

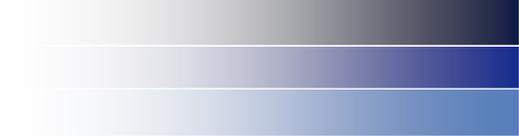


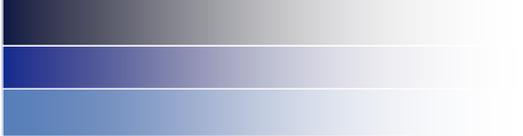
White Paper

April 28, 2009

Tactical Fueling Solutions for Fuel Asset Visibility and Control

Utilization of Commercial-off-the-Shelf (COTS) technology for improved fuels management and accountability at tactical fuel points





Contents

Contents.....	3
Executive Summary	4
Few Resources are More Vital to a Mechanized Military than Fuel	4
Why so Much Fuel?.....	4
The Scope of this Paper	4
Fuel Storage Locations	6
Manually Measuring Collapsible Storage Tanks.....	8
Recording the Receipt and Distribution of Fuels.....	10
Metering the Flow	10
Other Considerations	11
Joint Operations.....	11
Theft and Fraud.....	11
A Tactical Fuel Solution Using Real-world Technology	12
Accurate Measurement	12
Installation, Support and Maintenance	13
Hazardous Areas	14
Measurement Requests.....	14
Data Collection.....	14
Power and Communications.....	14
Automatic “Tank Strapping”	16
Mobile Computing	16
Recording Transaction Data.....	17
Uploading Data	17
Real-time Fuels Inventory Management and Accounting	17
Inventory at-a-Glance	17
Tank Status	18
Alarm Management.....	18
Reporting	19
Trending.....	19
Daily Reconciliation.....	20
Product Allocations.....	20
Security and Anti-Fraud	20
Enterprise Integration.....	21
Conclusion.....	22
Credits.....	23
About Varec	23
References	23
Copyright	24

Executive Summary

Recent figures provided by the Defense Logistics Agency (DLA) show “the U.S. military is using between 10 million and 11 million barrels of fuel each month to sustain operations in Afghanistan, Iraq and elsewhere”¹. At an estimated price of \$36 per barrel, the U.S. DoD is spending approximately one million dollars per day on fuel.

Few Resources are More Vital to a Mechanized Military than Fuel

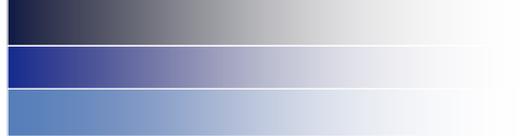
Supplying our forces with fuel is critical to the success of our operations; it provides advantages in communications, firepower and, of course, mobility. In Iraq alone, it is estimated that U.S. forces consume approximately 1.2 to 1.7 million barrels of fuel each month² to mechanize 27,000 vehicles. Overseeing this fuel supply requires the work of some 20,000 American soldiers and private contractors. Every day approximately 100 to 200 fuel trucks leave Kuwait for various locales in Iraq.

Why so Much Fuel?

In decades past, U.S. Army logisticians assumed that 50 percent of the tonnage moved onto a battlefield was ammunition, 30 percent was fuel, and the rest was food, water and supplies. Today, the fuel component may be as high as 70 percent³. Over the years, weapons technology and mechanized maneuver warfare tactics have driven the U.S. military to increase the amount of fighting vehicles used, while insurgency threats have required increased armor. The consequence is seen in fuel efficiency; for example, the Bradley fighting vehicle gets less than two miles per gallon and the M1 Abrams tank less than one. It is a vicious cycle: attacks on convoys produce a need for more armor, which produces a need for more fuel, which produces larger convoys, which produce more targets for attack.

The Scope of this Paper

There are many logistical challenges posed when managing these amounts of fuel. This paper discusses the problems associated with accounting for fuel stocks (fuel measurement) and recording transactions (fuel delivery) in a tactical, forward operating environment, such as a temporary fuel storage location in Iraq. It will also present how existing technology can be applied to provide a real-time solution for tactical



fuels inventory management with integration into an enterprise system, such as the U.S. Defense Energy Support Center's Business Systems Modernization-Energy (BSM-E).

Fuel Storage Locations

In Iraq, the U.S. military operates from temporary fuel farms (termed Fuel System Supply Points by U.S. Army) that store and distribute fuel from Collapsible Storage Tanks (also called fuel bladders or flexible tanks). Collapsible Storage Tanks (CSTs) are constructed from heavy duty, reinforced fabric that allows them to be rolled into compact, transportable units. Once deployed, they are simply unrolled into a dike system and filled on site. They are available in various sizes and include all pipe and valve connections. This allows configurations of CSTs based on local requirements. For example, a fuel farm (or base) may have four 50,000 gallon CSTs (50k bladders) providing a total storage of 200,000 gallons.



Once deployed, collapsible storage tanks are simply unrolled into a dike system and filled on site.

Table 1 - Common Sizes and Capacities of Collapsible Storage Tanks

Gallon Capacity	Approximate Flat Dimensions	Approximate Fill Height
1,000 gal	9'7" x 9'7"	26"
3,000 gal	13'9" x 13'9"	38"
5,000 gal	16'8" x 16'	44"
10,000 gal	21'3" x 20'	55"
20,000 gal	27'3" x 27'	60"
50,000 gal	65' x 24'	60"

Each CST is generally connected in parallel with inlet and outlet hoses. Portable fuel pumps move the fuel in/out of the CSTs and flow meters provide the operator with a means to record overall fuel moved. Fuel generally arrives by tank truck, pipeline or marine terminal facility. It is pumped into the CSTs and stored until it is required locally. It may be distributed to vehicles on site or placed into delivery vehicles, such as tank trucks, and then transported to a forward operating environment to refuel fighting vehicles.

Presently, fueling personnel manually perform inventory management processes. This is generally performed once a day by recording meter movement values or measuring CSTs using crude best practices. Once this timely process is complete, fueling personnel manually calculate an estimate of current fuel physical inventory. This can then be balanced against all daily fuel movements to monitor daily gains/losses and get a picture of overall fuel usage.

Manually Measuring Collapsible Storage Tanks

Presently, the height of a CST is measured and a volume is derived based on manufacturers' nominal CST strapping tables for a given CST size or a combination of metered volumes and corresponding height measurements performed by operators to create a strapping table on site. Three methods are commonly used to determine CST volume; the first, a visual estimate by looking at the CST, e.g. "say about 50% full", secondly the total volume is calculated based on metered inputs and outputs, thirdly the 'stick-method' is used. When performing the 'stick-method', a line (cord or string) is tied to the base of the vent pipe and pulled taught, horizontally across the CST. A level is used to ensure the cable is horizontal. The height of the tape from the base of the dike is recorded against a measuring stick and compared to the strapping table. This process may be repeated at intervals around the CST and an average measurement used. This 'stick-method' procedure is covered in DESC Policy I-11 and I-29.

On average, it takes two personnel 3-5 minutes to measure a single fuel CST; for an average base that operates 40 CSTs, a complete inventory measurement collection may take 2-3 hours.

At around a CST height of 9 to 11 inches, only best estimates can be recorded using manual measurement methods.

In standard, rigid petroleum Above Ground Storage Tanks (ASTs) found at fixed installations, such as terminals and refineries, have volume characteristics that are defined and known. The height (level) of the product

directly correlates to a volume that can be adjusted to API standards for



60°F. The nature of the flexible fabric and the CST 'squat' produced by the weight of the fuel inside a CST means the volume characteristic of each CST is unique. The visual estimates, metered values or 'stick-method' do not account for CST squat characteristics. To compound the issue, the fabric expands and contracts under the weight of the stored fuel and volumes change due to ambient temperature conditions, so the height to volume measurement of a fuel CST when it has been in service for 3 months will be different from when the CST was first installed. Also, at low volumes wrinkles restrict the level line, while the vent pipe may have begun to indent the normally taut and flat CST surface. This occurs around a CST height of 9 to 11 inches. Only best estimates can be recorded under these conditions.

This manual process may also introduce other variable factors, such as the levelness of the ground (dike floor), placement and leveling of the measuring stick from one reading to the next (even with establishing a reference point) or level reading and calculation errors.

CST squat is caused by the weight of the fuel pushing outwards on the sides of the tank. The weight stretches the CST fabric. It is not uncommon to experience a several inch difference in height from a newly filled CST to the same CST that is full and left to settle for a 24 hour period.



Recording the Receipt and Distribution of Fuels

A fuels operation completes a daily record of petroleum issues (DA form 3643) for local accountability. This form is hand written with column entries for fuel receipt and issue of fuel transactions. All entries for the day are manually calculated and transferred to monthly bulk petroleum summary records (DA form 3644 and 4702). All completed forms are then submitted to command or fleet headquarters for processing. In the dynamic environments of a forward fuels operation, paper records are easily lost, fuel volumes may be incorrectly calculated, hand written entries may be illegible or volumes may be “estimated”. Processing the forms at command level may trail actual transaction dates by days or weeks, which makes correcting any errors time consuming, and during active operations this may not be the highest priority.

The Pentagon adopted JP8 as “the single product on the battlefield”. However, sustainment efforts to support ongoing operations in Iraq and Afghanistan have included upwards of 14 fuel grades being supplied.



Metering the Flow

Typically, fuel is received into tactical storage areas through a single meter. The meter serves to control and validate a shipment to ensure a valid recorded receipt. Transfer of product from a single source, such as a pipeline, is a simple straight forward procedure. Likewise, for a single truck, a visual inspection of the vehicle’s tankage before and after product receipt is generally conducted to ensure total product offload and verify meter readings. Delivery from multiple sources, such as tank trucks, becomes an increasingly complicated activity, as multiple trucks can be simultaneously offloaded at one time. Correlating individual quantities cannot be reconciled and validated using a single meter. Therefore, actual manually recorded measurements from multiple trucks offloading at a single time become an estimated, non-validated quantity.

Other Considerations

Joint Operations

U.S. forces are increasingly performing joint operations and also working with other nations' forces. When there is such a coalition, supplying fuel to other parties requires timely measurements, sound accounting practices and the ability to invoice accurately and quickly. Even if U.S. forces have a command of internal accounting processes and procedures across services, invoicing and obtaining reimbursements when dealing with a manual paper process can be difficult. The problem can then be compounded when dealing with foreign entities. Thus, payments and reimbursements are delayed or even refused.

Theft and Fraud

The opportunity for fraud is ever present in a dynamic environment that lacks a timely, verifiable and auditable process. The ability to deter, identify and take correct action in a timely fashion is crucial in deterring product theft. The existing manual, paper-based process does not allow accurate daily reconciliation and consistent tracking of fuel disbursement and usage.

The U.S. military has encountered fraud and theft of fuel stocks in Iraq and Afghanistan.



A Tactical Fuel Solution Using Real-world Technology

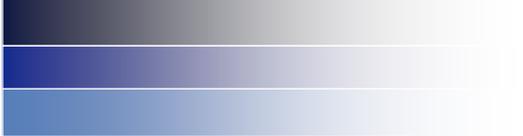
Varec's combination of systems, communications, instrumentation and application expertise have allowed a clear understanding of fuels accounting in the tactical theatre. Through extensive research, development, test and evaluation we are able to present a solution for complete asset visibility and control that enables effective decision support at all levels of command. The local level solution consists of a mobile laptop and handheld computers operating TacFuels® software, data collection units, flow meters and fuel gauges. A combination of these ruggedized devices is deployed based on the configuration of the tactical fuel point. Information from each local site can then be shared across networks using secure communications to base- or enterprise-level users.

Accurate Measurement

Many instrument technologies, such as radar, sonar, ultra-sonic and laser were evaluated, but Varec found that a combination of pressure and temperature technologies are currently the best suited technology for the application. The fuel gauge provides a reliable and precise digital measurement, thus removing the inconsistencies associated with manual measurement procedures. The pressure of the fuel in the CST can be directly related to the amount of fuel. Ambient temperature is an influencing factor on measured volume, especially in extreme locations, such as the deserts of Iraq or Afghanistan where there is a large day time to night time fluctuation. The Varec system utilizes temperature data to correct volumes to recommended American Petroleum Institute (API) standards for petroleum measurement. This standardization of volume measurements throughout the entire day and from location to location provides a true measurement of physical inventory.

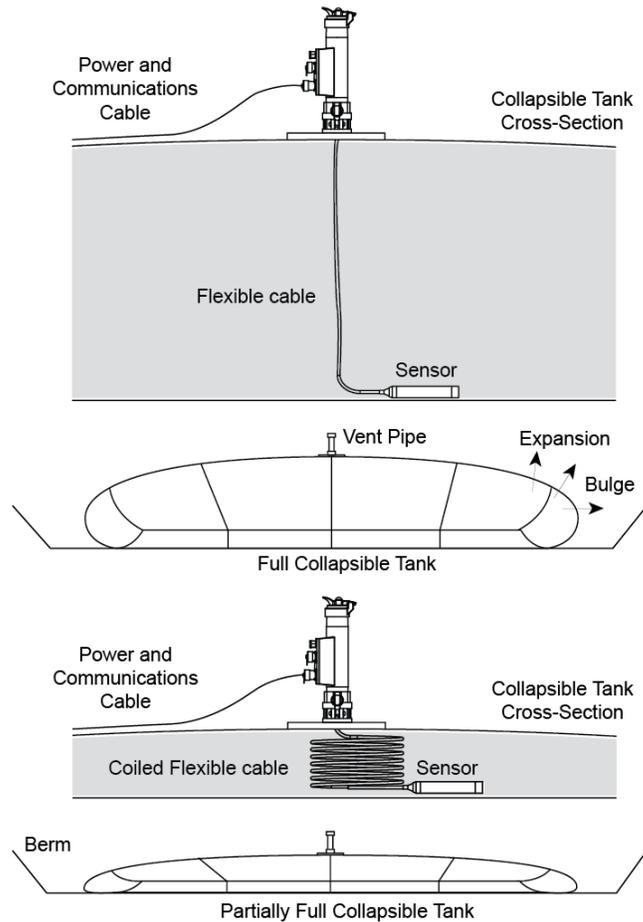
The Fuel Gauge can be easily installed or removed by military personnel in a few minutes with no specialized tools.





Installation, Support and Maintenance

The fuel gauge's pressure and temperature sensor is incorporated into a specially designed vent pipe with minimal support or maintenance requirements. It is a direct replacement for an existing collapsible storage tank vent pipe in new or existing CST installations. Venting characteristics are not compromised and the sensor can be easily installed or removed by military personnel in a few minutes with no specialized tools. All power and communications cables are connected via military style "quick" connect/disconnects that are familiar to military personnel.



Example of a standard fuel gauge installation on a full and partially full CST

Hazardous Areas

Due to the nature of petroleum products stored in CSTs the fuel farm is classified as a hazardous area. The fuel gauge instrument is approved as explosion proof, suitable for use in Class 1 Division 1 areas and compatible with all petroleum fuel products.

Measurement Requests

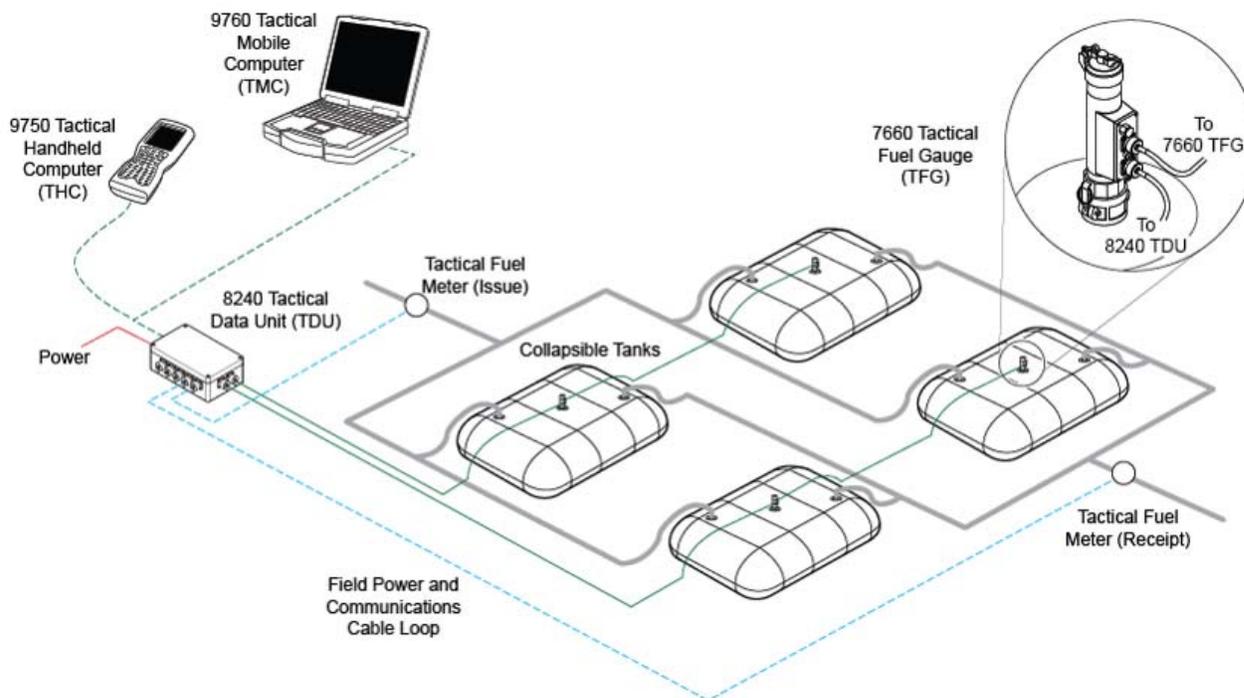
To minimize power requirements, the fuel gauge is normally in a suspended mode of operation that requires no power. When a measurement request is received by the Data Unit from a mobile or handheld computer, it activates the gauge to perform a measurement cycle. Inventory measurement cycle times and manpower allocations are dramatically reduced by providing an immediate measurement of product when requested.

Data Collection

The Data Unit provides three key functions for the tactical fuel system. It provides power to the fuel gauges and acts as a communications interface from the fuel gauges to the system software installed on the mobile computers. Most importantly and key to the overall system, it dynamically creates an accurate gauge chart (“strapping table”) for each CST in a TacFuels Measurement System – *an automatic “Tank Strapping” process.*

Power and Communications

Up to four fuel gauges can be connected in series (daisy chained) from a single power and communications port of a Data Unit. The Data Unit has configurations to support tactical fuel points with multiple fuel gauges. It is also approved for use in hazardous areas and can be installed at the fuel point on a standard military style ground rod. To provide support for larger tactical fuel points, multiple Data Units can be used. It receives power from a local generator or an integrated battery pack. Under battery operation, the Data Unit automatically shuts down when not in use. When polled by a TacFuels system computing device, it activates and collects inventory measurements. It is able to store data under battery power for up to 6 months.



Example of a standard tactical installation

System components, such as a mobile computer or handheld device, can be connected to the Data Unit continuously or connected periodically via military style “quick” connect/disconnects. A hardwired communications solution was selected for all components due to wireless security and visibility to the enemy in a tactical environment.

All TacFuels systems components are capable of communicating via commercial wireless/radio systems, such as Bluetooth. However, the system was developed to use hardwired communications due to the sensitive nature of fueling data and the strategic ways wireless communications infrastructures can be utilized by an enemy force.



Automatic “Tank Strapping”

The Data Unit is designed to dynamically create an accurate gauge chart (“strapping table”) for each CST. It is recommended that tank strapping is performed during installation of the TacFuels measurement system, again after a CST has settled and then periodically to improve fuel inventory management accuracy.

Tank strapping a CST involves creating a gauge chart of entries correlating volume measurements from the flow meter to pressure measurements inside the CST at the metered product temperature. The 8240 TDU performs a continuous data collection cycle until a strap table has been constructed. This table, which can include up to 1,000 data entry points, is then stored in the non-volatile memory of the Data Unit.

The tank strapping process compensates for the variances in tank construction and installation conditions, such as tank expansion, tank bulge and height measurements above manufacturer specifications. It allows increased accuracy and reliability of physical inventory measurements that can then be used throughout the system. During live testing when comparisons were made against manual measurements, ledger variances of physical to book inventories were reduced from 3.5% to 0.38% or 1,249 to 204 gallons on 53,695 gallons of total inventory.

Mobile Computing

Varec’s mobile and handheld computers run dedicated tactical fueling software that assists decision making at an accelerated pace. Laptop computers are utilized in the control area to manage, reconcile and report inventories, while handheld computers are used at the fuel point to request measurements and collect transactional data. Mobile computing reduces the errors associated with manual data recording, calculations and ‘paper form’ based process.

All recorded data is uploaded to the mobile computer, which automatically populates the transaction records in TacFuels software.



Recording Transaction Data

The handheld computer running TacFuels software provides a ruggedized local operator interface to collect, store and view fuel inventory and transactional movement data (receipts and issues). For example, during a disbursement to a fuel truck, vehicle, unit, fuel product and amount can be input manually into the handheld rather than recording this data on a paper form. An epoxy coated full alpha-numeric keypad and touch screen makes data entry a breeze.

Uploading Data

All recorded data is uploaded to the mobile computer, which automatically populates the transaction records in TacFuels software. Data upload can be accomplished in batches using a memory card transfer or automatically when the handheld is returned to a docking cradle. When connected to the Data Unit, the handheld is able to request measurements and display inventory overviews to the user on a color touch screen that is suitable for clear viewing both indoors and outdoors.

Real-time Fuels Inventory Management and Accounting

The mobile computer operating TacFuels software provides local military personnel real-time inventory and accounting tools to assist, manage, account and report on their current fuel stocks and transactional fuel movements (receipts and issues) on a daily basis.

An example overview display of a 120,000 gallon tactical fuel point in TacFuels software on a mobile computer

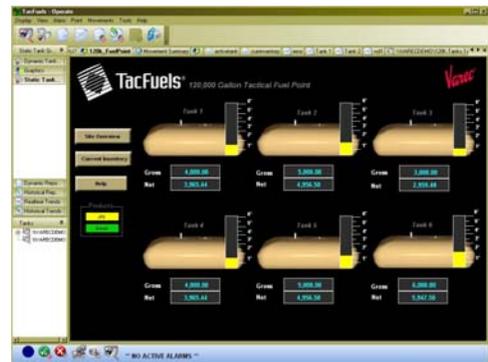


Inventory at-a-Glance

Tacfuels provides graphical views of the local tactical fuel point and individual details of each CST. The operator can quickly gain an idea of the total fuel stocks and their distribution throughout the CSTs.

TacFuels provides two types of tank groups: static and dynamic. A static group is composed of CSTs that have been explicitly identified as part of the group. For example, CSTs 1 through 6 located in the “120,000 gallon fuel point” are combined into a group. Dynamic tank groups are groups of CSTs that have common characteristics. You are able to define the requirements for the group based on variables. TacFuels then identifies the CSTs with the required characteristics and includes them in the group. For example, the CSTs that show a status of “filling” would show all CSTs that are receiving product. Operators can easily toggle between graphical and table formats, depending on their individual preference.

A tank overview display in TacFuels software. To perform the same function today, operators may need to review many paper forms, extract data and manually perform calculations, all of which takes time that may not be available to support a decision during a critical tactical situation.



Tank Status

Each individual CST display provides a clear indication of the contents and status of an individual tank. Measured values are obtained automatically from your fuel gauge via the Data Unit or handheld device and are used to provide calculated values.

From the Tank display you can monitor the transfer of products through your CST and any product movement is shown on the CST image as a flow icon.



Alarm Management

TacFuels provides the mobile computer operator pre-configured alarm settings for each CST; all they need to do is enable them during installation. TacFuels constantly monitors the system to check for conditions that may require immediate attention, such as overfill or a decreasing level on a static CST. If an alarm is triggered, TacFuels

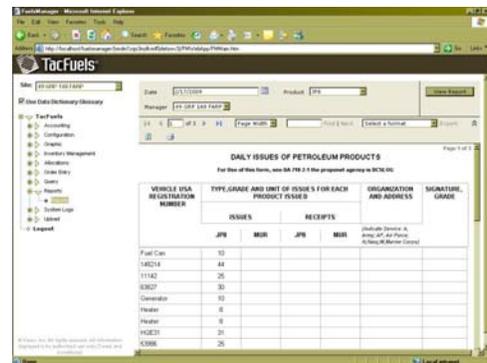
provides the tools to help effectively manage the situation in real-time. It supports multiple alarm groups and alarm priorities, each with its own color and audible attributes. For example, these include high and low level, temperature or CST specific alarms for illegal movement or reverse flow.

When an alarm situation occurs, the operator is notified regardless of which display is active. To assist with quickly resolving the issue, an alarm summary display allows you to quickly acknowledge the alarm and find out why the alarm occurred. TacFuels also creates a historic file of all alarms and events. You can use the Log File Browser to access this history, add comments for individual alarms or print logs for any selected day.

Reporting

Reports provide a way of recording and reviewing the daily activities across the local installation in a clear and concise manner. Two types of reports are available: real-time and historical. Real-time reports display live data while Historical reports are created from archived information within TacFuels.

Reports can be printed as required or scheduled to print at defined times, such as at the change of an operator shift. Simply activate or print the report to a local printer or Adobe Acrobat (PDF) file for electronic distribution.



Trending

Trends are provided to show a graphical view of collected data over a particular time period. An operator can create a CST Trend to track data from a single CST, such as temperature, pressure, level, flow, volume, etc., or a generic trend could be created to show any data collected in the TacFuels system, such as CST levels for four different CSTs simultaneously.

Trends show a graphical view of collected data over a particular time period. For example, they can be used to view the effects of ambient temperature on a CST; this could then assist with a decision as to when is the best time of day is to receive product.

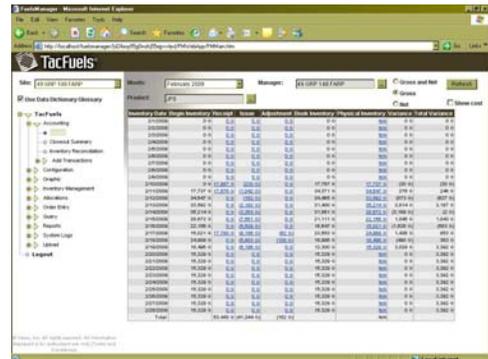
Daily Reconciliation

TacFuels provides an inventory accounting ledger that assists site operators to accurately track, reconcile and report fuel inventories usage down to the vehicle level.

Operators are able to work in real-time with updated data as product is received or disbursed. This minimizes any downtime by automating end-of-day or monthly bulk petroleum summary records, which can be generated by location, unit or product. All captured physical inventories from CST storage are automatically included in variance calculations for close-out records. Operators can also lock down accounting periods once reconciliation begins so that operational personnel cannot modify the data during reconciliation.

TacFuels allows the local operator to automatically deliver reports to command or fleet headquarters for processing via e-mail in standard formats, such as Microsoft Excel, Microsoft Word, CSV and PDF.

The TacFuels system enables timely and accurate record keeping and provides actual daily 'local' fuels inventory reconciliation with audit and documentation trails.

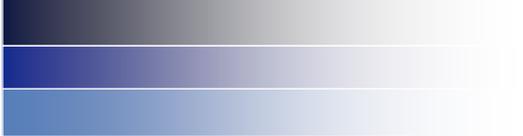


Product Allocations

TacFuels allows the control of product allocations down to the unit or vehicle level. Allocations can be defined per day, week, month or year and also configured to automatically reset at the end of the allocation period. This allows for complete command level control of product distribution and usage so that fuel inventories can be reserved for critical operations. For example, Company B may be allocated a maximum of 10,000 gallons to use over the next 10 days while performing required maneuvers. It also assists with over allocations and helps identify fraudulent or unauthorized disbursements.

Security and Anti-Fraud

TacFuels software utilizes standard Microsoft Windows user and group access rights throughout the system. This allows the tactical fuel point operators to manage data securely while providing authorized users



access to only the data that is relevant to their operations. The system includes detailed audit logging of records and configuration changes, including what was changed, who made the change and when.

Enterprise Integration

When multiple sites are combined into a command level TacFuels enterprise system, enterprise users are able to access reports and graphics overviews configured at each individual site or run queries across all site data to create custom reports based on their unique requirements. The local mobile computer connects to the enterprise via secured satellite or cellular communications when required. At command level, custom, real-time reporting of fuel assets assists with supply chain management, invoicing and logistical decision making across the entire tactical arena.

Conclusion

Varec's TacFuels solution improves existing processes for fuels accountability of tactical fuel points, such as collapsible storage tank fuel farms. Simplicity, cost, dependability and reliability drove the development effort. To ensure a seamless introduction of technology solutions to existing applications, TacFuels was designed to mirror existing paper based processes where possible. The resulting system reduces the cycle times, human resource allocations and is field proven for military personnel ease of use and acceptance. It provides greater command oversight and management, while helping to resolve many shortfalls encountered at the local level, such as fraudulent disbursements. Automating the measurement of fuel inventories and integrating handheld computers for transactional data input and collection greatly reduces the errors associated with manually recording the receipt, inventory measurement and distribution of bulk fuels.

TacFuels is also compatible with FuelsManager® systems already in use by many defense organizations, including the U.S. Department of Defense, NATO, the United Kingdom's Ministry of Defence and the Australian Ministry of Defence. Together, Varec's TacFuels and FuelsManager Defense provide a reliable mobile logistics and mobile enterprise computing solution that improves local fuels accounting reconciliation and reporting, and assists in regional logistical planning, monitoring and decision making, while also providing asset visibility and consumption at all levels of operation.



Credits

About Varec

Varec, Inc., delivers measurement, control and automation solutions and professional services for most major oil companies, defense organizations and airlines worldwide. Varec's FuelsManager® software applications and hardware products provide local level management and enterprise visibility of liquid petroleum assets at bulk storage facilities, marketing terminals, refineries, petrochemical plants and military fuel facilities.

References

1. American Forces Information Service
2. Associated Press, April 2008
3. Defense Science Board 2001 Study

Copyright

© Copyright 2009 Varec, Inc. All rights reserved. No part of this publication may be reproduced or transmitted in any form or for any purpose without the express permission of Varec, Inc. The information contained herein may be changed without prior notice. Some software products marketed by Varec, Inc. and its distributors contain proprietary software components of other software vendors.

All other product and service names mentioned are the trademarks of their respective companies. Data contained in this document serves informational purposes only.

These materials are subject to change without notice. These materials are provided by Varec, Inc. for informational purposes only, without representation or warranty of any kind, and Varec, Inc. shall not be liable for errors or omissions with respect to the materials. The only warranties for Varec, Inc. products and services are those that are set forth in the express warranty statements accompanying such products and services, if any. Nothing herein should be construed as constituting an additional warranty.