ELECTRICAL AND SCADA SYSTEM EVALUATION

Prepared for Lake Limerick Water System

August 2021

LLWS 21-0119

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Lake Limerick Water System

Electrical and SCADA System Evaluation

August 2021

Prepared by RH2 Engineering, Inc.

Prepared for the Lake Limerick Water System

Note: This evaluation was completed under the direct supervision of the following Licensed Professional Engineers registered in the State of Washington.

Sincerely,

RH2 ENGINEERING, INC.

Signed: 8/4/2021

Signed: 8/4/2021

Lake Limerick Water System

Electrical and SCADA System Evaluation

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SCADA Definitions and Acronyms

Broadband – A wide bandwidth data transmission medium with the ability to simultaneously transport multiple digital signals and traffic types.

DSL – Digital Subscriber Line. A family of technologies that provide Internet access by transmitting digital data over the copper wires of a local telephone network.

HMI – Human Machine Interface. An HMI is a software application that presents information to an operator or user about the state of a process and accepts and implements the operators control instructions. Typically, information is displayed in a graphic format (Graphical User Interface or GUI).

Industrial Communication Protocols – High level digital communication standards that are used between control system components. Serial Modbus, Modbus TCP/IP, Serial DF1, Allen-Bradley Ethernet, and Ethernet/IP are common types of open standard communication protocols that are used in the control industry. These protocols are used to package data into digital packets for transmission over wired or wireless communication systems.

Industrial Display – See OI below.

LAN – Local Area Network. Typically consists of an interconnection of networkable devices over a small area such as within a building or a control panel.

OI – Operator Interface. An OI usually consists of a small industrial HMI display. It communicates directly to the control panel PLC and allows operators to directly monitor all facility alarms and status information. An OI usually displays a subset of a full HMI system. Low-level facility setpoints usually are entered using the OI instead of the HMI system. These may include instrument calibration setpoints, alarm delays, and miscellaneous setup values.

OPC – Open Platform Communications (OPC) is a series of standards and specifications for industrial telecommunication.

PLC – Programmable Logic Controller (or Programmable Controller). A PLC is a digital computer used for automatic monitoring and/or control of processes.

SCADA – Supervisory Control and Data Acquisition. A SCADA system usually consists of the following subsystems.

- An HMI typically is a graphical Windows-based computer or touch screen that presents process data to a human operator, and through this, the human operator monitors and controls the process.

- A supervisory (computer) system gathering (acquiring) data on the process and sending commands (control) to the process.
- Communication infrastructure connecting the supervisory system to the PLCs or other data collection devices.
- PLCs connected to sensors in the process, converting sensor signals to digital data, and sending digital data to the supervisory system.
- Various process and analytical instrumentation.

TCP/IP – Transport Control Protocol/Internet Protocol. This low-level Internet protocol suite is the set of communications protocols used for the Internet and similar networks. TCP/IP is the most popular protocol stack for local and wide area networks. Some industrial communication protocols such as Modbus TCP/IP and Ethernet/IP use TCP/IP as the communication transport. TCP/IP is used by higher-level communication protocols to guarantee delivery of data in the correct order between one or many destinations.

UPS – Uninterruptable Power Supply. A UPS is an electrical apparatus that provides emergency power to a load when the input power source or main power fails.

VPN – Virtual Private Network. This extends a private network across a public network, such as the Internet. It enables a computer to send and receive data across shared or public networks as if it were directly connected to the private network, while benefitting from the functionality, security, and management policies of the private network. This is done by establishing a virtual point-to-point connection using dedicated connections, encryption, or a combination of the two.

WAN – Wide Area Network. A WAN typically consists of an interconnection of LANs over a larger geographic area.

Lake Limerick Water System

Electrical and SCADA System Evaluation

Executive Summary

Introduction

Lake Limerick Water System (LLWS) requested that RH2 Engineering, Inc., (RH2) provide a review of its electrical and standby power systems along with its existing Supervisory Control and Data Acquisition (SCADA) system that provides monitoring and control of its drinking water system.

Recommendations Criteria

The products and methodology selected are the result of considerations involving:

- Reliability and stability of water operations;
- Availability of local support from vendors, integrators, and service providers;
- Products that are regularly used in the water markets in the Pacific Northwest;
- Overall complexity of the system and the ability of staff to handle operations and maintenance (O&M);
- Capital improvement costs and O&M costs; and
- Length of time a product has been on the market and its popularity.

Based on the criteria identified above, RH2 recommends the process of phasing new control equipment into the water SCADA system to prevent future support issues. A typical life span for most SCADA system components is approximately 20 years. All of the LLLWS SCADA systems PLC and Industrial Display components have already reached the point where they are considered obsolete.

The LLWS SCADA HMI computer is running on Windows 10 and is using a currently supported version of AVEVA InTouch. Typically, SCADA HMI computers should be upgraded when support is no longer available from the vendors, or somewhere between 5 to 7 years.

The control of the wells and booster pumps should also be reconfigured to use the existing Variable Frequency Drives (VFDs) more efficiently. A discussion of possible control processes is identified in the Recommendation section.

Electrical improvements are recommended at Well 1 due to improper installation. A couple of electrical installation issues were also identified at Wells 3 and 5 due to lack of working space clearance; these issues can be resolved in the future should improvements occur at those locations.

Generator sizing and associated costs have been provided for facilities that do not currently have standby power, including Wells 1, 4, and 5.

Electrical and Standby Power System Evaluation

Existing Electrical Service

The utility power voltage configuration varies at each site: the Well 6 facility utilizes 480/277 Volts Alternating Current (VAC) three-phase, and Wells 1, 2, 3, 4, and 5 utilize 240 VAC three-phase (three transformer configuration) or high leg delta (two transformer configuration). The high leg delta two transformer approach is generally not as reliable for providing three-phase as a true three phase transformer approach. Electrical utilities have been phasing out this approach where possible. Upgrading those sites with high leg delta configurations to true three-phase power is recommended to improve utility power quality and reliability. LLWS has identified that more VFD faults have occurred at the sites with high leg delta configurations versus the true three phase power configurations.

The electrical utility is Mason County PUD No. 3. At Wells 1, 3, and 4, the existing utility service is delivered overhead to the facility via a service mast on the roof of the building. At Wells 5 and 6, the existing utility service is delivered to the facility underground.

VFD Failures and Recommendations

RH2 reviewed the VFD configuration at each location where VFD's are installed and recorded the VFD fault logs in order to determine which VFD faults have regularly occurred at each location. VFD fault logs could not be recorded at Well 2 since the VFD is not connected to power and at Well 5 since the VFD had recently been replaced and the new VFD has not been programmed. The VFD faults and recommendations for resolving the faults at each VFD are described below. While reviewing the VFD configuration, RH2 confirmed that the operational configurations of the VFD's are appropriate for operating the pumps. Any additional operational changes for improving water system VFD operations should be resolved in the PLC and SCADA system programming and not within the VFD configurations.

At each of the Well 3 booster pumps, a DC overvoltage fault has occurred frequently. DC overvoltage faults are typically caused by either power surges on the incoming utility power supply or if regeneration occurs when operating the pump and voltage is generated by the pump motor. This is a common fault issue with VFD's that we typically see caused by regeneration more than utility power surges. We recommend first trying to eliminate regeneration as the cause of the issue. The VFD manufacturer recommends either increasing the VFD deceleration time or verifying that parameter 2005 (overvoltage controller) is enabled. The deceleration time is currently at default. Enabling the overvoltage controller slows down the ramp down deceleration if voltage approaches the limit. This setting is enabled by default. If neither of these adjustments resolves the issue, then we recommend connecting a power quality meter to the utility power supply for approximately one month to determine if the facility is experiencing utility power surges coinciding with VFD faults. This data could then be provided to the PUD for resolution.

At Well 4, both DC overvoltage and DC undervoltage faults have occurred. The DC overvoltage resolution is the same as described above for Well 3. The deceleration time is currently set to 10 seconds. For the DC undervoltage fault, this occurs when there is a loss of power on one or more phases. This likely occurred from a power outage. Other possible causes are faulty wiring, but this would likely cause a persistent fault. We recommend monitoring this site to see if future undervoltage faults occur that may point to faulty wiring.

At Well 6, both booster pumps have experienced overspeed and motor phase faults. The motor phase faults occur when the motor speed exceeds the maximum speed setpoint by 20 percent. Based on the age of the alarms in the log, and these all occurring in rapid succession, this appears to be an old alarm caused by an improper parameter configuration that has been resolved. If this alarm continues to occur, this is due to improper parameter configuration. The current configuration is correct and is not implicated in causing this fault. The motor phase faults are caused by a loss of phase between the VFD and the motor. We recommend checking the cables, terminations, and motor to determine if there is a failure that is causing a loss of connection. The PUD previously monitored power out this location and recorded a large current unbalance. This is typically attributed to a failing motor which may also explain the loss of phase faults.

Well 1 Existing Electrical Equipment

The existing electrical equipment at Well 1 consists of a load center with a 50-Amp main circuit breaker that supplies single-phase power to the booster pump control power, PLC control equipment, heater, lighting, and outlets; a three-phase combination motor starter/disconnect switch for the Well 1 pump; and a three-phase disconnect switch and motor starter for the booster pump. The grounding system is bonded to the load center, but does not appear to be connected to the Well 1 combination motor starter/disconnect switch and booster pump disconnect. Neither enclosure is identified on the front of the enclosure as suitable for use as service entrance equipment. Also, since there is not a single point of service at this facility, it is considered a multi-main service. Each service connection should be individually grounded. Finally, some of the electrical equipment is installed on the wall with water piping located directly in front of the electrical equipment. The National Electrical Code (NEC) requires a minimum of 42-inches of working space from the front of the electrical equipment enclosures to the water piping.

Figure 1: Well 1 Electrical Equipment

Well 1 Recommended Electrical Improvements

RH2 recommends eliminating the multi-main disconnect configuration and creating a single point of connection for the electrical service and grounding system. Should LLWS decide to add a standby power system at this facility, creating a single-main electrical service will be necessary. Also, if any future electrical improvements are done at this facility, the existing electrical equipment located in front of the water piping will need to be relocated to allow for the required NEC working space clearance. During relocation of the equipment, RH2 recommends installing new motor starters and distribution equipment, as the existing equipment is nearing the end of its useful life.

Well 1 Standby Power

Well 1 does not currently have either permanent standby power or a portable generator connection available at the facility. The motor loads for the well pump and booster pump are 3 horsepower (HP) and 5 HP respectively. Miscellaneous single-phase loads at the facility are estimated to be a maximum of 20 Amps. Using the information collected during the site visit, the proposed generator is sized at 35 kilowatts (kW) based on Cummins PowerSuite generator sizing software. The Generator Sizing Report has been included in **Attachment 1**. These size generators are offered as both diesel and natural gas fueled. To integrate a permanent standby generator into the electrical system, an automatic transfer switch (ATS) will be required to allow for seamless generator operation during utility power outages. The ATS will not require manual control, and it will reduce operations staff time in responding to late night calls to reset. As mentioned above, a single-main service disconnect will need to be installed ahead of the ATS. As an alternative, a service entrance rated ATS can be installed which would also act as the service entrance disconnect.

Well 1 Cost Summary

The recommended electrical improvements and installation of the generator system will require several major components as well as conduit and conductor work. The major cost elements have been identified and summarized in **Table 1**.

Table 1

Opinion of Probable Construction Costs for
Electrical Improvements and Installation of Well 1 Permanent Standby Generator

Item Description	Cost
35 kW Diesel Generator with Sub-Base Fuel Tank, Sound-Attenuated Weatherproof Enclosure, Concrete Pad, and Bollards	$60,000
Automatic Transfer Switch; 125 A, Type 12 Enclosure	$8,000
Service Entrance Disconnect; 100 A, Type 4X Enclosure	$5,000
Electrical Equipment Relocation	$15,000
Load Center and Motor Starter Replacement	$17,500
Conduit and Wire	$14,000
Startup and Testing	$2,500
Construction Subtotal	**$122,000**
Sales Tax (8.5%)	$10,370
Contingency (20%)	$24,400
Mobilization (10%)	$12,200
Indirect/Engineering Costs (25%)	$30,500
Construction Total	**$199,470**

Well 2 Existing Electrical Equipment

The existing electrical equipment at Well 2 consists of a single-phase load center that supplies single-phase power to the building lighting and outlets; a three-phase transfer switch for either using a portable generator or utility power to provide power to the well pump; combination motor starter/disconnect switch for the Well 1 pump; and a VFD for the well pump. The VFD is mounted on the interior wall but is not currently connected to power or to the submersible pump motor. LLWS currently runs the pump for flushing purposes by manually connecting the three-phase power conductors to the motor conductors without the use of the VFD or separate motor starter. Otherwise Well 2 is currently not used and is considered offline due to a high level of manganese. Neither the load center nor transfer switch enclosures are identified on the front of the enclosure as suitable for use as service entrance equipment. Finally, some of the wiring inside the load center is not appropriately colored and labeled and does not meet code.

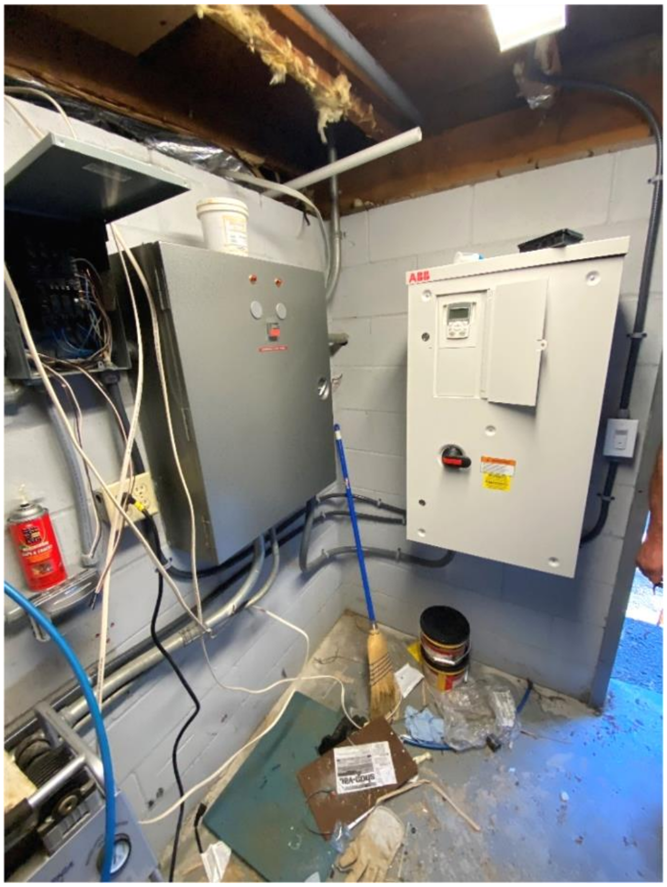


Figure 2: Well 2 Electrical Equipment

Well 2 Recommended Electrical Improvements

Complete replacement of the electrical equipment except for the VFD is required to get safely put Well 2 back into service. This includes installing a clearly marked main service disconnect and three-phase distribution panel. Conductors throughout the building also need to be replaced so that the building wiring is brought up to code. Assuming the well pump motor is in working condition, the existing VFD can connected and used for operating the pump. Should LLWS determine that a VFD is not needed for this facility, an across-the-line starter can be installed instead.

Well 2 Standby Power

Well 2 does not currently have permanent standby power available at the facility. The motor load for the well pump is estimated to be 25 horsepower HP based on the VFD size. Miscellaneous single-phase loads at the facility are estimated to be a maximum of 20 Amps. Using the information collected during the site visit, the proposed generator is sized at 30 kilowatts (kW) based on Cummins PowerSuite generator sizing software. The Generator Sizing Report has been included in **Attachment 2**. These size generators are offered as both diesel and natural gas fueled. To integrate a permanent standby generator into the electrical system, an automatic transfer switch (ATS) will be required to allow for seamless generator operation during utility power outages. The ATS will not require manual control, and it will reduce operations staff time in responding to late night calls to reset. A single-main service disconnect will need to be installed ahead of the ATS. As an alternative, a service entrance rated ATS can be installed which would also act as the service entrance disconnect.

Well 2 Cost Summary

The recommended electrical improvements and installation of the generator system will require several major components as well as conduit and conductor work. The major cost elements have been identified and summarized in **Table 2**.

Table 2

Opinion of Probable Construction Costs for
Electrical Improvements and Installation of Well 2 Permanent Standby Generator

Item Description	Cost
30 kW Diesel Generator with Sub-Base Fuel Tank, Sound-Attenuated Weatherproof Enclosure, Concrete Pad, and Bollards	$58,000
Automatic Transfer Switch; 125 A, Type 12 Enclosure	$8,000
Service Entrance Disconnect; 100 A, Type 4X Enclosure	$5,000
Load Center Replacement	$10,500
Conduit and Wire	$22,000
Startup and Testing	$2,500
Construction Subtotal	**$106,000**
Sales Tax (8.5%)	$9,010
Contingency (20%)	$21,200
Mobilization (10%)	$10,600
Indirect/Engineering Costs (25%)	$26,500
Construction Total	**$173,310**

Well 3 Existing Electrical Equipment

The existing electrical equipment at Well 3 consists of a 150 Amp main service disconnect located on the exterior of the building, 225 Amp ATS, 200 Amp three-phase distribution panel, 50 kW outdoor standby generator, and motor starters and VFDs for the well and booster pumps. The electrical distribution equipment, VFDs, and motor starters are in good condition and are not in need of replacement. Finally, the VFD equipment is installed on the wall with water piping located directly in front of the VFD and line reactor enclosures. The NEC requires a minimum of 42-inches of working space from the front of the electrical equipment enclosures to the water piping.

Figure 3: Well 3 Electrical Equipment

Well 3 Recommended Electrical Improvements

RH2 does not recommend any immediate electrical improvements to this facility. Should any future electrical improvements be performed at this facility, an electrical inspector may require the VFDs to be relocated so that water piping is not located directly in front of the enclosures to allow for the required NEC working space clearance.

Well 4 Existing Electrical Equipment

The existing electrical equipment at Well 4 consists of a three-phase distribution panel with a 100 Amp main circuit breaker and pump control panels for both the Well 4 pump and booster pump. The Well 4 pump control panel includes a VFD. The electrical distribution equipment, VFDs, and motor starters are in good condition and are not in need of replacement.

Figure 4: Well 4 Electrical Equipment

Well 4 Recommended Electrical Improvements

RH2 does not recommend any electrical improvements at this time.

Well 4 Standby Power

Well 4 does not currently have either permanent standby power or a portable generator connection available at the facility. The motor loads for the well pump and booster pump are 10 HP and 7.5 HP, respectively. Miscellaneous single-phase loads at the facility are estimated to be a maximum of 30 Amps. Using the information collected during the site visit, the proposed generator is sized at 40 kW based on Cummins PowerSuite generator sizing software. The Generator Sizing Report has been included in **Attachment 3**. These size generators are offered as both diesel and natural gas fueled. To integrate a permanent standby generator into the electrical system, an ATS will be required to allow for seamless generator operation during utility power outages. The ATS will not require manual control, and it will reduce operations staff time in responding to late night calls to reset. A main service disconnect will need to be installed ahead of the ATS. As an alternative, a service entrance rated ATS can be installed which would also act as the service entrance disconnect.

Well 4 Cost Summary

The installation of the generator system will require several major components as well as conduit and conductor work. The major cost elements have been identified and summarized in **Table 3**. A Diesel generator is used as a basis for estimating. There is a natural gas pipeline is located adjacent to the well site and may be used as a fuel source. The estimated generator costs below are reduced by $5,000 if a natural gas generator were to be used.

Table 3

Opinion of Probable Construction Costs for Installation of Well 4 Permanent Standby Generator

Item Description	Cost
40 kW Diesel Generator with Sub-Base Fuel Tank, Sound-Attenuated Weatherproof Enclosure, Concrete Pad, and Bollards	$65,000
Automatic Transfer Switch; 125 A, Type 12 Enclosure	$8,000
Service Entrance Disconnect; 100 A, Type 4X Enclosure	$5,000
Conduit and Wire	$10,000
Startup and Testing	$2,500
Construction Subtotal	**$90,500**
Sales Tax (8.5%)	$7,693
Contingency (20%)	$18,100
Mobilization (10%)	$9,050
Indirect/Engineering Costs (25%)	$22,625
Construction Total	**$147,968**

Well 5 Existing Electrical Equipment

The existing electrical equipment at Well 5 consists of a three-phase distribution panel with a 200 Amp main circuit breaker and a VFD for the Well 5 pump. The electrical distribution equipment and VFDs are in good condition and are not in need of replacement. The front covers are currently removed from the VFD and reactors. These should be installed as a safety precaution and to prevent premature failure. The telemetry equipment and VFD reactor enclosures have water piping directly in front of the enclosures, so the installation does not meet the NEC 42-inch working space requirement.

Figure 5: Well 5 Electrical Equipment

Well 5 Recommended Electrical Improvements

RH2 does not recommend any immediate electrical improvements to this facility. Should any future electrical improvements be performed at this facility, an electrical inspector may require that the telemetry and reactor enclosures be relocated so that water piping is not located directly in front of the enclosures to allow for the required NEC working space clearance.

Well 5 Standby Power

Well 5 does not currently have either permanent standby power or a portable generator connection available at the facility. The motor load for the well pump is 10 HP. Miscellaneous single-phase loads at the facility are estimated to be a maximum of 20 Amps. Using the information collected during the site visit, the proposed generator is sized at 25 kW based on Cummins PowerSuite generator sizing software. The Generator Sizing Report has been included in **Attachment 4**. These size generators are offered as both diesel and natural gas fueled. To integrate a permanent standby generator into the electrical system, an ATS will be required to allow for seamless generator operation during utility power outages. The ATS will not require manual control, and it will reduce operations staff time in responding to late night calls to reset. A main service disconnect will need to be installed ahead of the ATS. As an alternative, a service entrance rated ATS can be installed which would also act as the service entrance disconnect.

Well 5 Cost Summary

The recommended electrical improvements and installation of the generator system will require several major components as well as conduit and conductor work. The major cost elements have been identified and summarized in **Table 4**.

Table 4

**Opinion of Probable Construction Costs
for Electrical Improvements and Installation of Well 5 Permanent Standby Generator**

Item Description	Cost
25 kW Diesel Generator with Sub-Base Fuel Tank, Sound-Attenuated Weatherproof Enclosure, Concrete Pad, and Bollards	$55,000
Automatic Transfer Switch; 225 A, Type 12 Enclosure	$9,500
Service Entrance Disconnect; 200 A, Type 4X Enclosure	$7,000
Conduit and Wire	$10,000
Startup and Testing	$2,500
Construction Subtotal	**$84,000**
Sales Tax (8.5%)	$7,140
Contingency (20%)	$16,800
Mobilization (10%)	$8,400
Indirect/Engineering Costs (25%)	$21,000
Construction Total	**$137,340**

Well 6 Existing Electrical Equipment

The existing electrical equipment at Well 6 consists of a 200 Amp main service disconnect, 200 Amp ATS, three-phase distribution panel with a 200 Amp main circuit breaker, 5 Kilo-Volt Ampere (kVA) 480-240/120 VAC transformer, single-phase load center, and a pump control panel which includes the VFDs for the Well 6 pump and two booster pumps. Additionally, there is a 65-kW permanent standby generator located inside the building. The electrical distribution equipment and VFDs are in good condition and are not in need of replacement.

Figure 6: Well 6 Electrical Equipment

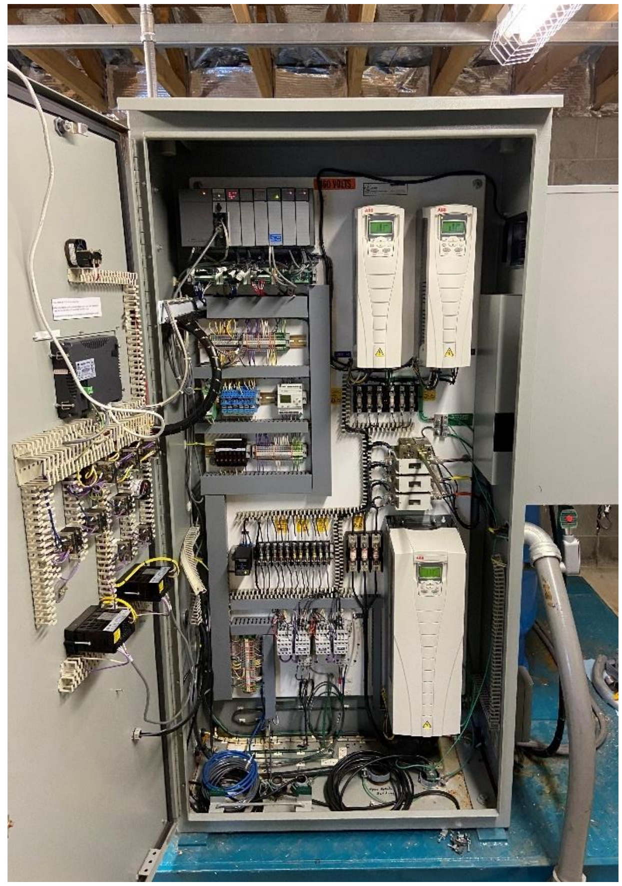


Figure 7: Well 6 Pump Control Panel Interior

Well 6 Recommended Electrical Improvements

RH2 does not recommend any electrical improvements at this time.

SCADA System Evaluation

SCADA PLC and Industrial Displays

Based on the equipment installed, the existing SCADA system (**Figure 8**) was implemented sometime during the last 20 to 25 years. This timeframe is based on the age of the Automation Direct Koyo and Rockwell Automation SLC-5/03 PLCs. These devices existed in the late 1990s and were typically not installed after the early 2000s. Only the Master controller and Well 6 have industrial displays that interface with the local PLC controllers.

SCADA Communications

The SCADA system uses two types of Freewave radios. FGR2-Plus 900 megahertz (MHz) radios are used for Wells 1-5 for communications between facilities. Well 6 uses the FGR2-C for SCADA communications. These radios can interface with the remote facilities over Ethernet or Serial RS-232. The Master DL205 PLC has an ECOM100 Ethernet interface that uses two Digi One IAP protocol converters to interface to remote sites. Digi One IAP is for communicating to the Serial RS-232 ports on the remote DL205 PLCs at Wells 1, 3, 4 and 5. The other Digi One IAP is for communicating to the Serial RS-232 port on the Well 6s SLC-5/03 PLC. Well 2 currently appears offline.

SCADA Computer System

The SCADA HMI computer system is based on the application known as AVEVA InTouch. This software was known for most of its 30-year history under the brand name of Wonderware InTouch. Unlike the SCADA system controllers, AVEVA InTouch is continuously upgraded with the latest version coming out in 2020. The water utility pays a yearly support fee to AVEVA's local distributer to keep the SCADA HMI computer software licenses current.

InTouch was the first Windows-based SCADA computer system HMI software that became popular in the early 1990s. Although InTouch originally was developed in the late 1980s, it was not until Windows started creating very stable server versions of its software in the early 1990s that InTouch became popular. Wonderware InTouch is currently considered the most popular commercial SCADA platform in the world. Due to its age, it will most likely be replaced by a newer version of InTouch or will be replaced by a newer software platform such as Ignition.

TopView is the SCADA systems alarm notification software and is also installed on the Windows 10 HMI computer. This software can contact on-call operations staff about system alarms or other facility status information via phone, email, or SMS messaging.

SCADA Instrumentation

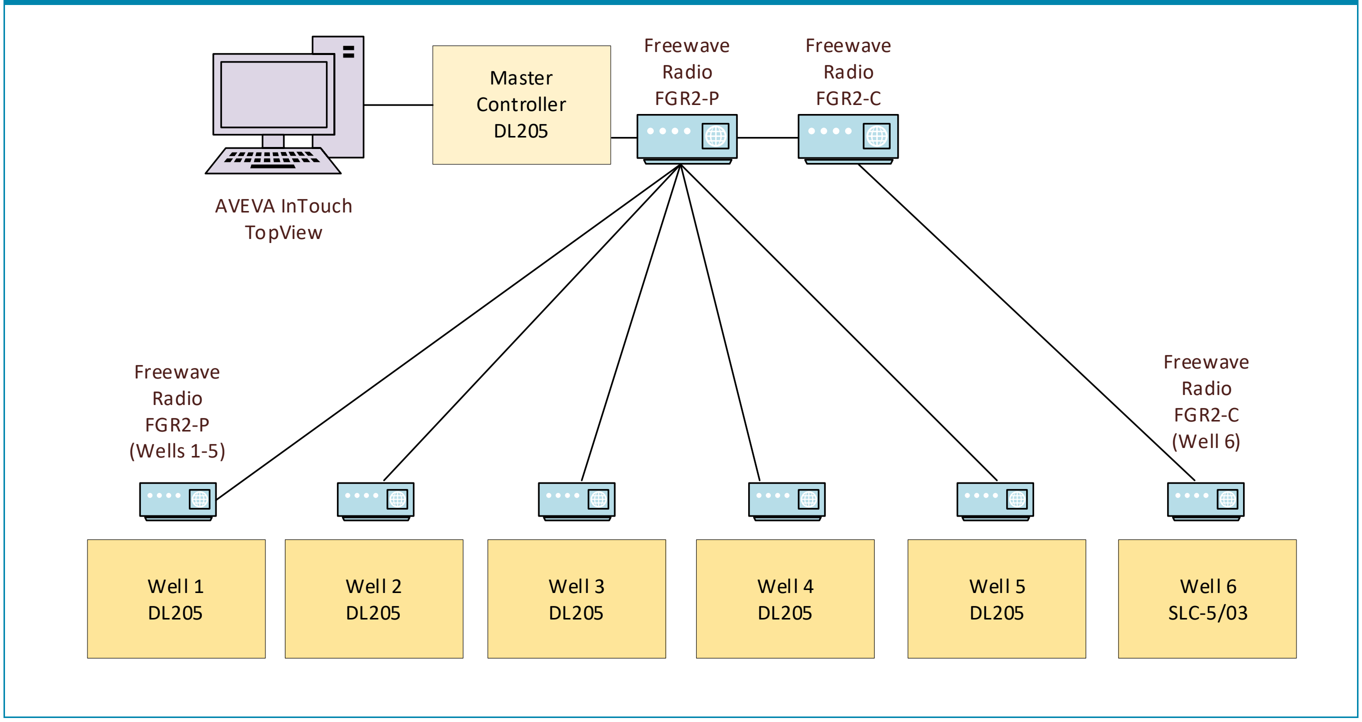
The SCADA system is currently using various level, pressure, and flow sensors for monitoring the water system. Motor control systems with ABB VFDs and valve systems are used for control of the five operational well/reservoir/booster facilities. Instrumentation for water systems is typically only upgraded when a facility is built, upgraded or when it has failed. Proactive replacement of critical SCADA instrumentation is not a common event. RH2 would recommend purchasing spare instruments for critical facilities that cannot be offline for long periods of time.

SCADA Control Panel Standards

The Master and Well 6 control panels are UL rated panels that were obviously fabricated in an UL508a and/or UL698a certified shop. Well 1, 3, 4, 5 control panels are not UL rated based on the components in the panel and the random wiring implementation.

Figure 8

EXISTING SCADA ARCHITECTURE



SCADA System Control

Well Control – Control of the well pumps is based on reservoir level for local reservoirs at Wells 1, 3, 4 and 6. These facilities use start/stop reservoir level setpoints for controlling the well pumps. For wells with VFDs, the speeds can also be adjusted to adjust the flow rate. For Well 5, control is based on start/stop pressure setpoints. Well 2 is not running but does report the system pressure and power conditions at the Well 2 location.

Booster Control – Control of the booster pumps is handled with start/stop pressure setpoints along with VFD speed control, if available. If a booster pump location has 2 booster pumps, additional lead/lag pressure setpoints are implemented. The duplex pump systems will alternate on a timed schedule.

SCADA System Recommendations

Although the existing SCADA system is operational, all SCADA system components have a lifespan. This component lifespan changes over time based on the following conditions.

1. Current condition of component.
2. Available support of the component.
3. Component replacement costs.

4. Obsolescence or lack of features compared to replacement technology.

SCADA Software AVEVA InTouch and TopView

As identified, InTouch has been used in the industrial industry for close to 30 years. It is still considered the most popular HMI software in the world but is not considered state of the art. InTouch's core technology is old, and only the addition of features like Archestra graphics have kept it relevant compared to modern software. The software's inability to understand how to natively handle multi-monitor systems is an example of that obsolescence. The architecture of InTouch software is perfectly designed for a single workstation environment, which was common in the 1990s. Schneider Electric purchased InTouch about 5 years ago and has been investing in keeping the software platform viable to keep their existing customer base. This investment will likely keep InTouch software current and will allow Schneider Electric to identify the replacement for InTouch at some time in the future. RH2 recommends staying with the existing InTouch application due to the cost of redeveloping the SCADA system for another HMI software platform.

TopView is a recent SCADA alarm notification program that recently started replacing software such as Win911. TopView was originally not designed for implementation with AVEVA InTouch, but a local integrator recently created connector software to integrate them. RH2 recommends staying with TopView if it is working well for the operators.

SCADA PLCs and Industrial Displays

A typical life span for most SCADA system components is approximately 20 years. Most of the existing SCADA system PLC and display components have already reached the point where they are considered obsolete. Rockwell Automation stopped supporting the SLC-5/03 PLC over a decade ago and no longer sells spare parts. Automation Direct still sells parts for the DL205 platform, but after 22 years this PLC is the oldest controller still supported by that company. It is unknown how long this support will continue but is probably based on the amount of equipment sold in a year.

The industrial displays at the Master and Well 6 locations are from Maple Systems and were discontinued several years ago. Newer displays are available for replacement although the existing display application may require minor changes to work on the new displays.

RH2 recommends regularly phasing new control equipment into the water SCADA system to prevent future support issues. Replacing an entire SCADA system at one time is a substantial investment which is why regular scheduled upgrades are easier to budget.

SCADA Communications

The Freewave radios used to communicate between SCADA facilities are still the current model, and they appear to be one of the few dependable communication mediums available. Cellular has become the most implemented method of SCADA communications in recent years, but that option requires a reliable cellular network with strong signals and redundant cell sites. Anything that requires copper wiring, such as analog phone lines or DSL are not an option due to lack of investment by the telecommunication companies. RH2 recommends the continued use of the Freewave radio system.

SCADA Control

VFD Updates

Based on issues with power loss during winter storms, we would recommend that the facility VFD's be configured for several automatic reset options when power conditions cause issues. RH2 has specific VFD standards on how they should be configured to handle some bad power conditions. This process requires obtaining the current settings, reviewing options in the VFD's operations manuals, and updating the settings in the field. In addition, we would recommend attaching the VFD speed control wiring to the PLC's for better control of flows.

Water System Control

The current water system control methodology is problematic due to existing hydraulic conditions when multiple facilities are pumping into a closed zone. A closed water zone consists of a water system that is pressurized and has no direct storage tanks to act as a buffer. Water is not compressible so when multiple pumps are pumping into the same pressurized system, each running facility will be fighting against the other running facility to get water into the system. The more powerful pumps will overpower the less powerful pumps. Energy efficiency also drops in this scenario because facilities cannot provide the optimum flow into the pressure zone.

A typical closed zone water system with multiple boosters pumping into it operates in very specific ways. There is usually a lead booster facility that is always running and always trying to maintain system pressure. Lag booster facilities only turn on when the lead booster cannot maintain pressure. These lag boosters come on in order and are only running for a short amount of time after system pressure has recovered to normal values. An optimally designed system typically only requires one booster for a closed zone with any additional boosters to be used as backups in case the first booster is offline.

The Lake Limerick system, however, requires multiple facilities to continuously pump simultaneously into the closed zone due to the number of well sources required to provide enough water during heavy demand periods. This requirement doesn't allow for the lead/lag control of multiple boosters pumping into a closed zone.

Adding a minimum amount of storage to the pressure zone would turn it from a closed zone to an open zone and that provides far better options for control.

Well Control

For wells with VFDs that are pumping to local reservoirs, the flow rate can be controlled so that operators can either select a fixed flow rate setpoint or have a linear flow rate where the flow is calculated based on the reservoir level. This method allows the flow to start at a high gallon per minute rate and then slow down as the reservoir level starts to fill. This allows the pump to run longer and attempts to reduce short cycling of the pumps. Using a VFD to control flow or pressure is accomplished using a proportional–integral–derivative (PID) control instruction in the PLC. PID control is a process that continuously adjusts the pump speed to maintain a specific flow or pressure setpoint.

Booster Control

If the system moves to an open zone with the addition of a common storage tank, the booster control is far more flexible and efficient. It can also operate in a similar manner to the well control to local reservoirs. Each production well facility would have start/stop setpoints associated with the common storage tank. Lead/Lag facilities would be defined by their start/stop setpoints. If VFD's are used for speed control, they can use the same linear level/flow control discussed the Well Control section.

Attachment 1

Well 1 Generator Sizing Report

Power Generation

Recommended Generator Report - C35 D6

Project - LLWS - Well 1

Comments -

Project Requirements

Frequency, Hz	: 60.0	**Generators Running in Parallel**	: 1
Duty	: Standby	**Site Altitude, ft(m)**	: 361(152)
Voltage	: 120/240, Series Delta	**Site Temperature, °C**	: 25
Phase	: 3	**Max. Altr Temp Rise, °C**	: 125
Fuel	: Diesel	**Project Voltage Distortion Limit, %**	:
Emissions	: EPA, stationary emergency application		

Calculated Individual Generator Set Load Running and Peak Requirements

Running kW	: 11.2	**Max. Step kW**	: 22.9 In Step 3	**Cumulative Step kW**	: 29.7
Running kVA	: 13.3	**Max. Step kVA**	: 37.5 In Step 3	**Cumulative Step kVA**	: 45.6
Running PF	: 0.84	**Peak kW**	: None	**Cumulative Peak kW**	: None
Running NLL kVA	: 0.0	**Peak kVA**	: None	**Cumulative Peak kVA**	: None
Alternator kW	: 11.25			**Pct Rated Capacity**	: 31.4

Generator Set Configuration

Alternator	: CA115-V14	**Engine**	: 4BT3.3-G5
BCode	: BB94	**Fuel**	: Diesel
Excitation	: EBS	**Displacement, cu in. (Litre)**	: 199.0(3.3)
Voltage Range	: 240/120V	**Cylinders**	: 4
Number of Leads	: 12	**Altitude Knee, ft(m)**	: 9500(2896)
Reconnectable	: Yes	**Altitude Slope, % per 985ft(300.2m)**	: 3
Full Single Phase Output	: No	**Temperature Knee, °F(°C)**	: 104(40)
Increased Motor Starting	: No	**Temperature Slope, % per 18°F(10.0°C)**	: 6
Extended Stack	: No	**Emissions**	: Tier 3
		Cooling Package	: High Ambient

Set Performance / Load Requirements

Set Performance		Load Requirements	
Running At	: 31.4% Rated Capacity		
Max. Step Voltage Dip, %	: 15	**Max. Allowed Step Voltage Dip**	: 15 In Step 3
Max. Step Frequency Dip, %	: 4	**Max. Allowed Step Frequency Dip**	: 10 In Step 2
Peak Voltage Dip, %	:	**Peak Voltage Dip Limit %**	: 15.0
Peak Frequency Dip, %	:	**Peak Frequency Dip Limit %**	: 10
Site Rated Standby kW/kVA	: 35 / 44	**Running kW**	: 11.2
		Running kVA	: 13.3
Site Rated Max. SkW	: 40	**Effective Step kW**	: 26.3
Max. SkVA	: 150	**Effective Step kVA**	: 45.6
Temp Rise at Full Load, °C	: 105	**Percent Non-Linear Load**	: 0.0
Voltage Distortion	:	**Voltage Distortion Limit**	:
Site Rated Max Step kW Limit	:	**Max Step kW**	:

*Note: Higher temperature rise at full rated load.

*Note: All generator set power derates are based on open generator sets.

Power Generation

Loads Summary Report

Project - LLWS - Well 1

Comments -

Project Requirements

Frequency, Hz	: 60.0	**Generators Running in Parallel**	: 1
Duty	: Standby	**Site Altitude, ft(m)**	: 361(152)
Voltage	: 120/240, Series Delta	**Site Temperature, °C**	: 25
Phase	: 3	**Max. Altr Temp Rise, °C**	: 125
Fuel	: Diesel	**Project Voltage Distortion Limit, %**	:
Emissions	: EPA, stationary emergency application		

Loads Summary List

***Note: Detailed Loads and Step Report available below**

Step No.	Load Name	Quantity	Running		Starting		Peak		Dip Limits, %		VTHD% Limit
			kW	kVA	kW	kVA	kW	kVA	Vdip	Fdip	
Step01	Miscellaneous Single-Phase Load	1	4.08	4.8	4.08	4.8	None	None	15.0	10.0	0.0
Step Summary			4.0	5.0	4.0	5.0	None	None	15.0	10.0	0.0
Step02	Well Pump	1	2.73	3.33	16.83	25.5	None	None	15.0	10.0	0.0
Step Summary			3.0	3.0	17.0	26.0	None	None	15.0	10.0	0.0
Step03	Booster Pump	1	4.44	5.22	22.88	37.5	None	None	15.0	10.0	0.0
Step Summary			4.0	5.0	23.0	38.0	None	None	15.0	10.0	0.0
Project Summary			Running		Max Starting		Cumulative Step		Cumulative Peak		Project VTHD% Limit
			kW	kVA	kW	kVA	kW	kVA	kW	kVA	
			11.2	13.3	22.9	37.5	29.7	45.6	0.0	0.0	0.0

***Note: Detailed Loads and Step Report available below**

Power Generation

Loads and Steps Detail Report

Project - LLWS - Well 1

Comments -

Project Requirements

Frequency, Hz	: 60.0	**Generators Running in Parallel**	: 1
Duty	: Standby	**Site Altitude, ft(m)**	: 361(152)
Voltage	: 120/240, Series Delta	**Site Temperature, °C**	: 25
Phase	: 3	**Max. Altr Temp Rise, °C**	: 125
Fuel	: Diesel	**Project Voltage Distortion Limit, %**	:
Emissions	: EPA, stationary emergency application		

Calculated Individual Generator Set Load Running and Peak Requirements

Running kW	: 11.2	**Max. Step kW**	: 22.9 In Step 3	**Cumulative Step kW**	: 29.7
Running kVA	: 13.3	**Max. Step kVA**	: 37.5 In Step 3	**Cumulative Step kVA**	: 45.6
Running PF	: 0.84	**Peak kW**	: None	**Cumulative Peak kW**	: None
Running NLL kVA	: None	**Peak kVA**	: None	**Cumulative Peak kVA**	: None
Alternator kW	: 11.25				

Step1

Calculated Individual Generator Set Step Load Requirements

Running kW	: 4.0	**Starting kW**	: 4.0	**Cumulative Step kW**	: 4.0
Running kVA	: 5.0	**Starting kVA**	: 5.0	**Cumulative Step kVA**	: 5.0
Running Amps	: 12.0	**Starting Non-linear kVA**	: 0.0		
Running Non-linear kVA	: 0.0				
Alternator kW	: 4.08				
Voltage Distortion Limit for step	: 0				

Miscellaneous Single-Phase Load Single Phase Quantity : 1 In this Step

Category : User Defined

Running kW	: 4.08	**Starting kW**	: 4.08	**Peak kW**	: None
Running kVA	: 4.8	**Starting kVA**	: 4.8	**Peak kVA**	: None
Running PF	: 0.85	**Starting PF**	: 0.85	**Cyclic**	: No
Running Amps	: 20.0	**Max. % Voltage Dip**	: 15.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 4.08			**Voltage**	: 240

Step2

Calculated Individual Generator Set Step Load Requirements

Running kW	: 3.0	**Starting kW**	: 17.0	**Cumulative Step kW**	: 21.0
Running kVA	: 3.0	**Starting kVA**	: 26.0	**Cumulative Step kVA**	: 30.0
Running Amps	: 8.0	**Starting Non-linear kVA**	: 0.0		

Running Non-linear kVA	0.0				
Alternator kW	2.73				
Voltage Distortion Limit for step	0				

Well Pump Three Phase Quantity : 1 In this Step

Category : Motor

Running kW	2.73	**Starting kW**	16.83	**Peak kW**	None
Running kVA	3.33	**Starting kVA**	25.5	**Peak kVA**	None
Running PF	0.82	**Starting PF**	0.66	**Cyclic**	No
Running Amps	8.02	**Max. % Voltage Dip**	15.0	**Max. % Frequency Dip**	10.0
Alternator kW	2.73			**Voltage**	240

Shaft Hp	3.0	**Method**	Across the line
Shaft kW	2.24	**Low Inertia**	No
Efficiency (%)	0.82	**LRkVA Factor**	8.5
Design	Standard NEMA Design B,C or D	**LRkVA Code**	K
Load Factor	100.0		

Step3

Calculated Individual Generator Set Step Load Requirements

Running kW	4.0	**Starting kW**	23.0	**Cumulative Step kW**	30.0
Running kVA	5.0	**Starting kVA**	38.0	**Cumulative Step kVA**	46.0
Running Amps	13.0	**Starting Non-linear kVA**	0.0		
Running Non-linear kVA	0.0				
Alternator kW	4.44				
Voltage Distortion Limit for step	0				

Booster Pump Three Phase Quantity : 1 In this Step

Category : Motor

Running kW	4.44	**Starting kW**	22.88	**Peak kW**	None
Running kVA	5.22	**Starting kVA**	37.5	**Peak kVA**	None
Running PF	0.85	**Starting PF**	0.61	**Cyclic**	No
Running Amps	12.57	**Max. % Voltage Dip**	15.0	**Max. % Frequency Dip**	10.0
Alternator kW	4.44			**Voltage**	240

Shaft Hp	5.0	**Method**	Across the line
Shaft kW	3.73	**Low Inertia**	No
Efficiency (%)	0.84	**LRkVA Factor**	7.5
Design	Standard NEMA Design B,C or D	**LRkVA Code**	J
Load Factor	100.0		

Power Generation

Steps and Dips Details Report

Project - LLWS - Well 1

Project Requirements

Frequency, Hz	: 60.0	**Generators Running in Parallel**	: 1
Duty	: Standby	**Site Altitude, ft(m)**	: 361(152)
Voltage	: 120/240, Series Delta	**Site Temperature, °C**	: 25
Phase	: 3	**Max. Altr Temp Rise, °C**	: 125
Fuel	: Diesel	**Project Voltage Distortion Limit, %**	:
Emissions	: EPA, stationary emergency application		

Calculated Individual Generator Set Load Running and Peak Requirements

Running kW	: 11.2	**Max. Step kW**	: 22.9 In Step 3	**Cumulative Step kW**	: 29.7
Running kVA	: 13.3	**Max. Step kVA**	: 37.5 In Step 3	**Cumulative Step kVA**	: 45.6
Running PF	: 0.84	**Peak kW**	: None	**Cumulative Peak kW**	: None
Running NLL kVA	: 0.0	**Peak kVA**	: None	**Cumulative Peak kVA**	: None
Alternator kW	: 11.25				

Generator Set Configuration

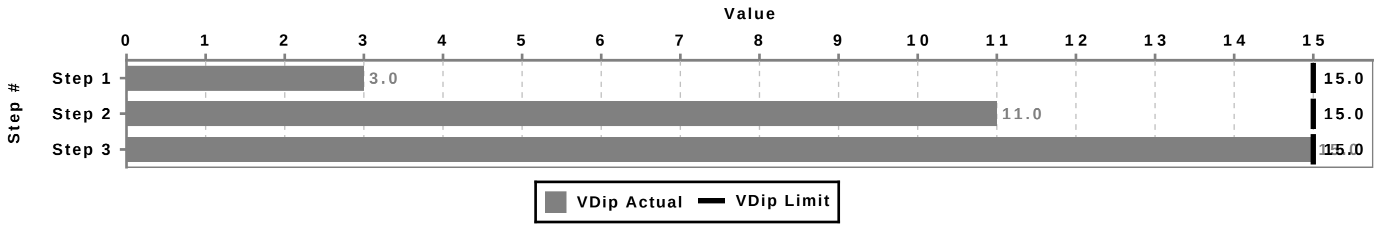
Model	: C35 D6	**Alternator**	: CA115-V14
Engine Model	: 4BT3.3-G5	**Excitation**	: EBS
Fuel	: Diesel		High Ambient

Step Level Dips Summary

Step #	Voltage Dip Limit (%)	Expected Step Voltage Dip (%)	Voltage Recovery Time (s) **	Frequency Dip Limit (%)	Expected Frequency Dip (%)	Frequency recovery Time (s) **
1	15	3	0.5	10	2	0.7
2	15	11	1.5	10	4	1.2
3	15	15	1.6	10	4	1.1

Note: Please refer to the model Spec. sheet for bandwidths used to report recovery times. For products manufactured in the United Kingdom it may be assumed that recovery times are based on ISO8528-5 G2 class bandwidths. Voltage and frequency recovery times are estimates. Typically, allow five to ten seconds between application of load steps when designing your system.

**Please note that in some cases the voltage and frequency recovery time estimates are not shown in list. This is a result of "dummy" data points temporarily being used to fill data gaps in the GenSize database. Please disregard these blank results.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11
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Step #
Step 1
Step 2
Step 3
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11.0
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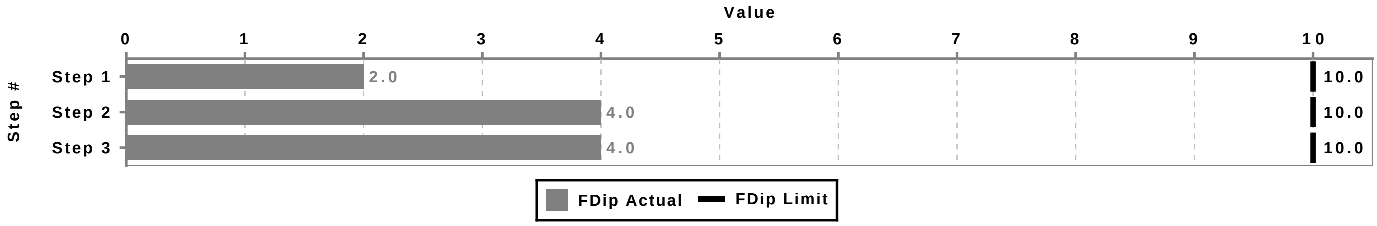
15.0
15.0
VDip Actual
VDip Limit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4
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6
7
8
9
10
Step #
Step 1
Step 2
Step 3
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4.0
4.0
10.0
10.0
10.0
FDip Actual
FDip Limit

Attachment 2

Well 2 Generator Sizing Report

Cummins Power Generation

Recommended Generator Report - C30 D6

Project - LLWS - Well 2

Comments -

Project Requirements

Frequency, Hz	: 60.0	**Generators Running in Parallel**	: 1
Duty	: Standby	**Site Altitude, ft(m)**	: 361(152)
Voltage	: 120/240, Series Delta	**Site Temperature, °C**	: 25
Phase	: 3	**Max. Altr Temp Rise, °C**	: 125
Fuel	: Diesel	**Project Voltage Distortion Limit, %**	: 10
Emissions	: EPA, stationary emergency application		

Calculated Individual Generator Set Load Running and Peak Requirements

Running kW	: 24.8	**Max. Step kW**	: 20.7 In Step 2	**Cumulative Step kW**	: 24.8
Running kVA	: 27.8	**Max. Step kVA**	: 23.0 In Step 2	**Cumulative Step kVA**	: 27.8
Running PF	: 0.89	**Peak kW**	: None	**Cumulative Peak kW**	: None
Running NLL kVA	: 23.0	**Peak kVA**	: None	**Cumulative Peak kVA**	: None
Alternator kW	: 45.52			**Pct Rated Capacity**	: 83.3

Generator Set Configuration

Alternator	: CA115-P14	**Engine**	: 4BT3.3-G5
BCode	: B986	**Fuel**	: Diesel
Excitation	: Shunt	**Displacement, cu in. (Litre)**	: 199.0(3.3)
Voltage Range	: 220/440-240/480	**Cylinders**	: 4
Number of Leads	: 6	**Altitude Knee, ft(m)**	: 10000(3048)
Reconnectable	: Yes	**Altitude Slope, % per 985ft(300.2m)**	: 3
Full Single Phase Output	: No	**Temperature Knee, °F(°C)**	: 122(50)
Increased Motor Starting	: No	**Temperature Slope, % per 18°F(10.0°C)**	: 6
Extended Stack	: No	**Emissions**	: Tier 3
		Cooling Package	: High Ambient

Set Performance / Load Requirements

Set Performance		Load Requirements	
Running At	: 83.3% Rated Capacity		
Max. Step Voltage Dip, %	: 14	**Max. Allowed Step Voltage Dip**	: 15 In Step 2
Max. Step Frequency Dip, %	: 3	**Max. Allowed Step Frequency Dip**	: 10 In Step 2
Peak Voltage Dip, %	:	**Peak Voltage Dip Limit %**	: 15.0
Peak Frequency Dip, %	:	**Peak Frequency Dip Limit %**	: 10
Site Rated Standby kW/kVA	: 30 / 38	**Running kW**	: 24.8
		Running kVA	: 27.8
Site Rated Max. SkW	: 39	**Effective Step kW**	: 23.3
Max. SkVA	: 71	**Effective Step kVA**	: 27.8
Temp Rise at Full Load, °C	: 120	**Percent Non-Linear Load**	: 84.0
Voltage Distortion	: 9.8	**Voltage Distortion Limit**	: 10
Site Rated Max Step kW Limit	:	**Max Step kW**	:

*Note: Higher temperature rise at full rated load.

*Note: All generator set power derates are based on open generator sets.

Power Generation

Loads Summary Report

Project - LLWS - Well 2

Comments -

Project Requirements

Frequency, Hz	: 60.0	**Generators Running in Parallel**	: 1
Duty	: Standby	**Site Altitude, ft(m)**	: 361(152)
Voltage	: 120/240, Series Delta	**Site Temperature, °C**	: 25
Phase	: 3	**Max. Altr Temp Rise, °C**	: 125
Fuel	: Diesel	**Project Voltage Distortion Limit, %**	: 10
Emissions	: EPA, stationary emergency application		

Loads Summary List

***Note: Detailed Loads and Step Report available below**

Step No.	Load Name	Quantity	Running		Starting		Peak		Dip Limits, %		VTHD% Limit
			kW	kVA	kW	kVA	kW	kVA	Vdip	Fdip	
Step01	Miscellaneous Single-Phase Load	1	4.08	4.8	4.08	4.8	None	None	15.0	10.0	0.0
Step Summary			4.0	5.0	4.0	5.0	None	None	15.0	10.0	0.0
Step02	Well Pump	1	20.72	23.02	20.72	23.02	None	None	15.0	10.0	10.0
Step Summary			21.0	23.0	21.0	23.0	None	None	15.0	10.0	10.0
Project Summary			Running		Max Starting		Cumulative Step		Cumulative Peak		Project VTHD% Limit
			kW	kVA	kW	kVA	kW	kVA	kW	kVA	
			24.8	27.8	20.7	23.0	24.8	27.8	0.0	0.0	10.0

***Note: Detailed Loads and Step Report available below**

Loads and Steps Detail Report

Project - LLWS - Well 2

Comments -

Project Requirements

Frequency, Hz	: 60.0	**Generators Running in Parallel**	: 1
Duty	: Standby	**Site Altitude, ft(m)**	: 361(152)
Voltage	: 120/240, Series Delta	**Site Temperature, °C**	: 25
Phase	: 3	**Max. Altr Temp Rise, °C**	: 125
Fuel	: Diesel	**Project Voltage Distortion Limit, %**	: 10
Emissions	: EPA, stationary emergency application		

Calculated Individual Generator Set Load Running and Peak Requirements

Running kW	: 24.8	**Max. Step kW**	: 20.7 In Step 2	**Cumulative Step kW**	: 24.8
Running kVA	: 27.8	**Max. Step kVA**	: 23.0 In Step 2	**Cumulative Step kVA**	: 27.8
Running PF	: 0.89	**Peak kW**	: None	**Cumulative Peak kW**	: None
Running NLL kVA	: 23.0	**Peak kVA**	: None	**Cumulative Peak kVA**	: None
Alternator kW	: 45.52				

Step1

Calculated Individual Generator Set Step Load Requirements

Running kW	: 4.0	**Starting kW**	: 4.0	**Cumulative Step kW**	: 4.0
Running kVA	: 5.0	**Starting kVA**	: 5.0	**Cumulative Step kVA**	: 5.0
Running Amps	: 12.0	**Starting Non-linear kVA**	: 0.0		
Running Non-linear kVA	: 0.0				
Alternator kW	: 4.08				
Voltage Distortion Limit for step	: 0				

Miscellaneous Single-Phase Load Single Phase Quantity : 1 In this Step

Category : User Defined

Running kW	: 4.08	**Starting kW**	: 4.08	**Peak kW**	: None
Running kVA	: 4.8	**Starting kVA**	: 4.8	**Peak kVA**	: None
Running PF	: 0.85	**Starting PF**	: 0.85	**Cyclic**	: No
Running Amps	: 20.0	**Max. % Voltage Dip**	: 15.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 4.08			**Voltage**	: 240

Step2

Calculated Individual Generator Set Step Load Requirements

Running kW	: 21.0	**Starting kW**	: 21.0	**Cumulative Step kW**	: 25.0
Running kVA	: 23.0	**Starting kVA**	: 23.0	**Cumulative Step kVA**	: 28.0
Running Amps	: 55.0	**Starting Non-linear kVA**	: 23.0		

Running Non-linear kVA	: 23.0				
Alternator kW	: 41.44				
Voltage Distortion Limit for step	: 10				

Well Pump Three Phase Quantity : 1 In this Step

Category : Motor

Running kW	: 20.72	**Starting kW**	: 20.72	**Peak kW**	: None
Running kVA	: 23.02	**Starting kVA**	: 23.02	**Peak kVA**	: None
Running PF	: 0.9	**Starting PF**	: 0.9	**Cyclic**	: No
Running Amps	: 55.44	**Max. % Voltage Dip**	: 15.0	**Max. % Frequency Dip**	: 10.0
Running NLL kVA	: 23.02				
Starting NLL kVA	: 23.02			**Voltage**	: 240
Alternator kW	: 41.44				

Shaft Hp	: 25.0	**Type**	: Variable Frequency Drive
Shaft kW	: 18.65	**Ramp Details**	: None
Rectifier Type	: 6 pulse	**THDI %**	: 26
Efficiency (%)	: 0.9	**THDV %**	: 10
Load Factor	: 100.0		

Power Generation

Steps and Dips Details Report

Project - LLWS - Well 2

Project Requirements

Frequency, Hz	: 60.0	**Generators Running in Parallel**	: 1
Duty	: Standby	**Site Altitude, ft(m)**	: 361(152)
Voltage	: 120/240, Series Delta	**Site Temperature, °C**	: 25
Phase	: 3	**Max. Altr Temp Rise, °C**	: 125
Fuel	: Diesel	**Project Voltage Distortion Limit, %**	: 10
Emissions	: EPA, stationary emergency application		

Calculated Individual Generator Set Load Running and Peak Requirements

Running kW	: 24.8	**Max. Step kW**	: 20.7 In Step 2	**Cumulative Step kW**	: 24.8
Running kVA	: 27.8	**Max. Step kVA**	: 23.0 In Step 2	**Cumulative Step kVA**	: 27.8
Running PF	: 0.89	**Peak kW**	: None	**Cumulative Peak kW**	: None
Running NLL kVA	: 23.0	**Peak kVA**	: None	**Cumulative Peak kVA**	: None
Alternator kW	: 45.52				

Generator Set Configuration

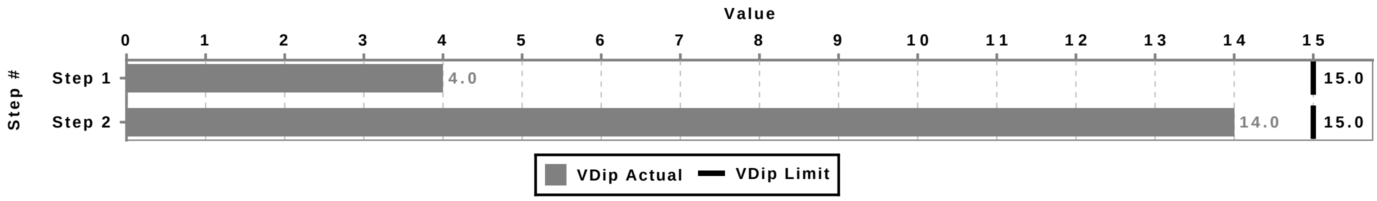
Model	: C30 D6	**Alternator**	: CA115-P14
Engine Model	: 4BT3.3-G5	**Excitation**	: Shunt
Fuel	: Diesel		High Ambient

Step Level Dips Summary

Step #	Voltage Dip Limit (%)	Expected Step Voltage Dip (%)	Voltage Recovery Time (s) **	Frequency Dip Limit (%)	Expected Frequency Dip (%)	Frequency recovery Time (s) **
1	15	4	0.4	10	2	0.2
2	15	14	1.9	10	3	1.3

Note: Please refer to the model Spec. sheet for bandwidths used to report recovery times. For products manufactured in the United Kingdom it may be assumed that recovery times are based on ISO8528-5 G2 class bandwidths. Voltage and frequency recovery times are estimates. Typically, allow five to ten seconds between application of load steps when designing your system.

**Please note that in some cases the voltage and frequency recovery time estimates are not shown in list. This is a result of "dummy" data points temporarily being used to fill data gaps in the GenSize database. Please disregard these blank results.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Step #
Step 1
Step 2
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14.0
15.0
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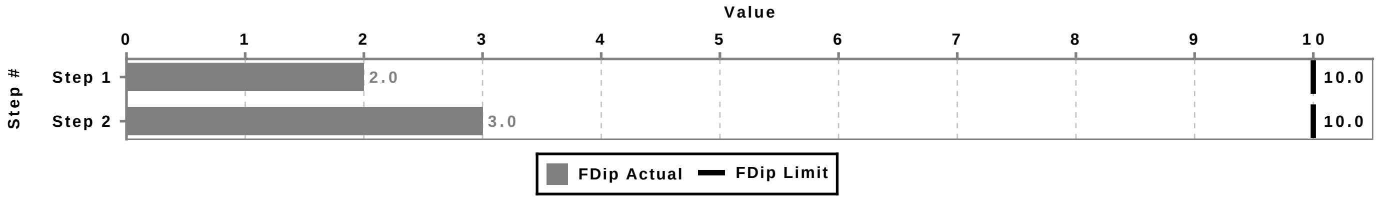
VDip Actual
VDip Limit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Step #
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10.0
10.0
FDip Actual
FDip Limit

Attachment 3

Well 4 Generator Sizing Report

Recommended Generator Report - C40 D6

Project - LLWS - Well 4

Comments -

Project Requirements

Frequency, Hz	60.0	**Generators Running in Parallel**	1
Duty	Standby	**Site Altitude, ft(m)**	361(152)
Voltage	120/240, Series Delta	**Site Temperature, °C**	25
Phase	3	**Max. Altr Temp Rise, °C**	125
Fuel	Diesel	**Project Voltage Distortion Limit, %**	10
Emissions	EPA, stationary emergency application		

Calculated Individual Generator Set Load Running and Peak Requirements

Running kW	21.0	**Max. Step kW**	28.1 In Step 3	**Cumulative Step kW**	42.5
Running kVA	24.0	**Max. Step kVA**	50.2 In Step 3	**Cumulative Step kVA**	66.7
Running PF	0.88	**Peak kW**	None	**Cumulative Peak kW**	None
Running NLL kVA	9.2	**Peak kVA**	None	**Cumulative Peak kVA**	None
Alternator kW	29.28			**Pct Rated Capacity**	52.5

Generator Set Configuration

Alternator	CA125-J14	**Engine**	4BT3.3-G5
BCode	BB94	**Fuel**	Diesel
Excitation	PMG	**Displacement, cu in. (Litre)**	199.0(3.3)
Voltage Range	240/120V	**Cylinders**	4
Number of Leads	12	**Altitude Knee, ft(m)**	5500(1676)
Reconnectable	Yes	**Altitude Slope, % per 985ft(300.2m)**	3
Full Single Phase Output	No	**Temperature Knee, °F(°C)**	104(40)
Increased Motor Starting	No	**Temperature Slope, % per 18°F(10.0°C)**	6
Extended Stack	No	**Emissions**	Tier 3
		Cooling Package	High Ambient

Set Performance / Load Requirements

Set Performance		Load Requirements	
Running At	52.5% Rated Capacity		
Max. Step Voltage Dip, %	12	**Max. Allowed Step Voltage Dip**	15 In Step 3
Max. Step Frequency Dip, %	3	**Max. Allowed Step Frequency Dip**	10 In Step 3
Peak Voltage Dip, %		**Peak Voltage Dip Limit %**	15.0
Peak Frequency Dip, %		**Peak Frequency Dip Limit %**	10
Site Rated Standby kW/kVA	40 / 50	**Running kW**	21.0
		Running kVA	24.0
Site Rated Max. SkW	42	**Effective Step kW**	34.5
Max. SkVA	181	**Effective Step kVA**	66.7
Temp Rise at Full Load, °C	105	**Percent Non-Linear Load**	39.0
Voltage Distortion	3.2	**Voltage Distortion Limit**	10
Site Rated Max Step kW Limit		**Max Step kW**	

*Note: Higher temperature rise at full rated load.

*Note: All generator set power derates are based on open generator sets.

Loads Summary Report

Project - LLWS - Well 4

Comments -

Project Requirements

Frequency, Hz	:	60.0	**Generators Running in Parallel**	:	1
Duty	:	Standby	**Site Altitude, ft(m)**	:	361(152)
Voltage	:	120/240, Series Delta	**Site Temperature, °C**	:	25
Phase	:	3	**Max. Altr Temp Rise, °C**	:	125
Fuel	:	Diesel	**Project Voltage Distortion Limit, %**	:	10
Emissions	:	EPA, stationary emergency application			

Loads Summary List

***Note: Detailed Loads and Step Report available below**

Step No.	Load Name	Quantity	Running		Starting		Peak		Dip Limits, %		VTHD% Limit
			kW	kVA	kW	kVA	kW	kVA	Vdip	Fdip	
Step01	Miscellaneous Single-Phase Load	1	6.12	7.2	6.12	7.2	None	None	15.0	10.0	0.0
Step Summary			6.0	7.0	6.0	7.0	None	None	15.0	10.0	0.0
Step02	Well Pump	1	8.29	9.21	8.29	9.21	None	None	15.0	10.0	10.0
Step Summary			8.0	9.0	8.0	9.0	None	None	15.0	10.0	10.0
Step03	Booster Pump	1	6.58	7.56	28.14	50.25	None	None	15.0	10.0	0.0
Step Summary			7.0	8.0	28.0	50.0	None	None	15.0	10.0	10.0
Project Summary			Running		Max Starting		Cumulative Step		Cumulative Peak		Project VTHD% Limit
			kW	kVA	kW	kVA	kW	kVA	kW	kVA	
			21.0	24.0	28.1	50.2	42.5	66.7	0.0	0.0	10.0

***Note: Detailed Loads and Step Report available below**

Power Generation

Loads and Steps Detail Report

Project - LLWS - Well 4

Comments -

Project Requirements

Frequency, Hz	: 60.0	**Generators Running in Parallel**	: 1
Duty	: Standby	**Site Altitude, ft(m)**	: 361(152)
Voltage	: 120/240, Series Delta	**Site Temperature, °C**	: 25
Phase	: 3	**Max. Altr Temp Rise, °C**	: 125
Fuel	: Diesel	**Project Voltage Distortion Limit, %**	: 10
Emissions	: EPA, stationary emergency application		

Calculated Individual Generator Set Load Running and Peak Requirements

Running kW	: 21.0	**Max. Step kW**	: 28.1 In Step 3	**Cumulative Step kW**	: 42.5
Running kVA	: 24.0	**Max. Step kVA**	: 50.2 In Step 3	**Cumulative Step kVA**	: 66.7
Running PF	: 0.88	**Peak kW**	: None	**Cumulative Peak kW**	: None
Running NLL kVA	: 9.2	**Peak kVA**	: None	**Cumulative Peak kVA**	: None
Alternator kW	: 29.28				

Step1

Calculated Individual Generator Set Step Load Requirements

Running kW	: 6.0	**Starting kW**	: 6.0	**Cumulative Step kW**	: 6.0
Running kVA	: 7.0	**Starting kVA**	: 7.0	**Cumulative Step kVA**	: 7.0
Running Amps	: 17.0	**Starting Non-linear kVA**	: 0.0		
Running Non-linear kVA	: 0.0				
Alternator kW	: 6.12				
Voltage Distortion Limit for step	: 0				

Miscellaneous Single-Phase Load Single Phase Quantity : 1 In this Step

Category : User Defined

Running kW	: 6.12	**Starting kW**	: 6.12	**Peak kW**	: None
Running kVA	: 7.2	**Starting kVA**	: 7.2	**Peak kVA**	: None
Running PF	: 0.85	**Starting PF**	: 0.85	**Cyclic**	: No
Running Amps	: 30.0	**Max. % Voltage Dip**	: 15.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 6.12			**Voltage**	: 240

Step2

Calculated Individual Generator Set Step Load Requirements

Running kW	: 8.0	**Starting kW**	: 8.0	**Cumulative Step kW**	: 14.0
Running kVA	: 9.0	**Starting kVA**	: 9.0	**Cumulative Step kVA**	: 16.0
Running Amps	: 22.0	**Starting Non-linear kVA**	: 9.0		

Running Non-linear kVA	: 9.0				
Alternator kW	: 16.58				
Voltage Distortion Limit for step	: 10				

Well Pump Three Phase Quantity : 1 In this Step

Category : Motor

Running kW	: 8.29	**Starting kW**	: 8.29	**Peak kW**	: None
Running kVA	: 9.21	**Starting kVA**	: 9.21	**Peak kVA**	: None
Running PF	: 0.9	**Starting PF**	: 0.9	**Cyclic**	: No
Running Amps	: 22.18	**Max. % Voltage Dip**	: 15.0	**Max. % Frequency Dip**	: 10.0
Running NLL kVA	: 9.21				
Starting NLL kVA	: 9.21			**Voltage**	: 240
Alternator kW	: 16.58				

Shaft Hp	: 10.0	**Type**	: Variable Frequency Drive
Shaft kW	: 7.46	**Ramp Details**	: None
Rectifier Type	: 6 pulse	**THDI %**	: 26
Efficiency (%)	: 0.9	**THDV %**	: 10
Load Factor	: 100.0		

Step3

Calculated Individual Generator Set Step Load Requirements

Running kW	: 7.0	**Starting kW**	: 28.0	**Cumulative Step kW**	: 43.0
Running kVA	: 8.0	**Starting kVA**	: 50.0	**Cumulative Step kVA**	: 67.0
Running Amps	: 18.0	**Starting Non-linear kVA**	: 0.0		
Running Non-linear kVA	: 0.0				
Alternator kW	: 6.58				
Voltage Distortion Limit for step	: 10				

Booster Pump Three Phase Quantity : 1 In this Step

Category : Motor

Running kW	: 6.58	**Starting kW**	: 28.14	**Peak kW**	: None
Running kVA	: 7.56	**Starting kVA**	: 50.25	**Peak kVA**	: None
Running PF	: 0.87	**Starting PF**	: 0.56	**Cyclic**	: No
Running Amps	: 18.21	**Max. % Voltage Dip**	: 15.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 6.58			**Voltage**	: 240

Shaft Hp	: 7.5	**Method**	: Across the line
Shaft kW	: 5.59	**Low Inertia**	: No
Efficiency (%)	: 0.85	**LRkVA Factor**	: 6.7
Design	: Standard NEMA Design B,C or D	**LRkVA Code**	: H
Load Factor	: 100.0		

Power Generation

Steps and Dips Details Report

Project - LLWS - Well 4

Project Requirements

Frequency, Hz	:	60.0	**Generators Running in Parallel**	:	1
Duty	:	Standby	**Site Altitude, ft(m)**	:	361(152)
Voltage	:	120/240, Series Delta	**Site Temperature, °C**	:	25
Phase	:	3	**Max. Altr Temp Rise, °C**	:	125
Fuel	:	Diesel	**Project Voltage Distortion Limit, %**	:	10
Emissions	:	EPA, stationary emergency application			

Calculated Individual Generator Set Load Running and Peak Requirements

Running kW	:	21.0	**Max. Step kW**	:	28.1 In Step 3	**Cumulative Step kW**	:	42.5
Running kVA	:	24.0	**Max. Step kVA**	:	50.2 In Step 3	**Cumulative Step kVA**	:	66.7
Running PF	:	0.88	**Peak kW**	:	None	**Cumulative Peak kW**	:	None
Running NLL kVA	:	9.2	**Peak kVA**	:	None	**Cumulative Peak kVA**	:	None
Alternator kW	:	29.28						

Generator Set Configuration

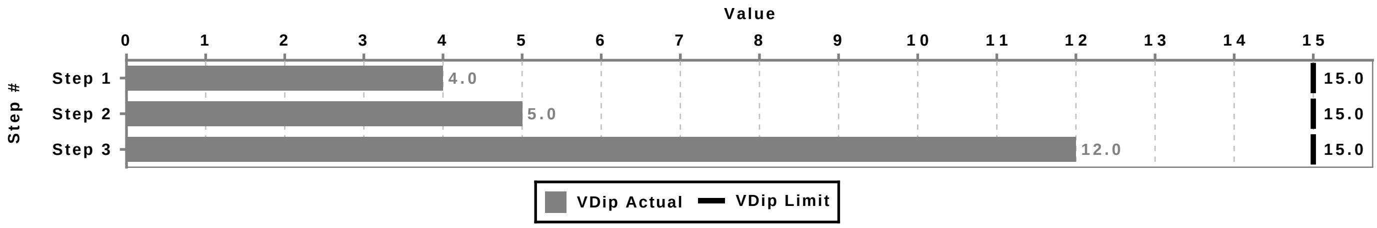
Model	:	C40 D6	**Alternator**	:	CA125-J14
Engine Model	:	4BT3.3-G5	**Excitation**	:	PMG
Fuel	:	Diesel			High Ambient

Step Level Dips Summary

Step #	Voltage Dip Limit (%)	Expected Step Voltage Dip (%)	Voltage Recovery Time (s) **	Frequency Dip Limit (%)	Expected Frequency Dip (%)	Frequency recovery Time (s) **
1	15	4	0.8	10	1	0.3
2	15	5	1.0	10	1	0.3
3	15	12	2.6	10	3	0.6

Note: Please refer to the model Spec. sheet for bandwidths used to report recovery times. For products manufactured in the United Kingdom it may be assumed that recovery times are based on ISO8528-5 G2 class bandwidths. Voltage and frequency recovery times are estimates. Typically, allow five to ten seconds between application of load steps when designing your system.

**Please note that in some cases the voltage and frequency recovery time estimates are not shown in list. This is a result of "dummy" data points temporarily being used to fill data gaps in the GenSize database. Please disregard these blank results.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Step 2
Step 3
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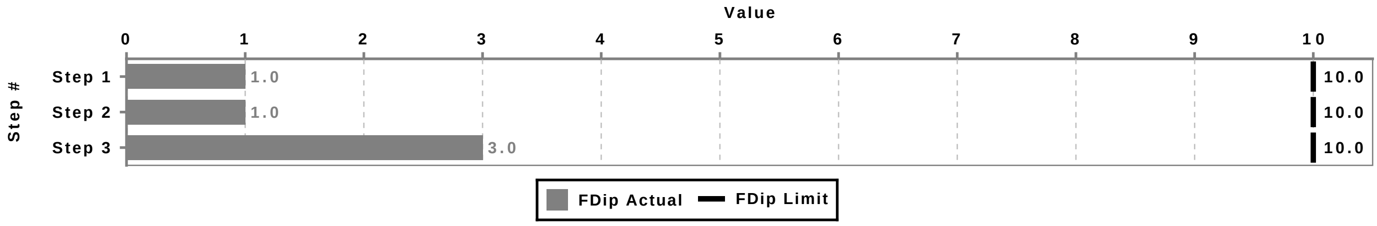
15.0
VDip Actual
VDip Limit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Step #
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Step 2
Step 3
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10.0
10.0
10.0
FDip Actual
FDip Limit

Attachment 4

Well 5 Generator Sizing Report

Power Generation

Recommended Generator Report - C25 D6

Project - LLWS - Well 5

Comments -

Project Requirements

Frequency, Hz	60.0	**Generators Running in Parallel**	1
Duty	Standby	**Site Altitude, ft(m)**	361(152)
Voltage	120/240, Series Delta	**Site Temperature, °C**	25
Phase	3	**Max. Altr Temp Rise, °C**	125
Fuel	Diesel	**Project Voltage Distortion Limit, %**	10
Emissions	EPA, stationary emergency application		

Calculated Individual Generator Set Load Running and Peak Requirements

Running kW	12.4	**Max. Step kW**	8.3 In Step 2	**Cumulative Step kW**	12.4
Running kVA	14.0	**Max. Step kVA**	9.2 In Step 2	**Cumulative Step kVA**	14.0
Running PF	0.88	**Peak kW**	None	**Cumulative Peak kW**	None
Running NLL kVA	9.2	**Peak kVA**	None	**Cumulative Peak kVA**	None
Alternator kW	20.66			**Pct Rated Capacity**	48.0

Generator Set Configuration

Alternator	CA115-L14	**Engine**	4BT3.3-G5
BCode	B986	**Fuel**	Diesel
Excitation	Shunt	**Displacement, cu in. (Litre)**	199.0(3.3)
Voltage Range	220/440-240/480	**Cylinders**	4
Number of Leads	6	**Altitude Knee, ft(m)**	10000(3048)
Reconnectable	Yes	**Altitude Slope, % per 985ft(300.2m)**	3
Full Single Phase Output	No	**Temperature Knee, °F(°C)**	122(50)
Increased Motor Starting	No	**Temperature Slope, % per 18°F(10.0°C)**	6
Extended Stack	No	**Emissions**	Tier 3
		Cooling Package	High Ambient

Set Performance		Load Requirements	
Running At	48.0% Rated Capacity		
Max. Step Voltage Dip, %	7	**Max. Allowed Step Voltage Dip**	15 In Step 2
Max. Step Frequency Dip, %	2	**Max. Allowed Step Frequency Dip**	10 In Step 2
Peak Voltage Dip, %		**Peak Voltage Dip Limit %**	15.0
Peak Frequency Dip, %		**Peak Frequency Dip Limit %**	10
Site Rated Standby kW/kVA	25 / 31	**Running kW**	12.4
		Running kVA	14.0
Site Rated Max. SkW	39	**Effective Step kW**	12.4
Max. SkVA	59	**Effective Step kVA**	14.0
Temp Rise at Full Load, °C	120	**Percent Non-Linear Load**	67.0
Voltage Distortion	4.7	**Voltage Distortion Limit**	10
Site Rated Max Step kW Limit		**Max Step kW**	

*Note: Higher temperature rise at full rated load.

*Note: All generator set power derates are based on open generator sets.

Power Generation

Loads Summary Report

Project - LLWS - Well 5

Comments -

Project Requirements

Frequency, Hz	: 60.0	**Generators Running in Parallel**	: 1
Duty	: Standby	**Site Altitude, ft(m)**	: 361(152)
Voltage	: 120/240, Series Delta	**Site Temperature, °C**	: 25
Phase	: 3	**Max. Altr Temp Rise, °C**	: 125
Fuel	: Diesel	**Project Voltage Distortion Limit, %**	: 10
Emissions	: EPA, stationary emergency application		

Loads Summary List

***Note: Detailed Loads and Step Report available below**

Step No.	Load Name	Quantity	Running		Starting		Peak		Dip Limits, %		VTHD% Limit
			kW	kVA	kW	kVA	kW	kVA	Vdip	Fdip	
Step01	Miscellaneous Single-Phase Load	1	4.08	4.8	4.08	4.8	None	None	15.0	10.0	0.0
Step Summary			4.0	5.0	4.0	5.0	None	None	15.0	10.0	0.0
Step02	Well Pump	1	8.29	9.21	8.29	9.21	None	None	15.0	10.0	10.0
Step Summary			8.0	9.0	8.0	9.0	None	None	15.0	10.0	10.0
Project Summary			Running		Max Starting		Cumulative Step		Cumulative Peak		Project VTHD% Limit
			kW	kVA	kW	kVA	kW	kVA	kW	kVA	
			12.4	14.0	8.3	9.2	12.4	14.0	0.0	0.0	10.0

***Note: Detailed Loads and Step Report available below**

Cummins Power Generation

Loads and Steps Detail Report

Project - LLWS - Well 5

Comments -

Project Requirements

Frequency, Hz	: 60.0	**Generators Running in Parallel**	: 1
Duty	: Standby	**Site Altitude, ft(m)**	: 361(152)
Voltage	: 120/240, Series Delta	**Site Temperature, °C**	: 25
Phase	: 3	**Max. Altr Temp Rise, °C**	: 125
Fuel	: Diesel	**Project Voltage Distortion Limit, %**	: 10
Emissions	: EPA, stationary emergency application		

Calculated Individual Generator Set Load Running and Peak Requirements

Running kW	: 12.4	**Max. Step kW**	: 8.3 In Step 2	**Cumulative Step kW**	: 12.4
Running kVA	: 14.0	**Max. Step kVA**	: 9.2 In Step 2	**Cumulative Step kVA**	: 14.0
Running PF	: 0.88	**Peak kW**	: None	**Cumulative Peak kW**	: None
Running NLL kVA	: 9.2	**Peak kVA**	: None	**Cumulative Peak kVA**	: None
Alternator kW	: 20.66				

Step1

Calculated Individual Generator Set Step Load Requirements

Running kW	: 4.0	**Starting kW**	: 4.0	**Cumulative Step kW**	: 4.0
Running kVA	: 5.0	**Starting kVA**	: 5.0	**Cumulative Step kVA**	: 5.0
Running Amps	: 12.0	**Starting Non-linear kVA**	: 0.0		
Running Non-linear kVA	: 0.0				
Alternator kW	: 4.08				
Voltage Distortion Limit for step	: 0				

Miscellaneous Single-Phase Load Single Phase Quantity : 1 In this Step

Category : User Defined

Running kW	: 4.08	**Starting kW**	: 4.08	**Peak kW**	: None
Running kVA	: 4.8	**Starting kVA**	: 4.8	**Peak kVA**	: None
Running PF	: 0.85	**Starting PF**	: 0.85	**Cyclic**	: No
Running Amps	: 20.0	**Max. % Voltage Dip**	: 15.0	**Max. % Frequency Dip**	: 10.0
Alternator kW	: 4.08			**Voltage**	: 240

Step2

Calculated Individual Generator Set Step Load Requirements

Running kW	: 8.0	**Starting kW**	: 8.0	**Cumulative Step kW**	: 12.0
Running kVA	: 9.0	**Starting kVA**	: 9.0	**Cumulative Step kVA**	: 14.0
Running Amps	: 22.0	**Starting Non-linear kVA**	: 9.0		

Running Non-linear kVA	: 9.0				
Alternator kW	: 16.58				
Voltage Distortion Limit for step	: 10				

Well Pump	Three Phase	Quantity	: 1 In this Step
Category	: Motor		

Running kW	: 8.29	**Starting kW**	: 8.29	**Peak kW**	: None
Running kVA	: 9.21	**Starting kVA**	: 9.21	**Peak kVA**	: None
Running PF	: 0.9	**Starting PF**	: 0.9	**Cyclic**	: No
Running Amps	: 22.18	**Max. % Voltage Dip**	: 15.0	**Max. % Frequency Dip**	: 10.0
Running NLL kVA	: 9.21				
Starting NLL kVA	: 9.21			**Voltage**	: 240
Alternator kW	: 16.58				

Shaft Hp	: 10.0	**Type**	: Variable Frequency Drive
Shaft kW	: 7.46	**Ramp Details**	: None
Rectifier Type	: 6 pulse	**THDI %**	: 26
Efficiency (%)	: 0.9	**THDV %**	: 10
Load Factor	: 100.0		

Steps and Dips Details Report

Project - LLWS - Well 5

Project Requirements

Frequency, Hz	: 60.0	**Generators Running in Parallel**	: 1
Duty	: Standby	**Site Altitude, ft(m)**	: 361(152)
Voltage	: 120/240, Series Delta	**Site Temperature, °C**	: 25
Phase	: 3	**Max. Altr Temp Rise, °C**	: 125
Fuel	: Diesel	**Project Voltage Distortion Limit, %**	: 10
Emissions	: EPA, stationary emergency application		

Calculated Individual Generator Set Load Running and Peak Requirements

Running kW	: 12.4	**Max. Step kW**	: 8.3 In Step 2	**Cumulative Step kW**	: 12.4
Running kVA	: 14.0	**Max. Step kVA**	: 9.2 In Step 2	**Cumulative Step kVA**	: 14.0
Running PF	: 0.88	**Peak kW**	: None	**Cumulative Peak kW**	: None
Running NLL kVA	: 9.2	**Peak kVA**	: None	**Cumulative Peak kVA**	: None
Alternator kW	: 20.66				

Generator Set Configuration

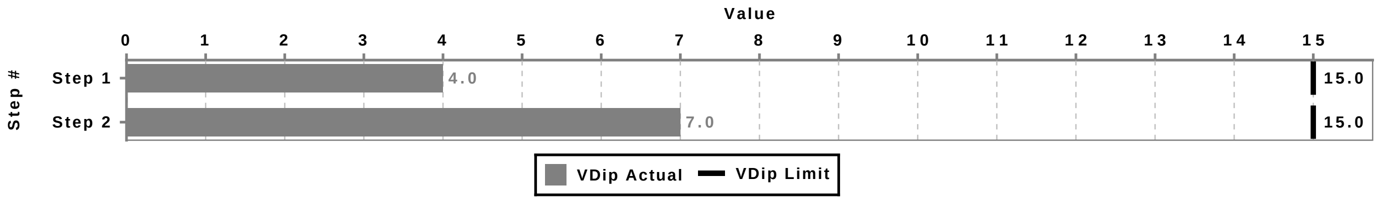
Model	: C25 D6	**Alternator**	: CA115-L14
Engine Model	: 4BT3.3-G5	**Excitation**	: Shunt
Fuel	: Diesel		High Ambient

Step Level Dips Summary

Step #	Voltage Dip Limit (%)	Expected Step Voltage Dip (%)	Voltage Recovery Time (s) **	Frequency Dip Limit (%)	Expected Frequency Dip (%)	Frequency recovery Time (s) **
1	15	4	0.6	10	1	0.2
2	15	7	1.3	10	2	0.4

Note: Please refer to the model Spec. sheet for bandwidths used to report recovery times. For products manufactured in the United Kingdom it may be assumed that recovery times are based on ISO8528-5 G2 class bandwidths. Voltage and frequency recovery times are estimates. Typically, allow five to ten seconds between application of load steps when designing your system.

**Please note that in some cases the voltage and frequency recovery time estimates are not shown in list. This is a result of "dummy" data points temporarily being used to fill data gaps in the GenSize database. Please disregard these blank results.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Step #
Step 1
Step 2
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7.0
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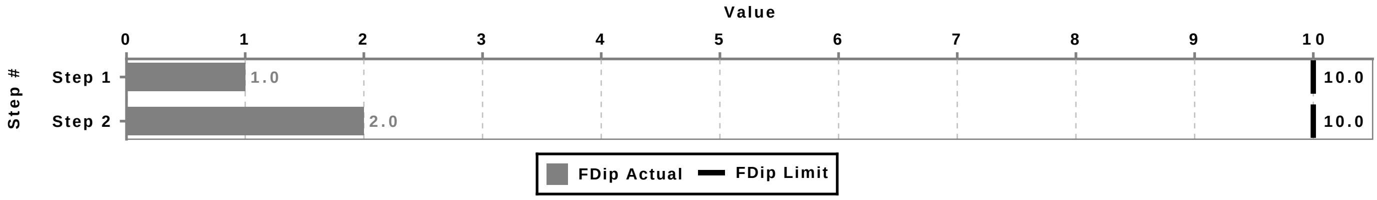
VDip Actual
VDip Limit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FDip Actual
FDip Limit