can be calculated, as represented by block 272. This narrower data sample is shown as all data points 250 between lines 252 and 254 in Figure 4. The remaining data sets can then used to determine the actual volume within the tank 155 (Figure 1) at a specific point in time, as represented by block 274.

Using statistical techniques known to those of skilled in the art, the sample mean and standard deviation can be used to determine a percent level of confidence that a measure of volume is accurate within the allowable threshold of accuracy. Alternately, the percent confidence threshold and the sample standard deviation for the volume measurements can be used to determine a volume threshold of accuracy. Temperature measurements can also be similarly filtered.

Using the product flow amounts, determined through the rapid accumulation of dispenser data, and the tank manifold volume readings or data that have been filtered in accordance with the method of Figure 5, the CIM system 120 (Figure 1) can adjust each tank manifold volume reading or data backwards, one by one, to a single time of reconciliation, and then analyze the same during the reconciliation process. Using this method of time-aligning the filtered data thus accumulated, the ripple/wave effect within the tank can be compensated by averaging the collective tank manifold volume readings or data aligned to that point in time. This method allows for compensation of the ripple/wave effect irregardless of ongoing sales transactions being dispensed. This method further allows for the consideration of fuel flow from one or more dispensers 145 (Figure 1).

Referring again to Figure 1, in addition to bringing a plurality of tank volumes to a single point in time, and as mentioned above, the methods, systems, and computer program products usable in system 100 can rapidly accumulate data for meter readings and temperatures at the dispenser 145 and bring meter readings and temperature readings 150 corresponding to the dispenser 145 back to a single point in time. A confidence level for both tank measurements and the dispenser readings can be generated based on the above described standard deviation, which is a function of the duration of the reconciliation process and the number of data points accumulated.
during this time period. Therefore, the longer the system collects data and performs the reconciliation process, the greater the reliability of the data and results.

As previously mentioned, during the reconciliation process the status of sales transactions are accounted for in a virtual real-time basis. By monitoring the various states of dispenser transactions, the CIM system 120 can separate those transactions that should be included in an adjusted physical inventory or volume versus adjusted book inventory or volume. The variance resulting from the analysis being the adjusted physical volume minus the adjusted book value. The adjusted physical volume for the tank 155 used for reconciliation can include both net interim sales plus the net physical tank volume. The net sales closed are then subtracted from, and the net deliveries added to, the net beginning value or the beginning book value in order to determine an adjusted book value.

The net interim sales can be divided into several categories. These include interim open sale, interim complete sale and interim stack sale. An interim open sale refers to a transaction that is occurring (i.e., sales transaction) at the time of reconciliation. In other words, the nozzle 220 (Figure 3) is "off" of the pump dispenser 145 and is either accumulating volume, i.e., fuel is flowing from the nozzle 220, or has the capability of increasing the volume flow. An interim complete sale occurs upon the hanging up of the nozzle 220 (Figure 3), i.e., return of the nozzle 220 (Figure 3) to a housing of the dispenser 145, but before the transaction has been fully closed, i.e., payment has been made and accepted. Interim stack sale, which is an extension of the interim complete sale, indicates that either another interim open sale or interim complete sale, or multiples thereof for interim complete sales, resides on the same dispenser 145. For example, after one interim complete transaction or sale, another customer can start using the pump or dispenser prior to the closure of the sale or transaction, i.e., payment has been made and accepted, that was previously considered an interim complete transaction or sale. Values of all of these interim open, complete and stacked sales or transactions then make up the net interim sales that are used for the adjusted physical volume in determining the variance, i.e., the difference between adjusted physical volume and the adjusted book volume.

Closed transactions can also include two states. These include closed transactions that are waiting to be sent to the CIM system 120, and those closed transactions that have been sent to the CIM system 120 from the retail system 130.
These closed transactions can be included in the adjusted book volume, but there also can be a mechanism whereby duplications are excluded. Accordingly, exemplary embodiments provide for determining and deleting duplicate copies of closed transactions, i.e., transactions that were waiting to be sent at the beginning of the reconciliation process, which have since been updated on the book balance at the CIM system 120. As would be recognized, this advantageous feature can be accomplished in many ways. For example, a comparison of closed transactions posted before or at the initiation of the reconciliation process and at the close of the initiation process can be compared, and duplicates extracted. Alternatively, an exception can be raised such that no closed transactions can be recorded to the CIM system 120 during the reconciliation time period. Other well known ways of determining duplicate reporting for closed transactions are also available. Accordingly, the specific process or system for determining duplicate closed sales transactions outlined above is provided for illustrative purposes only, and is not meant to limit or otherwise narrow the scope of the present invention unless explicitly claimed.

Generally, each transaction described above can have certain data associated with it that is useable for the reconciliation process. For instance, each transaction can have a data set associated with the transaction. This data set can include, but is not limited to, tank information identifying which tank(s) the fuel was dispensed from. As discussed before, fuel can be dispensed from a single tank or, in the case of intermediate grade fuel, from multiple tanks. The tank information can designate the tank(s) and the blend ratio where appropriate.

In addition to the above, the transaction data set can include the sale or transaction time, either commencing or completing the volume of fuel dispensed, the fuel’s temperature, and an associated invoice or identifying number. It will be understood that various other information can be associated with each transaction, and the above are only examples of some useful information.

As mentioned above with respect to Figure 3, the dispenser 145 can communicate with the retail system 130 in virtual real-time using various wireless communication technologies, such as RF, WiFi, etc. When the dispenser 145 is flagged as an interim sale or transaction, e.g., an interim open transaction, interim complete transaction or interim stack transaction, the measuring devices associated with the dispenser 145 can communicate at least temperature and volume readings
directly from the dispenser 145 for reconciliation purposes in a virtual real-time basis. By so doing, the CIM system 120 can receive temperature and volume readings (e.g., via wire or wireless signaling), on a real-time or virtual real-time basis regardless of the status of dispenser 145. With the control modules 228 (Figure 3) within each dispenser 145 assigning time-stamps to the temperature, volume and dispenser or pump status reads, and the clock within the control module 228 (Figure 3) indicating the offset from the time that has passed since the initiation of the reconciliation process, the reconciliation process can be performed regardless of the status of dispenser 145 as the offset time can be added to the reconciliation start time at the retail system 130.

To help better describe the reconciliation process and the process of bringing each measured value back to a single time to allow for accurate variance calculations between the book balance or inventor and the measured volume, the following example and description of the reconciliation process is provided.

Initially, once the CIM system 120 receives the measurement data and the time-stamps, the CIM system 120 can begin the reconciliation process. As an initial step, the process can include converting the measured fuel level readings to net tank gallons. Converting the measured fuel level readings utilizes a tank volume formula that provides a relationship between the height of fuel within a tank and the volume of fuel in the tank. Using the tank identifier, the CIM system 120 can identify the specific tank volume formula table and associated conversion processes to convert the measured height to a volume. Since a single formula cannot generally be identified as showing the true relationship of height to volume in the tank, piecewise formulas generally can. The piecewise formulas can be appropriately referenced with either a height or volume index. Additional description of the method for obtaining the chart and the associated conversion processes will be discussed hereinafter. For purposes of this example, provided below in Table 3 is a portion of the exemplary height to volume conversion data usable to determine the volume of fuel in the tank. The value of X is the actual measured height identified by the height measurement device, with at least a portion of the device disposed in the tank.

<table>
<thead>
<tr>
<th>Height (Inches)</th>
<th>Volume Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2.6613x2 + 50.029X</td>
</tr>
</tbody>
</table>
37

5  \[3.5x2 + 48.5 \cdot X - 6\]
9  \[2.75x2 + 59.95 \cdot X - 50.35\]
13 \[2x2 + 78.6 \cdot X - 167.7\]
17 \[2x2 + 79 \cdot X - 174\]

5  \[21 \cdot 1.5x2 + 99 \cdot X - 377.5\]

... ...

TABLE 3

Once the fuel level and conversion process are identified, the fuel level readings can be converted to gross volumes having the same time-stamp as the obtained fuel level reading. Using this information, the relative position of the temperature sensors or probes should be considered, by accessing the appropriate thermistor position information stored at the CIM system 120.

As mentioned before, each tank 155 can include one or more temperature measurement devices or sensors, such as thermistors with associated probes. The thermistors can measure the temperature at multiple different levels in the tank 155. One method for accurately installing the probe can include (i) identifying the span of the thermistors' probe, (ii) adding an offset per manufacturer information, (iii) dividing adjusted span by number of thermistors plus one to determine the thermistor increment or spacing between thermistors, and (iv) assigning heights to the thermistors as per the manufacturer numbering sequence. For instance, the thermistors can be numbered and the probe positioned according to the following Table 4.

<table>
<thead>
<tr>
<th>Thermistor Number</th>
<th>Height of Probe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20 inches</td>
</tr>
<tr>
<td>2</td>
<td>40 inches</td>
</tr>
<tr>
<td>3</td>
<td>60 inches</td>
</tr>
<tr>
<td>4</td>
<td>80 inches</td>
</tr>
<tr>
<td>5</td>
<td>100 inches</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

TABLE 4

With the thermistor information identified, those thermistors that are at or below the lowest measured fuel level reading can be used to determine liquid temperatures. Once the specific applicable thermistors are identified, the CIM system 120 can determine the representative temperature for the liquid by averaging the
temperature from the thermistors actually located in the fuel. Using this temperature and the API gravity (or other density measurement) for the product in the tank 155, the CIM system 120 can generate an appropriate gross to net conversion factor, as per the American Society for Testing and Materials (ASTM) formula known to those skilled in the art.

With this conversion factor, the CIM system 120 can then convert the gross inventory volume per fuel level to a net inventory volume that can be used for the reconciliation process. It will be understood that a similar number of steps can be taken to convert the interim gross sales volumes, i.e., the fuel flowing out of the selected tank, to a net volume, thus eliminating the possibility of variance caused by change in temperature when the fuel is dispensed.

With the net inventory volume and net fuel recorded sales identified, each having an associated time-stamp, the CIM system 120 can convert the individual time-stamped tank volumes to cumulative time-stamped volumes. This process can include sorting all time-stamped tank readings from the tank or manifold by their respective time-stamps. For instance, for a three tank manifold the results could be:

Tank 3 reading @ 17:28:39:165 — 11658.32 gal
Tank 1 reading @ 17:28:39:377 — 11658.12 gal
Tank 2 reading @ 17:28:39:581 — 11736.27 gal
Tank 3 Reading @ 17:28:40:398 — 11658.36 gal
Tank 1 Reading @ 17:28:40:611 — 11602.34 gal
Tank 2 Reading @ 17:28:40:815 — 11733.20 gal

With this ordered list, the CIM system 120 can order “series” of tank readings by taking the first time-stamped fuel height reading (regardless of which tank is read first) and associating it with the closest time-stamped reading of each additional tank in the manifold. Each tank reading can only reside in one series. For instance, for a three tank manifold the results could be:

1st Series
- Tank 3 reading @ 17:28:39:165 — 11658.32 gal
- Tank 1 reading @ 17:28:39:377 — 11658.12 gal
- Tank 2 reading @ 17:28:39:581 — 11736.27 gal

2nd Series
- Tank 3 Reading @ 17:28:40:398 — 11658.36 gal
- Tank 1 Reading @ 17:28:40:611 — 11602.34 gal
- Tank 2 Reading @ 17:28:40:815 — 11733.20 gal
Using only those tank readings that comprise a complete series, the CIM system 120 can calculate the time difference between the first time in the series and every time in the series. For instance, the first tank series could provide the following results:

<table>
<thead>
<tr>
<th>Tank Reading</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank 3 reading @ 17:28:39:165</td>
<td>0</td>
</tr>
<tr>
<td>Tank 1 reading @ 17:28:39:377</td>
<td>212</td>
</tr>
<tr>
<td>Tank 2 reading @ 17:28:39:581</td>
<td>416</td>
</tr>
</tbody>
</table>

With the differences calculated, the CIM system 120 can average the differences in time and then add the average difference back to the first time from the series to determine a cumulative series time-stamp. For instance, the average for the above-identified first series can be 209.33, so the cumulative series time-stamp can be 17:28:39:165 + 209.33 = 17:28:39:374.

With this cumulative series time-stamp identified, the CIM system 120 can then sum the volumes from each reading in the series and assign the summed volume to the cumulative series time-stamp. The first time-stamped series may become the “Time of Reconciliation.” So, in the example herein, the summed volume would be

Tank 3 reading—11658.32 gal  
+Tank 1 reading—11658.12 gal  
+Tank 2 reading—11736.27 gal  
= 35,052.71 gal

And, as mentioned above, the cumulative time-stamp associated with this volume would be 17:28:39:374. Note that other cumulative time-stamps from other series may be used for the Time of Reconciliation, which as described in greater detail below is the time that all measurement readings (e.g., temperature readings, dispenser volume readings, tank height readings, etc.) will be brought back to. Accordingly, the use of the first cumulative series time-stamp as the “Time of Reconciliation” is used for illustrative purposes only and is not meant to limit or otherwise narrow the scope of the present invention unless explicitly claimed.
In any event, once the Time of Reconciliation has been determined, a similar process can be performed for each additional series of data in preparation for aligning all tank manifold volume readings to the Time of Reconciliation. In particular, the above described process for determining a cumulative time-stamp and cumulative volume can be performed for each of the series. Accordingly, this aligning process can include identifying the time and volume of the "Time of Reconciliation" and each subsequent cumulative time-stamped tank manifold volume reading.

Once the Time of Reconciliation and subsequent cumulative times for each series are determined, the CIM system 120 can identify sales that appear to have been active beyond the bounds of the tank manifold readings (i.e., active beyond the end time period for the rapid accumulation of measurement data) and extrapolate a new dispenser or pump sales reading. The use of such extrapolated readings further facilitates the backward time alignment of successive tank manifold volume readings, back to the Time of Reconciliation. One method of performing this extrapolation is depicted in Figures 6 and 7.

Turning now to Figure 6, illustrated is a portion of the method to identify sales that appear to have been active beyond the bounds of tank manifold readings and to extrapolate new dispenser or pump sales readings. The method illustrated in Figure 6 is directed to backward-extrapolating a pseudo dispenser reading from the first of a pair of readings (for each dispenser) identified in the reconciliation process, while the method illustrated in Figure 7 describes the manner in which to forward-extrapolate a pseudo dispenser reading from a last pair of readings for a particular dispenser or pump during the reconciliation process, to encapsulate the last tank reading.

With continued reference to Figure 6, the process can include initially identifying whether or not the first of the paired readings is the first reading provided in the reconciliation of a particular pump or dispenser, as represented by decision block 302. If the first pair reading is the first reading for the particular pump, it is next determined whether or not the first of the paired readings is later than the Time of Reconciliation, as represented by decision block 304. If this is the case, it is next determined whether or not to use a "Late Pump Reading" rule, process, or method as described in decision blocks 306 and 308, and blocks 310 and 312.

More specifically, if the identified paired readings meet the criteria of decision block 302 and decision block 304, the CIM system 120 (Figure 1) determines whether
or not the first reading of the pump or dispenser volume is positive, as represented by decision block 306. When this is the case, it is next determined whether or not the next or subsequent reading shows a positive change in the volume at the pump or dispenser, as represented by decision block 308. If there is a positive change in volume, the CIM system 120 (Figure 1) calculates the flow rate of fuel based upon the first and second readings, as represented by block 310, and then calculates through extrapolation a new pump or dispenser reading that is tied back to the closest time-stamp tank manifold reading, as represented by block 312. If the particular new pump or dispenser reading is greater than zero, it can be used during the reconciliation process; otherwise the newly identified pump or dispenser reading will be discarded. When the new pump or dispenser reading is less than zero, and when any of the decision blocks 302, 304, 306 and 308 are not in the affirmative, the CIM system 120 (Figure 1) will use the pump or dispenser readings provided in the reconciliation as being constant in their display of the actual pump or dispenser volume, as represented by block 318.

Turning now to Figure 7, a similar process is provided for the last paired reading from a pump or dispenser during a reconciliation process. The process performed by the CIM system 120 (Figure 1), identified by reference numeral 330, can include determining whether the last of all of the paired readings for a pump or dispenser is the last reading provided in the reconciliation for that pump or dispenser, as represented by decision block 332. When the result of decision block 332 is in the affirmative, it is next determined whether or not the last of the paired readings for the pump or dispenser is earlier than the last tank manifold volume reading identified during the reconciliation process, as represented by decision block 334. When a last paired reading for the pump or dispenser is earlier than the last tank manifold volume reading, i.e. decision block 334 is in the affirmative, the process can further use an "Early Pump Read" rule, process, or method for determining an early pump or dispenser reading as provided for in decision blocks 336 and 338, and also blocks 340 and 342.

More specifically, it can be determined whether or not the last reading of the pump or dispenser has a volume amount that is greater than the amount for that pump or dispenser in the prior reading, as represented by decision block 336. When this is the affirmative, it is next determined whether there is a tank manifold reading after the
last known reading for the pump or dispenser associated with the reconciliation process, as represented by decision block 338. When this criterion has been met, the CIM system 120 (Figure 1) can then calculate the flow rate between the last pump or dispenser reading and the last tank manifold reading, as represented by block 340 and then calculate a new pump or dispenser reading forward to the closest time-stamp tank manifold reading, as represented by block 342. This new pump or dispenser reading can then be used during the reconciliation process. When any of decision blocks 332, 334, 336, and 338 are in the negative, the pump or dispenser readings provided in the reconciliation process are constant in their display of pump or dispenser volume.

These processes described in Figure 6 and 7 yield the following results that can be shown on a timeline:

\[ [TV_1] \rightarrow P_1V_1=1 \rightarrow [TV_2] \rightarrow P_1V_2=2 \rightarrow [TV_3] \]  

Where \( TV_n \) is the nth tank manifold volume reading, \( P_n \) is the nth pump reading, and \( V_n \) is the volume of the nth pump reading. When using the “Late Read Rule” one would create \( P_1V_6 \), with a time-stamp 1 second prior to that of \( P_1V_1 \) since the Late Pump Read Rule criteria all apply. When using the “Early Read Rule” one would create \( P_1V_3 \), with a time-stamp 1 second later to that of \( P_1V_2 \) since the Early Pump Read Rule criterion all apply.

Using the known flow rates between all time-stamped pump or dispenser readings, the CIM system 120 can interpolate a pump or dispenser sales reading for every pump or dispenser with a time-stamp equal to the time of each tank manifold volume reading. With this pump or dispenser sales reading determined, the CIM system 120 flow rate adjusts each tank manifold reading back to the “Time of Reconciliation,” by adding the pump or dispenser sales volumes back to the tank manifold reading.

With all relevant data read or adjusted back to the Time of Reconciliation, the CIM system 120 can determine physical volume from the multiple series of tank manifold readings by averaging all time-aligned net inventory volume readings together to determine a mean physical inventory. A standard deviation can also be calculated for the sample set of tank manifold readings, and readings that are +/- X standard deviations from the computed mean may be thrown out (where X may be user defined or some fixed value, e.g., 1 standard deviation). The remaining tank
manifold readings can then be averaged to generate the net physical volume at Time of Reconciliation. Using statistical methods known to those of skill in the art, a confidence level can also be shown for the volume determined using this method. As before, this confidence level is a function of the number of samples taken and the duration of the sampling size.

Once the net physical volume is determined, this net physical volume at Time of Reconciliation can be adjusted by the CIM system 120 for any interim sales associated with the manifold by adding back to the net physical volume at the time of reconciliation, the net interim sales at the time of reconciliation, which consist of interim active sales, interim completed sales, and interim stacked sales as described herein. In other words, those sales that were not already compensated for in the extrapolated dispenser or pump process previously described should be added back to the physical volume, since these sales will not appear on the book balance.

With the adjusted value, the CIM system 120 can then calculate the variance of adjusted net physical volume to perpetual book net volume, i.e., the volume identified by various transactions, with the volumes associated with the various transactions being converted to net temperature (e.g., 60 °F) volume terms before being added to the book balance. This variance calculation can include updating the net perpetual book balance to the Time of Reconciliation, and subtracting net perpetual book balance from adjusted net physical volume.

The following paragraphs illustrate one embodiment of a system for standardizing a volume of a liquid product. The liquid product is delivered from a fuel source by the carrier 105 (Figure 1) to the retail facility storage tank 155 (Figure 1) and is then delivered from the retail facility storage tank 155 through the dispenser 145 (Figures 1 and 3) to a consumer. The system can include the volume measurement device 108 (Figure 1) that measures a gross volume of liquid product upon delivery of the liquid product to the carrier 105 and generates volume data indicative of this gross volume. The system can also include the temperature measurement device 107 (Figure 1) that measures a temperature of liquid product upon delivery of the liquid product to the carrier 105 and generates temperature data indicative of this temperature. Furthermore, the system can include a volume measurement device 165 (Figure 1) that measures a gross volume of liquid product at the retail facility storage tank 155 and generates storage tank volume data indicative
of this gross volume. Likewise, the system can include a temperature measurement device 165 that measures a temperature of liquid product at the retail facility storage tank 155 and generates storage tank temperature data indicative of this temperature. The system can further include a time-stamp system 137 that can be located, by way of example and not limitation, in the tank gauge console 135 (Figure 1) configured to receive the storage tank volume data and the storage tank temperature data and to allocate a time-stamp to the storage tank volume data and the storage tank temperature data. Further still, the system can include a dispenser volume measurement device 224, 226 (Figure 3) that measures a gross volume of liquid product at a dispenser and generates dispenser volume data indicative of this gross volume, a dispenser temperature measurement device 230 (Figure 3) that measures a temperature of liquid product at the dispenser and generates dispenser temperature data indicative of this temperature, and a time-stamp system 137 (Figure 1) configured to receive the dispenser volume data and the dispenser temperature data and to allocate a time-stamp to the dispenser volume data and the dispenser temperature data.

In some embodiments, the time-stamp system 137 at the retail facility storage tank 155 communicates with the volume measurement device 165 and the temperature measurement device 165 at the retail facility storage tank 155 so as to receive volume data and temperature data and allocate a time-stamp to the volume data and temperature data generated at the retail facility storage tank 155. The time-stamp system 137 at the dispenser 145 communicates with the volume measurement device 224, 226 and the temperature measurement device 230 at the dispenser 145 so as to receive volume data and temperature data and allocate a time-stamp to the volume data and temperature data generated at the dispenser 145.

In one embodiment, the volume measurement device 108 that measures a gross volume of liquid product upon delivery of the liquid product to a carrier and the temperature measurement device 107 that measures temperature of liquid product upon delivery of the liquid product to a carrier, respectively, measure the volume and temperature of the liquid product as the liquid product is delivered from the distributor fuel source to the carrier. Alternatively, the volume measurement device that measures a gross volume of liquid product upon delivery of the liquid product to a carrier and the temperature measurement device that measures temperature of liquid
product upon delivery of the liquid product to a carrier, respectively, are located at
one of (i) a fuel source located with a distributor, (ii) the carrier and measure the
volume and temperature of the liquid product located within the carrier. The volume
measurement device that measures a gross volume of liquid product and the
temperature measurement device that measures temperature of liquid product upon
delivery of the liquid product to a carrier, respectively, may measure the volume and
temperature of the liquid product when the carrier is located at a fuel source at a
distribution facility.

Once the time-stamps are assigned, the volume and temperature data can be
adjusted back to a single point in time, so that net volumes can be calculated and used
to update the book balance during the reconciliation process. By time-stamping the
volume and temperature data, the flow of liquid product from the tank(s) and
dispenser(s) at the retail facility can be accurately measured and so relied upon during
the reconciliation process.

In making the above mentioned calculations for tank volume, and as discussed
herein, it is desirable to identify the height of the fuel in the tank and use this
measurement to determine the volume of liquid product within a tank. One manner or
method for converting the height of the fuel to a volume is by way of a calibration
chart, and associated processes. The tank manufacturer provides a chart that can be
used to make the height to volume conversions on a finite scale. However, the
manufacturers chart may assume that the tank was placed in the ground exactly
horizontally and vertically, and/or that the tank was manufactured to an exact
standard. If the tank is slightly off from the horizontal, vertical or the standard, this
can affect the height to volume conversion. It is sometimes necessary to calibrate the
expected height to volume relationship to account for this slight discrepancy. This
can be accomplished by identifying variance as a function of either height or volume
in the tank.

It should be noted that the calibration process is not limited to a single
tank. In many cases, there are multiple storage tanks holding the same type of
product that are manifoldsed together to form a manifoldsed group. A manifoldsed
group can be a group of one or more tanks allowing a cross-flow of product or a
group of one or more tanks that are plugged into a single trunk line going to a group
of dispensers. In either case, a manifoldsed group can include multiple tanks that,
because liquid product flows out of one or more of the tanks to the dispensers during delivery to a consumer, the flow of the liquid product can’t be tied back to any one of those tanks individually. Likewise, because there is cross-flow of product between those tanks, it is not feasible to keep an accurate book inventory on any one of those tanks individually. However, accurate book inventory can be maintained for the group. In some embodiments, the calibration process can be used to calibrate the manifolced group, rather than the individual tanks within the group.

In order to perform the calibration process, it is desirable to ensure that the manifolced group is normalized. The various gauges in the tanks in the group can give different readings at any one time. For example, one tank could read 65 inches, another 64 inches, and a third 61 inches. As long as this difference remains relatively constant, the tanks can be considered normalized. In other words, if all of the height values across all of the tanks in the tank group can be shown to have moved in parallel fashion when product is added or removed, i.e., the measured heights all moved up or down one inch, the group can be considered normalized, and the calibration process can be conducted. The degree to which the tank manifolced group is normalized can be shown using a method of tracking the standard deviation of height difference of the contents of the tanks in the manifolced group, across multiple sample readings of those heights. Tolerance limits can be set allowing the system to identify which reconciliation samples can be qualified for consideration in the calibration process.

Keeping in mind that there are many ways to perform this calibration process, two such ways will be discussed herein. In a first method, a single tank or manifolced series of tanks is filled. The product is then pumped out until the tank(s) can be considered empty. Measurements are made at incremental levels as the product is dispensed. These measurements can then be used to generate a calibration curve that allows a retail facility to read the level of product in the tank(s) and know with some accuracy how much variance there is in that measured reading. Variance that falls outside the limits of the calibration curve can then be initially unexplained variance. Using the various systems and methods discussed above, this initially unexplained variance can then be explained. This first method will be discussed in detail below with reference to Figures 8-11. In a second method to accomplish the
calibration process, historical data can be used to determine the calibration curve. This second method will be discussed below with reference to Figure 12.

The first method will be discussed with reference to Figures 8-11 and Table 5, shown below. Initially, the CIM system 120 treats the manufacturer’s height vs. volume chart as if the chart was correct when the tank is filled. For instance, data representative of the manufacturer’s chart can be stored in data storage at the CIM system 120 (Figure 1). Initial variance between manufacturer’s chart and calibrated chart pending is then zero. For instance,

<table>
<thead>
<tr>
<th>Manufacturer’s Chart</th>
<th>Calibrated Chart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>Volume</td>
</tr>
<tr>
<td>108”</td>
<td>19122</td>
</tr>
</tbody>
</table>

TABLE 5

Using Table 5 above, the fuel reconciliation process can be started as previously describe herein. When the next volume measurement is received (i.e. after the predefined amount of fuel has been dispensed), the CIM system 120 (Figure 1) can then calculate the variance from our “expected” volume based on the manufacturer’s charts. Below are examples of formulas that can be used to calculate the variance, with the identified volumes being adjusted to the average manifold temperature as taught herein:

\[
\text{Gross volume from chart readings} = \text{expected volume} \quad (2)
\]

\[
\text{Gross Initial volume} - \text{dispensed volume} = \text{calibrated volume} \quad (3)
\]

\[
\text{Calibrated volume} - \text{expected volume} = \text{variance} \quad (4)
\]

The variance can be calculated every time a new volume measurement is received during this tank calibration process. For example, a measurement can be received for every hundred gallons of fuel dispensed. When all volume and variance measurements have been calculated, the CIM system 120 (Figure 1) can generate the volume vs. the variance and the volume vs. height relationships for when the tank is tilted or otherwise deformed. Examples of these are illustrated in Figures 8 and 9.

Figure 8 illustrates a chart 350 comparing a volume 352 in the tank to a measured height 354 of the gauge in the tank. A base curve 356 represents the curve if the tank is sitting exactly upright, while a tilted curve 358 represents the curve for the tank as it is actually sitting. These two curves 356, 358 cross at a point 360, which represents the assumption that there is no variance when the tank is full.
Figure 9 illustrates one possible corresponding volume to variance chart 370. Chart 370 plots an actual variance 372 versus a measured volume 374, represented as line 376. From these initial graphs 350, 370, and data indicative of the curves and lines, the CIM system 120 (Figure 1), and more generally one or more methods and/or processes of the present invention, can determine if the volume and the variance have a significant relationship.

It is understood that the initial assumption that there is no variance when the tank is has been filled could be false. Primarily, the tank could be distorted such that the fill capacity differs from the manufacturer's specification, or perhaps the tank was not completely filled at all. However, because of the relationship between volume and variance shown, the CIM system 120 (Figure 1) can shift the calibrated curve in such a manner as to minimize the least squares difference in the calibration curve and the original curve. This can produce a graph 378, like that shown in Figure 10, which gives a more accurate representation of the volume to measured height relationship.

Note that in this graph 378, the cross over point between the base curve 356 and the tilted curve 358 is now at a new point 362, which can approximate an intermediate point of both curves 356 and 358. A new volume to variance graph 379 can also be created, as illustrated in Figure 11.

Once the graphs 378, 379 have been generated, the CIM system 120 (Figure 1) can generate data, such as but not limited to, one or more formulae that represent the curve and illustrate the variance as a function of height or inventory volume. The formulae identify the expected variance for any volume measurement on a specified tank manifold. Any variance observed deviating from this line can be an unexplained variance, which can be subject to later assignment through correlation analysis. Since the exact position of a tank underground is different for every tank, this process is completed for each tank in the system 100 (Figure 1) or for each series of manifolded tanks.

A height to volume reference chart derived from the variance curve discussed above can have the form as follows.

<table>
<thead>
<tr>
<th>Height (Inches)</th>
<th>Volume Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2.6613x2 + 50.029X</td>
</tr>
<tr>
<td>5</td>
<td>3.5x2 + 48.5 X - 6</td>
</tr>
</tbody>
</table>
TABLE 6

Any height measurement of liquid product with the tank between numbers on
the chart can use the formula of the lowest number. For example, if the measured
value is 5.5 inches, since 5.5 inches is greater than 5 but less than 9, the CIM system
120 (Figure 1) can use the data or formula indicated by height 5, where X is the
measured height. The use of such a piecewise data or formula chart allows infinite
interpolation capability between the known values.

During the above-described tank calibration process, it is desirable to append
the temperature and representative density of the fuel tank manifold, along with the
temperature and representative density of the fuel being dispensed, to every sales
transaction. This can be done so the gallons dispensed can be converted to what they
would have been at the tank temperature. This method can minimize bias in the tank
calibration curve, and therefore increase the accuracy of the system 100 (Figure 1).
The following describes one example of a process to accomplish this.

In order to correct for temperature, the temperature of the fuel in the tank is
accurately measured. Most tanks use a series of thermistors located at periodic height
within the tank to make these measurements, as described previously. By way of
example and not limitation, if the tank is a standard 10 foot tall tank, thermistors
could be located at heights of 20, 40, 60, 80 and 100 inches. Depending on the
measured height of the fuel, one or more of these thermistors would be read to
ascertain the fuel temperature in the tank. If one or more of these thermistors are
above the level of the fuel, they can be ignored as the air temperature in the tank can
differ markedly from the actual fuel temperature. In alternate embodiments, a
thermistor attached to the float that measures the fuel height can be used to measure
the fuel temperature. When the process is started, a period inventory temperature can
be calculated by averaging the temperature from the prior and current reconciliations.
The derived period inventory temperature can be used by the CIM system 120 (Figure
1) to temperature-correct each interim sales transaction to the same temperature as
what prevailed in the inventory tanks. As previously mentioned, this can be done using only the thermistors in the tanks that are below the fuel level.

As fuel is dispensed, each transaction can be accompanied by a temperature or data indicative of the temperature of the fuel at the point of measurement in the fuel dispenser. When the reported sales volume, or Accum_Volume, reaches the next incremental threshold volume, or Volume_Increment, then the total manifold volume can be converted to net volume terms, using an ASTM certified method, to obtain a conversion factor for converting volumes at the tank temperature to equivalent volumes at a standardized temperature, (e.g., 60°F). For example: the measured data could be Gross_Volume = 10,000 gallons, temperature = 73°F, and API Gravity = 57.5. The calculated data to achieve the volume of fluid at 60°F could be found using API Gravity at 60°F = 55.9, with a conversion factor = .9914 and the following equation:

$$\text{Net Volume} = \text{Conversion Factor} \times \text{Gross Volume}$$  \hspace{1cm} (5)

This results in temperature corrected net volume being 9914 = .9914 \times 10,000.

The CIM system 120 (Figure 1) can perform a similar calculation to convert each transaction volume dispensed into net standard temperature (e.g., 60°F) terms. Then the CIM system 120 (Figure 1) can take the sum of the net volume dispensed, and divide it by the tank conversion factor used to bring the tank inventory to net standard temperature terms. The result is dispensed volume temperature corrected to prevailing tank temperature. For example, if the calculated net dispensed volume or Net_Disp_Vol = 500 and the Tank_Conversion_Factor = .9914, then, using equation 6 below,

$$\text{Disp Vol at Tank Temp} = \frac{\text{Net Disp Vol}}{\text{Tank Conversion Factor}}$$  \hspace{1cm} (6)

the dispensed volume temperature corrected to prevailing tank temperature = 504.34 or 504.34 = 500 / .9914. It is the dispensed volume temperature corrected to prevailing tank temperature that the CIM system 120 (Figure 1) can use to subtract from the previous tank volume to calculate the calibrated volume, as described herein.

Each time Accum_Volume reaches the Volume_Increment amount, a new manifold temperature can be measured, and an average temperature can be calculated between this current measurement and the previous manifold temperature. This process can be repeated until the tank calibration process is complete.
The CIM system 120 (Figure 1) can periodically check the chart and data used to convert measured height of liquid within a tank to a volume of liquid within the tank, i.e., the strapping chart and data, for each tank within system 100 (Figure 1). Each tank within the system 100 (Figure 1) can have its own strapping chart and data. By periodically checking the chart and data, the accuracy of the strapping chart and the height to volume conversion factors can be periodically verified. When the CIM system 120 (Figure 1) performs a periodic check, a notification can be sent to the retail facility 128 (Figure 1) and associated retail system 130 (Figure 1) indicating that the calibration is being performed and that no deliveries are allowed to the tank being checked. Following notification, a reconciliation process can be performed to verify fuel volumes and temperatures. When a disparity is identified, i.e., the existing tank strapping chart does not mirror the reconciled volume, the strapping chart can be modified to accommodate for the disparity.

One disadvantage of the above system is that it restricts deliveries while the calibration process is ongoing. In large retail facilities, a single tank can be emptied of product in a matter of hours. A second method to calibrate the measurements has been developed to overcome this deficiency. This method is illustrated in Figure 12, which is based on the data shown in Table 7 below. Note that, while Table 7 illustrates a manifoldeed group of tanks, a similar approach can be conducted to determine a calibration curve for a single tank.

<table>
<thead>
<tr>
<th>Line #</th>
<th>Beg. Book</th>
<th>- Sales</th>
<th>+ Deliveries</th>
<th>End Book</th>
<th>ATG</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60,000</td>
<td>10,000</td>
<td>0</td>
<td>50,000</td>
<td>50,100</td>
<td>100</td>
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<tr>
<td>2</td>
<td>50,100</td>
<td>5,000</td>
<td>0</td>
<td>45,100</td>
<td>45,200</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>45,700</td>
<td>5,000</td>
<td>0</td>
<td>40,200</td>
<td>40,100</td>
<td>-100</td>
</tr>
<tr>
<td>4</td>
<td>40,100</td>
<td>10,000</td>
<td>15,000</td>
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<td>45,000</td>
<td>-100</td>
</tr>
<tr>
<td>5</td>
<td>45,000</td>
<td>10,000</td>
<td>0</td>
<td>35,000</td>
<td>34,800</td>
<td>-200</td>
</tr>
<tr>
<td>6</td>
<td>34,800</td>
<td>5,000</td>
<td>0</td>
<td>29,800</td>
<td>29,900</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>29,900</td>
<td>5,000</td>
<td>0</td>
<td>29,900</td>
<td>25,000</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>25,000</td>
<td>5,000</td>
<td>10,000</td>
<td>30,000</td>
<td>30,100</td>
<td>100</td>
</tr>
<tr>
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<td>0</td>
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<td>20,200</td>
<td>100</td>
</tr>
<tr>
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<td>20,200</td>
<td>5,000</td>
<td>0</td>
<td>15,200</td>
<td>15,200</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>15,200</td>
<td>10,000</td>
<td>0</td>
<td>5,200</td>
<td>5000</td>
<td>-200</td>
</tr>
</tbody>
</table>
TABLE 7

The data in Table 7 was generated as part of a tank calibration process, such as a calibration process described above. The tank calibration process can include modules, such as software modules and hardware modules, and/or functions which continually query a database accessible to the CIM system 120 (Figure 1) and/or the retail system 130 (Figure 1) to determine if a predefined amount of fuel has been dispensed. When the dispensed volume is greater than or equal to the volume increment, a fuel reconciliation can be performed which will calculate the variance from the expected volume based on the manufacturer's strapping charts and data. It will also calculate accumulated variance associated to a specific manifold volume, i.e., the volume of liquid product for one or more tanks manifolded or in fluid communication one to another. Figure 12 and Table 7 were generated using formulas 2-4 shown above. In addition, the following formula also applies:

\[
\text{accum\_variance} = \text{accum\_variance} + \text{variance}
\]  

(7)

Figure 12 shows a graph 380 that illustrates the additional method of generating a calibration curve for a tank or a manifolded tank group. The Graph 380 includes a measure of tank volume 380 on the "X" axis, and a measure of a variance 384 on the "Y" axis. Using the data from Table 7, a plurality of data points 388 can be plotted on the graph 380. As shown on line 1 of Table 7, the beginning book balance is 60,000 gallons. It is assumed that 60,000 gallons is the approximate tank fill level. Furthermore, it is assumed that at 60,000 gallons, there is no variance. If there were 10,000 gallons of sales before the next reconciliation and no deliveries, the ending book balance, or the calculated value that one would expect to be in the tank and to be reported through the automatic tank gauge would be 50,000 gallons. But in reading the height of the product, and using the formulas derived from the manufacturer's data for those tanks, it could be reported through the tank gauge that there were 50,100 gallons. So the accumulated variance from the representative top of the tank down to this position of the tank can be shown as a function of manifold volume alone. This 100 gallons of positive variance can be expected to reoccur in the future. The variance is measured and added to the accumulated variance every time a new volume measurement is received from the Tank Calibration Process. Thus, for
every volume measurement there is an associated accumulated variance that can be stored and plotted on the graph 380.

The 50,100 gallons becomes the new book balance. As shown in line 2 of Table 7, there is then an incremental 5,000 gallons of sales, which generates an ending book balance of 45,100. In reading the tank gauge and reading the strapping formulas or data, it could be determined that there were 45,200 gallons in the tank. These incremental points can then be plotted on the graph 380, which shows these three data points 388 (one starting point and two reconciliation points). Row three of Table 7 then shows a beginning book balance of 45,200 gallons. There are 5,000 gallons in sales. The physical inventory should then be 40,200. However, at this point, the automatic tank gauge provides a reading of 40,100 gallons, which is a variance of 100 gallons. These four data points are then used to construct a curve 390.

In line four of Table 7, a delivery is made into the tank(s). Every time a delivery occurs during the calibration process, the system will perform another fuel reconciliation. This provides a new starting point in which the accumulated variance is set to zero. It is desirable to set the accumulated variance back to zero to minimize any effects from a possible delivery variance. For example, if the book shows that 15,000 gallons were delivered, but only 14,800 gallons were actually delivered, this could skew the calculations. Lines 5-7 in Table 7 can then be used to provide another set of data points 388, which can then be used to generate a second curve 392. The above process is continued until the calibration process is finished, or another delivery is made. Any time a fuel reconciliation is run and the volume is greater than the previous reconciliation’s volume, then a delivery has occurred. This is illustrated in the graph 380 as another curve 394. A user can include as many segments as desired and/or for which historical data exists. After defining the segments to be used, calibration formula and data for the tank or manifolded tanks can then be generated.

The calibration formula can be built from the segments 390, 392, and 394 that were generated from the actual data retrieved from the normal reconciliation processes. The identified segments can be assigned a hierarchy and can be connected by using a technique of minimizing the least squares distance of the overlapping portions of those segments. This aligned curve is represented as a dashed line 396 in Figure 12.
From the data in Table 7 and the corresponding curves shown in Figure 12, it can be identified that there is a pattern-like relationship between the manifold volume and the accumulated variance. Geometrically, it can be shown that tilt, deformation or any other inaccuracy in the tank specification, or the inventory measurement apparatus of any individual tank, can invalidate the original formula representing the height to volume relationship for that tank. Furthermore, it can be shown that such inaccuracies are consistent or static in nature, and can combine in aggregate to show a pattern-like relationship. The above process provides a curve that substantially reduces or even eliminates the differences between the actual installation and the manufacturer’s original height to volume charts.

As long as there are a sufficient number of data points available in the historical data, the above method can be used to generate a volume to variance curve over the entire range of tank(s) volumes. Therefore, for a given measured volume, curve 396 represents the expected amount of variance due to the tank structure and/or placement. The curve 396 allows representation of both the variance that could be expected after filling the tank and later running a reconciliation at any fill level of the tank, or the incremental variance that could be expected between any two fill levels of the tank. Note that no operational limitations need to be imposed on the system to allow for the retrieval of the data to build the segments necessary to generate the calibration formula or data. No time period need be identified over which data is to be collected and analyzed, as is the case with the first method discussed above with reference to Figure 8-11. Additionally, the process outlined above with reference to Table 7 and Figure 12 allows for a periodic re-calibration on an as desired basis.

As alluded to above, methods, systems, and computer program products can be used with the system 100 of Figure 1 to probe end-to-end fuel temperature at various points, including all points of physical measurement for temperature correcting volume across the fuel management system. Because of the reporting of the temperatures through, for example, the antenna 234 (Figure 3) within the dispenser unit 145, and by using temperature readings taken during the rapid accumulation of data at other locations within the system, such as at the tank 155, this system 100 and the CIM system 120 allow for both consideration of and, where necessary, provides actual temperature measurements for, all points of physical measurement.
In particular, fuel temperatures can be measured at the loading rack 105 (as recorded in e.g., the bill-of-lading), at the liquid product storage tank 155, and at the fuel dispenser 145. There can be significant temperature change occurring both during delivery to retail facility 128 from the load rack 105, as well from the liquid product storage tank to the fuel dispenser 145. Therefore, the thermal expansion/contraction of the product can be taken into account in each transaction and in each executed reconciliation process. In other words, to allow true reconciliation to occur in net gallon terms, it is desirable to measure temperature in conjunction with every measurement of physical volume. Therefore, temperature and volume data can be collected from the dispenser and during any sales transactions for use in the reconciliation process performed by the CIM system 120.

The temperature readings of a dispensed sale at a dispenser 145 are unique per sales transaction, and are a function of one or more of the following variables: fluid temperatures; surrounding ground temperatures; pipe wall thickness; pipe wall material; proximity of the dispenser skirt relative to rays of the sun; ambient air temperature; fluid flow rate; and the duration of time since the last transaction. As previously mentioned, the methods, systems, and computer program products described herein allow one temperature to be measured in conjunction with the sale, regardless of whether the temperature correction is applied to the retail sale. Accordingly, the control module 228 (Figure 3) of dispenser 145 can report the gross volume of the sale and the temperature of the sale separately, which can also be reported by the retail system 130. This gross volume and temperature reporting advantageously provides for compensation of the different temperatures throughout the system 100, and offers both gross and net volume reporting not currently offered by typical dispensers.

Similarly, the methods, systems, and computer program products described herein provide for the perpetual net inventory book balance to be modified by a dynamic expansion coefficient of product relative to the temperature changes and density. Based on the API gravity report at the rack 105 and reported in the BOL, the CIM system 120 maintains data representative of fuel densities throughout the lifecycle of the fuel or product within the system 100. The storage and updating of such representative density values, combined with the updating and storage of temperature values, allows the CIM system 120 to dynamically identify the
appropriate gross to net conversion for any physical measurement of fuel. With this
data, the temperature-compensated amount of product used and remaining in the tank
155 can be accurately determined. For example, the CIM system 120 can use the
temperature and density to perform a temperature corrected gross to net conversion
for every transaction before posting to the net perpetual book balance.

The temperature correction hinges around the actual temperature of the fuel or
product that is being temperature corrected, and the density of the fuel or product that
is being temperature corrected. The density doesn’t allow one to perfectly identify the
elasticity between the volume and temperature of that fuel or product (i.e., it doesn’t
allow you to perfectly identify the coefficient of expansion). But since molecular
chains, hydrocarbons in particular, that have similar density, react very similarly to
temperature, the use of density and temperature is the most generally accepted method
across all facets of industry.

Because the density of the product changes, it is only necessary to know the
density value consistently and within reasonableness. In comparing two products of
non-like density or differing density, their reaction to temperature change will be
different. So the terminal systems (i.e. the rack 105), because of the amount of
volume that they store and deliver, are required to report density. Most of them have
the ability to measure density using densitometers or other measuring equipment that
can be used to determine the value. They report that on the bill of lading. A weighted
average or a FIFO (first-in-first-out) average of the density reportedly going into the
tank can then be weighted by the amount of volume going into the tank. This
provides a representative density for the product that is in the storage tank. That
density value and the temperature that is measured on a real-time on-site basis are
used to determine a temperature corrected volume conversion factor allowing one to
derive the net volume of that product.

It should be noted that the various reports and accumulated data can be
transmitted using Extended Markup Language (XML) document format or any other
format readable by computer systems. Using XML, for example, sales transaction
records can include headers that identify the status of a sale, the time of the sale, the
invoice number and other such information in a standard XML document. In such
instances, non-blended product would simply have a tank number, whereas, if a
blended product is used, then the tanks and blend ratios can be given and separated
using a standard means, e.g., separated by commas. Transaction date and time can also be associated with the transaction record along with an invoice number, volume and temperature.

The system can also determine a correlation between the variance and all of the qualitative and quantitative variance factors. It can accomplish this using multiple regression analysis. This allows the system to be able to indicate if there is a leak in a fuel tank, plumbing or dispensers. It also allows the system to determine if a dispenser needs to be recalibrated, if someone is stealing fuel, or if a truck has a leak or holds back fuel during a delivery. This is just some of the useful information the CIM system can provide.

Embodiments within the scope of the present invention also include computer-readable media for carrying or having computer-executable instructions or data structures stored thereon. Such computer-readable media can be any available media that can be accessed by a general purpose or special purpose computer. By way of example, and not limitation, such computer-readable media can comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to carry or store desired program code means in the form of computer-executable instructions or data structures and which can be accessed by a general purpose or special purpose computer. When information is transferred or provided over a network or another communications connection (either hardwired, wireless, or a combination of hardwired or wireless) to a computer, the computer properly views the connection as a computer-readable medium. Thus, any such connection is properly termed a computer-readable medium. Combinations of the above should also be included within the scope of computer-readable media. Computer-executable instructions comprise, for example, instructions and data which cause a general purpose computer, special purpose computer, or special purpose processing device to perform a certain function or group of functions.

Figure 13 and the following discussion are intended to provide a brief, general description of a suitable computing environment in which the invention may be implemented. Although not required, the invention will be described in the general context of computer-executable instructions, such as program modules, being executed by computers in network environments. Generally, program modules
include routines, programs, objects, components, data structures, etc. that performs particular tasks or implement particular abstract data types. Computer-executable instructions, associated data structures, and program modules represent examples of the program code means for executing steps of the methods disclosed herein. The particular sequence of such executable instructions or associated data structures represents examples of corresponding acts for implementing the functions described in such steps.

Those skilled in the art will appreciate that the invention may be practiced in network computing environments with many types of computer system configurations, including personal computers, hand-held devices, multi-processor systems, microprocessor-based or programmable consumer electronics, network PCs, minicomputers, mainframe computers, and the like. The invention may also be practiced in distributed computing environments where tasks are performed by local and remote processing devices that are linked (either by hardwired links, wireless links, or by a combination of hardwired or wireless links) through a communications network. In a distributed computing environment, program modules may be located in both local and remote memory storage devices.

With reference to Figure 13, an exemplary system for implementing the invention includes a general purpose computing device in the form of a conventional computer 420, including a processing unit 421, a system memory 422, and a system bus 423 that couples various system components including the system memory 422 to the processing unit 421. The system bus 423 may be any of several types of bus structures including a memory bus or memory controller, a peripheral bus, and a local bus using any of a variety of bus architectures. The system memory includes read only memory (ROM) 424 and random access memory (RAM) 425. A basic input/output system (BIOS) 426, containing the basic routines that help transfer information between elements within the computer 420, such as during start-up, may be stored in ROM 424.

The computer 420 may also include a magnetic hard disk drive 427 for reading from and writing to a magnetic hard disk 439, a magnetic disk drive 428 for reading from or writing to a removable magnetic disk 429, and an optical disk drive 430 for reading from or writing to removable optical disk 431 such as a CD-ROM or other optical media. The magnetic hard disk drive 427, magnetic disk drive 428, and
optical disk drive 430 are connected to the system bus 423 by a hard disk drive
interface 432, a magnetic disk drive-interface 433, and an optical drive interface 434,
respectively. The drives and their associated computer-readable media provide
nonvolatile storage of computer-executable instructions, data structures, program
modules and other data for the computer 420. Although the exemplary environment
described herein employs a magnetic hard disk 439, a removable magnetic disk 429
and a removable optical disk 431, other types of computer readable media for storing
data can be used, including magnetic cassettes, flash memory cards, digital versatile
disks, Bernoulli cartridges, RAMs, ROMs, and the like.

Program code means comprising one or more program modules may be stored
on the hard disk 439, magnetic disk 429, optical disk 431, ROM 424 or RAM 425,
including an operating system 435, one or more application programs 436, other
program modules 437, and program data 438. A user may enter commands and
information into the computer 420 through keyboard 440, pointing device 442, or
other input devices (not shown), such as a microphone, joy stick, game pad, satellite
dish, scanner, or the like. These and other input devices are often connected to the
processing unit 421 through a serial port interface 446 coupled to system bus 423.
Alternatively, the input devices may be connected by other interfaces, such as a
parallel port, a game port or a universal serial bus (USB). A monitor 447 or another
display device is also connected to system bus 423 via an interface, such as video
adapter 448. In addition to the monitor, personal computers typically include other
peripheral output devices (not shown), such as speakers and printers.

The computer 420 may operate in a networked environment using logical
connections to one or more remote computers, such as remote computers 449a and
449b. Remote computers 449a and 449b may each be another personal computer, a
server, a router, a network PC, a peer device or other common network node, and
typically include many or all of the elements described above relative to the computer
420, although only memory storage devices 450a and 450b and their associated
application programs 436a and 436b have been illustrated in Figure 4. The logical
connections depicted in Figure 4 include a local area network (LAN) 451 and a wide
area network (WAN) 452 that are presented here by way of example and not
limitation. Such networking environments are commonplace in office-wide or
enterprise-wide computer networks, intranets and the Internet.
When used in a LAN networking environment, the computer 420 is connected to the local network 451 through a network interface or adapter 453. When used in a WAN networking environment, the computer 420 may include a modem 454, a wireless link, or other means for establishing communications over the wide area network 452, such as the Internet. The modem 454, which may be internal or external, is connected to the system bus 423 via the serial port interface 446. In a networked environment, program modules depicted relative to the computer 420, or portions thereof, may be stored in the remote memory storage device. It will be appreciated that the network connections shown are exemplary and other means of establishing communications over wide area network 452 may be used.

Additional information related to the present invention is found in Schedule A, which forms a part of the specification herein. The “Liquid Product Inventory Reconciliation Guide” and Exhibits A-U, which are listed in Schedule “A”, form a part of this specification hereof. The Liquid Product Inventory Reconciliation” Guide and Exhibits A-U disclose the inventions disclosed in additional detail.
Preface

Reconciliation of liquid product inventories at high volume retail facilities has been a long standing challenge in the retail petroleum industry. High throughput sales and delivery volumes result in inventory being turned over multiple times daily. In developing the invention, it has been determined that inventory variance-sourcing factors reside both in the retail facility as well as in the process of loading, transporting, and unloading procured liquid product. To accurately reconcile inventory amounts all error-sourcing events require consideration. It is necessary to both monitor product temperature at every instance of volume measurement, and to isolate delivery periods from non-delivery periods, so as to adequately separate the error-sourcing factors affiliated with the two.

To adequately meet the unique needs mentioned, inventions were developed and associated with a complete inventory reconciliation solution to actually consider product temperature change in conducting variance accounting for delivery periods and non-delivery periods alike. This is achieved using several hardware/software systems. Hardware/software equipment to implement will include: communications with the delivery truck, custom configured automatic tank probe solutions for the inventory tanks, temperature measuring thermocouple devices in the dispensers, and various other communication enhancements allowing real-time reading of the dispensers. The following pages provide overview of the reconciliation processes and related inventions.
Reconciliation System Process--Overview

Overview—Temperature Correction

CIM can receive detailed transaction sales records (Exhibit N) from Retail System, including average temperature of the product dispensed in the sale, allowing the maintenance of a perpetual book inventory balance in both gross and net (temperature-corrected) volume terms. Calculation of a net volume book balance can be made possible by measuring the temperature of the liquid product as the product passes through the dispenser during the sales transaction. This temperature measurement can be done using a probe-type temperature metering device at the dispenser's meter housing or some other temperature measuring device known to those skilled in the art.

Physical inventory can also be available, via tank gauges, in both gross and net volume terms. Volume and product temperature within the tank can be provided by the tank probes. Product density, which affects the gross-to-net conversion factor, can be estimated from bill of lading data provided with each liquid product delivery.

Maintaining net volume terms at all points of product measurement allows CIM to reconcile appropriately regardless of temperature change during different stages of the liquid product lifecycle.
Reconciliation System Process--Overview

Overview--Reconciliation

CIM can run an inventory reconciling "snapshot" for every reconciliation process. This procedure can be run under three triggers: (See Snapshot Cycle—p 7)

1. Process scheduled basis
2. Delivering carrier request for delivery authorization &
3. Admin refresh request

The reconciling "snapshot" procedure can result in a new "snapshot" record every time it is run.
The "snapshot" request from CIM to Retail System, provides:
- Tank-Set ID
- # of seconds to accumulate data
  (See Exhibit G)

The "snapshot" record return can contain the following data fields:
- Tank-Set ID (also pushed out in the request)
- Start Date/Time/Second
- Petro/Water Float Heights (offset by millisecond)
- Inventory Temperature per Tank Gauge Thermistor or other appropriate gauge
- Interim Sales Volume by Dispenser (offset by millisecond)
- Interim Sales Temperature by Dispenser
  (See Exhibit H)

Every time this record is retrieved by CIM a book-to-actual reconciliation can occur.
**Reconciliation System Process--Details**

**Inventory Reconciliation "Snapshot" Procedure**

The standard inventory reconciling "snapshot" can be used for all reconciliation processes. Regardless of how it is triggered, the reconciliation can proceed as follows (it being understood that the inventories described herein may use one or more of the following steps, with one or more being omitted dependent upon the particular application of the invention and the reconciliation process):

A. CIM requests and receives from Retail System a current, time-stamped "snapshot" of tank height readings, tank temperature, interim sales volumes, interim dispenser temperature

B. CIM determines net physical inventory at a point in time, from data received from Retail System (See Exhibit A)

C. CIM updates its net perpetual book inventory balance with all transactions closed out (sales and deliveries) prior to the time of the reconciliation. (See Exhibit A)

D. CIM calculates net book-to-net physical inventory variance (See Exhibit A)

E. CIM posts an adjustment to its book inventory balance for the variance calculated (See Exhibit L)

F. CIM assigns the variance to its "most reasonable" source(s) (See Exhibit J)

G. CIM generates exception reports and alerts necessary admin recipients
## Reconciliation System Process--Details

### Inventory “Snapshot” Cycle

<table>
<thead>
<tr>
<th>Gallons Sold/Month (In Millions)</th>
<th>Retail Site Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 M</td>
</tr>
<tr>
<td></td>
<td>2 M</td>
</tr>
<tr>
<td></td>
<td>3 M</td>
</tr>
<tr>
<td></td>
<td>4 M</td>
</tr>
<tr>
<td></td>
<td>5 M</td>
</tr>
<tr>
<td>Average Deliveries/Day</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>22</td>
</tr>
<tr>
<td>Total Delivery “Snapshots”</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>44</td>
</tr>
<tr>
<td>Scheduled “Snapshots”: (Independent of Deliveries)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td><strong>Total “Snapshots”/Day</strong></td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>46</td>
</tr>
</tbody>
</table>

**Explanation:**

Every delivery can include usually includes two inventory “snapshots” to be taken—one before the delivery and one after. An admin-determined number of scheduled “snapshots” can also be taken. Each “snapshot” can result in a book-to-actual inventory variance adjustment. Each instance of variance can be assigned by GIS to the “most reasonable” source(s) and can trigger exception reporting if necessary.
Reconciliation System Process--Details

Variance Assignment

The inventory "snapshot" cycle allows CIM to identify business periods as being either sales periods w/ deliveries (i.e. "delivery" period) or sales periods w/o deliveries (i.e. "static" period). The following timeline displays how this can allow CIM to make the distinction, thus ensuring that no period of time goes un-isolated. (See Exhibit K)

Example:

<table>
<thead>
<tr>
<th>Delivery Day/Start Day</th>
<th>Delivery/End Day</th>
<th>Sales Start/Day</th>
<th>Sales End/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>[s] &quot;delivery&quot;</td>
<td>[s] &quot;static&quot;</td>
<td>[s] &quot;delivery&quot;</td>
<td>[s]</td>
</tr>
</tbody>
</table>

Key: [s] = Inventory "snapshot"; "delivery" = sales period w/ delivery; "static" = sales period w/o delivery

→ Isolating sales periods w/o deliveries, allows CIM to identify an "explained" retail system variance trend. Explained variance trend is compared to tolerable calibration thresholds, triggering exception reports as necessary.

→ Any excessive deviation from the trend indicates an "unexplained" variance. Unexplained variance can be assigned to either a "delivery" period or a "static" period, triggering exception reports as necessary.
Reconciliation Calculations

1. Beginning Inventory (Book) + Period Transaction Sales – Period BOL Deliveries
2. Physical Inventory (per tank probes) – Book Inventory
3. Ending Inventory (Book) – (Short/Over Adjustment)
4. Variance = Explained Variance

Variance Treatment:

CMI can compare explained and unexplained variance amounts to tiered thresholds individually and can generate exception reports as necessary. Variance surpassing upper tier limits can initiate exception reports in an “alarm” type fashion ensuring immediate attention to the necessary admin and maintenance personnel. CMI can be isolate the explained variance in a “delivery” period from that of a “static” period.

*System Variance Factor = Moving Linear Regression Slope multiplied by the associated R-Squared
Inventory Reconciliation Reporting

Overview—Reporting Objectives

The amount of detailed data coming to CIM from the perpetual inventory-supporting Retail System can be sufficient to generate the report types required by EPA/Regulatory bodies as well as management of the business entity using the system. Rather than restricting availability of these reports to the retail plaza and its present individuals, the invention and system can allow remote access to the various report types on the corporate-hosted CIM system. This will drastically improve the efficiency of inventory-type monitoring since the report users can be able to access real-time reports from their respective office locations rather than needing to travel to the retail facility. The model will not be restrictive where an onsite visit is required in conjunction with the report generation—in this case, the reports will simply be requested from an onsite computer that is interfaced to the corporate-based CIM system, and the reports can be generated real-time.

A few sample report types are included on the following pages—
1. The first report shows detailed reconciliation results
2. The second report shows variance observations against their respective thresholds
3. The third report shows accumulated variance over the course of a month
## Inventory Reconciliation Reporting--Sample

### Inventory Variance Report (Sample)

**Branch Name:** St. George  

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Tank(s)</th>
<th>Product</th>
<th>Beg Book</th>
<th>Sales</th>
<th>Deliveries</th>
<th>Period End Book</th>
<th>Actual</th>
<th>(Short)/Over</th>
<th>Total</th>
<th>Explained</th>
<th>Unexplained</th>
<th>BOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/31/03</td>
<td>13:43</td>
<td>1</td>
<td>Diesel #2</td>
<td>3001</td>
<td>4600</td>
<td>8000</td>
<td>8201</td>
<td>6177</td>
<td>(24)</td>
<td>12</td>
<td>(36)</td>
<td>Delivery</td>
<td>13872</td>
</tr>
<tr>
<td>12/31/03</td>
<td>14:56</td>
<td>2</td>
<td>Diesel #2</td>
<td>6177</td>
<td>3000</td>
<td>0</td>
<td>3177</td>
<td>3184</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>Static</td>
<td>-NA-</td>
</tr>
<tr>
<td>12/31/03</td>
<td>10:41</td>
<td>3</td>
<td>Unleaded</td>
<td>2500</td>
<td>2000</td>
<td>0</td>
<td>500</td>
<td>400</td>
<td>(100)</td>
<td>(9)</td>
<td>(91)</td>
<td>Static</td>
<td>-NA-</td>
</tr>
<tr>
<td>12/31/03</td>
<td>15:59</td>
<td>3</td>
<td>Unleaded</td>
<td>3509</td>
<td>4000</td>
<td>8500</td>
<td>8009</td>
<td>8000</td>
<td>(9)</td>
<td>(10)</td>
<td>9</td>
<td>Delivery</td>
<td>14569</td>
</tr>
</tbody>
</table>

**Variance Summary:**

- **Explained Variance by Product**
  - Diesel #2: $19 \text{ gallons} \times 0.25\%$
  - Unleaded: $27 \text{ gallons} \times 0.45\%$

- **Unexplained Static Variance by Product**
  - Diesel #2: $(36 \text{ gallons}) \times 0.46\%$
  - Unleaded: $(9 \text{ gallons}) \times 0.15\%$

**Variance Exceptions:**

<table>
<thead>
<tr>
<th>Delivery</th>
<th>Unexplained</th>
<th>Static Unexplained</th>
<th>Explained</th>
<th>Action(s) Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel #2</td>
<td>(36)</td>
<td>0</td>
<td>0</td>
<td>Reference BOL info, research delivery</td>
</tr>
<tr>
<td>Unleaded</td>
<td>(91)</td>
<td>(27)</td>
<td></td>
<td>Check Calibration of Pumps</td>
</tr>
</tbody>
</table>

**Note:** OIM can notify admin of exceptions via user-demanded report, automated email or automated text-messaging.
Reconciliation System Reporting - Sample

This report will allow the user to ensure that the variance determined with each reconciliation process fits within calibration thresholds (via actual variance plot) as well as variance per time thresholds (via time adjusted variance). Time adjusted variance plot is determined by plotting (expected var + unexpected var / hours) * 10. Multiplication factor of 10 is used since the time adjusted threshold limits are multiplied by 10. This is done to exaggerate the scale sufficiently to make it visible.
Reconciliation System Reporting--Sample

Single Tank Accumulated Variance for a Month--Example

![Graph](image)

- ♦ Acceptable +(-)
- ▲ Day's Unexplained Variance
- ←→ Accumulated Variance
Conclusion

By performing the preceding processes, and utilizing leak-detection functionality offered with existing solutions, the present invention enables a business entity using the inventive system to fulfill regulatory requirements, and any more stringent demands of the business. Using the present invention, a business can appropriately assign liquid product inventory variances to the sourcing factors and thereby mitigate their reoccurrence. The tank inventory snapshots, and the associated book-to-actual inventory reconciliations, can be calculated so frequently (as identified in the process cycle examples) that it can be possible to identify an actual time frame where a particular variance has occurred. This enables better identification of personnel on site, as well as the state of the equipment during that time frame. Given this level of reconciling functionality, the CIM system is able to send unique exception reports to the appropriate admin users on a real-time basis, enabling real-time follow-up. This total-package development will lead the industry in reconciling liquid product inventories through all stages of the retail business inventory cycle.
Exemplary Fuel Reconciliation Exhibit Library

Exhibit
Exhibit A—Net Inventory Variance Determination
Exhibit B—Thermistor Heights

5 Exhibit C—Data Storage Requirements
Exhibit D—Height to Volume Conversion Formulas
Exhibit E—Gross to Net Conversion Routine
Exhibit F—Quick Read ATG Look-Up
Exhibit G—Real-Time Reconciliation Request from Host

10 Exhibit H—Real-Time Reconciliation Data Response from Local to Host
Exhibit I—Local Treatment of Reconciliation Request
Exhibit J—Variance Assignment Procedures
Exhibit K—Business Period Activity Isolation (Delivery / Non-Delivery)
Exhibit L—Maintenance of Net Volume Book Balance

15 Exhibit M—On-Site Data Accumulation Methods
Exhibit N—Sales Transaction Record Format
Exhibit O—Local to Host Alarm Communication
Exhibit P—Reconciliation Data Report Example
Exhibit Q—Tank Strapping Procedure
Exhibit R—Exemplary Hardware Requirements
Exhibit S—Tank Strapping Temperature Correction Treatment
Exhibit T—Tank Strapping Calibration Calculations*
Exhibit U—BOL Delivery Record Format
Exhibit A—Net Inventory Variance Determination

I. CIM Send Fuel Reconciliation Request to POS (See Exhibit G)

II. CIM Receive and Parse the Reconciliation Response from POS (See Exhibit H)

---

Measurement Data

5  
  <Site> 01155
  <Time> 2004-06-03 23:00:00
  <UOM> Gallons, Inches, Fahrenheit
  <StartSnapShot> 2
  <Tank Set>

10  
  <SetId> AA
  <FCode> 02
  <Tanks>
    <Tank>
      <Id> 01
      <Water> 1.5"  
      <FuelLvl>

        <Fuel>Lvl:55.40|Time:23:00:00:04|Tmp:63.00/.62
        .00</Fuel>

20  
    <Fuel>Lvl:55.00|Time:23:00:01:04|Tmp:63.00/.62
    .00</Fuel>

    .
    .
    .
    </FuelLvl>

25  
    </Tank>

    .
    .
    .
    </Tanks>

30  
    </Tank Set>
    <Sales>
      <Sale>
        <Pump> 11

<Temp> 70.00

<FuelRecs>
  <Fuel>Vol:5.60|Time:23:00:00:00</Fuel>
  <Fuel>Vol:6.40|Time:23:00:01:00</Fuel>

</FuelRecs>
</Sale>
</Sales>

---

Closed Sales Data

<Closed Sales>
  <Closed Sale>
    Tank:2|Time:2004-06-03 22:36:00|Inv:123A4567|Vol:45.666|Tmp:56
  </Closed Sale>
</Closed Sales>

---

III. CIM Convert Fuel Level Readings to Net Tank Gallons

1) Use tank id from <Tank>...<Id> to reference the appropriate tank formula table.
   Result: Table 123

2) Use the fuel level <Fuel>Lvl... to reference the appropriate formula for each fuel level reading. (See Exhibit D)
   Result: FuelLvl: 55.40: Formula XY...
            FuelLvl: 55.00: Formula YZ...

3) Convert each fuel level reading into a gross volume, with the same time stamp as the fuel level reading.
   Result: FuelLvl:55.40 = 6068.61 Gallons (Gross)
            FuelLvl:55.00 = 6015.36 Gallons (Gross)

4) Identify which thermistors are at or below the lowest measured fuel level reading. To do this the process can use a field tied to the tank table that identifies at which height levels on the probe shaft there is a thermistor—(See Exhibit B)
   Result: Thermistor 1
Thermistor 2

5) Average the temperature of the thermistors determined in prior step.
Result: Thermistor 1: 61.00
Thermistor 2: 63.00
Average = 62.00

6) Reference API gravity for product in tank. (This can require delivering driver to report BOL information in conjunction with a delivery report. The API value can be included in the BOL information and can be used to update the estimated API of the product in that tank set.
Result: 36

7) Use average temperature from step 5) and API to reference the appropriate Gross to Net conversion factor (as per ASTM formula).
Result: .9XXX

8) Convert Gross Inventory Volume per Fuel Lvl to Net Inventory Volume.
Result: Net Inventory Volume per Fuel Lvl

IV. Convert interim (FuelRecs) gross sales volume to net volume

1) Reference API for product in tank
Result: 36

2) Use API density value and average temp of sale <Temp> 70.00 to reference appropriate Gross to Net conversion factor.
Result: .98XX

3) Convert Gross volume per FuelRec Sales snapshot to Net Fuel Rec Sales
Result: <Fuel>Vol: 5.XX|Time: 23:00:00:00</Fuel>
<Fuel>Vol: 6.XX|Time: 23:00:01:00</Fuel>

V. Convert Individual Time-Stamped Tank Volumes in Manifold to Cumulative Time-Stamped Manifold Volumes

1) Sort all time-stamped tank readings from the manifold by their respective time stamps.
Result: Example results from a 3-tank manifold—

Tank 3 reading @ 17:28:39:165—11658.32 gal
Tank 1 reading @ 17:28:39:377—11658.12 gal
Tank 2 reading @ 17:28:39:581—11736.27 gal

5

Tank 3 Reading @ 17:28:40:398—11658.36 gal
Tank 1 Reading @ 17:28:40:611—11602.34 gal
Tank 2 Reading @ 17:28:40:815—11733.20 gal

* 

10

2) Order “series” of tank readings by taking the first

time-stamped fuel height reading (irregardless of which tank

is read first) and associating it with the closest time-

stamped reading of each additional tank in the manifold. Each tank

reading can only reside in one series. Only tank readings that comprise

a complete series should be considered for step 3).

Result: Example results from a 3-tank manifold—

1st Series

Tank 3 reading @ 17:28:39:165—11658.32 gal
Tank 1 reading @ 17:28:39:377—11658.12 gal
Tank 2 reading @ 17:28:39:581—11736.27 gal

2nd Series

Tank 3 Reading @ 17:28:40:398—11658.36 gal
Tank 1 Reading @ 17:28:40:611—11602.34 gal
Tank 2 Reading @ 17:28:40:815—11733.20 gal

*Nth Series

3) Calculate the time difference between the first time in the series and

every time in the series.

Result: From 1st Series

<table>
<thead>
<tr>
<th>Reading Time</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>17:28:39:165</td>
<td>0</td>
</tr>
<tr>
<td>17:28:39:377</td>
<td>212</td>
</tr>
<tr>
<td>17:28:39:581</td>
<td>416</td>
</tr>
</tbody>
</table>

4) Average the differences in time
Result: From 1st Series

Average (0,212,416)

= 209.33

5) Add the average difference back to the first time from the
series to determine the cumulative series time stamp.

Result: From 1st Series

17:28:39:165 + 209.33

= 17:28:39:374

6) Sum the volume from each reading in the series.

Result: From 1st Series

Tank 3 reading—11658.32 gal
+ Tank 1 reading—11658.12 gal
+ Tank 2 reading—11736.27 gal

= 35,052.71 gal

7) Assign the cumulative time stamp for the series to the cumulative
volume for the series. The first time-stamped series becomes the
"Time of Reconciliation."

Result: From 1st Series

35,052.71 gal @ 17:28:39:374

* Repeat steps 3 through 7 until a cumulative time stamp and volume has
been assigned for each series.

VI. CIM Align All Tank Manifold Volume Readings to "Time of
Reconciliation."

1) Identify the time and volume of the "Time of Reconciliation"
and each subsequent time-stamped Tank Manifold volume
reading.

Result: For sales volume between Time of
Reconciliation and Manifold Series 2—
Time and Volume of Reconciliation

35,052.71 gal @ 17:28:39:374

Time and Volume of Manifold Series 2
34,993.90 gal @ 17:28:40:608

*
2) Identify sales that appear to have been active beyond the bounds of the tank manifold readings and extrapolate a new pump sales reading according the following rules:

If --The first of the paired readings is the first reading provided in the reconciliation for that pump

AndIf--The first of the paired readings is later than the "Time of Reconciliation"

Then --Consider use of a “late pump read rule”—

**Late Pump Read Rule:**

If --The first reading of a pump has a volume amount that is positive

AndIf--The next reading shows a positive change in volume

Then --Use the flow rate determinable between these two readings to extrapolate a new pump reading back to the closest time-stamped tank manifold reading.

*The new extrapolated reading must be >=0 or it is thrown out.

Else--Assume the pump readings provided in the reconciliation are consummate in their display of pumped volume.

Else--Assume the pump readings provided in the reconciliation are consummate in their display of pumped volume.

If--The last of all the paired readings for a pump is the last reading provided in the reconciliation for that pump

AndIf--The last of the paired readings for a pump is earlier than the last tank manifold volume reading

Then--Consider use of an “early pump read rule”—

**Early Pump Read Rule:**
If -- The last reading of a pump has a volume amount that is greater than the amount for that pump in the prior reading

AndIf--There exists a tank manifold reading after the last known reading for that pump

Then--Use the flow rate determinable between these two readings to extrapolate a new pump reading forward to the closest time-stamped tank manifold reading.

Else--Assume the pump readings provided in the reconciliation are consummate in their display of pumped volume.

Else--Assume the pump readings provided in the reconciliation are consummate in their display of pumped volume.

Results: For “Late Read Rule” and “Early Read Rule”

\[ TV_1 \rightarrow P_1 V_1 = 1 \rightarrow \ldots \rightarrow TV_2 \rightarrow P_1 V_2 = 2 \rightarrow \ldots \rightarrow TV_3 \]

*Where \( TV_n \) is the nth tank manifold volume reading, \( P_n \) is the nth pump reading, and \( V_n \) is the volume of the nth pump reading.

Late Read Rule

Create \( P_1 V_0 \), with a time stamp 1 second prior to that of \( P_1 V_1 \) since Late Pump Read Rule criteria all apply.

Early Read Rule

Create \( P_1 V_3 \), with a time stamp 1 second later to that of \( P_1 V_2 \) since Early Pump Read Rule criteria all apply.

\[ TV_1, P_1 V_0 = 0.3 \rightarrow P_1 V_1 = 1 \rightarrow \ldots \rightarrow TV_2 \rightarrow P_1 V_2 = 2 \rightarrow \ldots \rightarrow TV_3, P_1 V_3 = 2.3 \]

Using the known flow rates between all time stamped pump readings (including those generated in step 2), now interpolate a pump sales reading for every pump with a time stamp equal to the time of each tank manifold volume reading.

Result:

\[ TV_1, P_1 V_0 = 0.3 \rightarrow \ldots \rightarrow TV_2, P_1 V_2 = 1.3 \rightarrow \ldots \rightarrow TV_3, P_1 V_3 = 2.3 \]
4) Using the interpolated pump sales reading for every pump, flow rate adjust each tank manifold reading back to the "Time of Reconciliation," by adding the pumped sales volumes back to the tank manifold reading.

Result: All cumulative manifold volume readings at the "Time of Reconciliation" Time Stamp

Tank Manifold Reading 1

\[ TV_1 \]

Tank Manifold Reading 2 (Adjusted for dispensed flow)

\[ TV_2 - (P_1V_2 - P_1V_1) \]

Tank Manifold Reading 3 (Adjusted for dispensed flow)

\[ TV_3 - (P_1V_3 - P_1V_1) \]

VII. Determine Physical Volume from the multiple series of tank manifold readings.

1) Average all time-aligned net inventory volume readings together to determine a mean physical inventory.

2) Compute a standard deviation for the sample set of tank manifold readings.

3) Throw out readings that are +/- 1 standard deviation from the mean computed in step 1).

4) Average the tank manifold readings remaining after step 3).

Result: Net Physical Volume at Time of Reconciliation

IX. Adjust Time-Stamped Net Physical Volume for Interim Sales

1) Add back to the Net Physical Volume the Net Interim Sales, which consist of Interim Active Sales, and Interim Completed Sales

Result: Net Physical Volume Adjusted for Interim Sales at Time of Reconciliation

IX. Calculate Variance of Adjusted Net Physical Volume to Perpetual Book Net Volume.

1) Update Net Perpetual Book Balance (See Exhibit L) to the Time of Reconciliation.

2) Subtract Net Perpetual Book Balance from Adjusted Net
Physical Volume.
Result: Inventory (Shrink)/Gain

**Exhibit B—Thermistor Heights**

1. Get specifications of probe
   1) Get span of probe

   Result: 118" * Omntec provided 10' probe

   2) Add offset as per manufacturer's spec
      Result: 120" (=118" + 2" Omntec probe offset)

   3) Divide offset adjusted probe span by number of thermistors + 1 to
determine thermistor increment
      Result: 20" increment (=120"/6; 6=5 thermistors + 1)

   4) Assign heights to thermistors 1-X as per manufacturer's
      numbering sequence

   Result: Thermistor | Height * Omntec Probe
   1                | 20"
   2                | 40"
   3                | 60"
   4                | 80"
   5                | 100"

**Exhibit C—Data Storage Requirements**

1. Fields to Store Surrounding Completion of each Instance of Reconciliation:
   1) Request Time, as per Corporate Host
   2) Number of Seconds in Request
   3) Request Time, as per Site Host
   4) Requester ID
   5) Reconciliation Time, as per Site Host's time stamps
   6) Branch ID
   7) Manifold ID(s)
   8) Book Inventory per Manifold at Time of Reconciliation
      - Gross
      - Net
   9) Physical Inventory per Manifold at Time of Reconciliation
Gross
Net
Temp

10) Tolerance Factor Passed to Retail System
11) Retail System Turbulence Flag (Y/N)
12) Population Standard Deviation Statistic
13) Standard Deviation Tolerance Factor
14) Filtered Sample Size (# of Samples Remaining)
15) Filtered Sample Standard Deviation Statistic
16) Interim Sales Adjustment
     Gross
     Net
17) Summarized Sales Transaction Volume Per Dispenser From Last Reconciliation to Current Reconciliation
     Gross
     Net
18) Reported Delivery Detail (BOL # and Trip #) by Manifold from Last Reconciliation to Current Reconciliation
     Gross
     Net
19) Standard Height per Tank, per Manifold ID
20) Standard Temp per Tank, per Manifold ID

II. Required Duration of Storage
1) Raw measurement (Input) variables used for reconciliation (2 weeks)
2) Reconciliation result (Output) variables mentioned in requirement 1
   Online (6 Months)
   Archived (Indefinitely)

Exhibit D—Exemplary Height to Volume Conversion Formulas
Ex: 5.5" is greater than 5 but less than 9 so it would use the formula indicated by height 5
Height Volume
<table>
<thead>
<tr>
<th>Inches</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2.6613x2 + 50.029x</td>
</tr>
<tr>
<td>5</td>
<td>3.5x2 + 48.5x - 6</td>
</tr>
<tr>
<td>9</td>
<td>2.75x2 + 59.95x - 50.35</td>
</tr>
<tr>
<td>13</td>
<td>2x2 + 78.6x - 167.7</td>
</tr>
<tr>
<td>17</td>
<td>2x2 + 79x - 174</td>
</tr>
<tr>
<td>21</td>
<td>1.5x2 + 99.1x - 377.5</td>
</tr>
<tr>
<td>25</td>
<td>1.25x2 + 112.05x - 545.45</td>
</tr>
<tr>
<td>29</td>
<td>x2 + 127x - 769</td>
</tr>
<tr>
<td>33</td>
<td>x2 + 127.4x - 781.3</td>
</tr>
<tr>
<td>37</td>
<td>0.75x2 + 145.95x - 1125.9</td>
</tr>
<tr>
<td>41</td>
<td>0.5x2 + 166.5x - 1549</td>
</tr>
<tr>
<td>45</td>
<td>0.5x2 + 166.5x - 1548</td>
</tr>
<tr>
<td>49</td>
<td>0.25x2 + 191.05x - 2150.7</td>
</tr>
<tr>
<td>53</td>
<td>7E-12x2 + 218x - 2876</td>
</tr>
<tr>
<td>57</td>
<td>0.25x2 + 189.45x - 2060</td>
</tr>
<tr>
<td>61</td>
<td>-0.25x2 + 249.35x - 3855.2</td>
</tr>
<tr>
<td>65</td>
<td>-0.25x2 + 249.55x - 3868.4</td>
</tr>
<tr>
<td>69</td>
<td>-0.5x2 + 283.5x - 5021</td>
</tr>
<tr>
<td>73</td>
<td>-0.75x2 + 320.45x - 6386.1</td>
</tr>
<tr>
<td>77</td>
<td>x2 + 360x - 7949</td>
</tr>
<tr>
<td>81</td>
<td>x2 + 361x - 8029</td>
</tr>
<tr>
<td>85</td>
<td>x2 + 360.6x - 7994.9</td>
</tr>
<tr>
<td>89</td>
<td>-1.5x2 + 449.1x - 11912</td>
</tr>
<tr>
<td>93</td>
<td>-1.5x2 + 448.9x - 11893</td>
</tr>
<tr>
<td>97</td>
<td>-2x2 + 546x - 16608</td>
</tr>
<tr>
<td>101</td>
<td>-2x2 + 545.6x - 16567</td>
</tr>
<tr>
<td>105</td>
<td>-2.75x2 + 702.05x - 24727</td>
</tr>
<tr>
<td>109</td>
<td>-3.25x2 + 810.55x - 30614</td>
</tr>
<tr>
<td>113</td>
<td>-5x2 + 1204.4x - 52774</td>
</tr>
<tr>
<td>116</td>
<td>-12.5x2 + 2948.5x - 154170</td>
</tr>
</tbody>
</table>

Exhibit E—Gross-To-Net Conversion Process

/*<TOAD_FILE_CHUNK>*/
CREATE OR REPLACE PACKAGE lpm.TEMP_CORRECT AS
  PROCEDURE GetVCFactor(API60 IN OUT NUMBER, DEGF IN OUT NUMBER, VCFC IN OUT NUMBER, IFLAG IN OUT NUMBER);
END TEMP_CORRECT;
/

CREATE OR REPLACE PACKAGE BODY lpm.TEMP_CORRECT AS
  K0T NUMBER := 14890670;
  FUNCTION SetCurveCoefficients( IAPI IN NUMBER, K0 IN OUT NUMBER, K1 IN OUT NUMBER) RETURN NUMBER IS
    NBPI NUMBER := 370;
    NBP2 NUMBER := 480;
    NBP3 NUMBER := 520;
    NBP4 NUMBER := 850;
    -- COEFFICIENTS FOR DIESELS, HEATING OILS AND FUEL OILS
    K0F NUMBER := 1038720;
    K1F NUMBER := 2701;
    -- COEFFICIENTS FOR JET FUELS, KEROSENES, AND SOLVENTS
    K0J NUMBER := 3303010;
    K1J NUMBER := 0;
    -- COEFFICIENTS FOR TRANSITION BETWEEN JETS AND GASOLINES
    K1T NUMBER := -186840;
    -- COEFFICIENTS FOR GASOLINES AND NAPHTHENES
    K0G NUMBER := 1924571;
    K1G NUMBER := 2438;
    RC NUMBER := 0;
BEGIN
  IF (IAPI - NBP1 <= 0) THEN
    K0 := K0F;
    K1 := K1F;
  ELSIF (IAPI - NBP2 <= 0) THEN
    K0 := K0J;
  END IF;
K1 := K1J;
ELSIF (IAPI - NBP3 <= 0) THEN
    K0 := K0T;
    K1 := K1T;
ELSIF (IAPI - NBP4 <= 0) THEN
    K0 := K0G;
    K1 := K1G;
ELSE
    RC := -1;
END IF;
RETURN RC;
END;

-- THIS MODULE CAN BE DESIGNED TO CALCULATE A DENSITY
-- VALUE FROM A GIVEN VALUE OF API BY THE FORMULA
-- RHO = 141.5*999.012/(API + 131.5)
-- IN THIS EXEMPLARY CONFIGURATION IT IS ASSUMED THAT
-- THE API VALUE HAS BEEN ROUNDED TO THE NEAREST TENTH
-- DEGREE API AND THE VALUE MULTIPLIED BY 10. ALTHOUGH,
-- OTHER CONFIGURATIONS CAN USE OTHER SCHEMES. THE
-- OUTPUT VALUE OF RHO CAN BE RETURNED
-- AS AN INTEGER AND ROUNDED TO THE NEAREST HUNDREDTH
-- KILOGRAM/CUBIC METRE.
-- THE VALUE 1413601980 REPRESENTS 141.5*999.012*10000
-- CORRECT TO 10 DIGITS
PROCEDURE RHOB(IAPI IN NUMBER, IRHO IN OUT NUMBER) IS
    IDENOM NUMBER;
BEGIN
    IDENOM := IAPI + 1315;
    IRHO := TRUNC(((1413601980/IDENOM) + 5)/10);
END;

PROCEDURE SDIVB(INUM IN NUMBER, IDENOM IN NUMBER, IRES IN
OUT NUMBER) IS
    IRES1 NUMBER;
IRES2 NUMBER;
BEGIN
IRES1 := INUM / IDENOM;
IRES2 := (INUM - (IRES1 * IDENOM)) * 10000 / IDENOM;
IRES := (IRES1 * 10000) + IRES2;
END;

PROCEDURE ALFPAB(IRHO IN NUMBER, K0 IN NUMBER, K1 IN NUMBER, IALF IN OUT NUMBER) IS
INUM NUMBER;
IALF1 NUMBER;
IALF2 NUMBER;
IALFS NUMBER;
BEGIN
INUM := K1 * 10000;
SDIVB(INUM, IRHO, IALF1);
INUM := K0 * 100;
SDIVB(INUM, IRHO, IALFS);
SDIVB(IALFS, IRHO, IALF2);
IALF := TRUNC((IALF1 + IALF2 + 500)/1000);
END;

PROCEDURE MPYB(IX IN NUMBER, IY IN NUMBER, IZ IN OUT NUMBER) IS
IU1 NUMBER;
K1 NUMBER;
IV1 NUMBER;
IU2 NUMBER;
K2 NUMBER;
IV2 NUMBER;
K3 NUMBER;
BEGIN
IU1 := IX / 10000;
K1 := 10000 * IU1;
IV1 := IX - K1;
IU2 := IY / 10000;
K2 := 10000 * IU2;
IV2 := IY - K2;
K3 := IU1 * IV2 + IU2 * IV1 + IV1 * IV2 / 10000;
IZ := TRUNC((K3 + 5000) / 100000) + IU1 * IU2;
END;

PROCEDURE VCF6B(IALF IN NUMBER, IDT IN NUMBER, IVCF IN OUT NUMBER) IS
     ITERM1 NUMBER;
     ITERM2 NUMBER;
     ITERM3 NUMBER;
     IX NUMBER;
     ISUM1 NUMBER;
     ISUM2 NUMBER;
     ISUM3 NUMBER;
     ISUM4 NUMBER;
     ISUM5 NUMBER;
     ISUM6 NUMBER;
BEGIN
     ITERM1 := IALF * IDT;
     ITERM2 := ITERM1 / 5 * 4;
     MPYB(ITERM1, ITERM2, ITERM3);
     ITERM3 := TRUNC(ITERM3);
     IX := -1 * (ITERM1 + ITERM3);
     ISUM1 := 100000000 + IX;
     MPYB(IX, IX, ISUM2);
     ISUM2 := ISUM2 / 2;
     MPYB(IX, ISUM2, ISUM3);
     ISUM3 := ISUM3 / 3;
     MPYB(IX, ISUM3, ISUM4);
     ISUM4 := ISUM4 / 4;
     MPYB(IX, ISUM4, ISUM5);
     ISUM5 := ISUM5 / 5;
MPYB(IX, ISUM5, ISUM6);
ISUM6 := ISUM6 / 6;
IVCF := ISUM1 + ISUM2 + ISUM3 + ISUM4 + ISUM5 + ISUM6;
END;

PROCEDURE GetVCFactor(API60 IN OUT NUMBER, DEGF IN OUT NUMBER, VCF IN OUT NUMBER, IFK IN OUT NUMBER) IS
  IBP1 NUMBER := 400;
  IBP2 NUMBER := 500;
  ITMP1 NUMBER := 3000;
  ITMP2 NUMBER := 2500;
  ITMP3 NUMBER := 2000;
  IBAS NUMBER := 600;
  IEP1 NUMBER := 2500;
  IEP2 NUMBER := 2000;
  IEP3 NUMBER := 1500;

  -- VARIABLES FOR ROUNING INPUT PARAMETERS
  IAPI NUMBER;
  ITEMP NUMBER;
  IDT NUMBER;

  -- VARIABLES USED FOR CURVE COEFFICIENTS - SET BY CONDITIONS
  K0 NUMBER;
  K1 NUMBER;
  IRHO NUMBER;
  IRES NUMBER;
  IALF1 NUMBER;
  IALF NUMBER;
  IVCF NUMBER;
  JVCF NUMBER;
  PVCF NUMBER;
  CVCF NUMBER;
  VCFP NUMBER;
BEGIN
VCFC := -1;
-- ROUND INPUT PARAMETERS
IAPI := TRUNC((API60 * 10) + .5);
API60 := IAPI / 10;
ITEMP := TRUNC((DEGF * 10) + .5);
DEGF := ITEMPE / 10;
IDT := ITEMP - IBAS;
IFLAG := -1;
-- CHECK API RANGES
IF (IAP1 < 0) THEN
   -- IF API IS LESS THAN ZERO, RETURN
      -- FLAG AND VOLUME CORRECTION SET TO -1
   RETURN;
END IF;
-- DEFINE CURVE COEFFICIENTS
IF (SetCurveCoefficients( IAPI, K0, K1) < 0) THEN
   -- CURVE COEFFICIENTS COULD NOT BE DETERMINED, RETURN
   -- FLAG AND VOLUME CORRECTION SET TO -1
   RETURN;
END IF;
-- CHECK VALID TEMPERATURE RANGES
IF (ITEMP < 0) THEN
   -- RETURN ON NEGATIVE TEMP
   -- FLAG AND VOLUME CORRECTION SET TO -1
RETURN;
END IF;
IF (IAP1 - IBP1 <= 0) THEN
   IF (ITEMP - ITMP1 > 0) THEN
      RETURN;
   END IF;
ELSE
   IF (IAP1 - IBP2 <= 0) THEN
      IF (ITEMP - ITMP2 > 0) THEN

RETURN;
ELSE
  IF (ITEMP - ITMP > 0) THEN
    RETURN;
  END IF;
END IF;
END IF;
-- CALCULATE RHO
RHOB(API, IRHO);
  -- CALCULATE ALPHA
  IF (K0 = K0T) THEN
    -- CALCULATE ALPHA IN TRANSITION ZONE
    SDIVB(K0, IRHO, IRES);
    IRES := IRES * 10;
    SDIVB(IRES, IRHO, IALF1);
    IALF1 := TRUNC((IALF1 + 5)/10);
    IALF := TRUNC((IALF1 + K1 + 5)/10);
  ELSE
    ALFPAB(IRHO, K0, K1, IALF);
  END IF;
  -- CALCULATE VCF
  VCF6B(IALF, IDT, IVCF);
  IFLAG := 0;
  -- CHECK TO DETERMINE IF IN EXTRAPOLATED REGION
  IF (API - IBP1 <= 0) THEN
    IF (ITEMP - IEP1 > 0) THEN
      IFLAG := 1;
    END IF;
  ELSE
    IF (API - IBP2 <= 0) THEN
      IF (ITEMP - IEP2 > 0) THEN
        IFLAG := 1;
      END IF;
    ELSE
      IF (ITEMP - IEP2 < 0) THEN
        IFLAG := 1;
      END IF;
    END IF;
  END IF;
END IF;
ELSE
  IF (ITEMP - IEP3 > 0) THEN
    IFLAG := 1;
  END IF;
ENDIF;

JVCF := TRUNC(((IVCF / 1000) + 5) / 10);
PVCF := JVCF;
PVCF := PVCF / 10000;
IF (IVCF - 100000000) < 0 THEN
  -- VCF LESS THAN ONE, FIVE DECIMALS RETURNED
  JVCF := TRUNC(((IVCF / 100) + 5) / 10);
  CVCF := TRUNC(JVCF);
  CVCF := CVCF / 100000;
ELSE
  CVCF := PVCF;
ENDIF;
VCFP := PVCF;
VCFC := CVCF;
END;
END TEMP_CORRECT;
/

Exhibit F—Quick Read ATG Look-Up—Up

I. Send Request to Retail System including:
   1) Manifold Id(s)
   2) Branch Id

II. Receive quick read data from Retail System including:
   1) Manifold Id(s)
      a) Tank Id(s)
         i) Gross Volume
         ii) Net Volume
         iii) Fuel Height
iv) Water Height  
v) Fuel Temp  
vi) Ullage  
vii) Current Site Date and Time

III. Example

Request message to site to get the ATG tank level readout:

<TankReadReq>
  <SetId>
    Tank set Id (manifold id) of request 1
  </SetId>
</TankReadReq>

Response message from site with tank level information:

<TankReadResp>
  <Site>
    5 Digit site branch number
  </Site>
  <Time>
    Current site date and time in YYYY-MM-DD HH:MM:SS format
  </Time>
  <TankSet>
    <SetId>
      Tank set id (manifold id) that this response is for.
    </SetId>
    <Tanks>
      <Tank>
        <Id>
          Tank number
        </Id>
        <Volume>
          Tank volume
        </Volume>
        <TCVolume>
          Temperature corrected volume
        </TCVolume>
      </Tank>
    </Tanks>
  </TankSet>
</TankReadResp>
<TCVolume/>
<Water>
  Water level
</Water>
<FuelHeight>
  Fuel Height — float value
</FuelHeight>
<Temp>
  Temperature
</Temp>
<Ullage>
  Tank Ullage
</Ullage>

</Tank>

</ Tanks>

</TankReadResp>

Exhibit G—Real-Time Reconciliation Request from Host (CIM)

<FuelReconRequest>
  <Site>
    5 Digit site branch number
  </Site>
  <Time>
    Date/Time of request in YYYY-MM-DD HH:MM:SS: format
  </Time>
  <SnapShotSpan>
    Time span in seconds for snapshots
  </SnapShotSpan>
  <SetId>
    Tank set Id (manifold id) of request 1
<SetId>

Tank set Id (manifold id) of request 2

</SetId>

5


</FuelReconRequest>

Acknowledgement message back

10 <FuelReconRequest>

<Resp>

OK

</Resp>

</FuelReconRequest>
Exhibit H—Real-Time Reconciliation Data Response from Local (Retail System) to Host (CIM)

Fuel Reconciliation Response

This message can be sent from the site back to corporate:

```xml
<FuelReconResp>
  <Site>
    5 Digit site branch number
  </Site>
  <Time>
    Date/Time of message sent in YYYY-MM-DD HH:MM:SS format
  </Time>
  <UOM>
    This can be a three character value where:
    Position 1 = Volume measurement – L (liters) or G (gallons),
    Position 2 = Height measurement – I (inches) or C (centimeters)
    Position 3 = Temperature measurement – F (Fahrenheit) or C (Celsius)
  </UOM>
  <StartSnapshot>
    Beginning Date/Time of snapshots in YYYY-MM-DD HH:MM:SS format
  </StartSnapshot>
  <AmbTemp>
    Ambient temperature (outside temperature)
  </AmbTemp>
  <TankSet>
    <SetId>
      Tank set id (manifold id) that this response is for.
    </SetId>
    <FCode>
      Fuel code in this tank set
    </FCode>
  </TankSet>
</FuelReconResp>
```
<Id>
  Tank number
</Id>

<Water>
  Water level
</Water>

<FuelLvl>
  <Fuel> This can be a tokenized string in the format of 
  token:token:token:token:...
  where the tokens are:

<table>
<thead>
<tr>
<th>TOKEN</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lvl</td>
<td>Fuel level</td>
</tr>
<tr>
<td>Time F</td>
<td>Millisecond offset of snapshot, long integer value</td>
</tr>
</tbody>
</table>
  | Tmp or L | Temperatures, these can be positional, separated 
  |         | by a '/'. Temperature 1 can be first, temperature 
  |         | 2 can be second, etc. For example: 
  |         | 56.98/56.99/57.01/54.05/55.05 |

  For example:

  Lvl: 34.66|Time:10023|Tmp:56.98/56.99/57.01/54.05/55.05

  </Fuel>

  .

  .

  .

  </FuelLvl>

</Tank>

</Tanks>

</TankSetId>

<Sales>
  <Sale>
    <Pump>
      Pump number
    </Pump>
  </Sale>
</Sales>
Average temperature of sale

This can be a tokenized string in the format of

token: value|token: value...

where the tokens are:

<table>
<thead>
<tr>
<th>TOKEN</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vol</td>
<td>Fuel volume</td>
</tr>
<tr>
<td>Time</td>
<td>Millisecond offset of snapshot, long integer value</td>
</tr>
<tr>
<td></td>
<td>-1 indicates that the sale has completed pumping, but has not closed.</td>
</tr>
</tbody>
</table>

For example:

Vol:34.66|Time: 10033

This can be a tokenized string in the format of

token: value|token: value...

where the tokens are:
<table>
<thead>
<tr>
<th>TOKEN</th>
<th>Meaning</th>
</tr>
</thead>
</table>
| Tank  | Non-blended product - tank number. (example: Tank:1)  
Blended Product - tanks and blend ratio separated by commas. Blend ratio is decimal value to apply to the first tank in string (example: Tank:1,2,0.6000 means tank 1 and tank 2 are blended with 60% being from tank 1) |
| Time  | Transaction time in YYYY-MM-DD HH:MM:SS format |
| Inv   | Invoice number |
| Vol   | Volume |
| Tmp   | Temperature |

For example

One tank:

Tank:2|Time:2004-05-28
10:34:00|Inv:123A4567|Vol:45.666|Tmp:56

Blended tank:

Tank:4,6,0,6000|Time:2004-05-28
10:34:00|Inv:123A4567|Vol:45.666|Tmp:56

&lt;/ClosedSale&gt;

&lt;/FuelReconResp&gt;

Fuel Reconciliation error response

This message can be sent from the site back to corporate:

&lt;FuelReconResp&gt;

&lt;Site&gt;

  5 Digit site branch number

&lt;/Site&gt;

&lt;Time&gt;
Date/Time of message sent in YYYY-MM-DD HH:MM:SS format
</Time>
<Error>
Error message
</Error>
</FuelReconResp>

Acknowledgement of response message:
This message can be sent from the web service back to the site.
</FuelReconResp>
<Resp>
  OK
</Resp>
</FuelReconResp>

Exhibit I—Local (Retail System) Treatment of Reconciliation Request

1. Retail System Receives Reconciliation Request from CIM (see Exhibit G)
2. Retail System Views status on all transactions outstanding (i.e. not closed)
3. Retail System simultaneously generates base time-stamp and fires request for real-time data read on ATG, Temperature Probe, and Dispenser Totalizer Data Acquisition units, including the # of seconds for which to accumulate data.
4. Retail System Data Acquisition units retrieve request and request duration from Retail System PC and begin accumulating local time. Retail System Data Acquisition units respond to Retail System PC with measurement data. For example:
   While Accumulated Local Time <= Request Duration
   Do
       Retail System Data Acquisition units continue to request measurement data from peripheral measurement devices, assigning the local accumulation to each successive reading.
   End
   Retail System Data Acquisition units stop accumulating measurement readings.
Retail System Data Acquisition units report back to Retail System PC with measurement reading and accumulated time offset from time of request receipt.

5. Retail System awaits measurement data from all Retail System Data Acquisition units. When all data is received Retail System adds offset times to base time-stamp.

6. Retail System reports data back to Host (CIM)

**Exhibit J—Variance Assignment Procedures**

The following describes some of the most common reasons for variance in the fuel reconciliation process. These can change or be added to as required.

Variance Reasons:

**Loading:**
- Incorrect Volume Measurement
- Incorrect Density Measurement
- Incorrect Temperature Measurement
- Wrong Product

**Transporting:**
- Temperature Change
- Trailer Evaporation
- Trailer Leak
- Theft

**Delivery:**
- Delivery Evaporation
- Equipment Leak
- Product / Tank Mismatch
- Trailer Retain

**On Site Storage:**
- Incorrect Tank Calibration
- Faulty Probe
- Temperature Change
- Tank Leak
- Tank Evaporation
- Theft

**On Site Plumbing:**
Temperature Change
Plumbing Leak
On Site Dispensing:
  Temperature Change
  Dispenser Leak
  Dispenser Calibration
  Pulser Tampering
  Pump Test Override

The system can isolate some of the variance sections from other sections thereby allowing more accurate determination of the correlation between variance and the true causes for that variance. For example: If a variance occurs during a time period in which no delivery has taken place, but fuel has been pumped, the process can rule out the “Loading”, “Transporting” and “Delivery” sections for variance, so the process can more accurately correlate the variance to the “On Site” sections.

Furthermore, the system can measure the temperature of the product at every point of volume measurement, and make a correction adjustment to bring the volume into net terms. This can minimize the effect that temperature change can have on variance. The system can also find a qualitative or a quantitative correlation between the variance and all of the variance factors. It can accomplish this using multiple regression analysis. This allows the system to be able to indicate if there is a leak in a fuel take, pluming or dispensers. It also allows the system to determine if a dispenser needs to be recalibrated, if someone is stealing fuel, or if a truck has a leak or holds back fuel during a delivery. This is just some of the useful information the CIM system can provide.

Exhibit K—Business Period Activity Isolation (Delivery / Non-Delivery)

1) The designed system allows for reconciliation to take place on demand, allowing the business using the invention and system to dictate the time of physical to book reconciliation. This can be accomplished accurately by rapidly reading:
   - tank level measurements
   - tank product temperature at various strata layers
   - dispenser sales measurements and
   - dispenser temperature measurements
To accomplish the above measurements, the system enters what has been dubbed as a "Rapid Read" mode, hitherto referred to as a "snapshot." Rapid Read mode is unique to and possible for because 1) the CIM system uses the internet as a communication medium to tell the local Retail System exactly what tank manifold systems (includes plumbed tanks and dispenser) need to be measured and allows for process prioritization, drastically increasing focus of CPU power for gathering large quantities of raw data rapidly and 2) the local system allows for non-sale disturbing real-time reading of the interim dispensed quantity and temperature at each active dispenser, using an off-the-shelf pulse counter, in one configuration, that can be read over a network communication wire.

In contrast, other systems cannot allow user/host-dictated (i.e. real-time) reconciliation to occur. Instead, it listens for an idle business period before taking what it dubs as "essential" simultaneous readings of both the tank and dispenser systems, which can be used for later reconciliation.

The differences in functionality are material in every sense where an on demand reconciliation would be desirable. For instance: succeeding a short delivery the system could notify the delivering driver to check his hauling vessel for retain prior to accepting his next dispatch instruction.

2) The system does not require that tank measurements and dispenser measurements be taken simultaneously, but rather a process has been developed and documented allowing for near simultaneous readings to be aligned to a common time stamp. In contrast, some existing systems, for accuracy, take measurement readings simultaneously. Purportedly, the only way to accomplish this is to wait for an idle business time where there are no active sales on the manifold’s dispensers as true simultaneous readings from the manifold system are not likely possible or repeatable when sales are occurring.

3) The system allows for an on-demand reconciliation to be run as an appropriate consequence of classified events. These events include but are not limited to delivery prior authorization request (driver inputs BOL information and requests authorization to unload), delivery post authorization request (driver indicates unload completion and requests release from system so as to make available next dispatched load), and admin automated scheduled basis (daily cut-off period or other cycle as determined necessary).
The system can use the event triggering the reconciliation process to determine the business activities that took place from the prior request to that time (sales period w/o delivery, sales period w/delivery etc...) and thereby isolate reconciliation periods precisely.

In contrast, other systems rely on environmental conditions detected by the various measurement apparatus to detect a delivery (e.g. if the float rises significantly, then a delivery has been assumedly detected) and it cannot precisely isolate the pre-delivery sales period from the actual delivery period. The differences in functionality are material in every instance where precise reconciliation period determination would be required. For instance, if theft occurred by removing product from the fuel system in an unaccountable manner, just prior to the delivery, existing systems would likely include the variance generated by that event in association with the delivery, where on the other hand, the present invention’s on demand reconciliation capability would allow reconciliation to occur just prior to the delivery and absolutely vindicate the delivery process of any variance sourcing activities that took place prior to the delivery process.

4) The system allows both consideration of and where necessary provides actual temperature measurement for all points of physical measurement. The points of physical measurement can include:

- Loading Rack (Consideration of BOL)
- Liquid Product Storage Tank
- Fuel Dispenser

There can be significant temperature change occurring both during delivery to retail facility from load rack as well as from the liquid product storage tank to the fuel dispenser. To allow true reconciliation to occur, on net gallon terms, it is necessary to measure temperature in conjunction with every measurement of physical volume. The present invention allows for temperature to be measured at the physical location of the dispenser meter wheel and to record the temperature multiple times during any sales transaction. This temperature has consistently shown in repeated tests to be different than both the temperature in the liquid storage tank as well as neighboring dispensers plumbed to the same liquid storage tank. The temperature readings of a dispensed sale are unique per sales transaction and are a function of at least the following variables:
- Tank Fluid Temperature
- Surrounding Ground Temperature
- Pipe Wall Thickness
- Pipe Wall Material
- Proximity of Dispenser Skirt Relative to Rays of the Sun
- Ambient Air Temperature
- Fluid Flow Rate
- Duration of Time Since Last Transaction

The present invention allows the temperature to be measured in conjunction with the sale yet it does not have to apply the temperature correction to the retail sale—It can report the gross volume of the sale and the temperature corrected net volume of the sale separately.

In contrast, many existing systems take the average of the temperature in the tank at the beginning of the transaction and the temperature of the tank at the end of the transaction and to assign that average to the sale.

The inadequate dispenser temperature assignment method used in existing systems would result in reconciliation variance because the gross to net conversion of each book-adjusting sale would be performed with a temperature different than that of the product passing through the dispenser meter housing (i.e. the point of measurement).

This problem would be magnified where volume throughput is high.

**Exhibit L—Maintenance of Net Volume Book Balance**

Each transaction that transpires is converted to net 60 degree Fahrenheit volume terms before adjusting the Net book balance.

I. Sales Transactions records (See Exhibit N) include gross volume, manifold id and temperature. The ASTM provided Gross to Net conversion (See Exhibit E) formula is used to reference Gross to Net conversion factor, which is multiplied by the gross volume to arrive at Net Volume.

II. Delivery Transaction records (See Exhibit U) include gross volume, manifold id, temperature, and even include, as per the BOL, the Net Volume.

III. Reconciliation variances are computed as the difference between the Net Book Volume and the Net Physical volume. The variance calculated can be considered a Net Variance and it can be added to the Net Book Volume.
Exhibit M—On-Site Data Accumulation Methods

RF Wireless Unit

Exhibit N—Sales Transaction Record Format (Including Temperature)

<ClosedSales>

<ClosedSale>

This can be a tokenized string in the format of
token:value|token:value...

where the tokens are:

<table>
<thead>
<tr>
<th>TOKEN</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank</td>
<td>Non-blended product - tank number. (example: Tank:1) Blended Product - tanks and blend ratio separated by commas. Blend ratio is decimal value to apply to the first tank in string (example: Tank:1,2,0.6000 means tank 1 and tank 2 are blended with 60% being from tank 1)</td>
</tr>
<tr>
<td>Time</td>
<td>Transaction time in YYYY-MM-DD HH:MM:SS format</td>
</tr>
<tr>
<td>Inv</td>
<td>Invoice number</td>
</tr>
<tr>
<td>Vol</td>
<td>Volume</td>
</tr>
<tr>
<td>Tmp</td>
<td>Temperature</td>
</tr>
</tbody>
</table>

For example


Blended tank:Tank:4,6,0.6000|Time:2004-05-28 10:34:00|Inv:123A4567|Vol:45.666|Tmp:56

</ClosedSale>

</ClosedSales>
Exhibit O – Local to Host Alarm Communication

This message can be sent from the site back to corporate:

<TankAlarm>
  <Site>
  Site branch number
  </Site>
  <Time>
  Date/Time of message sent in YYYY-MM-DD HH:MM:SS format
  </Time>
  <Alarms>
    <Alarm>
      <Category>
      Category of alarm
      </Category>
      <Number>
      Id number of alarm
      </Number>
      <SensorNum>
      Sensor number or tank
      </SensorNum>
      <OccurDts>
      Time alarm occurred
      </OccurDts>
    </Alarm>
    <Alarm>
      <Category>
      Category of alarm
      </Category>
      <Number>
      Id number of alarm
      </Number>
      <SensorNum>
      Sensor number or tank
      </SensorNum>
  </Alarms>
</TankAlarm>
111

</SensorNum>
<OccurDts>
  Time alarm occurred
</OccurDts>

5
  </Alarm>

  

  

  

</Alarms>

10  </TankAlarm>

Acknowledgement of Alarm notification:
  <TankAlarm>
  <Resp>
    OK
  </Resp>
  </TankAlarm>

Exhibit P—Reconciliation Data Report Example

05001 BB Branch: Manifold:
Fuel Reconciliation Data

TABLE REQUEST TIME DURATION ACK MESSAGE INV TIME PHYSICAL INV
13759.91939
BOOK INV

111960.3298
TABLE TANK TEMPERATURE TURBULANCE
TANK READING 4 67.74 N
TABLE PUMP READING_TIME TEMPERATURE QUANTITY TRAN TYPE
INTERIM_SALE 14 28-DEC-2004 11:37:41:013000 0 .55 O
INTERIM_SALE 14 28-DEC-2004 11:37:42:036000 0 .55 O
INTERIM_SALE 8 28-DEC-2004 11:37:41:064000 0 12.38 O
INTERIM_SALE 8 28-DEC-2004 11:37:42:066000 0 12.38 O
INTERIM_SALE 9 28-DEC-2004 11:37:39:999000 0 5.593 C
<table>
<thead>
<tr>
<th>Tank Level</th>
<th>Date</th>
<th>Time</th>
<th>Type</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>W</td>
<td>0.22</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>S</td>
<td>76.53</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.52</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.52</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.52</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.52</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.52</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.5</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.5</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.5</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.5</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.5</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.5</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.5</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.5</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.5</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.5</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.5</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.5</td>
</tr>
<tr>
<td>Tank Level 4</td>
<td>28-Dec-2004</td>
<td>11:37:40</td>
<td>F</td>
<td>76.5</td>
</tr>
</tbody>
</table>

Fuel Reconciliation Data

Tank Level 4 28-Dec-2004 11:37:40:838000 F 76.5
Tank Level 4 28-Dec-2004 11:37:40:844000 F 76.5
TANK_LEVEL 4 28-DEC-2004 11:37:40 850000 F 76.5
TANK_LEVEL 4 28-DEC-2004 11:37:40 856000 F 76.5
TANK_LEVEL 4 28-DEC-2004 11:37:40 970000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:40 976000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:40 982000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:40 988000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:40 994000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:41 000000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:41 116000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:41 122000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:41 128000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:41 134000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:41 140000 F 76.5
TANK_LEVEL 4 28-DEC-2004 11:37:41 146000 F 76.5
TANK_LEVEL 4 28-DEC-2004 11:37:41 263000 F 76.5
TANK_LEVEL 4 28-DEC-2004 11:37:41 269000 F 76.5
TANK_LEVEL 4 28-DEC-2004 11:37:41 275000 F 76.5
TANK_LEVEL 4 28-DEC-2004 11:37:41 281000 F 76.5
TANK_LEVEL 4 28-DEC-2004 11:37:41 287000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:41 293000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:41 408000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:41 414000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:41 420000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:41 426000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:41 432000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:41 438000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:41 553000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:41 559000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:41 565000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:41 571000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:41 577000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:41 583000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:41 698000 F 76.51
114

TANK_LEVEL 4 28-DEC-2004 11:37:41:704000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:41:710000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:41:716000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:41:722000 F 76.51
5
TANK_LEVEL 4 28-DEC-2004 11:37:41:728000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:41:845000 F 76.52
05001 BB Branch: Manifold:

Fuel Reconciliation Data

TANK_LEVEL 4 28-DEC-2004 11:37:41:851000 F 76.52
10 TANK_LEVEL 4 28-DEC-2004 11:37:41:857000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:41:863000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:41:869000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:41:875000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:41:990000 F 76.51
15 TANK_LEVEL 4 28-DEC-2004 11:37:41:996000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:42:002000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:42:014000 F 76.5
20 TANK_LEVEL 4 28-DEC-2004 11:37:42:135000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:42:141000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:42:147000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:42:153000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:42:159000 F 76.52
25 TANK_LEVEL 4 28-DEC-2004 11:37:42:165000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:42:282000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:42:288000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:42:294000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:42:300000 F 76.52
30 TANK_LEVEL 4 28-DEC-2004 11:37:42:306000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:42:312000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:42:428000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:42:434000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:42:440000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:42:446000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:42:452000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:42:458000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:42:572000 F 76.5
TANK_LEVEL 4 28-DEC-2004 11:37:42:578000 F 76.5
TANK_LEVEL 4 28-DEC-2004 11:37:42:584000 F 76.5
TANK_LEVEL 4 28-DEC-2004 11:37:42:590000 F 76.5
TANK_LEVEL 4 28-DEC-2004 11:37:42:596000 F 76.5
TANK_LEVEL 4 28-DEC-2004 11:37:42:602000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:42:718000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:42:724000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:42:730000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:42:736000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:42:742000 F 76.53
TANK_LEVEL 4 28-DEC-2004 11:37:42:748000 F 76.53
05001 BB Branch: Manifold:
Fuel Reconciliation Data
TANK_LEVEL 4 28-DEC-2004 11:37:42:865000 F 76.52
TANK_LEVEL 4 28-DEC-2004 11:37:42:871000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:42:877000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:42:883000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:42:889000 F 76.51
TANK_LEVEL 4 28-DEC-2004 11:37:42:895000 F 76.51
TABLE TANK READING_TIME SENSOR TEMPERATURE
TANK_TEMPERATURE 4 28-DEC-2004 11:37:40:001000 1 59.01
TANK_TEMPERATURE 4 28-DEC-2004 11:37:40:001000 3 59.01
TANK_TEMPERATURE 4 28-DEC-2004 11:37:40:001000 4 59.29
TANK_TEMPERATURE 4 28-DEC-2004 11:37:40:001000 5 59.6
TABLE DATE INVOICE_NBR TEMPERATURE QUANTITY BLEND_RATIO TANK
Exhibit Q—Tank Strapping Procedure or Process

Preparation

I. User orders dispenser calibration service

II. User validates completion of dispenser calibration

III. User validates completion of hardware/software configuration at retail branch
IV. User notifies drivers/on-site personnel that no deliveries are allowed until strapping completion

**Strapping Procedure**

V. User identifies:

5

- Branch ID
- Manifold ID
- Max Time Span
- Min Volume
- Volume Increment
- Volume Unit of Measure (UOM)

VI. User initiates strapping data collection

VII. Host computer (CIM) uses the following process to accumulate the strapping data:

"""Create Variables

15

- Time_Span: Date/Time
- Time: Date/Time
- Min_Volume: Float
- Book_Volume: Float
- Volume_Increment: Float
- Accum_Volume: Float
- UOM: Char
- Tank_Height_Deviation: Float
- Deviation_Threshold: Float

"""Strapping Data Collection

25

While Time <= Time_Span

Do

Update Book_Volume

While Book_Volume >= Min_Volume

Do

30

Update Accum_Volume

If Accum_Volume >= Volume_Increment

Then

Run and Store Quick Read Samples (See Exhibit F)
Calculate Tank_Height_Deviation from Samples
If Tank_Height_Deviation <= Deviation_Threshold
Then
   Run Reconciliation (See Exhibit A,G,H)
   Store X:Y(Gross Manifold Vol:Temperature Corrected Variancem “Correct to Avg Manifold Temperature
   (See Exhibit S)
Else
   Reset Accum_Volume
Else
   Reset Accum_Volume
Else
   Break
While End
While End
IIIV. Host computer (CIM) notifies user of strapping data collection completion
IV. User Notifies drivers/onsite personnel that deliveries can commence
V. User views strapping data results and resulting calibration formulas (Manifold Level)
VI. User edits results if necessary
VII. User commits calibration formulas

Exhibit R—Exemplary Hardware Requirements
I. Inventory Measurement Device
The device needs to be able to provide either of the following sets of data:
1. Mass Only with Representative Time Stamp
   OR
2. Volume and Temperature, both with Representative Time Stamp
II. Transfer Measurement Device
The device needs to be able to measure inventory transfer at either input side or output
side or both. It must provide either of the following sets of data:
1. Mass only with Representative Time Stamp
OR
2. Volume and Temperature, both with Representative Time Stamp

III. Communication Medium

The devices utilized must be able to communicate the measurement readings electronically, in a format readable by either the Local, or the Host system.

**Exhibit S—Tank Strapping Temperature Correction Treatment**

It is desirable to append the temperature of the fuel tank manifold along with the temperature of the fuel being dispensed to every sales transaction, during the Tank Strapping process. This can be done so the gallons dispensed can be converted to what they would have been at the tank temperature. This method can minimize any bias in the tank strapping curve, and therefore increase the accuracy of the system. The following describes an exemplary process to accomplish this.

1) When the Tank Strapping process is started a period inventory temperature can be calculated, by averaging the temperature from the prior and current reconciliations. The derived period inventory temperature can be used to temperature-correct each interim sales transaction to the same temperature as what prevailed in the inventory tanks. This can be done using only the thermistors in the tanks that are below the fuel level (see Exhibit A). These are the only thermistors used because any thermistor above the fuel level would be air temperature, which could be different from the fuel temperature.

2) As fuel is dispensed each transaction can be accompanied by temperature of the fuel at the point of measurement in the fuel dispenser.

3) When the reported sales volumes (Accum_Volume in Exhibit Q) reaches the next incremental threshold volume (Volume_Increment in Exhibit Q), then the total manifold volume can be converted to net volume terms, using an ASTM certified method, to obtain a conversion factor for converting volume at tank temperature to equivalent volume at 60°F. For example:

- Measured: Gross_Volume = 10,000 gallons, Temperature = 73°F, API Gravity = 57.5
- Calculated: API Gravity at 60°F = 55.9, Conversion Factor = .9914,

\[
\text{Net\_Volume} = \text{Conversion\_Factor} \times \text{Gross\_Volume}
\]

\[
9914 = .9914 \times 10,000
\]
4) The process can do a similar calculation to convert each transaction volume
dispensed into net 60°F terms. Then the process can take the sum of the net volume
dispensed, and divide it by the tank conversion factor used to bring the tank inventory
to net 60°F terms. The result is dispensed volume temperature corrected to prevailing
tank temperature. For example:

Calculated:

\[
\text{Net Disp Vol} = 500 \\
\text{Tank Conversion Factor} = .9914 \\
\text{Disp Vol at Tank Temp} = \frac{\text{Net Disp Vol}}{\text{Tank Conversion Factor}} \\
\text{504.34} = \frac{500}{.9914} \\
\text{Disp Vol at Tank Temp} = 504.34
\]

5) It is the Disp Vol at Tank Temp that the system can use to subtract from our
previous tank volume to calculate our calibrated volume (see Exhibit T).

6) Each time Accum Volume reaches the Volume Increment amount a new
manifold temperature can be measured, and an average temperature can be calculated
between this current measurement and the previous manifold temperature. This
process can be repeated until the Tank Strapping Process (see Exhibit Q) is complete.

**Exhibit T – Tank Strapping Calculations**

1) Assume manufacturer’s height vs. volume chart is correct when tank is
approximately 90% filled. In other words, the variance is zero. Example:

<table>
<thead>
<tr>
<th>Manufacturer’s Chart</th>
<th>Calibrated Chart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>Volume</td>
</tr>
<tr>
<td>108”</td>
<td>19122</td>
</tr>
</tbody>
</table>

2) Then the fuel reconciliation process can be started (see Exhibit Q).

3) When the next volume measurement is received, (i.e. after the predefined
amount of fuel has been dispensed,) the process can then calculate the
variance from our “expected” volume based on the manufacturer’s charts.
Below are the formulas used to calculate variance. All volumes are
adjusted to the average manifold temperature (see Exhibit S).

\[
\text{Gross volume from chart readings} = \text{expected volume} \\
\text{Gross Initial volume - dispensed volume} = \text{calibrated volume} \\
\text{Calibrated volume - expected volume} = \text{variance}
\]
4) The variance can be calculated every time a new volume measurement is received from the Tank Strapping Process. For example: a measurement can be received for every hundred gallons of fuel dispensed.

5) When all volume and variance measurements have been calculated then the process can plot the volume vs. the variance and the volume vs. height relationships.

Example: The initial volume vs. height graph when tank is tilted.

Example: The initial volume vs. variance graph when tank is tilted.

6) From the graphs the process can see if volume and variance have a linear relationship.
7) We know that our initial assumption that there is no variance when the tank is 90% full is false. From the curvature of the volume to height graph the process can deduce that the variance is the least when the tank is half full. Because of the linear relationship between volume and variance the process can shift the calibrated curve up until the variance in the middle of the tank is zero. This can produce a graph like the following, which now gives us a more accurate representation of the volume to variance relationship.

8) The new volume to variance graph is shown below.

9) A formula representing this curve can allow explaining variance as a function of inventory volume. It can tell us the expected variance for any volume.
measurement on a specified tank manifold. Any variance observed deviating from this line can be unexplained variance which can be subject to correlation analysis (See Exhibit J).

Another alternate configuration of the methods and processes of identifying variances between a manufacturer’s strapping chart and the actual measured physical volume based upon the orientation and configuration of the tank is described hereinafter.

1) Start the Tank Calibration Procedure (see Exhibit Q). Note: After appropriate hardware and software installations and dispenser calibrations, this process may be started and run without interruption of sales or delivery transactions.

2) Assume that the manufacturer’s height vs. volume chart is correct at the highest point for which we have obtained a measurement during the Tank Calibration process. In other words, the variance is zero at that point.

Example:

<table>
<thead>
<tr>
<th>Manufacturer’s Chart</th>
<th>Calibrated Chart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>Volume</td>
</tr>
<tr>
<td>108”</td>
<td>19122</td>
</tr>
</tbody>
</table>

3) The Tank Calibration Process contains a function which continually queries the system database to determine if the predefine amount of fuel has been dispensed. When the dispensed volume is greater than or equal to the volume increment (see Exhibit Q) the system will perform a fuel reconciliation which will calculate the variance from the expected volume based on the manufacturer’s charts. It will also calculate accumulated variance associated to a specific manifold volume. Below are the formulas used to calculate variance and accumulated variance. All volumes are adjusted to the average manifold temperature (see Exhibit S).

\[
\text{expected_volume} = \text{Gross_volume_from_chart_readings}
\]

\[
\text{calibrated_volume} = \text{Gross_Initial_volume} - \text{dispensed_volume}
\]

\[
\text{variance} = \text{calibrated_volume} - \text{expected_volume}
\]

\[
\text{accum_variance} = \text{accum_variance} + \text{variance}
\]

4) The variance is measured and added to the accumulated variance every time a new volume measurement is received from the Tank Calibration
Process. Thus, for every volume measurement we have an associated accumulated variance that we will store and plot.

5) Every time a delivery occurs during the calibration process, the system will perform another fuel reconciliation. This gives us a new starting point in which we set the accumulated variance to zero, however we don’t use this point in the plot of the calibration curve. Then we continue with steps three and four until the calibration process is finish, or another delivery is made. Any time a fuel reconciliation is ran and the volume is greater than the previous reconciliation’s volume, then a delivery has occurred.

6) When the time limit or the minimum volume is reached in the calibration process, or the user decides to stop the calibration process, we will have many volume vs. accumulated variance data points. These data points will be grouped into segments, with a delivery being the point in time that separates each segment. From these data segments we will construct a single calibration curve. Below is a graph of what the initial data segments might look like if three deliveries took place during the calibration process.

![Volume vs. Accumulated Variance](image)

7) From the graph above we can see that we must handle the cases where segments partially overlap, fully overlap, or don’t overlap at all. We will perform some mathematical analysis on these segments in order to bring
all of these pieces together to form one smooth curve. In doing so we can assume that the curve with the highest endpoint (with respect to volume) is our most accurate segment. Therefore we will leave it as it is, and manipulate the other curves to align with the topmost curve.

In order to produce one continuous curve we can vertically shift each curve segment to produce a least mean squares fit with the curve segment with which it overlaps, or has the same endpoint.

After we have connected the segment into one curve, the plot of the volume vs. the accumulated variance may look similar to the following graph.

A formula representing this curve will be calculated and stored. This formula will allow explaining variance as a function of inventory volume. It will tell us the expected variance for any volume measurement on a specified tank manifold. Any variance observed deviating from this line will be unexplained variance which will be subject to correlation analysis (See Exhibit J).

**Exhibit U—BOL Delivery Record Format**

The Bill of Lading information captured per each delivery instance includes:

- Route Start Time
- Route End Time
- Freight Bill #
Truck 
Trailer 1 
Trailer 2 
Trailer 3 
5 Customer Name
Customer ID
Supplier Name
Supplier ID
Ship From Name
10 Ship From ID
Ship To Name
Ship To ID
BOL Date
BOL Start Time
BOL End Time
15 Wait Time
Supplier BOL
BOL Product Name
BOL Product ID
BOL Gross Volume
BOL Net Volume
BOL Volume UOM
BOL Density
BOL Density UOM
20 BOL Temperature
BOL Temp UOM
Retail Product Name
Retail Product ID

The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the
foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.
CLAIMS

We claim:

1. In a system having a centralized management system, a method for centrally monitoring and controlling the delivery of liquid product to a plurality of retail facilities from a carrier that transports liquid product, the method comprising:
   - receiving at the centralized management system a request from the carrier for instructions relating to delivery of liquid product;
   - based on data monitored by the centralized management system, determining liquid product needed in a retail facility selected from the plurality of retail facilities; and
   - posting an order providing instructions to the carrier regarding liquid product needed in the selected retail facility.

2. A method as recited in claim 1, wherein determining liquid product needed comprises one of: (i) determining a type of liquid product needed, (ii) determining an amount of liquid product needed, and (iii) determining the type and the amount of liquid product needed.

3. A method as recited in claim 1, wherein determining liquid product needed comprises determining a type and a volume of liquid product needed.

4. A method as recited in claim 1, wherein the request for instructions from the carrier comprises a request for instructions relating to at least one of a geographical location of a rack containing the liquid product, a current location of the carrier, a liquid product need of the retail facility, and a geographical location of the retail facility relative to the carrier and the rack.

5. A method as recited in claim 1, wherein posting the order can be based upon at least one of (i) the relative cost of delivered supply options, (ii) supply purchase fulfillment obligations, (iii) retail demand constraints, and (iv) the geographical location of the carrier relative to a rack where the liquid product can be loaded.

6. The method of claim 1, further comprising rejecting the order by the carrier, the carrier rejecting the order by sending a reason code to the centralized management system.
7. The method of claim 1, further comprising accepting the order by the
carrier, updating a status of the order at the centralized management system, and
forwarding the order to a loading terminal.

8. The method of claim 1, further comprising:

accessing a transaction record received from a loading terminal that
includes liquid product loading details;

validating that a supply and a volume of the liquid product match an
inventory need of the retail facility;

authorizing a specific tank to receive the liquid product; and

monitoring all tanks at the selected retail facility to insure that the
liquid product is delivered into said authorized tank.

9. The method of claim 8, wherein said loading details include at least
one of a liquid product temperature at said loading terminal, a type of liquid product,
a gross volume of liquid product, a temperature corrected net volume of liquid
product, and a density of liquid product.

10. The method of claim 8, further comprising monitoring a water level in
said authorized tank during delivery and suspending delivery if said water level
exceeds a predefined value.

11. The method of claim 1, further comprising:

posting transaction record data to the carrier for validation;

receiving validation from the carrier for said transaction record;

posting authorization to the carrier to deliver the liquid product into a
selected storage tank at the retail facility;

receiving notification of delivery completion; and

updating a book balance of available liquid product as per the
transaction record.

12. In a monitoring and control system for tracking liquid product
inventory, the system comprising at least one central computer connected to at least
one retail computer, a method for controlling the movement of the liquid product from
a delivery terminal to a designated storage tank of a retail facility, the method
comprising:

sending an electronic request for a delivery of the liquid product to the
at least one central computer using a portable computing device;
receiving a delivery of the liquid product in a delivery vehicle at the
delivery terminal;
transporting the liquid product to the retail facility;
requesting authorization to deliver the liquid product to the designated
storage tank;
receiving authorization to deliver the liquid product to the designated
storage tank; and
delivering the liquid product into the designated storage tank.

13. The method of claim 12, wherein said electronic request is a supply
option for delivery to the retail facility.

14. The method of claim 12, further comprising:
   having the at least one central computer post an order with an order
   number to said portable computing device;
   having a driver of said delivery vehicle accept said order; and
   having the at least one central computer forward said order to a
   terminal computer at the delivery terminal.

15. The method of claim 12, wherein receiving authorization to deliver the
liquid product further comprises transmitting an electronic transaction record from a
terminal computer at the delivery terminal to the at least one central computer.

16. The method of claim 15, wherein said electronic transaction record
includes at least one of the following: a route start and end time, a freight bill number,
a customer name, a customer identification number, a supplier name, a supplier
identification number, a ship from name, a ship from identification number, a ship to
name, a ship to identification number, a transaction date, a start and end time, a
supplier product name, a product identification number, a gross volume, a net volume
as a function of temperature, a specific gravity of the product, a volume unit of
measure (UOM), a density UOM, a temperature and a temperature UOM, a retail
product name and a retail product identification number.

17. The method of claim 12, wherein requesting authorization to deliver
further comprises:
   sending an authorization request from said portable computing device
to the at least one retail computer, said authorization request including at least
   a product type and a product volume;
verifying that said at least one product type and said product volume match a requirement in the designated storage tank;

performing a book balance to a physical balance reconciliation process for the designated storage tank;

sending a loading transaction record from the at least one retail computer to said portable computing device; and

verifying said loading transaction record prior to delivering the liquid product.

18. The method of claim 12, wherein delivering the liquid product further comprises:

unloading all of the liquid product into the designated storage tank;

notifying the at least one retail computer that the liquid product has been unloaded;

updating a book balance of the designated storage tank to include a volume of liquid product contained in said delivery vehicle;

performing a book balance to a physical balance reconciliation process for the designated storage tank; and

verifying that the volume of liquid product contained in the delivery vehicle was delivered to the designated storage tank.

19. The method of claim 18, further comprising monitoring all tanks at the retail facility to insure that the liquid product goes into the designated storage tank.

20. The method of claim 18, further comprising monitoring a water level in the designated storage tank during delivery and suspending delivery if said water level exceeds a predefined value.

21. The method of claim 12, wherein the at least one central computer monitors and manages physical and reported book sales for the retail facility.

22. A liquid product storage and delivery system, the system comprising:

a centralized management system that delivers orders to one or more carriers to deliver a liquid product to one or more retail facilities, the centralized management system monitors the liquid product inventory at the plurality of retail facilities; and

a designated retail facility of the one or more retail facilities, the designated retail facility including one or more storage tanks that receive the
liquid product, the designated retail facility receives data indicative of a future
delivery of the liquid product from both the centralized management system
and a carrier of the one or more carriers that is to deliver the liquid product to
the one or more storage tanks.

23. The system as recited in claim 22, wherein the carrier delivers a
request to delivery the liquid product to the centralized management system.

24. The system as recited in claim 23, where the request comprises a
request for instructions relating to at least one of a geographical location of a rack
containing the liquid product, a current location of the carrier, a liquid product need of
the retail facility, and a geographical location of the retail facility relative to the
carrier and the rack.

25. The system as recited in claim 22, further comprising a loading
terminal remote from the centralized management system, the carrier receives the
liquid product from the loading terminal.

26. The system as recited in claim 22, wherein the carrier delivers an
electronic delivery record to the retail facility before delivering the liquid product to
the one or more storage tanks.

27. The system as recited in claim 22, wherein the retail facility delivers
data indicative of the completion of a delivery of the liquid product by the carrier to
the centralized management system.

28. In a system having a centralized management system and at least one
retail facility, a method for interrupting delivery of a liquid product to the at least one
retail facility, the method comprising:

   monitoring one or more tanks at the at least one retail facility for liquid
   product delivery from a delivery vehicle;

   identifying delivery of the liquid product to an unauthorized tank of the
   at least one retail facility; and

   automatically terminating delivery of the liquid product when a control
signal is sent to the delivery vehicle from at least one of (i) the retail facility,
and (ii) the centralized management system to interrupt delivery of the liquid
product into the unauthorized tank.
29. The method of claim 28, wherein automatically terminating delivery further comprises sending the control signal to the delivery vehicle via a wireless communication protocol.

30. The method of claim 28, further comprising shutting down a common air flow solenoid on the delivery vehicle to stop delivery of the liquid product.

31. The method of claim 28, further comprising automatically shutting off at least one pump dispenser in fluid communication with said unauthorized tank to prevent delivery of the liquid product to a customer of the at least one retail facility.

32. The method of claim 28, further comprising:

- monitoring a water level within said one or more tanks at the at least one retail facility;
- identifying that a water float within one or more of said one or more tanks has risen above a predetermined threshold; and
- when said water float has risen above said predetermined threshold, automatically terminating delivery of the liquid product by sending said control signal to the delivery vehicle via a wireless communication protocol.

33. The method of claim 32, further comprising, when said water float has risen above said predetermined threshold, automatically shutting off at least one pump dispenser in fluid communication with one or more of said one or more tanks to prevent delivery of the liquid product to a customer of the at least one retail facility.

34. A system to prevent a delivery vehicle from delivering liquid product to an unauthorized storage tank in a retail facility having a plurality of storage tanks, the system comprising:

- a centralized management system connected to at least one computer in the retail facility;
- at least one sensor located in each storage tank of the plurality of storage tanks in the retail facility, said at least one sensor being electronically connected to the centralized management system; and
- a valve on the delivery vehicle electronically connected to the centralized management system, the valve capable of interrupting the flow of liquid product during a delivery;

wherein the centralized management system monitors said at least one sensor in each of the plurality of storage tanks while liquid product is being
delivered into any of said plurality of storage tanks, and wherein the centralized management system sends a control signal to the delivery vehicle to close said valve when the liquid product is being delivered into an unauthorized tank of said plurality of storage tanks.

35. The system of claim 34, wherein each storage tank of said plurality of storage tanks comprises at least one sensor, said at least one sensor performs a real-time measurement of the amount of liquid product in each of said plurality of storage tanks.

36. The system of claim 34, wherein said valve is connected to a solenoid that receives the signal and operates said valve.

37. The system of claim 34, wherein the delivery vehicle is connected to the centralized management system via a wireless communication protocol.

38. The system of claim 34, wherein said control signal is sent automatically by the centralized management system.

39. The system of claim 34, wherein the centralized management system activates an alarm at the retail facility and an operator then manually closes said valve to stop said delivery.

40. The system of claim 34, wherein the centralized management system further sends a signal to at least one liquid product dispenser connected to said unauthorized tank, the signal shutting down said at least one liquid product dispenser so that no liquid product can be dispensed from said unauthorized tank.

41. The system of claim 34, wherein said at least one sensor further measures an amount of water in each of said plurality of storage tanks, and the centralized management system interrupts the delivery of the liquid product when the amount of water in any of said plurality of storage tanks exceeds a predetermined value.

42. In a retail facility having a plurality of storage tanks for liquid product, the retail facility being connected to a centralized management system, a method for interrupting a delivery of liquid product from a delivery vehicle into an unauthorized storage tank, the method comprising:

    monitoring a level of liquid product in each of the plurality of storage tanks;

    identifying delivery of liquid product to an unauthorized tank; and
automatically terminating delivery of the liquid product when a control
signal is sent from at least one of the retail facility and the centralized
management system to the delivery vehicle.

43. The method of claim 42, wherein monitoring the level of liquid
product in each of the plurality of storage tanks includes collecting data from a sensor
located in each of the plurality of storage tanks to obtain an accurate, real-time
measurement of the level of liquid product with each of the plurality of storage tanks.

44. The method of claim 43, wherein said collected data is collected at a
rate of at least 10 times per second for each said sensor, and wherein said collected
data is processed to minimize the effects of wave motion in each of the plurality of
storage tanks to generate the accurate measurement of the level of liquid product in
each of the plurality of storage tanks.

45. The method of claim 42, further comprising shutting down a common
air flow solenoid on the delivery vehicle to stop delivery of the liquid product.

46. The method of claim 42, further comprising automatically shutting off
at least one pump dispenser in fluid communication with said unauthorized tank to
prevent delivery of the liquid product to a customer of the retail facility.

47. The method of claim 42, wherein the delivery vehicle is connected to
the centralized management system via a wireless protocol.

48. The method of claim 42, further comprising:

monitoring a water level within said unauthorized tank at the retail
facility; and

automatically interrupting delivery of the liquid product into said
unauthorized tank by sending said control signal to the delivery vehicle when
said water level rises to a predetermined value.

49. In a dynamic liquid product distribution environment, a method of
providing a virtual real-time perpetual book to physical reconciliation for one or more
of a plurality of tanks while liquid product is being dispensed therefrom, the method
comprising:

receiving a request to perform a liquid product book to physical
reconciliation process for one or more storage tanks;

identifying the status of one or more liquid product dispensers
corresponding to the one or more storage tanks;
while said one or more liquid product dispensers are in an active state, taking a plurality of measurements within the one or more storage tanks and said one or more liquid product dispensers; and

based on said plurality of measurements, automatically performing
said liquid product book to physical reconciliation process.

50. The method of claim 49, wherein said plurality of measurements include at least a volume of liquid product in each of the one or more storage tanks and a flow volume of liquid product for each of said one or more liquid product dispensers.

51. The method of claim 50, wherein each of said plurality of measurements is taken at rapid intervals of less than 2 seconds over a predetermined period of time.

52. The method of claim 51, wherein said predetermined period of time is either a default value or set by a user.

53. The method of claim 51, wherein taking said plurality of measurements comprises: (i) using a measurement device within each of the one or more storage tanks, and (ii) using the measurement device within each of the one or more liquid product dispensers.

54. The method of claim 50, wherein said flow volume of liquid product is added to said volume of liquid product in each of the one or more storage tanks.

55. The method of claim 50, wherein the one or more storage tanks are a manifold of storage tanks, and wherein each of said plurality of measurements has a corresponding time-stamp, the method further comprising:

identifying a series of measurement readings for each storage tank within the manifold of storage tanks, said series of measurement readings identified based on said corresponding time-stamp;

summing said series of measurement data for determining a cumulative volume for liquid product within said manifold of storage tanks;

calculating a time difference between a first time-stamp in said series of measurement readings and one or more subsequent time-stamps within said series of measurement readings;

based on the time difference, determining a cumulative time-stamp for said series of measurement readings; and
assigning said cumulative time-stamp to a determined cumulative volume.

56. The method of claim 55, wherein said determined cumulative time-stamp is a time of reconciliation to which said plurality of measurements will be adjusted to.

57. At a centralized station, a method of performing a virtual real-time liquid product book to physical volume reconciliation by rapidly accumulating data over a predetermined time period at a plurality of measurement devices and monitoring sale transactions during the predetermined time period, the method comprising:

   receiving a request to initiate a liquid product book to physical volume reconciliation process for one or more storage tanks, said request received while one or more liquid product dispensers, corresponding to said one or more storage tanks, are in an active state;

   collecting a plurality of measurement data from a plurality of measurement devices over a predetermined period of time, said plurality of measurement data taken at rapid intervals over said predetermined period of time;

   assigning a time-stamp to each of said plurality of measurement data;

   monitoring sales transactions during said predetermined period of time; and

   after said predetermined period of time, using said plurality of measurement data and said monitored sales transactions to complete the liquid product book to physical volume reconciliation process.

58. The method of claim 57, wherein said plurality of measurement data includes at least a volume of liquid product in each of said one or more storage tanks and a flow volume of liquid product for each of said one or more liquid product dispensers.

59. The method of claim 58, wherein said flow volume of liquid product for dispensers active beyond said predetermined period of time is added to said volume of liquid product in each of said one or more storage tanks.

60. The method of claim 59, wherein predefined pump rules and the time in which said flow volumes are collected are used to determine what time-stamp and
what flow volume to add to said volume of liquid product in each of said one or more storage tanks.

61. The method of claim 57, wherein said rapid intervals are periods of less than 2 seconds.

62. The method of claim 57, wherein said predetermined period of time is either a default value or set by a user.

63. The method of claim 57, wherein said one or more storage tanks are a manifold of storage tanks, the method further comprising:

- identifying a series of measurement readings for each storage tank within said manifold of storage tanks, said series of measurement readings identified based on a corresponding time-stamp;
- summing said series of measurement readings for determining a cumulative volume for liquid product within said manifold of storage tanks;
- calculating a time difference between a first time-stamp in said series of measurement readings and one or more subsequent time-stamps within said series of measurement readings;
- based on said time difference, determining a cumulative time-stamp for said series of measurement readings; and
- assigning said cumulative time-stamp to a determined cumulative volume.

64. The method of claim 63, wherein said determined cumulative time-stamp is a time of reconciliation to which said plurality of measurements are adjusted to.

65. The method of claim 63, wherein a plurality of cumulative time-stamps for a plurality of cumulative volumes are determined, the method further comprising:

- determining flow volume of liquid product for said one or more dispensers active beyond said predetermined period of time;
- determining a time-stamp for each of said determined flow volumes, said time-stamps corresponding to said plurality of cumulative time-stamps;
- adding said determined flow volume of liquid product for said one or more dispensers active beyond said predetermined period of time to each of the corresponding plurality of cumulative volumes in order to adjust said plurality of cumulative volumes back to a time of reconciliation;
averaging said plurality of cumulative volumes to determine a mean physical inventory;

computing a standard deviation for said determined mean;

eliminating data readings from said plurality of cumulative volumes that are above or below a predetermined number of standard deviations; and

average the remaining plurality of cumulative volumes not eliminated for determining a net physical volume at said time of reconciliation.

66. The method of claim 65, further comprising:

adjusting said net physical volume by adding interim sales;

updating net perpetual book balance to said time of reconciliation; and

subtracting said net perpetual book balance from said adjusted net physical volume to determine an inventory gain or loss.

67. The method of claim 57, wherein one or more other devices are temporarily disabled during at least a portion of said predetermined period of in order to reserve computing resources for rapidly collecting said plurality of measurement data from said plurality of measurement devices over said predetermined period of time by taken at rapid intervals over said predetermined period of time.

68. The method of claim 67, wherein said one or more other devices are one or more leak detection devices.

69. The method of claim 57, wherein based on the number of measurement data collected and a length of said predetermined period of time, the method further comprises determining a confidence level that the book to physical reconciliation process is accurate.

70. In a dynamic liquid product distribution environment, a computer program product for implementing a method of providing a virtual real-time perpetual book to physical reconciliation for one or more of a plurality of tanks while liquid product is being dispensed there from, the computer program product comprising one or more computer readable media having stored thereon computer executable instructions that, when executed by a processor, can cause the distributed computing system to perform the following:

receive a request to perform a liquid product book to physical reconciliation process for one or more storage tanks;
identify the status of one or more liquid product dispensers corresponding to the one or more storage tanks;

while said one or more liquid product dispensers are in an active state, take a plurality of measurements using measurement devices within the one or more storage tanks and said one or more liquid product dispensers; and

based on said plurality of measurements, automatically perform said liquid product book to physical reconciliation process.

71. The computer program product of claim 70, wherein said plurality of measurements include at least a volume of liquid product in each of the one or more storage tanks and a flow volume of liquid product for each of said one or more liquid product dispensers.

72. The computer program product of claim 71, wherein said flow volume of liquid product is added to said volume of liquid product in each of the one or more storage tanks.

73. The computer program product of claim 71, wherein the one or more storage tanks are a manifold of storage tanks, and wherein each of said plurality of measurements has a corresponding time-stamp, the computer program product further comprising computer executable instructions that can cause the messaging system to perform the following:

identify a series of measurement readings for each storage tank within the manifold of storage tanks, said series of measurement readings identified based on said corresponding time-stamp;

sum said series of measurement data for determining a cumulative volume for liquid product within said manifold of storage tanks;

calculate a time difference between a first time-stamp in said series of measurement readings and one or more subsequent time-stamps within said series of measurement readings;

based on the time difference, determine a cumulative time-stamp for said series of measurement readings; and

assign said cumulative time-stamp to a determined cumulative volume.

74. A method of filtering physical volume measurements within a tank at a point in time, the method comprising:
receiving a plurality of measurement data at a plurality of times, each measurement data representing a volume of liquid product within the tank;
comparing each volume of liquid against at least one predetermined volume identified as being unreliable;
generating a second set of measurement data by eliminating any measurement data from said plurality of measurement data that is identified as being unreliable;
determining a sample mean and a standard deviation for said second set of measurement data; and
filtering said second set of measurement data to generate a third set of measurement data by eliminating any measurement data from said second set of measurement data that has a value plus or minus a predetermined number of said standard deviations from said standard mean.

75. The method as recited in claim 74, wherein any measurement data of said plurality of measurement data that is identified as being unreliable comprises data above or below one or more defined thresholds relative to any other measurement data within said plurality of measurement data.

76. The method as recited in claim 75, wherein said one or more defined thresholds can be at least one of a maximum tank volume and a minimum tank volume, such that said measurement data that is greater than said maximum tank volume and/or measurement data that is lesser than said minimum tank volume is eliminated when said second set of measurement data is generated.

77. The method as recited in claim 74, further comprising associating each said measurement data of said third set of measurement data with a common time.

78. The method as recited in claim 74, further comprising averaging each said measurement data of said third set of measurement data at a common time.

79. The method as recited in claim 74, wherein the tank is one of a plurality of tanks that are connected together with a manifold.

80. The method as recited in claim 79, further comprising generating one or more series of said measurement data, each of said one or more series comprising one said volume of liquid product for each tank of the plurality of tanks connected to said manifold.

81. The method as recited in claim 80, further comprising:
averaging said volume of liquid from each tank of said plurality of tanks connected to said manifold to generate a cumulative volume for a first series of said one or more series; and
determining a time-stamp for each of said measurement data of said series, each said time-stamp representing a time of said plurality of times when said measurement data was measured; and
following determining an average of differences between said time-stamps for said first series, generating a cumulative time-stamp for said first series.

82. The method as recited in claim 80, further comprising aligning all of said one or more series to said cumulative time-stamp of said first series.

83. A method of filtering physical volume determinations within an inventory tank at a point in time, the method comprising:
    receiving a measurement data at a plurality of times, said measurement data including data representative of a temperature of liquid product within a tank and a volume of the liquid product within said tank;
    comparing each volume of liquid against at least one predetermined volume identified as being unreliable;
    generating a second set of measurement data by eliminating any measurement data from said measurement data that is identified as being unreliable;
    determining a sample mean and a standard deviation for said second set of measurement data; and
    filtering said second set of measurement data to generate a third set of measurement data by eliminating any measurement data from said second set of measurement data that has a value plus or minus a predetermined number of said standard deviations from said standard mean.

84. The method as recited in claim 83, wherein any measurement data of said measurement data that is identified as being unreliable comprises data above or below defined one or more thresholds relative to any other measurement data within said measurement data.

85. The method as recited in claim 84, wherein said one or more defined thresholds can be at least one of a maximum tank volume and a minimum tank
volume, such that measurement data that is greater than said maximum tank volume and/or measurement data that is lesser than said minimum tank volume is eliminated when said second set of measurement data is generated.

86. The method as recited in claim 83, further comprising associating each said measurement data of said third set of measurement data with a common time and averaging each said measurement data of said third set of measurement data at the common time.

87. A method of filtering physical volume measurements of a liquid within a tank made at a plurality of times to compensate for waves motions within the tank, the method comprising:

receiving, at a centralized management system, a measurement data for a plurality of times, each measurement data representing a volume of liquid product within the tank;

comparing each volume of liquid against at least one predetermined volume;

generating a second set of measurement data by eliminating from said measurement data any data corresponding to said at least one predetermined volume;

determining a sample mean and a standard deviation for said second set of measurement data; and

filtering said second set of measurement data to generate a third set of measurement data by eliminating any measurement data from said second set of measurement data that has a value that is more or less than a predetermined number of said standard deviations from said standard mean.

88. A method as recited in claim 87, wherein said at least one predetermined volume comprises a volume that is identified as being unreliable.

89. A method as recited in claim 87, wherein data of said measurement data that is identified as being unreliable comprises: (A) a volume of liquid that is that is more than a maximum tank volume; (B) a volume of liquid that is that is less than a minimum tank volume; or (C) one or more other volumes of liquid that are identified as being unreliable.

90. The method as recited in claim 87, further comprising associating each said measurement data of said third set of measurement data with a common time.
91. The method as recited in claim 87, further comprising averaging each said measurement data of said third set of measurement data at the common time.

92. A method of providing virtual real-time status of sales transactions in order to perform a liquid product fuel reconciliation regardless of ongoing sells, the method comprising:

   receiving a request to perform a liquid product book to physical reconciliation for one or more storage tanks;

   identifying a duration for accumulation of measurement data used for said reconciliation;

   during said identified duration, monitoring a status of one or more dispensers for dispensing liquid product from said one or more storage tanks; and

   based on said status of said one or more dispensers, updating at least one of (i) a physical inventory, and (ii) a book value to appropriately determine the book to physical reconciliation.

93. The method of claim 92, wherein said status is an interim status for updating the physical inventory, and wherein said interim status is chosen from one of an interim open, interim closed, or interim stacked transaction.

94. The method of claim 92, wherein the duration for accumulation of measurement data used for said reconciliation is adjustable by a user.

95. The method of claim 92, wherein the duration for accumulation of measurement data used for said reconciliation is a predefined default value.

96. The method of claim 92, wherein said status is a closed transaction and the book value is updated with information corresponding to said closed transaction.

97. The method of claim 96, further comprising:

   determining that one or more closed transactions that were awaiting to be sent to the book value prior to said request to perform said reconciliation was sent during said duration of the accumulation of measurement data; and

   deleting the determined one or more closed transactions in order to prevent duplicate recording on the book value.

98. A method of providing virtual real-time status of sales transactions in order to perform a liquid product fuel reconciliation regardless of ongoing sells, the method comprising:
generating a request to perform a liquid product book to physical reconciliation for one or more storage tanks, said request including an identification of a duration for accumulation of measurement data used for said reconciliation;

during said identified duration, monitoring a status of one or more dispensers for dispensing liquid product from said one or more storage tanks; and

based on said status of said one or more dispensers, updating at least one of (i) a physical inventory, and (ii) a book value to appropriately determine the book to physical reconciliation.

99. The method of claim 98, wherein said status is an interim status for updating the physical inventory, and wherein said interim status is chosen from one of an interim open, interim closed, or interim stacked transaction.

100. The method of claim 98, wherein the duration for accumulation of measurement data used for said reconciliation is adjustable by a user.

101. The method of claim 98, wherein the duration for accumulation of measurement data used for said reconciliation is a predefined default value.

102. The method of claim 98, wherein said status is a closed transaction and the book value is updated with information corresponding to said closed transaction.

103. A computer program product for implementing a method of providing virtual real-time status of sales transactions in order to perform a liquid product fuel reconciliation regardless of ongoing sells, the computer program product comprising one or more computer readable media having stored thereon computer executable instructions that, when executed by a processor, can cause the distributed computing system to perform the following:

receive a request to perform a liquid product book to physical reconciliation for one or more storage tanks;

identify a duration for accumulation of measurement data used for said reconciliation;

during said identified duration, monitor a status of one or more dispensers for dispensing liquid product from said one or more storage tanks; and
based on said status of the one or more dispensers, update at least one of (i) a physical inventory and (ii) a book value to appropriately determine the book to physical reconciliation.

104. The computer program product of claim 98, wherein said status is an interim status for updating the physical inventory, and wherein said interim status is chosen from one of interim open, interim closed, or interim stacked.

105. The computer program product of claim 98, wherein the duration for accumulation of measurement data used for said reconciliation is adjustable by a user.

106. The computer program product of claim 98, wherein the duration for accumulation of measurement data used for said reconciliation is a predefined default value.

107. The computer program product of claim 98, wherein said status is a closed transaction and the book value is updated with information corresponding to said closed transaction.

108. The computer program product of claim 107, further comprising computer executable instructions that can cause the messaging system to perform the following:

- determining that one or more closed transactions that were awaiting to be sent to the book value prior to said request to perform said reconciliation was sent during said duration of the accumulation of measurement data; and
- deleting the determined one or more closed transactions in order to prevent the duplicate recording on the book value.

109. A system for providing virtual real-time status of sales transactions in order to perform a liquid product fuel reconciliation regardless of ongoing sells, the method comprising:

- an input interface that receives a request to perform a liquid product book to physical reconciliation for one or more of storage tanks;
- a program module that identifies a duration for accumulation of measurement data used for said reconciliation;
- a plurality of measurement devices used to collect the measurement data used for said reconciliation;
one or more computing devices configured to monitor a status of one
or more dispensers for dispensing liquid product from said one or more
storage tanks during said identified duration; and

a central computing device for updating either a physical inventory or
a book value based on said status of said one or more dispensers, the updating
used to appropriately determine the book to physical reconciliation.

110. The system of claim 109, wherein said status is an interim status for
updating the physical inventory, and wherein said interim status is chosen from one of
an interim open, interim closed, or interim stacked transaction.

111. The system of claim 109, wherein the duration for accumulation of
measurement data used for said reconciliation is adjustable by a user.

112. The system of claim 109, wherein the duration for accumulation of
measurement data used for said reconciliation is a predefined default value.

113. The system of claim 109, wherein said status is a closed transaction
and the book value is updated with information corresponding to said closed
transaction.

114. The system of claim 113, wherein the central computing device further
performs the following:

determining that one or more closed transactions that were awaiting to
be sent to the book value prior to said request to perform said reconciliation
was sent during said duration of the accumulation of measurement data; and
deleting the determined one or more closed transactions in order to
prevent duplicate recording on the book value.

115. A method of real-time communication of temperature and volume
readings directly from a dispenser, the method comprising:

collecting flow data indicative of a volume of a liquid product
dispensed from the dispenser at a plurality of times during a defined time
interval;

collecting temperature data indicative of a temperature of the liquid
product dispensed from the dispenser at the plurality of times during the
defined interval; and

transmitting said flow data and said temperature data to at least one of
a retail system and a centralized inventory management system.
116. The method of claim 115, wherein said flow data and said temperature data are transmitted via the Internet, frame relay or a wireless connection.

117. The method as recited in claim 115, wherein collecting flow data further comprises accumulating at a control module within the dispenser a plurality of pulses from a dispenser pulser, each pulse of said plurality of pulses representing the volume of liquid dispensed from the dispenser.

118. The method as recited in claim 115, further comprising generating at said control module a time-stamp for one or more of said plurality of pulses.

119. The method as recited in claim 118, further comprising associating said time-stamp with one or more of said temperature data.

120. The method as recited in claim 115, further comprising collecting dispenser status data indicative of a status of one or more sales transactions at the dispenser.

121. The method as recited in claim 120, further comprising associating said time-stamp with one or more of said dispenser status data.

122. The method as recited in claim 115, further comprising calculating an offset time for the dispenser, said offset time being the difference between a first time associated with a start of a reconciliation process and a second time associated with an end of the reconciliation process.

123. The method as recited in claim 115, wherein transmitting said flow data and said temperature data comprises periodically transmitting said flow data and said temperature data.

124. The method as recited in claim 115, wherein transmitting said flow data and said temperature data comprises transmitting said flow data and said temperature data upon the dispenser receiving a request from at least one of the retail system and the centralized inventory management system.

125. A method of real-time communication of temperature and volume readings directly from a dispenser to at least one of a retail system and a centralized inventory management system, the method comprising:

   collecting a plurality of flow data at a plurality of times at the dispenser, each of the plurality of flow data corresponding to a volume of liquid product dispensed from the dispenser during a time interval;
while said liquid product is dispensed from the dispenser, collecting a plurality of temperature data at a plurality of times within said time interval, each said temperature data being representative of a temperature of said liquid product at one of said plurality of times; and

transmitting said plurality of flow data and said plurality of temperature data to at least one of a retail system and a centralized inventory management system.

126. The method of claim 125, wherein said plurality of flow data is transmitted via the Internet, frame relay or a wireless connection.

127. The method as recited in claim 125, wherein collecting a plurality of flow data further comprises:

accumulating a plurality of pulses from a pulser disposed within the dispenser, each pulse of said plurality of pulses representing the volume of liquid dispensed from the dispenser; and

generating a time-stamp for one or more of said plurality of pulses.

128. The method as recited in claim 125, wherein collecting a plurality of flow data further comprises:

accumulating a plurality of pulses from a pulser disposed within the dispenser, each pulse of said plurality of pulses representing said volume of liquid dispensed from the dispenser; and

generating a plurality of time-stamps for the defined time interval; and

associating each time-stamp of said plurality of time-stamps with said volume of liquid dispensed from the dispenser.

129. The method as recited in claim 125, further comprising collecting dispenser status data indicative of sales transaction status of the dispenser.

130. The method as recited in claim 129, further comprising associating a plurality of time-stamps with said dispenser status data.

131. A computer program product for implementing a method of real-time communication of temperature and volume readings directly from a dispenser to at least one of a retail system and a centralized inventory management system, the computer program product comprising one or more computer readable media having stored thereon computer executable instructions that, when executed by a processor, can cause the distributed computing system to perform the following:
collecting a plurality of flow data at a plurality of times at the
dispenser, each of the plurality of flow data corresponding to a volume of
liquid product dispensed from the dispenser during a time interval;
while said liquid product is dispensed from the dispenser, collecting a
plurality of temperature data at a plurality of times within said time interval,
each said temperature data being representative of a temperature of said liquid
product at one of said plurality of times; and
transmitting said plurality of flow data and said plurality of
temperature data to at least one of a retail system and a centralized inventory
management system.

132. The computer program product of claim 131, wherein said plurality of
flow data is transmitted via the Internet, frame relay or a wireless connection.

133. The computer program product of claim 131, wherein collecting a
plurality of flow data further comprises:
accumulating a plurality of pulses from a pulser disposed within the
dispenser, each pulse of said plurality of pulses representing the volume of
liquid dispensed from the dispenser; and
generating a time-stamp for one or more of said plurality of pulses.

134. The computer program product of claim 131, wherein collecting a
plurality of flow data further comprises:
accumulating a plurality of pulses from a pulser disposed within the
dispenser, each pulse of said plurality of pulses representing said volume of
liquid dispensed from the dispenser; and
generating a plurality of time-stamps for the defined time interval; and
associating each time-stamp of said plurality of time-stamps with said
volume of liquid dispensed from the dispenser.

135. The computer program product of claim 131, further comprising
collecting dispenser status data indicative of sales transaction status of the dispenser.

136. The computer program product of claim 135, further comprising
associating a plurality of time-stamps with said dispenser status data.

137. A dispenser for delivering a liquid product to a consumer through a
nozzle, the dispenser comprising:
a first totalizer that receives signals from a pulser;
a second totalizer, in parallel with said first totalizer, that receives signals from said pulser; and
a data acquisition unit communicating with at least said second totalizer, wherein said data acquisition unit receives from said second totalizer data indicative of a volume of the liquid product dispensed through the nozzle.

138. A dispenser as recited in claim 137, wherein said data acquisition unit is in signal communication with said second totalizer.

139. A dispenser as recited in claim 137, wherein said data acquisition unit further comprises a control module that controls a receipt of said data from said second totalizer.

140. A dispenser as recited in claim 138, wherein said control module delivers said data to at least one of a retail system and a centralized inventory management system.

141. A dispenser as recited in claim 138, wherein said control module wirelessly transmits said data to at least one of a retail system and a centralized inventory management system.

142. A dispenser as recited in claim 137, wherein said data acquisition unit further comprises a temperature module that collects temperature data indicative of a temperature of the liquid product dispensed from the dispenser.

143. A dispenser as recited in claim 142, further comprising an outlet conduit disposed between said nozzle and a dispenser meter of the dispenser.

144. A dispenser as recited in claim 143, wherein said temperature module is in signal communication with a temperature probe disposed in said outlet conduit.

145. A dispenser for delivering a liquid product, the dispenser comprising:
a pump meter that directs the liquid product from a tank and to a nozzle;
a pulser cooperating with said pump meter, said pulser generating a plurality of pulses indicative of a volume of the liquid product that said pump meter directs to said nozzle;
a first totalizer that receives a plurality of signals from said pulser;
a second totalizer, in parallel with said first totalizer, that receives said plurality of signals from said pulser; and
a data acquisition unit in signal communication with said first totalizer and said second totalizer, wherein said data acquisition unit receives from said second totalizer data indicative of a volume of the liquid product dispensed through said nozzle.

146. A dispenser as recited in claim 145, wherein said data acquisition unit further comprises:

   a control module that controls a receipt of said data from said second totalizer; and

   a temperature module that collects temperature data indicative of a temperature of the liquid product dispensed through said nozzle.

147. A dispenser as recited in claim 146, wherein said control module delivers said data and said temperature data to at least one of a retail system and a centralized inventory management system.

148. A dispenser as recited in claim 146, wherein said control module wirelessly transmits said data and said temperature data to at least one of a retail system and a centralized inventory management system.

149. A method for collecting flow data using a dedicated totalizer within a dispenser, the method comprising:

   receiving a plurality of pulses at a first totalizer within the dispenser;

   upon receiving data representative of said plurality of pulses from said first pulser at a second dedicated totalizer within the dispenser, generating reading data indicative of a volume of liquid product flowing from the dispenser; and

   sending said reading data corresponding to said dedicated totalizer to at least one of a retail system and a centralized inventory management system.

150. The method as recited in claim 149, wherein sending said reading data comprises wirelessly transmitting said reading data to at least one of said retail system and said centralized inventory management system.

151. The method as recited in claim 149, further comprising comparing said reading data against said volume of liquid product flowing from the dispenser defined by said first totalizer.
152. The method as recited in claim 149, further comprising generating a pulse to gallon conversion ratio based upon said reading data and said volume of liquid product flowing from the dispenser defined by said first totalizer.

153. The method as recited in claim 149, further comprising collecting temperature data indicative of a temperature of the liquid product dispensed from the dispenser.

154. The method as recited in claim 153, further comprising collecting said temperature data from a temperature probe disposed in an outlet conduit disposed between a nozzle and a dispenser meter of the dispenser.

155. A method for performing an on-demand book balance to physical balance reconciliation process, the method comprising:

- receiving an indication that a delivery of product is about to occur;
- based on the received indication, automatically initiating a first book balance to physical balance reconciliation of one or more liquid product storage tanks at a retail facility prior to receiving a delivery of liquid product;
- following completion of the first book to physical balance reconciliation, delivering an amount of liquid product as indicated on a delivery document;
- upon receiving an indication that an amount of liquid product has been delivered, automatically performing a second book to physical reconciliation process to identify one or more discrepancies between said indicated amount of liquid product and a physical amount of liquid product actually delivered to said one or more liquid product storage tanks.

156. The method as recited in claim 155, wherein said first book balance to physical balance reconciliation is capable of being conducted while fuel is dispensed from said one or more liquid product storage tanks.

157. The method as recited in claim 155, wherein a centralized management system determines whether the amount of liquid product has actually been delivered to said retail facility.

158. The method of claim 156, wherein said amount is indicated on a delivery document provided by a carrier of the liquid product.

159. The method of claim 158, wherein both a gross volume and a temperature measurement is taken for all measurements in the reconciliation process,
said volume and temperature measurements being used to convert all measured volumes into a net volume at 60°F Fahrenheit.

160. The method of claim 159, further comprising appending a time-stamp to all physical measurements of the liquid product and converting all of said measurements to a common time.

161. The method as recited in claim 156, further comprising reporting a discrepancy between amounts reportedly delivered and amounts that were actually delivered to at least one of a carrier, the retail facility, and a centralized management system.

162. In a system having a centralized management system, a method for performing an on-demand reconciliation process, the method comprising:

using the centralized management system, initiating a book balance to a physical balance reconciliation of one or more liquid product storage tanks at a retail facility, said reconciliation is capable of being conducted while a liquid product is dispensed from said one or more liquid product storage tanks;

receiving a delivery of an amount of said liquid product; and

following delivery of the liquid product, performing a second book to physical reconciliation process to identify one or more discrepancies between (A) the amount of said liquid product reportedly delivered to said one or more storage tanks; and (B) the physical liquid product actually contained within said one or more liquid product storage tank.

163. The method of claim 162, wherein said amount is indicated on a delivery document provided by a carrier of the liquid product.

164. The method of claim 163, wherein both a gross volume and a temperature measurement is taken for all measurements in the reconciliation process, said volume and temperature measurements being used to convert all measured volumes into a net volume at 60°F Fahrenheit.

165. The method of claim 164, further comprising appending a time-stamp to all physical measurements of the liquid product and converting all of said measurements to a common time.

166. The method as recited in claim 162, further comprising reporting a discrepancy between amounts reportedly delivered and amounts that were actually
delivered to at least one of a carrier, the retail facility, and the centralized management system.

167. The method as recited in claim 162, further comprising: notifying a carrier in the event that a reported amount of liquid product was not actually delivered to the retail facility.

168. In a system having a centralized management system, a method for performing an on-demand reconciliation process, the method comprising:

initiating a book balance to a physical balance reconciliation of one or more liquid product storage tanks at a retail facility, said reconciliation capable of being conducted while fuel is dispensed from said one or more liquid product storage tanks; and

following said reconciliation, performing at regular intervals additional book to physical reconciliation processes to identify one or more discrepancies between (A) an amount of liquid product reportedly contained within said one or more liquid product storage tanks; and (B) physical liquid product actually contained within said one or more liquid product storage tanks.

169. The method of claim 168, wherein both a gross volume and a temperature measurement is taken for all measurements in the reconciliation process, said volume and temperature measurements being used to convert all measured volumes into a net volume at 60° Fahrenheit.

170. The method of claim 169, further comprising appending a time-stamp to all physical measurements of the liquid product and converting all of said measurements to a common time.

171. A method as recited in claim 168, wherein the additional book to physical reconciliation process are performed at five minute intervals.

172. A computer program product for implementing a method for performing an on-demand reconciliation process, the computer program product comprising one or more computer readable media having stored thereon computer executable instructions that, when executed by a processor, can cause the distributed computing system to perform the following:

initiating a book balance to a physical balance reconciliation of one or more liquid product storage tanks at a retail facility, said reconciliation
capable of being conducted while fuel is dispensed from said one or more liquid product storage tanks; and

following said reconciliation, performing at regular intervals additional book to physical reconciliation processes to identify one or more discrepancies between (A) an amount of liquid product reportedly contained within said one or more liquid product storage tanks; and (B) physical liquid product actually contained within said one or more liquid product storage tanks.

173. The computer program product of claim 172, wherein both a gross volume and a temperature measurement is taken for all measurements in the reconciliation process, said volume and temperature measurements being used to convert all measured volumes into a net volume at 60° Fahrenheit.

174. The computer program product of claim 173, further comprising appending a time-stamp to all physical measurements of the liquid product and converting all of said measurements to a common time.

175. The computer program product of claim 172, wherein the additional book to physical reconciliation process are performed at five minute intervals.

176. A system for standardizing a volume of a liquid product delivered from a distributor to a consumer, the system comprising:

- a plurality of volume measurement devices, wherein at least one volume measurement device is located at each of (i) a fuel source located with a distributor, (ii) a storage tank at a retail facility, and (ii) a dispenser that delivers the liquid product to the consumer, and wherein each said volume measurement device measures a gross volume of the liquid product at, respectively, said distributor fuel source, said retail facility storage tank, and said dispenser and generates volume data indicative of said gross volume;

- a plurality of temperature measurement devices, wherein at least one temperature measurement device is located at each of (i) said distributor fuel source, (ii) said retail facility storage tank and (iii) said dispenser, wherein each said temperature measurement device measures a temperature of the liquid product at, respectively, said distributor fuel source, said retail facility storage tank, and said dispenser and generates temperature data indicative of said temperature; and
a plurality of time-stamp systems, wherein at least one time-stamp system is located at each of (i) said retail facility storage tank, and (ii) said dispenser, and wherein each said time-stamp system receives said volume data and said temperature data and allocates a time-stamp to each of said volume data and said temperature data generated at, respectively, said retail facility storage tank and said dispenser.

177. The system of claim 176, wherein said gross volumes are converted into net volumes by a centralized management system that receives said temperature data and said volume data.

178. The system of claim 177, wherein said centralized management system uses said volume data and said temperature data to perform a book to physical volume reconciliation, and wherein said centralized management system produces a variance report that shows a difference between said book volume and the physical volume.

179. The system of claim 178, wherein said reconciliation process can be performed at any time during the day, regardless of whether the liquid product is being delivered from a delivery vehicle into said retail facility storage tank or pumped out of said retail facility storage tank through said dispenser.

180. The system of claim 178, wherein the difference is reported to a driver of said delivery vehicle before said delivery vehicle leaves said retail facility.

181. The system of claim 180, wherein said driver verifies that the complete delivery was accomplished and said delivery vehicle is empty.

182. The system of claim 176, wherein said dispenser reports said volume data, said temperature data, and a net volume to a centralized management system.

183. The system of claim 182, wherein said net volume is standardized to a temperature of 60 degrees Fahrenheit.

184. A method of standardizing a volume of a liquid product across a fuel management system, the method comprising:

   measuring a gross volume and a temperature of the liquid product at each of a fuel source located with a distributor, a storage tank at a retail facility and a dispenser at said retail facility, wherein said temperature measurements and said gross volume measurements in said tank and at said dispenser are each given a time-stamp; and
using said measurements of gross volume, temperature, and each of said time-stamps, reconciling gross to net volumes of the liquid product at a single point in time.

185. The method of claim 184, further comprising performing a book to physical inventory reconciliation using said measured volumes.

186. The method of claim 185, wherein said inventory reconciliation is performed both before and after delivery of the liquid product to said retail facility storage tank to ensure a complete delivery.

187. The method of claim 186, further comprising identifying a discrepancy between the book inventory and the physical inventory, and informing a driver of a delivery vehicle that the discrepancy exists.

188. The method of claim 187, wherein said driver verifies that the delivery is complete and said delivery vehicle is empty.

189. The method of claim 185, wherein the inventory reconciliation is performed in real time, even while said dispenser is dispensing liquid product.

190. The method of claim 185, further comprising reporting both a gross volume and a net volume from said dispenser to a centralized management system.

191. The method of claim 184, wherein reconciling gross to net volumes can be performed at any time during the day, regardless of whether the liquid product is being delivered from a delivery vehicle into said retail facility storage tank or pumped out of said retail facility storage tank through said dispenser.

192. The method of claim 184, wherein said net volume is standardized to a temperature of 60° Fahrenheit.

193. A computer program product for implementing a method of standardizing a volume of a liquid product across a fuel management system, the computer program product comprising one or more computer readable media having stored thereon computer executable instructions that, when executed by a processor, can cause the distributed computing system to perform the following:

measuring a rack gross volume and a rack temperature of the liquid product at a rack located with a distributor,

measuring a tank gross volume and a tank temperature of the liquid product at a storage tank at a retail facility
measuring a dispenser gross volume and a dispenser temperature of the
liquid product at a dispenser at said retail facility,

assigning a time-stamp to each measured gross volume and each
measured temperature; and

using each measured gross volume, measured temperature, said time-
stamp, reconciling gross to net volumes of the liquid product at a single point
in time.

194. The computer program product of claim 193, further comprising
performing a book to physical inventory reconciliation using said measured volumes.

195. The computer program product of claim 193, wherein said inventory
reconciliation is performed both before and after delivery of the liquid product to said
storage tank to ensure a complete delivery.

196. The computer program product of claim 193, wherein the inventory
reconciliation is performed while said dispenser is dispensing the liquid product.

197. The computer program product of claim 193, wherein the inventory
reconciliation is performed while one or more storage tanks receive the liquid
product.

198. The computer program product of claim 193, further comprising
reporting both a gross volume and a net volume from said dispenser to a centralized
management system.

199. A system for standardizing a volume of a liquid product, the system
comprising:

a volume measurement device for measuring a gross volume of liquid
product and for generating volume data indicative of said gross volume,

a temperature measurement device for measuring a temperature of
liquid product and for generating temperature data indicative of said
temperature, and

a time-stamp system configured to receive said volume data and said
temperature data generated by the volume measurement device and the
temperature measurement device and to allocate a time-stamp to the volume
data and the temperature data.

200. A system as recited in claim 199, wherein
the volume measurement device measures a gross volume of liquid
product at a retail facility storage tank and generates storage tank volume data
indicative of said gross volume,

the temperature measurement device measures a temperature of liquid
product at the retail facility storage tank and generates storage tank
temperature data indicative of said temperature, and

the time-stamp system is configured to receive said storage tank
volume data and said storage tank temperature data and to allocate a time-
stamp to the storage tank volume data and the storage tank temperature data
generated.

201. A system as recited in claim 200, further comprising:

a dispenser volume measurement device that measures a gross volume
of liquid product at a dispenser and generates dispenser volume data indicative
of said gross volume,

a dispenser temperature measurement device that measures a
temperature of liquid product at the dispenser and generates dispenser
temperature data indicative of said temperature, and

a time-stamp system configured to receive said dispenser volume data
and said dispenser temperature data and to allocate a time-stamp to the
dispenser volume data and the dispenser temperature data.

202. A system as recited in claim 201, wherein the liquid is delivered from a
distributor fuel source by a carrier to a retail facility storage tank and is delivered
from the retail facility storage tank through a dispenser to a consumer.

203. A system as recited in claim 202, further comprising:

a volume measurement device that measures a gross volume of liquid
product upon delivery of the liquid product to a carrier and generates volume
data indicative of said gross volume upon delivery of the liquid product to a
carrier, and

a temperature measurement device that measures a temperature of
liquid product upon delivery of the liquid product to a carrier and generates
temperature data indicative of said temperature upon delivery of the liquid
product to a carrier.
204. A system as recited in claim 203, further comprising a time-stamp system configured to receive (i) said volume data that is indicative of gross volume of liquid product upon delivery of the liquid product to a carrier and (ii) said temperature data that is indicative of temperature of liquid product upon delivery of the liquid product to a carrier and to allocate a time-stamp to the volume data and the temperature data that is indicative of gross volume and temperature of liquid product upon delivery of the liquid product to a carrier.

205. A system as recited in claim 203, wherein the volume measurement device that measures a gross volume of liquid product upon delivery of the liquid product to a carrier and the temperature measurement device that measures temperature of liquid product upon delivery of the liquid product to a carrier, respectively, measure the volume and temperature of the liquid product as the liquid product is delivered from the distributor fuel source to the carrier.

206. A system as recited in claim 203, wherein the volume measurement device that measures a gross volume of liquid product upon delivery of the liquid product to a carrier and the temperature measurement device that measures temperature of liquid product upon delivery of the liquid product to a carrier, respectively, measure the volume and temperature of the liquid product located within the carrier.

207. A system as recited in claim 199, wherein

the volume measurement device measures a gross volume of liquid product at a dispenser and generates volume data indicative of said gross volume,

the temperature measurement device measures a temperature of liquid product at the dispenser and generates temperature data indicative of said temperature, and further comprising:

a time-stamp system configured to receive said volume data and said temperature data generated at the dispenser and to allocate a time-stamp to the volume data and the temperature data generated at the dispenser.

208. A system as recited in claim 199, wherein the liquid is delivered from a distributor fuel source by a carrier to a retail facility storage tank and is delivered from the retail facility storage tank through a dispenser to a consumer, and wherein
the volume measurement device measures a gross volume of liquid
data indicative of said gross volume;

the temperature measurement device measures a temperature of liquid
data indicative of said temperature, and

the time-stamp system is configured to receive volume data and
temperature data from said retail facility storage tank or said dispenser and to allocate a time-stamp to the volume data and the temperature data generated therefrom.

209. A system for standardizing a volume of a liquid product, wherein the liquid product is delivered from a fuel source by a carrier to a retail facility storage tank and is delivered from the retail facility storage tank through a dispenser to a consumer, the system comprising:

a volume measurement device that measures a gross volume of liquid
product upon delivery of the liquid product to a carrier and generates volume
data indicative of said gross volume;

a temperature measurement device that measures a temperature of liquid product upon delivery of the liquid product to a carrier and generates temperature data indicative of said temperature;

a volume measurement device that measures a gross volume of liquid product at a retail facility storage tank and generates storage tank volume data indicative of said gross volume;

a temperature measurement device that measures a temperature of liquid product at the retail facility storage tank and generates storage tank temperature data indicative of said temperature;

a time-stamp system configured to receive said storage tank volume data and said storage tank temperature data and to allocate a time-stamp to the storage tank volume data and the storage tank temperature data;
a dispenser volume measurement device that measures a gross volume of liquid product at a dispenser and generates dispenser volume data indicative of said gross volume;

a dispenser temperature measurement device that measures a temperature of liquid product at the dispenser and generates dispenser temperature data indicative of said temperature; and

a time-stamp system configured to receive said dispenser volume data and said dispenser temperature data and to allocate a time-stamp to the dispenser volume data and the dispenser temperature data.

210. A system as recited in claim 209, wherein the time-stamp system at the retail facility storage tank communicates with the volume measurement device and the temperature measurement device at the retail facility storage tank so as to receive volume data and temperature data and allocate a time-stamp to said volume data and temperature data generated at said retail facility storage tank; and wherein

the time-stamp system at the dispenser communicates with the volume measurement device and the temperature measurement device at the dispenser so as to receive volume data and temperature data and allocate a time-stamp to said volume data and temperature data generated at said dispenser.

211. A system as recited in claim 209, wherein the volume measurement device that measures a gross volume of liquid product upon delivery of the liquid product to a carrier and the temperature measurement device that measures temperature of liquid product upon delivery of the liquid product to a carrier, respectively, measure the volume and temperature of the liquid product as the liquid product is delivered from the distributor fuel source to the carrier.

212. A system as recited in claim 209, wherein the volume measurement device that measures a gross volume of liquid product upon delivery of the liquid product to a carrier and the temperature measurement device that measures temperature of liquid product upon delivery of the liquid product to a carrier, respectively, measure the volume and temperature of the liquid product located within the carrier.

213. A system as recited in claim 209, wherein the volume measurement device that measures a gross volume of liquid product and the temperature measurement device that measures temperature of liquid product upon delivery of the
liquid product to a carrier, respectively, measure the volume and temperature of the liquid product when the carrier is located at a fuel source at a distribution facility.

214. A system as recited in claim 209, wherein the volume measurement device that measures a gross volume of liquid product upon delivery of the liquid product to a carrier and the temperature measurement device that measures temperature of liquid product upon delivery of the liquid product to a carrier, respectively, are located at at least one of (i) a fuel source located with a distributor; and (ii) the carrier.

215. A system as recited in claim 209, wherein the volume measurement device that measures a gross volume of liquid product upon delivery of the liquid product to a carrier and the temperature measurement device that measures temperature of liquid product upon delivery of the liquid product to a carrier, respectively, are located at a fuel source located with a distributor.

216. A system for balancing a net inventory of a liquid product, the system comprising:

- a volume measurement device that measures a gross volume of liquid product upon delivery of the liquid product to a carrier and generates volume data indicative of said carrier liquid product gross volume;
- a temperature measurement device that measures a temperature of liquid product upon delivery of the liquid product to a carrier and generates temperature data indicative of said carrier liquid product temperature;
- a density measuring device for measuring a density of liquid product upon delivery of the liquid product to the carrier and for generating density data indicative of said carrier liquid product density;
- a volume measurement device for measuring a gross volume of liquid product at a storage tank and for generating volume data indicative of said storage tank liquid product gross volume;
- a temperature measurement device for measuring a temperature of liquid product at a storage tank and for generating temperature data indicative of said storage tank liquid product temperature; and
- a density measuring device for measuring a density of liquid product at a storage tank and for generating density data indicative of said storage tank liquid product density;
wherein said tank liquid product density and liquid product volume data and said carrier liquid product density and liquid product volume data are used to determine a new volume adjusted tank liquid product density after said liquid product is delivered to said storage tank.

217. The system of claim 216, wherein the volume adjusted tank density is temperature adjusted to a temperature of 60° Fahrenheit.

218. A method for balancing a net inventory of a liquid product, the method comprising:

recording a density and a temperature for a volume of the liquid product when the liquid product is delivered to a delivery vehicle;

recording a density and a temperature of an additional volume of the liquid product in a storage tank;

delivering the liquid product from the delivery vehicle into the storage tank; and

using the recorded density and temperature values to calculate a volume adjusted net inventory balance of the product in the tank.

219. The method of claim 218, wherein the net inventory balance is temperature adjusted to a temperature of 60° Fahrenheit.

220. The method of claim 218, further comprising performing a book to physical inventory reconciliation using the calculated net inventory balance as the physical inventory balance.

221. The method of claim 220, wherein the inventory reconciliation is performed both before and after delivery of the liquid product to the tank to ensure a complete delivery.

222. The method of claim 221, further comprising identifying a discrepancy between the book inventory and the physical inventory, and informing a driver of the delivery vehicle that the discrepancy exists.

223. The method of claim 222, wherein the driver verifies that the delivery is complete and the delivery vehicle is empty.

224. The method of claim 220, wherein the inventory reconciliation is performed in real time, even while a dispenser connected to the tank is dispensing liquid product.
225. A method for balancing net inventory using a dynamic expansion coefficient of product relative to a temperature change and a reported density change of the product, the method comprising:

receiving a Bill of Lading report that includes a measurement of a density and a temperature of the product reported at a rack and delivered to a delivery vehicle;

utilizing the reported density for maintaining correct densities through an inventory cycle of the product; and

utilizing a plurality of expansion coefficients to dynamically convert a gross volume measurement to a net volume measurement for transactions of liquid product in a tank and at a dispenser in order to maintain a net perpetual book balance.

226. The method of claim 225, wherein the net book balance is temperature adjusted to a temperature of 60° Fahrenheit.

227. The method of claim 225, further comprising performing a book to physical inventory reconciliation using the calculated net volume measurement as the physical inventory balance.

228. The method of claim 227, wherein the inventory reconciliation is performed both before and after delivery of the liquid product to the tank to ensure a complete delivery.

229. The method of claim 228, further comprising identifying a discrepancy between the book inventory and the physical inventory, and informing a driver of the delivery vehicle that the discrepancy exists.

230. The method of claim 229, wherein the driver verifies that the delivery is complete and the delivery vehicle is empty.

231. The method of claim 228, wherein the inventory reconciliation is performed in real time, even while a dispenser connected to the tank is dispensing liquid product.

232. A method for measuring physical volume of a liquid product in a manifold set of tanks, the method comprising:

identifying three or more volume book balances of the volume of the liquid product in the manifold set of tanks at three or more reconciliation times;

monitoring an amount of the liquid product dispensed from the manifold set of tanks;
measuring a physical volume of the liquid product in each tank of the manifold set of tanks at the three or more reconciliation times;

generating variance data indicative of a difference between the physical volume and the three or more volume book balances; and

generating data for use in determining the volume of the liquid product in the manifold set of tanks based upon a measured height of the liquid product in the manifold set of tanks.

233. The method as recited in claim 232, wherein identifying three or more volume book balances comprises identifying an initial volume book balance and two or more addition volume book balances.

234. The method as recited in claim 232, wherein monitoring the amount of liquid product comprises tracking the amount of product dispensed from one or more dispensers at a retail facility.

235. The method as recited in claim 232, wherein measuring the physical volume of the liquid product at the manifold set of tanks comprises measuring a tank physical volume of the liquid product in each tank of the manifold set of tanks and aggregating the tank physical volumes to generate the physical volume of the liquid product at the manifold set of tanks.

236. The method as recited in claim 232, wherein the manifold set of tanks comprises one or more tanks in fluid communication one with another.

237. The method as recited in claim 232, wherein generating variance data comprises:

identifying a first difference between a first volume book balance at a first reconciliation time and a first physical volume at the first reconciliation time;

identifying a second difference between a second volume book balance at a second reconciliation time and a second physical volume at the second reconciliation time;

identifying a third difference between a third volume book balance at a third reconciliation time and a third physical volume at the third reconciliation time; and

generating data indicative of the relationship between the first difference, the second difference, the third differences.
238. The method as recited in claim 232, wherein generating variance data comprises:

identifying a first volume book balance at the first reconciliation time, the first reconciliation time being associated with a delivery of the liquid product to the manifold set of tanks;

identifying two or more volume book balances at two or more reconciliation times, the two or more reconciliation times occurring at times when the liquid product is only being dispensed from the manifold set of tanks; and

generating differences between the first volume book balance, the two or more volume book balances, and the physical volume at the first reconciliation time and the two or more reconciliation times.

239. The method as recited in claim 238, further comprising

identifying a plurality of volume book balances at a plurality of reconciliation times subsequent to the two or more reconciliation times; and

generating differences between the plurality of volume book balances and the physical volume at the plurality of reconciliation times.

240. The method as recited in claim 239, further comprising identifying each reconciliation time of the plurality of reconciliation times when the liquid product is delivered to the manifold set of tanks.

241. The method as recited in claim 240, further comprising assigning the variance data with a zero value at each reconciliation time of the plurality of reconciliation times when the liquid product is delivered to the manifold set of tanks.

242. The method as recited in claim 232, further comprising:

calculating variance data indicative of a difference between the physical volume and the three or more additional volume book balances; and

generating an expected variance to the physical volume using the variance data.

243. The method as recited in claim 232, further comprising generating a relationship between three or more data points representative of the variance data, the data representative of the relationship being used to calibrate the manifold set of tanks.
244. The method as recited in claim 232, wherein measuring the physical volume can occur at specific times based upon an amount of the liquid product dispensed from one or more dispensers at a retail facility.

245. A method for determining a volume of liquid product in a manifold set of tanks at a retail facility, the method comprising:

identifying a plurality of book volumes of liquid product in the manifold set of tanks between a first delivery of liquid product and a second delivery of liquid product;

identifying a plurality of measured physical volumes of liquid product in the manifold set of tanks between the first delivery of liquid product and the second delivery of liquid product, each measured physical volume of said plurality of measured physical volumes being associated with one book volume of said plurality of book volumes;

determining a variance between each measured physical volume of said plurality of measured volumes and each book volume of said plurality of book volumes;

generating, using the variance, an expected variance to each of the plurality of measured physical volumes, the combination of the expected variance and the measured physical volume being the volume of the liquid product in the manifold set of tanks.

246. The method as recited in claim 245, further comprising monitoring the amount of liquid product dispensed from one or more dispensers at the retail facility.

247. The method as recited in claim 245, wherein identifying the plurality of measured physical volumes comprises measuring and aggregating the tank physical volumes of the liquid product in one or more tanks of the manifold set of tanks.

248. The method as recited in claim 245, wherein determining variance data comprises:

identifying a first difference between a first volume book balance at a first reconciliation time and a first physical volume at the first reconciliation time;

identifying a second difference between a second volume book balance at a second reconciliation time and a second physical volume at the second reconciliation time;
identifying a third difference between a third volume book balance at a
third reconciliation time and a third physical volume at the third reconciliation
time; and

generating data indicative of the relationship between the first
difference, the second difference, the third differences.

249. A computer program product for implementing a method for
determining a volume of liquid product in a manifold set of tanks at a retail facility,
the computer program product comprising one or more computer readable media
having stored thereon computer executable instructions that, when executed by a
processor, can cause the distributed computing system to perform the:

identifying a plurality of book volumes of liquid product in the
manifold set of tanks between a first delivery of liquid product and a second
delivery of liquid product;

identifying a plurality of measured physical volumes of liquid product
in the manifold set of tanks between the first delivery of liquid product and the
second delivery of liquid product, each measured physical volume of said
plurality of measured physical volumes being associated with one book
volume of said plurality of book volumes;

determining a variance between each measured physical volume of
said plurality of measured volumes and each book volume of said plurality of
book volumes;

generating, using the variance, an expected variance to each of the
plurality of measured physical volumes, the combination of the expected
variance and the measured physical volume being the volume of the liquid
product in the manifold set of tanks.

250. The computer program product of claim 249, further comprising
monitoring the amount of liquid product dispensed from one or more dispensers at the
retail facility.

251. The computer program product of claim 249, wherein identifying the
plurality of measured physical volumes comprises measuring a tank physical volume
of the liquid product in each tank of the manifold set of tanks and aggregating the tank
physical volumes to generate the physical volume of the liquid product at the
manifold set of tanks.
252. The computer program product of claim 249, wherein the manifold set of tanks comprises one or more tanks in fluid communication one with another.

253. The computer program product of claim 249, wherein determining variance data comprises:

identifying a first difference between a first volume book balance at a first reconciliation time and a first physical volume at the first reconciliation time;

identifying a second difference between a second volume book balance at a second reconciliation time and a second physical volume at the second reconciliation time;

identifying a third difference between a third volume book balance at a third reconciliation time and a third physical volume at the third reconciliation time; and

generating data indicative of the relationship between the first difference, the second difference, the third differences.

254. The computer program product of claim 249, wherein determining variance data comprises:

identifying a first volume book balance at the first reconciliation time, the first reconciliation time being associated with a delivery of the liquid product to the manifold set of tanks;

identifying two or more volume book balances at two or more reconciliation times, the two or more reconciliation times occurring at times when the liquid product is only being dispensed from the manifold set of tanks; and

generating differences between the first volume book balance, the two or more volume book balances, and the physical volume at the first reconciliation time and the two or more reconciliation times.

255. The computer program product of claim 254, further comprising

identifying a plurality of volume book balances at a plurality of reconciliation times subsequent to the two or more reconciliation times; and

generating differences between the plurality of volume book balances and the physical volume at the plurality of reconciliation times.
256. The computer program product of claim 255, further comprising identifying each reconciliation time of the plurality of reconciliation times when the liquid product is delivered to the manifold set of tanks.

257. The computer program product of claim 256, further comprising assigning the variance data with a zero value at each reconciliation time of the plurality of reconciliation times when the liquid product is delivered to the manifold set of tanks.
200 Start

Sending An Electronic Request For A Delivery Instruction from The CIM Using A Portable Computing Device

202

Receiving A Delivery Of The Product In A Delivery Vehicle At A Loading-Terminal

204

Transporting The Product To The Retail Facility

206

Requesting Authorization To Deliver The Product To The Storage Tank

208

Receiving Authorization To Deliver The Product To The Storage Tank

210

Delivering The Product Into The Storage Tank

212

End

Fig. 2
Start

Receiving A Plurality Of Measurement Data At A Plurality Of Times

Comparing Each Volume Of Liquid Against At Least One Predetermined Volume

Generating A Second Set Of Measurement Data By Eliminating Any Data That Exceeds The Predetermined Volume

Determining A Sample Mean And A Standard Deviation For The Second Set Of Measurement Data

Filtering The Second Set Of Measurement Data To Generate A Third Set Of Measurement Data

Determining A Sample Mean And A Standard Deviation For The Third Set Of Measurement Data

Using The Sample Mean From The Third Set Of Data As The Volume Of Product In The Tank

End

Fig. 5
300

Start

302

Is The First Of The Paired Readings The First Reading For Reconciliation?

304

Yes

Is The First Of The Paired Readings Later Than The "Time Of Reconciliation"?

No

306

Yes

Is The First Reading Of Volume Positive?

No

308

Yes

Does The Next Reading Show A Positive Change?

No

310

Calculate The Flow Rate Of Fuel Based Upon The First And Second Readings

312

Calculate New Pump Reading Back To Closest Time-Stamped Manifold Reading

314

Assume Pump Or Dispenser Readings Provided In The Reconciliation Are A Constant

No

Value Greater Than Zero?

Yes

Use Value

316

End

Fig. 6
Start

Is the last of all of the paired readings for a pump the last reading provided in the reconciliation?

If yes, proceed to:

Is the last of the paired readings for the pump earlier than the last tank manifold volume reading?

If yes, proceed to:

Is the volume of the last reading greater than the volume of the previous reading?

If yes, proceed to:

Is there a tank manifold reading after the last known reading for the pump?

If yes, calculate the flow rate and proceed to:

Calculate the new pump reading forward to the closest time-stamped manifold reading.

If no, calculate the flow rate and proceed to:

End

Use pump reading provided in the reconciliation.

Fig. 7