Western State Hospital – Lakewood, WA

Campus Essential Electrical Systems

August 3, 2018

STUDY

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1.0 Executive Summary

Hargis Engineers, Inc. (Hargis) was retained by the State of Washington to provide a high-level study of the existing campus essential electrical systems at the Western State Hospital Campus in Lakewood, WA. The essential electrical systems are defined by NFPA 99 as a system comprised of alternate sources of power and all connected distribution systems and ancillary equipment, designed to ensure continuity of electrical power to designated areas and functions of a health care facility during disruption of normal power sources, and also to minimize disruption within the internal wiring system. This study is in response to recent aging/failing equipment with a desire for improved electrical system reliability, redundancy and capacity to support the campus needs of today as well as the long term goals. Actual size of equipment for future capacity will need to be confirmed with the campus master plan.

In addition, we have reviewed emergency/standby generator codes for how and when emergency or standby power is needed within a building or space. This review is to help the owner classify their generators and power distribution systems as well as maintenance requirements based on the classification of the emergency and standby power systems. This study did not review individual building electrical distribution systems or their emergency power requirements.

Most of the electrical systems addressed in this report are nearing or at the end of their economic and useful lives of 20 to 40 years. Inadequate, unreliable, and in some cases unsafe, these existing electrical systems are a significant liability. Isolated equipment failures have occurred multiple times over the last few years, impacting operations and requiring immediate resources for system repairs; however, because of the system redundancy there was no significant downtime to the facility. The replacement of these systems is essential to provide the reliable electrical infrastructure necessary to meet the operational, security and life safety requirements at this facility.

Without the necessary system improvements, this pattern of equipment failure will inevitably increase. When large electrical equipment or cabling fails, considerable portions of the facility could be without utility or backup power for months, significantly impacting facility operations, life safety, and security. Since much of the electrical equipment is unique for the application, 6 to 9 months is often required to procure replacement equipment. Emergency repairs are costly, address only the immediate problem, and do not provide a mechanism for necessary strategic system improvements.

Most importantly, continued use of the existing electrical equipment could potentially lead to a significant safety event resulting in injuries - or even loss of life - to staff, contractors, or patients. Catastrophic failure of equipment with known problems, such as the existing medium voltage sectionalizing equipment, is very possible. Failure of emergency generators or ancillary equipment could hamper efforts to adequately respond to a fire or other life safety events. This equipment needs to be replaced, not repaired.

Funding is needed to provide a safe and reliable electrical infrastructure that will serve the facility for decades, while allowing necessary system improvements to be accomplished in a strategically-planned and cost-effective manner.

Table 1

Option	Title	Scope	Rationale	Cost	Risks and Disadvantages
1	Replace medium voltage distribution equipment and transfer switches that have failed or are have exceed their expected useful life and essential to the campus distribution equipment	• New Medium Voltage transfer switches for ATS #1 and ATS #2 and add maintenance bypass. • New Medium Voltage switchgear for distribution equipment for dual fed utility Main-Tie-Main with vacuum breakers and protective relays. • Replace medium voltage Buss #1 and Buss #2 with new lineup of metal clad switchgear with vacuum breakers and protective relays.	The existing medium voltage distribution equipment and transfer switches have failed and spare parts are no longer available. These need to be replaced. Four of the six sections of medium voltage Buss #1 and Buss #2 have been operational for beyond their expected useful life and need to be replaced. Add maintenance bypass to the new transfer switches to allow maintenance and repair without having to shutoff buildings on campus.	$3,358,331	Replacing the equipment like for like does not address the other campus needs for additional capacity and redundancy and the design should consider future needs from a capacity and redundancy. Replacing equipment in its current locations will require extensive shutdowns or running on generator for long periods of time and will put the facility at risk of losing power if some of the existing equipment fails during construction.
2	Install new generators and add paralleling equipment.	• Perform work from Part 1 • Replace Generators #1 & #2 with three 1250 kW 480V generators • Add paralleling gear and master controller • New transformers to feed 4,160V loops	Existing Generator #1 has reached its expected life and should not be relied upon to provide backup power for an additional 20+ years. Adding capacity and redundancy to the system needs to be considered when sizing the equipment. At a minimum an additional 25% capacity is needed for the campus to maintain current operations and have flexibility to remodel without adding to the campus. Paralleling generators will help to maximize the equipment and provide additional capacity and redundancy where it's needed.	$3,443,055	Replacing equipment in its current location will not be possible if this option is taken. Coordinating locations of new equipment as well as cutovers to prevent downtime will need to be a large consideration of the future design and can have an impact on overall cost. Size of equipment will need to be verified with the campus master plan
3	• Remove Generator #4 • Replace Building 29 transfer switches	• Remove Generator #4 • Add transformer and equipment so loads from Generator #4 can be added to Generator #5. • Add remote generator docking station to allow for remote generator or load bank testing. • Replace transfer switches in Building 29	• Generator #4 is beyond its expected useful life and replacement parts are becoming more difficult to find. Generator #5 has spare capacity to allow the loads from Generator #4 to be added to Generator #5. • Add a remote generator docking station to provide the ability to easily connect a generator in the event that Generator #4 fails. • Replace aging transfer switches that have reached their expected useful life	$809,657	Adding loads to Generator #5 may have an impact on any expansion projects of building 28.

2.0 Introduction

2.1 Background

Western State Hospital, established in 1871, is the largest inpatient psychiatric facility in the State of Washington. It occupies a 264 acre campus including 44 buildings totaling 1.1 million square feet and currently serving over 900 patients with approximately 1,750 staff positions and 800 beds. Western State Hospital is operated by the Behavioral Health and Services Integration Administration (BHSIA) of the Washington Department of Social and Health Services (DSHS). The entire WSH site is located within the site of Fort Steilacoom which is listed on the National Register of Historic Places and requires additional site preparation, planning and execution when the scope of work includes disturbing the grounds for digging and excavation.

The campus is comprised of Western State Hospital (WSH) and the Child Study and Treatment Center (CSTC) and includes specialized secure units including the Center for Forensic Services (CFS) for patients who have been committed to Western State Hospital by a court of law or meet the criteria for involuntary treatment. Given the population served, WSH is committed to providing a safe environment for patients, staff, and the surrounding community.

In addition to the code-required emergency power within the buildings, the campus is required to have an emergency disaster plan. The facility is required to establish and implement an emergency disaster plan including shelter, heat and power for critical functions for three days. The majority of the campus currently has generator backup power which is critical for the campus to stay operational on a 24 hours a day/7 days a week basis. Prolonged interruptions and outages of the electrical service can severely impact the operations of the WSH facility and impair the WSH staff's ability to perform regular operation or respond to emergencies and other events. It should be noted that review of existing building code-required emergency power was not included as part of this study.

Due to the operating needs of the facility and existing conditions of the aging and failed components of the essential electrical system, WSH is exploring options for repairing or replacing pieces of the existing distribution equipment and campus generator systems. Where replacement is required, increasing the equipment sizes, quantities and ratings to address the needs for increased electrical capacity and redundancy to improve reliability should be a consideration.

2.2 Objective

The Department of Enterprise Services and DSHS has contracted Hargis Engineers, Inc. to complete a high level assessment of the existing campus essential electrical system infrastructure on the Western State Hospital campus and to provide recommendations for replacement, repair, and improvements where practical.

Specifically, the study has the following objectives.

- Existing conditions assessment of essential electrical components
- Identify deficiencies including equipment, capacity, reliability and code
- Provide code analysis for classifications of essential electrical systems and when emergency power is required vs. backup power
- Recommend infrastructure improvements to bring the campus infrastructure into compliance with current codes and standards
- Provide ROM costs for improvements

2.3 Methodology

The team observed the operation of the existing campus essential electrical system during a monthly test, and also documented existing equipment and conditions and identified deficiencies.

Current codes, standards, State of Washington RCWs and WAC, system capacity, and age of the equipment were used to evaluate the generator and distribution system's ability to ensure reliable performance to provide power 24 hours a day/7 day's week as required to support the operational requirements of the facility. The system maintenance, testing and ability to accommodate future improvements and enhancements also needs to be considered in the evaluation of the system.

Classifying the generator and distribution systems as an emergency system or optional standby backup power system is determined by how the hospital administration classifies each building and the patient care being provided in each building. Information regarding definitions and code requirements for the different types can be found is Section 4 of this report. There are different requirements for emergency systems than for optional standby backup power systems and a summary of the criteria is contained in the following table.

Table 2- Criteria for Emergency Electrical Systems vs Backup Power systems

Emergency Equipment Requirements	• Generator classification Level 1, Type 10 • Distribution classification (NFPA 70 Article 517 or 700) • Required where equipment failure could result in the loss of human life or in Patient Care areas. • Separation requirements/separate pathways for life safety and normal power • Specific testing and maintenance requirements • Bypass and backup capability when providing service and maintenance on equipment • Weekly maintenance inspections • More stringent testing requirements with specific equipment to be tested

Backup Power Equipment Requirements	• Generator classification Level 2, Type 60 (except NFPA 99 which requires all generators to be Level 1, Type 10) • Distribution classification (NFPA 70 Article 700) • Not code required to support owner or operational needs • No separation requirements/same pathways for backup and normal power • Testing and maintenance criteria is less stringent • Bypass capabilities are recommended but not required

Members of the WSH facilities staff were interviewed to learn about known issues and better understand the present challenges faced by the staff when testing and maintaining the current systems on the campus.

3.0 Existing Conditions

3.1 Operational Needs

As a health care facility supporting 900 patients plus 1,750 staff - year round, 24 hours per day - WSH requires robust and reliable electrical infrastructure to support the facility's mission and contribute to a safe and secure environment for patients and staff. The majority of the existing medium voltage (15kV) power distribution system that supports the essential electrical system is nearing or at the end of its economic and useful life. These essential electrical systems – including transformers, generators, switchgear, cabling and ancillary equipment - are mission critical, essential for facility operations during normal operating conditions and, even more importantly, during emergency conditions. In their current state, these electrical systems are not reliable, and are a significant liability.

In May 2018, Transfer Switch #1 failed to operate and the facility is currently operating on Transfer Switch #2, shown in Photo 1, which is the same vintage as Transfer Switch #1 and could fail at any time.

Photo 1: Transfer Switch #2

The original system was setup with an N+1 redundancy so the campus would not lose power from a single point of failure. Because of this redundancy the transfer switch failure did not result in a downtime to the facility, but any failure of equipment from this point forward will. Electrical component and/or system failures will continue to escalate as they remain in use beyond their service life. Since much of the electrical equipment is unique to the particular installation, replacement equipment can take 6 to 12 months to procure. . The addition of new buildings added to the campus have used the spare capacity within the system and there will no longer by N+1 redundancy on campus so and future equipment failure could result in extended downtime for multiple buildings on campus Therefore, addressing these types of equipment failures via emergency projects is not prudent.

In addition to replacing antiquated critical electrical infrastructure, multiple upgrades are necessary to improve redundancy and capacity of the essential electrical systems at WSH.

3.2 Essential Electrical Systems

The WSH campus is primary metered from two separate utility feeds that are labeled the McNeil Island Feed and the Custer Feed. The primary service is a 12,470 Volt 3 phase service with a fused service disconnect switch at each utility feed. The locations for the utility feeds are indicated in image 1. Both utility feeds enter into Main-Tie-Main distribution equipment with capability to transfer from one utility to the other to improve reliability and redundancy. The automatic transfer portion has been disabled and has to be transferred manually by Tacoma Power. The Main-Tie-Main distribution equipment feeds the Main Campus distribution equipment which has five distribution sections feeding the campus. These sections are indicated on Riser Drawing E9.00 and shown in Photo #2 below.

Photo 2: Main Distribution Equipment with Main-Tie-Main

Of the five sections only three are still energized and it is unknown if the switches are properly operating. The equipment has not been exercised since 2015 because facility staff is not confident that these sections will able to be switched back on if they are switched off. The Main Campus distribution equipment no longer has replacement parts available and should be replaced.

Image 1: Campus Utility Feeds

Buildings 28 and 29 were previously fed from the campus switchboard but the switches feeding those buildings were removed and used for spare parts to keep the equipment operational. Currently Buildings 28 and 29 are only fed from the Fort Steilacoom utility feed and each has a dedicated generator. Generator #4 provides emergency and backup power to Building 29 and Generator #5 provides emergency and backup power to Building 28. There are a total of five generators on campus, Generators #1 and #2 energize the 4,160V medium voltage loops, and Generator #3 provides power to maintenance support buildings. Generators and transfer equipment are described in more detail below.

Downstream of the Main Campus Switchboard there are two 4,160 Volt 2,000 KW transformers that feed Transfer Switches #1 and #2 then distribute through distribution equipment identified as Buss #1 and Buss #2. These two busses support the 4,160 Volts medium voltage loops on campus that provide power to all of the buildings with the exception of Buildings 28 and 29. Buss #1 and Buss #2 are made up of six distribution switch sections, three sections per Buss powering two separate loops for redundancy and reliability. Four of the sections were installed in the 1960s and two sections were installed in 1984 along with Generator #1 and the Automatic Transfer Switches #1 and #2 (ATS #1 and ATS #2). All of the equipment mentioned above has either failed, has no replacement parts available, or is beyond its economical useful life and should be replaced. In addition, the new kitchen building has been added onto the 4,160V medium voltage loops and there is no additional capacity left within the system to support any changes on the campus including remodels to buildings, technology infrastructure upgrades or new buildings on campus.

3.2.1 Generator and ATS #1

Generator #1 is a 1,500 kW generator operating at 4,160 Volts and is located inside a small building near the medium voltage electrical equipment. The generator provides backup power for most of the buildings on campus as well as the CSTC. Refer to campus one-line diagram for distribution. The generator is a Caterpillar engine installed in 1984 and is connected to the bulk fuel storage tank systems on campus. The engine currently leaks oil but spare parts are still commercially available. ATS #1 was installed in 1984 and does not have internal bypass capabilities to allow for maintenance. All loads need to be transferred to ATS #2 to do any maintenance or repair on ATS#1 or Generator #1. The generator has a battery charger on the wall, remote stop button outside the building and does not have a remote generator panel at the maintenance facility nor is it monitored by the campus fire alarm system. The mechanical louvers for airflow through the generator building are not functioning and locked in the open position. The bulk fuel storage tank system is made up of two 20,000 gallon fuel tanks allowing operation of the generator for seven days. During monthly testing in April, after normal power was available at the transfer switch, the generator was put into cooldown mode but turned off and power was not transferred back to normal power. There was no power available to the buildings on that feeder until the generator was manually restarted, manual transfer of power was initiated from the generator to utility power, and then the generator was put into cooldown mode. Facility staff reported that the following month during the test the transfer switch did not transfer power and smoke was seen coming out of the switch. This was being reviewed further by maintenance but the equipment has reached its economic useful life and should be replaced if the facility is to have reliable backup power from the generator and distribution equipment. Power transferred to the generator after 36 seconds would classify the generator and transfer switch as a Level 2, Class 168, Type 60 Emergency Power Supply System per NFPA 110.

3.2.2 Generator and ATS #2

Generator #2 is a 1,500 kW generator operating at 4,160 Volts and is located inside a small building away from the medium voltage electrical equipment. The generator provides backup power for most of the buildings on campus as well as the CSTC. Refer to campus one-line diagram for distribution. The generator is a Caterpillar engine installed in 1994 and is connected to the bulk fuel storage tank systems on campus. The engine is within its economic useful life and spare parts are still commercially available. ATS #2 was installed at the same time as ATS#1 and does not have internal bypass capabilities to allow for maintenance. All loads need to be transferred to ATS #1 to do any maintenance or repair on ATS#2 or Generator #2. The generator has a battery charger on the wall, a remote stop button outside the building and does not have a remote generator panel at the maintenance facility nor is it monitored by the campus fire alarm system. The bulk fuel storage tank system is made up of two 20,000 gallon fuel tanks allowing operation of the generator for seven days. During monthly testing in April, after normal power was available at the transfer switch, the generator was put into cooldown mode but turned off and power was not transferred back to normal power. There was no power available to the buildings on that feeder until the generator was manually restarted, manual transfer of power was initiated from the generator to utility power, and then the generator was put into cooldown mode. Facility staff reported that the following month during the test the transfer switch did not transfer power and smoke was seen coming out of the switch. This was being reviewed further by maintenance but the equipment has reached its economic useful life and should be replaced if the facility is to have reliable backup power from the generator and distribution equipment. Power transferred to the generator after 47 seconds would classify the generator and transfer switch as a Level 2, Class 168, Type 60 Emergency Power Supply System per NFPA 110.

3.2.3 Generator and ATS #3

Generator #3 is a 250 kW generator operating at 480 Volts and is located in the steam plant (Building 5) next to the medium voltage distribution equipment Buss #1 and Buss #2. The generator provides backup power for buildings 1, 2, 3, 4, 5, 11, 12, 32, 33, and 34 but is installed downstream of Generator #1 so it only provides backup power if Generator #1 is not functional. ATS #3 is approximately 10 years old. Refer to campus one-line diagram for distribution. The generator is a Caterpillar engine installed in 1964 and is connected to the small fuel storage tank within Building 5. There are no outdoor air louvers or other openings into the space for cooling of the generator radiator. The generator is redundant and could be removed if additional redundancy was added upstream. The generator and ATS #3 does not separate life safety loads from other loads and is providing optional standby power for WSH operations only. While the generator starts within 10 seconds, the transfer switch is set to delay transfer of power for 120+ seconds. Under the current setup the generator and transfer switch would classify as a Level 2 Class 168, Type 120 Emergency Power Supply System per NFPA 110.

3.2.4 Generator #4 and ATSs

Generator #4 is a 700 kW generator operating at 480 Volts and is located in the penthouse of Building 29. The generator provides backup and emergency life safety power within Building 29 and has five transfer switches that are located in the Main Electrical Room. The generator and ATSs are original to the building and were installed in 1981. The generator is a Cummins engine with limited spare parts available. Maintenance staff recently replaced the governor on the engine and at that time was told that there were no additional governors available for this engine and once the existing one fails the generator will not be able to operate. The outdoor air louvers are no longer functioning and locked in the open position. The ATSs do not always transfer power and maintenance staff has noted the need to hit the enclosures to get them to operate and transfer power. Generator #4 and the associated ATSs were installed to meet 1981 NFPA 70 article 517 which requires generator power for Life Safety and Critical power systems. The transfer switches and generator have reached the end of their economical useful life and should be replaced. The generator starts and transfers power within eight seconds. Under the current setup the generator and transfer switch would classify as Level 1 Class 168, Type 10 Emergency Power Supply System per NFPA 110.

3.2.5 Generator #5 and ATSs

Generator #5 is a 750 kW generator operating at 4,160 Volts and is located in the penthouse of Building 28. The generator provides backup and emergency life safety power within Building 28 and has five transfer switches that are located in the Main Electrical Room. The generator and ATSs are original to Building 28 and were installed in 1999. The generator is a Kohler engine and operates at 30% capacity or less during monthly testing. The outdoor air louvers are no longer functioning and locked in the open position. The distribution system and transfer switches separate loads as required by NFPA 70 article 517 for Life Safety and Critical, mechanical power and owner optional power systems. The generator starts and transfers power within eight seconds. Under the current setup the generator and transfer switch would classify as Level 1 Class 168, Type 10 Emergency Power Supply System per NFPA 110.

4.0 Code Review of Essential Electrical Systems for Emergency and Backup Power

A code analysis of current codes and requirements, as well as previous versions of codes, was performed to identify when requirements were adopted and what code considerations should be applied to the various buildings on campus. WSH staff can review the information provided to help them understand what code requirements may be applicable to various buildings on campus depending on the services, occupancy and use within each building. The codes reviewed as well as an overview of some the applicable sections are shown below. This is not meant to be a comprehensive list and it is recommended the full code sections be reviewed to understand the full requirements of the essential electrical system within each building.

4.1 NFPA 99 - Health Care Facilities Code

The 2015 version of NFPA 99 is applicable to existing facilities and previous versions were not reviewed. The following is an overview of some of the items found in NFPA 99 but is not a complete list. Refer to the complete NFPA 99 standard for all requirements.

1.3.4 Defines Patient Care Spaces as: The governing body of the facility or its designee shall establish the following areas in accordance with the type of patient care anticipated (see definition of patient care spaces in chapter 3.3.127).

3.3.127 Patient Care Space is any space of a health care facility wherein patients are intended to be examined or treated.

(1) Category 1 spaces: Space in which failure of equipment or system is likely to cause major injury or death of patients, staff, or visitors.
(2) Category 2 spaces: Space in which failure of equipment or a system is likely to cause minor injury to patients, staff, or visitors.
(3) Category 3 spaces: Space in which the failure of equipment or a system is not likely to cause injury to patients, staff, or visitors but can cause discomfort.
(4) Category 4 spaces: Space in which failure of equipment or a system is not likely to have a physical impact on patient care.

3.3.45 Defines an essential Electrical System as: A system comprised of alternate sources of power and all connected distribution systems and ancillary equipment, designed to ensure continuity of electrical power to designated areas and functions of a healthcare facility during disruption within the internal wiring system.

6.3.2.2.10 requires Category 1 spaces shall be served by a Type 1 Essential Electrical System (EES); Category 2 spaces shall be served by a Type 1 EES; Category 3 or 4 shall NOT be required to be served by an EES. *If they are installed they would be considered a Type 3 EES system.*

6.4.1.1.6 requires generator sets installed as an alternate source of power for essential electrical systems shall be designed to meet the requirements of the service. Type 1 and Type 2

EES power sources shall be classified as Type 10, Class X, Level 1 generator sets per NFPA 110. Type 3 EES power sources shall be classified as Type 10, Class x, Level 2 generator sets per NFPA 110. This means all essential electrical systems (Type 1, Type 2 or Type 3) shall be Type 10 generator set per NFPA 110 and automatically transfer power within 10 seconds.

4.2 NFPA 101 - Life Safety Code

The 2012 version of NFPA 101 is applicable to the campus and a requirement of the federal government. The following is an overview of some of the items found in NFPA 101 but is not a complete list. Refer to the complete NFPA 101 standard for all requirements.

The following definitions can be used to help determine what section of NFPA 101 applies to each building on campus based on how they are used and the type of care provided. Chapter 19 applies to existing health care facilities and Chapter 33 applies to existing residential board and care occupancies. How the buildings are classified will determine what systems and portions of NFPA 70 - National Electrical Code apply to each building. Refer to section 4.4 of this report for more information regarding that code. If a building is classified as a High-Rise building then there are additional requirements for egressing that need to be considered.

3.3.36.7 Defines High-Rise Building as: A building where the floor of an occupiable story is greater than 75 ft above the lowest level of fire department vehicle access.

3.3.88.2* Defines Limited Care Facility as: A building or portion of a building used on a 24-hour basis for the housing of four or more persons who are incapable of self-preservation because of age; physical limitations due to accident or illness; or limitations such as mental retardation/developmental disability, mental illness, or chemical dependency.

**The annex expands on this definition to state that limited care facilities and residential board and care occupancies both provide care to people with physical and mental limitations. However, the goals and programs of the two types of occupancies differ greatly. The requirements of NFPA 101 for limited care facilities are based on the assumption that these are medical facilities, that they provide medical care and treatment, and that the patients are not trained to respond to the fire alarm; that is, the patients do not participate in fire drills but, rather, await rescue. (See Section 18.7.)*

The requirements for residential board and care occupancies are based on the assumption that the residents are provided with personal care and activities that foster continued independence, that the residents are encouraged and taught to overcome their limitations, and that most residents, including all residents in prompt and slow homes, are trained to respond to fire drills to the extent they are able. Residents are required to participate in fire drills. (*See section 32.7.)*

3.3.188.7* Defines Health Care Occupancy as: An occupancy used to provide medical or other treatment of care simultaneously to four or more patients on an inpatient basis, where such patients are mostly incapable of self-preservation due to age, physical or mental disability, or because of security measures not under the occupants' control.

**The annex notes that health care occupancies include hospitals, limited care facilities, and nursing homes.*

3.3.188.12* Defines Residential Board and Care Occupancies as: An occupancy used for lodging and boarding of four or more residents, not related by blood or marriage to the owners or operators, for the purpose of providing personal care services.

**The annex notes examples of facilities that are classified as residential board and care occupancies with one example being facilities for social rehabilitation, alcoholism, drug abuse, or mental health problems that contain a group housing arrangement and that provide personal care services but do not provide acute care.*

3.3.206* Defines Personal Care as: The care of residents who do not require chronic or convalescent medical or nursing care.

**The annex notes that personal care involves responsibility for the safety of the resident while inside the building, personal care might include daily awareness by management of the resident's functioning and whereabouts, making and reminding a resident of appointments, the ability and readiness for intervention in the event of a resident experiencing a crisis, supervision in the areas of nutrition and medication, and actual provisions of transient medical care.*

Chapter 19 - Existing Health Care Occupancies notes the following requirements that impact the essential electrical system requirements.

19.2.9.1 Emergency lighting shall be provided in accordance with Section 7.9.

19.5.1.1 Utilities shall comply with the provisions of Section 9.1.

19.5.1.2 Existing installations shall be permitted to be continued in service, provided that the systems do not present a serious hazard to life.

Chapter 33 - Existing Residential Board and Care Occupancies notes the following requirements that impact the essential electrical system requirements.

33.3.2.9 Emergency lighting in accordance with Section 7.9 shall be provided in all facilities meeting any of the following criteria:

(1) Facilities having an impractical evacuation capability
(2) Facilities having a prompt or slow evacuation capability with more than 25 rooms, unless each room has a direct exit to the outside of the building at the finished ground level.

33.3.6.1 Utilities shall comply with the provisions of Section 9.1.

Chapter 7 - Means of Egress shall apply to both new and existing buildings with Section 7.9 having an impact on the essential electrical system within a building.

7.9.1.3 Where maintenance of illumination depends on changing from one energy source to another, a delay of not more than 10 seconds shall be permitted.

7.9.2.1 Emergency illumination requirements are indicated in this section with minimum requirements for emergency power duration, illumination levels, max to min ratios among other requirements.

7.9.2.3 The emergency lighting system shall be arranged to provide the required illumination automatically in the event of any interruption of normal lighting due to any of the following:

(1) Failure of a public utility or other outside electrical power supply
(2) Opening of a circuit breaker or fuse
(3) Manual act(s), including accidental opening of a switch controlling normal lighting facilities.

7.9.2.4 Requires emergency generators providing power to emergency lighting systems to be installed, tested, and maintained in accordance with NFPA 110.

7.9.2.5 Requires unit equipment and battery systems for emergency luminaires shall be listed to ANSI/UL 924.

7.9.3 Covers periodic testing of Emergency Lighting equipment in accordance with one of three options offered by 7.9.3.1.1 which covers manual testing requirements, 7.9.3.1.2 which covers self-testing requirements, and 7.9.3.1.3 which covers computer based self-testing requirements. Refer to each section for the type of testing required by the equipment within each building.

Chapter 9 covers building service and fire protection equipment that have requirements on the essential electrical system as follows:

9.1.2 Electrical wiring and equipment shall be in accordance with NFPA 70 unless such installations are approved existing installations, which shall be permitted to be continued in service.

9.1.3.1 Emergency generators and standby power systems shall be installed, tested, and maintained in accordance with NFPA 110.

9.1.3.2 New generator controllers shall be monitored by the fire alarm system, where provided, or at an attended location, for the following conditions:

(1) Generator running

(2) Generator fault
(3) Generator switch in nonautomatic position.

4.3 NFPA 110 - Standard for Emergency and Standby Power Systems

The 2016 version of NFPA 110 is the most current version and is applicable for maintenance of existing systems. The following is an overview of some of the items found in NFPA 110 but is not a complete list. Refer to the complete NFPA 110 standard for all requirements.

1.3 States this document applies to new installations of EPSSs (Emergency Power Supply Systems), except that the requirements of Chapter 8 shall apply to new and existing systems. Existing systems shall not be required to be modified to conform, except where the authority having jurisdiction determines that the nonconformity presents a distinct hazard to life.

8.1.2 During the routine testing, the EPS may be out of service for several hours or the fuel supply could fall below the minimum necessary level. It may be prudent to have an alternate power source available during testing.

8.3.1 The EPSS shall be maintained to ensure to a reasonable degree that the system is capable of supplying service within the time specified for the type and time duration specified for the class.

8.3.2.1* The operational test shall be initiated at an ATS and shall include testing of each EPSS component on which maintenance or repair has been performed, including the transfer of each automatic and manual transfer switch to the alternate power source, for a period of not less than 30 minutes under operating temperature.

**The handbook states when components of an EPSS are repaired or replaced, the operation of the system must be verified. An operational test is necessary when any part of the EPSS has had a repair that affects the reliability of the system.*

8.3.4 Transfer switches shall be subjected to a maintenance and testing program that includes all of the following operations:

(1) Checking connections
(2) Inspection or testing for evidence of overheating and excessive contact erosion
(3) Removal of dust and dirt
(4) Replacement of contacts when required

8.3.7* A fuel quality test shall be performed at least annually.

**The Handbook states the requirement for fuel quality and fuel management shall be the responsibility of the AHJ. They are responsible for acceptance of the fuel quality standard and means of assessment to be used. If there is not an established testing method this section* *recommends the use of ASTM D975, Standard Specification for Diesel Fuel Oils, which contains test methods for existing diesel fuel.*

8.4.1* EPSSs, including all appurtenant components, shall be inspected weekly and exercised under load at least monthly.

**The handbook states that this section covers inspection procedures and notes weekly inspections may be provided for specific generators. In lieu of that there are weekly inspection items identified in the appendix Figure A8.3.1(a) which can be used.*

8.4.2* Diesel generator sets in service shall be exercised at least once monthly, for a minimum of 30 minutes, using one of the following methods:

> (1) The date and time of day for required testing shall be decided by the owner, based on facility operations
> (2) Under operating temperature conditions and at not less than 30 percent of the EPS standby nameplate kW rating

**The handbook states that once a system has been commissioned, operational tests are necessary to adequately test the performance of the generator. The monthly test for diesel-powered generator sets provides two test methods. If one of these test parameters can be met, the alternative monthly/annual test in 8.4.2.3 is not required to be implemented. Where neither of the methods can be achieved, 8.4.2.3 provides the alternative monthly test, which is then augmented by an annual test. Many facilities install oversized generators for future expansion. The loading percentage is based on the generator nameplate kW rating and not on the actual load of the building. A test that uses 100 percent of the existing EPSS load might not meet 30 percent of the generator nameplate kW rating. There is a difference between prime and standby ratings. Often two kW nameplate ratings are found on engine-driven generators: "standby" and "prime." A 100 kW standby generator is normally considered an 80 kW set for prime power. The generator set manufacturer should be consulted where the nameplate data does not indicate rating type. A permanent record of the rating should be maintained and readily available.*

8.4.2(1) Exhaust temperature monitoring is a method of measuring proper EPS loading. There is no load percentage required for this test. The load needs to be sufficient to achieve the exhaust temperature recommended by the manufacture.

8.4.2(2) The minimum load is intended to limit the possibility of wet-stacking (incomplete combustion), which may occur when a diesel generator is lightly loaded. Operation at 30 percent of the nameplate kW rating for 30 minutes should minimize the build-up of residual fuel in the system.

8.4.6 Transfer switches shall be operated monthly.

8.4.7 EPSS circuit breakers for Level 1 system usage, including main and feed breakers between the EPS and the transfer switch load terminals, shall be exercised annually with the EPS in the “off” position.

8.4.7.1 Circuit breakers rated in excess of 600 Volts for Level 1 system usage shall be exercised every 6 months and shall be tested under simulated overload conditions every 2 years.

8.4.8 EPSS components shall be maintained and tested by qualified person(s).

8.4.9* Level 1 EPSS shall be tested at least once within every 36 months.

**The handbook states this requirement applies to all generator types if they supply a Level 1 EPSS. The intent is to ensure that the EPSS with all its auxiliary systems is capable of running with load for the duration of its assigned class. It is not intended that a full facility power outage be conducted as part of these tests. This 36-month test is not a requirement for a Level 2 EPSS.*

8.4.9.2 Where the assigned class is greater than four hours, it shall be permitted to terminate the test after four continuous hours.

8.5 Covers records of maintenance and testing and requires that all records be available to the AHJ on request.

8.5.3 The record shall include the following:

(1) The date of the maintenance report
(2) Identification of the servicing personnel
(3) Notation of any unsatisfactory condition and the corrective action taken, including parts replaced
(4) Testing of any repair in the time recommended by the manufacturer.

8.5.4 Records shall be retained for a period of time defined by the facility management or by the authority having jurisdiction.

4.4 NFPA 70 - National Electrical Code

The 2017 version of NFPA 70 (National Electrical Code - NEC) has been adopted by the state of Washington with amendments. This code has the requirements for how to install the systems, separation of systems, and what loads are permitted to be emergency or life safety depending on the applicable article. There are multiple versions of this code and you have to look at when a system was installed to understand the requirements at the time of installation. There are four articles within the NEC that have requirements for generators and backup power.
Article 517 covers healthcare facilities and applies to facilities that provide patient care as defined in NFPA 99. Article 700 is for Emergency Systems, Article 701 is for Legally Required Systems, and Article 702 is for Optional Standby Systems. These are the requirements for how to design and install the system. Since the systems are existing, these codes should be reviewed

for any projects that add to or modify the systems. The code also requires maintenance and testing to be completed per manufacturer instructions and industry standards and also references NFPA 99, NFPA 101, and NFPA 110. The following is an overview of some of the items found in NFPA 70 (NEC) but is not a complete list. Refer to the complete NFPA 70 standard for all requirements.

517.2 Provides the following definitions:

Health Care Facilities* - Buildings, portions of buildings, or mobile enclosures in which human medical, dental, psychiatric, nursing, obstetrical, or surgical care are provided.

**The handbook notes that the terms "health care facility" should not be confused with the term "health care occupancy". The NEC does not designate the type of facility or level of care provided. The governing body of the facility determines the type of services being provided at a facility. For example, depending on the jurisdiction, a chiropractic office may or may not be a facility covered under Article 517.*

Patient Care Space* - Any space of a health care facility wherein patients are intended to be examined or treated [NFPA 99: 3.3.127].

**Informational Note No. 1 states the governing body of the facility designates patient care space in accordance with the type of patient care anticipated.*

517.10* States that Part II of Article 517 shall apply to patient care space of all health care facilities.

**The handbook notes the designation of the types of patient care spaces is the responsibility of the governing body of the health care facility.*

700.1* States Article 700 applies to the electrical safety of the installation, operation, and maintenance of emergency systems consisting of circuits and equipment intended to supply, distribute, and control electricity for illumination, power, or both, to required facilities when the normal electrical supply or system is interrupted.

**Informational Note No.1 states for further information regarding wiring and installation of emergency systems in health care facilities see Article 517.*

**Informational Note No. 2 states for further information regarding performance and maintenance of emergency systems in health care facilities see NFPA 99.*

**Informational Note No. 3 states for specification of locations where emergency lighting is considered essential to life safety see NFPA 101.*

**Informational Note No. 4 states for further information regarding performance of emergency and standby power systems see NFPA 110.*

There are multiple requirements within Articles 517 and 700 for design and installation of the essential electrical systems and distribution systems but for existing conditions they refer to maintenance and testing per NFPA 110.

4.5 WAC 296-46B - Electrical Safety Standard, Administration and Installation

There are multiple amendments to NFPA 70 that could apply to the existing essential electrical system. The following is an overview of some of the items found in WAC 296-46B but is not a complete list. Refer to the complete WAC 296-46B for all requirements.

The Washington State Amendments to NFPA 70 for Article 517 are specific to sizing the generators, feeders, and equipment. If a facility is using Article 517 for the essential electrical systems, the generator must be sized to meet or exceed the summation of all of the existing loads plus the added loads for the life safety branch, critical branch and equipment branch power systems.

The Washington State Amendments for NFPA 70 Article 700.01 states that in all health or personal care facilities all exit and emergency lights must be installed in accordance with Article 700 NEC and located as required in standards adopted by the State Building Code Council under chapter 19.27 RCW.

4.6 WAC 246-337 - Residential Treatment Facility

Article 140 requires emergency lighting be provided on each floor. Of the five generators on campus only Generators #4 and #5 currently support this requirement.

Article 070 requires all licensed facilities to establish and implement an emergency disaster plan including shelter, heat and power for critical functions for three days. Of the five generators on campus, Generators #1, #2, #4, and #5 currently support this requirement.

4.7 WAC 246-320 - Hospital Licensing Regulations

WAC 246-320 is the state requirements for a licensed hospital operating within the state of Washington. Section 246-320-505 is for design, construction review, and approval of plans for any project at campus and will need to be followed. In addition, 246-320-151 covers reportable events and notes that it is the hospital's responsibility to report a failure or facility system malfunction that affects patient diagnosis, treatment, or care within the facility.

5.0 Recommendations and ROM Costs

Modifications and equipment replacement of the essential electrical system components will impact the day-to-day operations of the facilities as well as the patients that depend on them throughout the WSH/CSTC facilities. The work will need to be carefully planned and coordinated to minimize the impact on critical ongoing operations that must be maintained throughout construction. Electrical system outages will be required to accomplish the installation as well as for cutovers from old to new electrical systems. However, these impacts will need to be managed carefully and minimized through coordinated work sequencing and installation of temporary utilities. Detailed coordination and planning with patient care providers and facility operations at the facility will be required.

Table 2

1	• New Medium Voltage transfer switches for ATS #1 and ATS #2. • New Medium Voltage switchgear for distribution equipment for dual fed utility Main-Tie-Main with vacuum breakers and protective relays. • Replace medium voltage Buss #1 and Buss #2 with new lineup of metal clad switchgear with vacuum breakers and protective relays.	$3,358,331
2	• Perform work from Part 1. • Replace Generators #1 & #2 with three 1,250 kW 480V generators. • Add paralleling gear and master controller. • New transformers to feed 4,160V loops.	$3,443,055
3	• Remove Generator #4. • Add transformer and equipment so loads from Generator #4 can be added to Generator #5. • Add remote generator docking station to allow for remote generator or load bank testing. • Replace transfer switches in Building 29.	$809,657

Single or multiple projects could be used to address the existing deficiencies and failed equipment on campus. Failed components need to be replaced before any more equipment fails so the facility can maintain the existing emergency disaster plan. In addition, replacing failed equipment with new modern systems will improve electrical system reliability, improve safety for the performance and operation of the essential electrical systems on campus, and reduce costs for ongoing maintenance and operations. Recommended improvements include the following:

- ➢ Replace existing dangerous and unsafe medium-voltage switching equipment in numerous locations throughout the facility that has been identified by facility staff as not safe and/or operation of which could lead to catastrophic failure.

- Test and possibly replace existing oil-filled medium-voltage equipment (likely some containing PCBs), including transformers to avoid likely imminent failure and associated operational and environmental implications.
- Replace existing failing and inadequate code-required essential power systems, including emergency generators, transfer switches and associated power distribution equipment.
- Replace Buss #1 and Buss #2 with new medium-voltage power distribution equipment and cabling to provide additional capacity and redundancy on campus. Confirm load and system size requirements with campus master plan. A minimum of 25% spare capacity within the system should be maintained.
- Upgrades to main-tie-main medium voltage electrical distribution equipment. Confirm load and system size with campus master plan.
- New generators, paralleling gear, electrical equipment and transformers to feed the medium voltage campus loops. Equipment to have redundancy such that a single equipment failure will not result in downtime within any building on campus. Confirm load and system size with campus master plan.

In order to achieve the recommendation and concepts above, any project will require additional research, site discovery and design coordination, and the following will also need to be addressed:

- The availability of existing record drawings and documents for WSH is very limited. Significant field verification will be required to adequately verify and document the existing conditions prior to issuing construction documents for bid.

- The availability of existing loading criteria at the campus loop and building level is limited. A metering study will be required to verify existing conditions for permitting and to validate system sizing and equipment selections.

- Some of the existing oil-filled equipment likely contains PCBs. Confirmation and coordination of an approach to address this will be required during the design phase.

- Because of the limitations in replacing electrical equipment in the existing buildings or electrical service yard and routing new conduits into existing facility buildings, the new installation will need to be coordinated in detail. Where existing underground ducts cannot be reused, new underground conduit will require additional preparation, planning, and execution as well as additional permitting and time for the historical site.

Careful coordination and site analysis will need to be conducted to finalize the exact routing of the new underground conduit duct banks and new equipment locations. Concepts have been developed based upon site observation, but there has been limited as-built drawing documentation available for the remaining utility infrastructure. A complete locate process will need to occur to validate the final pathway and identify any existing conflicts in the design phase.

cost opinion

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Western State Hospital - Essential Electrical Systems

Western State Hospital

BASIS OF OPINION	Study	**PREPARED BY**	Doug Svee	**DATE**	August 3, 2018
JOB NUMBER	17103.09	**CHECKED BY**	Erik Stearns	**GC OVERHEAD & PROFIT**	10%
				GC GENERAL CONDITIONS	10%

project summary	cost	general contractor general conditions	general contractor OH&P	total
Option 1				
Electrical	$2,258,600	225,860	248,446	2,732,906
Civil/Earth Work	$54,300	5,430	5,973	65,703
	Subtotal - Option 1	**$225,860**	248,446	**$2,798,609**
			Design Contingency @ 20%	**$559,722**
			Total project Cost	**$3,358,331**
Option 2				
Electrical	$2,271,250	227,125	249,838	2,748,213
Mechanical	$40,000	4,000	4,400	48,400
Civil	$60,000	6,000	6,600	72,600
	Subtotal -Option 2	**$237,125**	260,838	**$2,869,213**
			Design Contingency @ 20%	**$573,843**
			Total project Cost	**$3,443,055**

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BASIS OF OPINION	Study	**PREPARED BY**	Doug Svee	**DATE**	August 3, 2018
JOB NUMBER	17103.09	**CHECKED BY**	Erik Stearns	**GC OVERHEAD & PROFIT**	10%
				GC GENERAL CONDITIONS	10%

project summary	cost	general contractor general conditions	general contractor OH&P	total
Option 3				
Electrical	$517,615.00	51,762	56,938	626,314
Mechanical	$20,000	2,000	2,200	24,200
Architectural	$20,000	2,000	2,200	24,200
	Subtotal - Option 3	**$51,762**	**56,938**	**$674,714**
			Design Contingency @ 20%	**$134,943**
			Total project Cost	**$809,657**

TOTAL ELECTRICAL	**$7,611,043**

EXCLUSIONS

1 - Phased construction
2 - Sales tax
3 - Escalation
4 - Electrical & Telecom Utility Services est.
5 - Permits (Electrical, DOH, Archeological, Other)
6 - Temporary Power

electrical **cost opinion**

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BASIS OF OPINION	Study	**PREPARED BY**	Doug Svee	**DATE**	August 3, 2018
JOB NUMBER	17103.09	**CHECKED BY**	Erik Stearns	**OVERHEAD & PROFIT**	15%

	quantity		material cost		labor cost		engineering opinion		
description	**number**	**unit**	**unit cost**	**total**	**unit cost**	**total**	**subtotal**	**OH&P**	**total**
option 1									
Electrical Infrastructure									
Demolition	1	LS	1,200.00	1,200	19,200.00	19,200	20,400	3,060.00	23,460
new transfer switches	2	EA	275,000.00	550,000	19,200.00	38,400	588,400	88,260.00	676,660
new medium votlage switchgear	1	EA	500,000.00	500,000	43,200.00	43,200	543,200	81,480.00	624,680
Misc. Medium Voltage Feeders and Connections	1	EA	75,000.00	75,000	20,000.00	20,000	95,000	14,250.00	109,250
Medium Voltage Buss w/ Vacuum Breakers	8	EA	82,500.00	660,000	4,000.00	32,000	692,000	103,800.00	795,800
Testing	1	EA	5,000.00	5,000	20,000.00	20,000	25,000	3,750.00	28,750
Subtotal Site Electrical							1,964,000	294,600	**2,258,600**

electrical **cost opinion**

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BASIS OF OPINION Study **PREPARED BY** Doug Svee **DATE** August 3, 2018

JOB NUMBER 17103.09 **CHECKED BY** Erik Stearns **OVERHEAD & PROFIT** 15%

	quantity		material cost		labor cost		engineering opinion		
description	number	unit	unit cost	total	unit cost	total	subtotal	OH&P	total
option 2									
Electrical Infrastructure									
Demolition	1	LS	8,500.00	8,500	38,400.00	38,400	46,900	7,035.00	53,935
new 1250 kW Generators	3	EA	340,000.00	1,020,000	10,500.00	31,500	1,051,500	157,725.00	1,209,225
Generator enclosures	3	EA	60,000.00	180,000	5,000.00	15,000	195,000	29,250.00	224,250
new parallaling equipment	1	EA	325,000.00	325,000	43,200.00	43,200	368,200	55,230.00	423,430
new 2000 kVA transformers	2	EA	70,000.00	140,000	19,200.00	38,400	178,400	26,760.00	205,160
Misc. Feeders and Connections	1	LS	75,000.00	75,000	20,000.00	20,000	95,000	14,250.00	109,250
Testing	2	EA	5,000.00	10,000	15,000.00	30,000	40,000	6,000.00	46,000
Subtotal Site Electrical							1,975,000	296,250	**2,271,250**

electrical **cost opinion**

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BASIS OF OPINION Study | **PREPARED BY** Doug Svee | **DATE** August 3, 2018

JOB NUMBER 17103.09 | **CHECKED BY** Erik Stearns | **OVERHEAD & PROFIT** 15%

description	quantity		material cost		labor cost		engineering opinion		
	number	unit	unit cost	total	unit cost	total	subtotal	OH&P	total
option 3									
Electrical Infrastructure									
Demolition (Includes crane)	1	LS	35,000.00	35,000	40,000.00	40,000	75,000	11,250.00	86,250
new 150 Amp transfer switches	1	EA	4,000.00	4,000	2,500.00	2,500	6,500	975.00	7,475
new 200 Amp transfer switches	2	EA	16,500.00	33,000	2,500.00	5,000	38,000	5,700.00	43,700
New 600 Amp transfer switches	1	EA	27,500.00	27,500	4,500.00	4,500	32,000	4,800.00	36,800
New 1000 Amp transfer switches	2	EA	41,000.00	82,000	6,500.00	13,000	95,000	14,250.00	109,250
new 1000 kVA dry type transformer	1	EA	87,000.00	87,000	20,000.00	20,000	107,000	16,050.00	123,050
Misc. feeder/conduit work	1	LS	40,000.00	40,000	10,000.00	10,000	50,000	7,500.00	57,500
Misc. Medium Voltage work	1	LS	20,000.00	20,000	9,600.00	9,600	29,600	4,440.00	34,040
Generator Docking Station	1	LS	12,500.00	12,500	4,500.00	4,500	17,000	2,550.00	19,550
Subtotal Site Electrical							450,100	67,515	**517,615**

6.0 Appendices

A. Reference Standards and Codes

B. Riser Diagrams

Appendix A Reference Standards

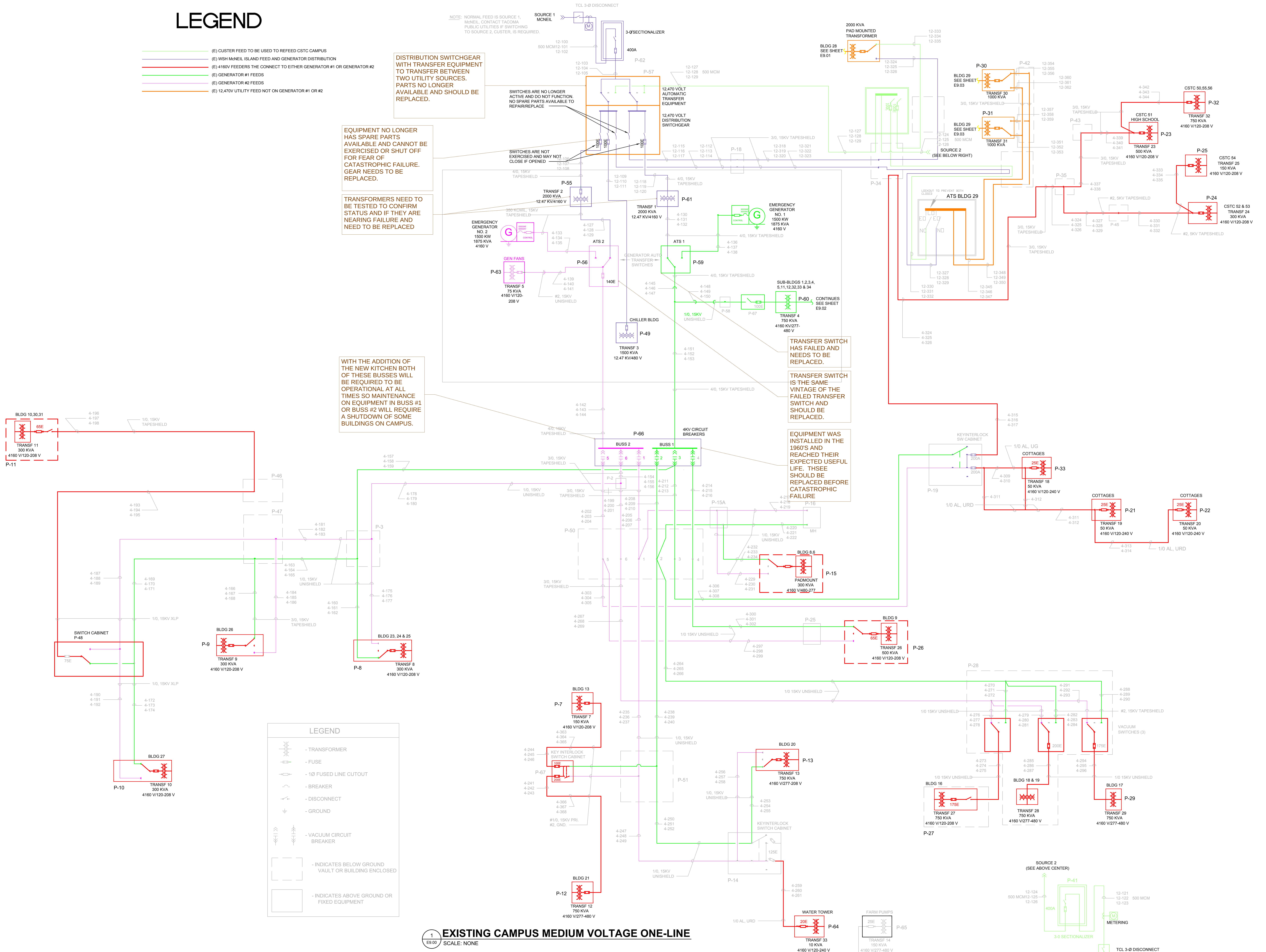
The following references were used to prepare this study:

- NFPA 99: Health Care Facilities 2015 edition
- NFPA 101: Life Safety Code 2002 and 2012 editions
- NFPA 110: Standard for Emergency and Standby Power Systems 2002, 2005, 2010, 2016 editions
- National Electrical Code, 1984, 1987, 1999, 2002, 2005, 2008, 2014, 2017 Editions
- WAC 296-46B: Electrical Safety Standards, Administration and Installation
- WAC 246-337 - Residential Treatment Facility
- WAC 246-320 - Hospital Licensing Regulations

Appendix B - Riser Diagrams

LEGEND

- (E) CUSTER FEED TO BE USED TO REFEED CSTC CAMPUS
- (E) WSH McNEIL ISLAND FEED AND GENERATOR DISTRIBUTION
- (E) 4160V FEEDERS THE CONNECT TO EITHER GENERATOR #1 OR GENERATOR #2
- (E) GENERATOR #1 FEEDS
- (E) GENERATOR #2 FEEDS
- (E) 12,470V UTILITY FEED NOT ON GENERATOR #1 OR #2



EXISTING CAMPUS MEDIUM VOLTAGE ONE-LINE

1 E9.00 SCALE: NONE

SHEET IS FOR REFERENCE ONLY. NO WORK THIS SHEET

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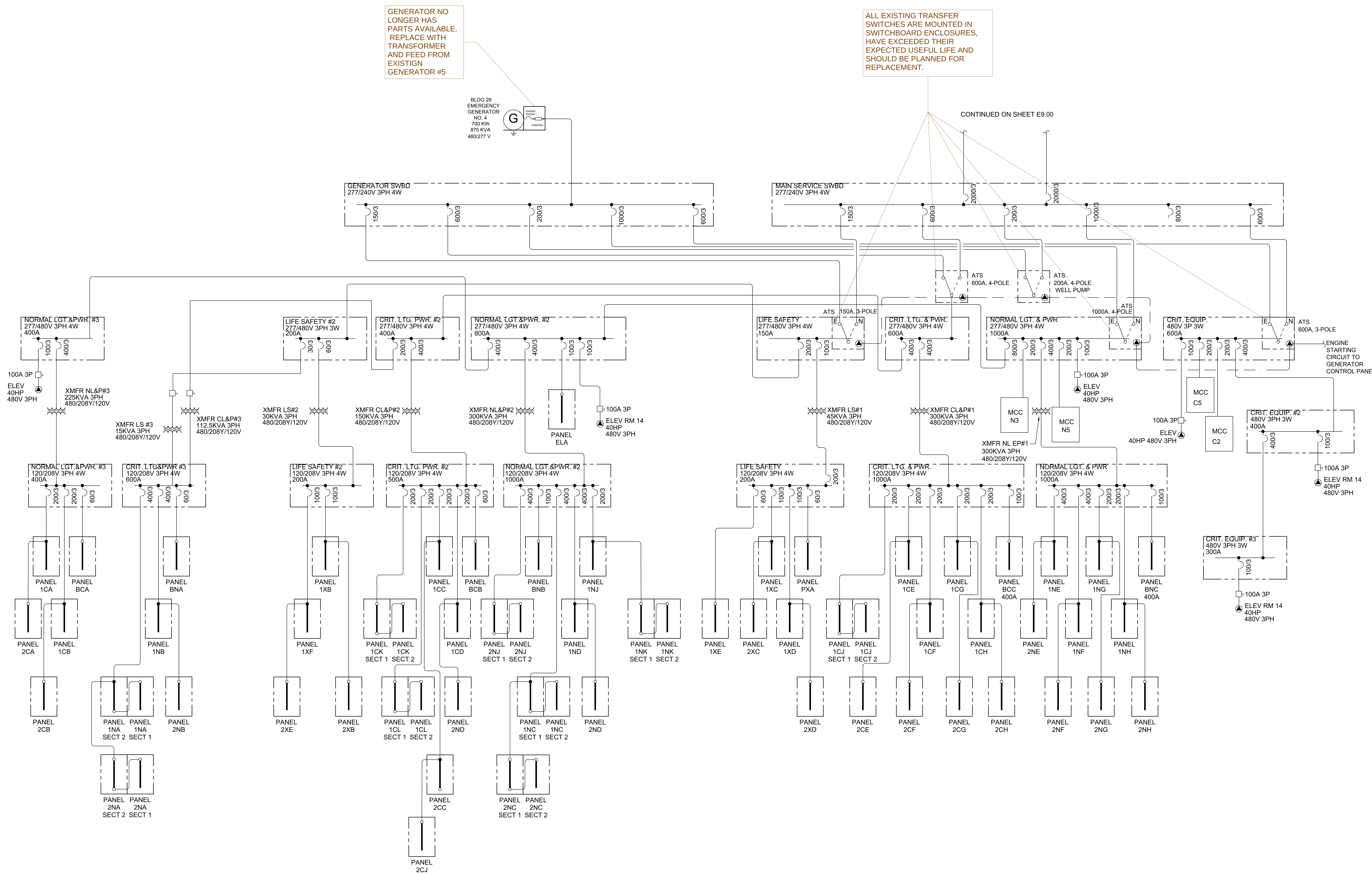
APPROVED BY	ES
SHEET TITLE	

CAMPUS MEDIUM VOLTAGE ONE-LINE

SHEET NUMBER

E9.00



1 E9.01 BLDG 29 EXISTING BUILDING ONE-LINE DIAGRAM

SCALE: NONE

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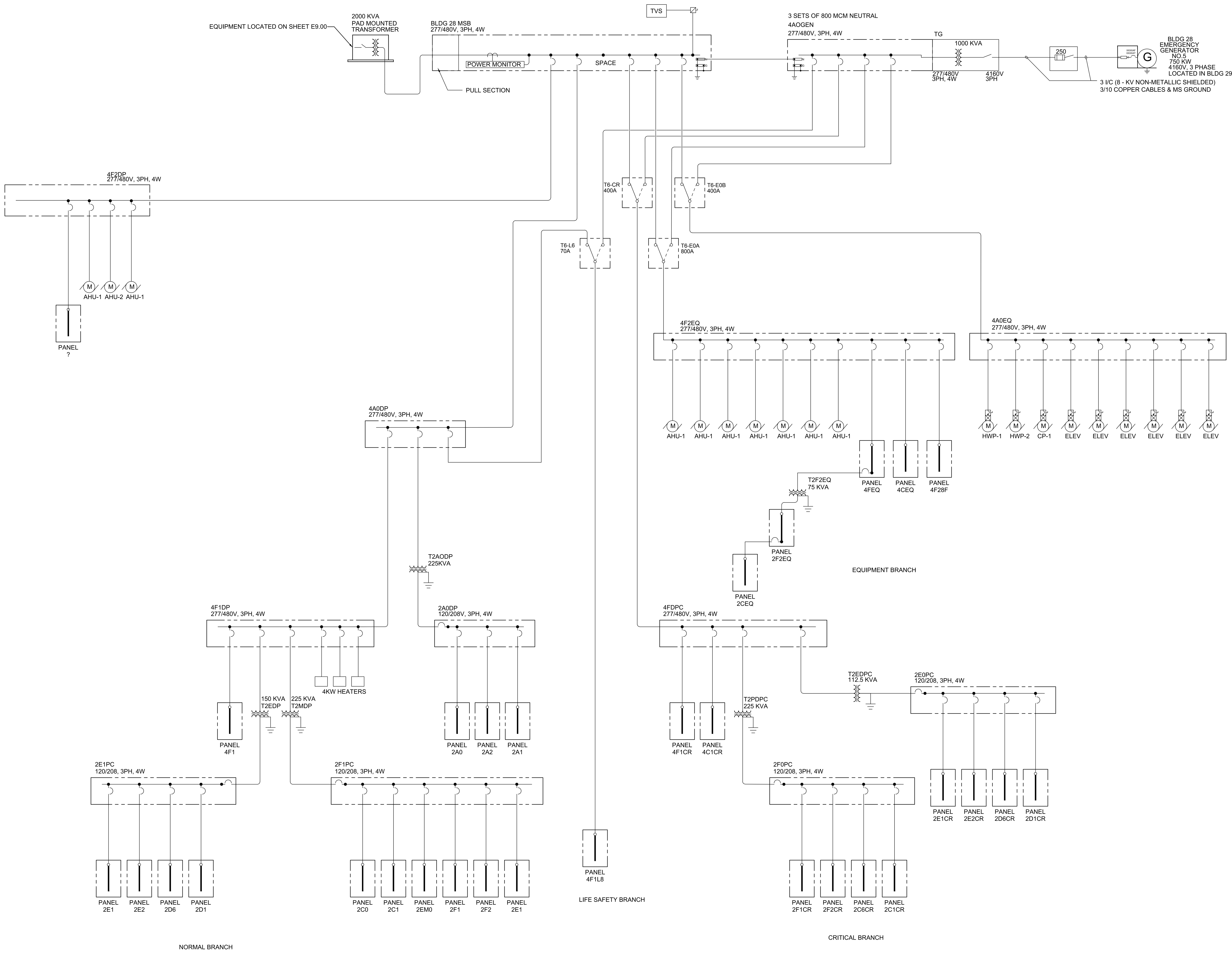
BLDG 29 EXISTING BUILDING ONE-LINE DIAGRAM

SHEET NUMBER

E9.01



1
E9.02
BLDG 28 EXISTING BUILDING ONE-LINE DIAGRAM
SCALE: NONE

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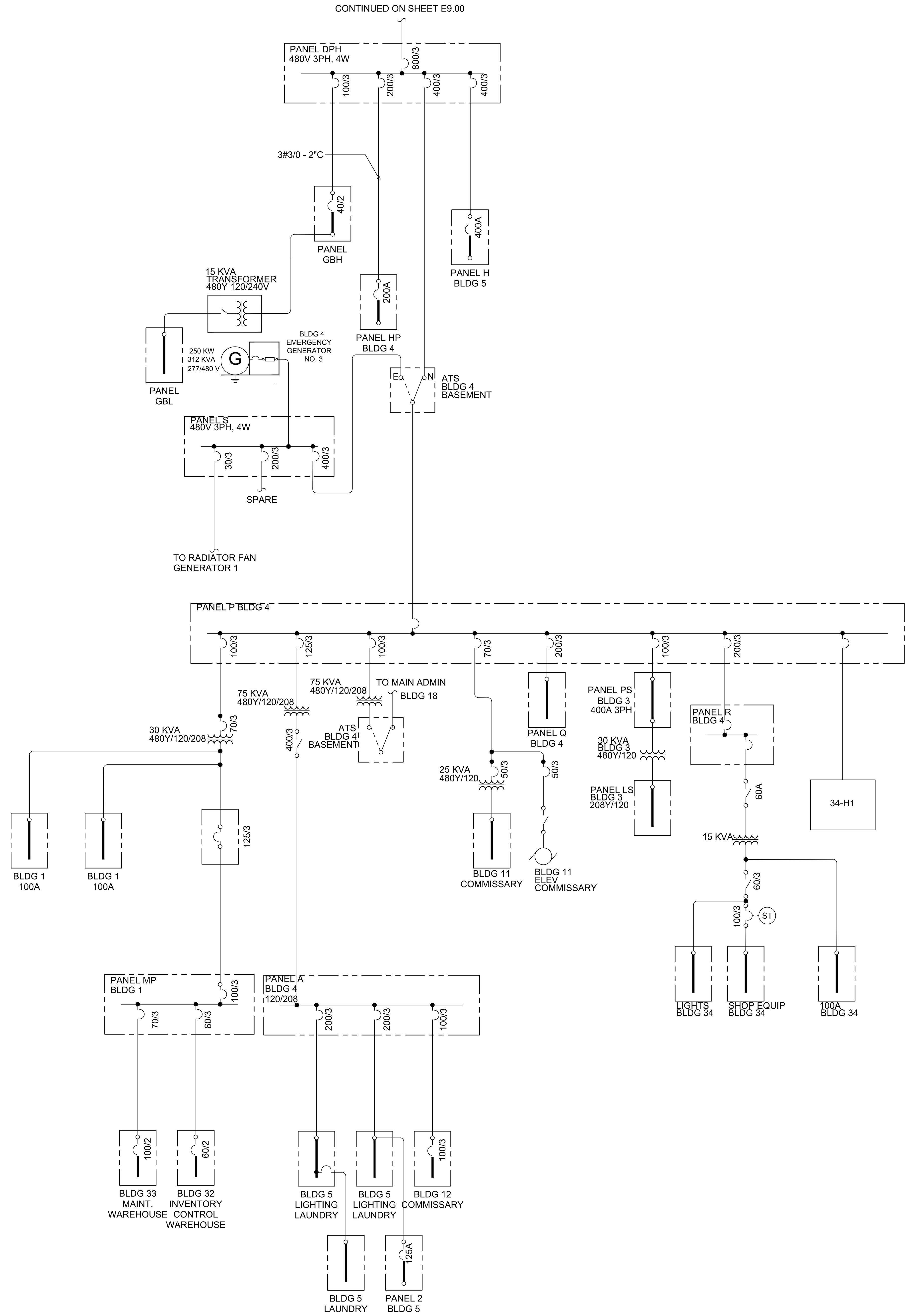
BLDG 28 EXISTING BUILDING ONE-LINE DIAGRAM

SHEET NUMBER
E9.02



1 E9.04 **BLDG 4 EXISTING ONE-LINE DIAGRAM**
SCALE: NONE

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SHEET NUMBER
E9.03