Mission Critical Stored Fuel System

Events of September 11th have influenced how fuel for standby generators can be stored securely. Bill Durkin shares his extensive experience in the design and construction of systems for critical fuel supplies.

Introduction

The information age has arrived, and with it has come an ever-increasing need to process, protect and exchange information. The wealth that is generated with this information is difficult to fathom, but the old saying that information is power rings true. We have become dependant upon this information exchange to perform everyday tasks, and grow increasingly impatient when this data transfer does not happen quickly enough. Our society has become more dependant upon a network of server computer farms to store data, process credit/debit transactions, maintain a seamless line of communication and sustain the infrastructure and fluency of the internet.

This dependency equates to a growing revenue stream that is continuing to widen as Communication and E-commerce companies come to market with new communication devices and better ways to buy online. Data Centers for financial institutions must have the network operating 24/7 to process transactions and generate billing statements. Communication companies must process voice and data communications via cell phones without any disruption to service. The cost of not doing business at this level has become both unacceptable and unaffordable. Companies must use this type of networked infrastructure to maintain a competitive edge, whether it is outsourced or internal. The dependency of the business operation on this infrastructure dictates that the network must always be operational.

Stored fuel systems with diesel generator sets are the most reliable and feasible source of independent backup power. The recent power crisis has shown the amount of instability that can exist within our own power grid. This has dramatically increased the focus on the need for stable power. With this in mind, owners of businesses that recognize the dependency on this infrastructure are either investing in backup generation systems on grand scales, or outsourcing their server requirements. These systems may be designed to keep the operation going for up to 72 hours with stored fuel or indefinitely with fuel deliveries. Owners of such businesses are investing heavily in redundant and extremely robust backup generation and fuel storage systems. This investment is considered required insurance to protect against power outages, natural disasters and work shutdowns.

Cost justification

One lesson that we have learned all to often is that these natural and man-made disasters do, in fact take place. These systems are designed to minimize the impact of such events on the infrastructure of business and communication. The cost of such backup systems varies widely depending on built- in redundancies, runtime requirements, and overall scale of the system. With cost of not doing business measured in the thousands per second, these systems are considered inexpensive insurance. It is likely that even a million dollar system will pay for itself in one extended power outage. The following example does not include any of the intangible losses associated with a power outage or disruption to service.

The example Web hosting center was built in late 2000 and cost between $800-$850 per square foot to build. This site is a 50,000 square foot facility that leases floor space for $65-$85 per month. For this example the following assumptions have been made: site is leased at 90% capacity, cost to build was $825 per square foot and the leased space is going for $75 per square foot. This would pencil out to a total construction cost of $41,250,000 to build and gross annual revenue of $40,500,000. The potential revenue that these sites are capable of generating is extremely impressive and every power outage would equate to an immediate loss of that revenue. In this particular example, one 24-hour power outage would equal an immediate loss of $125,000. This would not account for all the intangible losses, such as loss of existing and future contracts. The customer of such systems expects full redundancy and absolutely no interruption to service. It has become a standard of business to operate at this level.

Tank farm at the Tukwila Data Center, consisting of six 40,000-gallon brine filled, double wall fiberglass fuel storage tanks.

Design Parameters

While some of these services are relatively new, the need for stable power is not. Communication companies have been backing up the electrical power to remote sites for a long time. The parameters that have changed are the recognition of fuel instability and the scale of the backup systems. Larger scale designs require a system engineered to transfer fuel at a higher rate and over a longer distance. The recognition of fuel instability has lead to an emerging market for fuel polishing systems.

One consistency throughout this emergence of stored fuel systems has been the need for them to be well designed, redundant, and built more rapidly than ever before. Once the capital for these large-scale server farms has been provided, sites need to generate revenue as soon as possible. Every day spent in construction is one day of lost revenue.

This awareness leads to a compressed project schedule that demands efficiency and creative approaches. With existing designs typically lacking in depth and detail, owners often choose the design build method. With design and construction occurring on top of one another, the project is constantly evolving making flexibility, accuracy, and precise communication absolutely critical. This presents an opportunity for the seasoned petroleum equipment supplier to act as a consultant by providing the owner with a working fuel system specification and design implementation.

The Tukwila (Washington) Data Center, built in the summer of 2000, was constructed using the design build method. It is one of the largest facilities of its kind with a total fuel storage capacity of 240,000 gallons of fuel.

What started with a paper napkin approach rapidly became a successful plan. Through preliminary sketches and precise communication, the design was implemented with focus on construction details and ease of understanding. Along with the drawings, an equipment schedule was generated that listed every component that was to be installed in the underground equipment. This approach left little for consideration in the field once the plans were issued for construction.

The typical builder of these facilities is new to the petroleum industry and not always familiar with the technology currently available or even what is involved in building a large scale fuel storage and transfer system. The focus with a network server rich environment is to keep the equipment up and running and adequately cooled. The primary focus is on the heating, ventilation, and air conditioning. Fuel storage and transfer is typically an after-thought that is incomplete in design and functionality. Most of the engineering community that is responsible for the design is familiar with fuel transfer systems that are much smaller in scale. The call for redundancy and longer run times has pushed the limits of existing designs and generated a need for a more adaptable and creative design approach. This requirement generated some unique opportunities for the equipment supplier to provide design input and system packaging.

Each of the large-scale stored fuel systems that have been built to date is typically unique. The fuel system design has a tendency to be driven through job site restraints, local code issues and/or owners requirements. These constraints and the inevitable compressed schedule create a design build atmosphere where accurate communication is critical and design parameters change daily. It suits the equipment supplier well to have a "heavy hand" in design input and maintain a close relationship with all who are involved in the construction of the project.

The exact design approach to each system will vary with the previously mentioned parameters, but the basics remain the same. The fuel storage system is a matter of reverse engineering once the load requirements and run time considerations have been determined. After the anticipated load is calculated, the run time requirements equate to a finite quantity of stored fuel. Conveyance of this fuel can be accomplished through many conventional methods and some unconventional methods. This is where the equipment supplier has a unique opportunity to present all of the possible options for the complete system to the owner. Important questions designed to force the owner to focus on longevity, operability, maintenance and redundancy issues must be asked. How much is the owner willing to invest in a backup system? How often does the owner expect to rotate the fuel? Is a fuel maintenance program that includes a polishing system in the scope?

These questions bring the equipment supplier to the table not only as the supplier but also as the fuel systems expert and consultant. Partnering with the design team solidifies this relationship and helps eliminate miscommunications. Within the design build arena paper napkin designs can lead to complete construction documents within a relatively short period of time. The drawings were scratched out in a meeting with the design engineer and translated into a CAD document the following day. Plans were issued for construction shortly there after.

One of many hand sketches created for the Tukwila Data Center during meeting with the design engineer.

Click here to enlarge.

Click here to enlarge.

Hand sketches placed in CAD format and issued for construction.

Finished Installation

Design specifics

To determine the stored fuel system scale for the project the system was essentially reverse engineered. First consideration is given to the critical electrical load requirements. This load is typically dependant upon the square footage of the facility, which equates to a required cooling capacity for the servers.

The critical load (measured in watts) dictates the number and size of the generators. The anticipated run time requirements and generator fuel consumption at full load will dictate the fuel storage requirements. Fuel transfer rates are dependant upon generator fuel consumption rates and day-tank storage capacity, which is usually dictated by local code.
Other considerations have an impact on system design such as required redundancy and communication ability with the building management system.

This example describes the design specifics of the fuel storage and transfer system for a Data Center recently built in Tukwila, Washington. The system contains 6 phases with each phase consisting of 6 each 2 MW generators, 1ea 500-gallon day-tank, 1ea 40,000 gallon brine filled double wall fiberglass storage tank, control transfer system and an automated tank level and leak monitoring system. The runtime requirements were 72 hours and with 3each 2mw generators per phase running at full load this dictated a stored fuel capacity of approximately 35, 000 gallons. Taking useable fuel into consideration this dictated a fuel storage tank with a 40,000-gallon capacity.

Maximum day tank capacity allowed by local codes was 500 gallons and a redundancy requirement of N+1 (at least one complete back up system for each working system) is an owner requirement.

500-gallon day tank with two overflow return pumps.

With these considerations in mind Northwest Pump & Equipment Co. met with the Mechanical contractor's design engineers, generated preliminary sketches and made design recommendations. The approach was to use a combination of tried and true technology with cutting edge fuel cleaning technology.

The transfer of fuel from storage tank to the day tank was challenging due to the length of the pipe and quantity of pipes required. Each phase has a completely redundant fuel oil supply and return piping system. The total length of flexible 1.5" pipe inside a 4.5" carrier pipe used up to phase # 3 is 12,000 feet. The phase 4, 5 and 6 piping has been capped off for future completion. With the infrastructure for all 6 phases being built into the fuel tank farm and the N+1 redundancy requirement, achieving adequate piping slope became another challenge. An additional owner requirement was to have future access to the fuel piping that was inside the building, but to have it below grade. To achieve this requirement multiple sumps were used at strategic points with slope split between these sumps. Each sump contained an optic liquid sensor to detect any fuel leaks. Slope was achieved by strapping the secondary piping to PVC tubes that were cut in half and bolted to Unistrut frames. The Unistrut frames were then adjusted to achieve this slope requirement. All of the piping was routed through an underground access way constructed of concrete with manholes over all sumps and also located at strategic points through the ceiling of the access way.

Twenty-four piping runs enter the Tukwila Data Center from the tank farm. Each tank has two fuel supply-piping runs and two fuel return runs. The redundancy illustrates how serious the owners of data centers consider a power outage.

Each storage tank has an independent fuel polishing system that cleans the fuel on a predetermined schedule and is capable of transferring fuel between phases. The product is cleaned when removing the fuel from one end of the tank, pumping it through a water removal strainer and filtering it down to 2 microns before returning it to the opposite end of the tank. The intent of this type of system is to help keep the fuel fresh and most importantly remove the water in the system. If the water is left in the system it will eventually lead to microbial growth that creates a sludge layer and can eat away at tank linings, piping systems and emergency generators. This system will also aid in the prevention of filter clogging on generator sets, which is obviously unacceptable. One of these systems will typically pay for themselves within one to two years. This usually equates to a complete rotation change of the fuel that is stored. For example the Tukwila Data Center used one polisher per fuel tank. Each tank stored approximately 35,000 gallons of useable fuel. This particular fuel polisher is a computer-controlled system with a touch-screen interface, pressure differential arms, leak detection, and RS 485 interface. The total cost of each system is just over $30,000.00. This system would more than pay for itself by preventing the need for a replacement of the stored fuel. Estimates vary, but without this type of system the stored fuel would probably require replacement within one year, assuming the fuel is to maintain compliance with the Generator's manufacturers specifications. This does not even begin to address the cost to the life of the system if the fuel is not properly maintained and bacterial growth is introduced.

Basic stored fuel system. Fuel supply and return system is illustrated as a simplex system. Duplex supply and return applied to the Tukwila design.

Control System

Having all the correct hardware in place is always a critical part of the fuel storage system, but to create an operational system that lives up to the owner's expectations overshadows everything. The control system consists of the proper application of these hardware components. Controls are often excluded from the generic plan sets because of the inherent complexity and difficulty in specifying. The control package is the big question when discussing these large-scale fuel storage systems. The equipment supplier has a unique opportunity to demonstrate system knowledge and once again become the consultant. To keep costs down and maintain the system schedule it pays for the owner to invest in a packaged system approach especially when considering a control package. The equipment supplier already knows the design limitations of the equipment that is being controlled so it becomes natural to have that supplier perform the control analysis and propose the prepackaged control system. This streamlines the design process and the supplier is held accountable for the system operability not just the components. This type of accountability is required on a successful design build project and this complete packaging approach ensures compatibility among system components.

Summary

Most of the heavy investors of these large-scale systems are creating a backbone infrastructure designed to support the inevitably enormous communication, data transfer and storage needs of the 24/7 global economy. As more and more businesses begin to bring goods to market via e-commerce or use the web as a form of presentation, the demand for web site and communication stability will grow and with it the need for a stable power supply.

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